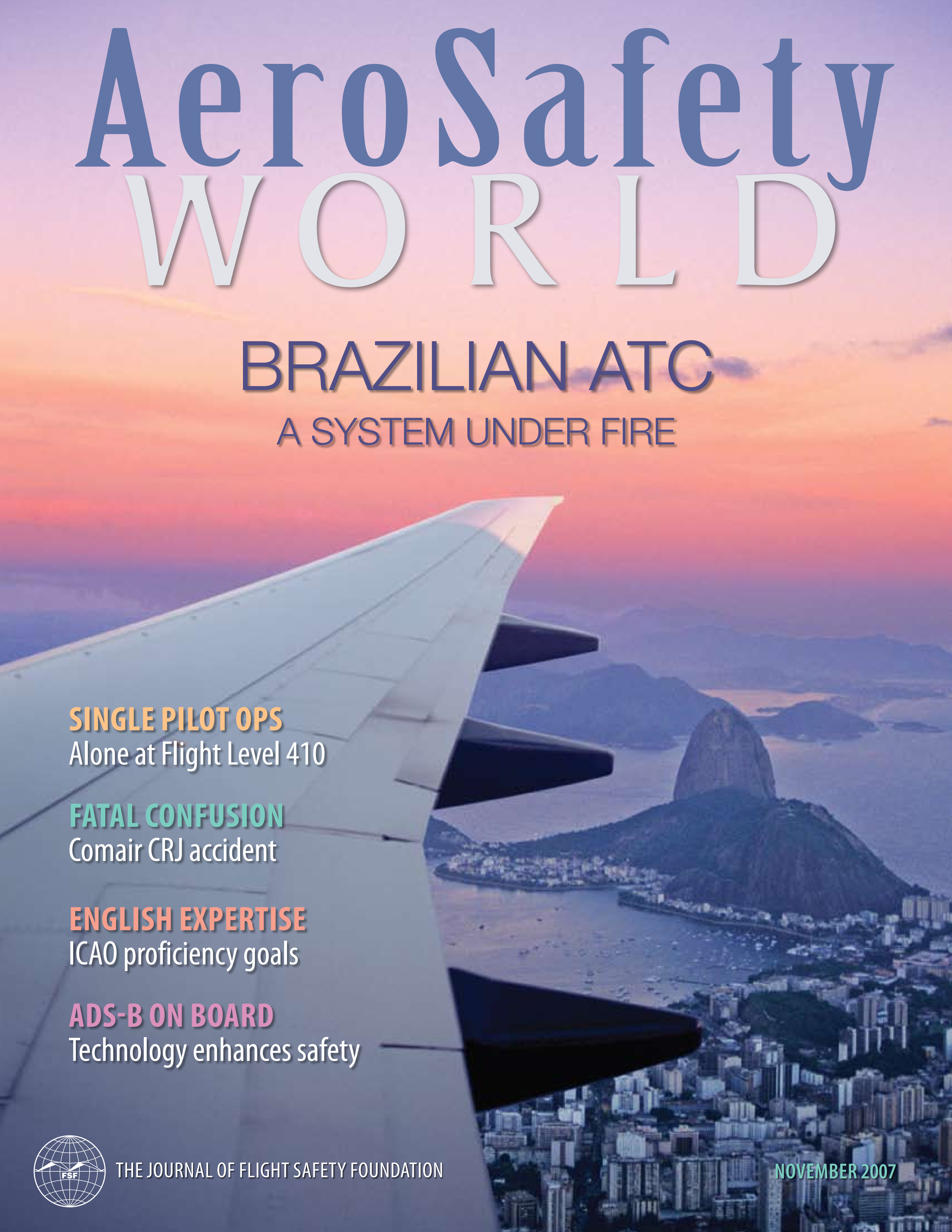
AeroSafety WORLD

BRAZILIAN ATC
A SYSTEM UNDER FIRE



SINGLE PILOT OPS
Alone at Flight Level 410

FATAL CONFUSION
Comair CRJ accident

ENGLISH EXPERTISE
ICAO proficiency goals

ADS-B ON BOARD
Technology enhances safety

THE JOURNAL OF FLIGHT SAFETY FOUNDATION

NOVEMBER 2007

SUPPORT YOUR LOCAL Regulator

I spent time as an observer at the recent International Civil Aviation Organization (ICAO) Assembly and came away with interesting data regarding the status of safety oversight around the world. ICAO since 1996 has been auditing contracting states' compliance with ICAO standards. To ICAO's credit, a couple of things have happened recently. First, there has been a big — and painful — move toward public disclosure of some audit data. Second, in 2005, ICAO moved beyond just reviewing compliance with standards to implement a powerful new audit that assesses a nation's overall ability to oversee its industry.

At the Assembly, ICAO shared summary data from the first 53 states to go through this new audit. While these states represent only a 28 percent sample, this is a nice cross-section of different-sized administrations and geographic locations. The data confirm what many of us have been worried about for a long time: Embarking on a great aviation industry expansion, we are building on a very fragile safety oversight foundation.

These audits clearly show a shortage of qualified people. The report says, "With respect to aircraft operations, approximately half of the audited states have an insufficient number of flight operations inspectors to adequately perform safety oversight of civil aviation activities. Often, this insufficient number of inspectors is due to the fact that a flight operations inspector's remuneration is not favorable when compared with corresponding remuneration in the aviation industry."

The report goes on to say, "Forty percent of the states do not adequately review and approve a prospective air operator's training manual before granting an air operator certificate, including the training manuals for flight and cabin crewmembers and for aircraft dispatchers/flight operations officers." That is pretty basic stuff, and it is not getting done.

Here is another tough finding: "Approximately 62 percent of states audited do not formally include the airworthiness inspection division in the approval of an air operator certificate or the associated specific operational approval." And just to drive the point home, here is one more thing that none of us want to hear: "Concerning aircraft operations, 68 percent of the audited states have not developed a formal surveillance program to monitor air operators' compliance with national regulations and international standards."

True, safety actually happens in the airline and on the flight line, but let's remember that safety is also a partnership. High levels of safety are not sustainable without high levels of safety oversight. The ICAO report drove this home with a statistical analysis correlating accident rates with a region's lack of effective implementation in oversight functions, licensing, surveillance and resolution of safety deficiencies. The relationship proved to be extraordinarily strong.

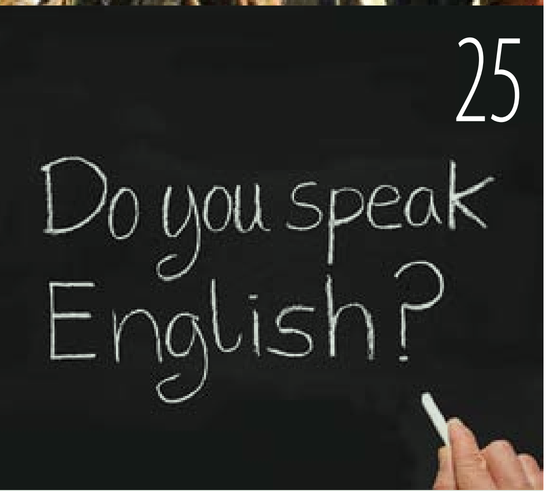
Around the world, people are putting together strategies to maintain safety in the face of extraordinary growth. If those strategies do not explicitly provide for a healthy and competent regulatory authority, they are doomed to fail. It sometimes may be difficult, but remember to support your local regulator.

William R. Voss
President and CEO
Flight Safety Foundation

AeroSafetyWORLD

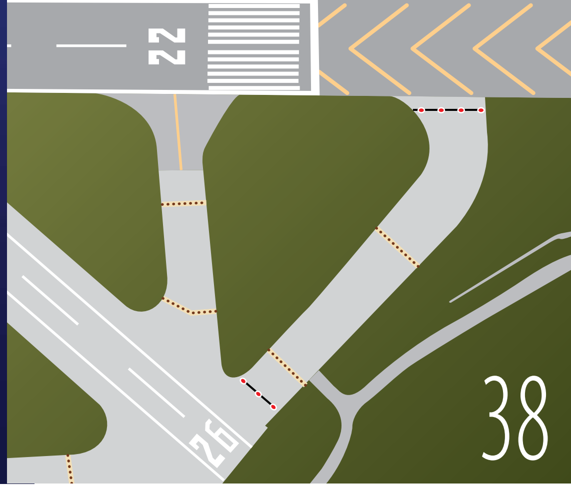
contents

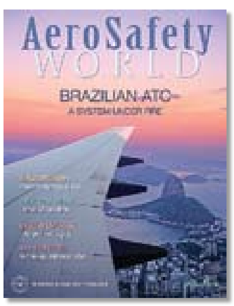
November2007 Vol 2 Issue 11



features

departments





About the Cover
Brazil's ATC system examined.
Photo composite: © Joseph Luoman/iStockphoto, © Thinkstock LLC

We Encourage Reprints (For permissions, go to <www.flightsafety.org/asw_home.html>)

Share Your Knowledge

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.

The publications staff reserves the right to edit all submissions for publication. Copyright must be transferred to the Foundation for a contribution to be published, and payment is made to the author upon publication.

Sales Contacts

Europe, Central USA, Latin America
Joan Daly, joan@dalyllc.com, tel. +1.703.983.5907

Northeast USA and Canada
Tony Calamaro, tcalamaro@comcast.net, tel. +1.610.449.3490

Asia Pacific, Western USA
Pat Walker, walkercom1@aol.com, tel. +1.415.387.7593

Regional Advertising Manager
Arlene Braithwaite, arlenetbg@comcast.net, tel. +1.410.772.0820

Subscriptions: Subscribe to *AeroSafety World* and become an individual member of Flight Safety Foundation. One year subscription for 12 issues includes postage and handling — US$350. Special Introductory Rate — $280. Single issues are available for $30 for members, $45 for nonmembers. For more information, please contact the membership department, Flight Safety Foundation, 601 Madison Street, Suite 300, Alexandria, VA 22314-1756 USA, +1 703.739.6700 or membership@flightsafety.org.

AeroSafetyWORLD
telephone: +1 703.739.6700

William R. Voss, publisher,
FSF president and CEO
voss@flightsafety.org, ext. 108

J.A. Donoghue, editor-in-chief,
FSF director of publications
donoghue@flightsafety.org, ext. 116

Mark Lacagnina, senior editor
lacagnina@flightsafety.org, ext. 114

Wayne Rosenkrans, senior editor
rosenkrans@flightsafety.org, ext. 115

Linda Werfelman, senior editor
werfelman@flightsafety.org, ext. 122

Rick Darby, associate editor
darby@flightsafety.org, ext. 113

Karen K. Ehrlich, web and print production coordinator
ehrlich@flightsafety.org, ext. 117

Ann L. Mullikin, production designer
mullikin@flightsafety.org, ext. 120

Susan D. Reed, production specialist
reed@flightsafety.org, ext. 123

Patricia Setze, librarian
setze@flightsafety.org, ext. 103

Flight Safety Foundation

FLIGHT SAFETY FOUNDATION
SINCE 1947

Serving Aviation Safety Interests for More Than 50 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 1,140 individuals and member organizations in 142 countries.

MemberGuide

Flight Safety Foundation
601 Madison Street, Suite 300, Alexandria, VA, 22314-1756 USA
tel: +1 703.739.6700 fax: +1 703.739.6708

www.flightsafety.org

Member enrollment — ext. 105
Ann Hill, director, membership and development — hill@flightsafety.org

Seminar registration — ext. 101
Namratha Apparao, membership services coordinator — apparao@flightsafety.org

Seminar/*AeroSafety World* sponsorships — ext. 105
Ann Hill, director, membership and development — hill@flightsafety.org

Exhibitor opportunities — ext. 105
Ann Hill, director, membership and development — hill@flightsafety.org

***AeroSafety World* orders** — ext. 101
Membership Department — membership@flightsafety.org

Technical product orders — ext. 111
Maya Barbee, staff accountant — barbee@flightsafety.org

Library services/seminar proceedings — ext. 103
Patricia Setze, librarian — setze@flightsafety.org

Web Site — ext. 117
Karen Ehrlich, web and print production coordinator — ehrlich@flightsafety.org

AUTOMATIC Recovery

Already I can hear keyboards clicking to protest this editorial, telling me that control of an aircraft should never be taken from the pilot without his or her approval. I'll bet that some of those gearing up to write are pilots of Airbus aircraft with fly-by-wire (FBW) flight controls, which are on all Airbus aircraft in production. And this leads me to my first point: Automatic recovery systems won't be ground-breaking violations of pilot authority. Unlimited pilot authority already is a thing of the past, at least on Airbus equipment.

Envelope protection was an advanced idea when Airbus designed its FBW flight control system for the A320, the first Airbus line to have it. There was a lot of distressed discussion at the time, some pilots saying that when faced with hitting something hard they'd like to have the option of risking pulling the wings off of the airplane to avoid an impact. Airbus quietly and repeatedly said that the protection meant that pilots could immediately throw in full control input without fearing disintegration, and therefore would have a better chance of missing what needed to be missed.

Boeing took the other path with its 777 FBW, and did not add envelope protection. I'm unaware of any in-service event so far that could be used to argue the Airbus approach, either pro or con.

However, I had the Armavia Airlines A320 crash at Sochi, Russia (*ASW*, 10/07, p. 44), on my mind when I heard Don Bateman, Honeywell's chief engineer, flight safety systems, speak at the 60th International Air Safety Seminar in Seoul, South Korea. He talked about automatic recovery systems, and what he said struck home.

After the terrorist attacks of Sept. 11, 2001, I was appalled at the serious discussion about development of systems to remotely control aircraft suspected of having been hijacked. Of course, the easier route to achieving repeated safe landings is to prevent hijackings in the first place, and that argument won the day.

However, when Don started talking about automatic recovery systems, I still had in my head a vivid image of the Armavia crew, already behind their aircraft on a dark late-night approach in weather to a coastal airport backed up against a mountain range, struggling to cope with the tower's order for a go-around that pitched them into an unanticipated turn that went so bad the aircraft ended up hitting the Black Sea with the terrain awareness and warning system (TAWS) repeatedly telling them to pull up.

Implicit in Bateman's endorsement of automatic recovery systems is his frustration that, after his invention of the ground-proximity warning system (GPWS) and then the enhanced GPWS, some pilots still are not properly responding to TAWS warnings and similar red-flag indications that their flight is in imminent peril, and people are dying.

By its very nature, an automatic recovery would be a brief transfer of control until stabilized flight unthreatened by terrain or traffic conflicts is restored, giving overtaxed pilots a "do-over," albeit with a heightened sense of having been closer to disaster than they had believed.

The technology to do this is not difficult, Bateman maintained, and with the ability comes the question of whether we have a moral obligation to bring such a system into being. If we know we can prevent three, four or more accidents a year, why not do it?

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

The Hull Story Isn't the Whole Story

I very much enjoy your magazine, *AeroSafety World*. Unfortunately, I must offer some fundamental criticisms of a recent article.

It is a pity to see that Flight Safety Foundation continues to use hull loss rates as a measure of aviation safety (*ASW*, 9/07, p. 51). For a long time, safety indicators based on hull losses have come under heavy criticism from many aviation safety specialists. Hull loss rates simply don't give us the right picture regarding aviation safety. The value of the aircraft often determines whether an accident is a hull loss or not.

For instance, the same type of accident that occurred with the same amount of damage to two different aircraft are both not necessarily counted in the hull loss statistics. If one aircraft is relatively new, it could be that the accident does not result in a hull loss. However, if the other aircraft is old, it could make the threshold to become a hull loss even if the damage is minor.

I understand that the Foundation is just quoting data from Boeing. However, I believe that the Foundation should not simply copy their statistics without considering the clear limitations of this information. The Foundation is clearly the body to educate the aviation community on this topic. I hope you will do so in the future.

Gerard van Es
Air Transport Safety Institute
National Aerospace Laboratory (NLR)—Netherlands

The editor replies: See Jim Burin's cover story (ASW, 2/07, p. 16) in which he declares that the Foundation is, indeed, stepping away from the use of "hull loss" in favor of a different measure, "major accident," which he defined in a sidebar article. We reiterated our approach to accident classification in an endnote of the Data Link article you refer to.

As for the Boeing data, we cannot change what they publish to conform to how we think it should be. The Data Link article's statement that "worldwide commercial jet hull loss accidents less frequently resulted in fatalities in the past 10 years compared with earlier years" accurately reflected Boeing's data, and we drew no unwarranted conclusions about safety from the fact.

The Boeing report actually agreed with your, and our, position; it said, "Generating statistics based upon hull loss has been de-emphasized in this publication, although it has not been completely eliminated. Hull loss is not necessarily a good indicator of accident severity. The age of the fleet and the economics of repairs are resulting in less severe accidents becoming hull loss accidents."

Your letter will be a good reminder for everyone that we do need to move away from an outdated and misleading metric.

Foot Note

With respect to the article "Cautious Footwork" (*ASW*, 9/07, p. 10), we want to inform you that, after more than 11 million flight hours performed by the EMB-145 family of aircraft (which includes the Legacy 600), we are not aware of any reports of a TCAS switch-off or selection of STANDBY mode on the transponder's RMU in connection with the use of the footrest device.

All technical and ergonomic analyses relating to the use of the footrest by EMB-145 (including Legacy 600) pilots demonstrate that the normal use of the footrest does not create a risk of an involuntary or accidental switching off of the TCAS.

All such technical elements have been submitted to the Brazilian Certification Authority (ANAC) and are currently under review by ANAC and the FAA.

Antonio C. Victorazzo
Embraer

AeroSafety World encourages comments from readers, and will assume that letters and e-mails are meant for publication unless otherwise stated. Correspondence is subject to editing for length and clarity.

Write to J.A. Donoghue, director of publications, Flight Safety Foundation, 601 Madison St., Suite 300, Alexandria, VA 22314-1756 USA, or e-mail <donoghue@flightsafety.org>.

NOV. 1–2 ➤ Second Annual Aviation Health Conference. Quaynote Communications. London. Lorna Titley <lorna@quaynote.com>, <http://www.quaynote.com/ankiti/www/?code=uk07&f=home&conf=381a49808c0ceeab0da60a934822e741>, +44 (0)20 8531 6464.

NOV. 1–2 ➤ 8th Safeskies International Aviation Safety Conference. Safeskies Australia. Canberra, Australia. <safeskies@bigpond.com>, <www.safeskiesaustralia.org/index.html>, +61 2 6236 3160.

NOV. 5–7 ➤ 17th ACI World Annual General Assembly, Conference and Exhibition and ACI Latin America Regional Conference and Assembly. Airports Council International. Buenos Aires, Argentina. <aci@aci.aero>, <www.aci.aero/cda/aciworld/display/main/aciworld_content.jsp?zn=aci&cp=1112-2133_128_2>, +41 22 717 8585.

NOV. 8 ➤ COPAC Flight Safety Seminar: Safety Management System. Colegio Oficial De Pilotos de la Aviación Comercial (Spanish Professional Pilot Association). Madrid, Spain. <comunicacion1@copac.es>, <www.copac.es>, +91.590.02.10.

NOV. 9 ➤ IS-BAO Workshop. International Business Aviation Council. Oakland, California, U.S. <info@ibac.org>, <www.ibac.org/is-bao/Audit%20Workshop.htm>, +1 514.954.6198.

NOV. 8–9 ➤ 2007 Intermodal Conference on Safety Management and Human Factors. Interfleet Technology. Sydney, Australia. Joey Anca, <joseanca@interfleetaust.com>, <www.conferenceworks.net.au/hfactors>, +61 (0)3 96003655.

NOV. 11–13 ➤ 13th Annual U.S./Central Europe/Eurasia/Canada Airport Issues Conference. American Association of Airport Executives, International Association of Airport Executives and Munich Airport. Munich, Germany. Natalie Fleet, <natalie.fleet@aaae.org>, <www.aaae.org/products/_640_US_Central_Europe_Eurasia_Airport_Issues_Conference/index.html>, +1 703.824.0500, ext. 132.

NOV. 11–15 ➤ 10th Anniversary Dubai Airshow 2007. Fairs and Exhibitions. Dubai. Nandini Rego. <www.dubaiairshow.org/airshow07/site/show_info/introduction.php>, +971 4 286 7755.

NOV. 13–14 ➤ Aircraft Rescue and Firefighting (ARFF) for Cargo Aircraft Symposium. Air Line Pilots Association, International. Herndon, Virginia, U.S. Tina Long, <tina.long@alpa.org>, <ox.ca/40a>, +1 703.689.4228.

NOV. 14–16 ➤ Runway Safety Summit. American Association of Airport Executives. Milpitas, California, U.S. Christy Hicks, <christy.hicks@aaae.org>, <http://www.aaae.org/products/meeting_details.html?Record_id=475>, +1 703.824.0500.

NOV. 27–28 ➤ ATM Agenda 2007: Fragmentation Explained — Defragmentation Explored. Helios Information Services. London. Stacey Paddock, <atmagenda@askhelios.com>, +44 1276 452 811.

NOV. 28–30 ➤ 4th Annual International Aviation Safety Forum. U.S. Federal Aviation Administration. Chantilly, Virginia, U.S. <www.faa.gov/news/conferences_events/2007safetyforum>.

DEC. 3–4 ➤ LIMA 2007 International Aerospace & Aviation Conference. Langkawi, Malaysia. World Aerospace, <www.lima2007.com>, +603-2691-2484.

DEC. 5–6 ➤ Crew Management Conference 2007. Brussels. Flight International. Cathy Fuller, <cathy.fuller@rbi.co.uk>, +44 208 652 3749.

JAN. 29–FEB. 1 ➤ NBAA 19th Annual Schedulers & Dispatchers Conference. National Business Aviation Association. Savannah, Georgia, U.S. Dina Green, <dgreen@nbaa.org>, <web.nbaa.org/public/cs/sdc/2008/index.php>, +1 202.783.9357.

FEB. 5–7 ➤ 16th Annual Safety-Critical Systems Symposium. Centre for Software Reliability. Bristol, England. Joan Atkinson, <joan.atkinson@ncl.ac.uk>, <www.csr.ncl.ac.uk/calendar/csrEventView.php?targetId=377>, +44 191 222 7996.

FEB. 13–17 ➤ Lawyer Pilots Bar Association. Miami. <www.lpba.org>, +1 410.571.1750.

FEB. 19–24 ➤ Singapore Airshow. Singapore Airshow & Events. <www.singaporeairshow.com.sg>, +65 6542 8660.

FEB. 24–26 ➤ Heli-Expo 2008. Helicopter Association International. Houston. Marilyn McKinnis, <marilyn.mckinnis@rotor.com>, <www.heliexpo.com>, +1 703.683.4646.

FEB. 25–27 ➤ OPS Forum 2008: Fly Safe, Fly Smart, Fly Green. International Air Transport Association. Madrid, Spain. <www.iata.org/events/ops08/index.htm>.

MARCH 10–12 ➤ 20th annual European Aviation Safety Seminar (EASS). Flight Safety Foundation and European Regions Airline Association. Bucharest, Romania. Namratha Apparao, <apparao@flightsafety.org>, <www.flightsafety.org/seminars.html#eass>, +1 703.739.6700, ext. 101.

MARCH 13–15 ➤ ARSA 2008 Annual Repair Symposium. Aeronautical Repair Station Association. Washington, D.C. <arsa@arsa.org>, <www.arsa.org/node/400>, +1 703.739.9543.

MARCH 18–20 ➤ Aviation Industry Expo. National Air Transportation Association. Dallas. Jill Ryan, <jill.ryan@cygnusexpos.com>, <aviationindustryexpo.com/as3gse/index.po>, 800.827.8009, ext. 3349.

MARCH 31–APRIL 2 ➤ 15th Annual SAFE (Europe) Symposium. SAFE (Europe). Geneva, Switzerland. <safe.distribution@virgin.net>, <www.safeeurope.co.uk>, +44 (0)7824 303 199.

APRIL 14–17 ➤ 59th Annual Avionics Maintenance Conference. ARINC. Tulsa, Oklahoma, U.S. Samuel Buckwalter, <Samuel.Buckwalter@arinc.com>, <www.aviation-ia.com/amc/upcoming/index.html>, +1 410.266.2008.

APRIL 23–26 ➤ AEA Convention and Trade Show. Aircraft Electronics Association. Washington, D.C. <info@aea.net>, <www.aea.net/Convention/FutureConventions.asp?Category=6>, +1 816.373.6565.

APRIL 29–MAY 1 ➤ 53rd annual Corporate Aviation Safety Seminar (CASS). Flight Safety Foundation and National Business Aviation Association. Palm Harbor, Florida, U.S. Namratha Apparao, <apparao@flightsafety.org>, <www.flightsafety.org/seminars.html#cass>, +1 703.739.6700, ext. 101.

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

If you have a safety-related conference, seminar or meeting, we'll list it. Get the information to us early — we'll keep it on the calendar through 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

Upgraded ELTs Urged

Operators of general aviation aircraft should be required to install upgraded emergency locator transmitters (ELTs) with features that provide more precise information about aircraft location, the U.S. National Transportation Safety Board (NTSB) says.

In a safety recommendation to the U.S. Federal Aviation Administration (FAA), the NTSB said that the 406-megahertz (MHz) ELTs should be installed "at the earliest possible opportunity." The NTSB noted that the worldwide satellite search-and-rescue system will stop processing alerts for older 121.5-MHz ELT signals on Feb. 1, 2009, and suggested that the FAA consider establishing a compliance date for the upgrade before then.

© HR Smith Group

The 121.5-MHz signal is an analog signal emitted by ELTs and other devices, including pizza ovens and stadium scoreboards; as a result, every time a 121.5-MHz signal is detected by satellites, it must be verified. Data show that more than 99 percent of these signals are "false or non-emergency alerts," the U.S. National Oceanic and Atmospheric Administration (NOAA) says.

In contrast, a 406-MHz ELT emits a digital signal "that allows for a unique identification code to be transmitted along with its distress signal," the NTSB said. "Because each identification code is unique and required by law to be registered in a NOAA database, rescue authorities can immediately identify exactly which aircraft is in trouble and, more importantly, get in touch with the emergency point of contact registered to the aircraft's ELT. This allows the rescue coordination centers to quickly confirm whether the distress is real and thus begin to mobilize appropriate [search-and-rescue] authorities."

Signals from a 406-MHz ELT are stronger than those from a 121.5-MHz ELT, and are accurate to within 1 to 3 nm (2 to 6 km); in comparison, the position indicated by a 121.5-MHz ELT is accurate to within 12 to 15 nm (22 to 28 km).

Because a federal law currently requires installation of either a 121.5-MHz ELT or a 406-MHz ELT, the NTSB recommendation asks the FAA to "seek authority from Congress to require the installation" of 406-MHz devices.

Disorientation

The crew of a McDonnell Douglas MD-83 deviated from their approach course to Dublin Airport after mistaking the red obstacle lights on the roof of a nearby building for runway approach lights, the Irish Air Accident Investigation Unit (AAIU) says.

A preliminary AAIU report on the Aug. 16, 2007, incident said that as the airplane deviated to the left of the approach course for Runway 34 and descended below the minimum descent altitude, an air traffic controller issued instructions to turn right and climb and then provided radar vectors for an approach and landing on Runway 16.

During the subsequent investigation, AAIU personnel conducted a series of approaches to Runway 34 and found that the four red obstacle lights atop a 16-story building located southwest of the runway threshold "appeared at night to resemble the red and white lights of a runway approach light system," the report said.

As a result of the investigation, the Irish Aviation Authority (IAA) issued an operations notice for Dublin Airport to require that "when Runway 34 is in use, all ATIS [automatic terminal information service] broadcasts will include the following phraseology: Caution — lights on a building 1.5 nm [2.8 km] southwest of the threshold of Runway 34 have the potential to disorientate flight crews."

Also as a result of the investigation, the AAIU recommended an IAA review of the suitability of the obstacle lighting on the building.

© Dublin Airport Authority


Serious business at the Singapore Airshow…
Dr. Vijay Mallya
Chairman & CEO
Kingfisher Airlines Limited
Tony Tyler
Chief Executive
Cathay Pacific Airways
Steven F. Udvar-Hazy
Chairman & CEO
International Lease Finance Corporation

Automatic Heat

Citing a 2005 icing incident involving a Boeing 717-200, the U.S. National Transportation Safety Board (NTSB) has recommended requiring that air data sensor heating systems on all new airplanes be designed so that they activate automatically after engine start.

The NTSB, in a safety recommendation to the U.S. Federal Aviation Administration (FAA), said that the FAA should require the change for all new airplanes certificated under U.S. Federal Aviation Regulations Part 25, "Airworthiness Standards: Transport Category Airplanes." In addition, the NTSB recommended modification of existing airplanes certificated under Part 25 to incorporate automatic activation of the system whenever possible. If modification is not possible, flight deck warnings should provide "an upgraded warning associated with the failure to activate the heating system," the NTSB said.

In the May 12, 2005, incident, the crew of a Midwest Airlines 717 experienced unreliable airspeed indications while climbing through 19,000 ft in heavy rain and icing conditions. After experiencing "significant gains and losses of altitude," the crew declared an emergency, regained control and diverted to Kirksville, Missouri, U.S. None of the 80 people in the airplane was injured in the incident, and the airplane was not damaged.

The NTSB said that its investigation, which is continuing, has focused on the air data sensor heating system, which heats the pitot probes that provide airspeed indications on the flight deck. Pilots of 717s must activate the air data sensor heating system manually, as a pre-takeoff checklist item; cockpit warnings and advisories serve as reminders.

"The Safety Board was unable to determine from available evidence whether the pilots activated the air data heating system before the event," the NTSB said. However, analysis of data from the flight data recorder revealed "differences in airspeed between the captain's and first officer's flight displays and rates of airspeed change [that are] consistent with a lack of air data sensor heating while the airplane climbed into colder temperatures."

Tests revealed no deficiencies in the pitot/static system, the air data sensor heating system or airspeed indication systems, and the absence of such deficiencies "suggests that the lack of pitot probe heating … was caused by … the flight crew's failure to activate the system," the NTSB said. The cockpit warnings and advisories had been ineffective, the NTSB added.


U.S. National Aeronautics and Space Administration

Improvement Strategy

The International Civil Aviation Organization (ICAO), working with African civil aviation authorities and the air transport industry, has developed a new strategy to improve aviation safety in Africa. The policy has been endorsed by representatives of 40 states in ICAO's African region and by other members of the aviation community.


© Dana Britton/Dreamstime.com

The *Comprehensive Regional Implementation Plan for Aviation Safety in Africa* represents "the most coordinated and inclusive effort ever to deal with the very serious safety challenges facing the majority of African states," said Roberto Kobeh González, president of the Council of ICAO.

The plan emphasizes a "holistic and systemic approach" to safety improvements and calls for identification of safety risks, development of prioritized recommended actions and continuous monitoring and evaluation, ICAO said.

The plan will combine elements of ICAO's Global Aviation Safety Plan and the industry's Global Aviation Safety Roadmap to "focus on activities with the highest return for improving safety," ICAO said.

European Safety Initiative

The European General Aviation Safety Team (EGAST), designed to serve as a forum for the sharing of safety data and best practices, has held its first meeting in Cologne, Germany.

EGAST includes representatives of manufacturers, regulators, flying clubs, accident investigators, international organizations and researchers, and is intended to help revitalize general aviation.

EGAST is part of the European Strategic Safety Initiative (ESSI), which was established in 2006 to enhance European aviation safety through analysis of safety data, coordination of safety initiatives around the world and implementation of cost-effective action plans.

Turning Down the Heat

Helicopter operators should be warned of the dangers of using standard refueling nozzles during "hot" refueling, or refueling while an engine is running, the Irish Air Accident Investigation Unit (AAIU) says.

In a safety recommendation to the Irish Aviation Authority (IAA), the AAIU said that the IAA should issue an aeronautical information circular to disseminate the warning, as well as to prohibit the hot refueling of helicopters if the fuel pump does not have a refueling nozzle with a vapor seal.

"Using a standard nozzle, the fuel displaces vapor in the tank, causing the vapor to exit through the filling point," the AAIU said. "The filling point is invariably located high on the side of the helicopter, close to the engine. Consequently, flammable vapor exiting at the filling point can be ignited by the hot engine exhaust, or by ingestion into the engine(s), if the helicopter is refueled while the engine is running."

The safety recommendation was prompted by AAIU's ongoing investigation of the Sept. 23, 2006, hot refueling of a Eurocopter AS 350 at a helicopter landing site in County Kildare and the helicopter's subsequent off-field landing because of low fuel. The report said that, because a pilot must remain at the flight controls during hot refueling, he or she cannot visually check the contents of the fuel tanks to ensure that they contain sufficient fuel for the planned flight. The investigation was continuing.

© Ken Babione/iStockphoto

Managing Risks

The Civil Aviation Safety Authority of Australia (CASA) is seeking input from the aviation community on the emerging risks of passenger operations. The information, being collected over the next three to five years, will be used to aid in development of longer-term risk management programs, CASA said.

"These may be risks within the aviation industry which are present now and are likely to increase, or are not yet present but are likely to emerge over the next three to five years," CASA said. "They may emerge either through changes to the operational task which the supporting systems have not adapted to, or cases where the supporting systems themselves have deteriorated and are no longer controlling risks as well as they did before."

The information is being solicited online at <casa.gov.au/corporat/emergingrisk/index.htm>.

© Bradley Mason/iStockphoto

In Other News …

The **European Union** (EU) has added two airlines to its list of those banned for safety reasons. The September revision of the EU "blacklist" added Ukrainian Mediterranean Airlines, based in Ukraine, and Mahan Air, based in Iran. … **Mick Quinn** has been named deputy CEO of operations at the Civil Aviation Safety Authority of Australia; he is a veteran air safety official at Qantas and the Emirates Group and a former executive director of rail safety regulation in New South Wales. … Capt. **Henry P. "Hank" Krakowski**, formerly vice president of flight operations for United Airlines, has been named chief operating officer of the U.S. Federal Aviation Administration.

Compiled and edited by Linda Werfelman.

© Alexander Watts/Airliners.net

Third in a series focusing on the development and safety benefits of precision-like approaches, a project of the FSF International Advisory Committee.

BY DON BATEMAN AND DICK MCKINNEY

Dive-and-Drive Dangers

A Boeing 767 appears out of the mist, level at 250 ft above the ground, nose high, landing flaps set, engines producing a mighty roar. A large aircraft completing a non-precision "dive-and-drive" instrument approach in bad weather is an awesome and frightening sight, especially because the risk of an accident during such an approach is five times higher than when flying a precision approach.

The dive-and-drive technique originated in the 1970s. The idea was to get down to the minimum descent altitude (MDA) as quickly as possible so that the flight crew has more time to search for the airport. Basically, the technique is to fly the staircase-like vertical profile depicted on the approach chart. The profile is based on the minimum obstacle clearance height — or heights for step-down fixes — between the final approach fix (FAF) crossing altitude and the MDA. Some operators recommend descent rates up to 1,500 fpm to get to the step-down altitudes and eventually the MDA.

This technique results in a high-workload approach, with large power, pitch and trim changes required to follow the vertical profile.

Unstabilizing Influence

Dive-and-drive is the antithesis of the stabilized approach recommended by the Flight Safety Foundation (FSF) Approach-and-Landing Accident Reduction (ALAR) Task Force (see "Recommended Elements of a Stabilized Approach," p. 14).

The dive-and-drive technique does not conform to the following recommended elements of a stabilized approach:

- Element no. 2 — The dive-and-drive technique requires large changes in pitch to fly the vertical profile.
- Element no. 4 — Some aircraft-specific procedures require keeping the flaps in the approach setting until the decision to land is made. The result is that the aircraft will not be in the landing configuration below 1,000 ft above airport elevation in instrument meteorological conditions.

- Element no. 5 — As mentioned earlier, descent rates greater than 1,000 fpm are practiced by some operators.

- Element no. 6 — Power settings greater than and less than those required to fly a normal constant descent angle are required to fly dive-and-drive approaches.

Constant-Angle Technique

The FSF ALAR Task Force recommends that nonprecision approaches be conducted using the constant descent angle approach technique.[1]

Constant descent angle approaches are conducted the same way that normal visual and precision approaches are conducted. Lateral guidance is provided by a localizer (LOC), VHF omnidirectional radio (VOR), nondirectional beacon (NDB), global positioning system (GPS) or flight management system lateral navigation (FMS LNAV).

The aircraft is flown on an approximately 3-degree continuous descent from about 5 nm (9 km) from the runway threshold to touchdown. Although there is no electronic glideslope, vertical guidance can be provided by the FMS VNAV (vertical navigation) or with a specified FMS approach angle or descent rate appropriate for the groundspeed taken from the approach chart.

The essential element for conducting a safe approach is to ensure that the aircraft is flown *at or above* all step-down altitudes from the FAF until approaching the MDA. If the visual references required to continue to landing have not been acquired prior to reaching the MDA, a missed approach climb must be conducted. No turns may be conducted until the aircraft reaches the missed approach point (MAP) depicted on the chart.

The constant descent angle technique allows the approach to be stabilized. It also lowers flight crew workload. The flight handling of these approaches is the same as during visual and precision approaches. Of equal importance to safety, flying a constant descent angle approach requires less time at minimum obstacle clearance heights and reduces the likelihood of altitude deviations due to high sink rates. Finally, aircraft position and attitude relative to the runway are determined by using the same visual references that are used during precision approaches.

The nose-high pitch attitude while flying level at the MDA using the dive-and-drive technique causes many pilots to perceive that they are too high as they near the visual descent point (VDP) because the runway appears much lower in the windshield than it would on a normal descent path. The usual result is excessive nose-down pitch and high sink rates from the MDA to the runway.

Recommended Elements of a Stabilized Approach

All flights must be stabilized by 1,000 ft above airport elevation in instrument meteorological conditions (IMC) and by 500 ft above airport elevation in visual meteorological conditions (VMC). An approach is stabilized when all of the following criteria are met:

1. The aircraft is on the correct flight path;
2. Only small changes in heading/pitch are required to maintain the correct flight path;
3. The aircraft speed is not more than V_{REF} + 20 kt indicated airspeed and not less than V_{REF};
4. The aircraft is in the correct landing configuration;
5. Sink rate is no greater than 1,000 fpm; if an approach requires a sink rate greater than 1,000 fpm, a special briefing should be conducted;
6. Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;
7. All briefings and checklists have been conducted;
8. Specific types of approaches are stabilized if they also fulfill the following: instrument landing system (ILS) approaches must be flown within one dot of the glideslope and localizer; a Category II or Category III ILS approach must be flown within the expanded localizer band; during a circling approach, wings should be level on final when the aircraft reaches 300 ft above airport elevation; and,
9. Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

An approach that becomes unstabilized below 1,000 ft above airport elevation in IMC or below 500 ft above airport elevation in VMC requires an immediate go-around.

Source: Flight Safety Foundation Approach-and-Landing Accident Reduction (ALAR) Task Force (V1.1 November 2000)

Conducting a nonprecision approach using the dive-and-drive technique is difficult and requires much higher concentration and teamwork than conducting an instrument landing system (ILS) approach or precision-like constant descent angle approach.

In a study performed during development of the FSF *ALAR Tool Kit*, several pilots were asked when they last conducted a nonprecision approach. Most pilots, especially those from the United States, replied, "When I had my last simulator ride." Some pilots said that the dive-and-drive technique is markedly different from the way they normally fly approaches and that they get very little practice in this procedure to maintain proficiency.

Traps and Tribulations

Traps await those who are unprepared to conduct a nonprecision approach. Consider, for example, the implications of a late runway change that would require you to conduct the LOC/DME (distance measuring equipment) back-course approach to Runway 34L at Reno/Tahoe (Nevada, U.S.) International Airport (Figure 1, p. 16) in weather conditions near minimums.

Considerable chart study and briefing would be required before beginning this challenging approach. With the late change of plan, where are you going to park the jet while you study and brief the approach? *This approach should not be briefed on final approach.*

So, you "buy time" by telling air traffic control (ATC) that you need to hold. The controller clears you to navigate directly to the Mustang VOR, then via a heading of 190 degrees to intercept the IRNO Runway 34L back-course localizer to the WAGGE intersection, hold south, right turns, maintain 12,000 ft.

The following are some of the questions that you will have to answer:

- How will you set the course deviation indicator (CDI) to intercept, to hold and to conduct the approach?
- When will you select back course?
- How will you conduct the procedure turn when you are finally cleared for the approach?
- What will you use to determine your distance from Runway 34L? Note that some operators require one pilot to fly the approach using ground-based navigation aids while the other pilot monitors the approach using the FMS procedure — or vice versa. In this case, after crossing the FAF — GIGER — the FMS will indicate the distance to the threshold of Runway 34L, and that distance will be different from the IRNO DME information.
- Why does the 3.5-degree descent path begin at 9.1 DME instead of at the FAF? This ensures that the descent path remains at or above the obstacle clearance limits indicated by the step-down altitudes.
- There are no approach lights for Runway 34L, but there is a precision approach path indicator (PAPI). At what point is it safe to fly the PAPI? Flying the PAPI is prohibited beyond 6 nm from the runway threshold due to terrain. In order to conduct the approach at or above the step-down limits, the crew must maintain the 3.5-degree path until passing the IRNO 4.0 DME fix.
- Are you authorized to use the VNAV DA (decision altitude)? If not, you will be required to begin the climb for the missed approach soon before reaching 5,060 ft, to avoid descending below the MDA.

Reducing the Risks

A review of nonprecision approach accidents and incidents shows that the greatest risk is a premature descent. A common cause is loss of positional awareness, which can also contribute to an unstabilized approach.

A premature descent can be prevented by using all available navigation tools to assess your three-dimensional position in space relative to the runway end. A valuable mental check is that, inbound from the FAF, the aircraft should be about 300 ft above airport elevation for each nautical mile from the runway — about 900 ft when 3 nm from the runway, for example.

Another risk is misidentification of the DME location. There can be a false assumption that the DME is colocated with the VOR when it actually is colocated with the LOC, or vice versa. This false assumption could create an error in judging distance to the runway. The crew must ensure that they know where the DME is actually located.

Altimeter errors can result from incorrect altimeter settings reported by air traffic controllers or from flight crew confusion about the units of measurement — inches of mercury versus hectopascals, for example. Before the approach is initiated, the crew must ensure that their altimeter settings are correct and cross-check that the settings are based on the proper reference — QNH, sea level, or QFE, field elevation.

Deviations below minimum obstacle heights can result if the crew fails to add corrections to minimum crossing altitudes when significant errors in actual versus indicated altitudes are caused by unusually low temperatures.

Flight crews must be alert for an ATC clearance that could result in a premature descent or a late descent or late turn to final approach that further could result in a rushed approach.

A late change of the landing runway can lead to distractions resulting in failure to complete the landing checklist, properly set up the radios and/or navigation instruments, verify the available ground navigation aids, or properly set up the flight management computer or FMS.

Flight crews must take the time necessary to properly prepare for all approaches. If the pilots feel rushed, they should refuse the change or buy time by requesting a hold or a delaying vector.

Failure of flight crewmembers to work as a team greatly increases the risks during a nonprecision approach. Pilots should practice monitoring and cross-checking as a team by following recommended crew resource management (CRM) practices. While the pilot flying flies the procedure, the pilot monitoring monitors the approach using all the available instruments, navigation aids and ATC clearances. An optimum partnership is formed when the pilot monitoring independently monitors and cross-checks all the instruments, looking for unusual descent rates or altitudes, and is not afraid to speak up about a discrepancy and or an unstabilized approach.

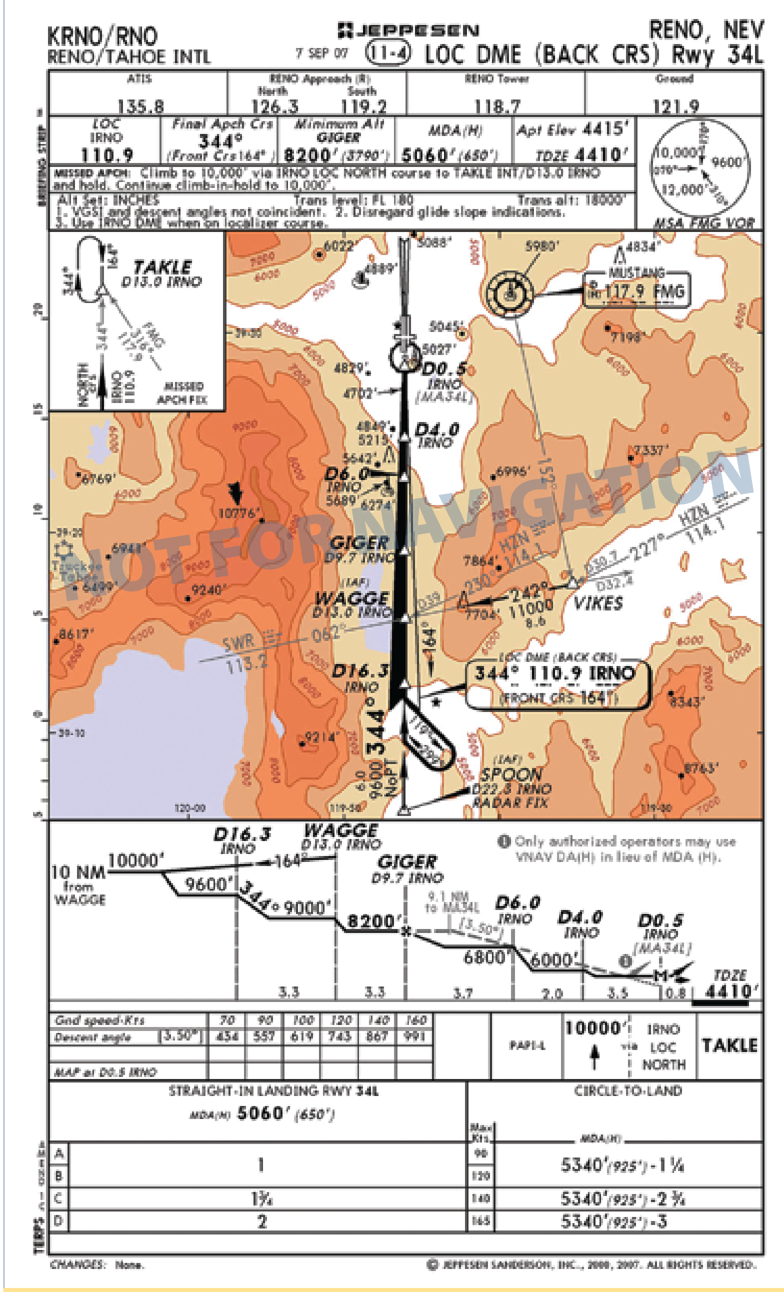
Failure to follow standard operating procedures (SOPs) for approach and landing has resulted in inappropriate aircraft configurations, excessive airspeeds, excessive descent rates at the recommended 1,000-ft and 500-ft "approach gates" and violation of published minimum altitudes.[2] These errors cause unstabilized approaches with great risks of runway overruns or other mishaps.

Stabilizing Tools

The following are among the tools that should be used to help determine safe approach altitudes and to conduct stabilized approaches:

- The radio altimeter is invaluable for cross-checking the barometric altimeters. The indicated radio altitude should be within reasonable values when taking into account the terrain below the aircraft and the corrected altimeter altitude, especially at the FAF.
- Tones, automated voice callouts and advisories generated by the radio altimeter are invaluable for awareness of the terrain along the approach path and when approaching the minimum altitude for the

The Reno Approach



Source: Boeing, Jeppesen

Figure 1

approach. Monitor the radio altimeter from the initial approach fix (IAF) to the FAF for radio altitudes below 500 ft. From the FAF to the MDA, radio altitude should not drop below 250 ft.[3]

- A ground-proximity warning system (GPWS) can provide alerts of unsafe terrain clearance when the aircraft is not in landing configuration. When the landing gear and flaps are extended, however, GPWS terrain alerts are automatically disabled; only alerts and warnings of high descent rates are provided.

- A terrain awareness and warning system (TAWS) — also called enhanced GPWS (E-GPWS) and ground collision avoidance system (GCAS) — is required aboard most turbine-powered airplanes and is an excellent addition to *any* commercial or business aircraft. When fitted with a direct signal from GPS and an updated terrain/obstacle/runway database, it is an excellent backup in providing alerts/warnings of a premature descent to within 1/4 nm of the runway end. GPS altitude provided to E-GPWS allows the system to generate an internal independent vertical altitude reference of aircraft altitude and projected flight path to terrain. This allows E-GPWS independence from any pressure altimeter error or altimeter setting error or standard. E-GPWS monitors the approach altitude with reference to the airport. It will provide an alert if the aircraft has inadvertently descended to approximately less than one degree approach slope to the runway. A simple visual check on the ground to determine if your aircraft has GPS direct to the E-GPWS is to vary the captain's altimeter setting when the navigation display range is set to show some terrain or obstacle; the terrain or obstacle should show no effect or change in color.

- A vertical situation display (VSD) that depicts terrain and the projected flight path of the aircraft is another valuable tool for monitoring the approach.

- The weather radar system, in ground-mapping mode, can help in cross-checking the aircraft's horizontal position, especially when significant terrain exists along the approach path or the approach is being conducted over water to an airport located on higher ground.

- A head-up display (HUD) is a great tool for monitoring the approach and stabilizing the aircraft's flight path relative to the runway. Remember, however, that during the last mile of a nonprecision approach, actual visual acquisition of the runway is required. A HUD will not display obstacles or terrain and never should be used as a substitute for an approved approach procedure.

If your aircraft is fitted with flight management tools to conduct a constant descent angle approach, learn to use them; understand their limitations and the importance of initiating the approach at the correct distance from the runway or fix and the importance of correct altimetry. The use of constant descent angle approach tools can greatly reduce the risks of an unstabilized approach and reduce pilot workload. Always cross-check and monitor other instruments, navigation aids and the aircraft's indicated position.

When the precision-like constant descent angle technique becomes the standard for all nonprecision approaches, some of the problems discussed in this article will be resolved. Required navigation performance (RNP), and the GPS local area and wide area augmentation systems will provide precision-like accuracy and reliability — and when available for all runways, they will provide simpler and safer ways to fly. ●

Don Bateman is chief engineer, flight safety avionics, at Honeywell. Bateman designed and led engineering teams in the development of both the ground-proximity warning system (GPWS) and the enhanced GPWS. An electrical engineering graduate of the University of Saskatchewan and a licensed pilot, Bateman was an engineer with Boeing and United Control Corp., which was acquired by Honeywell.

Capt. Dick McKinney began his aviation career in the U.S. Air Force, serving as an air traffic controller, fighter pilot, weapons officer, flight commander, standards evaluation officer, command post chief and squadron commander, retiring with the rank of colonel. He then served as an American Airlines pilot, check airman, ground school instructor and chairman of the training standards committee. McKinney is an International Air Transport Association flight operations auditor.

Notes

1. FSF ALAR Task Force. "ALAR Briefing Note 7.2 — Constant-Angle Nonprecision Approach." *Flight Safety Digest* Volume19 (August–November 2000), 139–145.

2. The FSF ALAR Task Force defines *approach gate* as "a point in space — 1,000 ft above airport elevation in instrument meteorological conditions or 500 ft above airport elevation in visual meteorological conditions — at which a go-around is required if the aircraft does not meet defined stabilized approach criteria."

3. These values — 500 ft from the IAF to the FAF and 250 ft from the FAF to the MDA — are the minimum obstacle clearance heights specified by the *United States Standard for Terminal Instrument Procedures* (TERPS).

A System UNDER FIRE

Brazil struggles to return to world-class safety status.

BY EDVALDO PEREIRA LIMA

Brazil began the new century with meaningful improvements in civil aviation safety. The annual count for all civil aircraft accidents decreased from 75 to 58 between 1997 and 2005, while the number of fatal accidents decreased from 40 to 22 (Figure 1). Meanwhile, the civil fleet in Brazil increased from 9,962 to 10,831 aircraft. Scheduled commercial aviation had zero fatalities and zero accidents from 2003 to 2005. The perception grew that Brazil finally had reached the top ranks of aviation safety, particularly in air traffic management.[1]

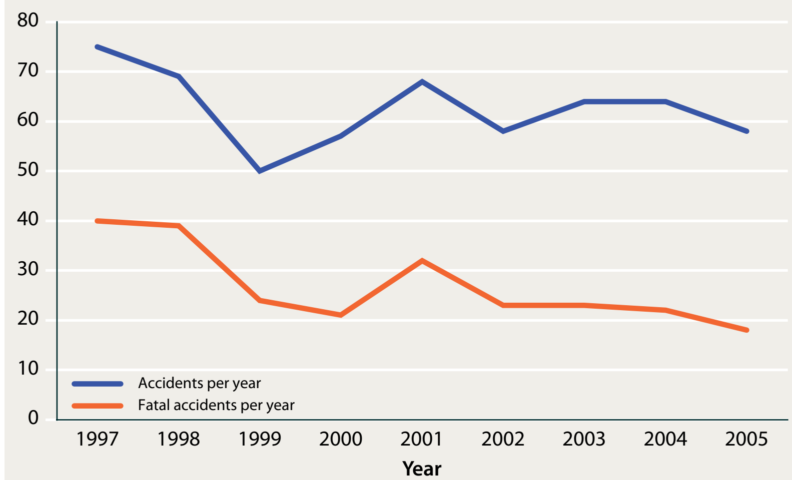
Then all hell broke loose on a bright afternoon over the Amazon jungle on Sept. 29, 2006, when a Gol Boeing 737-800 and an ExcelAire Embraer Legacy 600 collided at 37,000 ft. Both aircraft were flying on the same airway, in opposite directions. The business jet pilots conducted an emergency landing at a nearby air base with nobody injured. The 737 spiraled into the jungle, and 154 people died.

Public trust in the soundness of the country's air traffic control (ATC)

Cindacta I in Brasilia is the busiest part of Brazil's air traffic control system and the place most heavily impacted by controller discord and system disruptions.

system began to shatter. In parallel with the technical investigation begun by the Center for the Investigation and Prevention of Aeronautical Accidents (CENIPA), the Federal Police started a criminal investigation of its own. It was said that the two U.S. pilots of the business jet would be indicted, as well as the air traffic controllers (ATCOs) who were working the Legacy flight.

Brazilian Civil Aviation Safety 1997–2005



Note:

Data include commercial aviation (scheduled and non-scheduled service), corporate aviation, air taxi operations, helicopters and private aircraft.

Source: CENIPA

Figure 1

The business jet, on a delivery flight out of Embraer's main plant, had departed from São José dos Campos to North America via Manaus. The 737 was flying south from Manaus to Brasília. News was leaked that the Legacy should have descended from 37,000 ft to 36,000 ft after overflying Brasília, which it seems, never happened. The Brasília Area Control Center (ACC) lost radio contact with the Legacy and failed to regain contact until the tragedy occurred. The business jet's transponder, it appears, was not on. In June 2007, a federal court judge proceeded with indictments against both Legacy pilots and four ATCOs.

A Road of Trials

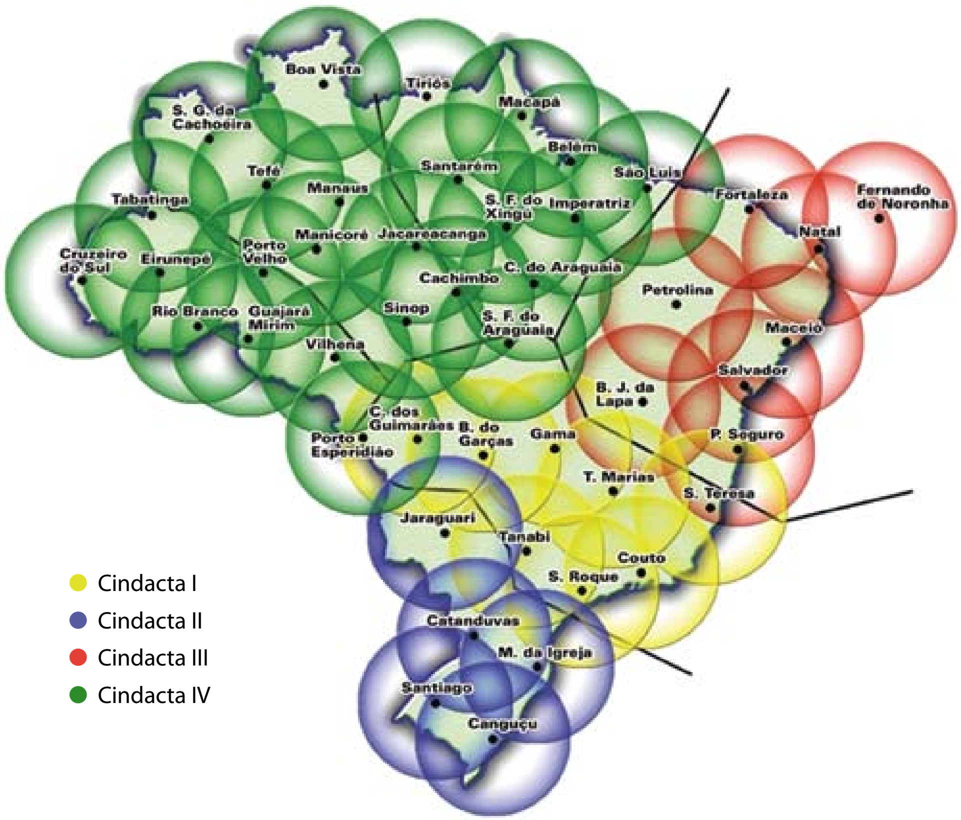
A month after the accident, on Oct. 20, a cascade of events began that nearly brought the air transport system in Brazil to its knees. On that day, a small number of ATCOs who had monitored the two flights were removed from work at Cindacta I, the top ACC in Brazil's ATC system. Several others requested and took medical leaves.

Brazil Flight Information Region (FIR) airspace covers 22.0 million square km (8.5 square mi), of which 8.5 million square km (3.3 million sq mi) are over Brazil's vast territory. The continental airspace management is split between four ACCs, of which Cindacta I is the busiest. It covers 1.5 million square km (0.6 million sq mi), including the capital city, Brasília, and three other major cities, São Paulo, Rio de Janeiro and Belo Horizonte. Five of the busiest airports in Brazil are in Cindacta I airspace.

ATCOs working at Cindacta I felt the pressure. The additional controller absences compounded a heavy workload for the already understaffed work force. That pressure, the possible prosecution of their colleagues and the apparent lack of leadership for three days immediately following the accident combined to create a sense of betrayal among the controllers.

Controller leaders said that the ATCOs decided not to work to extreme limits. Instead of each controller monitoring up to 25 aircraft simultaneously in a sector, they would stick to a maximum of 14. They also leaked to the media news of malfunctioning equipment. Flights began to be delayed throughout the Brazilian network. On and off through the end of the year, hundreds of flights were delayed more than one hour, a dozen flights were cancelled every day, and the situation at major airports was chaotic.

Brazilian Airspace Coverage



Note:
Cindacta is a Portugese acronym for Integrated Air Defense and Air Traffic Control Center

Source: DECEA

Figure 2

The initial federal response was indifferent, as if the problem had not reached the magnitude that it had; the first statement by the government held that the problem would be solved soon by hiring an additional 60 ATCOs.

However, another volatile problem then became public. Civil ATC is managed by the Brazilian Air Force (FAB) through its Department of Airspace Control (DECEA). The ATCOs are mostly FAB personnel, but there also are civilian professionals working in the organization, as well as civilian staff providing services to DECEA but hired by Infraero, the airport body. The difference in wages in favor of Infraero ATCOs is significant, adding an additional element of tension to the situation.

On Nov. 2, the military management began to press ATCOs to work extra hours; the controllers reacted by handling even fewer aircraft. On Dec. 15, an equipment failure at Cindacta I paralyzed most air traffic in Brazil for several hours.

On March 30, this year, controllers at Cindacta I and Cindacta IV at Manaus stopped working, grounding nearly all civil air traffic for several hours. They denied that they were sabotaging the ATC system, creating the crisis. They said they had previously pointed out system weaknesses but had been ignored. They cited "an incompatibility between military life and air traffic control" and stated that they did not trust their equipment and did not trust their commanders. They said ATCOs were the subject of unjust and overly severe punishment by their military superiors.[2]

In June 2007, the Command of Aeronautics (COMAER), the top executive layer of the FAB, tried to stem the conflict with a tough approach: a few ATCO leaders were jailed for several days, removed from duties at top ACCs and forbidden to talk to the news media without authorization. Some controllers continue at press time to face prosecution in a military court for the original accident or for the job actions that followed.

A Brief Background

Brazil's civil aviation infrastructure has been developed with backing of the federal government through FAB and some of its key branches. The Department of Civil Aviation (DAC) eventually became the civil aviation organizational body. When Brazil signed the Chicago Convention in 1944, FAB managed ATC. By the 1970s, an integrated air defense and ATC system was implemented, putting both military and civil aviation operations under a single umbrella. This would save resources in a developing country much in need of upgrading to a world-class airspace environment. The system eventually was named the Brazilian Airspace Control System (SISCEAB), and its executive body became DECEA.

SISCEAB evolved with the establishment of four Integrated Air Defense and Air Traffic Control Centers, which gave birth to the Portuguese acronym Cindacta. A center would be established at each of the four territorial FIRs in Brazil, starting with Cindacta I in Brasília in October 1976. Thirty years later, the four centers were fully established, including Cindacta II in Curitiba, III in Recife and IV in Manaus (Figure 2). Each of these stations operates an air defense section and an ACC for civil air traffic.

At the same time, a plan was advanced to provide full radar coverage above 29,000 ft for the entire Brazilian territory. A consortium set up by the French firm THOMSON-CSF and the Brazilian Hidroservice engineering company won a bid to provide hardware and software for Cindacta I. Technological upgrades were implemented in 1991 and 2002. By the late 1990s, with the establishment of Cindacta IV and the full implementation of the Amazon Surveillance System (SIVAM), Brazil achieved total airspace radar coverage. Software upgrades became Brazilian products over time.

Last year, according to DECEA, Brazil had in place a complex air traffic management system, comprising a technological arsenal of 70 primary radars, 81 secondary radars, 16 weather radars, six approach radars, one ground control radar, and myriad navigational aids, including 77 VHF omnidirectional radios (VORs), six distance measuring equipment (DME)/VORs, 95 DMEs, 235 nondirectional beacons, 157 visual approach slope indicators, 18 VHF direction finders, 37 instrument landing systems (ILSs), 24 localizer approach systems (ALSs) and 4,634 VHF/UHF/HF communication radios.

In May 2006, as hardware approached the end of its operational life, DECEA launched a revitalization plan to completely replace navigational aids — 755 pieces of equipment — by 2008/2009. In fact, 16 pieces of equipment were to have been replaced in 2007.

A Shadow Side

When Public Labor Prosecutor Fábio de Assis Fernandes last year examined ATC labor/management relations, he found it unreasonable to believe that the air transport crisis was due to a bunch of rioting ATCOs. He produced a report that stated, "The problems of the air transport segment in Brazil are old and structural, unknown by civilian society due to the lack of transparency and a control model characteristic of a militarized system." Emphasis was given to his view that ATCOs cannot be blamed for errors caused by equipment malfunctions. "The responsibility to maintain

© Tamon Takeoka/AirTeamImages.com

adequate radar and radio network operations belongs to the employers. It is undeniable that the existence of failures and poor reliability creates tensions and emotional stresses on the workers who are in the position to provide effective air traffic control."[3]

Fernandes found support from workplace health specialist Rita de Cássia Araújo, an employee of the Municipal Secretary of Health for the city of São Paulo. Updating a dissertation she wrote in 2000 at the University of São Paulo on the working environment of ATCOs at both the São Paulo–Guarulhos International Airport Control Tower and at the São Paulo Terminal Area Approach Control, she said the situation has improved only slightly. In a recent article, Araújo noted that, "turned scapegoats, controllers' spirit has hit bottom."

She emphasized that the military mindset typical of the "political-management context of the Brazilian civil aviation should be considered as contributing to an additional mental and physiological load, wearing out ATCOs. The submission to the rigid hierarchical discipline and other stressful conditions — alternate shifts, low wages, double work shifts, low professional self-esteem and family problems — affect their physical vigilance at work."

Further, Araújo said that the lack of dialogue between ATCOs and their supervisors would lead controllers to hide latent failures. And those, she points out, "are evident in the heart of systemic structures before an accident happens, introduced by higher hierarchical levels associated with institutional and management layers." To improve the reliability of a system, she said, those latent failures must be identified.[4]

The Brazilian Court of Audit (TCU) also took a systemic approach. An audit report the TCU released last December states, "The development and growth of air transport, which reflects on the economy, are restrained by the operational capacity of the air traffic control body." This capacity is dependent on the right coordination of the different agencies related to civil aviation and on "the right availability of budget resources, as the system must expand to respond to the current lack of a link between the growth of flights and the real possibility of controlling a greater number of aircraft," the report said.[5]

Federal government bodies related to ATC include the Civil Aviation National Council (CONAC), COMAER, airport manager Infraero and the National Civil Aviation Agency (ANAC), which replaced DAC in early 2006 and is now the independent civil aviation regulatory agency, no longer linked to the FAB.

Those bodies should work with close cooperation, but the TCU judged that they were not. DAC had built a professional aviation staff, but ANAC's first management staff was selected using political criteria and was not up to the challenge. However, after the July TAM Airbus A320 accident at Congonhas, the Minister of Defense was replaced and attempts were made to get those agencies working together in a more

Military controllers' wages are noticeably lower than their civilian counterparts in the same facilities.

efficient way.[6] Changes brought some improvements, but much remains to be done.

Another problem singled out by the TCU is the lack of adequate finance resources to respond to the specific needs of the various players. Basically, resources come from airport and air transport taxes and service fees collected by Infraero. Of the total collected, Infraero should keep 41 percent, up to a maximum of R$90 million (US$51.1 million) per year, to cover its own expenses and transfer 51 percent to COMAER, which funds DECEA. The audit report pointed out that Infraero is retaining amounts beyond both its R$90 million limit and beyond its 41 percent share.

"In the last six years," says the audit report, "Infraero failed to pass to COMAER some R$582 million." As a result, the report says, DECEA had required, for 2004 and 2005, resources of about "R$715 million and R$667 million, respectively, for the operation, maintenance, development and modernization of SISCEAB, but was granted R$468.7 million for 2004 and R$495 million for 2005."

The report says that the crisis that began in 2006 was not a surprise, as several technical alerts issued by DECEA and COMAER anticipated the problem well in advance, but the Ministry of Planning and the Civil House of the President of the Republic did not pay attention to those alerts. "The crisis," states the report, "is no more than a sequence of errors regarding budget cuts on proposals elaborated by DECEA, limitations imposed upon the expenditure of approved budget, indifference to the need to expand and modernize SISCEAB and the inefficient allocation of human resources."[7]

A View From the Hot Seat

Air Major Brigadier Ramon Borges Cardoso is the interim General Director of DECEA, which manages some 4,000 aircraft movements every day.

"Airspace control is dependent on a balance with the airport infrastructure and the air transport route network," Borges said, explaining the situation in Brazil. "Any unbalancing on any of these sectors affects the other two. And this is happening. While all bodies were linked to COMAER, there was planning management unity. When Infraero was separated, and later ANAC replaced DAC, we lost that."

© DECEA

Borges

The lack of dialogue between government agencies allowed the commercial aviation route network to be structured to pass through two main hubs: Congonhas airport in São Paulo and Brasília International Airport. Any weather problem in Congonhas affected the systemwide route network. If traffic was deviated to São Paulo–Guarulhos International Airport at peak hours, the number of gates there could not accommodate the traffic, and aircraft had to wait on taxiways for gates to open.

This system at press time was being rearranged by ANAC, mostly as a result of the TAM A320 accident in July. Airlines were told to avoid using Congonhas as a hub for domestic long haul operations. As a result of route network restructuring, "Cindacta I's [share of] air traffic management is to decline from 56 percent of all Brazilian traffic to 40 percent, as traffic will be shifted to Cindacta III in Recife and Cindacta II in Curitiba," Borges said. "Operational positions will be increased in both ACCs, from eight to 24 consoles in Curitiba and from four to 18 in Recife, by 2017."

Technology is not an issue, he said. Besides en route radars, Brazil has terminal radars at all major terminal areas. Ten weather radars in the Amazon area and seven in Southern Brazil, the two most critical regions in this aspect, provide sufficient coverage.

"We are implementing monopulse secondary radars, a first step to Mode S, then [we will] implement definitively CSN/ATM [communication navigation surveillance/air traffic management]," Borges said. "Automatic dependent surveillance–contract (ADS-C) and controller-pilot data link are being tested on the Europe–South America corridor; digital clearance delivery is to start this year in São Paulo, Rio de Janeiro and Brasília."

At Cindactas II and III, software is being changed from French products to Brazilian developments produced by Atech, based on DECEA's specifications. Cindactas I and IV already have new Brazilian software, with CNS/ATM functionalities incorporated.

The largest problem remains staff size: There are not enough ATCOs and not enough technicians. The current force level "does not allow us to keep [controllers] 24 hours of the day in all operational positions," Borges says. "As we don't have enough controllers, sometimes aircraft may stay grounded for lack of capacity in airspace control. However, as flight numbers are to keep growing — we expect 12 percent per year growth in the next five years — we'll be able to respond. Some 600 new ATCOs are to join by the end of 2008."

That may be of some help, but there's another obstacle to be overcome. FAB cannot grow its labor force beyond a limit set by law. COMAER now is working with the House of Representatives to change that, allowing a 20 percent increase in labor. The departure of highly qualified personnel seeking better job opportunities also is a challenge.

Poor controller English proficiency is a problem pointed out by ATCOs themselves when they were permitted to talk to the media. Borges disagrees and says there's a sufficient knowledge of technical phraseology. However, Brazil — plus 129 other countries, he adds — is not ready to meet the International Civil Aviation Organization's (ICAO's) language proficiency requirements deadline, originally set for next March (see story, p. 25). Under these requirements, ATCOs are expected to be able to communicate at Level 4 — an "operational" proficiency with English — using both technical phraseology and plain English. "We plan to have one English-proficient ATCO at every shift, but it is impossible to have all 4,000 ATCOs [expected for 2009] trained to colloquial English level by then," he said.

There's a real problem if you look at it another way, Borges says: "Native English-speaking pilots sometimes speak in high velocity, not worrying about clear pronunciation, using slang. This makes it very difficult for an ATCO to understand them. And sometimes those who fly under FAA [U.S. Federal Aviation Administration] rules do not know and do not employ ICAO [language] rules when flying here. They request procedures that exist in the United States only. … The ATCO doesn't understand what he is asking. We have to work with IATA [International Air Transport Association] and ask them to help pass along to pilots the need to apply ICAO rules here."

Hierarchical conflicts between ATCOs and their superiors are seen in a linear way by Borges. Military personnel know they will work under military rules, in a military-managed environment, when getting the job, he says. If they don't enjoy it and want to leave, they are free to do so, he adds, supposedly after their military enlistments expire. Borges maintains there is no problem now that the ATCO leaders whom the management considers "rioters" await military judgment. "Congonhas now has an average of 10 percent of all flights delayed, which is acceptable," he says.

Demilitarization? "Ten years from now, radars will begin to be phased out for air traffic control; CSN/ATM will be implemented instead. COMAER's position is that, by that time, a separation be done. The FAB will provide air defense utilizing radars, and a civil agency and its civil control centers will do air traffic control. Civilian ATCOs would then perform activities today done by military personnel." ●

Edvaldo Pereira Lima is an aviation journalist living in Brazil.

Notes

1. Data released by CENIPA. Available at press time in Portuguese at <http://www.cenipa.aer.mil.br/paginas/estatisticas.htm>.
2. "Manifesto dos Controladores de Vôo" ("Air Traffic Controllers Manifesto"). Released to the media on March 30, 2007.
3. "Relatório das Condições de Trabalho dos Controladores do Tráfego Aéreo" ("Report on the Working Conditions of Air Traffic Controllers"). Released in January 2007.
4. Araújo, Rita de Cássia."Prevenção ou Punição? Considerações Para Revisão da Lógica no Controle do Tráfego Aéreo no Brasil" ("Prevention or Punishment? Considerations on the Reviewing of Air Traffic Control Logic in Brazil"). Released by the author.
5. "Acórdão 2420/2006 — Plenário — Relatório de Levantamento de Auditoria no Sistema de Controle do Tráfego Aéreo." Audit report signed by Minister Augusto Nardes. Available at press time in Portuguese at <http://www.tcu.gov.br/>.
6. On July 17, 2007, the A320 overran the runway while landing at Congonhas Airport and struck a TAM express cargo facility, killing 199 people, including all aboard. This was the worst air accident ever in Brazil; the second worst was the 737/Legacy midair collision in 2006. The A320 accident stirred a number of changes in the air transport system of Brazil. Minister of Defense Waldir Pires was replaced by Nelson Jobim. There were top management changes at Infraero and ANAC.
7. Nardes.

Speaking the Same Language

ICAO has approved a series of proposals designed to minimize delays in compliance with its English language proficiency requirements.

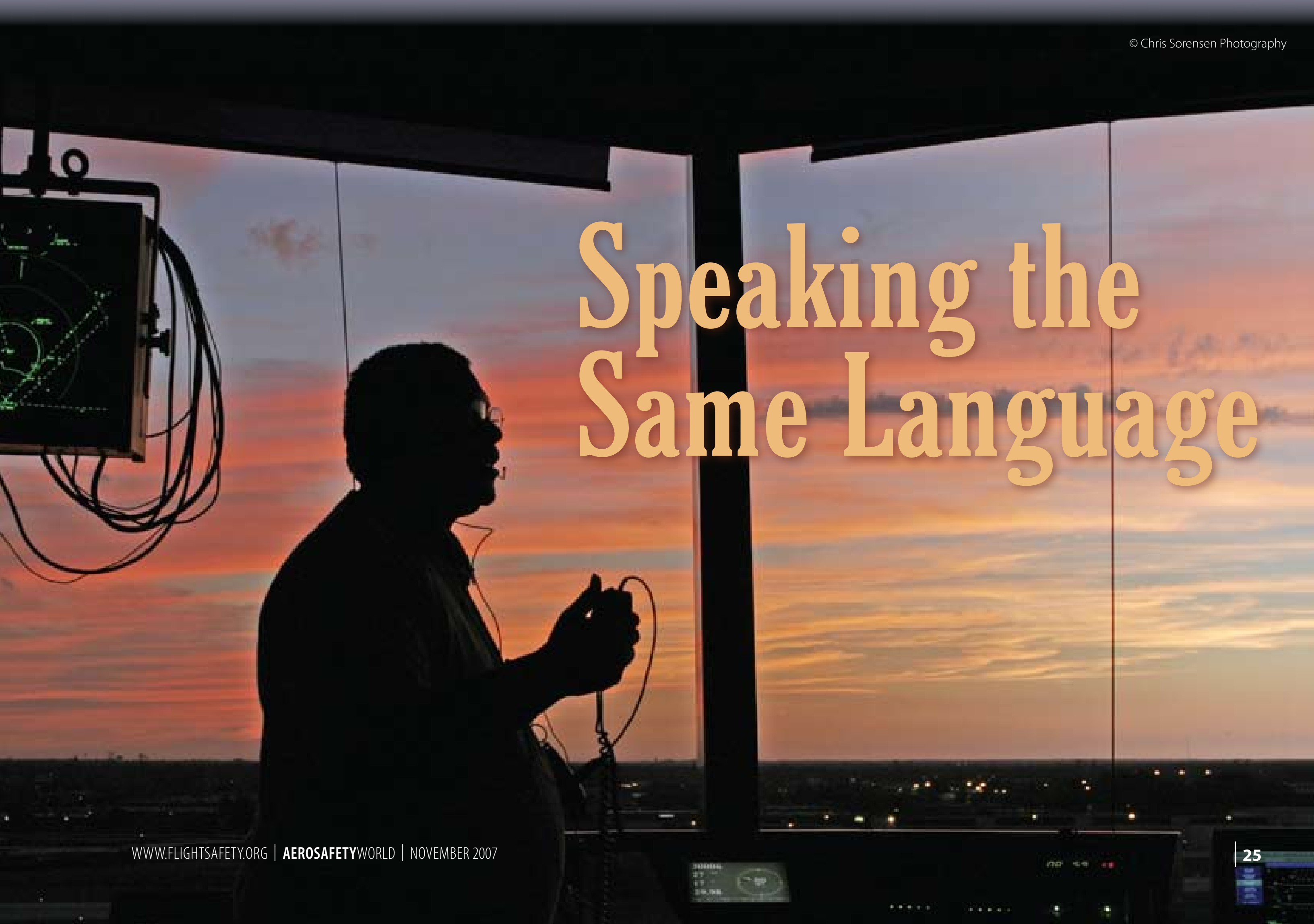
BY LINDA WERFELMAN

Responding to warnings that some states will miss the 2008 deadline for compliance with English language proficiency requirements for pilots and air traffic controllers, the International Civil Aviation Organization (ICAO) has approved a resolution to allow more time for learning while pressing authorities to spell out their training and testing plans.

The ICAO resolution, adopted in late September during the 36th session of the ICAO Assembly in Montreal, also calls for establishment of globally harmonized language testing criteria.

Under previously existing requirements, approved in 2003, ICAO formally designated English as the language of international pilot-controller communications and established a March 5, 2008, deadline for completion of initial testing of pilots and controllers to ensure that they complied with English language proficiency requirements. Aeronautical station operators also must comply.

ICAO defines six levels of language proficiency, from “pre-elementary” at Level 1 to “expert” at Level 6, and says that pilots and controllers must demonstrate an “operational”



© Chris Sorensen Photography

— Level 4 — proficiency or better to be permitted to conduct international flight operations (see "Minimum Requirements").[1] Those who achieve Level 4 or Level 5 proficiency must undergo periodic re-testing; those at Level 6 are exempt from further tests.

Subsequent surveys of ICAO member states drew responses in large part from states in which English is a primary language; most of these states said that they were ready to meet the language proficiency requirements. However, ICAO audits found that a number of states had not established testing standards or developed plans for implementing the requirements.

When the ICAO Assembly convened in September, an introductory report from the Council of ICAO said that action was needed to "mitigate the impact of a delay in compliance by some states."[2] Nevertheless, the Council said, "While some states may not be compliant by March 2008, the applicability date establishes a milestone that helps to retain the focus required to implement the safety standards related to language proficiency as soon as practicable."

© Stephen Rees/Fotolia

In a separate presentation to the Assembly, the International Federation of Air Traffic Controllers' Associations (IFATCA) said that many states were "not progressing at an acceptable pace with respect to timely implementation of language training" and that ICAO should establish and enforce "a method of accountability" for noncompliance. Other organizations and states asked ICAO to extend the March 2008 deadline or otherwise limit its scope. The proposals were not included in the Assembly's final action.

The ICAO resolution, which acknowledges the difficulties that some states have had in implementing language proficiency programs, as well as the need for more time to comply with the ICAO requirements, says that states that will not meet requirements by the March 2008 deadline should — by that date — develop implementation plans.

Those implementation plans should include a timeline for adoption of the language proficiency requirements in the national regulations and a timeline for establishment of language training and assessment capabilities, as well as a description of "a risk-based prioritization system for the interim measures to be put in place until full compliance … is achieved," the resolution says. In addition, the plan should describe procedures for "endorsing licenses to indicate the holders' language proficiency level," the resolution says.

Other provisions of the resolution call for states that will miss the deadline to "post their language proficiency implementation plans, including their interim measures to mitigate risk … on the ICAO Web site" before March 5, 2008. The states also must notify ICAO of the ways their operations do not meet the language proficiency standards and include information about those differences in their aeronautical information publications.

As long as a particular state has complied with these requirements, its pilots and air traffic controllers should be permitted to continue their work as usual, even without proficiency in English, the resolution says.

The resolution says that all states should allow pilots who do not meet ICAO language proficiency requirements to continue to operate in their airspace for up to three years after March 5, 2008, "provided that the states which issued … the [pilot] licenses have made their implementation plans available to all other contracting states."

The resolution also urges states "not to restrict their operators … from entering the airspace under the jurisdiction … of other states where air traffic controllers or radio station operators do not yet meet the language proficiency requirements."

William R. Voss, president and CEO of Flight Safety Foundation, which for years has advocated development of English language proficiency requirements within aviation, said that although pilots and air traffic controllers from many states will need more time to become proficient in aviation English, "this is one of those rare occurrences where a failure to meet an aggressive target is better for safety than a more conservative approach.

"This is a vital safety issue. Many states will not make the [March 2008] deadline, but the system is far better off because people are trying to get it done."

'A Lot of Activity'

Elizabeth Mathews, a specialist in applied linguistics and the leader of the international group that developed ICAO's English language proficiency requirements, said that the delays in meeting the requirements are, at least in part, a result of the complexity of language training.

"But we're seeing various degrees of progress around the world regarding implementation," said Mathews, company director of Aviation English Services, which specializes in teaching aviation English. "What's very positive and encouraging is that there's a lot of activity in this area."

She praised the ICAO resolution as a workable solution that maintains pressure on states to comply with the language proficiency requirements while also maintaining the credibility of the ICAO standards.

United Airlines Capt. Rick Valdes, the International Federation of Air Line Pilots' Associations (IFALPA) representative to the ICAO study group that developed the language proficiency requirements, said he was relieved that the ICAO Assembly rejected proposals to abolish the March 2008 deadline, instead modifying the actions that states will be required to complete by March and allowing more time for learning English.

"The March 5 deadline was a must to get the process rolling, understanding that there might be a lot of states that are not going to be compliant by that date," Valdes said. "You've got to start somewhere. If you put it off for three years, then

Minimum Requirements

Pilots, air traffic controllers and aeronautical station operators must demonstrate at least Level 4 proficiency by meeting the following criteria established by the International Civil Aviation Organization (ICAO):

- "Pronunciation, stress, rhythm and intonation are influenced by the first language or regional variation but only sometimes interfere with ease of understanding;
- "Basic grammatical structures and sentence patterns are used creatively and are usually well controlled. Errors may occur, particularly in unusual or unexpected circumstances, but rarely interfere with meaning;
- "Vocabulary range and accuracy are usually sufficient to communicate effectively on common, concrete and work-related topics. Can often paraphrase successfully when lacking vocabulary in unusual or unexpected circumstances;
- "Produces stretches of language at an appropriate tempo. There may be occasional loss of fluency on transition from rehearsed or formulaic speech to spontaneous interaction, but this does not prevent effective communication. … Fillers are not distracting;
- "Comprehension is mostly accurate on common, concrete and work-related topics when the accent or variety used is sufficiently intelligible for an international community of users. When the speaker is confronted with a linguistic or situational complication or an unexpected turn of events, comprehension may be slower or require clarification strategies; [and,]
- "Responses are usually immediate, appropriate and informative. Initiates and maintains exchanges even when dealing with an unexpected turn of events. Deals adequately with apparent misunderstandings by checking, confirming or clarifying."

— LW

Note

1. ICAO. "ICAO Rating Scale for Operational Level 4." *Frequently Asked Questions About ICAO*. <www.icao.int/icao/en/trivia/peltrgFAQ.htm#lang>.

© iStockphoto

three years from now, we're going to be exactly where we are today."

Instead, the new guidelines will allow states to tell ICAO by the March 2008 deadline that "we're not going to be able to do it, this is the reason why, this is how we're going to fix it, and we should be compliant within the new three-year time frame," he said.

Global Harmonization

Although other provisions of the ICAO resolution called for establishment of globally harmonized language testing criteria, the ICAO budget does not currently include funds for development of such a program. After funding is approved, the criteria will be developed, said Nicole Barrette-Sabourin, training officer at ICAO's Aviation Training Policy and Standards Unit.

Harmonized testing criteria will be "one of the most important ways that ICAO can provide support to member states on the implementation of these language proficiency requirements," Mathews said. "It's a response from ICAO to calls from many sectors of the industry."

In addition, the standardization of testing criteria is "probably the most important next step that ICAO can take," she said.

"There is a lot of bad language-teaching. … It's very much a buyer-beware market."

"Language testing and training is by and large an unregulated industry, or sometimes we call it a self-regulating industry … and it doesn't regulate itself very well," she added. "As a result, there's wide variety in quality and effectiveness of language training programs and also language testing programs."

In a presentation to the Flight Safety Foundation International Air Safety Seminar in October in Seoul, South Korea, Mathews said, "Around the world, there is a lot of bad language-teaching. … It's very much a buyer-beware market."[3]

Valdes agreed, adding that standardization and accreditation are part of any effective language training program.

"Today, ICAO English language testing and training does not have any accreditation process in place," he said. "Quite a few English-language schools have found a new medium to generate revenue, and even though they don't know anything about aviation, they are approaching the aviation industry as the means for the revenue, without understanding and taking the time to read the ICAO document that establishes the guidelines and the requirements. … Just because they've been teaching English for 50 years doesn't mean they understand the concept of aviation English."

ICAO is unlikely to monitor training, however, Barrette-Sabourin said, adding that the variety in the content of training programs, cultures and media, among other factors, would make oversight of training programs very difficult.

Training will improve to match the quality and demands of testing, she said, and ultimately, "good testing will have a 'washback' effect on training." The "washback effect" refers to the tendency of a test to influence the content of the related academic training.

Implementation Workshops

Another provision of the resolution says that ICAO will develop a series of workshops to be held in each ICAO region to help states develop their implementation plans.

Training programs already are in place at some airlines and air traffic control organizations.

For example, Eurocontrol already has an English language proficiency test for air traffic controllers. The test includes two sections — an Internet-based listening comprehension test and an interactive speaking test, which uses visual and nonvisual communication. Eurocontrol says the two-part examination is designed to help Eurocontrol's member states comply with the new language rules and "ensure that all air traffic controllers in Europe will have a valid and reliable tool to measure their English language proficiency."[4]

Officials at China Southern Airlines describe the language proficiency requirements as "a major challenge," especially for airlines with large pilot populations.[5]

"It is rare for China Southern Airlines (CSN) to launch such a big training program," representatives of the airline said in a May presentation to an ICAO symposium on aviation language.

Their first step, they said, was a survey of the airline's 2,600 pilots to determine their familiarity with English. One factor was pilot age; younger pilots are more likely to have studied English in school, compared with pilots educated in the 1980s, when Japanese was the choice of most foreign-language students, they said.

By May 2007, the airline — working with training provider RMIT English Worldwide — had established English language training centers in 18 locations throughout China where CSN pilots are based, they said. Estimates were that, by the end of February 2008, 1,000 CSN pilots would reach Level 4 proficiency and 450 would reach Level 3; by the end of 2008, another 1,000 pilots were expected to reach Level 4.

Administrators of a program developed for pilots in Brazil found during a preliminary survey that pilots often complained of being "de-motivated" by English language materials encountered in previous English classes and frustrated by teachers who were unfamiliar with aviation and the crewmembers' routine.[6]

Adriana Lage Toma of the Advanced Training Organization in São Paulo said that weekly three-hour classes were offered at various times of day from Monday through Saturday, allowing pilots to choose sessions according to their work availability. After 125 class hours, tests found that 81 percent of the "low Level 3" students who began the program had progressed to Level 4; tests also found that 8 percent were evaluated at "high Level 3" and 3 percent had not achieved the minimum requirements to progress to the next class level.

"There is still a lot to be done in order to help those who … couldn't achieve the results designed," she said. "More research and study are taking place to find ways of assisting these students." ●

Notes

1. ICAO. *Manual on the Implementation of ICAO Language Proficiency Requirements*, Document 9835. 2004.
2. ICAO. *Assembly — 36th Session: Report of the Technical Commission on Agenda Item 30, A36-WP/359*. Sept. 26, 2007.
3. Mathews, Elizabeth. "ICAO Language Proficiency Requirements: The Value of Content-Based Language Training for the Aviation Industry." In *Sharing Global Safety Knowledge: Proceedings of the 60th Annual International Air Safety Seminar*. Alexandria, Virginia, U.S.: Flight Safety Foundation, 2007.
4. Eurocontrol. *Eurocontrol Launches English Language Proficiency Test for ATCOs.* <www.eurocontrol.int/corporate/gallery/content/public/docs/pdf/pressreleases/2007/070907_ELPAC_IANS.pdf>.
5. Yizhi, Zhou; Hesheng, Ou; Jingyu, Cao; Junqing, Li. "Aviation English Training Project for Pilots in China Southern Airlines." Paper presented to the Second ICAO Aviation Language Symposium, Montreal, May 2007.
6. Toma, Adriana Lage. "A Case Study — Training Aviation English to On-the-Job Brazilian Pilots." Paper presented to the Second ICAO Aviation Language Symposium, Montreal, May 2007.

Alone at 41,000 Feet

Single pilots of VLJs and other technically advanced aircraft need comprehensive training in resource management.

BY BARBARA K. BURIAN AND R. KEY DISMUKES

The cockpit could be a crowded place in the early days of commercial aviation. Pilots and copilots were accompanied by flight engineers, navigators and radio operators, and together they got the aircraft and its occupants from point A to point B. As aircraft systems became more reliable and technology advanced, the six crewmembers eventually became three and then two. Although large transport category aircraft are still piloted by two flight deck crewmembers, single-pilot commercial operations will expand greatly with the advent of very light jets (VLJs) and other technically advanced aircraft (TAA).[1]

The demand for pilots for fractional operations, air taxi services and corporate flying is expected to approach that for major airlines during the next 12 years. Single-pilot operations in TAA will help operators meet this demand. At the same time, some TAA will enable single pilots flying for personal reasons to extend into high-altitude, high-speed operations that have been the exclusive domain of commercial aviation.

There is a natural concern about how flight safety will be affected by single-pilot operations in TAA. Single-pilot flying is nothing new, being the predominant mode in tactical military operations and personal flying. However, military flying has far different requirements and risks than either commercial or personal flying, and personal flying by single pilots in TAA in the upper flight levels will bring with it demands that differ from the demands of personal flight in airplanes such

© Honda Aircraft Company

Many very light jets — including the Hondajet, scheduled to go into production in 2010 — are designed for either one pilot or two.

as Beech Bonanzas, Cirrus SR22s or Diamond Twin Stars.[2]

Manufacturers have been developing advanced technologies to reduce workload and enhance situational awareness for single-pilot operations in all types of aircraft. One manufacturer even describes its automation and avionics suite as a virtual copilot.[3] The technology systems currently or soon to be available can do much to support the single pilot, but advanced technology does not really replace the second pilot, at least not yet. Technology cannot perform some of the most critical functions of a second pilot, and in some instances in which advanced technology performs some of the second pilot's tasks, it does so differently, thereby creating new kinds of workload and cognitive demands for the single pilot.

Let us examine what is lost when the second pilot steps out of the cockpit and what is gained when advanced technology steps in. This examination can help developers optimize design of automation, training and procedures for single-pilot operations and will help pilots prepare to better meet the challenges of single-pilot operations in TAA and VLJs.

The Role of a Second Pilot

Obviously a second pilot takes on some of the workload and assists with tasks far beyond fetching coffee and conducting preflight inspections in the rain. While one pilot checks the weather and plans the route, the other pilot may supervise fueling, load luggage and brief passengers. The pilot who is not flying can program the flight management system (FMS) or global positioning system (GPS), perform checklists, handle air traffic control (ATC) communication, look up landing distances for a high-altitude wet runway and so on.

Beyond relieving the flying pilot of some cockpit tasks, a second pilot also provides a second set of informed eyes. The copilot can keep track of aircraft configuration, energy state and flight progress; monitor instruments, weather radar and the actions of the other pilot; look for airports and traffic; and read approach charts and minimum equipment list (MEL) procedures. In short, the copilot takes in information and processes it intelligently.

Most importantly, copilots act on that information. They tell the flying pilot that the fuel burn is greater than expected, they correct the incorrect numbers dialed into the altitude alerter, they recognize that an approach is unstable and advocate going around, they verify that the engine being shut down is the one that is malfunctioning, and they point out that a checklist has not yet been completed. Through hard experience, the airline industry has learned that monitoring, cross-checking and challenging are crucial roles for the pilot not flying — so much so that this pilot is now usually called the monitoring pilot.[4]

Equally important, if not more so, the second pilot plays a crucial role as a sounding board — someone to help think through decisions, to question a course of action, to help identify risks and to suggest alternatives. It is in this role that the second pilot makes some of his or her greatest contributions to the flight.

The Role of Advanced Technology

Advanced technology can greatly reduce workload in the cockpit. It can automatically check the status of systems on startup, manage cabin pressure, prompt troubleshooting steps when systems fail and simplify the tasks of navigation and conducting approaches. With technological assistance, flying a perfect holding pattern in strong winds aloft is a snap, identifying the location of a thunderstorm relative to the route of flight becomes easy, and the top of descent is calculated for the pilot and shown graphically in relation to the aircraft's current position.

Through sensors, data-link and on-board databases, advanced technology also takes in information and processes it for presentation to the pilot. For example, a moving map may be combined with weather, terrain and traffic information in a single display, and a ring surrounding the aircraft's position may show how far the aircraft can go with existing fuel and winds. Multi-function displays also can depict a vast amount of information, such as airport layouts, to support situational awareness during taxiing.

Although advanced technology and copilots both assist the flying pilot by providing crucial information, the way in which this information is provided differs substantially. Technology can only make the information available, preferably in an easy-to-interpret format. It is often up to the pilot to know that the information exists and how and where to locate it. In situations of high workload, the pilot may forget the information is available or may lack the time to access it. In contrast, a copilot can determine what information the pilot needs at a given moment, call attention to that information in a manner that minimally interferes with the ongoing task, and help the pilot think through the implications of the information. Additionally, technology can provide information crucial to decision making but cannot tell the pilot that a decision must be made. Technology will not question the pilot's behavior, identify risks or suggest alternate courses of action. Without the second pilot, the sounding board is gone.

Technology Brings Benefits, Problems

Advanced technology and cockpit automation also have introduced problems and hidden levels of complexity. Hart Langer, while vice president of operations at United Airlines, characterized the FMS as "a giant vacuum cleaner that sucks in eyeballs and fingertips." For example, when given last-minute runway changes during approaches to busy airports, flight crews have gotten into trouble by attempting to re-program the FMS — action that has diverted their attention from other flight tasks — instead of using a lower level of automation to control the flight path.

Airline pilots have been known to ask three questions about flight deck automation: What is it doing? Why is it doing it? What is it going to do next? In fact, several airline accidents have occurred because the pilots were confused about the mode in which the automation was operating. Although there are fewer automated flight modes in TAA compared with modern transport category aircraft, the potential remains for confusion and mistakes. For example, it is not uncommon for pilots to miss a GPS's failure to switch from terminal mode to approach mode 2 nm (4 km) from the final approach fix and to mistakenly continue to fly the approach. Several studies have found that training for automation and advanced technology too often focuses on which buttons to push and does not provide pilots with adequate mental models of how the advanced technology operates and why.

Displays and interfaces that use layered menus and "soft keys" — buttons that perform different functions, depending on previous button presses — greatly increase demands on pilot memory and attention. Working memory — what we can hold in mind at any one instant — and attention are cognitive resources of extremely limited capacity that are essential to managing concurrent tasks, maintaining situational awareness, evaluating risks and making decisions. Single-pilot operations require innovative approaches to the design of advanced technologies and displays to reduce cognitive demands substantially below the demands from technologies designed for two-pilot cockpits. In addition to design, training and procedures for managing advanced technologies must be tailored to single-pilot operations.[5,6,7]

CRM vs. SRM

Following a series of accidents involving perfectly functioning aircraft in the 1970s, the airline industry and the U.S. National Aeronautics and Space Administration (NASA) developed the concept of crew resource management (CRM), which has been credited with averting accidents and saving lives. Single-pilot resource management (SRM) is an analogue of CRM, but successful implementation of SRM requires close examination of how resource management in a single-pilot cockpit differs from that in a multi-crew cockpit.

U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 120-51E lists topics to be addressed in CRM training such as communications processes and decision behavior, including briefings, inquiry and advocacy, crew self-critique and conflict resolution.[8] Team building and maintenance of the team also are essential elements of CRM, including leadership and followership behaviors, interpersonal relationships, group climate, shared situational awareness, avoiding distractions and distribution of workload. Clearly, the emphasis is very much on the crew — how its members communicate, coordinate and work together as a team.

In SRM, the emphasis must shift. Workload management becomes central, because the single pilot lacks a crewmember who can share the skilled tasks of piloting. It is through proper workload management that the single pilot is able to maintain situational awareness, avoid distractions, retain enough mental capacity to make good decisions and utilize the advanced technology and resources to their greatest effect. An effective approach to workload management is particularly important when considering the speed with which events will transpire in VLJs, and thorough familiarity and currency with the advanced technology is essential.

How a single pilot approaches workload management must be very different than how a crew might manage it. Planning and preparation, always crucial in aviation, become even more so for single pilots. Planning should not just address expected conditions, routing, cruising altitudes, notices to airmen (NOTAMs), destination approaches, risk assessment and mitigation, passenger needs, and the like, but must also anticipate contingencies such as unforecast weather changes and equipment failures. As much work as possible should be accomplished before flight and during relatively low workload phases of flight. For example, complete flight plans should be entered into the avionics before taxi-out — climbout is not the time to be punching numbers into the box.

When workload becomes heavy during flight because of unanticipated events, such as complicated re-routings or equipment malfunctions, the single pilot must be proactive in off-loading as much work as possible. Strategic use of automation is crucial, but of course this requires a solid and accurate mental model of how the automation works and proficiency in setting it up. When getting overloaded, pilots can build in extra

Manufacturers of some very light jets, including Adam Aircraft's A700, have entered into partnerships with training providers to teach owner-operators about single pilot resource management.

time, for example, by negotiating with ATC to turn away from rising terrain or to enter holding to sort things out. Prioritization and the strategic shedding of tasks can also provide time and free up mental resources to perform the most crucial tasks. Strategic shedding is the thoughtful elimination or deferment of less essential tasks to allow the time and mental and physical resources necessary to devote to more essential tasks.

Managing workload effectively does require a strategic approach. Unfortunately, the Catch-22 of workload management is that strategic behavior requires mental resources. When pilots get overloaded, strategic management often falls away as pilots adopt the less demanding — and far less effective — tactic of just reacting to events as they occur.[9] Situational awareness, judgment and decision making are impaired when pilots are overloaded. Skill at strategic management of workload requires explicit training in specific techniques. Ideally, this training includes practice in simulators with realistic flight scenarios.

The challenge of cockpit task management is not limited to overload situations, though. The single pilot does not have the luxury of focusing on one task to completion before turning to other tasks; rather, he or she must "multi-task," switching attention among task demands, something like a circus juggler. Multi-tasking is far more vulnerable to error than most people realize, as evidenced by the large number of automobile accidents in which cell phone conversations were involved. When focusing on one task that demands mental resources, such as re-programming an FMS, we are all vulnerable to the "tunneling" of attention in which we lose track of the status of other tasks. Research is needed to identify specific techniques for effectively managing attention allocation during concurrent tasks in single-pilot operations.

Although SRM has been mentioned in pilot literature for some time, detailed and comprehensive SRM training programs, for the most part, have yet to be developed.

Challenges in Training

There are several ways to facilitate safe and efficient single-pilot operations in both commercial and personal flying. Manufacturers already are contributing by designing advanced technology to support the single pilot and to simplify cockpit tasks. This technology can be enhanced by careful analysis of both the benefits and the difficulties encountered with existing airline cockpit automation. Innovative ways to make automation displays and functions more transparent and to reduce cognitive demands would benefit not only single-pilot operations but also crew operations. Automation training that focuses on developing solid mental models rather than on "switchology" would reduce workload and errors.

SRM training could greatly help single pilots manage their tasks, but this training will be effective only if detailed curricula are developed that focus on the special character of single-pilot operations. For single pilots who do not fly frequently, maintaining currency in TAA is a crucial challenge.

VLJs and other TAA are the result of remarkable engineering innovations. Our challenge is to be equally innovative in developing technology functionality and interfaces, training and procedures to better support single-pilot operations. ●

Barbara K. Burian, Ph.D., studies aviation safety human factors in the Human Systems Integration Division at NASA Ames Research Center. R. Key Dismukes, Ph.D., is chief scientist for aerospace human factors in the Human Systems Integration Division at NASA Ames. Both are general aviation pilots.

Notes

1. "Technically advanced" typically refers to small aircraft with sophisticated avionics, engines — such as those with full authority digital engine control (FADEC) — and autoflight systems comparable to those of modern airliners. In this article, it refers to glass cockpit, high performance aircraft such as VLJs, though much of the discussion applies to single-pilot operations in other TAA, such as the Cirrus SR22.

2. National Business Aviation Association (NBAA). *Training Guidelines for Very Light Jets and Technically Advanced Aircraft*. <http://web.nbaa.org/public/ops/safety/vlj>.

3. Eclipse Aviation. *Flying the Eclipse 500*. <www.eclipseaviation.com/eclipse_500/avio_ng/flying_the_eclipse_500.html>.

4. Sumwalt, R.L. III; Thomas, R.J.; Dismukes, R.K. *Enhancing Flight-Crew Monitoring Skills Can Increase Flight Safety*. In *Keeping Safety a Worldwide Priority: Proceedings of the 55th annual International Air Safety Seminar*, Flight Safety Foundation. Alexandria, Virginia, U.S.: Flight Safety Foundation, 2002.

5. NBAA.

6. Burian, B.K.; Dismukes, R.K. (2007). *Training the VLJ Pilot*. <http://human-factors.arc.nasa.gov/eas>.

7. Burian, B.K. "Very Light Jets in the National Airspace System." In *Proceedings of the 14th International Symposium on Aviation Psychology*. Dayton, Ohio, U.S: Wright State University Press, 2007.

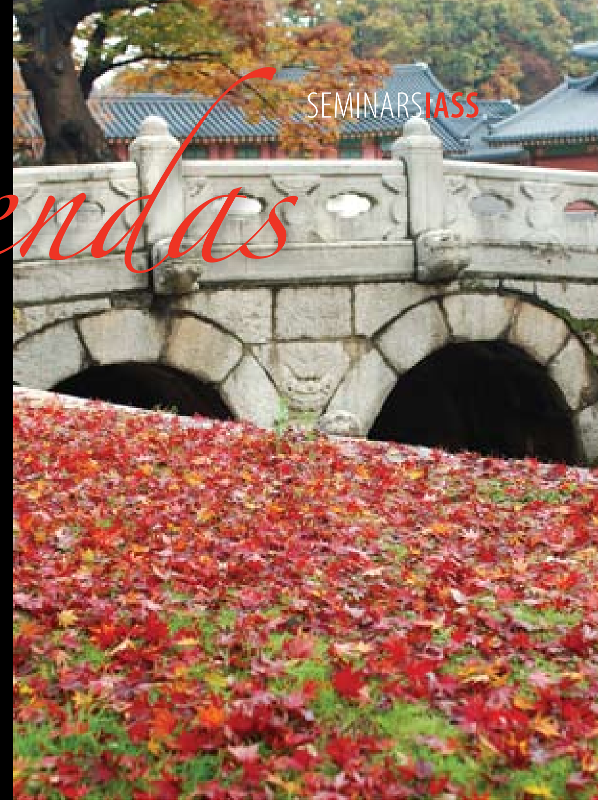
8. FAA. AC 120-51E, *Crew Resource Management Training*. Jan. 22, 2004. <http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/80038cf51aace53686256e24005cbb23/$FILE/AC120-51e.pdf>.

9. Dismukes, R.K.; Berman, B.A.; Loukopoulos, L.D. *The Limits of Expertise: Rethinking Pilot Error and the Causes of Airline Accidents*. Aldershot, England: Ashgate, 2007.

BY WAYNE ROSENKRANS | FROM SEOUL

Converging *Agendas*

Completing existing work plans will be essential to future aviation risk management.



Speakers from left, Voss and Huntzinger
Photos: Alan Bond

Accelerating the reduction of accident risks in airline flight operations requires implementing widely endorsed safety measures without being overwhelmed by industry growth, several presenters told the joint meeting of the 60th annual International Air Safety Seminar (IASS), International Federation of Airworthiness 37th International Conference and International Air Transport Association (IATA). Finishing tasks already planned will be the key element differentiating future aviation risk management from some past efforts, William R. Voss, FSF president and CEO, told the October meeting. "There does not seem to be a problem knowing how to do safety; there is a problem of implementation — of getting it done," Voss said.

This imperative already is shifting Flight Safety Foundation's priorities to implementation of the *Global Aviation Safety Roadmap;* promoting safety management systems (SMSs); expanding threat and error management within business aviation; modernizing air traffic control; integrating runway safety efforts; and addressing the systemic threats induced by projected industry growth, insufficient qualified personnel, weak political will and criminalization of aircraft accidents. Legacy FSF initiatives, such as approach and landing accident reduction, will remain important priorities, Voss said.

Although many aviation safety specialists have decried the practice of some governments of arresting aviation personnel involved in aircraft accidents and charging them with criminal offenses, the arguments must be articulated carefully, he said. "We are not going to change all the laws, we are not going to amend all the constitutions around the world, and we are not going to change all the hearts and minds of the public," Voss said. "But at the very least, we need to make sure that the prosecutors and the jurists/judges understand that there is a balance to be made — a tradeoff to be considered — between the need for justice and the need to support reporting systems that will save lives."

The worldwide airline industry is forecast to double in size within 20 to 25 years, with some of the most rapid growth projected in Asia and the Middle East. Yet, market forces also have decimated some airlines' ability to retain people. "The lack of qualified personnel has become acute in Asia and Africa and is emerging in Russia, Eastern Europe and the Middle East," Voss said. In some developing states, inadequate political will of civil aviation officials to override powerful economic interests in favor of safety also has become a major challenge, he said.

SMSs have begun to permeate civil aviation authorities, airlines, air traffic service providers and airports, among other elements of the industry, and in many cases they have been mandated. But enthusiasm can conceal the inertia of conventional systems. "SMSs clearly must be done by the aircraft operators and others and done well, but the trouble is that this involves, really, a fundamental overhaul of the regulatory system in the world," Voss said.

SMSs soon will have profoundly positive effects on organizations and individuals, said David Huntzinger, vice

president of safety, security and compliance for Korean Air. For example, as Korean Air has developed its SMS, risk-based predictive tools — such as a new predeparture threat and error management checklist — have been especially challenging. "Our checklist formalizes the flight crew's review of the flight, and it forces them to come up with corrective measures ahead of time," Huntzinger said. "Once you get an SMS done — looking at the things in front of you before they happen — you change the way you work forever."

Signs of Advances

Michael Comber of IATA reviewed follow-up activities of the Industry Safety Strategy Group (ISSG), which produced the *Roadmap,* and the International Civil Aviation Organization (ICAO). ICAO has absorbed the *Roadmap* into its processes and has begun working with states in Africa, the Middle East, Latin America and Southeast Asia under this framework. "ICAO's presence gives confidence to each state participating; the concept of the *Roadmap* is not to start with a blank sheet but to use what is already in a state or region in the best way possible," said Comber, director of ICAO relations and co-chairman of the ISSG. "What makes the *Roadmap* unique … is that it helps all the players involved to focus on important things and agree on where to put the investment first."

A novel technique for investigating "clusters of events" — based on greater awareness of seemingly unrelated accidents/incidents that reveal common patterns — has produced promising results, said Pierre Jouniaux, head of the Incident Investigation Division of the Bureau d'Enquêtes et d'Analyses (BEA) of France. Since 2003, the BEA has incorporated these findings into reports on icing, runway incursions, winter operations and midair collisions. The BEA also has applied this method to the Air France Airbus A340 runway overrun at Toronto in August 2005, comparing the accident with other occurrences involving convective weather. "Data for the past 10 years … show that runway excursions and abnormal contact with the runway happen all over the world and on a regular basis," Jouniaux said, citing an example in which the flight crew of an A340 landed 30 m (98 ft) short of the runway threshold at a French airport while unaware that their approach had become unstabilized at 150 ft. Causal factors included the autothrust response to wind shear, in which a headwind decreased from 23 kt to zero kt in four seconds, and suddenly reduced visibility in a rain shower. "The crew was aware of the wind shear, but they did not take any protective action," he said. "They did not brief for a go-around, and there were no criteria to tell them when an approach should be aborted in the presence of convective weather with cumulonimbus near the runway."

Following up the March 2005 publication of a consensus-based smoke/fire/fumes checklist template, the Air Line Pilots Association, International (ALPA) has called for adding equipment to aircraft to improve the flight crew's ability to detect and suppress in-flight fires, and to make appropriate decisions. Capt. H.G. "Boomer" Bombardi, ALPA's in-flight fire project team leader, said that Airbus and Boeing Commercial Airplanes — both participants in the checklist initiative — have factored the template into new aircraft-specific smoke/fire/fumes checklists. "Current aircraft systems do not provide adequate protection, detection or feedback, so it is tough to know whether you have the event under control," Bombardi said. ALPA wants the U.S. Federal Aviation Administration to mandate use of the standardized checklist and "to require all passenger and cargo transport category aircraft to be equipped with detection systems throughout the entire aircraft, extinguishing devices and a system of feedback monitoring."

Airbus and Boeing discussed technologies and training, respectively, to improve flight crew situational awareness and performance in uncommon scenarios. An Airbus specialist reviewed a new high-energy approach monitoring system and a new traffic-alert and collision avoidance system (TCAS) mode of the autopilot and flight director, which were in the

Speakers from left,
Comber and Bombardi
Photos: Alan Bond and Wayne Rosenkrans

Carbaugh and Jouniaux
Photos: Wayne Rosenkrans

process of certification on the Airbus A380 and expected to be on other Airbus types in 2008.

Airline pilots typically have ample instrument indications of a low-energy aircraft state during an approach, said Capt. Etienne Tarnowski, an Airbus experimental test pilot. "When an airplane is in a high-energy situation — for example, too high and too fast — pilots [may misperceive] the severity because the information presented to them is in the green zone [indicating normal operation]," Tarnowski said. "Many of us have the temptation to try to continue. … This is what leads to possible runway overruns, lateral excursions, short or hard landings, tire bursts and very hot brakes." The monitoring system provides on the navigation display a color-coded arc around the flight path, called the *standard energy circle arc,* "with an airplane symbol representing the present position and the circle arc [representing] the computed distance required for the airplane to descend and decelerate from the present altitude and speed down to the landing elevation at approach speed, assuming a given descent profile speed and flying technique." This arc assumes standard descent procedures while a *limit energy circle arc* shows the aircraft performance possible using speed brakes and configuration changes.

TCAS mode helps a flight crew to respond safely and consistently to TCAS resolution advisories (RAs). "[Relying on the pitch cue of the primary flight display] does not provide unambiguous information or prevent overreactions or opposite reactions," Tarnowski said. "During an RA [with autopilot on], the autopilot mode automatically reverts to the TCAS mode and the autopilot guides the [aircraft] with the required pitch authority [for a vertical rate of 1,600 fpm]. If the pilot is flying the aircraft with the flight director on when the RA occurs, the flight director vertical mode automatically reverts to TCAS mode so that if the pilot follows the flight director pitch bar … guidance provided by TCAS mode ensures the proper pitch authority required by the maneuver [and] the minimum deviation from the latest air traffic control clearance is actually achieved with no overreaction." When clear of the traffic conflict, TCAS mode assists the flight crew to return to the target altitude at a 1,000 fpm vertical rate.

Pilot education and simulator training remain essential elements in mitigating the threat of high altitude loss of control in large commercial jets, said Capt. Dave Carbaugh, chief pilot, flight operations safety, of Boeing. In the second quarter of 2007, an international industry team that developed the 1998 *Airplane Upset Recovery Training Aid* assigned a subteam to update guidance on upset threats in high-altitude operations via a supplement scheduled for release in January 2008. "The airplane is in a performance-limited condition [at high altitude, but] it does not have to be at the maximum limit — just initially near the limited condition — for other [factors] to have an impact and cause an incident," Carbaugh said. "Thunderstorm conditions associated with winds, turbulence and icing effects are a factor."

In normal operations, selection of an automation mode that provides an adequate margin of safety helps to prevent high-altitude upsets. "When selected, lateral navigation mode — provided the flight management computer is programmed correctly — should protect the airplane against too much bank and a possible stall situation," Carbaugh said. In events studied by the subteam, loss of control often has involved flight crews failing to maintain sufficient distance from convective weather, causing an inadvertent encounter with turbulence or icing associated with thunderstorms. The maneuvering to avoid thunderstorms itself could induce an upset if at high altitude the flight crew inadvertently keeps a bank-angle setting selected during low-altitude operation. If an upset occurs, flight crews cannot be reluctant to use the maximum thrust available during their recovery, and they must understand the consequences of improper rudder use, including the risk of structural failure, he said.

The 2007 IASS drew about 350 attendees. The next IASS will be Oct. 27–30, 2008, at the Sheraton Hotel and Resort Waikiki in Honolulu. ●

The CRJ crew lined up for takeoff on the wrong runway.

MISTAKEN

In pre-dawn darkness, the Comair pilots chatted with each other as they inadvertently taxied their regional jet onto a runway that was half as long as the runway assigned for takeoff. The Bombardier CRJ100ER was destroyed in the subsequent overrun at Blue Grass Airport in Lexington, Kentucky, U.S. The captain, flight attendant and 47 passengers were killed; the first officer was seriously injured.

In its final report on the Aug. 27, 2006, accident, the U.S. National Transportation Safety Board (NTSB) said that the probable causes were "the flight crewmembers' failure to use available cues and aids to identify the airplane's location on the airport surface during taxi and their failure to cross-check and verify that the airplane was on the correct runway before takeoff."

Contributing factors were "the flight crew's nonpertinent conversation during taxi, which resulted in a loss of positional awareness, and the Federal Aviation Administration's [FAA's] failure to require that all runway crossings be authorized only by specific air traffic control (ATC) clearances," the report said.

The CRJ was being operated as Flight 5191. At the time, Comair served 97 cities in the United States, Canada and the Bahamas. The all-jet airline was conducting an average of 772 flights daily and employed more than 6,400 people, including 1,631 pilots.

The captain, 35, had 4,710 flight hours, including 3,082 flight hours in type. He had flown various general aviation airplanes before attending Comair Aviation Academy. After he was graduated in August 1998, the academy employed him as a flight instructor. He was hired by Comair in November 1999 and upgraded from first officer to captain when he earned his type rating in January 2004. He had 1,567 flight hours as a CRJ pilot-in-command.

The check airman who administered a line check of the captain in May 2006 said that he received standard scores. First officers who recently had flown with the captain said that he followed standard operating procedures (SOPs), called for checklists at the appropriate time, established a good working environment in the cockpit and demonstrated good crew resource management (CRM).

The first officer, 44, had 6,564 flight hours, including 3,564 flight hours in type. He had been a Beech 1900 captain for Gulfstream International Airlines before being hired by Comair in March 2002. The report said that he earned a CRJ second-in-command type rating in November 2005.

The check airman who administered a line-oriented evaluation of the first officer in April 2006 said that he "met standards and that nothing stood out regarding his performance during the evaluation," the report said. Captains who had recently flown with the first officer said that he had good situational awareness, was articulate in conducting checklists and demonstrated good CRM. "Pilots who had flown with the first officer stated that he was looking forward to upgrading to captain," the report said.

The captain had conducted six previous flights at the Lexington airport, and the first officer had conducted 12 previous flights at the airport. The pilots had not flown together before the accident flight.

U.S. Geological Survey

The report said that the pilots had rest periods that were longer than required by federal aviation regulations or company policy before they arrived at the airport at 0515. They picked up their flight release paperwork, which included the flight plan, weather information, notices to airmen (NOTAMs) and the airplane's registration number.

Two CRJs were parked on the terminal ramp. The crew boarded one of the airplanes and started the auxiliary power unit (APU). After being told by a Comair ramp agent that they were in the wrong airplane, the crew shut down the APU and proceeded to the CRJ assigned to the flight.

One Controller on Duty

The cockpit voice recorder (CVR) recording began at 0536. The crew conducted the preflight checklists while engaged in a nonpertinent conversation, the report said.

The first officer established radio communication with the airport traffic control tower at 0549. He requested clearance to Atlanta and said that they had received automatic terminal information service (ATIS) information "alpha," which indicated that Runway 22 was in use. The runway is 7,003 ft (2,135 m) long and 150 ft (46 m) wide.

ATIS information alpha also indicated that winds were from 190 degrees at 8 kt, visibility was 8 mi (13 km) and that there were a few clouds at 6,000 ft and a broken ceiling at 9,000 ft. Temperature was 24 degrees C (75 degrees F), and dew point was 19 degrees C (66 degrees F).

One controller was on duty. He was handling all tower and radar approach and departure services, as well as recording ATIS broadcasts and attending to other operational and administrative tasks. He had been assigned to the Lexington airport in 1989, one year after being hired by the FAA.

The report noted that one controller frequently was assigned to the midnight shift at Lexington despite verbal guidance issued by the FAA in April 2005 to all facilities providing tower and radar service; the agency said that two controllers should be assigned to midnight shifts, so that tower and radar responsibilities could be split. Nevertheless, the report said that NTSB could not determine if the Lexington air traffic manager's decision to assign only one controller to the midnight shift contributed to the accident.

After receiving their clearance to Atlanta, the captain made a public address system announcement, welcoming the passengers and providing brief details about the flight. He then told the first officer, "Run the checklist at your leisure."

The crew had agreed that the first officer would conduct the takeoff and the flight to Atlanta. While conducting a departure briefing, the first officer asked, "He said what runway? One of them. Two four?" The captain replied, "It's two two."

"The first officer continued the departure briefing, which included three additional references to Runway 22," the report said. Flight data recorder (FDR) data indicated that both pilots later set the heading bugs in their flight displays to 227 degrees, the magnetic heading for Runway 22.

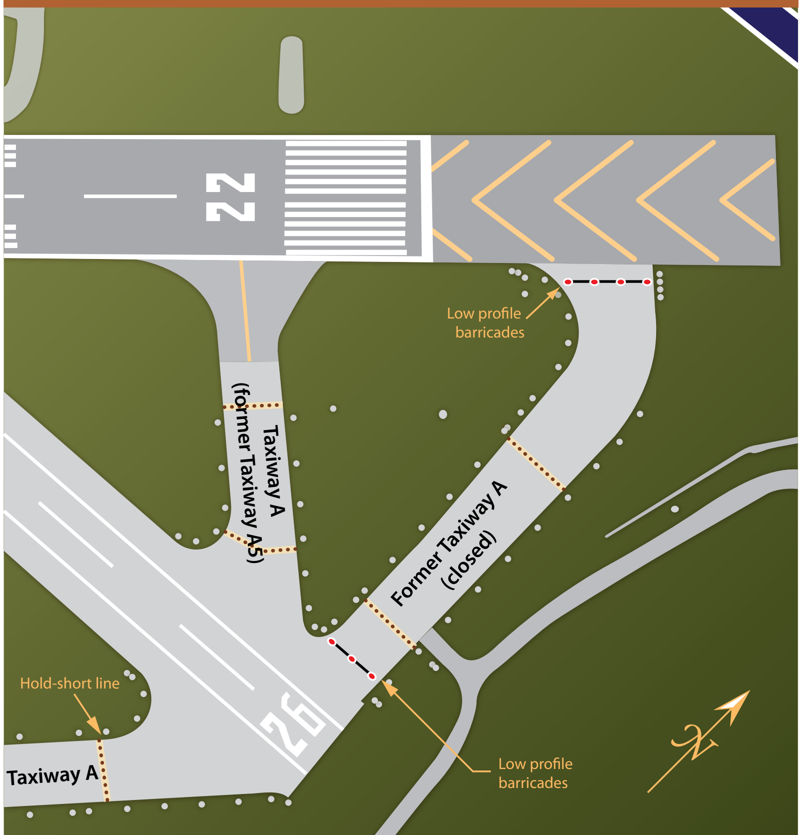
'Short Taxi'

During the departure briefing, the first officer told the captain that "lights were out all over the place" when he arrived on a positioning flight the night before. The first officer said that they would taxi

BY MARK LACAGNINA

IDENTITY

Lexington Taxiways



Source: Susan Reed, based on U.S. National Transportation Safety Board report

Figure 1

on Taxiway Alpha and added, "Two two's a short taxi." Noting that the crew had not yet received taxi instructions from ATC, the report said that the first officer's comment indicated that he likely was referring to an airport diagram during the departure briefing.

The report said that because of ongoing construction at the airport, there were discrepancies in the airport diagrams produced by the FAA and by Jeppesen. The diagrams did not show that Taxiway A north of Runway 26 had been closed and barricaded, or that Taxiway A5 had been redesignated as Taxiway A (Figure 1). The closure of Taxiway A also was the subject of a NOTAM that was not included in the crew's flight release paperwork. However, the report said that these factors did not affect the crew's ability to find their way to the correct runway. "The navigational task … was straightforward and inherently simple," the report said.

The engines were started, and the first officer told the controller at 0602 that they were ready to taxi. The controller told the crew to taxi to Runway 22. "This instruction authorized the airplane to cross Runway 26 (the intersecting runway) without stopping," the report said.

The report noted that among recommendations issued in 2000 to prevent runway incursions, NTSB called on the FAA to require controllers to issue explicit clearances to flight crews to cross each runway as they taxi to the assigned departure runway. "If these safety recommendations had been implemented before this accident, the controller would have been required to issue a specific taxi clearance for the airplane to cross Runway 26 and then issue a specific taxi clearance for the airplane to continue taxiing to Runway 22," the report said. "These procedures would have provided the flight crew with better awareness of the airplane's position along the taxi route and would have required the controller to visually observe the airplane's position and monitor the taxi as the airplane progressed toward the departure runway. Thus, the flight crew's surface-navigation error might have been prevented."

Nonpertinent Conversation

While taxiing, the crew resumed the nonpertinent conversation they had begun earlier. The report noted that nonpertinent conversations during critical phases of flight are prohibited by federal aviation regulations and by company policy.[1]

"The captain had the responsibility to assert both his leadership role and command authority to stop the discussion [but] allowed the conversation to continue," the report said. "Also, instead of initiating the nonpertinent conversation, the first officer should have been monitoring the captain's actions and independently assessing the airplane's location along the taxi route."

The captain stopped the airplane at the hold-short line for Runway 26, which was about 560 ft (171 m) from the hold-short line for Runway 22. "The controller did not notice that the flight crew had stopped the airplane short of the wrong runway because he did not anticipate any problems with the airplane's taxi to the correct runway and thus was paying more attention to his radar responsibilities than his tower responsibilities," the report said.

The CRJ was motionless for 50 seconds. "[This] should have provided the flight crew with ample time to look outside the cockpit and determine the airplane's position on the airport," the report said. "At this position, the flight crew would have been able to see the Runway 26 holding position sign, the '26' painted runway number, the Taxiway Alpha lights across Runway 26, and the Runway 22 holding position sign in the distance."

At 0605, the first officer used an incorrect flight number when he told the controller, "At your leisure, Comair one twenty-one ready to go." Nevertheless, the controller said, "Comair one ninety-one, Lexington tower. Fly runway heading. Cleared for takeoff." Taking over the task of radio communication, the captain replied, "Runway heading. Cleared for takeoff. One ninety-one." The report noted that the runway number was not mentioned in any of these radio transmissions.

The captain began to taxi the airplane across the Runway 26 hold-short line and called for the "Line Up" checklist. While the first officer was conducting the checklist, the captain taxied the airplane onto Runway 26, which was 3,501 ft (1,067 m) long and 150 ft wide, and had painted markings limiting usable width to 75 ft (23 m). The runway was designated for use only by light aircraft in daytime visual meteorological conditions. The runway centerline lights were out of service, and the edge lights had been disconnected in 2001.

Back to the Window

The report said, "The controller did not detect the flight crew's attempt to take off on the wrong runway because, instead of monitoring the airplane's departure, he performed a lower-priority administrative task that could have waited until he transferred responsibility for the airplane to the next air traffic control facility."

The controller performed the task — recording an hourly traffic count — at the tower cab's center console, with his back to the window overlooking the runways. "The controller stated that it might have been possible for him to detect that the accident airplane was on the wrong runway if he had been looking out the tower cab window," the report said. "In addition, the controller stated that, in his 17 years working at [Lexington], an air carrier airplane had never departed from Runway 26."

The report noted that the controller had reported for duty about 2330 the night before the accident and likely was experiencing fatigue. "But the extent that fatigue affected his decision not to monitor the airplane's departure could not be determined, in part because his routine practices did not consistently include the monitoring of takeoffs," the report said.

Completing the "Line Up" checklist, the first officer said, "Transponder's on. Packs on. Bleeds closed. Cleared for takeoff. Runway heading. Six grand. Anti-ice off. Lights set. Takeoff config's okay. Line-up check's complete."

Bombardier CRJ100ER


© Josh Akbar

The Canadair Group of Bombardier in 1987 began design studies based on the Challenger business jet for the Canadair Regional Jet (CRJ). The first model, the CRJ100, entered service in 1992. The 50-passenger airplane is powered by General Electric CF34-3A1 engines flat-rated at 9,200 lb (41 kilonewtons).

The CRJ100ER, the extended-range version, has a higher maximum takeoff weight — 51,000 lb (23,134 kg) versus 47,450 lb (21,523 kg) — which allowed an increase in fuel capacity to 14,305 lb (6,489 kg) from 9,380 lb (4,255 kg). Maximum landing weight is 47,000 lb (21,319 kg).

Source: *Jane's All the World's Aircraft*

At 0605:57, the captain said, "All yours." The first officer replied, "My brakes, my controls."

'Weird With No Lights'

Figure 2 is an approximation of the captain's primary flight display when the takeoff was begun. The display likely showed a nearly 40-degree difference between the heading-bug setting and the indicated magnetic heading. "The CVR did not record any awareness by the flight crewmembers about this offset … or any discussion about the need to cross-check the airplane's position on the runway," the report said.

At 0606:05, the CVR recorded a sound similar to increasing engine power. The first officer said, "Set thrust, please." The captain replied, "Thrust set."

The airplane was crossing the intersection of the runways at 0606:16, when the first officer said, "[That] is weird with no lights." The captain said, "Yeah." Six seconds later, the captain said, "One hundred knots." The first officer said, "Checks."

The report said that there were numerous cues, including the absence of runway lighting, that the airplane was on the wrong runway, but the crew did not correctly interpret the cues or notice them until it was too late to successfully reject the takeoff. Accelerate-stop performance data provided by Bombardier indicated that the crew would have had to reject the takeoff when the captain made the 100-kt airspeed callout to bring the airplane to a stop on the runway with maximum braking.

The CRJ was 236 ft (72 m) from the departure end of the runway when the captain said, "V one, rotate." FDR data indicated that these callouts were made when airspeed was 131 kt, which was 6 kt below the calculated V_1 speed and 11 kt below the calculated rotation speed, VR.[2] Soon thereafter, he said, "Whoa."

"The captain's early VR callout and subsequent 'whoa' exclamation indicated that he recognized that something was wrong with the takeoff," the report said. "FDR data showed that, in response, the first officer pulled the control column full aft and that the airplane rotated at a rate of about 10 degrees per second, which is three times the normal rotation speed. The abnormal column input showed that the first officer also recognized that something was wrong with the takeoff."

The CVR recorded an unintelligible exclamation by one of the pilots just before the airplane struck a berm about 265 ft (81 m) beyond the end of the runway at 0606:33. "FDR airspeed and altitude data showed that the airplane became temporarily airborne after impacting the berm but climbed less than 20 feet off the ground," the report said.

The CVR recorded another unintelligible exclamation soon before the airplane struck trees 900 ft (274 m) from the end of the runway. "This impact caused the cockpit to break open and the left wing fuel tank to rupture, allowing a fuel-air mixture to ignite," the report said.

The airplane struck the ground and slid 400 ft (122 m) before striking two large trees. "The impacts breached the passenger cabin, separating it into two sections and allowing a large amount of fuel, fuel vapor and fire to enter the cabin," the report said. "The fuselage traveled another 150 feet [46 m] before coming to a stop [photograph, p. 43]. The airplane structure continued to burn, and the fire eventually consumed the entire fuselage and cabin interior."

The first officer received serious blunt-force injuries. "The first officer's survival was directly attributable to the prompt arrival of the first responders, their ability to extricate him from the cockpit wreckage and his rapid transport to the hospital, where he received immediate treatment," the report said.

Heading-Bug Setting

Source: U.S. National Transportation Safety Board

Figure 2

Investigators were not able to interview the first officer. "His attending physician stated that the first officer was 'medically unfit' to be interviewed," the report said. "The first officer's wife stated that he did not remember the accident."

'Uncharacteristic Performance'

Based on the findings of the investigation, NTSB made several recommendations to the FAA for reducing the risk of aircraft departing on the wrong runway (*ASW*, 10/07, p. 8).

The report said that the flight crew's performance during the accident flight appeared to have been uncharacteristic. "The captain and the first officer were described favorably by company personnel, and pilots who had flown with them described both as competent pilots," the report said.

"The captain was described as someone who managed the cockpit well, adhered to SOPs and demonstrated good CRM. The first officer was preparing for an opportunity to upgrade to captain and was described as someone who would have made a good captain because of his adherence to SOPs."

The report said that there was insufficient evidence to determine that the crew's performance was affected by fatigue.

Investigators searched the U.S. Aviation Safety Reporting System database and found 114 reports of "wrong-runway" incidents from March 1988 to September 2005. The report noted some more recent incidents. On Oct. 30, 2006, for example, a Boeing 737 departed from the wrong runway in Seattle. On April 18, 2007, an Airbus A320 crew, assigned to depart from Miami on Runway 30, began the takeoff roll on Runway 27, which was closed; they rejected the takeoff after seeing a truck on the runway.

"The Comair Flight 5191 accident and other wrong-runway takeoff events demonstrate that all pilots are vulnerable to this and other types of surface navigation errors," the report said. "Even when navigation tasks are straightforward and simple, there is a potential for a catastrophic outcome resulting from human error if available cues are not observed and considered during taxi and the airplane's position is not cross-checked at the intended runway." ●

U.S. Geological Survey

The CRJ struck a berm and several trees before coming to a stop about 1,800 feet (549 m) from the runway.

This article is based on NTSB Aviation Accident Report NTSB/AAR-07/05, *Attempted Takeoff From Wrong Runway; Comair Flight 5191; Bombardier CL-600-2B19, N431CA; Lexington, Kentucky; August 27, 2006*. The 173-page report contains illustrations and appendixes.

Notes

1. Commonly called the *sterile cockpit rule*, U.S. Federal Aviation Regulations Part 121.542, "Flight crewmember duties," prohibits flight crewmembers from engaging in "any activity during a critical phase of flight which could distract any flight crewmember from the performance or his or her duties." The rule also states, in part, that "nonessential conversations in the cockpit … are not required for the safe operation of the aircraft."

2. The FAA defines V_1 in part as "the maximum speed in the takeoff at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance."

ADS-B

UPS Airlines takes aim at runway incursions and unstabilized approaches.

BY WAYNE ROSENKRANS

Five of UPS Airlines' 107 Boeing 757s and 767s currently have second-generation ADS-B avionics.

The U.S. Federal Aviation Administration's (FAA's) selection of ITT Corp. to lead a team of companies to provide ground station services for the Next Generation Air Transportation System (NextGen)[1] reflects a growing trend in several countries around the world to base future air traffic control (ATC) on automatic dependent surveillance–broadcast (ADS-B) technology.

The safety benefits expected from Next-Gen receive less attention than traffic capacity and funding issues, but they could include less risk of ground collisions, unstabilized approaches, wake turbulence encounters, complex low-altitude vectoring and altitude deviations. And these benefits could arrive sooner than the FAA's 2010–2013 time frame for completion of the ground infrastructure. Safety benefits might accelerate if U.S. airlines upgrade their fleets before the FAA's proposed requirements for "ADS-B out" [2,3] take effect in January 2020, according to UPS Airlines, a U.S. airline with 11 years of experience with ADS-B.

Capt. Bob Hilb, advanced flight systems manager, UPS Airlines, believes that reducing the risk of runway incursions could emerge as the greatest safety benefit of ADS-B. "The U.S. Commercial Aviation Safety Team found that none of the mitigating strategies it studied were more than 50 percent effective, and many of them were a lot less effective — except ADS-B enabling traffic displayed on surface moving maps in the cockpit," Hilb said.

UPS Airlines already has experienced a situation in which a crew was able to see on its cockpit display of traffic information (CDTI) that another aircraft was landing on the same runway, Hilb said. The cause was a combination of controller and crew errors. "Our crew saved the situation by being able to see that an aircraft was on final behind them and alerting ATC," Hilb said. "Many times, when aircraft are on parallel runways — one a takeoff runway and the other a landing runway — the traffic-alert and collision avoidance system (TCAS) is not accurate enough to know whether another aircraft actually is landing on its landing runway or on the parallel

On Board

© UPS Airlines

departure runway. After installing ADS-B, the on-board system becomes accurate enough to tell the difference."

The FAA's airport surface detection equipment, model X, (ASDE-X) complements ADS-B avionics by immediately generating a complete traffic display on cockpit moving maps. "ASDE-X is fairly accurate," Hilb said. "For example, when ASDE-X upgrades are completed in late 2008 at Louisville [Kentucky, U.S.], UPS Airlines crews not only will be able to see on their cockpit displays the positions and movements of all company aircraft equipped with ADS-B out during their daily rush period from 2300 to 0130, but all other aircraft landing/taxiing at Louisville with an operating transponder."

Another safety benefit will be new means of reducing wake turbulence encounters near Louisville. "If you use time-based separation of arriving aircraft every time, you end up with a very predictable system and you can do more to alleviate the wake turbulence threat," Hilb said. "Once we have determined where everybody is and when they are coming in to land, we can schedule arrivals an hour or more in advance. Spacing can be assigned and calculated way before aircraft get into the terminal area."

Elimination of low-altitude vectoring in the arrival procedures, made possible by ADS-B, also generates safety benefits. The main benefit would be a reduction in unstabilized approaches, Hilb said. "Low-altitude vectoring is a high-workload situation, and crews tend to make more mistakes," he said.

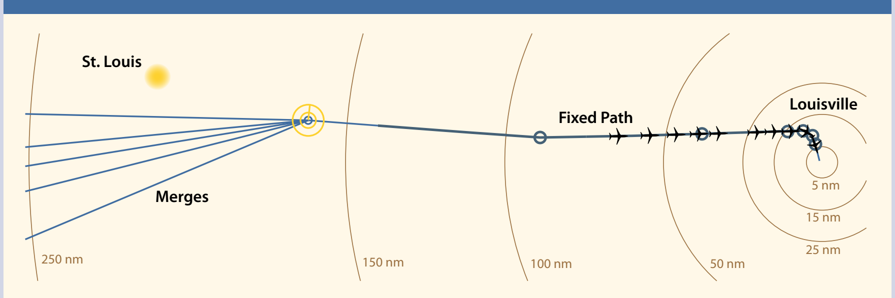
Continuous Descent Arrivals

Airlines may struggle making a safety case for installing ADS-B equipment, but the avionics also offer operational benefits. For UPS Airlines, one focus has been harnessing the technology to address the unpredictability of arrivals of company aircraft to its hub airport in Louisville. "What we are trying to do is change the way the current ATC system handles these arrivals, which makes the peaks and valleys in the operation very random," he said. "Our crews get a lot of long vectors at low altitude because of the uneven flows that come in." In March 2007, the airline told a subcommittee of the U.S. Congress that "our flights end up driving around at low, highly inefficient altitudes while waiting their turn for landing — sometimes flying 60 to 70 nm [11 to 130 km] to travel the last 40 nm [74 km] of flight."

The airline is on the verge of introducing procedures and training for precisely scheduling arrivals with time-based spacing rather than distance-based spacing, enabling a high degree of predictability about when each aircraft will touch down, maximizing airspace utilization. Under the pending ATC procedure (Figure 1) for Louisville, a NextGen required navigation performance (RNP) area navigation (RNAV) continuous descent arrival, each aircraft follows the same fixed flight path from Flight Level 350 (about 35,000 ft) to the runway using a near flight-idle power setting without intermediate level-offs or any low-altitude vectoring by ATC. The airline has obtained FAA certification for this procedure, but operations have not begun pending final approval from the FAA.

"We have built this arrival on RNP RNAV navigation, and the difference in the way we do it currently versus the way we will do it in a scheduled system

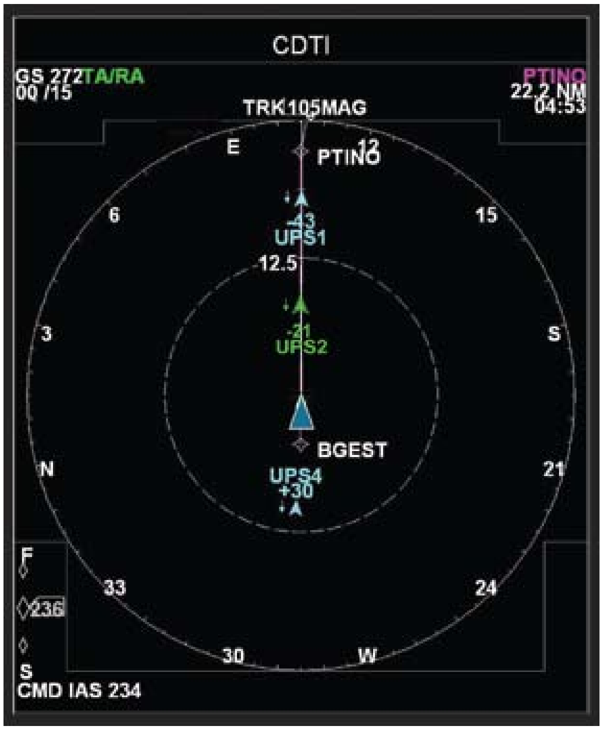
RNP RNAV Continuous Descent Arrival



RNP = required navigation performance RNAV = area navigation nm = nautical mile

Source: UPS Airlines

Figure 1



© UPS Airlines

The cockpit display of traffic information shows the own ship as a blue triangle merged behind the UPS2 airplane and actively controlling its speed to maintain proper in-trail spacing.

with ADS-B is that we had to 'build the arrival to the runway,'" Hilb said. "We created one fixed path to the runway but we could have multiple merges with aircraft coming onto the constant/calculated path from different directions. About 8 or 10 nm [15 or 19 km] out, we would bring aircraft streams together into one stream to the runway." With future data communication, dynamic alterations of the fixed path would be able to adjust the procedure for thunderstorms.

Part of the concept of the procedure is for each aircraft crew joining the fixed path, or already on the fixed path, to maintain specified spacing ahead of them for the aircraft sequenced to merge onto the path from another direction. "Whenever a crew gets within ADS-B range, which is about 100 nm (185 km), they start following the aircraft merging from the other direction," Hilb said. "We build the schedule, then we turn the spacing over to the aircraft crews."

Unstabilized Approaches Vanish

During flight testing of continuous descent arrivals, the strict scripting removed the ATC variability that leaves crews guessing how they will fit into the traffic flow. "Continuous descent arrivals are so scripted that every crew has to put flaps out and gear down at the same point," Hilb said. "It is totally predictable, and the whole procedure also is designed so that crews have sufficient energy management that they do not get caught behind the power curve — or ahead of it if they have too much energy. We now get the aircraft spacing we need to an accuracy within a couple of seconds. We also found that unstabilized approaches disappeared; we did not see any during our tests."

In place of conventional vectoring, flight crews on a continuous descent arrival slow down or speed up along the fixed path with automation and guidance generated by the ADS-B avionics.

"It is hard to measure the pilots' workload, but we think it will be lower because it is totally predictable," Hilb said. "ADS-B gives them an extra speed display to monitor but typically from 35,000 feet there are less than 15 speed changes in a half hour, one speed change every two minutes. We also have done away with a lot of the ATC-pilot voice communication about level-offs." Level-offs have been associated with deviations from assigned altitudes, so that risk is reduced simply by eliminating level-offs, he said.

Smarter Visual Approaches

ADS-B technology also will play a role in visual approaches by UPS Airlines crews using CDTI assisted visual separation upon approval by the FAA. In this procedure, if a crew loses sight of the aircraft in front of them in visual meteorological conditions (VMC) because of haze, sun glare or ground lights at night, for example, they will be able to continue the approach using the CDTI.

"If a crew is arriving at an airport on a visual approach, the ADS-B information allows them to do a better visual approach because they can electronically couple with the aircraft they are following, and know its call sign, airspeed and closure rate, and anticipate what its crew will be doing," Hilb said. In the long term, the airline will have to demonstrate to the FAA that spacing based on ADS-B is precise and predictable enough on every flight in VMC and instrument meteorological conditions for the regulator to change the rules to shift responsibility for separation and wake turbulence avoidance from ATC to the crew of the aircraft following.

Upgrade Paths to ADS-B

New-generation large commercial jets such as the Airbus A380 and Boeing 787 can be equipped with ADS-B fully integrated into their flight decks. The feasibility and cost of retrofitting ADS-B avionics in older aircraft depend primarily on the aircraft generation, Hilb said. "For commercial aviation, ADS-B really can be an upgrade to current equipment," he said.

UPS Airlines considers its latest retrofitting solution for the 757s and 767s simple. The airline basically upgraded Mode S transponder software, added another processor to the existing TCAS hardware and added CDTIs.

With new software, nearly any Mode S transponder delivered in the last 10 to 15 years can be modified to continuously broadcast ADS-B out messages; some aircraft already have the software and only require the latest update. Standard TCAS hardware incorporates a radio operating on the 1090 MHz frequency that can be converted to receive the ADS-B out datalink signal. Aviation Communication and Surveillance Systems (ACSS), a company partnering with the airline in ADS-B system development, added a second processor to the existing TCAS box. "We then call that box a 'surveillance processor' because it not only receives TCAS signals but has all the ADS-B receiver functionality," Hilb said.

Next, decisions about CDTIs have to be made. "The airline can get a standalone display or upgrade the avionics on board aircraft so that ADS-B is integrated into the glass displays it already has," Hilb said. "Trying to do such an integration on a retrofit basis would be very expensive, however. We needed CDTIs and capability for future controller-pilot datalink communication. The Boeing Class 3 electronic flight bag (EFB) gave us multiple applications on one system, so that is where our cockpit display of traffic information is, and where we plan to have the data communication and digital terminal charts and aircraft document functionality."

Operational plans to use RNP RNAV continuous descent arrivals and CDTI assisted visual separation require more display equipment than CDTIs, however. "Because the EFB is not in the pilots' forward field of view — it is off to the side — we had to place the speed commands and distance information in their forward field of view while they are using the ACSS SafeRoute merging and spacing application on the EFB," Hilb said. "We installed a small, inexpensive display in front of the crew that shows the distance to the aircraft in front of them and the speed that they need to maintain. When the crew switches to the assisted visual separation, the display again gives distance to the aircraft in front of them but also gives them closure rate in knots and a plus sign if their own aircraft is gaining or a minus sign if the two aircraft are moving apart. The most expensive part of retrofitting is equipping an aircraft with these displays."

Some specialists argue that wide adoption of ADS-B avionics will be essential to reap the full benefits of this technology. "Everybody — or at least a sufficient percentage — has to be equipped to make the benefits possible," Hilb said. But if just one airline equips its fleet with ADS-B avionics and then introduces RNP RNAV continuous descent arrivals, its competitors would be disadvantaged because "all would be left flying the low-altitude vectors and spending a lot more time and fuel getting into the airport," he said.

Hesitation about equipping aircraft with ADS-B too soon is understandable, he said. "ADS-B is brand new technology, and until the industry actually has been flying it for awhile, the majority of people are in wait-and-see mode; they are not going to invest any money until they see ADS-B completely working — until we demonstrate that the technology is more than 'just a middle-of-the-night system for UPS,'" Hilb said. "Until airlines know the benefits are real and actually see ADS-B working, they will not step up to acquire the avionics. But the cost is coming down to less than what we paid for ADS-B, and there will be more competition."

ADS-B avionics, meanwhile, are becoming more mature and robust after years of refinements by international standards committees. "UPS Airlines has found that with ADS-B, everything is now performing pretty close to the way it should be," Hilb said. ●

Notes

1. U.S. Joint Planning and Development Office. *Operational Concept for the Next Generation Air Transportation System (NextGen).* Version 2.0. June 13, 2007. When its selection was announced Aug. 30, 2007, ITT Corp. said that a team of contract companies "will deploy a nationwide air traffic control surveillance network consisting of field radio sites, data processing centers, network operations centers and equipment to enable delivery of surveillance data to air traffic control facilities." ADS-B development and implementation for ATC currently are under way in Australia, Canada, a number of European countries and India.

2. FAA, U.S. Department of Transportation. "Automatic Dependent Surveillance-Broadcast (ADS-B) Out Performance Requirements to Support Air Traffic Control (ATC) Service." Notice of proposed rulemaking. Oct. 1, 2007.

3. An aircraft equipped for "ADS-B out" transmits the aircraft's position, velocity and other specific message elements once per second. An aircraft equipped for "ADS-B in" can receive these message elements.

Measure for Measure

A statistician offers his perspective on the relative usefulness of different ways of measuring aviation safety.

BY ARNOLD BARNETT

Given empirical evidence and common sense, which metrics are easiest to justify?

There is no consensus about how best to measure the risk of flying. Recently, *The Wall Street Journal* used "fatal accidents per million departures" as its safety metric in a news story. Earlier *Journal* articles had cited statistics about "fatal accidents per 100,000 flight hours." The Boeing Co., not surprisingly, has long focused on "hull losses per million departures," although it has recently given equal emphasis to major events in which the hull was not destroyed.[1] The U.S. National Transportation Safety Board (NTSB) has calculated "passenger deaths per 100 million passenger miles," in part to facilitate comparisons with the safety of ground travel.[2]

This diversity among safety metrics raises several questions for the statistician. Given empirical evidence and common sense, which metrics are easiest to justify? Which are easiest to understand? As a practical matter, do all the metrics move up and down in unison? If so, trying to determine which one is the "best" might be a waste of time.

A quick visit to Google turns up nine primary safety metrics that have been used recently:

- Fatal accidents per 100,000 flight hours;
- Fatal accidents per million departures;
- Hull losses per million departures;
- Passenger deaths per 100 million passenger miles;
- Passenger deaths per million passengers carried;
- Passenger death risk per randomly chosen flight;
- Annual aviation death risk per million citizens;
- Accidents per 100,000 flight hours; and,
- Accidents per million departures.

Most of these statistics need no explanation, but some warrant further elaboration. "Passenger death risk per randomly chosen flight" is the answer to the question, "If a passenger chose a flight and seat at random from flights of interest — e.g., scheduled U.K. domestic jet flights in 1990–1999 — what is the probability he would not survive it?" "Annual aviation death risk per million citizens" is the ratio of a region's number of passengers killed in aviation accidents to its total population.[3] "Accidents" include all aviation events that cause death, serious injury or substantial damage. The great majority of accidents do not cause death.

Death is the most prominent common factor in the metrics above, appearing directly in seven of them. That emphasis seems sensible: if one assumes that *the air traveler's greatest fear is of being killed in a plane crash*, then statistics that reflect the likelihood of that outcome have intuitive appeal. Nonfatal injuries, terrifying near-accidents and massive property damage are certainly serious matters, but as a U.S. Supreme Court justice once said, death is different. Aviation metrics that suggest near-term mortality risk get closer to the issue of greatest interest than do other possible categories.[4]

The statistician recognizes that none of the indicators listed manifestly comes closest to the heart of the matter. To someone who believes that a 2,500-mi (4,023-km) flight from Sydney, Australia, to Perth entails far greater death risk than a 500-mi (805-km) flight from Sydney to Melbourne, a metric that treats flight length as irrelevant would seem deficient. To the person who believes that an upsurge in nonfatal accidents does *not* foreshadow a rise in fatal events, a safety indicator that is dominated by nonfatal accidents would seem lamentable.

Yet the statistician would also recognize that, unlike the choice of a favorite ice cream flavor, the selection of the best safety measure is more than a matter of personal taste. Every indicator listed above depends on one or more key assumptions. These assumptions can be tested against existing data, and when an axiom is inconsistent with the evidence, it undermines those metrics that depend on its accuracy.

Four General Truths About Aviation Safety

We will concentrate on passenger[5] deaths caused by aviation accidents, and will not consider terrorist and criminal acts. In evaluating specific risk indicators, four general points should be borne in mind.

1. *Passenger mortality risk on a flight is essentially independent of the flight's length or duration.*

The primary difference between long flights and short ones is that the former involve far more time at cruising altitude than the latter. But research at Boeing and elsewhere has demonstrated that only a small proportion of fatal air accidents are caused by crises at cruise altitudes. Other research has indicated that the average (intended) flight lengths for ill-fated airplanes are virtually the same as those for all airplanes.

Of the 15 scheduled U.S. domestic jet flights that resulted in fatal accidents from 1987 through 2006, only one was at cruise altitude when the emergency arose. Ninety-three percent occurred during the takeoff/climb or descent/landing phases of flight. Moreover, the flight distances of the segments that ended in fatal accidents were not especially large, averaging 626 mi (1,007 km), which is below the average segment length of approximately 750 mi (1,207 km) for all U.S. domestic jet flights over 1987–2006.[6]

What these patterns suggest is that all flight segments, regardless of length, entail nearly the same passenger death risk. Thus, an air journey from Montreal to Vancouver with intermediate stops at Toronto and Calgary is roughly three times as risky as a nonstop flight from Montreal to Vancouver. Yet the total distance traveled in the two itineraries is practically the same, as is the amount of time spent flying and the number of miles amassed by the traveler. This example suggests why using flight length, passenger miles or trip duration as the measure of passenger exposure to risk can lead to questionable inferences about safety.

2. *The category "fatal accidents" appears too broad for assessments about passenger mortality risk.*

The classification "fatal accident" makes no distinction between a crash that kills all 300 passengers aboard a plane and another event that kills one passenger out of 300. Thus, if a year with one accident that kills hundreds of travelers is followed by a year with two accidents that killed one passenger apiece, then risk would double under the criterion "number of fatal accidents."

Treating all fatal accidents alike would be appropriate if, once a life-threatening emergency has arisen, it is a matter of sheer luck how many perish. But a review of accidents suggests that it is not simply luck. Pilot skill can make a big difference. In one event in 1991, a Nigerian jet had to make an emergency landing at night. Because no available airport was near enough, the pilots had to put down in a field in the dark. Four passengers died in the crash, but 44 survived. At the former Eastern Airlines' terminal at JFK, a plaque memorialized the heroism of Capt. Charles White, whose plane suffered a midair collision over Connecticut. He managed a crash landing on a hillside. Three passengers out of the 45 aboard died, and the captain also perished as he tried to rescue a handicapped traveler from the burning wreckage.

Both of these events were fatal accidents. But is it irrelevant that 92 percent of the passengers (82 of 89) survived accidents that could well have killed everyone aboard? Moreover, the increased use of cabin floor lighting and fire-retardant materials aims to reduce fatalities in aircraft fires, even if it cannot eliminate them. Many observers believe, for example, that, but for improved precautions against fire, the death toll in the 1988 crash of Delta Air lines Flight 1141 would have been far greater than it was. However, because the event involved fatalities, the improved survival would not be reflected in fatal-accident statistics.

3. *The raw number of deaths in a fatal accident is an incomplete measure of the accident's safety implications.*

If an airliner hits a mountain, killing all passengers, the implications for system safety are not three times as large if 120 passengers are aboard rather then 40. And a crash that kills 15 passengers out of 15 does not have the same statistical meaning as one that kills 15 out of 250. In the latter case, excellent emergency procedures may have prevented a far worse outcome. Safety indicators that use raw numbers of deaths, in other words, are vulnerable to irrelevant fluctuations in the fraction of seats occupied, yet insensitive to salient information about the passenger survival rate.

Furthermore, one crash that kills everyone aboard a widebody jet might yield the same death toll as five crashes without survivors in smaller jets that are half full. One could argue that "a life is a life," and that the two scenarios involve the same degree of tragedy. It is not at all clear, however, that both scenarios say the same thing about the mortality risk of flying.

4. *The total number of major aviation accidents is a poor proxy for passenger mortality risk.*

It is sometimes suggested that the total number of accidents — fatal and otherwise — is a better barometer of system safety than statistics that focus on events that cause deaths. Because fatal crashes are mercifully rare, data about them can oscillate dramatically over time even in the absence of trends; the overall rate of accidents might be less susceptible to instability and thus might in principle be more informative.

One problem in using all accidents as a risk indicator is that, in some instances, a nonfatal accident might say more about the safety of the system than about the dangers it presents to passengers. In 1983, for example, an Air Canada Boeing 767 ran out of fuel at cruising altitude. The pilots made an emergency landing at an abandoned airstrip in Manitoba, damaging the airplane and causing some minor injuries, but avoiding any deaths. This event would be classified as an accident, as would a crash that killed everyone on board. But many people viewed what happened in Manitoba as more reassuring than horrifying.

Moreover, data analysis works against the notion that the overall accident rate is a "smoother" version of a risk statistic tied to deaths. Between the early 1970s and the mid-1980s, domestic U.S. jet accidents more than doubled while disastrous accidents — those that killed more than half the passengers on board — fell by a factor of *eight*.[7] Over 1990–1996 on major U.S. jet carriers, there was a *negative* correlation between an airline's rate of nonfatal accidents and the mortality rate among its passengers, i.e., airlines with more nonfatal accidents tended to have fewer deaths.[8] Every accident is of concern to aviation safety professionals, who must learn whatever they can from the event. But if the goal is to reflect the death risk that passengers face, then blurring the distinction between fatal and nonfatal accidents can be highly misleading.

Implications of the Four General Truths

How does it all add up? Every one of the nine risk metrics introduced earlier takes the form of a fraction, the numerator of which reflects the frequency and/or consequences of adverse events in aviation. In all but one of the fractions, the denominator is a measure of the amount of flying performed.[9] Thus, we effectively have a series of cost-benefit ratios, which differ, however, in how costs and benefits are measured.

The discussion above suggests that most of the numerators we have seen are flawed. Ratios that have number of accidents, number of deaths or total number of fatalities as their numerators *discard information about key events* that offers perspective about them. Most of the denominators seem flawed not because they use too little information, but because they use too much.

Of the nine risk measures, only one — passenger death risk per randomly chosen flight — avoids all the interpretive problems we have identified. It weights each crash by the *percentage* of passengers killed, meaning that a crash into a mountain killing all passengers is treated the same way whether the plane is half-full or completely full.[10] And the survival rate of a fatal accident fully enters the calculation. At the same time, risk exposure is measured on a per-departure basis, with no weight given to miles covered or hours in the air.

Transparency

Quite apart from their conceptual strengths and weaknesses, which of the indices just discussed are easiest to comprehend? We assume, as before, that the passenger is most interested in the risk that she will be killed on a forthcoming flight. How easy is it to infer a risk estimate from each index, even accepting it on its own terms?

Two metrics stand out as being intuitively accessible. "Passenger death risk per flight" and "passengers killed per million passengers carried" would seem the most transparent in estimating mortality risk, for each of them directly answers a question in the form of, "What are the odds?"

The other statistics appear less informative. The statistic "fatal accidents per million departures" falls short, for it says nothing about the chance of *surviving* an accident in which there are some fatalities. "Deaths per million flight hours" is incomplete because it does not indicate how many passengers landed safely over the million flight hours. The denominator of "deaths per million citizens" includes people who did not fly as well as those who did; hence, the metric says little about the risk to the air traveler. And the ratio "deaths per million passenger miles" would require adjustments in both numerator and denominator to generate a mortality risk statistic for, say, a 500-mi (805-km) flight.

Does It Matter?

The metric "passenger death risk per flight" (which is sometimes referred to as the Q-statistic) appears to get top marks in both conceptual soundness and transparency. Thus, if a statistician adheres to the four "general truths" above, he would likely conclude that the Q-statistic is the most attractive single metric of mortality risk. But we said earlier that if different safety indicators move the same way over time and across regions, then it doesn't matter much on which ones we focus. The statistician would therefore investigate with actual data whether the metrics move in parallel.

The prime statistical measure of whether two quantities move up and down together is the *coefficient of correlation*, which varies from minus 1 to 1. A coefficient near 1 means that the two quantities essentially move in lockstep: When one of them increases or decreases, it is all but certain that the other does the same. A coefficient near minus 1 implies opposite movements. When the coefficient is near zero, there is almost no relation between the movement of one quantity and that of the other. A coefficient around 0.5 typically means that the two quantities move the same way about 75 percent of the time and in opposite directions 25 percent of the time.

Table 1 concerns U.S. Federal Aviation Regulations Part 121 U.S. domestic flights — practically all passenger flights except air taxis — over the 20-year period 1987–2006. For every year, each of the nine safety metrics was calculated, and then the coefficient of correlation between each of the statistics and death risk per flight was computed. Each of the two metrics based on total accidents is *negatively* correlated with the Q-statistic, meaning that years in which accidents were relatively high tend to correspond to years in which mortality risk was low. The other metrics are positively correlated with death risk; because the coefficients fell in a narrow range around 0.5, however, the correlation is moderate but not strong.

In short, there is appreciable discrepancy between movements over time in death risk per flight and in the other metrics. At this point, there are two different ways one could proceed. One could argue that "death risk per flight" is the most defensible (or least objectionable) measure of passenger mortality risk, and adopt it as the primary statistic on the subject. Or —following the lead of the NTSB — one could release a "smorgasbord" of several of the listed statistics, and leave it to the reader to synthesize them to get an overview of passenger safety.

The statistician would be wary of the latter approach. When different statistics arise from contradictory starting premises, combining them to get a "holistic" impression has no clear logical underpinning. And it would be hard to justify any formal weighting scheme for the different statistics, as is suggested by the failure of attempts to create a "Dow Jones"–type index of aviation safety. Asserting that a synthesis of several

Mortality Risk Per Flight: Not Obvious From Most Statistics

Coefficient of Correlation Between Various Safety Metrics and Mortality Risk per Flight, U.S. FARs Part 121 Carriers, 1987–2006

Statistic	Correlation with Mortality Risk per Flight
Deaths per million passengers carried	0.56
Deaths per 100 million passenger miles	0.57
Deaths per million citizens	0.53
Hull losses per million departures	0.56
Fatal accidents per million departures	0.41
Fatal accidents per million flight hours	0.35
Accidents per million departures	– 0.18
Accidents per million flight hours	– 0.13

FARs = U.S. Federal Aviation Regulations

Source: Calculations by the author

Table 1

flawed statistics somehow transcends their deficiencies is a bit like saying that eight wrongs make a right.

Under these circumstances, we use the Q-statistic to assess patterns in passenger mortality risk.

Some Calculated Q-Statistics

Here we apply the Q-statistic in two ways: We consider scheduled commercial jet flights from 1960 onward, which is essentially the entire period during which passenger jet operations have taken place. We present the 1960–1999 data by decade, breaking the flights into four nonoverlapping categories, namely, developed world domestic; developing world international; between developed and developing world; and flights that begin and end in the developing world.

The calculated Q-statistics are shown in Table 2.

The key patterns in the data are obvious. Throughout the world and without *any* exceptions, jet travel has consistently become safer decade by decade. Overall jet passenger mortality risk fell by more than 90 percent between the 1960–1969 and 2000–2006 periods. The data offer no evidence that the percentage rate of improvement declined from decade to decade; this outcome is especially impressive because, as risk goes down, one might think that further improvement is harder to achieve. It is also apparent, however, that death risk is far lower on jet flights in the developed world than on those involving the developing world.

In assessing aviation safety metrics, the statistician would argue that no risk indicator should go unexamined, and that its underlying premises should be made explicit. When an indicator arises from premises that fare well under scrutiny, it is perhaps especially worthy of respect. The last thing the statistician would say is that, given that all safety indicators are imperfect, we are free to choose among them however we wish. If we lack an accurate understanding about present levels of safety, it seems less likely that we will be able to make flying even safer in the future. ●

Passenger Jet Travel: Safer by the Decade

Passenger Mortality Risk, Commercial Jet Aviation, 1960–2006

Period	Q-Statistic (Death Risk per Flight)
Developed World Domestic	
1960-69	1 in 1 million
1970-79	1 in 3 million
1980-89	1 in 4 million
1990-99	1 in 13 million
2000-06	1 in 70 million
Developed World International	
1960-69	1 in 400,000
1970-79	1 in 1 million
1980-89	1 in 4 million
1990-99	1 in 6 million
2000-06	1 in 9 million
Between Developed and Developing World	
1960-69	1 in 200,000
1970-79	1 in 300,000
1980-89	1 in 600,000
1990-99	1 in 1 million
2000-06	1 in 1.5 million
Within Developing World	
1960-69	1 in 100,000
1970-79	1 in 200,000
1980-89	1 in 400,000
1990-99	1 in 500,000
2000-06	1 in 2 million

Note: Statistics do not include crashes caused by criminal or terrorist acts. The calculations entail some approximations about the numbers of flights performed; see Barnett and Higgins[7] and Barnett and Wang[8] for discussions of the methodology and data sources used.

Source: Calculations by the author

Table 2

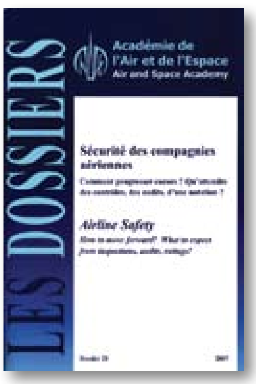
Arnold Barnett, Ph.D., is the George Eastman professor of management science at the Massachusetts Institute of Technology. He received the FSF President's Citation in 2002 for "harnessing the power of innovative statistical analysis to build conceptual bridges between data and significant aviation safety issues so that they can be readily understood."

Notes

1. The Boeing Co. *Statistical Summary of Commercial Jet Airplane Accidents: Worldwide Operations, 1959–2006*. <www.boeing.com/news/techissues>.
2. Air Transport Association of America. Table, "U.S. Passenger Fatalities per 100 Million Passenger Miles," based on data from the NTSB. <www.airlines.org/economics/specialtopics/Airline+Safety.htm>.
3. U.S. Office of Hazardous Materials Safety. Table, "A Comparison of Risk: Accidental Deaths — United States — 1999–2003." <hazmat.dot.gov/riskmgmt/riskcompare.htm>.
4. Of course, an aircraft insurer might be most interested in hull loss rates. But we are taking the passenger's perspective in this article.
5. Mortality risks for on-board crewmembers are similar to those for passengers; however, data that would allow precise calculations for crewmembers are not available.
6. For example, the Economics Briefing of the International Air Transport Association, <http://www.iata.org/economics>, estimated the 2005 average sector length in U.S. domestic operations as 1400 km (about 870 mi). We use the more conservative figure of 750 mi because jet transport sector lengths have slowly increased in recent years.
7. Barnett, A.; Higgins, M.K. "Airline Safety: The Last Decade." *Management Science* Volume 35 (January1989), p. 7.
8. Barnett, A.; Wang, A. "Passenger Mortality-Risk Estimates Provide Perspective About Airline Safety." *Flight Safety Digest* Volume 19 (April 2000), Table 1, p. 3.
9. The exception is the denominator in "annual aviation death risk per million citizens."
10. See Barnett and Higgins (note 7) for the formula by which death risk per flight (the Q-statistic) is calculated.

The Rating Game

Can the safety of charter airlines be independently rated like the financial soundness of corporations?



REPORTS

Airline Safety: How to Move Forward? What to Expect From Inspections, Audits, Ratings?

Académie de l'Air et de l'Espace (Air and Space Academy). Dossier 28. 2007. 60 pp. Appendixes. In English and French. Available via the Internet at <www.anae.fr/new/fr/publi/detail.php?varIDpubli=131> or from the Academy.*

After the fatal accident at Sharm-el-Sheikh, Egypt, on Jan. 3, 2004, and other accidents involving charter airlines, the Academy considered the idea of a "rating" system for airlines, along the lines of financial ratings of companies. The organization's subgroup Section IV, which concerns itself with "ethics, law, sociology and economy of air and space," studied charter airline safety in terms of current efforts for improvement and sought to understand financial rating procedures.

The report says, "Interstate cooperation requires each state to implement ICAO's [the International Civil Aviation Organization's] stipulations in the case of aircraft on its register and to agree to foreign aircraft flying over its territory. … And yet ICAO guidelines are open to wide differences of interpretation. The level of determination demonstrated by each state to enforce these regulations and the means devoted to such enforcement are extremely varied, leading to great disparities in the true level of safety from one operator to another."

After noting the steps that manufacturing, airline and regulatory professionals — as well as the charter airline industry — are taking to reduce risks, the report examined the possibilities for a safety rating system for charter airlines.

"Let us imagine for a moment that the various difficulties and objections have been sorted out," the report says. "Certain organizations would thus attribute an assessment to airlines (for example, from AAA to C) and publish this rating. The impact would be huge:

- "The public would of course favor the safest airlines, even if it involved paying a surcharge … ;
- "Intermediaries (tourist organizations, tour operators, events organizers) would take this rating into account in their commercial actions; certain airlines specializing in cheap charter flights but choosing not to compromise on safety would have an advantage over less scrupulous ones … ;
- "Crews, in the front line as regards safety levels, would be alerted by poor ratings and insist on improvement, in which they themselves would also actively participate; [and,]
- "The impact would obviously be highest in upper management circles … . The mere announcement of a rating system would lead to a surge in awareness and dynamic actions in favor of safety."

It sounds like a winning idea, but the devil is in the details.

The report considers the "awkward question" of who could rate charter airlines. "It is impossible to envisage a national, governmental service determining this rating, because it might be accused of favoritism and be at the mercy of reprisals in the event of bad marks given to an airline of a different state," the report says. "And the coexistence of a system of administrative authorization with a variable rating system would be difficult to justify."

The same criticism could be leveled at associations of countries such as the European Union or ICAO, the report says. In addition, "the agency should be independent of insurance companies because access to certain data could distort the insurer-airline and insurer-manufacturer relationship," it says. If any organization is to be a rater, it should be fully independent, says the report.

The practicalities of grading safety are unlike those of grading a company's finances.

"The fine grading of financial appraisal, from AAA to C, is not easy to apply to safety — the public and other partners would find it difficult to deal with varying degrees of safety," the report says. "Aviation safety, which concerns the physical safety of persons, is generally seen as more binary: 'go' (satisfactory) or 'stop' (unsatisfactory). In reality, of course, there is an amber zone between green and red in which a *temporary* drop in the safety level can be accepted. This occurs at all stages of the weaving of safety, from aircraft design to actual flight. The inspector or auditor says, 'Here is an anomaly, put it right before such-and-such a date and, if necessary, take such-and-such a preventive compensatory measure.'"

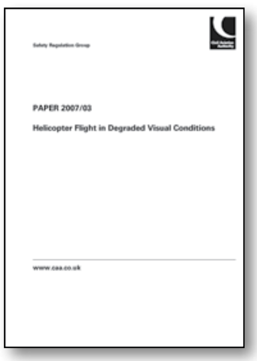
While the rating organization and the civil aviation authority of the charter airline's state of registration might be separate in principle, the latter could not fail to respond to the former, the report says: "It would hardly seem possible for a state authority to consent to aircraft flying in the full knowledge that ongoing risks had been identified that ruled out a maximum quality label."

The report says that issues of legal responsibility would be complicated by an independent rating organization. When the state regulates and inspects an airline, there is an established legal framework for determining questions of liability. But if a private rating organization expressed no reservations about an airline that went on to have an accident where it was allegedly at fault, would the rating organization be subject to lawsuits?

"There will necessarily be a certain degree of overlap between the state and contractual systems," the report says. "What will a court of law think in the aftermath of an accident if a state audit, according to its regulatory logic, has maintained an airline's flight authorization in the face of a suspension of its private certification?"

Some of the report's conclusions are:

- "Each country must sweep in front of its own door and improve its own system for monitoring its own airlines. But the effect of national actions on foreign airlines will remain limited";
- "It is above all on an international level that efforts must be engaged: ICAO's highly ambitious Universal Safety Oversight Audits Program and the Unified Strategy Program [designed to overcome safety weaknesses identified in the oversight audits] must be pursued with all the determination necessary to overcome national resistance"; and,
- "Travel operators reject the concept of being 'safety assemblers' as they are the 'assemblers' of other services (transport, food, guides, etc.). Each air transport service provider must therefore provide sufficient guarantees on its own. A system of certification by an independent third party is the only suitable answer at present."


PAPER 2007/03

Helicopter Flight in Degraded Visual Conditions

www.caa.co.uk

Helicopter Flight in Degraded Visual Conditions

U.K. Civil Aviation Authority (CAA) Safety Regulation Group. Paper 2007/03. September 2007. 198 pp. Figures, tables, photographs, references, glossary, appendixes. Available via the Internet at <www.caa.co.uk/docs/33/Paper200703.pdf> or from CAA.**

The CAA hired QinetiQ to perform a research program to investigate factors affecting civil helicopter accidents in deteriorated visual conditions, such as a reduced level of light and/or visibility (particularly cases where rapidly degrading visual conditions were encountered); pilot loss of situational/spatial/attitude awareness; misleading visual cues; pilot workload saturation; and controlled flight into terrain.

The methodology was, first, to review relevant civil aviation accident data from 1975 to 2004 to identify principal causal factors and establish the extent of the problem. The factors were then tested using piloted simulation experiments based on accident scenarios. Data from these experiments were analyzed, and the results were compared with the findings of a review of regulations and requirements bearing on helicopter flight in conditions of poor visibility.

Data analysis showed that during the study period, total occurrences per year increased from one per year to about 2.5 per year, mostly because of a greater incidence of accidents resulting from spatial disorientation.

"The majority of cases occurred during daytime and out of close contact with the surface," the report says. "Inadvertent entry into instrument meteorological conditions [IMC] was probably the most significant factor."

In the simulation experiments, two test pilots evaluated a test matrix of maneuvers and visual conditions based on information from the accident case studies. It was concluded from an earlier study of requirements for civil helicopter handling qualities that the equivalent military requirements could provide a source of guidance to improve the civil requirements. Considered particularly relevant to civil helicopter operations affected by poor visual cues was Aeronautical Design Standard-33 (ADS-33) and its Useable Cue Environment (UCE) concept. ADS-33 UCE was used as the basis for the design of the simulation-based investigation.

"The trial met its objectives and was successful in demonstrating how pilot situational awareness can be eroded in visual flight rules operations as visual conditions degrade, a key factor being the division of attention between the guidance and stabilization tasks," says the report.

Reviewing regulations and advisories was intended to identify any deficiencies and omissions pertinent to flights of the types featured in the accident data. Researchers reviewed Joint Aviation Requirements Parts 27 and 29 and associated advisory circulars; Joint Aviation Requirements–Operations 3; International Civil Aviation Organization Annexes 6 and 14; and various CAA Flight Operations Department communications.

"Civil regulations and requirements in the area of handling qualities are very subjective and open to interpretation by manufacturers and qualification test pilots," says the report. It notes that "there are no detailed requirements or guidance given for night operations."

Recommendations include introducing instrument flight rules dynamic stability requirements and special requirements for night and reduced-visibility operations; specifying the installation of an attitude indicator, even for visual flight rules operations, to mitigate the dangers of inadvertent entry into IMC; raising pilot awareness of problems in reduced visibility related to the interaction between aircraft handling qualities and visual cueing conditions; and providing guidance on whether to fly in marginal conditions.

WEB SITES

International Association of Oil and Gas Producers (OGP), <www.ogp.org.uk>

This Web site may be new to many readers, since it is not one of the usual places aviation researchers look for information.

OGP "helps members achieve continuous improvements in safety, health and environmental performance" through knowledge sharing. The association has made several of its publications available to nonmembers to download, read online or print at no cost. Four publications of aviation interest are:

- "Safety Performance of Helicopter Operations in the Oil & Gas Industry, 2004 Data" — The 2006 report is based on information submitted by helicopter operators worldwide about operations, accidents and incidents;

- "Aircraft Management Guidelines" — This 168-page document was released in April 2007 by the OGP aviation subcommittee to "provide a ready reference for the management of aviation … to plan, develop and control, safely and efficiently, air transport operations that are best suited to their needs";

- "Fatigue Management in the Workplace" — The guide identifies causes of fatigue; health and safety risks resulting from fatigue; and strategies to manage fatigue in the workplace. General information on sleep and the body's clock is also addressed; and,

- "Safety Performance Indicators, 2006 Data" — The report presents safety performance for air transport and other segments of the oil and gas producing industry. Graphics show accident, incident and injury rates and other key indicators.

The publications section contains other reports on helicopter data, safety and operations; helidecks; aviation weather; human factors; and similar topics. Many are accessible online at no charge, as are current and archived issues of the association's newsletter, *Highlights*.

International Business Aviation Council, <www.ibac.org/home.htm>

The International Business Aviation Council (IBAC) "is a nonprofit, nongovernmental association which represents, promotes and protects the interests of business aviation in international policy and regulatory forums," says its Web site. IBAC membership comprises business aviation organizations worldwide.

The council's Web site and library section offer some information to nonmembers. Examples of downloadable documents in full text at no cost are:

- "IBAC Bulletins" for business aviation operators who operate aircraft in an international environment;

- Reports of studies like "Business Aviation Safety Brief: Summary of Global Accident Statistics 2001–2005" and "Accident Analysis: Jet and Turboprop Business Aircraft 1998–2003: Potential Impact of IS-BAO [International Standard for Business Aircraft Operations]";

- Pertinent issues involving the International Civil Aviation Organization (ICAO), European Aviation Safety Agency, and other regulatory and guidance organizations;

- "IBAC Update," a quarterly newsletter, current and archived;

- Position papers on topics like airport access and required navigation performance (RNP); and,

- Reprints of selected ICAO articles and working papers. ●

Sources

* Académie de l'Air et de l'Espace
Ancien Observatoire de Jolimont
BP 75825 — 31505 Toulouse cedex, France
Internet: <www.anae.fr>

** U.K. Civil Aviation Authority
The Stationery Office
P.O. Box 29
Norwich NR3 1GN, United Kingdom
Internet: <www.tso.co.uk/bookshop>

— *Rick Darby and Patricia Setze*

Starved of Fuel

Automatic transfer system failed during a long-range flight.

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

Computer Malfunction Blocked Warnings

Airbus A340-600. No damage. No injuries.

Eleven hours after the A340 departed from Hong Kong with 293 passengers and 18 crewmembers for a flight to London on Feb. 8, 2005, the no. 1 engine lost power. The aircraft was in Dutch airspace at Flight Level (FL) 380 (about 38,000 ft). The flight crew observed an indication that the inner wing tank that supplies fuel to the no. 1 engine was empty.

"Initially, the pilots suspected a leak had emptied the contents of the fuel tank feeding the no. 1 engine, but a few minutes later, the no. 4 engine started to lose power," said the report by the U.K. Air Accidents Investigation Branch (AAIB).

The flight crew opened all the fuel crossfeed valves, and the no. 4 engine regained power. They attempted unsuccessfully to restart the no. 1 engine while still at FL 380. "The QRH [quick reference handbook] states that the maximum guaranteed altitude for a relight is FL 300," the report said. "Although [this was] read out aloud by the copilot, none of the three pilots seemed to have absorbed the information or said that a descent would be required, probably because most of their attention was focused on trying to understand the fuel problem."

During the restart attempt, the commander noticed that most of the 25,000 kg (55,115 lb) of fuel aboard the aircraft was in the trim tank and the center tank, and that fuel was not being transferred automatically from these tanks to the four inner wing tanks, which directly supply fuel to their respective engines. He told the copilot to manually transfer fuel from the trim and center tanks to the inner tanks.

The crew's efforts to manually transfer fuel were effective, but the pilots became confused by indications on the electronic centralized aircraft monitor (ECAM) fuel status page. "The flight crew were unsure whether the fuel was transferring into the inner tanks, partly because the arrows that symbolize fuel transfer in progress were not displayed," the report said.

The commander told air traffic control (ATC) that they had a fuel management problem and declared an emergency. He requested and received clearance to divert to Amsterdam (Netherlands) Schiphol Airport. The A340, with three engines operating, was landed without further incident about 22 minutes later. The report noted that the fuel management problem had not caused the aircraft's center of gravity to move beyond limits.

The flight crew received no warnings about the failure of the automatic fuel transfer system or the low fuel quantity in the inner tanks.

The A340's automatic fuel transfer system is governed by two fuel control and monitoring computers (FCMCs). The report said that the computer with the highest "health level" is designated automatically as the master; the other computer is the standby, or slave. Investigators determined that a malfunction of the master FCMC in the incident aircraft had caused the automatic fuel transfer system to fail about eight hours before the no. 1 engine ran down. "The slave FCMC was not able to take control as master FCMC due to its lower health status," the report said.

Due to the nature of the master FCMC's malfunction, which affected data bus output, and continued operation of the slave FCMC, the flight crew received no warnings about the failure of the automatic fuel transfer system or the low fuel quantity in the inner tanks. "The only indication to the flight crew of the failure of the fuel transfer system was the information presented on the [ECAM] fuel status page," the report said. "The flight crew were not monitoring the fuel status page closely, nor were they required to."

Based on the findings of the incident investigation, the AAIB recommended revision of European and U.S. transport category aircraft certification standards to include a requirement for an independent low fuel warning system for each tank that directly supplies fuel to an engine. The recommendation was accepted by the European Aviation Safety Agency, which said it plans to issue proposed rule making by the end of 2007, and was rejected by the U.S. Federal Aviation Administration (FAA), which said that an independent low fuel warning system would be redundant.

Flight Continued After Bird Strike

Boeing 767-300. Substantial damage. No injuries.

The aircraft was being rotated for takeoff from Melbourne (Australia) Airport the evening of Oct. 3, 2006, when the flight crew saw a large flock of birds. "With no evasive maneuver available to the crew at this stage of flight, the aircraft encountered the flock and sustained multiple strikes," said the report by the Australian Transport Safety Bureau (ATSB).

The crew noticed a change in the sound produced by the left engine and felt a slight airframe vibration. They also observed that the vibration indication for the left engine had increased to 4.5 units; exhaust gas temperature had not changed, however. "There were no changes noted to the engine parameters for the right engine," the report said.

The crew reported the bird strike to ATC and continued the climb. They reduced power from the left engine, and the vibration decreased. "Maintenance watch informed the crew that there was a maximum engine vibration limit of 2.5 units, but if they could keep it below 2.0, they were not concerned," the report said. "The crew reduced the power on the left engine by about 10 percent, and the vibration level reduced to about 1.3 units."

The crew decided to continue the one-hour flight to Sydney at FL 290, which is below the 767's maximum single-engine operating altitude. "The vibration level on both engines remained below one unit for the remainder of the flight," the report said. "During the descent into Sydney, the crew reduced the left engine to flight idle as a precautionary measure and conducted an asymmetric-thrust approach and landing. The aircraft landed without further incident."

Minor damage from the bird strike was found on the aircraft's nose, landing gear and wing leading edges. However, several fan blades in both engines had been deformed, and the precooler for the left engine had been blocked.

The report said that the flight crew's decision to continue the flight "did not fully take into account the potential effect of the bird strike on the durability of the left engine, nor did it account for the performance of the aircraft if the right engine ceased operating during the flight."

The operator subsequently issued a policy requiring flight crews of its twin-engine aircraft to land at the nearest suitable airport if an obvious sign of engine damage is observed after a bird strike.

Fuselage Punctured by Deicing Vehicle

Boeing 747-200F. Substantial damage. No injuries.

The cabin failed to pressurize during the airplane's departure in nighttime instrument meteorological conditions (IMC) from Anchorage, Alaska, U.S., for a cargo flight to Dallas on Dec. 23, 2006. The flight crew returned to the airport and landed the 747 without further incident, said the report by the U.S. National Transportation Safety Board (NTSB).

Maintenance personnel found a gouge that penetrated the fuselage near the cargo door. Subsequent examination of the 747 by an FAA inspector indicated that the gouge was 18 in (46 cm) long and 1 to 2 in (3 to 5 cm) wide. The inspector also found a shallower gouge that was about 3 ft (1 m) long. "The damage was consistent with the size and shape of the counterbalance weight on the truck used to deice the airplane," the report said.

The NTSB said that the probable cause of the accident was "the failure of the deicing truck crew to maintain sufficient distance from the parked airplane during deicing, which resulted in a collision and substantial damage to the airplane."

Ice Ingestion Causes Engine Flameouts

Cessna Citation II. Substantial damage. Four minor injuries.

The NTSB report said that the purpose of the flight, which originated at Fairbanks, Alaska, U.S., on Sept. 30, 2005, was to find icing conditions suitable for icing-certification tests of a prototype helicopter. Two research scientists were aboard as passengers. The Citation, which was a restricted category airplane equipped for atmospheric research, encountered icing conditions while cruising in IMC at an unspecified altitude.

The report said that neither pilot could recall "if or when the airplane's anti-ice [system] was turned on prior to the accident sequence." The anti-ice system heats the leading edges of the inboard sections of the wings and the engine inlets. The report indicated that the crew might have activated the anti-ice system when they activated the deicing boots after about 1.0 in (2.5 cm) of ice had accumulated on the leading edges of the wings. The deicing boots protect the outboard sections of the wings.

Photographs taken by a passenger showed that the deicing boots shed the ice from the outboard sections of the wing but that ice remained on the inboard sections. About four minutes later, the occupants heard a loud bang and both engines flamed out.

"An engineer from the airplane's manufacturer said that if the anti-ice system was activated after ice had accumulated on the wings, it would take two to four minutes for the anti-ice portion of the wings and engine inlets to heat sufficiently to shed the ice," the report said.

The pilots made several unsuccessful attempts to restart the engines. The Citation broke out of the clouds at about 6,000 ft. "The captain reported that he selected a fairly clear, burned area with some trees and landed the airplane with the landing gear retracted," the report said. "The airplane sustained structural damage to the wings, fuselage and empennage." The accident occurred about 60 nm (111 km) west of Fort Yukon.

Examination of the engines revealed that fan blades had broken off and had been ingested by both engines.

NTSB concluded that the probable cause of the accident was "the pilot's improper use of anti-icing equipment during cruise flight, which resulted in ice ingestion into both engines [and] the complete loss of engine power."

TURBOPROPS

Wing Separates on Takeoff

Grumman Turbo Mallard. Destroyed. 20 fatalities.

The right wing separated about one minute after the amphibious airplane took off from Miami Seaplane Base for a scheduled flight to Bimini, Bahamas, the afternoon of Dec. 19, 2005. The Turbo Mallard crashed in a shipping channel, killing the two pilots and 18 passengers, three of whom were lap-held infants.

The NTSB report said that the wing separated under normal flight loads because of pre-existing fatigue fractures and cracks in the rear Z-shaped stringer, to which the wing skin is fastened, and cracks in the lower wing skin and lower rear spar cap.

"Repetitive fuel leaks were indicators of structural damage inside the right wing."

A major repair had been performed on the wing skin in the failure area, which was near a fuel sump drain. The operator's maintenance records contained no information about the repair, which included installation of one external doubler and three internal doublers intended to relieve structural loads in the wing skin.

The repair was ineffective "because the doublers did not restore the load-carrying capability of the skin in the area of the fuel sump drain, and the repair did not properly address the underlying cause of the skin cracking, which was the cracked or fractured rear Z-stringer," the report said. "Repetitive fuel leaks near the area where the accident airplane's right wing separated from the fuselage were indicators of structural damage inside the right wing."

In its determination of probable cause, the NTSB said that the wing separation resulted from the failure of the operator's maintenance program to "identify and properly repair fatigue cracks in the right wing and the failure of the [FAA] to detect and correct deficiencies in the company's maintenance program."

Based on the findings of the investigation, the NTSB made several recommendations to the FAA for improving its oversight of maintenance performed by commercial aircraft operators (*ASW*, 9/07, p. 8).

The accident airplane was built in 1947 and had accumulated 31,226 flight hours. The original radial piston engines had been replaced with turboprop engines, and passenger seating had been increased from 10 to 17 seats. The conversion — from a G-73 Mallard to a G-73T Turbo Mallard — had been performed in accordance with a supplemental type certificate (STC) issued by the FAA to Frakes Aviation in 1971.

The report said that the FAA had "missed an opportunity" by not requiring a full recertification, rather than an STC, for the Turbo Mallard. "A new type certificate would likely have included a fatigue analysis of the airplane," the report said. "Such a fatigue analysis likely would have included a determination of a safe operating life for the wing structure that would have been used as the basis for inspection and retirement requirements that could have prevented the accident."

EMS Pilot Faulted for Continuing Approach

Beech King Air A100. Substantial damage. No injuries.

The pilot was notified at 0030 local time on Jan. 5, 2006, of an emergency medical services (EMS) flight from Traverse City, Michigan, U.S., to pick up a patient at Sault Ste. Marie and transport the patient back to Traverse City.

The pilot said that during his preflight weather briefing, he was especially concerned about runway conditions at Sault Ste. Marie but was told by the flight service specialist that there were no notices to airmen (NOTAMs) about runway conditions at the airport.

The NTSB report said that the King Air departed from Traverse City at 0110. The pilot conducted the VOR (VHF omnidirectional radio) approach to Sault Ste. Marie's Runway 32, which is 5,235 ft (1,596 m) long and 100 ft (31 m) wide. The airplane broke out of the clouds about 900 ft above ground level (AGL) and was about 2 mi (3 km) from the runway when the pilot observed that the runway was covered by snow and slush, and that the runway lights were difficult to see.

The pilot said that the airplane veered left after touching down on the runway and that the left main landing gear struck a snow bank. The airport manager said that the King Air touched down left of the runway centerline and traveled 1,200 ft (366 m) before striking the snow bank and coming to a stop perpendicular to the runway, with the nose landing gear and main landing gear off the runway edge. Damage was substantial, but the pilot and two passengers were not injured.

The NTSB said that the probable causes of the accident were the pilot's "inadequate in-flight decision to continue the approach to land," his inability to maintain directional control and the contaminated runway. Among the contributing factors was the failure of airport personnel to issue a NOTAM about the contaminated runway.

Pitch-Control Problem on Takeoff

BAE Systems Jetstream 41. No damage. No injuries.

The flight crew conducted a flight control check as part of their preflight preparations before departing from Durham, England, with three passengers the morning of Jan. 12, 2007. The commander tightened the condition lever friction wheel after applying takeoff power and transferred control to the copilot.

"The aircraft was rotated normally into the climb, and the landing gear was retracted," the AAIB report said. "At about 400 feet … the copilot stated that he was having control difficulties and could not push the aircraft's nose down using the control column. The commander took control, and he, too, found it was difficult to control the pitch attitude, resorting to power reduction to reduce the rate of climb."

The crew reported the control problem to ATC and requested and received clearance to return to the airport. The controller provided vectors to intercept the instrument landing system (ILS) localizer 10 nm (19 km) from the runway.

"The decision was made to keep the flaps at their takeoff setting of 9 degrees in case further flap extension exacerbated the problem," the report said. "The crew found that it was possible to control the pitch attitude satisfactorily using power variations, and a safe landing was made."

Company engineers found that the elevator trim wheel and the condition lever friction wheel had jammed. The wheels, which rotate on a common shaft in the center pedestal, had come in contact "such that application of nose-down elevator trim also caused rotation of the friction wheel in the 'tighten' sense until the two had jammed together," the report said.

The company concluded that the problem had been caused by the use of greater-than-normal force on the condition lever friction wheel. "In this incident, what the crew initially believed to be an abnormality in the primary pitch controls appears, in fact, to have been an out-of-trim condition," the report said.

Low Clouds on Night Visual Approach

Lancair IV-P Propjet. Destroyed. Three fatalities.

The pilot canceled his instrument flight rules flight plan about 10 nm (19 km) from Provo (Utah) Municipal Airport the night of June 8, 2006. The airport was reporting 10 mi (16 km) visibility, scattered clouds at 100 ft and 1,800 ft, and a broken ceiling at 2,800 ft, the NTSB report said.

The experimental, single-turboprop airplane was over a lake, on short final approach to Runway 13, when it began to turn right. The descending turn continued until the airplane struck the water.

Because of the low clouds, it was "unlikely that the pilot was able to maintain visual contact with the airport during his approach," the report said.

The pilot had completed a familiarization training course in the airplane the day before the accident. His flight instructor had told him not to fly at night until he had accumulated 50 flight hours in the Lancair and not to fly in IMC until he had 100 flight hours in the airplane.

PISTON AIRPLANES

Broken Door Jams Landing Gear

Piper Navajo. Substantial damage. No injuries.

Daytime visual meteorological conditions (VMC) prevailed for the commercial flight from Kramfors, Sweden, to Umeå on May 13, 2006. During approach, the flight crew received no indication that the left main landing gear was down and locked, said the report by the Swedish Accident Investigation Board.

The crew cycled the landing gear, but the green light for the left main landing gear did not illuminate. They conducted low passes near the airport traffic control tower with the landing gear extended and retracted. The controller and a maintenance technician summoned to the tower saw the left gear door hanging at a 45-degree angle to the underside of the wing during each pass; the rest of the left main landing gear remained retracted.

"After about one hour circling around and over Umeå airport, with repeated attempts to resolve the situation, the commander decided to perform an emergency landing," the report said. "After evaluating the alternatives, it was decided to land on the snow at the right side of the runway."

The crew shut down the engines and feathered the propellers before landing the airplane with the gear retracted and with full flaps. The report described the touchdown as gentle. The Navajo veered left while sliding on the snow, which was 30–50 cm (12–20 in) deep, and came to a stop near the edge of the paved runway. The pilots and the six passengers were not injured.

Examination of the airplane revealed fatigue damage to the gear door hinge, which broke when the crew initially attempted to lower the landing gear on approach. "The actuating rod in the hydraulic cylinder that maneuvers the gear door then got stuck in a position between half open and closed, blocking the landing gear from being extended," the report said.

Weather Was Below Approach Minimums

Cessna 414. Destroyed. Two fatalities.

Nighttime IMC prevailed when the airplane arrived at Edwards County Airport near Rocksprings, Texas, U.S., on a business flight from Houston on Feb. 9, 2007. The uncontrolled airport was reporting 3/4 mi (1,200 m) visibility in mist, a 300-ft overcast and winds from 020 degrees at 10 kt, gusting to 14 kt.

The NTSB report said that the pilot was familiar with the airport and the two nonprecision approaches — a VOR approach and a global positioning system (GPS) approach — to Runway 14. The circling minimums are 500 ft and 1 mi for the VOR approach and 700 ft and 1 mi for the GPS approach.

The last recorded ATC radar data showed the airplane about 232 ft AGL with a groundspeed of 186 kt. "Two witnesses reported that the airplane circled over the airport and then descended straight to the ground [east of the runway]," the report said. "A detailed examination of the wreckage of the airplane failed to reveal any anomalies with the airframe, structure or systems."

Fuel Order Was Not Verified

Beech E55 Baron. Substantial damage. Two minor injuries.

There were 55 gal (208 liters) of fuel aboard the Baron, but the pilot believed that he had 115 gal (435 liters) of fuel when he departed from Friday Harbor, Washington, U.S., the morning of Oct. 12, 2006, for a personal flight to Nampa, Idaho.

"The shortfall of 60 gallons [227 liters] was the result of a refueling request that the pilot made to a fixed base operator that did not take place and that the pilot did not verify had taken place," the NTSB report said.

Both engines lost power due to fuel exhaustion when the Baron was cruising at 7,500 ft above Ontario (Oregon) Municipal Airport. "The pilot spiraled down over the airport and entered the pattern for Runway 14," the report said. "He said that he intentionally elected to 'err on the side of landing long and not have any risk of being short.'"

The pilot told investigators that, on short final approach to the 4,300-ft (1,311-m) runway, the airplane was "clearly high and fast, pretty much as expected, but not slowing, which was not expected." The Baron touched down about 1,000 ft (305 m) from the departure end of the runway, overran the runway and struck a concrete irrigation channel.

HELICOPTERS

Heads Down When S-76 Hit Water

Sikorsky S-76A. Destroyed. One minor injury.

The helicopter departed from Amelia, Louisiana, U.S., in VMC the morning of Oct. 22, 2006, to pick up a passenger on an oil-drilling platform 60 nm (111 km) offshore. Weather conditions at the platform included a 500-ft overcast, 2 mi (3,200 m) visibility in rain showers and 15-kt winds, the NTSB report said.

The pilot said that he could see the platform on final approach, but there was no visible horizon. He told the copilot, who had 10 flight hours in type, to arm the floats and activate the windshield wipers. "The pilot added that the copilot appeared to be fumbling with the switches [and he] looked down to see what was happening," the report said. "At that time, the helicopter impacted the water in a near-level attitude, rolled over and began filling with water."

The pilots were wearing life vests but were unable to deploy the life raft before the helicopter sank in 6-ft (2-m) swells. The pilots were in the water about 40 minutes when they decided to swim toward an abandoned platform that they believed was about 2 mi away. They swam for 2.5 hours before reaching the platform, where they found drinking water, food and medical supplies.

The report said that both pilots were suffering from severe fatigue when they were rescued by the crew of a Bell 407 and transported to a hospital. The first officer was treated for a puncture wound in his thigh.

The NTSB said that the probable causes of the accident were "the flight crew's failure to maintain clearance with the water and their diverted attention to secondary tasks while preparing to land."

Power Line Struck During Search Flight

Robinson R44. Minor damage. One serious injury.

The helicopter was engaged in a police search of the coast near Punakaiki, New Zealand, the afternoon of Nov. 9, 2006. The pilot had not conducted a reconnaissance of the area before beginning the flight, said the report by the New Zealand Transport Accident Investigation Commission.

"The pilot said that the search was mostly conducted at a very low 'hover-taxi' speed at a height of about 50 m [164 ft] AGL but went as low as 3 m [10 ft] when hovering near something of interest," the report said.

The pilot said that, after he flew around Motukutuku Point, he lost sight of a power line that ran along the coast and assumed that the power line had been routed underground. The report said that the power line blended with the terrain in the area.

Soon after the pilot turned the R44 toward the beach, the occupants heard a bang, and the windshield shattered. "The pilot immediately felt winded [i.e., out of breath] but kept control and brought the helicopter to a high hover," the report said. He then landed the helicopter on the beach and used a satellite telephone to notify the company of the accident.

The pilot received a small puncture wound to his chest; the three police officers aboard the helicopter were not injured. The R44's rotor blades, as well as the windshield, were damaged and required replacement.

Soon after the pilot turned the R44 toward the beach, the occupants heard a bang, and the windshield shattered.

Load Shift Causes Drive Shaft Separation

Aerospatiale SA-319B. Substantial damage. No injuries.

The Alouette was being used to transport the wreckage of a Piper Super Cub from an unspecified site near Mulchatna River to Port Alsworth, Alaska, U.S., on Sept. 23, 2006. The helicopter's 100-ft (30-m) external load line was attached to a spreader bar on the Super Cub's wing structure, and covers designed to spoil lift were placed on the airplane's wings.

The helicopter was being flown at 60 kt and about 2,000 ft AGL when the pilot felt the external load shift. "The helicopter then suddenly pitched nose-down about 45 degrees," the NTSB report said. "The tail boom of the helicopter was struck by one or more main rotor blades, severing the tail rotor drive shaft."

The pilot released the external load and conducted an autorotative landing on soft tundra. "One of the main landing gear wheels dug into the terrain, and the helicopter's tail boom was struck by the main rotor blades, severing about two feet off the aft end of the tail boom," the report said. The pilot and crewmember were not injured.

The NTSB said that the probable cause of the accident was "the pilot's failure to adequately secure the external load rigging." ●

Preliminary Reports

Date	Location	Aircraft Type	Aircraft Damage	Injuries
Sept. 3, 2007	San José, Costa Rica	North American Sabreliner 70	substantial	6 none
The landing gear collapsed when the Sabreliner overran the runway during a rejected takeoff.				
Sept. 5, 2007	Cross City, Florida, U.S.	Cessna 208B	substantial	1 none
The pilot was unable to restart the engine after it failed at 11,000 ft during a nighttime positioning flight. The Caravan struck trees during an attempted emergency landing at the Cross City airport.				
Sept. 7, 2007	Goma, Democratic Republic of Congo	Antonov An-12	destroyed	8 fatal
The cargo airplane reportedly overran the runway and caught fire during a crash landing.				
Sept. 8, 2007	Buhl, Germany	Robinson R22 Beta	destroyed	2 fatal
The helicopter crashed on a highway after the tail boom failed during a level turn.				
Sept. 10, 2007	Hobbs, New Mexico, U.S.	Cessna 402B	substantial	1 none
The airplane ran off the side of the runway after the left main landing gear collapsed on landing. The gear actuator rod was found fractured.				
Sept. 11, 2007	Port-au-Prince, Haiti	Cessna 208B	destroyed	5 serious, 5 minor
Initial reports said that either the engine failed or a door came open during departure for a scheduled flight to Cap-Haitien. The Caravan overturned during the emergency landing.				
Sept. 11, 2007	Nokomis, Florida, U.S.	Bell 206B	destroyed	2 fatal, 1 serious
The helicopter was being used to photograph a racing boat when it struck the water at about 74 kt.				
Sept. 14, 2007	Guadalajara, Mexico	Boeing 737-200	substantial	109 none
The flight crew conducted a go-around because of an asymmetric flap indication and used the alternate flap-extension system. The 737 then was landed with the landing gear retracted.				
Sept. 14, 2007	Chamblee, Georgia, U.S.	Israel Aircraft Industries Astra	substantial	2 none
Light rain was falling when the airplane overran the runway on landing and struck the localizer installation.				
Sept. 16, 2007	Phuket, Thailand	McDonnell Douglas MD-82	destroyed	89 fatal, 41 NA
The MD-82, inbound from Bangkok, overran the runway and struck an embankment while landing in heavy rain and strong winds.				
Sept. 19, 2007	Chattanooga, Tennessee, U.S.	Beech B90 King Air	destroyed	4 minor
The pilot diverted to Chattanooga because of low-fuel indications. Both engines flamed out on final approach, and the pilot conducted an emergency landing in a parking lot, where the King Air struck cars and a light pole.				
Sept. 20, 2007	near McGrath, Alaska, U.S.	Shorts SC-7 Skyvan	substantial	1 fatal
The airplane struck trees while taking off for a maintenance ferry flight from a 1,100-ft (335-m) gravel runway.				
Sept. 21, 2007	Fort Lauderdale, Florida, U.S.	Beech H18	destroyed	1 minor
The airplane crashed on a highway soon after takeoff.				
Sept. 24, 2007	Malemba-Nkulu, Democratic Republic of Congo	Let 410	destroyed	1 fatal, 5 serious, 1 none
The airplane overran the runway on landing and came to a stop in a cemetery.				
Sept. 24, 2007	Tixkokob, Mexico	Gulfstream II	destroyed	2 NA
The airplane was being chased by Mexican air force aircraft when it was crash-landed in an open field. Authorities found 3.6 tons (3.3 tonnes) of cocaine aboard the G-II and arrested both pilots.				
Sept. 26, 2007	Entebbe, Uganda	Cessna 406	destroyed	2 fatal
The airplane crashed and burned during takeoff for a geophysical survey flight.				
Sept. 28, 2007	St. Louis	McDonnell Douglas MD-82	minor	143 none
A left-engine fire warning occurred during initial climb. The flight crew discharged the fire bottles, shut down the engine and returned to St. Louis for a single-engine landing.				
Sept. 29, 2007	Philadelphia	Boeing 737	minor	1 minor, 1 none
The windshield collapsed when the 737 struck a bird on departure. The crew returned to Philadelphia and landed the airplane without further incident.				
Sept. 30, 2007	King Salmon, Alaska, U.S.	Helio H-295 Super Courier	destroyed	4 fatal
Visual meteorological conditions prevailed when the single-piston-engine floatplane struck trees and terrain on initial approach to a lodge.				

NA = not available

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