# AeroSafety WORLD

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Adding important details

## CHECKLISTS & MONITORING
NOT AS EFFECTIVE AS BELIEVED

THE JOURNAL OF FLIGHT SAFETY FOUNDATION

JULY 2010

# JOINING The Team

That new face at Flight Safety Foundation is me, Kevin Hiatt, and I'd like to introduce myself. I joined the Foundation in early July. In my role as executive vice president, I have been charged by the Executive Committee of the FSF Board of Governors to oversee the daily operations of the staff, support President and Chief Executive Officer Bill Voss and provide additional aviation safety insight.

My professional aviation career began in 1976 when I graduated from the Aviation Technology program at Purdue University. At that time, the U.S. military was not inducting any new pilots, so I stayed on the civilian side of flying and took the classic entry-level job — flight instructor. That progressed into an opportunity to fly for a corporation in larger multi-engine aircraft. After a few years in that segment of the industry, I started flying for what was then called a commuter airline, the forerunner of the industry segment now known as regional airlines. It was there that I first checked out as a captain and moved into turboprops.

A bit later I was selected to fly for Delta Air Lines. I spent 26 years at Delta, flying almost every Boeing and Douglas airliner they had. During that time, I worked in the Flight Safety Department and in Flight Operations. Just prior to an early retirement, I was chief pilot of the Atlanta International Airport pilot crew base. Being far too young to be truly retired, I went to work for World Airways first as director, and then vice president of safety and security. I stayed at World for five years.

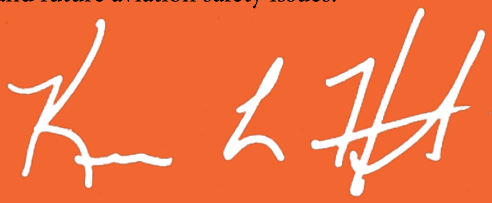
With this background I believe that I can bring useful, relevant aviation and safety experience to the Flight Safety Foundation, my flying experience enhanced by my recent focus on safety business management. I hope to use my experience to reinforce a staff already highly knowledgeable in all aspects of aviation safety.

I will be interacting with a staff of 21 in Alexandria, Virginia. U.S., and five in Melbourne, Australia, to make our operations more efficient, economical and responsive to aviation industry safety needs, and, most importantly, the safety needs of our valued Foundation members.

In meetings with FSF directors we already have begun to explore new ways to conduct our research, business and communications. Bill Voss brings his exciting vision to our Foundation, and I will bring the energy and experience to carry out the processes to make those ideas become real.

Your input as members and readers is very important. I welcome your correspondence and telephone calls discussing any topic concerning the safety of our worldwide aviation industry.

I view my new role at the Flight Safety Foundation as giving me the opportunity to expand my efforts in aviation safety throughout the industry. It's an honor to join the Foundation, an organization that holds a unique place in the history of the aviation industry worldwide and plays a key role in bringing the industry together to address current and future aviation safety issues.



*Kevin L. Hiatt*
*Executive Vice President*
*Flight Safety Foundation*

AeroSafetyWORLD

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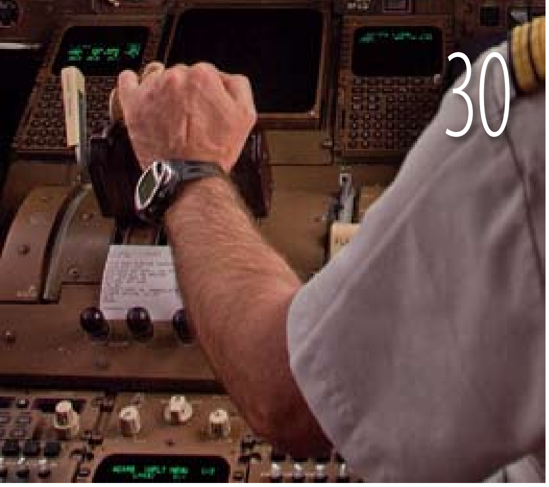






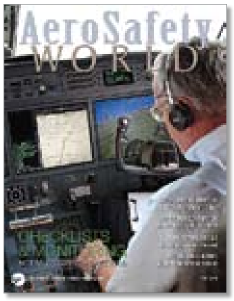


**About the Cover**
More work is needed to trap cockpit errors.
J.A. Donoghue

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

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**AeroSafety**WORLD
telephone: +1 703.739.6700

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

**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**, webmaster and
production coordinator
ehrlich@flightsafety.org, ext. 117

**Ann L. Mullikin**, art director and designer
mullikin@flightsafety.org, ext. 120

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

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

# SURPRISE Surprise

Surprises in aviation are rarely pleasant, and that's what a couple of Continental Airline pilots got in late 2008 when they taxied for departure from Denver International Airport (DEN) with the tower reporting winds of 11 kt, 70 degrees off the nose. No one, absolutely no one who flies aircraft with hard sides, hears danger alarms when the wind is 11 kt, even when it's a direct crosswind. When, as the U.S. National Transportation Safety Board (NTSB) reports, the local controller upped the ante to 27 kt when issuing the takeoff clearance, even that fell short of being a critical issue.

If, however, the pilots had known that control tower displays were showing a 35-kt wind with 40-kt gusts, then one would expect at least a "wait a minute" moment and further consideration of conditions. But they didn't know, and the peak gusts actually were more like 45 kt, and the aircraft departed the runway.

Frankly, at first blush, this data gap sounds like the kind of safety-of-flight information issue that I thought had been pretty well hammered out in the 1930s. And, I suppose, this might be the overriding takeaway one can extract from this accident: Just because we're not talking about the old threats, don't assume they have gone away.

We discussed in these pages the wind threats posed by "gravity waves," including the kind of conditions encountered in DEN's downslope location (*ASW*, 2/10, p. 32).

In fact, despite these special conditions that are known to occur there, the NTSB reports that the airport air traffic control facility had in place no special procedures to allow for and warn of the effects of winds such as this.

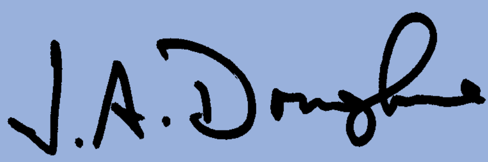
Moreover, Continental's training did not include near-ground handling in strong and gusting crosswinds. And finally, "Boeing did not adequately consider the dynamic handling qualities of the Boeing 737 during takeoff or landing in strong and gusty crosswinds," NTSB said, adding that other manufacturers probably don't do this, either.

So it appears as if every major entity involved in this accident didn't pay sufficient attention to the threat of strong gusting crosswinds close to the ground. I'm amazed.

Everyone who learns how to fly in the regular progression, from light aircraft to light twins, starts out knowing full well what a strong crosswind can do to an aircraft. But as the progression of equipment continues to heavier and more capable aircraft, and it takes more and more wind to create concern, the attention given to the threat apparently declines. But, as is shown by the DEN accident, plus several other airliner events that have been filmed and posted on the Internet, it is, indeed, an issue that needs continued attention.

Maybe this is the next frontier of aviation safety: Trying to figure out what threats we are beginning to take for granted in our quest to train and plan and create mitigations for increasingly specific threats.

Letting an airplane get blown off of a runway, or scraping a wing tip or rolling an airplane into a big ball of aluminum might be considered a runway excursion or approach and landing accident, but it also is a loss of control accident in my book, and should be added to the growing list of events indicting the level of planning, training and airmanship in some parts of the industry today.



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

# Serving Aviation Safety Interests for More Than 60 Years

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

## Member**Guide**

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

**flightsafety.org**

**Member enrollment** — ext. 102
**Ahlam Wahdan**, membership services coordinator — wahdan@flightsafety.org

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**Web site** — ext. 117
**Karen Ehrlich**, webmaster and production coordinator — ehrlich@flightsafety.org

Regional Office: GPO Box 3026 • Melbourne, Victoria 3001 Australia
Telephone: +61 1300.557.162 • Fax +61 1300.557.182

**Paul Fox**, regional director — fox@flightsafety.org

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

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

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

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

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

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

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

**AUG. 8–9 ➤ Quality Auditing in Aviation Maintenance — Part M and Part 145.** AVISA Gulf. Abu Dhabi, United Arab Emirates. <www.avisa-ltd.com>, +44 (0)845 0344 77.

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

**AUG. 10 ➤ Fuel Tank Safety — Phase 1 and 2.** AVISA Gulf. Abu Dhabi, United Arab Emirates. <www.avisa-ltd.com>, +44 (0)845 0344 77.

**AUG. 11–12 ➤ Aviation Safety Management Systems Overview.** PAI Consulting. Alexandria, Virginia, U.S. <SMS@PAIconsulting.com>, <www.paiconsulting.com/SMS.html>, +1 703.931.3131.

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

**AUG. 23–27 ➤ Aviation Lead Auditor Training.** ARGUS PROS. Denver. John Darbo, <John.Darbo@argus.aero>, <www.pros-aviationservices.com/alat_training.htm>, +1 513.852.1057.

**AUG. 24 ➤ Training, Standardization and Compliance Conference (TSCC 2010).** Joe Gibbs Racing, Hendrick Motorsports, Michael Waltrip Racing and the Southeast Aviation Corporate Management Association. Concord, North Carolina, U.S. Aggie Mitchard, <amitchard@JoeGibbsRacing.com>, <www.regonline.com/TSCC>, +1 704.785.2110, ext. 2006.

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

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

**AUG. 30–SEPT. 3 ➤ Aviation SMS Course and Workshop Taught in Spanish.** PRISM. Bogotá, Colombia. John Darbo, <John.Darbo@argus.aero>, <www.aviationresearch.com/ProductsServices/PRISMSolutions.aspx>, +1 513.852.1057.

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

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

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

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

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

**SEPT. 14–17 ➤ Wildlife Hazards and Aviation Training.** AviAssist Foundation. Kilimanjaro Airport, Tanzania. Tom Kok, <tom.kok@aviassist.org>, <www.aviassist.org/pages/website_pages.php?pgid=6&CategoryID=33>.

**SEPT. 15–16 ➤ Atlantic Conference on Eyjafjallajökull and Aviation.** Keilir Aviation Academy. Keflavik, Iceland. <conferences@keilir.net>, <en.keilir.net/keilir/conferences/eyjafjallajokull>, +354 664 0160.

**SEPT. 20-22 ➤ Wildlife Hazards and Aviation Master Class.** AviAssist Foundation. Kilimanjaro Airport, Tanzania. Tom Kok, <tom.kok@aviassist.org>, <www.aviassist.org/pages/website_pages.php?pgid=6&CategoryID=33>.

**SEPT. 20–23 ➤ Flight Data Monitoring and Flight Operational Quality Assurance in Commercial Aviation.** Cranfield Safety and Accident Investigation. Cranford, Bedfordshire, England. Matthew Greaves, <m.j.greaves@cranfield.ac.uk>, +44 (0)1234 754243.

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

**SEPT. 23–24 ➤ Safety Aspects of Air-Ground Communications (Challenges and Solutions).** Flight Safety Foundation South East Europe–Middle East–Cyprus, Eurocontrol and International Federation of Air Traffic Controllers' Associations. Larnaka, Cyprus. <info@flightsafety-cy.com>, <www.flightsafety-cy.com>.

**SEPT. 26–27 ➤ ICAO/McGill University Worldwide Conference and Exhibition: Air Transport: What Route to Sustainability?** International Civil Aviation Organization and McGill University. Montreal. Maria Damico, <maria.damico@mcgill.ca>, <www.icao.int/ICAO-McGill2010>.

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

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

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

# Safety News

## Maintenance Training

Maintenance personnel should receive more on-the-job training before they are permitted to perform critical work on aircraft, the U.S. National Transportation Safety Board (NTSB) says.

The NTSB, in two safety recommendations, called on the U.S. Federal Aviation Administration (FAA) to require that mechanics performing "required inspection item [tasks] and other critical tasks receive on-the-job training or supervision when completing the maintenance task until the mechanic demonstrates proficiency in the task."

The FAA also should ensure that inspectors of required inspection items (RIIs) receive similar supervision, the NTSB said.

The NTSB cited a Dec. 14, 2008, incident in which an Air Wisconsin Bombardier CRJ100ER landed at Philadelphia International Airport with the left main landing gear retracted. The airplane's left wing, aileron and flap were damaged substantially, but the three people in the airplane were not injured.

The NTSB investigation is continuing, but the board said that, because of its preliminary findings, it is "concerned about training for mechanics and inspectors."

The accident airplane's main landing gear uplock assemblies were replaced during maintenance on Dec. 13 and 14. The task was identified on the work order as an RII — defined by the FAA as an item that could "result in a failure, malfunction or defect endangering the safe operation of the aircraft, if not performed properly or if improper parts or materials are used."

The mechanic who performed the work on the left uplock assembly had not previously replaced an uplock assembly and had received no on-the-job training for the task, the NTSB said, adding that he was not supervised while performing the work. He said that he had relied on the airline's maintenance manual and the mechanic who was working on the right uplock assembly for guidance while performing his work.

However, the NTSB said, the mechanic who replaced the right uplock assembly told investigators that it was the first time he had replaced an uplock assembly on a CRJ.

"When the incident mechanic replaced the left uplock assembly, the

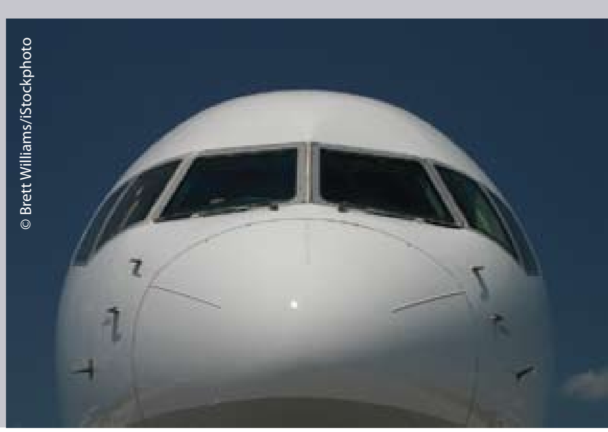
U.S. National Transportation Safety Board

upper attachment bolt, nut and cotter pin assembly used to mount the left [main landing gear] uplock assembly to the structure were installed but did not engage the uplock assembly, which allowed the uplock assembly to pivot about the lower bolt," the NTSB said. "Because the upper attachment bolt did not engage the uplock assembly, the left [main landing gear] remained in the up-and-locked position and did not respond to the pilot's commands to lower prior to landing."

The mechanic was not properly trained or supervised for the task, the NTSB said, adding that similar situations have occurred at other airline maintenance facilities.

## Windshield Fires

Citing 11 reports in two decades of fire or flames on the windshields of Boeing 757s, 767s and 777s, the U.S. Federal Aviation Administration (FAA) has issued an airworthiness directive (AD) requiring operators to inspect or replace specific flight deck windows.



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The AD, which affects 1,212 U.S.-registered airplanes, is intended to prevent "smoke, fire or cracking of the inner layer of the forward viewing window," the FAA said, noting that the problem is caused by loose electrical connections designed to heat the windows and prevent icing.

The AD offers operators two options: Either begin inspections of each of two window designs within 500 hours and continue them at specified intervals, or install a new, redesigned window.

The most recent of the windshield fires occurred May 16, 2010, when the crew of a United Airlines 757 reported a small fire on the flight deck and conducted an emergency landing at Washington Dulles International Airport. The fire was contained before landing, and none of the 112 people in the airplane was injured, the U.S. National Transportation Safety Board said.

Although there have been no windshield fires on 747s, the FAA said it would propose a similar AD later this year for those airplanes because of similarities in their windshields.

## *ALAR Tool Kit*, Revisited


Flight Safety Foundation has released an updated version of its *Approach and Landing Accident Reduction (ALAR) Tool Kit* to include current data and a new section on runway excursions, developed from the Foundation's Runway Safety Initiative.

The original *ALAR Tool Kit* was released in 2000, and 40,000 copies have since been distributed worldwide. The Foundation has used the tool kit at more than 30 ALAR workshops around the world, including a May workshop organized in Lusaka, Zambia, by the AviAssist Foundation, one of the Foundation's regional affiliates.

## Increased Inspections

Wikimedia

The U.S. Federal Aviation Administration (FAA) has told operators of 138 Boeing 767s that they must conduct initial pylon inspections after 8,000 flights — not 10,000 flights, as had been required by a 2005 airworthiness directive (AD). The pylons attach the engines of the 767s to the wings.

The inspection must be performed within 90 days or 400 flights after the most recent inspection conducted in accordance with the AD.

The FAA also shortened the required interval for repetitive inspections to every 400 flights — instead of the previous requirement of every 1,500 flights.

The inspections are designed to check for cracking of the pylon mid-spar structural fittings and an adjacent structure. As an alternative to the inspections, operators may replace the fittings.

Since the AD's adoption, cracking has been reported in the mid-spar structural fitting of two 767s, the FAA said, warning that "undetected cracking could lead to fracture of the structural components, damage to the pylon and separation of the engine from the wing."

## Wind Research

A Dec. 20, 2008, accident on a Denver runway in gusty crosswinds has prompted the U.S. National Transportation Safety Board (NTSB) to press for research and development of training programs to help pilots take off and land in adverse wind conditions.


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The NTSB called for research into mountain wave and downslope conditions at airports located downwind of mountainous terrain, including Denver International Airport (DEN), where the Continental Airlines Boeing 737-500 accident occurred. The airplane slid off the left side of a runway during takeoff and was substantially damaged by the post-crash fire. Six of the 115 people in the airplane were seriously injured.

The NTSB said the probable cause of the accident was the captain's "cessation of right rudder input … when the airplane encountered a strong and gusty crosswind that exceeded the captain's training and experience." Cited as contributing factors were the air traffic control system's failure to require the dissemination of critical wind information to air traffic controllers, and "inadequate crosswind training" for pilots because of "deficient simulator wind gust modeling."

The accident investigation prompted 14 safety recommendations to the U.S. Federal Aviation Administration (FAA), including calls for archiving airport low-level wind shear alert system (LLWAS) data to be used in future research and collecting data on surface winds from a number of major U.S. airports, including DEN.

The data should be used in efforts to improve the delivery of crosswind and gusty wind alerts to air traffic controllers, the NTSB said. Other recommendations called for the development of runway selection programs that "consider current and developing wind conditions and include clearly defined crosswind components, including wind gusts" in selecting an active runway.

The NTSB also asked the FAA to require operators to ensure that pilot simulator training programs include scenarios involving realistic, gusty crosswind conditions.

## Training Enhancements

The Russian Aviation Authorities should consider enhancing training requirements for air carrier pilots transitioning to new aircraft, the Russian Air Accident Investigation Commission (AAIC) says.

The suggestion was one of 40 safety recommendations that resulted from the AAIC's investigation of the Sept. 13, 2008, fatal crash of a Boeing 737-500 in Perm, Russia (see p. 18). The AAIC cited several training-related issues as contributing causes.

The agency recommended that the Russian Aviation Authorities "consider the practicability of increasing requirements to flight training programs and transition training programs and elaborate a mandatory syllabus minimum for every aircraft type in order to improve the level of training."

Another recommendation called for development of a crew resource management training program for crews of two-pilot airplanes, "and ensure this program is mandatory for flight personnel who transition from multicrew aircraft."

Among the other recommendations were calls for the Russian Aviation Authorities to:

- "Develop and implement English language proficiency requirements for flight personnel who fly aircraft with documentation in English, as well as maintenance personnel who maintain the above-mentioned aircraft"; and,



- "Consider the practicability of using aircraft with Western-type attitude indicators at colleges of initial flight training."

The AAIC also recommended that airlines take steps to ensure that their flight personnel strictly comply with standard operating procedures, develop measures to maintain safety when pilots transition to new aircraft types and "ensure that airline psychologists, when selecting applicants for transition training, pay more attention to their personal traits with regard to their emotional reaction and behavior in abnormal situations (increased workload, stress), and if they find negative traits, give particular recommendations as to whether these pilots are suitable for transition training."

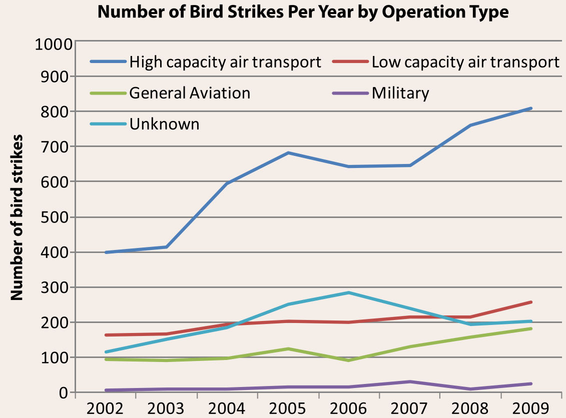
## Bird Strikes on the Rise

The number of bird strikes reported in Australia increased steadily from 2002 through 2009, the Australian Transport Safety Bureau (ATSB) says.

Throughout the eight-year period, 9,287 bird strikes were reported, including 1,477 in 2009, about double the number reported in 2002, the ATSB said. Of the 9,287 bird strikes, four resulted in injury and eight resulted in serious aircraft damage.

"The increase in the number of bird strikes … is consistent with the increase in the number of high capacity aircraft movements over the period, as well as a greater willingness of people in aviation to report safety occurrences to the ATSB," the agency said. Most of the bird strikes occurred within 5 km (3 nm) of an airport.

**Number of Bird Strikes Per Year by Operation Type**




Source: Australian Transport Safety Bureau

## In Other News …

The European Commission has issued the 14th update of its list of airlines banned from operating in the European Union. Two Indonesian air carriers — Metro Batavia and Indonesia Air Asia — were removed from the **blacklist**, which added Surinam's Blue Wing Airlines and expanded operating restrictions on Iran Air. … The **SESAR Joint Undertaking**, which aims to unify European air traffic management systems, has endorsed 13 associate partners to participate in the program. … Officials of the European Union and the United States have signed an agreement to launch the second stage of the **"Open Skies"** agreement designed, in part, to enhance regulatory cooperation.

*Compiled and edited by Linda Werfelman.*

**Crew observations show that checklists and monitoring are not as effective as generally assumed.**

# Designing a Better Error Trap

BY BENJAMIN A. BERMAN AND R. KEY DISMUKES

Early morning at the gate, powering up the jet from cold. Flow-scan the overhead panel, as you have done so many times before. Up and down, left to right. All the switches are in their usual positions. Last is the air panel — six switches and two rotary selectors. A quick glance shows they are good. You call for the checklist. The first officer's first challenge is "Pressurization?" Your eyes go to the landing altitude rotary selector on the air panel. "Set," you reply.

It is still dark after takeoff. Climbing through 3,000 ft, the first officer, the flying pilot, calls, "Flaps up, 'After Takeoff' checklist." You run your hands around the overhead panel, turning off the

ignition and auxiliary power. Pressurization check: A peek at the differential gauge shows that it is off the lower peg. Just then the controller instructs you to contact departure. After acknowledging, you pick up the checklist. "Pressurization?" Remembering your earlier glance at the gauge, you reply, "Checked."

Through 15,000 ft now, and an insistent beeping jars your senses. The takeoff warning horn. Why now? While you think about this, the master caution light comes on, indicating an equipment cooling fan failure. As you get out of your seat to check the fan's circuit breakers, you tell the first officer to keep flying. You stand up, turn around and feel a bit woozy. The last thing you remember is deciding, for some reason, to sit down in the narrow aisle behind the pilot seats.

Accident investigators comb through the wreckage for clues and determine you did not notice that the pressurization system selector on the air panel had been left on "MAN" (manual) by the maintenance department. The pressure differential had increased enough in manual mode to let you see the gauge off zero but not enough to maintain a livable atmosphere as the aircraft climbed. It is likely you forgot that the takeoff warning horn, which you had heard during systems tests before every flight, doubles as a cabin altitude warning. The conclusion: Both pilots succumbed to hypoxia because they did not identify, or react to, a lack of pressurization.

A sequence much like this occurred on Aug. 14, 2005, as a Helios Airways Boeing 737 climbed out from Larnaca, Cyprus (*ASW*, 1/07, p. 18). Automation kept the aircraft aloft and on its programmed flight plan until the fuel was exhausted over Grammatiko, Greece.

Although such accidents are extremely rare, they point to the crucial roles played by checklists and monitoring in helping pilots catch system malfunctions and human error, and manage the challenging situations that sometimes arise on routine flights.

## Line Observations

To find out how checklists and monitoring work in actual practice, we observed line operations during 60 flights conducted by three air carriers from two countries.[1] We used a structured technique to observe and record checklist and monitoring performance, and situational factors that might affect performance. Because an important function of checklists and monitoring is to catch, or "trap," operational errors, we also recorded deviations in aircraft control, navigation, communication and planning. When a deviation was observed, we tracked whether crewmembers identified and corrected it, and whether there were any consequences that might affect the outcome of the flight.

During the 60 flights, we recorded 899 deviations, of which 194 were in checklist use, 391 in monitoring and 314 in operating procedures (Table 1, p. 14). The total number of deviations per flight ranged from one to 38.

Many of the deviations we observed were errors. For example, one airline had a mixed 737 fleet, with a few aircraft requiring the first officer to place the pressurization system in flight mode during the flow portion of the "After Start" checklist procedure. On one flight, perhaps reverting to the procedure required for the more common aircraft, the first officer omitted this during the flow check. The pilots then did not notice the incorrect system configuration while conducting two subsequent checklists, both of which included verification of the relevant panel settings.

Some deviations, however, were not necessarily intrinsic errors. For example, several involved a standard operating procedure (SOP) at all three airlines that required the monitoring (nonflying) pilot to make a callout 1,000 ft prior to reaching each assigned altitude during climb and descent. We observed 137 instances of pilots omitting this callout or making it late. Climb and descent are busy periods, and at times a pilot may need to give priority over a callout to other tasks, such as air traffic control (ATC) communications. Consequently, omitting or delaying this callout may sometimes be a strategic workload management choice rather than an error.

This is not to suggest that the 1,000-ft callout is trivial. On the contrary, it ensures that both pilots concur about the altitude target, directs the attention of a flying pilot who might be distracted back to the impending level-off and draws both pilots' attention to what the autopilot is supposed to be doing.

Airlines should examine their SOPs to specifically define the objectives of each procedure and to determine whether it is realistic to assume that pilots can perform the procedure reliably under actual line conditions. Pilots must be aware that in deviating from any procedure, they might be giving up safety margin that is not apparent.

## Checklist Deviations

Among the most common deviations in checklist usage was incorrect application of the *flow and check* procedure implemented by the three airlines. The procedure involves using a memory-based flow pattern for setting systems and controls, and then following up with verification using a printed or electronic checklist.

In 48 of the 194 checklist deviations recorded, the flow and check procedure was not performed correctly. One or

J.A. Donoghue

**Deviations Observed on 60 Line Flights**

| Category | Deviation | Number |
|---|---|---|
| Checklists | Flow-check as read-do | 48 |
| | Responded without looking | 43 |
| | Item omitted/incomplete/incorrect | 42 |
| | Poor timing | 31 |
| | Performed from memory | 17 |
| | Not initiated | 13 |
| | Total | 194 |
| Monitoring | Callout late or omitted | 211 |
| | Not monitoring aircraft state or position | 67 |
| | Verification omitted | 113 |
| | Total | 391 |
| Primary procedures | Systems configuration | 62 |
| | Contingency planning/execution | 57 |
| | Crew — crew coordination | 56 |
| | Automation — FMS | 40 |
| | Crew — ATC coordination | 33 |
| | Automation — MCP | 18 |
| | Conducting unstabilized approach | 10 |
| | Crew — ground personnel coordination | 8 |
| | Profile planning/execution | 7 |
| | Lateral path control | 7 |
| | Crew — flight attendant coordination | 6 |
| | Aircraft configuration | 4 |
| | Vertical path control | 3 |
| | Automation — head-down | 2 |
| | Airspeed control | 1 |
| | Total | 314 |
| **Grand total** | | **899** |

ATC = air traffic control; FMS = flight management system; MCP = mode control panel

Source: Benjamin A. Berman and R. Key Dismukes

**Table 1**

both pilots tasked with the flow procedure did not do it or attended to only some of the flow items. As a result, most items were performed only while using the checklist, eliminating the protective redundancy designed into the flow and check procedure; other items — those that were in the flow procedure but not repeated in the checklist — were not completed.

Many people find it difficult to force themselves to carefully check something twice within a brief period. A pilot may consider it wasteful of limited time and attention, and less efficient than combining the flow and the checklist into a single sequence of actions. If airlines want to maintain the error-trapping value of a redundant flow and check procedure, they must explicitly acknowledge this human tendency and explain to pilots why they are asked to check things twice. Airlines should clearly define which items should be double-checked and which responses can rely on a memory of having performed the item during the flow. Airlines also should review normal checklists to eliminate excessive repetition of items on the flow and the checklist.

## Looking Without Seeing

We observed 43 instances in which checklist items were responded to without effective visual verification. In some cases, the responses were incorrect. For example, a first officer challenged, "Doors?" and the captain responded, "Closed," although the aft cargo door was actually open, as indicated on the overhead panel. The captain was looking down at his flight bag when he responded. The first officer caught the error, however.

On another flight, the captain responded, "On," to the challenge "APU [auxiliary power unit] bleed?" but the bleed was off. Because the captain was looking at the bleed switch when he made the incorrect response, this may have been an instance of "looking without seeing," in which we see what we *expect* to see, rather than what is actually there.

We observed a pilot using a nice technique of pointing to each item on the overhead panel as he gave the response. This makes the checklist more reliable by drawing both pilots' attention to the items being verified, and it can also slow the pace of checklist execution just enough to make checking more effective. In general, taking a few extra seconds to perform an error-trapping procedure in a deliberate manner — that is, carefully and thoughtfully — makes it much more effective. The "point and shoot" technique is worth adopting, and airlines should promote and train deliberateness.

Checklist items were omitted or performed incompletely or incorrectly in 42 instances. For example, the checklist item "hydraulics" had a specified response of "Set and checked," referring to setting the pump switches on the overhead panel to the "ON" position and checking the pressure gauges on the forward instrument panel. Some pilots looked only at the overhead panel before making the specified response, omitting the other item, the gauge indications, that was to be verified. This shows the vulnerability to error of checklist designs that include more than one item on a single challenge-response element, and the subtlety of breakdowns in this area. We suspect that many of the pilots involved in this kind of deviation were not even aware of the omission.

Another common checklist deviation was initiating a checklist at a bad time. We observed this in 31 instances. Some were delayed initiations, with heavy workload a key factor; others involved pilots calling for a checklist when it interfered with other tasks and posed a significant distraction or workload spike. For example, a captain called for the "Taxi" checklist just as the aircraft was approaching a runway intersection, drawing the first officer's attention away from visually clearing the taxi path from his side of the flight deck. This is an example of an error-trapping procedure that can potentially detract from safety when not handled properly. Pilots can reduce this risk by exercising proactive workload management, deliberately choosing the optimal time to perform a checklist (within the guidelines of the SOP) so as to minimize interference with other tasks. Airlines should train this mode of workload management, and reinforce it in line checks and line observations.

## Deviations in Monitoring

Among the 391 monitoring deviations that we observed, 211 involved callout omissions. Callouts are the outward manifestations of monitoring that are scripted into SOPs and are easier to observe than other aspects of monitoring. Some omitted callouts more clearly undermined flight safety than the "1,000 to go" callouts previously discussed. For example, a flight crew was engrossed in increasing the descent gradient to accommodate a "slam dunk" ATC clearance when the monitoring pilot omitted the callout at 1,000 ft above airport elevation. This illustrates the tendency of pilots to shed monitoring when primary control task workload is high and the corollary that monitoring tends to drop out of the picture just when it is needed most.



Verification omissions occurred in 113 instances. In one case, while descending through Flight Level (FL) 310 (approximately 31,000 ft), the flight crew received clearance to FL 240. The first officer set and called out the new altitude, but the captain was distracted by conversation and did not verify the new altitude on the primary flight display. There was no adverse outcome because the first officer had set the altitude correctly.

Potentially more consequential was an instance in which the first officer transposed the digits of a heading assigned by ATC while the captain was occupied with taxiing the aircraft onto the runway. The captain did not verify the heading selection at this busy time. The error was not trapped. In this case, the observer spoke up about the heading mis-selection to reduce the risk of a traffic conflict after departure.

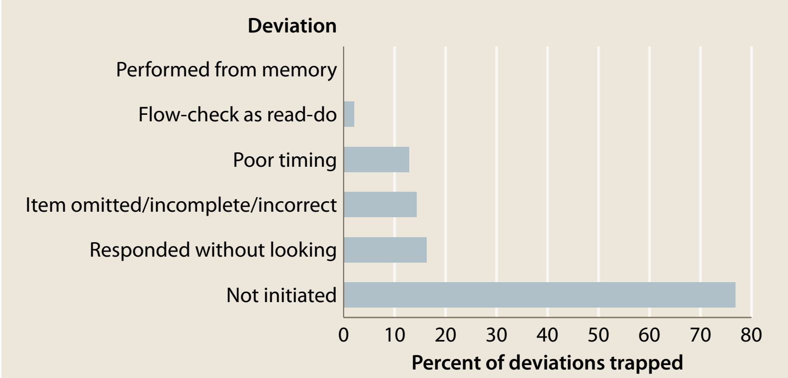
Another frequent deviation was not monitoring the aircraft, observed in 67 instances. Both the flying pilot and monitoring pilot are required to attend to the aircraft. We observed numerous instances of pilots looking elsewhere as the aircraft began turning or leveling off at an assigned altitude, most often while under autopilot control. Not monitoring the aircraft suggests over-reliance on automation, an understandable reaction to automation's high reliability. But accidents and incidents have happened when the automation was misprogrammed. Automation does fail occasionally, but because it generally is so reliable, pilots likely do not even realize when they may, at least at times, no longer be actively monitoring the aircraft.

## Procedural Deviations

The 314 deviations in primary procedures included 62 involving configuration of equipment/systems. An example was when a captain turned on the engine anti-ice system before the airplane entered the clouds in icing conditions but neglected to turn on the engine ignition.

Deviations in planning for, or responding to, contingencies occurred in 57 instances. For example, an airplane was at 6,000 ft and near the end of a flight when ATC transmitted, "Braking action fair reported by all types." The crew made no comment in response, and they did not recalculate landing distance for the reported braking condition.

**Trapping of Checklist Deviations**

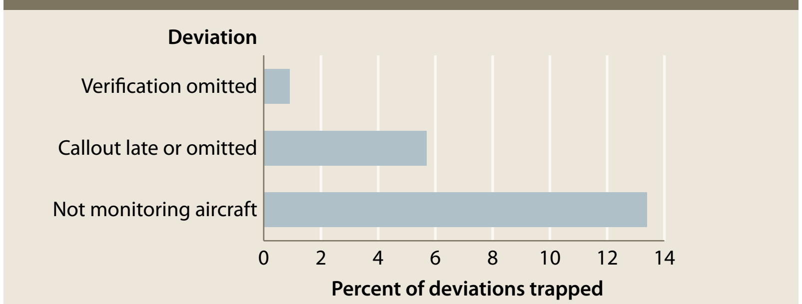



**Note**: 14.4 percent of all checklist deviations were trapped.

Source: Benjamin A. Berman and R. Key Dismukes

**Figure 1**

**Trapping of Monitoring Deviations**




**Note**: 5.6 percent of all monitoring deviations were trapped.

Source: Benjamin A. Berman and R. Key Dismukes

**Figure 2**

We recorded 56 deviations in crew-crew coordination. In one instance, a flight crew was cleared to navigate directly to a fix; the captain entered and executed the route change without waiting for the first officer to confirm the change.

Deviations in data entry or in use of the flight management system or the mode control panel occurred in 40 and 18 instances, respectively. An example was a first officer who did not arm the autopilot to capture the instrument landing system (ILS) localizer as the flight neared the final approach course.

## Effectiveness of Trapping

Overall, only 18 percent of the observed deviations were trapped by the crew. However, the efficiency of the trapping varied dramatically among the deviation types. More than 14 percent of the checklist deviations were trapped (Figure 1), while only about 6 percent of the monitoring deviations were caught (Figure 2). The best performance was in primary procedural deviations, with more than 35 percent trapped (Figure 3). However, there were eight instances in which flight crews failed to reject unstabilized approaches before or upon reaching the point at which a go-around was required by SOPs, and there were 10 discrete deviations during these approaches in which crews then did not challenge or trap their continuation of the approach while unstabilized.

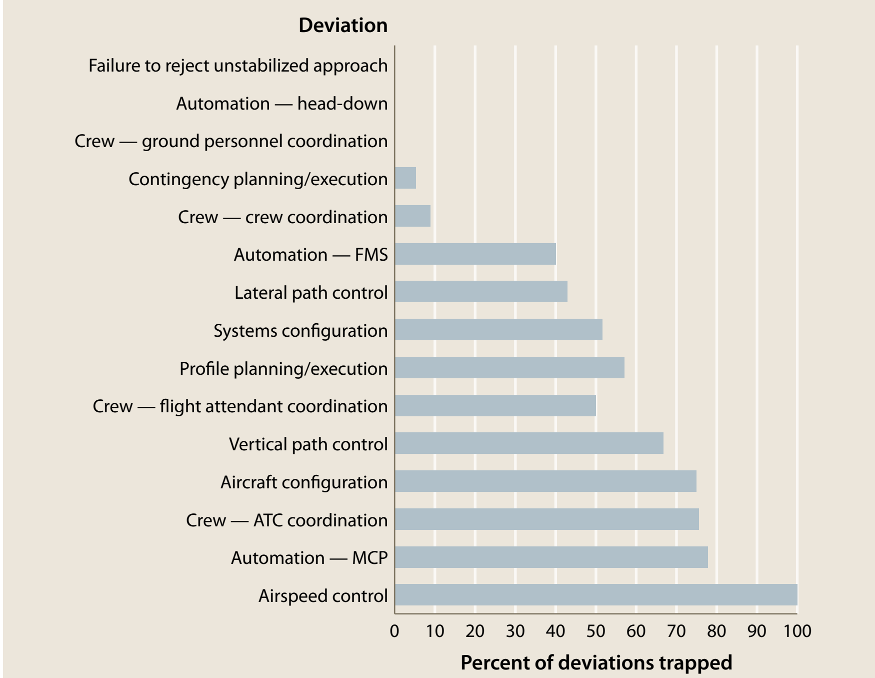
Pilots trapped most erroneous mode control panel entries, most system misconfigurations and most failures to call for a checklist. In contrast, they rarely caught deviations in contingency planning, crew-crew coordination, monitoring and most aspects of checklist execution. From the jump seat, we were not able to distinguish whether deviations by one pilot were not noticed by the other pilot or whether the other pilot noticed but chose not to speak up.

One of the key discoveries from our study was that, although primary procedures most often were performed as prescribed, checklists and monitoring currently do not trap all procedural threats and errors to the degree that the aviation industry generally assumes. For example, even though slightly more than half of the 62 instances of system misconfiguration were trapped, many of these events were not identified or corrected. The industry needs more reliable trapping for this and many other kinds of primary procedural deviations.

Most checklist and monitoring deviations were not trapped either by the flight crewmembers or by others. It appears that pilots are not likely to notice or take corrective action when checklists and monitoring have been weakened and their error-trapping functions cannot be relied upon. This may remain as a latent threat, allowing a primary procedural deviation to slip through.

Captains and first officers, and flying pilots and monitoring pilots, made about the same number of deviations overall. However, we found that first officers were significantly less effective at trapping errors while they were performing the monitoring role; they caught 12.1 percent of the deviations that captains made as the flying pilot, while captains caught 27.9 percent of deviations that first officers made as the flying pilot. Previous studies based on flight simulator observations and on accidents found a similar disparity. The greater difficulty that first officers face in challenging their captains (compared to the reverse) is clearly a stubborn problem for which a solution has not yet been found.

**Trapping of Primary Procedural Deviations**




ATC = air traffic control; FMS = flight management system; MCP = mode control panel

**Note**: 35.4 percent of all primary procedural deviations were trapped.

Source: Benjamin A. Berman and R. Key Dismukes

**Figure 3**

## Implications

In our full report, we discuss factors that make even experienced, conscientious pilots vulnerable to the observed deviations. It is naïve to think that any crew can always perform perfectly in real-world conditions; nevertheless, our findings show that checklist and monitoring performance can be improved. In responding to these findings, airlines must not assume that the deviations are the result of laziness. Pilots face interruptions and concurrent task demands during actual line operations, and idealized SOPs do not take these factors into account. Also, pilots cope with operating procedures and equipment designs that sometimes are poorly matched to the ways the human mind processes information. Finally, pilots may slip into rushing through procedures when they are under the time pressures now common in airline operations; neither pilots nor airlines may recognize just how much rushing undermines reliable performance.

For these reasons, simply admonishing pilots to follow procedures as written is unlikely to improve performance. Rather, we encourage airlines to analyze actual operations thorough line observations, revise procedures and practices as needed, provide training to help pilots understand the cognitive nature of vulnerability to error, and provide specific techniques to reduce that vulnerability. Pilots, flight managers, procedures designers, equipment designers and scientists should work together in this effort. The full report of our study provides detailed suggestions for reducing vulnerability and improving deviation trapping.

*Benjamin A. Berman is a senior research associate at the U.S. National Aeronautics and Space Administration (NASA) Ames Research Center/ San Jose State University and a pilot for a major U.S. air carrier. R. Key Dismukes, Ph.D., recently retired from NASA as chief scientist for aerospace human factors at the Ames Research Center.*

### Note

1. This article is based on a study funded by NASA and the U.S. Federal Aviation Administration. When published, the full report, *Checklists and Monitoring in the Cockpit: Why Crucial Defenses Sometimes Fail*, will be available from <human-factors.arc.nasa.gov/ihs/flightcognition/>.

# Misgauged Recovery

BY MARK LACAGNINA

**An unfamiliar, Western-type attitude indicator was little help to the disoriented Russian captain when an upset occurred.**

Spatial disorientation was the primary cause of the Sept. 13, 2008, crash of a Boeing 737-500 at Perm, Russia, according to the final report by the Russian Air Accident Investigation Commission (AAIC). Contributing factors were inadequate crew resource management (CRM), a lack of proficiency in basic aircraft handling and a lack of skills associated with the use of a "Western-type" attitude indicator for recovery from an upset.

During the approach to Perm's Bolshoye Savino Airport, the flight crew was challenged by night instrument meteorological conditions, as well as by a navigation programming error and a "throttle stagger" that made manual engine management difficult and led to control problems caused by asymmetric thrust. The copilot, the pilot flying, abruptly handed over control to the captain when the aircraft was in a steep climbing left turn. The captain, whose spatial disorientation was exacerbated by alcohol and fatigue, was unable to recover. The aircraft rolled nearly inverted, entered a steep descent and fragmented when it struck terrain at high


The accident aircraft landing at Perm in happier days.

speed. All 82 passengers and six crewmembers were killed.

The aircraft was operated by Aeroflot-Nord, which was rapidly adding 737s to its fleet and training pilots to fly them. The report said that there were "serious drawbacks" in the transition training that the accident pilots had received, and it faulted the airline for pairing a captain with limited experience as a pilot-in-command with a copilot with limited experience in type.

The captain, 35, had more than 3,900 flight hours, including 90 hours in an Antonov 2 during his primary training and about 2,700 hours as a Tupolev 134 copilot. His experience in 737s comprised 1,190 hours, with 477 hours as captain. The copilot, 43, had more than 8,900 flight hours, including about 7,000 hours in An-2s and 1,600 hours as a Tu-134 copilot. He had logged 236 hours in 737s.

The aircraft that the pilots had flown before transitioning to the 737 — the An-2, a large utility biplane, and the Tu-134, which has fuselage-mounted turbofan engines and a flight deck accommodating two pilots and a navigator — have "Eastern-type" attitude indicators, in which the horizon remains fixed horizontally and the aircraft symbol tilts to show bank angle (Figure 1). Conversely, the horizon line in the 737's Western-type attitude indicator tilts while the aircraft symbol remains fixed horizontally.

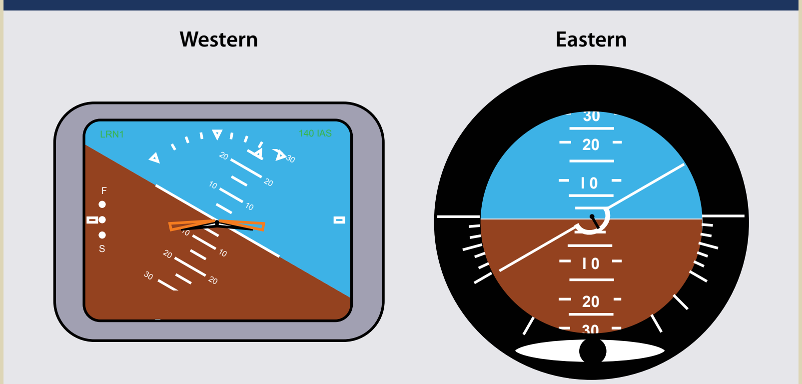
Neither pilot had any experience with two-pilot flight crew operations or modern "glass" flight decks when they began their 737 transition training. The captain was trained in 2006 at a U.S. facility that was not approved by Russian authorities. The report said that an adequate assessment of the training was not possible because the captain's file did not contain all the pertinent documents. The copilot was trained in 2007–2008 at an approved facility in Russia. His records reflected inattention to standard operating procedures and CRM practices, and substandard proficiency in flying with a thrust asymmetry. Instructors' notes recommended that the copilot pay more attention to controlling airspeed and attitude during approach.

Both pilots had received English language instruction at the airline's training center. Although they were not engaged in international flight operations, the training was necessary because all the documentation for the 737 was in English. Both pilots received passing grades. However, the report said that the relatively large amount of material included in the training syllabus and the relatively short period of training made it highly doubtful that the pilots assimilated all the instruction. Moreover, analysis of recorded statements by the copilot during the accident flight indicated that his English proficiency was not suitable for operating the 737, especially the flight management system (FMS) and autoflight systems.

## Throttle Stagger

The accident aircraft was among 12 737s operated by Aeroflot-Nord. The aircraft was owned by a Bermudan company, previously operated in China and had accumulated about 43,491 flight

**Attitude Indicator Display Differences**




Source: Daniel W. Knecht

**Figure 1**

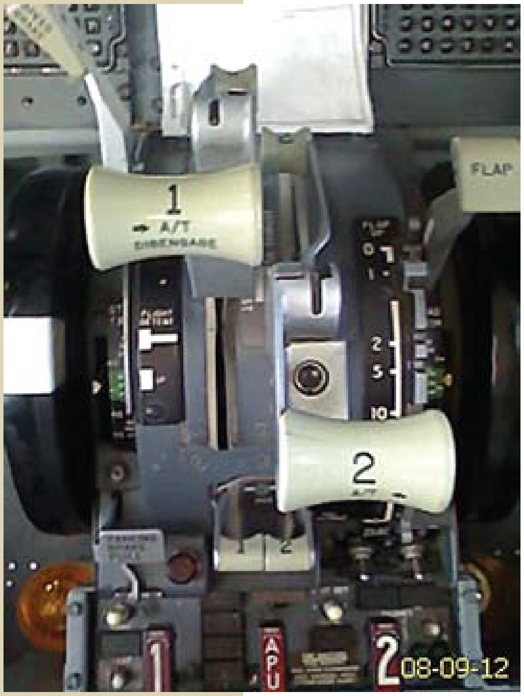



Photo taken on a previous flight shows throttle stagger required to maintain 83 percent fan speed on both engines.

hours when the airline began flying it about four months before the accident.

The aircraft had a throttle-stagger condition that exceeded the limits specified in the aircraft maintenance manual (AMM). This condition requires the throttles to be placed in different positions to match engine settings. Recorded flight data showed that during partial-power operations, engine fan speeds varied up to 20 percent with the throttles in the same position. Setting the engines to produce identical fan speeds resulted in a throttle stagger of up to 15 degrees, with the left throttle ahead of the right throttle. The report noted, however, that there was no throttle stagger at idle and "almost none" at takeoff power.

The report said that the airline's maintenance personnel did not follow the procedures recommended by the AMM to correct the problem, which initially was identified more than a month before the accident.

Maintenance documents indicated that the 737 was being operated with an inoperative traffic-alert and collision avoidance system and an inoperative autothrottle. The autothrottle was designated as inoperative because it had disengaged several times during a previous flight. However, maintenance personnel had not complied with minimum equipment list provisions requiring the circuit breakers to be pulled and "collared" to prevent them from being reset, and the autothrottle switch to be placarded as inoperative.

Investigators found that the autothrottle actually was functioning properly and that the uncommanded disengagements were related to the throttle stagger. Despite its designation as inoperative, the autothrottle was used during seven subsequent flights, including the accident flight.

## 'Totally Drunk'

The captain and copilot were conducting their third flight together. The scheduled departure time from Moscow's Sheremetyevo Airport was 2112 coordinated universal time (0312 local time). Both pilots had received 15 hours of rest before reporting for duty and had passed medical examinations before the flight. However, the report said that the captain's schedule during the previous three days did not comply with national regulations and was conducive to fatigue; he had conducted six flights, including two night flights, and had taken almost no rest at night.

Before starting the engines, the captain made a public address announcement to the passengers. The report said that one passenger sent a text message to a friend in England, saying that he was frightened because the captain sounded "like he is totally drunk." He said that other passengers were worried but had been assured by flight attendants that everything was all right.

While completing the initialization of the inertial reference system (IRS), the copilot made two slight errors in entering the stand's geographical coordinates in the FMS. The immediate result was a misposition of 1 minute, or approximately 1 nm (2 km). The captain, who was supposed to be monitoring the copilot's preflight actions, did not catch the error.

The 737 departed from Moscow at 2113. The captain flew the takeoff and then transferred control to the copilot. The copilot flew the aircraft with the autopilot and autothrottle engaged. Perm is about 675 nm (1,250 km) east of Moscow. The cruise altitude was 9,100 m (about 29,900 ft).

Because of the IRS initialization error and normal IRS drift — as well as the inability of the FMS to update its position via the global positioning system (the aircraft did not have a

U.K. Air Accidents Investigation Branch

GPS receiver) or signals from ground navigational facilities (there were none on the route) — the misposition increased to more than 4.5 nm (8.3 km) as the aircraft neared Perm. The crew began the descent at about 2245.

## Confusion Reigns

The automatic terminal information system indicated that surface winds at Perm were from 050 degrees at 6 kt, visibility was 5 km (3 mi) in light rain and mist, the ceiling was overcast at 240 m (787 ft) and the instrument landing system (ILS) approach to Runway 21 was in use.

The report said that analysis of cockpit voice recorder (CVR) data indicated that the captain likely experienced an inordinately high level of stress during the final phases of the flight. Conversation between the pilots often was not related to flight tasks and was replete with expletives and spiteful remarks about the flight attendants and the Airport Control Service. No checklists or mandatory cross-checks were performed, and few required callouts were made during the approach.

The CVR data also showed that the crew was confused by arrival instructions issued by the approach controller to facilitate an aircraft departing from Perm. The instructions differed from the standard arrival route and approach fixes that the copilot had entered in the FMS. After lengthy discussions with the captain, the controller told the crew to navigate directly to the outer marker for the ILS approach. The report said that this instruction annoyed the pilots.

Nearing the airport from the west, the crew relied solely on the inaccurate IRS navigation data rather than tuning the frequency for the outer marker and using the automatic direction finder as a backup. As a result, the aircraft crossed over the runway, rather than the outer marker. The controller did not mention this to the crew.

Following the controller's radar vectors, the copilot maneuvered the 737 onto a right downwind leg for Runway 21 while descending to 2,100 m (about 6,900 ft). The autopilot was in a navigation mode, and the copilot became confused when the aircraft began turning left. "Where's it going?" he said. "I don't understand where it's going." The captain told the copilot to use the autopilot's heading mode.

When power was increased to level the aircraft at 2,100 m, the throttle stagger became so great that the autothrottle automatically disengaged. The captain told the copilot to control the engines manually. Rather than positioning the throttles to match engine fan speed, however, the copilot kept the throttles together. The resulting asymmetric thrust caused a significant left roll moment.

At 2301, the controller issued a further descent clearance to 600 m (about 1,970 ft) and told the crew to maintain 190 kt. The controller then said, "Are you descending? My radar shows 1,800." The report said that the question provoked an "intense reaction" by the captain, who asked "twice emotionally" how low they should descend. The copilot replied that the assigned altitude was 600 m and then said, "Why doesn't it descend? I've pressed heading select." The CVR recording indicated that the captain was annoyed when he told the copilot to select the autopilot's level change mode.

## 'Take It'

The controller told the crew to turn to the base leg when ready but did not assign a heading. The copilot turned the 737 from the 030-degree downwind heading to a southerly heading to intercept the ILS localizer.

The aircraft was still in the clouds when it reached 600 m. After the copilot advanced the throttles to hold that altitude, the autopilot reached the limits of its control travel in countering the left roll moment, and the aircraft began turning left. The copilot attempted to use the control wheel steering switch to manually level the wings while keeping the autopilot on line but inadvertently pressed the stabilizer-trim switch, causing the autopilot to disengage.

The copilot was unable to maintain control. The aircraft was in a 30-degree left bank and a 20-degree nose-up attitude at 2308, when he told the captain, "Take it. Take it."

The report said that the captain had lost situational awareness during a long discussion with the approach controller. "Take what?" he asked. "I can't do it either." The captain abruptly applied left aileron and did not correct the pitch attitude. The bank angle increased to 76 degrees, and the aircraft made an almost full barrel roll before descending to the ground, the report said.

A postmortem examination of the captain revealed that the level of ethyl alcohol in his body before he died exceeded regulatory limits, the report said. No alcohol was found in the bodies of the other crewmembers.

*This article is based on the English translation of AAIC final report no. B737-505 VP-BKO. The official report, in Russian, is available at <www.mak.ru/russian/investigations/2008/vp-bko_report.pdf>. The English translation is available from the U.K. Air Accidents Investigation Branch at <www.aaib.gov.uk/publications/foreign_reports.cfm>.*

# PROFESSIONALISM COUNTS

BY JOHN ALLEN

*John M. Allen is director, Flight Standards Service of the U.S. Federal Aviation Administration*

All pilots are trained to be diligent and precise. We are trained to use checklists and to follow rules to the letter. If we advance to commercial service, we wear professional uniforms that indicate to our passengers that we are the people responsible for keeping them safe.

Regrettably, we've seen a number of instances over the last year or so in which professionalism was wanting. People who should have known better — who were trained to know better — allowed themselves to become complacent, or even worse, cavalier. Too often, we hear of pilots who allow themselves to lose focus and flight discipline, especially below 10,000 ft when idle conversation should cease.

The passenger sits in the cabin comfortably, knowing that the men and women up front are solely focused not just on getting there but on getting there safely. Passengers trust that the well-trained and experienced pilots flying the plane take their jobs seriously and are acutely aware and prepared whenever they enter a cockpit.

That's where professionalism enters the picture.

We use checklists not because we're afraid we'll forget or overlook. We use them because they form the backbone of precision — precision that means we take a task that we've done a thousand times and treat it like we're doing it for the first time.

We know about redundancies and back-up systems, and we mentally flip through alternate scenarios and contingencies all the time. Even if we have never experienced an unusual event, we run through what we'd do if one occurred and plan for the unexpected. And flight instructors and check pilots introduce scenarios such as an engine-out on takeoff, even though such events may never occur in a pilot's lifetime of flying.

There can be no argument on this point. The only way for us to step up to the next level of safety is to intensify the practices and procedures that have brought us this far. But there is one particular skill that's not mentioned in any of our logbooks or in the rules for general aviation or air carriers.

I'm talking about a transfer of experience — mentoring. If you're a long-time veteran, you need to go out of your way to impart wisdom to the ones just coming on line. As I've said on more than one occasion, this needs to be stamped on our foreheads. It needs to become part of our DNA.

The primary requirement for mentoring is that you speak up. If you've got experience and you're keeping your mouth shut, you're doing a disservice to our profession. This is not the time to be a person of few words. New pilots need to hear from you. This is about safety, and safety is about saving lives.

I learned from professionals that you have to work at professionalism, and that takes discipline. The real professionals among us always have time to do things the right way at the right time every time. They lead by example, and they always have time to explain what they did, why and how. They study, they practice, and they take notes on their own performance. They know how they've done, and they're willing to share those pearls of wisdom.

Now I appeal to you to make sure that you do the same. Lessons learned need to be transferred to your younger colleagues. Everyone makes mistakes, but the experienced pilots among you are in the position to prevent catastrophe and to breed in professionalism.

It's with this same approach in mind that I ask you to embrace the advances that are coming on line with NextGen, our plan to modernize the system. I want you to take particular notice that I did not call it "FAA's plan," because it is not that in any way, shape or form. NextGen has been designed specifically with you in mind. We have reached out to industry, manufacturers, line pilots, engineers, mechanics, dispatchers, and even an attorney or two.

**If you're a long-time veteran, you need to go out of your way to impart wisdom to the ones just coming on line.**

The result is an upgrade — a sweeping overhaul, really — that quite literally will change how we fly. For those of us who remember the days before the traffic-alert and collision avoidance system (TCAS), this change will be along those same lines. It very well may be a transformation on the same order of magnitude as the introduction of radar.

NextGen uses the latest computer, software and satellite firepower to give us a level of situational awareness we've never seen. While it's true that we've got a system that's humming along quite nicely, something better is coming online as we speak. There's no need for trepidation. I can remember as a line pilot having my doubts about CAT II [Category II instrument landing system] auto land — until I made my first one at Frankfurt International Airport.

Moving from the analog world into the digital environment will be easier to handle than we realize. Giving up the "control" to a machine wasn't easy for me, but it made the system safer and gave me another tool in the cockpit, with the human still playing an essential role.

But in both cases — professionalism and NextGen — the primary element for success rests with you. I'm counting on you to help make it happen. In the meantime, fly safe.

BY WAYNE ROSENKRANS

# Survival on the Hudson

**Inattention to safety briefings, life vests and life lines increased risks after US Airways Flight 1549 touched down.**

The public's intuition that "fortuitous" circumstances contributed to all occupants surviving the January 2009 ditching of an Airbus A320 in the Hudson River has been seconded by the final accident report of the U.S. National Transportation Safety Board (NTSB) on US Airways Flight 1549.[1] Now-famous images of people without life vests or life lines standing on the wings, however, contain a less obvious message about shared responsibility for safety aboard aircraft. Rather than dwell on the unusually favorable circumstances, the NTSB took the opportunity to redirect the attention of government, the airline industry and the

© AP Photo/Alexandre Valerio

**Close proximity of personnel and vessels capable of rescuing Flight 1549 occupants overcame the serious threat of cold water immersion.**

traveling public to the critical survival factors they do control.

For example, noting that "only about 10 passengers [of 150] retrieved life vests themselves after impact and evacuated with them" and that only 77 retrieved flotation-type seat cushions, the survival factors sections of the report essentially said that crewmembers and passengers disregard at their peril the life-saving knowledge and equipment provided. "The NTSB notes that, after exiting the airplane through the overwing exits, at least nine passengers unintentionally fell into the water from the wings," the report said.

Several explanations were offered by investigators. "Although the accident flight attendants did not command passengers to don their life vests before the water impact, two passengers realized that they would be landing in water and retrieved and donned their life vests before impact, and a third passenger attempted to retrieve his life vest but was unable to do so and, therefore, abandoned his attempt," the report said. "Many passengers reported that their immediate concern after the water impact was to evacuate as quickly as possible, that they forgot about or were unaware that a life vest was under their seat, or that they did not want to delay their egress to get one. Other passengers stated that they wanted to retrieve their life vest but could not remember where it was stowed." In all, 101 life vests were left stowed under passenger seats.

The accident analysis does not devalue the positive outcomes of the captain's judgment, the cabin crew's performance or the passengers' orderly behavior, and the report notes, "The NTSB concludes that the captain's decision to ditch on the Hudson River[2] rather than attempting to land at an airport provided the highest probability that the accident would be survivable. … Contributing to the survivability of the accident was the decision making of the flight crewmembers and their crew resource management during the accident sequence; the fortuitous use of an airplane that was equipped for an extended-overwater [EOW][3] flight, including the availability of the forward slide/rafts, even though it was not required to be so equipped; the performance of the cabin crewmembers while expediting the evacuation of the airplane; and the proximity of the emergency responders to the accident site and their immediate and appropriate response to the accident," the report said.


U.S. National Transportation Safety Board (Photo courtesy of passenger 4C)

The lessons learned reflected the importance of leaving as little to chance as possible in preparations to survive an aircraft accident. "The investigation revealed that the success of this ditching mostly resulted from a series of fortuitous circumstances, including that the ditching occurred in good visibility conditions on calm water and was executed by a very experienced flight crew. … "The investigation revealed several areas where safety improvements are needed," the report said.

The accident airplane was one of 20 EOW-equipped A320s — among the airline's fleet of 75 A320s. Each of four slide/rafts was rated to carry 44 people and had an overload capacity of 55. Also aboard, but not counted toward EOW equipment, were two off-wing ramp/slides, one at each pair of overwing exits.

"The accident airplane had the statements, 'Life Vest Under Your Seat' and 'Bottom Cushion Usable for Flotation,' printed on the [overhead] passenger service units (next to the reading light switches) above each row of seats," the report said. The four life lines were designed to be retrieved after ditching from an overhead bin, attached to top corners of door frames on both sides of the airplane fuselage and anchored to a designated point on top of each wing.

The importance of these items becomes clear by considering that only two detachable slide/rafts were available for Flight 1549 occupants

Top, one passenger jumped into the 41° F (5° C) Hudson River from door 1L before the slide/raft was deployed manually; bottom, overwing-exit life line–attachment points were unused, and nine passengers fell into the water.

Photos: U.S. National Transportation Safety Board

— at door 1L and door 1R — with a combined capacity to carry 110 of the 155 occupants if the airplane had sunk before they were rescued. The NTSB determined that about 64 occupants were rescued from these slide/rafts, while about 87 were rescued from the wings and off-wing ramp/slides.

## Survival Scenario

Loss of thrust in both engines prompted the captain of Flight 1549 to commit to the ditching as the safest course of action despite its necessitating an evacuation in harsh winter temperatures. The flight crew later said that its top priority then was to touch down with a "survivable sink rate." Analysis of the digital flight data recorder showed that "the airplane touched down on the Hudson River at an airspeed of 125 kt calibrated airspeed with a pitch angle of 9.5 degrees, [a descent rate of 12.5 fps] and a right roll angle of 0.4 degree," the report said.

The evacuation began within seconds after the airplane's rapid deceleration on the river's surface after touchdown at about 1527 local time. The captain opened the flight deck door and commanded an evacuation by speaking directly to the forward flight attendants and passengers. He observed then that the evacuation already had begun.

"The water in the back of the airplane rose quickly, which, in addition to improvised commands from flight attendant B to 'go over the seats,' resulted in numerous passengers climbing forward over the seatbacks to reach a usable exit," the report said. "However, some aft passengers remained in the aisle queue to the overwing exits. Many of these passengers noted that, when they arrived at the [overwing] exits, the wings were crowded and people were exiting slowly. They also reported that the aisle forward of the overwing exits was completely clear and that the flight attendants were calling for passengers to come forward to the slide/rafts."

The NTSB estimated the evacuation sequence and timing: The left overwing exits were opened by passengers at 1530:58, contrary to the airline's ditching procedures, and the first passenger subsequently exited; flight attendant A opened door 1L to its locked-open position against the fuselage at 1531:06, and no water entered, but this crewmember had to operate the manual inflation handle to deploy the slide/raft because the automatic system appeared to have failed; flight attendant C opened door 1R at 1531:11, automatically causing full deployment of the slide/raft at 1531:16; one passenger jumped into the water from door 1L at 1531:23 before its slide/raft began to inflate; the slide/raft at door 1L began to inflate at 1531:26; the first vessel arrived on scene at 1534:40; and the last vessel departed the scene after rescuing the last passengers from the left off-wing ramp/slide at 1554:43.

Eight of the passengers exited the aircraft, re-entered the aircraft to obtain one or more life vests, then exited from a different door. Flight attendant B did not become aware of a serious injury to her left shin until aboard the door 1R slide/raft.

"A review of passenger exit usage indicated that, in general, passengers from the forward and mid parts of the cabin evacuated through the exit closest to their seats," the report said. "However, aft-seated passengers indicated that water immediately entered the aft area of the airplane after impact and that the water rose to the level of their seat pans within seconds; therefore, they were not able to exit from their closest exits because these exits were no longer usable."

Several safety equipment irregularities occurred, affecting crew actions and passenger behavior. "Flight attendant C … stated that door 1R started to close during the evacuation, intruding about 12 in [30 cm] into the doorway and impinging on the slide/raft," the report said. "She stated that she was concerned that the slide/raft would get punctured, so she assigned an 'able-bodied' man to hold the door to keep it off of the slide/raft."

One female passenger with a lap-held child received assistance from a fellow passenger shortly before the touchdown. "When the captain [announced] 'Brace for impact,' the male passenger in [seat] 19F offered to brace her [nine-month-old] son for impact," the report said. "The lap-held child's mother [in seat 19E] stated that she thought the passenger in 19F 'knew what he was doing,' and she gave her son to him." None of these passengers was injured.

All three flight attendants described the evacuation process as relatively orderly and timely. The captain and first officer said that while assisting the cabin crew with the evacuation, they observed passengers without life vests outside the airplane. "[The captain and first officer] obtained some life vests from under the passenger seats in the cabin and passed them out to passengers outside of the airplane," the report said. The flight crew also conducted the final cabin inspection to ensure no passengers had been left, then exited onto the slide/raft at door 1L.

## Emergency Response

Air traffic control tower personnel at LaGuardia Airport activated the area's emergency alert notification system via its crash telephone at 1528:53. This immediately notified numerous agencies to respond with predetermined personnel and equipment according to the LaGuardia Airport emergency plan. The airport dispatched one rescue boat. Personnel from New York Waterway (NY WW) also responded to the accident although they were not part of the emergency plan.

"The airplane was ditched on the Hudson River near the NY WW Port Imperial Ferry Terminal in Weehawken, New Jersey," the report said. "Many NY WW ferries were operating over established routes in the local waterway, and the ferry captains either witnessed the accident or were notified about it by the director of ferry operations. Seven NY WW vessels responded to the accident and recovered occupants."

The first responders considered the winter weather conditions a serious risk to survival. "The post-crash environment, which included a 41° F [5° C] water temperature and a 2° F [minus 17° C] wind chill factor, and a lack of sufficient slide/rafts (resulting from water entering the aft fuselage) posed an immediate threat to the occupants' lives," the report said. "Although the airplane continued to float for some time, many of the passengers who evacuated onto the wings were exposed to water up to their waists within two minutes."

The Port Imperial Ferry Terminal was designated as the central triage site; nevertheless, captains of vessels dropped off the Flight 1549 occupants at the closest locations in New York and New Jersey because the aircraft was drifting and some passengers were wet and at risk of cold-induced injury.

Among the 45 passengers and five crewmembers transported to hospitals, flight attendant B and two passengers had sustained serious injuries. One of those

Top, the detachable door 2L slide/raft was one of two unavailable due to aft water entry; bottom, a manual inflation handle and a ditching release handle were found in the forward galley.

Top, life vest storage pouches were beneath economy-class seats on Flight 1549; bottom, the FAA had tested four underseat stowage configurations.

U.S. National Transportation Safety Board

U.S. Federal Aviation Administration

passengers was admitted to a hospital for treatment of hypothermia. The other was treated for a fractured xiphoid process, an "ossified extension" of the lower part of the sternum. "Two passengers not initially transported to a hospital later furnished medical records to the NTSB showing that one had suffered a fractured left shoulder and the other a fractured right shoulder," the report said. "Flight attendant B sustained a V-shaped, 12-cm-long 5-cm-deep [5-in by 2-in] laceration to her lower left leg that required surgery to close." The cause of flight attendant B's laceration was a vertical beam that punctured the cabin floor in front of her jump seat about 11 in (28 cm) forward of the seat pan.

## Life Vest Awareness

Passenger interviews indicated that about 70 percent of the passengers did not watch any of the preflight safety briefing. "The most frequently cited reason for [inattention] was that the passengers flew frequently and were familiar with the equipment on the airplane, making them complacent," the report said.

Flight 1549 passengers could learn about the availability of life vests only from the safety information cards in seatback pockets or the overhead statements, although some assumed that all commercial passenger jets carry life vests. "US Airways' FAA-accepted In-Flight Emergency Manual followed [FAA] advisory circular guidance and specified that, if the airplane is equipped with both flotation seat cushions and life vests, flight attendants should brief passengers on both types of equipment, including the location and use of life vests," the report said. "The cockpit voice recorder recorded flight attendant B orally brief the location and use of the flotation seat cushions; however, it did not record her brief the location of or the donning procedures for life vests. … A life vest demonstration was not required because the flight was not an EOW operation."

## Braced But Injured

The safety information cards also provided instructions on the operation of the emergency exits and depicted passenger brace positions that were similar to FAA guidance on brace positions. Three of four seriously injured passengers were hurt during the airplane's impact with the water.

"The two female passengers who sustained very similar shoulder fractures both described assuming similar brace positions, putting their arms on the seat in front of them and leaning over," the report said. "They also stated that they felt that their injuries were caused during the impact when their arms were driven back into their shoulders as they were thrown forward into the seats in front of them. The brace positions they described were similar to the one depicted on the US Airways safety information card."

The passenger seats on the accident airplane were 16-g compatible seats. The NTSB noted that new seats have a nonbreakover seatback design, which minimizes head movement and body acceleration before striking the seatback from behind, resulting in less serious head injuries.

"Guidance in [FAA Advisory Circular 121-24C] did not take into consideration the effects of striking seats that do not have the breakover feature because research on this issue has not been conducted," the report said. "The NTSB concludes that … in this accident, the FAA-recommended brace position might have contributed to the shoulder fractures of two passengers."

## Unused Life Vests

Overall, 19 passengers attempted to obtain a life vest from under a seat, and 10 of them reported difficulties retrieving it. "Of those 10 passengers, only three were persistent enough to eventually obtain the life vest; the other seven either retrieved a flotation seat cushion or abandoned the idea of retrieving flotation equipment altogether," the report said.

Most passengers who attempted to don or donned life vests already were seated in a slide/raft, ramp/slide or standing on a wing. "Of the estimated 33 passengers who reported eventually having a life vest, only four confirmed that they were able to complete the donning process by securing the waist strap themselves," the report said. "Most of the passengers who had life vests either struggled with the strap or chose not to secure it at all for a variety of reasons."

Airline industry safety standards for overwater flight have not anticipated scenarios in which passengers exit onto the wings after a ditching, the report said. "Each overwing exit pair [in this case] was equipped with an automatically inflating, off-wing Type IV exit ramp/slide," the report said. "The off-wing ramp/slides did not have quick-release handles [for detachment]."

Despite a regulation requiring the life lines at overwing exits — which are intended to be opened by passengers, not flight attendants — circumstances in which they could be used effectively after ditching have been unclear, the report said. The passenger safety information card lacked information about the location of the life lines and how to use them. "Further, no information is provided to passengers about life lines during the preflight safety demonstration or individual exit row briefings," the report said, and placards above the overwing exit signs only depicted deployed life lines from a pair of overwing exits. The NTSB concluded that life lines could have been used to assist Flight 1549 passengers on both wings, "possibly preventing them from falling into the water."

The off-wing ramp/slides on the accident airplane, as is typical in the industry, had no quick-release girts to enable occupants to free the ramp/slides from the sinking airplane for flotation out of the water or handholds. "Some passengers immediately recognized their usefulness and boarded the ramp/slides to get out of the water," the report said. "Eventually, about eight passengers succeeded in boarding the left off-wing slide and about 21 passengers, including the lap-held child, succeeded in boarding the right off-wing ramp/slide."

Summary statements in the report encouraged the government and airline industry to reconsider past NTSB recommendations validated by facts of this event. "The circumstances of this accident demonstrate that even a non-EOW flight can be ditched, resulting in significant fuselage breaching," the report said. "Therefore, all passengers, regardless of whether or not their flight is an EOW operation, need to be provided with adequate safety equipment to ensure their greatest opportunity for survival if a ditching or other water-related event occurs."

*To read an enhanced version of this story, go to <flightsafety.org/asw/jul10/hudsonsurvival.html>.*

**'Most of the passengers who had life vests either struggled with the strap or chose not to secure it at all for a variety of reasons.'**

### Notes

1. NTSB. "Aircraft Accident Report: Loss of Thrust in Both Engines After Encountering a Flock of Birds and Subsequent Ditching on the Hudson River, US Airways Flight 1549, Airbus A320-214, N106US, Weehawken, New Jersey, January 15, 2009." Accident Report NTSB/AAR-10/03, PB2010-910403, Notation 8082A, May 4, 2010. The report contains safety recommendations, including references to NTSB safety recommendations dating from the 1980s that remain relevant to survival factors. It is available at <www.ntsb.gov/publictn/2010/AAR1003.pdf>.
2. About two minutes after takeoff, at an altitude of 2,800 ft, the aircraft experienced an almost complete loss of thrust in both engines after encountering a flock of birds and subsequently was ditched about 8.5 mi (14 km) from LaGuardia Airport, New York City, New York, U.S. The accident occurred Jan. 15, 2009.
3. EOW operations, with respect to aircraft other than helicopters, are operations over water at a horizontal distance of more than 50 nm (93 km) from the nearest shoreline.

# Diminishing Skills?

**An examination of basic instrument flying by airline pilots reveals performance below ATP standards.**

BY MICHAEL W. GILLEN

With the advent of advanced, highly automated cockpits in current transport category jet aircraft, pilots no longer fly solely by reference to raw data from airplane instruments, and as a result, their basic instrument flying skills may have diminished.

In a study designed to assess their instrument flying skills, 30 airline pilots were asked to perform five basic instrument maneuvers without using automation. In addition, the pilots were questioned about their perceptions of their own instrument skill levels. Analysis of the findings revealed that, although the pilots believed that they retained a high degree of skill, all of the flight maneuvers were performed at levels below those required for U.S. airline transport pilot (ATP) certification.

Previous studies have found that opportunities for pilots to practice and maintain their skills decrease significantly over time, in part because of airline policies, advanced automation and increased long haul flying. In addition, a 1998 report from the Australian Bureau of Air Safety Investigation (now the Australian Transport Safety Bureau) found that 43 percent of pilots surveyed said that their manual flying skills had declined after they started flying advanced technology aircraft.[1]

Most pilots hand fly their aircraft at some stages of each flight. Anecdotal evidence indicates that the main reasons for this are the pilot's personal satisfaction in performing manual flying tasks, the requirement to perform manual flying exercises during simulator sessions (including recurrent training and license renewal) and the need to be able to manually fly the aircraft should the automated systems fail.

Nevertheless, it appears that both the pilots who were tested and their airlines have failed to maintain their perceived level of manual flight skills. In response, some airlines have implemented supplementary simulator programs to bolster these skills.[2]

A 1996 report by the U.S. Federal Aviation Administration (FAA) Human Factors Team — established after the April 26, 1994, crash of a China Airlines Airbus A300 in Nagoya, Japan, that killed 264 people and seriously injured seven — found that pilots often misunderstood the operation of automation equipment, as well as when it should be used.[3]

For example, accident investigators found that the China Airlines first officer had been hand flying the A300, with the autothrottles engaged, on an instrument landing system (ILS) approach when he inadvertently selected the takeoff/go-around mode, causing an increase in thrust. The crew disengaged the autothrottles and manually reduced thrust but then engaged the autopilot and failed to recognize that it was trimming the horizontal stabilizer nose-up.

The Human Factors Team said that its members were concerned that incidents and accidents such as this one appeared to highlight difficulties in flight crew interactions with increasing flight deck automation.

A follow-up report by the FAA Performance-Based Operations Aviation Rulemaking Committee and the Commercial Aviation Safety Team (CAST) is expected to be released later this year.

Other studies in the 1990s found that highly automated cockpits tend to change the ways pilots perform tasks and make decisions. The studies identified problems in the use of advanced automated systems, including mode misunderstanding, failures to understand automated system behavior, confusion or lack of awareness concerning what automated systems are doing and why, and difficulty tracing the functioning or reasoning process of automated agents.[4,5]

## Focus on Instrument Flight

The study that is the subject of this article gathered data from airline pilots employed by U.S. carriers during a recurrent training cycle. The average experience level of the 30 participating pilots was 7.1 years (in both aircraft and seat) with a range from two to 16 years. Seventeen of the pilots were captains and 13 were first officers; 18 flew narrowbody airplanes, and 12 flew widebody airplanes.

The study focused on two aspects of basic instrument flying. First, a qualitative survey was given to pilots to gauge their perception of their own instrument skills. The second part of the study required the use of "first look" data — data derived from a pilot flying a maneuver without a pre-briefing — from participating airlines. The first look data were obtained from a maneuver set comprising a takeoff, an ILS approach, holding, a missed approach and an engine failure at $V_1$.[6] These maneuvers were flown without the use of autothrottles, a flight director or a flight management computer/map and solely by reference to raw data obtained from the heading, airspeed, attitude and vertical speed instruments. The data subsequently were de-identified.

**Eighty percent of the pilots said that they 'strongly agree' with the survey statement 'I usually hand fly the aircraft below 10,000 ft.'**

## Simulator Performance

The pilots performed the five basic instrument maneuvers in an FAA-certified Level D simulator — the most advanced type of simulator, with a 180-degree wrap-around visual display and a daylight visual system. The maneuvers were rated by an FAA-certified check pilot and were graded on a scale of 1 through 5, based on the standards of both a major airline and the FAA.

The rating scale was as follows:

- 5 — Well within airline standards. Performance was exemplary.
- 4 — Within airline standards. Pilot flew to ATP standards.
- 3 — Minor deviations from airline standards that were promptly corrected. Pilot flew at the basic instrument level.
- 2 — Major deviations (e.g., full-scale localizer/glideslope deflection) for more than 10 seconds.
- 1 — Major deviations from airline standards that were not promptly corrected and/or were unsafe; or the pilot was unable to perform the maneuver/task without assistance. Crash or loss of control.

## Comparisons

The type of aircraft the pilots typically flew was a factor in comparing both the survey responses and the performance of maneuvers. The pilots were divided into two categories determined by the aircraft that they were flying at the time: widebody (A340, Boeing 747, 767) or narrowbody (A320, 737, 717). This distinction was required because these two pilot groups fly a similar number of hours per month but have vastly different numbers of takeoffs and landings. During a typical 20-hour assigned flight sequence, a narrowbody pilot may conduct as many as 12 or 15 takeoffs and landings, whereas a widebody pilot typically would conduct two. Because of the higher number of cycles, narrowbody pilots might be expected to perform better on the maneuvers than widebody pilots.

## 'Glass' vs. Non-'Glass'

The study compared self-reported experience in "glass" airplanes — those with highly automated flight management systems and electronic flight instrument systems — and non-glass airplanes, along with the amount of time that had passed since the pilot last flew a non-glass aircraft, a majority of which are being retired. These results were further analyzed to take into account specific survey responses relating to pilot experience.

In answer to these questions, more than 56 percent of the pilots said that they had either never flown a non-glass aircraft or that the last flight had been more than 10 years earlier.

Forty-six percent said that they had spent two years or less flying non-glass aircraft, compared to 20 percent who had flown non-glass aircraft for more than 10 years.

In contrast, 73 percent said that they had been flying glass aircraft for at least 10 years. None of the surveyed pilots indicated that he or she had two years or less in glass aircraft.

## Self-Assessments

In assessing their own basic instrument flying skills, 80 percent of the pilots said that they "strongly agree" with the survey statement "I usually hand fly the aircraft below 10,000 ft." A pilot retains maximum skill by routinely hand flying below this altitude in the most maneuver-intensive phases of flight. The positive responses, however, did not indicate if the pilots had been using all of the aircraft's advanced capabilities or flying by "raw data" while hand flying.

Sixty percent of the pilots agreed with the statement that they feel comfortable flying by reference to raw data only.

In response to the statement "I could fly a takeoff, $V_1$ cut, ILS and a missed approach using only raw data," 53 percent of pilots strongly agreed and 47 percent somewhat agreed. No pilots disagreed with the statement. Although their responses indicate that the pilots believed that they could fly these maneuvers, the "somewhat agree" responses indicate that some believed that their performance might not be perfect.

Asked if they believed that their basic instrument skills had declined over time, 26 percent of pilots strongly agreed, and 53 percent said that they "somewhat agree." Only one pilot strongly disagreed with the statement; however, 16 percent said they "somewhat disagreed."

More than three-quarters of pilots said that they practice basic instrument skills often, with 33 percent strongly agreeing and 46 percent somewhat in agreement with that statement. Twenty percent of the pilots somewhat disagreed with the statement.

## Simulator Performance

Analysis showed that the average grades given the pilots for their performance of the five maneuvers were significantly below the FAA's standards for acceptable ATP performance and closer to the basic instrument level (Table 1).

The lowest rating — less than 2.4 — was for the holding maneuver, which rarely, if ever, is performed by reference to raw data instrumentation. The highest — 3.2 — was for takeoffs, which typically involve reference to such instrumentation.

Further analysis of the data revealed no significant differences between the pilots of widebody and narrowbody airplanes in their performance on the individual maneuvers or on a composite measure.

## Misplaced Confidence?

Technical failures in advanced glass aircraft can significantly degrade cockpit instrumentation. Poor basic instrument flying skills make these

**Maneuver Ratings**

| | Number of Pilots | Mean[1] |
|---|---|---|
| Takeoff maneuver | 30 | 3.2000 |
| $V_1$ cut maneuver | 30 | 3.0333 |
| Holding maneuver | 30 | 2.3667 |
| ILS maneuver | 30 | 2.9667 |
| Missed approach | 30 | 3.0667 |

ILS = instrument landing system

**Note**

1. The mean is the average of maneuver ratings received by all 30 participants. Each maneuver was rated on a scale from 1 to 5. A grade of 4 represented the standards established by the U.S. Federal Aviation Administration for an airline transport pilot.

Source: Michael W. Gillen

**Table 1**

failures more difficult to detect because cross-checking raw data from the basic instruments is the key factor in quickly identifying failures.

In addition, when these failures occur, pilots must use basic instrument skills to safely fly the airplane. Pilots who are competent in basic instrument flying enhance their overall flying skills; because they can devote less attention and cognitive function to physically flying the airplane, they can spend more time managing their environment.

**Most pilots in the study agreed that their instrument skills have declined over time.**

Although most pilots in the study agreed that their instrument skills have declined over time, their survey responses indicated that they felt they could still fly basic instrument maneuvers. However, their survey responses do not correlate with their actual maneuver grades, leading to the conclusion that the pilots had a false sense of confidence.

The maneuver grades generally conform to what the literature review revealed in related studies that found that skills, when not used, decline over time. This was observed throughout the study in the average maneuver grades.

The suggestion in earlier studies was that if a skill set was learned and practiced over a long period of time, it would be retained longer than if it was practiced over a shorter period of time. This was not seen in the widebody–narrowbody comparison. Although pilots of widebody aircraft had more experience flying older-generation aircraft, their maneuver grades were similar to those of narrowbody pilots, and there was no statistical difference between maneuver grades for the two groups. This is most likely because, as mentioned earlier, although both groups of pilots fly a similar number of monthly hours, narrowbody pilots fly many more cycles than widebody pilots and spend more time maneuvering the aircraft; one result is improved flying skills.

The results of the maneuvers performed as part of this study show that airline pilots' basic instrument skills may decline over time. This is associated with the decreased use of these skills in routine line flying. In addition, newer-generation aircraft generally do not lend themselves to basic instrument flying, and most companies do not train or promote this type of flying. Although rare, some failures in advanced glass aircraft can degrade aircraft instrumentation to the extent that pilots must fly the aircraft using raw data. During the past 10 years, two such failures have occurred at an airline that participated in the study. In both cases, the flight crews landed the airplanes safely.

Airline safety can be improved by ensuring that pilots are competent not only when all advanced instrumentation is functioning but also when that instrumentation fails. Pilots possessed these basic instrument skills at one time in their careers, and their skill levels can be increased through training and practice.

*Michael W. Gillen is an A320 captain for a major U.S. airline and a former manager of human factors at that airline. He also is owner and president of Colorado Aviation Consultants, which provides consulting, safety seminars and worldwide aircraft ferry and test services.*

## Notes

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6. U.S. Federal Aviation Regulations Part 1.2 defines $V_1$ 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. $V_1$ also means the minimum speed in the takeoff, following a failure of the critical engine at $V_{EF}$, at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance." ($V_{EF}$ is "the speed at which the critical engine is assumed to fail during takeoff.")

U.S. National Transportation Safety Board

# FRACTURED BLADE

**Accident investigators traced the fatal crash of an AS 350D to a fatigue fracture in a power turbine blade.**

BY LINDA WERFELMAN

The fatigue fracture of an Aerospatiale AS 350D power turbine blade caused a loss of engine power that led to the May 24, 2008, fatal crash of an Island Express Helicopters air taxi flight on Santa Catalina Island off the coast of California, the U.S. National Transportation Safety Board (NTSB) says.

One passenger was killed in the accident, along with the pilot and another Island Express employee; the three other passengers received serious injuries. The helicopter was destroyed.

The accident flight began at 0907 local time, when the helicopter left the Queensway Bay Heliport in Long Beach, California, to transport the four passengers to Two Harbors in Avalon on Santa Catalina Island. After departure from Long Beach, the pilot "reported via radio that they were mid-channel at 0914 and that they were on final to land at 0919," the NTSB said in the final report on the accident.

Witnesses said that they had seen the helicopter approaching the island from the north at about 300 ft above ground level (AGL). As it neared the landing site at Two Harbors, they heard a "pop" and saw flames from the back of the engine. The helicopter then descended, struck the ground and burst into flames.

One of the surviving passengers said that just after the popping sound, the pilot told the passengers that he intended to conduct an autorotation.

"Since the pilot stated to passengers that he was going to autorotate, it is likely that the helicopter experienced a loss of power after the loud pop," the report said.

"During the descent, the pilot had to clear numerous obstacles, including buildings and power lines, to reach an open field located beyond the obstacles but short of the normal landing area. … Because of the relatively low altitude at which the loss of power occurred, it is likely that the accident pilot had to trade rotor rpm to maintain the altitude needed to clear the obstacles and reach the open field. This would have resulted in a lack of sufficient rotor rpm to arrest the helicopter's descent rate as it approached the ground."

## First Flight of the Day

The accident flight was the pilot's first flight of the day, on his 14th consecutive duty day.

He held a commercial pilot certificate with a rotorcraft helicopter rating and an instrument rating, along with a flight instructor certificate with a rotorcraft helicopter rating. U.S. Federal Aviation Administration (FAA) records showed that the pilot had failed his first practical test for the flight instructor certificate in April 1998 because of unsatisfactory performance of a straight-in autorotation; the following month, he passed his second practical test and was granted the certificate.

When the accident occurred, he had accumulated 5,692 flight hours, including 3,942 hours in AS 350-series helicopters, 63 hours of simulated instrument flight and 340 hours at night. He was hired by Island Express in January 2003 and completed initial new hire training in March, when he passed an airman competency/proficiency check administered by the FAA principal operations inspector. The inspector said that the pilot "did rather well" on his check ride, performing maneuvers that included a straight-in autorotation, a hovering autorotation and a simulated engine failure.

The helicopter was manufactured in 1984. Its original Turbomeca Arriel 1B engine had been replaced in 2001 by a Honeywell LTS101-600A-3. The helicopter had accumulated 9,687 flight hours, and had a total airframe time of 9,681 hours and an engine total time of 13,027 hours or 30,199 power turbine cycles. The last annual inspection was completed July 17, 2007, at 8,708 hours.

Records showed that during the accident flight, the helicopter was being operated within published weight and balance limits.

The helicopter was registered to Island Express in 2000, after previously having been operated by companies in several other states. The company was authorized to conduct flights under U.S. Federal Aviation Regulations Part 135, "Commuter and On-Demand Operations," and to maintain its helicopters according to the original equipment manufacturer maintenance programs.

Island Express Helicopters, based in Long Beach, was founded in 1982 and conducts on-demand flights, sightseeing flights and flights to service offshore oil platforms near Huntington Beach and Long Beach. Company officials estimated that their helicopters fly about 3,200 hours per year from the Queensway Heliport.

At the time of the accident, the company had four helicopters and 19 employees, including four pilots and three maintenance personnel.

At 0928, eight minutes after the accident, reported weather conditions at Catalina Airport, at an elevation of 1,597 ft and about 5 nm (9

## Aerospatiale AS 350

The Aerospatiale (now Eurocopter) AS 350 is a light five/six-seat utility helicopter first flown in 1974.

The first versions to be marketed were AS 350Bs, powered either by an Avco Lycoming or a Turbomeca Arriel turboshaft engine. The AS 350C was first produced in 1978 and superseded later the same year by the AS 350D, marketed only in North America.

The AS 350D is equipped with an Avco Lycoming LTS 101-600A-2 engine and a rotor system of three fiberglass blades. Its maximum takeoff weight is 4,300 lb (1,950 kg). Maximum cruise speed is 124 kt, and maximum rate of climb at sea level is 1,575 fpm. Range with maximum fuel at sea level and no reserves is 410 nm (759 km).

Source: *Jane's All the World's Aircraft* km) southeast of the accident site, included wind from 080 degrees at 3 kt; thin broken clouds at 700 ft AGL, broken clouds at 1,500 ft AGL and overcast clouds at 2,000 ft AGL; and visibility of 10 mi (16 km) in light rain.

The chief pilot for Island Express, who was flying another company helicopter in the area at the time of the crash, observed unrestricted visibility to the west with broken clouds at 3,500 to 4,000 ft. Winds at his location were light and from the west, and he told investigators that wind conditions appeared to be similar along the western shore of the island.

The helicopter was not equipped with a cockpit voice recorder or flight data recorder, and the equipment was not required.

Passengers said they heard a popping sound just before the pilot of this AS 350D told them he planned an autorotation near the designated landing site on California's Santa Catalina Island.



## Damaged Blades

The crash occurred about 0.2 mi (0.4 km) from the intended landing site, "on open down-sloping terrain bordered on the north by a series of power transmission lines and on the east by small hills," the report said.

Investigators observed localized damage of four consecutive power turbine blades, two of which were fractured transversely, "across the airfoil above the blade root platform, and two were fractured high up their respective airfoils near the blade tips," the report said. The other power turbine blades had generalized damage. All blades were in place and securely attached to the power turbine wheel.

A metallurgical examination, conducted with a scanning electron microscope, found "striation features typical of fatigue cracking on the pressure (concave) side" of one of the blades with a transverse fracture.

"The fatigue crack features emanated from the boundary area between the base material and a casting pin," the report said, noting that the fracture features on the three other damaged blades "exhibited a matte texture consistent with overstress separation."

The report said that when hollow core power turbine blades are cast, 10 cylindrical platinum pins are used to position an internal mold; after the casting has been completed, the internal mold is removed, but the 10 pins remain a part of the blade.

The metallurgical exam found "striations typical of fatigue" from the edges of two pins. The striations from pin No. 4 "progressed forward towards the leading edge and rearwards toward pin No. 5, and the fatigue from pin No. 5 progressed rearward toward the trailing edge," the report said.

After the NTSB completed its examination of the blades, Honeywell conducted additional examinations, with the oversight of NTSB investigators, and found additional fatigue cracks emanating from pins in the pressure side of the airfoil in two other blades.

Honeywell also issued Service Bulletins LT 101-71-00-0252 and LTS 101-71-00-0253 to require removal and inspection of the turbine assemblies "to address a service-related difficulty with power turbine rotor blade part No. 4-141-084-06 cracking at the mid-span of the airfoil that can lead to a blade separation and subsequent inability to maintain powered flight, resulting in potential injuries and damage to the aircraft."

Two FAA airworthiness directives concerning issues discussed in the accident report were pending, the NTSB said.

*This article is based on NTSB accident report SEA08MA136 and supporting docket information.*

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BY WAYNE ROSENKRANS | FROM ORLANDO

# Virtually Interactive

**Flight simulator instructors keep an open mind about real-time synthesis of ATC environments.**

Efforts to computer-generate air traffic control (ATC) environments inside flight simulation training devices (FSTDs) have advanced significantly in step with an emerging consensus about the benefits, several specialists say. The airline industry has spent about six years considering systems and methods that would go far beyond current training of candidates for the multi-crew pilot license (MPL) in a few countries. Panelists spoke in April during the World Aviation Training Conference and Trade Show (WATS 2010) in Orlando, Florida, U.S.

Other conference speakers urged caution in deploying the emerging capabilities, saying that disruptive effects on primary training objectives for experienced airline pilots ultimately could outweigh the safety benefits of added realism. Synthesized interactive ATC radio communication also might complicate an already rapid proliferation of special purpose operational training, said Rory Kay, executive air safety chairman, Air Line Pilots Association, International (ALPA), and a United Airlines captain.

"Sessions increasingly are crammed with mandatory training and checking of maneuvers such as [those for] controlled flight into terrain, traffic-alert and collision avoidance system, head-up display, Category III autoland, wind shear, required navigation performance–area navigation and [airplane] upset recovery, and the list will keep getting longer," Kay said. "We need more time, not less, in training scenarios to truly practice basics, and to be truly trained to proficiency."

Proponents of ATC simulation in FSTDs have stressed that in environments of high-density traffic control, airline flight crews' attention unavoidably becomes divided between flying the aircraft and listening to radio

Babbitt, top, and Hamza

Photos: Wayne Rosenkrans

communication for the flight's call sign, but airline pilot training standards have yet to formally recognize the corresponding need for realistic ATC communication in FSTDs.

"We wouldn't be in the golden age of safety without going hand-in-hand with the golden age of automation," U.S. Federal Aviation (FAA) Administrator Randy Babbitt told the attendees. "We have far greater capabilities today to replicate almost anything in an aircraft, and to expose people not in harm's way but in the educational way to situations that will confront them as crewmembers. We can replicate every scenario [with] wonderful positive teaching tools. We should maximize simulation usage."

Implementing ATC simulation in FSTDs involves human factors issues and technical challenges that the industry has not faced previously, said Nassima Hamza, business development manager, Thales Training and Simulation. "Delivering a user-friendly, robust system that eventually will try to simulate a human being is not an easy task — especially when it has to interact intelligently with the crew on the flight deck by means of speech recognition and, at the same time, be coherent and correlated with the rest of the cues provided by the other simulator subsystems."

Last year, Hamza coordinated an international industry survey sponsored by the Royal Aeronautical Society and Halldale Media Group, asking pilot-training professionals to identify safety objectives for improving pilots' radiotelephony skills in relation to ATC and the roles they see for ATC simulation.[1]

"The majority of respondents said they had never used an FSTD fitted with ATC simulation, and they agreed it is a missing link," Hamza said. "Interestingly, training professionals and regulators each have a different opinion on the efficiency of instructor role-play as an acceptable means of compliance. Most respondents see benefit in using ATC simulation outside the scope of the MPL, but some concerns were expressed over its use for training experienced crews."

The respondents' priorities were: developing situational awareness in a realistic environment with audible and visible air/ground traffic, generating interactive communication with ATC and correct aircraft locations, representing ATC communication workload in connection with a virtual controller, strictly using International Civil Aviation Organization (ICAO) phraseology, developing threat and error management skills through scenario-based training, and enhancing English skills, especially for pilots from non-English-speaking countries, she said.

The forthcoming adoption of ICAO Doc 9625, *Manual of Criteria for the Qualification of Flight Simulation Training Devices*,[2] by national aviation authorities will push further the need for acceptable systems (see "Temporary Guidance for Air Traffic Control Environment Simulation System, 2009," p. 40). "The first key is for all stakeholders to carry on defining the ATC simulation solution that would enhance the learning experience without compromising or conflicting with the prime flight training objective," she said.

Future flight crew licensing regulations of the European Aviation Safety Agency (EASA) are expected to incorporate this concept, said Marsha Bell, vice president, Commercial Pilot Training and Systems, Adacel, and panel moderator. "ICAO Annex 1, *Personnel Licensing*, and *PANS-OPS Training* are not explicitly requiring ATC environment simulation," she added. "Authorities around the world are allowing for other means of compliance, like flights in the cockpit of the MPL candidate's future airline. This will be the case for another two to three years."

## Safety Benefit Questions

One conference speaker said the industry has yet to take full advantage of FSTDs. "The question is, 'Have we really increased flight safety by harnessing new flight simulation technology?'" said Kip Caudrey, senior manager, simulator evaluation, standards and regulatory affairs for Boeing Training. "There are things that could be done in a flight simulator these days that we are not doing, or that we could do better."

He included air traffic controller and air/ground traffic simulation to a list of potential FSTD-based improvements comprising stall recognition and recovery training, upset recovery

## Temporary Guidance for Air Traffic Control Environment Simulation System, 2009

Functions relevant to developing flight simulation training device technology applications and training requirements:

- Dynamic automated environment
- Voice-initiated transmissions, background traffic
- Automated weather reporting
- Party line (background chatter)
- Simulated communications system interaction with simulator
- Communication simulation interaction with instructor
- Message triggering
- Datalink communications
- Correlation with other traffic
- Phraseology
- Flight phase–specific air traffic control frequency recognition
- Other communication (dispatch, maintenance, cabin crew, etc.)
- Instructor override of the system

— International Civil Aviation Organization

training, storm front avoidance procedures, unavoidable thunderstorm entry, runway incursion avoidance, realistic landing training, special airport training, and volcanic ash encounters. "Each one of these would significantly improve flight safety," Caudrey said.

"Anyone involved with ATC simulation [already has] an appreciation of the runway incursion challenge," he said. "With additional aircraft over the next 20 years … the greatest risk is runway incursions [involving] pilots not understanding taxi instructions. … Much as we also would like to say there is standard [pilot-ATC phraseology everywhere], pilots know that, unfortunately, this is just not true. … It is going to be a long time before we can really replicate what goes on in the real world."

### Text-to-Speech

Text-to-speech (TTS), speech recognition and speech synthesis constantly are evolving and already are more advanced than the airline community may realize, said panelist Marc Fabiani, product manager, Network TTS, Nuance Communications.

"TTS is at a very high level, and the output is rather natural and can be indistinguishable from human speech," Fabiani said, playing audio files of speech generation with several synthetic voices. "In terms of accuracy … the speech actually can be better than a human being's because we can leverage [computer] intelligence in terms of how abbreviations, [verbal] shorthand and pronunciations work. The technology can encode much more knowledge and be a lot more accurate than one human being." The text in–speech out capability has become easy to use; software programmers send the script from a dialogue or other textual information and the speech is audio-streamed or saved to a computer audio file for further processing, Fabiani said.

Several speech-processing challenges remain, however, for handling interaction of synthetic air traffic controllers and human pilots. "We do not have the voice variety that many [system engineers] would need to be able to emulate multiple users, such as multiple pilots or [controllers]. We offer at best a half dozen voices per language.

"Another issue is expressivity. We can select different moods out of the [TTS processing] engine, but we cannot expect the TTS engine to act on its own … understanding the whole script and pronouncing [responses] in a certain way based on that information. It does not have that artificial intelligence capability yet. It lacks the full spectrum of emotions, so it can 'speak' with urgency or passion but not panic or [humor]."

### Expanding Interest

U.S. research on improving training for pilot-ATC radio communication lately has been driven by the FAA's Advanced Qualification Program (AQP), based on data from line-oriented flight training (LOFT) and initial operating experience (IOE), said Judith Bürki-Cohen, principal investigator, Flight Simulator Human Factors Program, U.S. National Transportation Systems Center.

"The Next Generation Air Transportation System [NextGen] for the United States will affect pilot-ATC communications training," she said. "This will involve transitioning from primarily voice to primarily data communications. ... Much tighter communication and automation will be one additional factor."

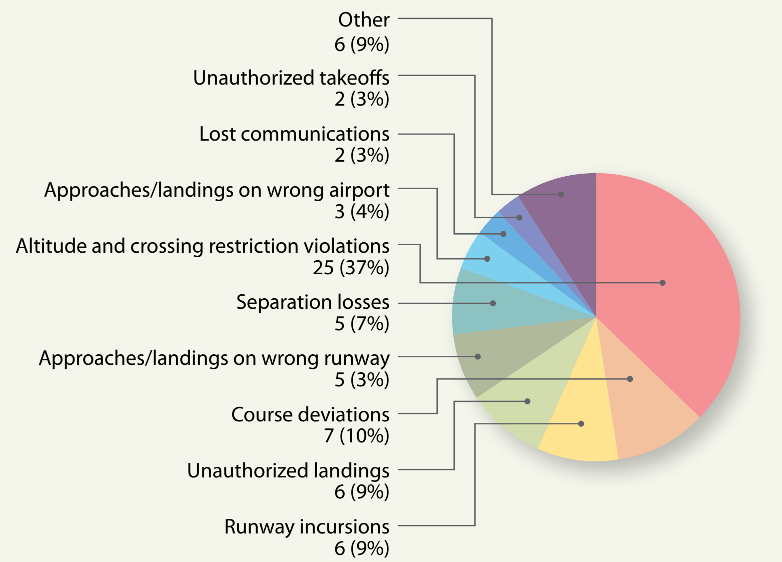
When they first arrived for IOE, some airline pilots observed in her studies seemed to experience difficulty dealing with ATC in high-density airspace, Bürki-Cohen said. A second study attempted to validate the earlier observations by analysis of the U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) database for relevant reports involving IOE and radio communication, and 93 errors were found (Figure 1 and Figure 2).

"The majority were altitude and crossing restriction violations, but we even have had unauthorized takeoffs and landings on the wrong runway and even at the wrong airport, etc.," she said. "Some of these issues may be alleviated and some issues will not be alleviated by data communication [datacomm] — meaning data-linked textual and visual information. This information does not disappear, and the pilots can read it when they are ready. Some clearances may even be uploaded directly to flight management systems. At the same time, with datacomm, pilots will not hear the urgency in the controller's voice."

Datacomm also is expected to reduce misunderstandings caused by pilots' and controllers' accents, speech rates and culturally different intonations, especially when pilots operate into airports where languages are foreign to them, she said. "The [datacomm] challenge will be an enormous increase in head-down time," Bürki-Cohen said. "The pilots also will lose the party line, and this will affect not only the situational awareness of the pilots but also that of controllers, because pilots may ask more questions about weather and traffic information, information that otherwise they would have gleaned from the party line or from other aircraft. Also, datacomm readback by the pilot is passive — just a button push — so the controller [may wonder] 'Does this pilot really understand what I mean?' The controllers get no information from the intonation, the hesitation or perhaps the emotion of the pilot that they can hear in the voice."

For the foreseeable future, both professions will interact in a mixed voice and datacomm environment, she said. ATC communication requiring immediate response, such as many clearance instructions, still will be delivered by voice.

**Pilots' Error Types Involving ATC Radio Communication**



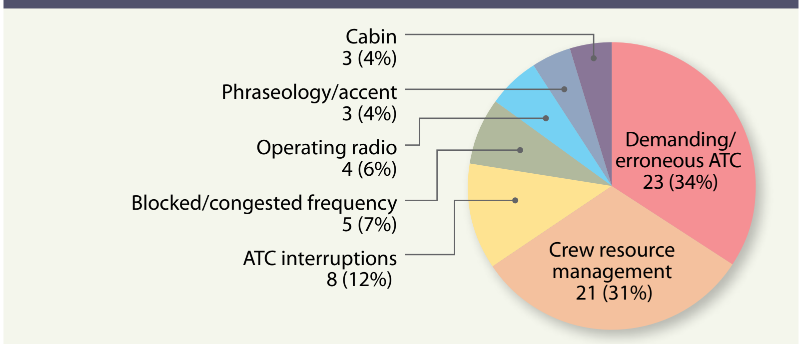

ATC = air traffic control; NASA = U.S. National Aeronautics and Space Administration; ASRS = Aviation Safety Reporting System

**Notes**: Error types were assigned by human factors specialists to 67 NASA ASRS pilot reports in which ATC radio communication during initial operating experience flights was the primary factor in 93 errors.

Source: U.S. National Transportation Systems Center

**Figure 1**

**Contributing Factors in Pilot Errors Involving ATC Radio Communication**




ATC = air traffic control; NASA = U.S. National Aeronautics and Space Administration; ASRS = Aviation Safety Reporting System

**Notes**: Categories were assigned by human factors specialists to 67 NASA ASRS pilot reports in which ATC radio communication during initial operating experience flights was the primary factor in 93 errors.

Source: U.S. National Transportation Systems Center

**Figure 2**

Some specialists have concerns that attention to aircraft call signs and recognition of urgency in voices could diminish as flight crews transition primarily to visually displayed information in NextGen. "Therefore, simulation of radio communication is very important for safety, and likely will remain so for clearances requiring immediate action," Bürki-Cohen said.

### Role-Playing Experience

Although ATC simulation for FSTDs initially was driven by MPL requirements, the airline industry should expect expansion to other types of ab initio training "where the pilot's ATC communication skill set is not going to be acquired by exposure — time in aircraft — but by the synthetic environment of the simulator," said Bryan Burks, vice chair, Training Council, ALPA, and an Alaska Airlines captain.

ICAO's International Working Group on FSTDs spent about three years addressing what it deemed a clear training need for this emerging technology. "The interesting part will be the interplay as the industry introduces simulated ATC environments into training for pilots other than MPL candidates or brand-new, zero-time ab initio pilots," said Burks, a working group member. "That remains a challenge … one that ALPA is looking at based on a data-driven approach. If it works and it doesn't impede or harm the training objective, we look forward to incorporating that technology … into other training activities for more mature pilots, recurrent training or type-rating training. Right now, it is still in beta test and its appropriate place … is in MPL or ab initio training."

As in the case of datacomm, ALPA expects the technology itself to introduce problems. "Where we take a conservative approach is crews [receiving] recurrent training or type rating training, with training objectives defined according to written performance standards that usually don't involve ATC interaction," Burks said. "So first, do no harm."

The primary benefits for other airline pilots likely will be indirect. "This would unload the instructors and evaluators, who often use scripted types of ATC communications with the pilots," Burks said. "It would allow them to focus on evaluation better than when role-playing ATC." A psychological component is that, when pilots go into the flight simulator for a checking or evaluation event, they may perform differently for an examiner or check airman issuing ATC instructions than they would if a real controller were issuing the instructions. "If we had a technology that could be a truer pilot-ATC interface, we could take out this artificiality," he noted.

The flight crew–ATC interaction is especially important when conducting FSTD training to mitigate specific threats such as unstabilized approaches involving flight crew compliance with unsafe ATC instructions. "Sometimes ATC is a threat that the flight crew has to manage," Burks said. "Through the instructor-led role-playing of ATC, we might not reach the desired objective if it involves ATC-crew interplay during an incident or accident scenario."

### U.S. Regulatory Perspective

Human speech emulation and artificial intelligence powerful enough to enhance ATC realism in FSTDs have been discussed by government and industry for several years, said Mike Wilson, aviation safety inspector, Air Carrier Training Branch, FAA.

"The FAA and other regulators must make sure that we are continuing to capitalize on crew training and not only maximize, but require [flight] simulation," Wilson said. "We want more effective training, not just more training." External pressures keep building to accomplish ever more training objectives in simulator sessions, he said.

"The variety of new technologies about to come into the stream of pilot training — datacomm, required navigation performance, enhanced flight visual systems — all require new phraseology, new terminology and new acronyms that have to be addressed," Wilson said. TTS technology may provide more flexibility in training, but regulation writing likely will have to follow industry consensus about a sound basis for any mandatory changes, he added.

"Right now, there is no FAA requirement [for simulation of ATC environment] although Doc 9625 incorporates that as a task requirement," Wilson said. "To adopt it from the FAA side, we need to have a discussion to determine what kind of requirement is necessary. ATC environment training [already] is a part of every pilot's training; it's just completed now in a different way —without the new technology. New FSTD certification would not be required because ATC environment simulations would not fit the criteria of an aircraft safety of flight issue."

"In an environment of changes [to the National Airspace System] on an almost daily or monthly basis, we need the flexibility of TTS so that we can incorporate some of the new [avionics] boxes that create a need for further pilot training. Our overarching goal in the last six years has been to allow for this technology to grow."

#### Notes

1. Royal Aeronautical Society; Halldale Media Group. "Industry Consultation: ATC Simulation in Flight Crew Training." November 2009.

2. ICAO. *Manual of Criteria for the Qualification of Flight Simulation Training Devices.* Doc 9625, Third Edition, 2009.

Optimizing flight attendants' retention of safety knowledge and skills can enhance crew resource management.

# Joint Cognitive Systems

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BY ZAKARIA BANI-SALAMEH, MERZA ABBAS AND LINA BANI-SALAMEH

If airline crewmembers on the flight deck and in the cabin see themselves as "locked out" of each other's domains not only by a fortified door, but also by differences in their cognitive tasks and professional cultures, safety of flight can be threatened. Accidents have occurred, for example, in situations in which pilots discouraged reports of aircraft technical irregularities from the cabin and in which flight attendants hesitated or failed to report to the cockpit possible threats they observed.

Although worldwide praise for cabin crew performance has followed some high-profile accidents — especially the January 2009 landing of

US Airways Flight 1549 on the Hudson River in New Jersey, U.S. (p. 24) — studies and safety articles citing other events had noted deficiencies in the ability of some flight attendants to handle onboard emergencies and called for modifying various details of training. The in-flight safety assurance model we propose is a step toward modeling flight attendant cognition for enhancing safety-related performance through continuous professional development (CPD).

The most-cited accidents and incidents have involved cabin crew reluctance to report threats such as smoke or airfoil ice because they assumed flight crews knew about them; unwillingness to speak up for fear of a rebuke from the captain if the issue was reported incorrectly or not judged to be serious; inadequate or no preflight information, leaving flight attendants insufficiently prepared for known potential threats; and inadequate information conveyed to cabin crew during emergencies. Accident reports and safety studies we reviewed mentioned cognitive task performance deficiencies in a fragmented way, however, or did not focus on how flight attendants should develop and retain professional expertise.

Cognitive task design today enables innovative solutions to such problems. Crew resource management (CRM), one of the most familiar examples of cognitive task design, originated partly from the idea that flight attendants should function as extra eyes and ears for two-pilot flight decks.

Yet such a narrow view of the cabin crew — as simply an external input to a joint cognitive system (JCS) that researchers would label the *pilots–flight deck* — constrains the cabin crew's potential effectiveness. JCS in this context basically means a system in which humans interact with machines and each other to maintain control of a safety-critical activity. This type of cognition is distinct from how the industry considers the knowledge, thought processes or goals of individuals.

Studying the entire activity requires macro-cognition, awareness of the "system of systems" in which all the JCSs interact. In reality, therefore, the *flight attendants–cabin* also constitutes a JCS and, at the system level, should have a relationship to the pilots–flight deck like that of widely recognized JCSs such as the air traffic service provider, the airline, the civil aviation authority and the meteorological service.[1] We have called this approach *extended JCS.*

Our in-flight safety assurance model is one way to help determine how the industry can ensure an expert flight safety schema for flight attendants in the extended JCS. This type of schema, or cognitive frame of reference and organization of experience, means the individual and collective ability to accurately perceive what is occurring, similar to situational awareness in CRM training. Moreover, CPD becomes the major strategy to overcome professional cultural differences between the cockpit and the cabin, achieving a more unified culture of professionalism.

These concepts flowed from our study of the perceptions of 249 flight attendants and supervisors at two de-identified international airlines (Table 1, p. 46) in 2009. The survey captured opinions about the effectiveness of acquiring and retaining safety knowledge and skills (SKS) in relation to normal learning opportunities depicted in the in-flight safety assurance model.[2]

Our findings, especially the participants' low agreement with survey-item statements that each learning factor in the model had been effective for them, showed that the quality of engagement and the residual effects of each factor over time can lead to deterioration in SKS and self-confidence.

## Extended JCS

In the past decade, human cognition and interaction on the flight deck have been studied extensively. The role of the cabin crews, despite its prominence in CRM training, often has been ignored or downplayed. For example, one compilation of analyses — essentially explaining flight operations as integrated JCSs that strive to achieve safe flights — surprisingly overlooked the flight attendants–cabin. Erik Hollnagel of the University of Linköping, Sweden, edited and contributed to this compilation. Airlines were one of several examples of applying perspectives of cognitive task analysis and cognitive task design to various industries. In his chapter and those of others, the basic JCS of interest was called the "pilot–cockpit" and comprised all the human, technological and procedural resources of the flight deck.

Our literature review came up empty with respect to content, quality and effectiveness of flight attendant training and the system-level safety contribution of the cabin crew. A 2008 study concurred, noting, "Ironically, the safety role of cabin crew (flight attendants) receives no attention in the academic literature. Given that cabin crew take responsibility for millions of passengers annually, it is argued that the quality of the training delivered to enable them to undertake their safety role effectively is an important consideration for all air transport passengers and airline personnel."[3] Other researchers made similar observations more than 10 years ago.

Extended JCS and our model could help ensure that decision making by airlines and civil aviation authorities considers flight attendants' cognitive task model as well as that of pilots. How flight attendants deal with turbulence encounters, for example, should more deeply consider factors such as preflight briefings, in-flight supervisor decisions, line experience with and without handling actual emergencies, crew demographics, standard operating procedures (SOPs) in the cabin, CRM, JCS interactions and recurrent training.

Increasingly, aspects of training and SKS retention that may warrant scientific research come to light through nonpunitive, voluntary reporting systems. A good example of training issues was a 2008 study on retention of SKS for first aid, cardiopulmonary resuscitation and automated external defibrillators.[4]

The researchers found a significant decline in these skills between training sessions. They attributed this to the instructional techniques employed, variations in program delivery and the length of time between training and re-assessment. In some cases, cabin crewmembers also may not have had adequate training to properly manage a sudden cardiac arrest (*ASW*, 5/10, p. 42). The report recommended further investigation and modification of training methods, including frequent brief SKS reviews, ideally performed before preflight briefings; updated training technologies that improve retention; and refresher training at intervals of less than 12 months.

## Enhancing Expertise

In current instructional systematic design (ISD) and applications, *experts* means workers who mentally generate abstract representations of internalized factors in dealing with

**SKS Retention and Expertise Development Among Flight Attendants, 2009**

| Survey Item Subject | Findings | Research Team Comments |
|---|---|---|
| Effectiveness of basic safety training, preflight briefing, in-flight experience and recurrent training | Overall, there was low confidence in factors in the IFSA model diagram (p. 47). PFBs were disliked by flight attendants; supervisors reported having higher alertness than other cabin crewmembers. | Except for PFBs and RT, participating flight attendants had minimal SKS reinforcement other than the cabin safety manual. |
| Correlation of BST, PFBs, RT, normal in-flight experience, self-perceived expertise and problem-solving ability with self-assessed performance | Differences among flight attendant and supervisor perceptions were significant only for PFBs and normal in-flight experience. | Flight attendants highly rated PFBs as important to emergency preparedness; supervisors rated normal in-flight experience as a key factor in enhancing competence. |
| Effectiveness of self-study of cabin safety manual between recurrent training classes | Flight attendants who had hands-on experience of emergencies highly rated expertise gained from the manual and mental rehearsal. | Overall, experience was the most effective reinforcement of initial SKS mastery, retention and practice of SOPs. |
| Differences of perception by job description, gender, age, work experience and level of education | Flights attendants and supervisors with 12–16 years of experience highly rated BST and normal in-flight experience. | Perceptions of importance of PFBs were highest among flight attendants with 12–16 years of experience. |
| Level of confidence in recalling BST and SKS to perform normal duties and emergency tasks | Flight attendants and supervisors had no widely held opinion of what factors, other than PFBs, benefit SKS retention. | RT was rated low overall for enhancing SKS and SKS retention. |
| Effects of personal experience in abnormal events and emergencies on developing expert flight safety schema | Flight attendants who only had observed responses to emergencies credited BST more than others. | PFBs were most meaningful and appreciated among flight attendants who had hands-on experience of in-flight emergencies. |

BST = basic safety training; IFSA = in-flight safety assurance; PFBs = preflight briefings; RT = recurrent training; SKS = safety knowledge and skills; SOPs = standard operating procedures

**Note**: From a random sample of 600 recipients at two de-identified major airlines, 53-question surveys were completed by 249 flight attendants and supervisors.

Source: Zakaria Bani-Salameh, Merza Abbas, Muhammad Kamarul Kabilan, Leong Lai Mei and Lina Bani-Salameh

**Table 1**

reality, and make decisions based on in-depth understanding of workplace situations.[5] Models are well suited to demonstrating how people can be transformed into experts from non-experts, those who do their normal work by learning facts and following rules.[6]

Our in-flight safety assurance model (Figure 1) suggests that desired outcomes result from direct and indirect interactions, or cause-and-effect relationships, among specific modifiable factors. It takes a holistic view, connecting key developmental opportunities over time. Basic safety training, pre-flight briefings and recurrent training are the primary inputs; routine in-flight operating competence and expert flight safety schema are the outputs.

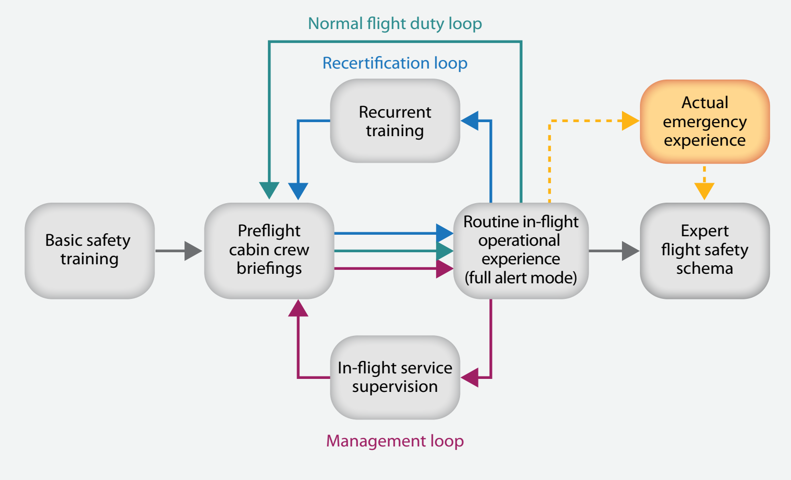
The normal flight duty loop in the diagram represents the dominant flow of cognitive tasks; flight attendants enter this loop only after demonstrating initial mastery of SKS, and with the airline's cabin safety manual at hand as their guide to SOPs and emergency procedures. The normal flight duty loop and routine experience also represent the state of in-flight preparedness; they are a "standby mode" in which flight attendants are expected to be fully alert and vigilant.

As safety practitioners, flight attendants also are expected to continually read their manuals and rehearse the emergency procedures in their minds, too often without adequate learning support except for the recurrent training.

For continuous safety improvement, we recommend adding more frequent, intensive refresher exercises using computer-based training — simulating recollection and application of SKS under stress — especially for dealing with emergency situations that require error-free performance.

*Zakaria Bani-Salameh, a flight attendant since 1996, conducts research in educational technology applications to aircraft cabin safety and in the field of English for specific purposes under a doctoral fellowship program at the School of Education, University of Science of Malaysia (USM). Merza Abbas, Ph.D., is director of the Centre for Instructional Technology and Multimedia, USM. Lina Bani-Salameh, Ph.D., is a faculty member in the School of Education at Yarmouk University in Jordan.*

**In-Flight Safety Assurance Model**




Source: Zakaria Bani-Salameh, Merza Abbas and Lina Bani-Salameh

**Figure 1**

## Notes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BY RICK DARBY

# Safety in Numbers

**The 2009 C-FOQA aggregate data show improvements in most metrics.**

The rate of unstable approach events declined 36 percent in 2009 from the previous year among aviation departments participating in Flight Safety Foundation's corporate flight operational quality assurance (C-FOQA) program, according to a statistical summary report prepared by Austin Digital, which aggregates and analyzes the data.[1]

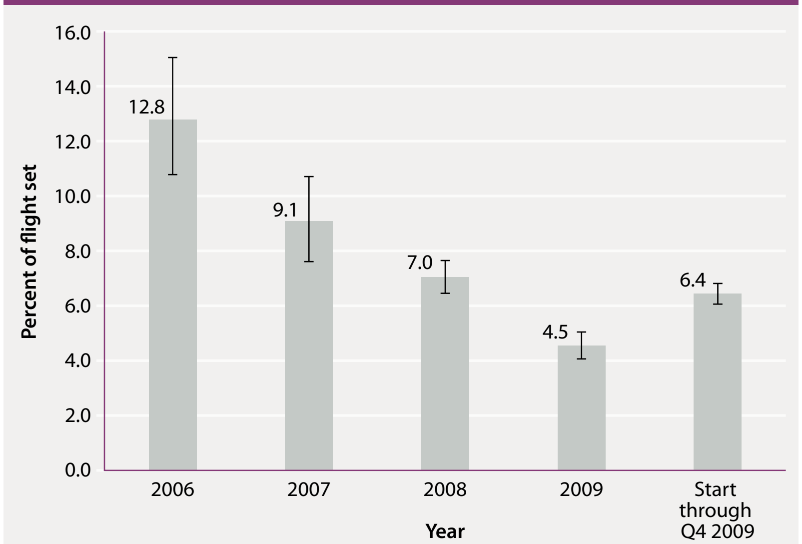
The 4.5 percent rate of unstable approach events in 2009 was the lowest since data collection and analysis began in 2006 (Figure 1), when the rate was more than 2.5 times higher, at 12.8 percent. The mean rate for the four years was half that for 2006. In addition, as the C-FOQA program has grown to include more organizations and more flights, the data have become more statistically significant — as shown by the decreasing size of the error bars.[2]

The FSF Corporate Aviation Committee and the National Business Aviation Association Safety Committee developed the C-FOQA program to enable corporate flight departments to use a safety monitoring system similar to those used by many airlines. The system collects flight data, recorded and downloaded from a quick access recorder, which are then analyzed for exceedances of selected parameters from predetermined values. The results are available confidentially to each participating operator for its own fleet, and publicly in de-identified and aggregated form.

As of 2009's fourth quarter, 27 aircraft of 11 types contributed to the aggregated data set.[3] The number of flights per quarter hovered around 200 through the third quarter of 2007, then began a rapid rise as participation in the program increased. Quarterly flight numbers peaked at more than 1,480 in 2009's second quarter, and decreased to 1,230 in the fourth quarter.

Unsafe practices or occurrences are defined as exceedances of standard event limits developed by the Foundation. The exceedances are ranked, in ascending severity, as caution events or warning events. Events are further subdivided by genre. Aircraft limitation events, related to equipment and configuration, represent conditions that place undue stress on the aircraft. Events potentially necessitating aircraft maintenance are another category. Yet another is flight operations events.

**C-FOQA Unstable Approach Event Rates, 2006–2009**




C-FOQA = corporate flight operational quality assurance; Q = quarter

**Note**: Error bars represent a 90 percent confidence interval.

Source: Flight Safety Foundation C-FOQA program and Austin Digital

**Figure 1**

Few aircraft limitation events in 2009 triggered either cautions or warnings. An exception was "flap airspeed limit exceedance," with 47 caution events and one warning event. The largest number of warning events was three, for "flap/slat altitude limit exceedance."

Among aircraft maintenance events, "reverse thrust while slow" triggered 23 cautions, and "hard landing" triggered four. There were four warning events for "roll attitude disagreement." No other category of aircraft maintenance events resulted in more than one warning event.

## Flight Operations Events

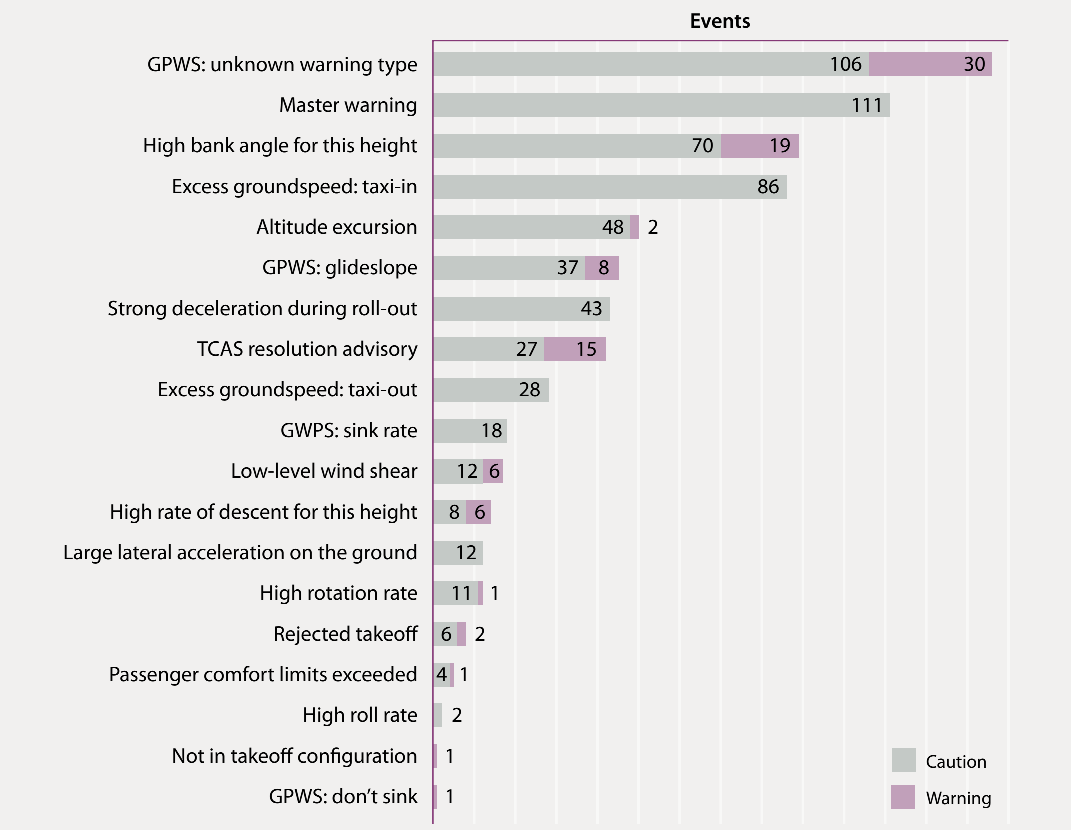
"GPWS [ground proximity warning system]: unknown warning type" accounted for the largest number of both caution events and warning events in 2009 — 106 and 30, respectively (Figure 2). "Master warning" had the next-highest number of caution events, but no warning events. "Excess groundspeed: taxi in" followed in number of caution events, but also had no warning events.

"High bank angle for this height" had the second-highest number of warning events, 19. "TCAS [traffic-alert and collision avoidance system] resolution advisory" accounted for 15 warning events. Other categories in which warning events were recorded included "altitude excursion," "GPWS: glideslope," "low-level wind shear," "high rate of descent for this height," "high rotation rate," "rejected takeoff," "passenger comfort limits exceeded," "not in takeoff configuration" and "GPWS: don't sink."

"GPWS: unknown warning type," with the greatest number of events in 2009, had been fifth in 2008. The 2009 total events in the category, including both caution and warning events, was 136, an 84 percent increase over the comparable number in the previous year, 74.

There were fewer examples of "master warning" caution events in 2009, 111 compared with 158 in 2008, a 30 percent improvement. "Excess groundspeed: taxi in," the category with the second-largest number of instances in 2008, decreased by 37 percent in 2009.

**C-FOQA Flight Operations Events, 2009, by Type**

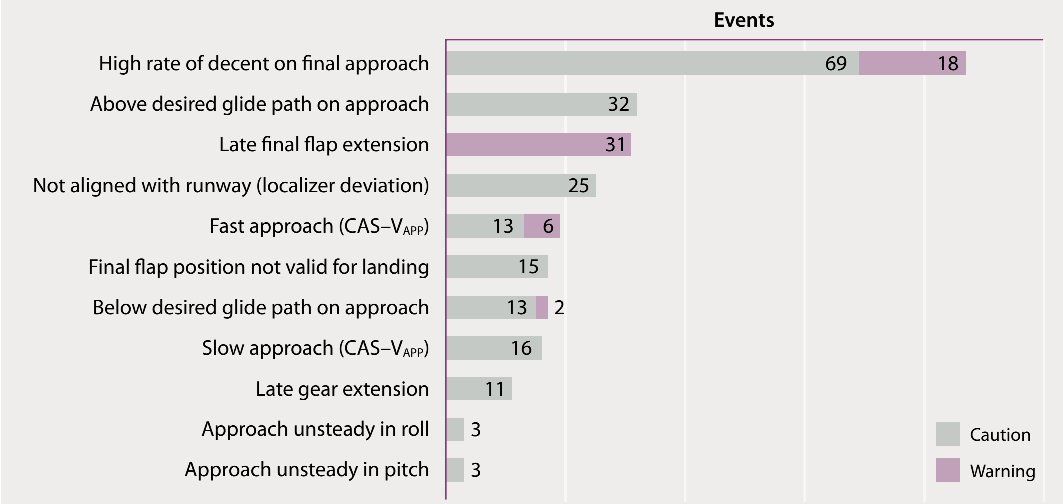



C-FOQA = corporate flight operational quality assurance; GPWS = ground proximity warning system; TCAS = traffic-alert and collision avoidance system

Source: Flight Safety Foundation C-FOQA program and Austin Digital

**Figure 2**

**C-FOQA Unstable Approach Events, 2009, by Causal Factor**

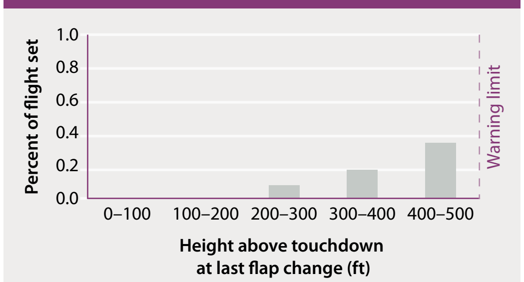



C-FOQA = corporate flight operational quality assurance; CAS = calibrated airspeed; $V_{APP}$ = approach speed

Source: Flight Safety Foundation C-FOQA program and Austin Digital

**Figure 3**

**C-FOQA Late Flap Extension Distribution, 2009**




C-FOQA = corporate flight operational quality assurance

**Note**: Only an expanded view around the event limit is shown.

Source: Flight Safety Foundation C-FOQA program and Austin Digital

**Figure 4**

Overall, quarterly flight operations event rates have decreased since the second quarter of 2008, from occurring in 20.7 percent of flights to 12.8 percent in the last two quarters of 2009, a 38 percent drop. From the start of the C-FOQA program through the end of 2008, the mean rate was 15.8 percent.

## Approach Events

The report is particularly concerned with event rates related to approach stability and landing performance — potential contributors to approach and landing accidents. In considering unstable approaches, exceedances up to 10 percent beyond the standard event limits are defined as caution events; above 10 percent, as warning events.

"High rate of descent on final approach" was the most common type of unstable approach event in 2009, resulting in 69 caution events — more than twice the next highest category — and 18 warning events (Figure 3). But the largest number of warning events, 31, involved "late final flap extension." Because it considered late flaps to be critical, the Foundation defined it as a warning event. The criterion was final flap selection below 500 ft height above the runway touchdown zone elevation (HAT).

In "high rate of descent on final approach" events, the 2009 numbers were worse than 2008's. The 69 caution events and 18 warning events added 38 percent and 13 percent, respectively.

But 2009's 31 warning events for "late final flap extension" were a 35 percent reduction from the 48 in the previous year, and localizer deviations — where the aircraft was not aligned with the runway — dropped from 46 to 25, or 46 percent.

Other improvements were evident in 2009 as well. In the "above desired glide path on approach" category, the 32 caution events recorded were a decrease of 32 percent from 47 in 2008. The year-over-year improvement in "final flap position not valid for landing" was 45 percent, and in "late gear extension," 52 percent.

In 2008, there had been 17 caution events and six warning events for "fast approach." The corresponding numbers for 2009 were 13 — 24 percent fewer — and six. Most "high rate of descent" events occurred at lower altitudes, less than 300 ft HAT. Fewer than 1 percent of flights were flagged as warning event limit exceedances in the "late flap extensions" category, and most occurred in the 400–500 ft HAT range (Figure 4). Three exceedances were recorded as low as 200–300 ft HAT, however.

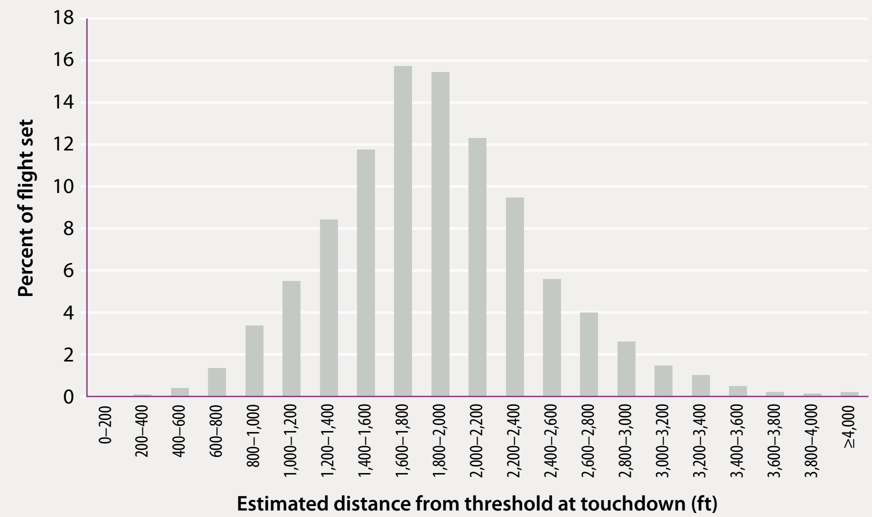
For "fast approach" events, the caution event limit triggered when the aircraft exceeded a reference value[4] by more than 20 kt from 500 ft HAT to 50 ft above ground level (AGL), and the warning limit triggered if the reference value was exceeded by more than 25 kt. The percentage of flights recording exceedances was about 0.5, and about 0.1 percent exceeded the warning limit by more than 32 kt. "Slow approaches," at 500 ft HAT to 50 ft AGL, exceeded the corresponding caution limit reference value by more than 12 kt in about 0.5 percent of flights.

## Landing Events

The report includes a scatter plot of groundspeed versus airspeed at touchdown that indicates that tailwind landings greater than 10 kt were a relatively small fraction of tail wind landings.

The aircraft distances from the threshold at touchdown resembled a standard "bell curve" distribution, with about 2 percent within zero to 800 ft (244 m) and about 4 percent beyond 3,000 ft (914 m; Figure 5). About 4 percent of flights had less than 3,750 fit (1,143 m) of runway distance remaining at touchdown (Figure 6). When the aircraft had slowed to 80 kt, about 6 percent of flights had less than 2,500 ft (762 m) remaining.

### C-FOQA Distribution of Distance From Threshold at Touchdown, 2009

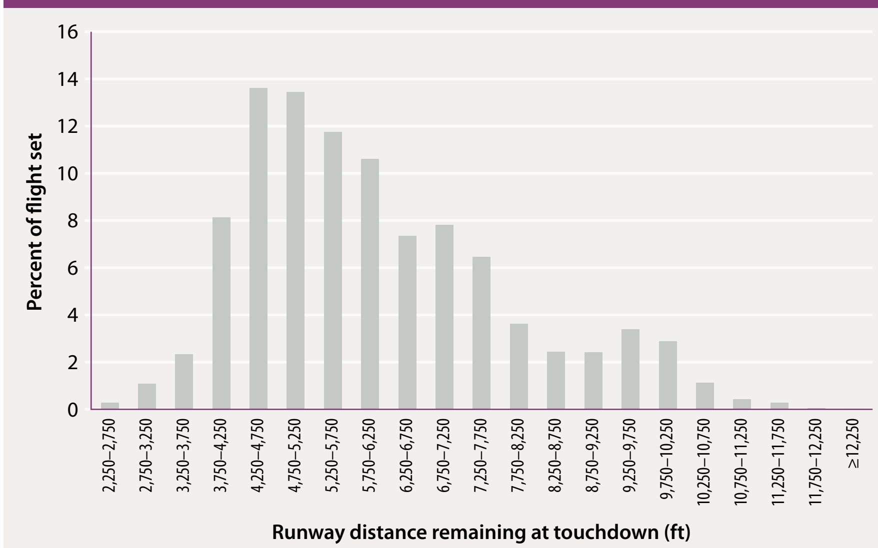



C-FOQA = corporate flight operational quality assurance

Source: Flight Safety Foundation C-FOQA program and Austin Digital

Figure 5

### C-FOQA Distribution of Runway Distance Remaining at Touchdown, 2009




C-FOQA = corporate flight operational quality assurance

Source: Flight Safety Foundation C-FOQA program and Austin Digital

Figure 6

### Notes

1. The report is available on the FSF Web site at <flightsafety.org/current-safety-initiatives/corporate-flight-operational-quality-assurance-c-foqa>.

2. The error bars represent that there is a 90 percent probability that the rate for the C-FOQA operators would fall within the range shown if there were an infinite number of their flights available for analysis.

3. Aircraft that contributed to the data set included the Bombardier Challenger 300, 605, Global Express and Global Express XRS; Dassault Falcon 900EX and 7X; Embraer ERJ-135; and Gulfstream 450, 550, IV and V.

4. The reference value for "fast approach" was set at one standard deviation from the average for the approach for the type. A standard deviation is the square root of deviation from the mean, which shows how much the range varies from the average.

# Night Light

**Flight crew distraction and confusing lighting were implicated in misaligned nighttime takeoffs.**

## REPORTS

### Staying Centered — Or Not

**Factors Influencing Misaligned Take-Off Occurrences at Night**

Todd, Melanie A. Australian Transport Safety Bureau (ATSB) AR-2009-033. June 2010. 44 pp. Figures, tables, appendixes.


"The night pleases us, because it suppresses the idle details, just as our memory does," wrote the Argentine literary figure Jorge Luis Borges. But for flight crews lining up to roll their aircraft down the runway when most of the world is dark, there are no idle details. They must see and understand the picture presented partly through visual cues, such as runway centerline and edge lighting systems, which are different from lighting and markings they rely on in daylight.

The study was triggered by five misaligned nighttime takeoff occurrences investigated by the ATSB during a four-year period. All involved aircraft with takeoff weights greater than 5,700 kg/12,500 lb. In addition, the report examines ATSB and international aviation safety investigation reports, as well as data from the U.S. National Aeronautics and Space Administration Aviation Safety Reporting System, of misaligned takeoffs in night visual meteorological conditions.

For example, on the night of Jan. 30, 2006, an Airbus A319 was flying scheduled passenger service from Las Vegas to Montreal. Shortly after beginning the takeoff, the flight crew realized that the aircraft was rolling along the runway edge instead of the centerline. Three runway edge lights were damaged.

The investigation determined that the pilot flying was likely to have been relying on peripheral vision while steering because of the need to concentrate on the forward view; that the rolling takeoff reduced the time available to check position; and that the pilot was misled by "confusing aerodrome markings, especially taxiway lead-in lines that directed aircraft onto the runway edge lights, resulting in the misalignment of the aircraft at the beginning of the takeoff roll."

The search for contributing factors encompassed 24 occurrences of taking off on the runway edge lighting and eight occurrences of taking off on closed or wrong runways or on taxiways. Causal factors were ranked by frequency.

In both types of occurrences, the most common factor was "flight crew divided attention/distraction/eyes inside" because of workload or unfamiliarity with the airport layout. That situation was found in 14, or more than half, of runway edge takeoffs, and seven of the eight takeoffs from the wrong location.

Fourteen of the runway edge takeoffs included "confusing runway/taxi entry/lighting," involving lights, markings and signage. That factor was found in four wrong-location takeoffs.

Almost as common — in 13 occurrences — among runway edge takeoffs was "displaced threshold (lights and markings start further down runway) or intersection departure."

Additional factors responsible for misaligned takeoffs included poor visibility or rain; a wide runway or extra pavement near the taxiway; centerline lighting absent or out of service; an air traffic control (ATC) clearance while the aircraft was taxiing or entering the runway; crew fatigue; and recessed runway edge lights at taxiways.

"Distraction was reported to occur in the events analyzed for a number of reasons, including flight crew dealing with an unusual event or problem, or flight crew performing checklist items or setting power/checking instruments/readings," the report says. "Some of these items, such as completing checklists, are a normal and necessary part of the departure phase of flight. However, they may act as a distraction to flight crew if conducted out of sequence, such as during the line-up phase."

Divided attention is created when flight crewmembers must be "eyes inside" the cockpit for an excessively long time during taxi because of an unusual situation, the report says: "While multi-crew operations partially mitigate this risk by articulating and dividing aircraft handling and monitoring roles between the pilots, there are still times when both crewmembers may not be processing the external environmental cues accurately."

Besides poor visibility, unusual pavement configurations create particular difficulties at night. "Pilots operating from a runway with a greater width, or additional paved areas at taxiway entry, than most standard runways can believe that they are in the center of the runway when they are actually lined up on the edge," the report says.

The report discusses the problem that sometimes can be caused by recessed lighting — flush with the surface — on taxiway and runway edges. Centerline lighting is always recessed so that the aircraft wheels can cross without damage. "Often runways will have recessed lights at the runway edge where the taxiway meets the runway," the report says. "Recessed runway edge lighting can therefore act as confirmation that the flight crew have lined up on the centerline, when this is not actually the case."

The report notes the significance of the color, position and brightness of taxiway and runway lighting in the events the study reviewed. "In some cases, the difference in color between taxiway lights and normal runway lights was either not noted by the flight crew, or they believed the lights were the correct color when they were not," the report says.

The ATSB has produced a "pilot information card" to raise awareness of factors that could lead to a misaligned takeoff. Side 1 of the card reads, "Don't lose the edge." Side 2 asks, "Got any of these?" and lists distraction or divided attention; confusing runway layout; displaced threshold or intersection departure; poor visibility or weather; ATC clearance during runway entry; no centerline lighting on runway; fatigue; and recessed runway edge lighting. It concludes, "If so, the risk of a misaligned takeoff or landing has just increased."

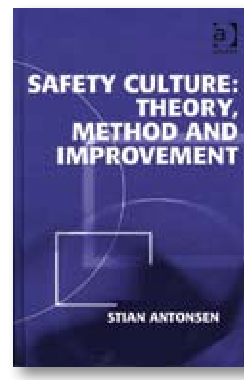
— *Rick Darby*

## BOOKS

### Culture, Meet Safety

**Safety Culture: Theory, Method and Improvement**

Antonsen, Stian. Farnham, Surrey, England and Burlington, Vermont, U.S.: Ashgate, 2009. 184 pp. Figures, tables, reference, indexes.




"The proposed relationship between organizational culture and safety is the topic of this book," Antonsen says. "This relationship, epitomized by the concept of safety culture, has undoubtedly become one of the hottest topics of both safety research and practical efforts to improve safety. For instance, most oil companies today have programs devoted to improving the company's safety culture." Yes, safety culture will continue to be a hot topic.

The book's framework is an effort to answer a general question: "How can a cultural approach contribute to the assessment, description and improvement of safety conditions in organizations?" Antonsen says that the question can be subdivided for clearer understanding into subordinate questions:

- "What are the theoretical foundations of a cultural approach to safety?
- "How can the relationship between organizational culture and safety be investigated empirically?

- “In actual organizations, what links exist between organizational culture and safety? [and,]

- “How can research on safety culture be translated into techniques and principles for improving safety?”

As a foundation for the book, the author examines the meaning of both organizational culture and safety. The first is hard to pin down, but he says, “I reserve the term organizational culture to apply to the informal aspects of organizations.”

The idea of safety is inseparable from the idea of risk and is often expressed in terms of the likelihood of an event occurring multiplied by the seriousness of the event’s consequences. That seems simple and theoretically unarguable, but measuring the risk is less clear in practice. Antonsen says, “The traditional quantitative risk analysis is based on the assumption that there is some objective and true level of risk ‘out there’ and that one can come close to estimating this through the use of standardized techniques. Cultural theorists like Mary Douglas and Douglas Wildavsky have voiced strong objections to this concept of risk. Their argument is that risk will always be, at least to some extent, socially constructed.”

The “social construct” theory does not imply that the dangers are partly or wholly imaginary — although in extreme cases, like belief in witchcraft, they might be — but that decisions about what risk is acceptable have a culturally influenced component. Antonsen cites “research [that] has shown that people are usually more afraid of events that in all likelihood they will never experience, such as nuclear radiation and plane crashes, than the events that are quite likely to cause serious harm, such as driving a car or painting their house.”

Putting together the various outlooks on the subject, the author says that a definition of safety will have three elements: “a *state* or *situation* where the statistical risk is deemed to be acceptable, or as low as reasonably practicable”; “a *feeling* of security and control”; and “a form of *practice*, in the sense that it refers to our ability to reduce or eliminate the likelihood of hazardous events occurring.”

The subject is explored in chapters including “Safety Culture and Power,” “Assessing Safety Culture,” “An Empirical Case Study — Safety Culture on Offshore Supply Vessels,” and “Improving Safety Through a Cultural Approach — Limitations, Constraints and Possibilities.”

— *Rick Darby*

## WEB SITES

### Heliport Safety Manual

**Heliport Safety, Educational and Regulatory Information, <www.raysyms.com/heliport-safety-educational-and-regulatory-information>**

“Next to design faults, the next most common cause of helicopter accidents at heliports is human error,” says Raymond A. Syms & Associates (RAS&A). “Most of these errors could have been avoided with proper training and heliport operational knowledge.”

Syms developed a prototype “Heliport Facility and Training Manual Development Training Aid” to help professionals safely operate their hospital heliports. The training aid helps interested parties customize their own safety materials, training programs and operations manuals. Rather than starting with a blank slate, heliport owners, operators and others can use


the training aid as a guide. RAS&A says, “This heliport facility manual is designed for the heliport owner and users and covers the minimum standards that should be addressed with respect to facility administrative management, flight operations, safety and training. This manual has been written to become a mandatory training requirement for all personnel whose job descriptions include activity around the heliport.”

The 16-page document identifies guidelines and responsibilities for four departments — hospital administration, medical teams, security teams and ground maintenance teams. It offers suggestions, examples and recommendations on such topics as general operating rules; pilot and facility briefing sheets; emergency procedures and notifications checklists; sample illustrations, such as a campus map labeling streets and buildings; a sample security policy; and an equipment list (for example, hearing and eye protection and portable oxygen) to be stored in a connecting passageway.

The safety and training portion of the document provides standard operating procedures for maintenance personnel and familiarizes heliport personnel with hazards and safety concerns associated with helicopter flight operations. A catch-all general safety list targets all staff members with instructions from the obvious, “Do not throw anything toward or from the aircraft” to the not-so-obvious, “Never approach the helicopter until signaled by the pilot or other member of the flight crew.”

Detailed information about the training aid, its contents and intended use, and information for requesting a copy are available on the Web site. The free training aid is available to qualified helicopter aviation professionals.

— *Patricia Setze*

## Ash Cloud Guidance

**International Federation of Air Line Pilots’ Associations, <www.ifalpa.org>**

The International Federation of Air Line Pilots’ Associations (IFALPA) was formed in response to creation of the International Civil Aviation Organization (ICAO) by the United Nations. According to IFALPA’s history, “The fact that ICAO was to make decisions on aviation policy without pilot representation immediately began to interest several pilots’ associations. … This was the reason for the birth of IFALPA in April of 1948 during a conference of pilots’ associations held in London for the express purpose of providing a formal means for the airline pilots of the world to interact with ICAO.”


IFALPA has permanent observer status in the ICAO Air Navigation Commission. In this capacity, IFALPA recently submitted its position paper, *Volcanic Ash Operations*. The executive summary says, “The ultimate responsibility for the safe conduct of a flight rests with the pilot-in-command. The pilot-in-command must therefore be given adequate tools, training information and guidelines to deal with volcanic ash.” The eight-page paper makes recommendations regarding standards, recommended practices and guidance materials; aircraft and operator certifications; ash cloud modeling; risk analysis; airspace management; aerodromes; and flight operations. References and an appendix are included.

The IFALPA Web site has a significant amount of information for members and non-members, such as briefing leaflets, safety bulletins and the *InterPilot* newsletter. Three new briefing leaflets from the aircraft design and operation committee are “Volcanic Ash Guidance for CRJ Series,” “Boeing Volcanic Ash Advice” and “Airbus Volcanic Ash Advice.” Position papers and other documents may be read online or downloaded at no cost.

If you find yourself swimming in an alphabet soup, check out the “aviation jargon buster,” a lengthy list of acronyms, terms and definitions. Or, maybe you already know that VAAC means Volcanic Ash Advisory Centre and VAW means volcanic ash warnings.

— *Patricia Setze*

# At the Verge of a Stall

**The 747 flight crew was unaware that most of the leading-edge flaps had retracted on liftoff.**

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

### Thrust Reversers Were Unlocked

Boeing 747-400. No damage. No injuries.

Shortly after lifting off the runway, the flight crew was surprised by stall warnings that, unknown to them, were triggered by a loss of lift due to the uncommanded retraction of most of the wing leading-edge flaps. "The pilot flying was able to prevent the aircraft from stalling, with support from the other crewmembers, and to keep the aircraft flying until the leading-edge flaps re-extended and normal performance capability returned," said the final report on the serious incident by the South African Civil Aviation Authority (CAA).

The incident occurred the evening of May 11, 2009, as the 747 departed from O.R. Tambo International Airport in Johannesburg for a scheduled flight to London with 265 passengers and 18 crewmembers. Takeoff weight was 365,000 kg (804,679 lb), or 31,890 kg (70,305 lb) below the maximum certified takeoff weight.

The flight crew had planned for a reduced-power takeoff from Runway 03L, which is 4,418 m (14,495 ft) long, and had calculated 150 kt for $V_1$ and 168 kt for $V_R$. The first officer was the pilot flying. He had 9,300 flight hours, including 1,950 hours in type. The pilot-in-command had 11,000 flight hours, including 8,500 hours in type. There was another pilot on the flight deck, but the report did not provide information on this crewmember.

The 747 was accelerating through 126 kt when an amber message appeared on the engine indicating and crew alerting system (EICAS) display, cautioning that the no. 3 (right inboard) engine thrust reverser was in transit. A similar EICAS message for the no. 2 (left inboard) engine thrust reverser appeared as the aircraft accelerated through 160 kt. The report did not say whether the pilots observed or reacted to the messages.

The first officer was rotating the aircraft for takeoff when all the "Group A" leading-edge flaps retracted. Each wing has 14 leading-edge flaps, with eight designated as Group A and six as Group B. Group A comprises three Krueger flaps between the wing root and the inboard engine pylon, and five variable-camber flaps between the inboard pylon and the outboard engine pylon; the six Group B variable-camber flaps are outboard of the outboard pylon.

Retraction of the Group A leading-edge flaps would have caused the EICAS flap indication display to change color. However, "this change is hardly visible, and the flight crew may not have noticed it," the report said, concluding that "at no time was the aircrew aware that the Group A leading-edge flaps had retracted."

Soon after the 747 became airborne at 176 kt, the stick shaker activated and "significant" buffeting occurred, the report said. "In order to counteract the stall warning and buffeting, the pilot flying (who also had aerobatic flying experience and was familiar with aircraft buffeting) continued to fly the aircraft with the pilot-in-command calling out the aircraft heights AGL [above ground level]."

The leading-edge flaps remained in the retracted position for about 23 seconds but then extended when the crew retracted the landing gear at a height of 56 ft above the runway and at a calibrated airspeed of 177 kt. "After the automatic re-extension of the leading-edge flaps, the aircraft's performance returned to normal," the report said.

The pilots discussed the incident and, lacking a clear understanding of what had caused it, decided to return to the airport. They declared an emergency and, in coordination with air traffic control, flew the aircraft to 15,000 ft, where fuel was dumped to reduce weight below the maximum landing weight. The crew then landed the 747 without further incident.

"Ground testing revealed that the reversers were not fully stowed against the stops and that one of the four locking gearboxes on both no. 2 and no. 3 engines had unlocked," the report said. "The other thrust reverser locks were still in place, and the translating reverser cowls did not move during the event. No evidence was found that the thrust reversers had in fact deployed."

The Group A leading-edge flaps on the 747-400 were designed to retract automatically either when a reverse thrust lever is moved or when thrust reverser in-transit signals are generated by both inboard engines or by both outboard engines. The report said that this design feature was intended to reduce fatigue of the flap panel surfaces by preventing their direct exposure to engine exhaust flow redirected by the thrust reversers.

The report said that the U.S. Federal Aviation Administration in July 2009 issued an airworthiness directive requiring compliance with a Boeing service bulletin recommending that operators of 747-400s equipped with Rolls-Royce engines disable electronic connections that cause the leading-edge flaps to automatically retract in response to thrust reverser in-transit signals.

The South African CAA also recommended that 747-400 operators ensure that thrust reversers are fully stowed after maintenance is performed and to require visual inspections "to ensure the thrust reversers have motored to the fully stowed position."

## 'Jolted' by Turbulence

Airbus A320-232. No damage. Two serious injuries, two minor injuries.

No warnings of turbulence had been issued for the area, and the on-board weather radar system showed no precipitation returns within 20 nm (37 km) as the A320 neared Fort Myers, Florida, U.S., the afternoon of July 10, 2009. Nevertheless, the airline's standard operating procedure was to illuminate the seat belt sign when descending through 18,000 ft.

Before beginning the descent from cruise altitude, the captain had made a public address system announcement that included instructions for the passengers to take their seats and to fasten their seat belts when the seat belt sign was illuminated. "Additionally, a flight attendant made a public announcement when the seat belt sign was illuminated," said the report by the U.S. National Transportation Safety Board (NTSB).

About four minutes later, while descending through 12,500 ft, "the airplane was jolted as it flew through a small cumulus cloud," the report said. "Specifically, the airplane dropped about 20 ft instantaneously, experiencing a positive g load of 1.98 followed by a negative g load of 0.43 less than one second later."

A passenger who did not have her seat belt fastened suffered two fractured ribs when she struck the stowed tray table in front of her. Another passenger was in an aft lavatory and suffered two spinal fractures during the turbulence encounter. Two other passengers sustained minor injuries.

**A passenger who did not have her seat belt fastened suffered two fractured ribs.**

None of the flight attendants was injured. "The captain had instructed the flight attendants via intercom to sit down a few minutes prior to the turbulence encounter," the report said.

## Brakes Lock, Tires Burst

Boeing 737-500. Minor damage. No injuries.

Company personnel had complied with minimum equipment list provisions for operating the 737 with an inoperative anti-skid system, and the flight crew had discussed the operating procedure for landing the airplane with the system inoperative before they departed from Oklahoma City with 118 people aboard for a scheduled flight to Houston the afternoon of March 27, 2008.

The crew also briefed the anti-skid-inoperative landing procedure several times during the flight, the NTSB report said, noting that the procedure included manual deployment of the speed brakes and thrust reversers after touchdown, and minimal manual application of the wheel brakes during the landing roll to avoid tire damage.

However, recorded flight data showed that the speed brakes and thrust reversers were not deployed after touchdown at Houston's George Bush Intercontinental Airport and that wheel brake pressure increased to 3,000 psi, the upper limit, "at the same time weight was transferred to the nose gear," the report said, noting that this indicated that the wheel brakes were manually applied on touchdown.

**The brake pressure caused the main landing gear wheels to lock, and all four tires burst.**

The brake pressure caused the main landing gear wheels to lock, and all four tires burst. The captain told investigators that he assumed control when he felt the 737 shudder on touchdown. "The captain reported that he did not apply brakes during the event, as the airplane was slowing rapidly," the report said. "He reported that he maintained runway centerline by utilizing the tiller. The airplane came to a stop toward the end of the runway, and the flight crew and passengers disembarked using airstairs." A small fire in the right main landing gear was extinguished by aircraft rescue and fire fighting personnel.

## Hard Landing Not Reported

Airbus A321-211. Substantial damage. No injuries.

The copilot was undergoing his first two sectors of line training during flights between Manchester, England, and Ibiza, Spain, on July 18, 2008. The commander, a training captain, reviewed the copilot's file before departing from Manchester and found that the copilot, who had received base training in the A320, was having difficulty landing the A321, said the report by the U.K. Air Accidents Investigation Branch (AAIB).

During the flight, the commander briefed the copilot on the differences between landing the A321 and the A320, which is smaller and lighter. "The commander instructed the copilot that he would 'talk him through' the landing and specifically that he would instruct him to check the rate of descent with a nose-up sidestick input at 20 ft above touchdown," the report said. The copilot had been taught to flare the A320 at 30 ft.

The copilot flared the A321 too late at Ibiza, and the landing was described as "firm." The commander decided to fly the return leg to Manchester and transfer control to the copilot for the approach and landing.

The copilot conducted the approach to Manchester with the autopilot disengaged and the autothrottle engaged. "The commander gave a coaching narrative during the final moments before touchdown but, as the copilot closed the thrust levers, realized that the landing was 'going to go wrong,'" the report said. "The aircraft touched down firmly and bounced. The commander stated that he considered taking control but noted that the copilot appeared to be holding the aircraft's attitude and that intervention was not necessary."

The copilot later told investigators that he had become confused by the commander's coaching. The report noted that despite the commander's perception of differences in landing technique, the procedure established for the A320 also is applicable to the A321.

After parking the aircraft on stand, the commander and copilot discussed the landing and agreed that it had not been a "hard" landing. However, the commander also asked company line engineers who had flown as passengers if they thought it had been a hard landing. "They replied that if no 'load 15 report' had been produced on the flight deck printer and the commander did not consider the landing to have been heavy, then in their opinion no action needed to be taken," the report said.

A load 15 report is generated when certain parameters — including descent rate, vertical acceleration and gross weight — are exceeded on landing. A load 15 report and/or a commander's report of a hard landing typically requires a follow-up engineering inspection for structural damage. Although a load 15 report had been generated after the landing in Manchester, the aircraft's data management unit had not been programmed to automatically print the report. The commander was unaware that a load 15 report was available only by manual interrogation of the unit.

Two more flights were conducted in the A321 before the load 15 report was found during an unrelated engineering inspection of the landing gear. The report showed a vertical acceleration of 2.7 g during the touchdown at Manchester. Further examination of the aircraft revealed that the hard landing — categorized by engineers as "severe hard," according to the report — had caused a crack in the forward lug of the left main landing gear support rib.

### Misleading Parking Guidance

Boeing 747-400. Minor damage. No injuries.

Following a flight from Singapore to London Heathrow Airport with 237 passengers and 19 crewmembers the night of July 29, 2009, the commander visually checked to ensure that the aircraft parking information system (APIS, also called a visual docking guidance system) at the assigned stand had been activated. He also checked that the aircraft clearance zone was clear before turning the aircraft in to the stand.

"He noted that the APIS lateral guidance was illuminated and interpreted this as the system having been activated," the AAIB report said. "He commenced the left turn onto the stand, monitoring the lateral guidance, which was functioning correctly." However, the APIS had not been activated; a wiring defect was causing the lateral guidance to illuminate. The commander initially had not noticed that the APIS alphanumeric display of the aircraft type, "B747," which indicates that the system is active and is programmed properly for the arriving aircraft, was not illuminated.

The "turn round manager" (TRM) had arrived on stand five minutes before the 747 and had noticed that a number of baggage containers had been parked improperly. Because of this, he did not activate the APIS before he went to the terminal building to seek help in moving the baggage containers and to summon a marshaller to guide the aircraft.

As he was about to enter the terminal building, the TRM heard the aircraft taxiing in. "He moved back onto the stand and approached the front left side of the aircraft, and attempted to signal the commander to stop, using his hands to form a cross above his head," the report said. "His signal was not seen by the commander, and with the aircraft not stopping, the TRM ran around the front of the stand and activated the [APIS] 'STOP' button."

During his visual check of the stand, the commander had not seen a baggage cart that was protruding into the aircraft clearance zone. "It was probably hidden behind other vehicles and containers as he turned onto the stand," the report said.

As the commander taxied the 747, using the APIS lateral guidance, he became concerned that he did not see the aircraft type on the APIS display or a readout of distance to go. "He began to feel uneasy at the proximity to the terminal building and stopped the aircraft," the report said. "This was coincident with the word 'STOP' illuminating on the [APIS]."

The cowling on the left outboard engine had been dented when it struck the baggage cart before the aircraft came to a stop 11 m (36 ft) beyond the correct stopping point.

## TURBOPROPS

### Wrong Engine Shut Down

Beech King Air A90. Substantial damage. Four serious injuries, four minor injuries.

While climbing through 3,900 ft after departing from Pitt Meadows Airport in British Columbia, Canada, for a skydiving flight the afternoon of Aug. 3, 2008, the pilot heard a bang and felt the aircraft "shudder" and yaw right. He lowered the nose, shut down the right engine, feathered the propeller and moved the left engine power lever full forward. There was no response because it was the left engine that had failed.

The pilot turned back but was unable to reach the airport. The King Air touched down in a cranberry bog, bounced when it struck a mound, spun around when the left wing dug into the soft ground, and flipped over. Four skydivers were seriously injured. Although seat belts had been installed in the cabin floor when the airplane was modified for skydiving flights, all seven skydivers had been sitting on unattached wooden benches, said the report by the Transportation Safety Board of Canada.

The U.S.-registered aircraft had accumulated 13,257 flight hours since it was built in 1966. Investigators found that the left Pratt & Whitney Canada (PWC) PT6A-20 engine had been operated for 4,435 hours since its last overhaul, which exceeded the maximum time between overhauls (TBO) of 3,600 hours specified by the engine manufacturer.

The aircraft operator believed that the engines could be run "on condition" with no requirement for oil analyses, borescope inspections or condition-trend monitoring. The report noted that PWC did not offer an on-condition maintenance program; it did have a TBO-extension program, but the accident aircraft was not qualified for the program both because it was flown fewer than 300 hours a year and because it was used for skydiving flights.

**'The pilot had not received any training on the King Air for over two years, decreasing his ability to react appropriately.'**

An examination of the left engine revealed that the engine-driven fuel pump drive splines were worn and corroded "beyond the point of failure," the report said. The worn drive splines likely had disengaged and then re-engaged momentarily, causing the left engine to surge before flaming out due to fuel starvation. The right yaw caused by the surge likely reinforced the pilot's conclusion that the right engine had failed. "Moreover, the pilot had not received any training on the King Air for over two years, decreasing his ability to react appropriately," the report said.

"The King Air A90 emergency checklist requires that, in the event of an engine failure, the pilot shall apply maximum power, confirm the power loss by reference to engine instrumentation, then shut down the failed engine and feather its propeller," the report said. It noted, however, that the original, horizontal arrangement of the engine instruments in King Airs "makes it difficult to readily identify and confirm which engine is malfunctioning." The newer, vertical arrangement of the instruments, on the other hand, "makes identification of engine malfunction intuitive," the report said.

## Stall During an S-Turn

Socata TBM 700. Destroyed. One fatality.

The single turboprop was at 960 ft AGL and about 3 nm (6 km) from the threshold of Runway 09 at Cobb County–McCollum Field in Kennesaw, Georgia, U.S., the afternoon of July 15, 2008, when the airport traffic controller asked the pilot to make an S-turn to accommodate a departing airplane.

Recorded air traffic control radar data indicated that groundspeed was 147 kt when the airplane was banked left to begin the S-turn. The pilot apparently did not increase power, and the recorded groundspeed was 89 kt when he entered a right bank at 960 ft. At this time, the controller told the pilot, "Half an S-turn was fine. You can turn toward the runway now."

Witnesses saw the TBM enter a steep left bank toward the extended runway centerline. The airplane stalled, rolled inverted and descended in a steep nose-down attitude into a heavily wooded city park. "The airplane struck several trees and subsequently the ground, and came to an abrupt stop with no forward movement," the report said. "There was a post-impact fire which consumed much of the airplane and the surrounding landscape." No one on the ground was hurt.

During his most recent application for a medical certificate in December 2006, the private pilot, 66, had reported 975 flight hours. The accident report said that he had logged 44 flight hours in the TBM 700. "Toxicology testing indicated that the pilot had been using Tramadol, a prescription painkiller with potentially impairing effects," the report said. "The pilot had not reported its use on his most recent application for an airman medical certificate. … It is unclear what role, if any, the medication or the condition for which it might have been used played in the accident."

### Normal, Backup Gear Systems Fail

Cessna 441 Conquest II. Substantial damage. No injuries.

Night visual meteorological conditions prevailed when the air ambulance departed from Double Eagle II Airport (KAEG) in Albuquerque, New Mexico, U.S., to pick up a trauma patient in Socorro on July 3, 2009. "While en route, thunderstorms developed along the intended route of flight, so the pilot decided to return to KAEG," the NTSB report said.

When the pilot attempted to extend the landing gear, the circuit breaker tripped. He waited one minute for the circuit breaker to cool and attempted to reset it, but the circuit breaker tripped again. The pilot then conducted the checklist for the emergency gear-extension system, which uses nitrogen pressure to "blow" the gear down, but the landing gear did not extend.

"The pilot attempted to maneuver the airplane in an attempt to lower the landing gear," the report said. "The gear was confirmed in the retracted position by another pilot utilizing night vision goggles during a low approach at KAEG."

The pilot decided to divert the flight to Albuquerque International Airport, which has a longer runway. "During the landing flare, the pilot shut off both engines, and the airplane settled onto the runway," the report said. "The airplane slid to the right side of the runway and came to a stop."

Examination of the 441 revealed a malfunction of the landing gear selector switch that caused the circuit breaker to trip and a loose fitting on the nitrogen bottle that rendered the emergency gear-extension system inoperative.

## PISTON AIRPLANES

### Propeller Separates, Hits Fuselage

Britten-Norman Trislander. Substantial damage. Three minor injuries.

The pilot departed from New Zealand's Great Barrier Island for a scheduled flight with 10 passengers to Auckland the afternoon of July 5, 2009. He heard a "pattering sound" and the sound of the propellers going out of synchronization as the three-engine airplane climbed through 500 ft. He was adjusting the engine and propeller controls when he heard a loud bang and a passenger scream.

"Looking back to his right, the pilot saw that the entire propeller assembly for the right engine was missing and that there was a lot of oil spray around the engine cowling," said the report by the New Zealand Transport Accident Investigation Commission. "The aeroplane fuselage was extensively damaged and a passenger door was removed, leaving a large opening adjacent to some passengers." Three passengers sustained abrasions when struck by debris from a shattered cabin window.

The pilot shut down the right engine, turned back to the airport and landed the airplane without further incident. Investigators found that corrosion had caused fatigue cracks to form in the right engine crankshaft flange, to which the two-blade propeller assembly is mounted. The flange had fractured during the accident flight, causing the propeller assembly to separate from the crankshaft. The assembly had then shattered a window before striking the passenger door. However, "no part of the propeller assembly entered the cabin," the report said.

The Trislander was built in 1972 and had accumulated 18,289 hours. The engine had accumulated 2,230 hours since its last overhaul, exceeding Lycoming's recommended TBO by 30 hours. Minor corrosion of the crankshaft flange had been found during an inspection of the engine in October 2004. "The flange had been removed and the area protected with etching and painting at that time," the report said. "However, some time later the protection was compromised and the corrosion started." Subsequent routine inspections did not require removal of the propeller hub; thus, the corrosion on the crankshaft flange could not have been found.

The report noted that the crankshaft was "an older design that has since been progressively superseded by those with flanges less prone to cracking."

### Water, Mollusk Contaminate Fuel

Cessna U206F. Substantial damage. One minor injury.

While preparing the single-engine utility airplane for a cargo flight from Isleboro, Maine, U.S., to Rockland the morning of June 15, 2009, the pilot found water in samples of fuel drained from the tanks. "He continued to sump the tanks until the fuel samples were [free] of water," said the NTSB report.

The pilot said that the takeoff was normal until the engine began to lose power at about 300 ft AGL. "The pilot rejected an open field to his left for landing due to lack of altitude/glide distance and chose to land straight ahead in heavily wooded terrain," the report said.

Investigators found that the engine had failed because the airplane's fuel supply was contaminated by water, grease "plasticizers" and "a mass that resembled a snail (land mollusk)," the report said. "The mass subsequently dissolved in the sample jar, but the remains were suspended in the water at the bottom of the jar."

## HELICOPTERS

### Combustion Case Bursts

Bell 407. Substantial damage. No fatalities.

The helicopter was departing from a cruise ship in Talbot Bay, Western Australia, for a sightseeing flight the morning of Sept. 25, 2008, when the engine emitted a loud bang and lost power about 30 ft above the water. The pilot did not have time to activate the emergency floats before the 407 struck the water. "The cockpit and cabin quickly filled with water, and the helicopter rolled onto its side before rolling inverted," said the report by the Australian Transport Safety Bureau.

The report did not provide information about injuries but said that two of the six passengers were unable to exit the helicopter, and one lost consciousness. However, both passengers were rescued by the pilot and by cruise ship personnel before the helicopter sank.

"The investigation found that there had been a 'burst' failure of the engine outer combustion case as a result of ongoing high-cycle fatigue cracking during normal engine operation," the report said.

The Rolls-Royce 250-C47B engine had accumulated 5,056 hours. The helicopter operator said that the original outer combustion chamber had been replaced in 2005 because of corrosion. As a result, the operator had required the addition of a cleaning and corrosion-inhibiting compound to the water for compressor rinses performed at the end of each flying day. A routine dye-penetrant inspection of the new combustion case was performed six months before the accident, and no cracks were found.

"The engine manufacturer reported being aware of only two combustion case failures of this type in more than 21 million flight hours with the 250 series of engines," the report said. Nevertheless, Rolls-Royce initiated the development of modifications to reduce case stress.

### Rotor Blades Strike Power Line

Hughes 269B. Destroyed. Two fatalities.

The pilot and a utility company employee were conducting a power line patrol flight near Salesville, Arkansas, U.S., the morning of July 15, 2008. About 1 1/2 hours into the flight, while the helicopter was being maneuvered parallel to a set of power lines, the main rotor blades struck a high-voltage line that passed 100 ft above and perpendicular to the lines that the crew was inspecting.

The pilot and passenger were killed when the helicopter struck terrain. "According to [the utility company], the passenger normally flew with a map that showed the terrain, obstructions and crossing power lines and annotated observations in a small notebook," the NTSB report said. "The map and notebook were not located in the wreckage."

| Preliminary Reports, May 2010 | | | | |
|---|---|---|---|---|
| **Date** | **Location** | **Aircraft Type** | **Aircraft Damage** | **Injuries** |
| May 1 | Elba, Italy | de Havilland Canada DHC-8-300 | minor | 51 none |
| The Dash 8 was landed without further incident after a propeller severed a power line on final approach. | | | | |
| May 2 | New Albany, Indiana, U.S. | Jetprop DLX | destroyed | 2 fatal |
| The airplane, a turboprop conversion of the Piper Malibu, was in a spiral when it struck terrain. | | | | |
| May 5 | Mitú, Colombia | Embraer 145LR | substantial | 41 none |
| The landing gear collapsed when the 145 overran the wet, 5,770-ft (1,759-m) runway on landing. | | | | |
| May 10 | Amsterdam, Netherlands | Boeing 737-800 | minor | 186 NA |
| Two passengers were injured during an emergency evacuation at the gate when flames were observed near the 737's auxiliary power unit. | | | | |
| May 11 | Bristol, Virginia, U.S. | Bell 407 | substantial | 2 none |
| The helicopter landed hard during an autorotation initiated after the engine lost power during a state police training flight. | | | | |
| May 12 | Tripoli, Libya | Airbus A330-200 | destroyed | 103 fatal, 1 serious |
| Visibility was about 5 km (3 mi) in mist when the A330, inbound from South Africa, struck terrain about 1.5 km (0.8 nm) from the runway. | | | | |
| May 12 | Astrakhan, Russia | Antonov 2R | destroyed | 12 none |
| The pilots landed the An-2R in an open field after the engine failed shortly after takeoff for a skydiving flight. All the occupants exited the biplane before it was engulfed in flame. | | | | |
| May 13 | Manaus, Brazil | Embraer 810C | destroyed | 6 fatal |
| The airplane, a Seneca II built under license from Piper, struck terrain during a forced landing shortly after departing Manaus for a flight to Maués. | | | | |
| May 13 | Pikwitonei, Manitoba, Canada | Beech 55 Baron | substantial | 1 none |
| The pilot used a mobile telephone to report a complete electrical failure during a positioning flight to Thompson. The Baron struck terrain on approach to the Pikwitonei airport. | | | | |
| May 15 | Poeketi, Suriname | Antonov 28 | destroyed | 8 fatal |
| Weather conditions were described as "rough" when the An-28 crashed in a forest about 10 minutes after departing from Godo Holo for a scheduled flight to Paramaribo. | | | | |
| May 15 | Godwin Glacier, Alaska, U.S. | Robinson R44 | substantial | 2 NA |
| Whiteout conditions prevailed when the R44 struck terrain and rolled over. The two occupants and seven sled dogs were rescued by a U.S. Coast Guard helicopter crew. | | | | |
| May 16 | Clearwater, Florida, U.S. | Piper PA-46-350P | substantial | 2 serious, 1 minor |
| The pilot said that he retracted the flaps too early on takeoff for a relief flight to Haiti. The Malibu Mirage struck trees and a house. | | | | |
| May 17 | Kabul, Afghanistan | Antonov 24B | destroyed | 44 fatal |
| The An-24B was in heavy fog when it crashed in a mountain pass north of Kabul during a scheduled flight from Kunduz. | | | | |
| May 17 | Lucena City, Philippines | Robinson R44 II | destroyed | 4 fatal |
| One person on the ground was among the fatalities when the helicopter crashed in a residential area soon after departing from a high school field. | | | | |
| May 19 | Cascavel, Brazil | Embraer 110P Bandeirante | destroyed | 2 none |
| The cargo airplane struck terrain short of the runway during an approach with 2,000-m (1.25-mi) visibility in fog. | | | | |
| May 22 | Mangalore, India | Boeing 737-800 | destroyed | 158 fatal, 7 serious, 1 none |
| Inbound from the United Arab Emirates, the 737 overran the wet, 8,030-ft (2,448-m) runway and came to a stop in a ravine. | | | | |
| May 23 | Mönchgrün, Germany | Fairchild-Hiller FH-1100 | destroyed | 4 fatal |
| The helicopter crashed near a highway during a sightseeing flight. | | | | |
| May 26 | Cartwright, Newfoundland, Canada | Piper Chieftain | destroyed | 2 fatal |
| The Chieftain crashed in adverse weather conditions about 90 km (49 nm) from Cartwright during a flight from Goose Bay. | | | | |
| May 26 | Guatemala City, Guatemala | Piper Navajo | destroyed | 4 fatal |
| One person on the ground was among the fatalities when the Navajo crashed into a factory while returning to the airport with a vacuum pump failure. | | | | |

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.

<table>
<tr><th colspan="7">Selected Smoke, Fire and Fumes Events in the United States, February–April 2010</th></tr>
<tr><th>Date</th><th>Flight Phase</th><th>Airport</th><th>Classification</th><th>Sub-classification</th><th>Aircraft</th><th>Operator</th></tr>
<tr><td>Feb. 1</td><td>Descent</td><td>Lubbock, Texas (LBB)</td><td>Normal landing</td><td>Smoke in the cockpit</td><td>Learjet 25</td><td>Corporate/ charter</td></tr>
<tr><td colspan="7">The crew observed the distance measuring equipment display become extremely bright, followed by the circuit breaker tripping. The crew noticed an electrical smell and smoke in the cockpit that went away shortly after the circuit breaker tripped. No special handling was requested; landing was normal.</td></tr>
<tr><td>Feb. 5</td><td>Climb</td><td>Houston (IAH)</td><td>Return to airport, unscheduled landing</td><td>Lavatory smoke</td><td>Boeing 757</td><td>Continental Airlines</td></tr>
<tr><td colspan="7">The crew reported smoke in a lavatory. The aircraft returned to IAH, where it landed without incident. Maintenance technicians removed and replaced an engine.</td></tr>
<tr><td>Feb. 11</td><td>Takeoff</td><td>Dallas (DFW)</td><td>Emergency landing, unscheduled landing</td><td>Smoke in cockpit, smoke warning</td><td>Embraer EMB-145</td><td>American Eagle Airlines</td></tr>
<tr><td colspan="7">After takeoff, the crew detected and reported an odor of smoke; moments later, they received an engine indicating and crew alerting system lavatory smoke warning and the lavatory warning horn. The crew declared an emergency and returned to DFW.</td></tr>
<tr><td>Feb. 17</td><td>Cruise</td><td>Washington (DCA)</td><td>Unscheduled landing</td><td>Fumes in cabin</td><td>Boeing 737</td><td>Allegheny Airlines</td></tr>
<tr><td colspan="7">A flight attendant reported fumes in the aft galley. The flight attendant turned off galley power and the fumes dispersed. Later, flight attendants reported that the smell had returned. Recirculation fans were shut off and pack switches placed on "HIGH." The smell stopped and did not return. Maintenance technicians removed and replaced the cabin recirculation fan.</td></tr>
<tr><td>Feb. 23</td><td>Climb</td><td>Denver (DEN)</td><td>Diversion, unscheduled landing</td><td>Smoke in cabin</td><td>Embraer EMB-190</td><td>Corporate/charter</td></tr>
<tr><td colspan="7">The crew reported a burning smell in the cabin during the climb-out from DEN. The crew declared an emergency and returned to the airport. Maintenance found the ducting of Pack 2 damaged.</td></tr>
<tr><td>March 5</td><td>Climb</td><td>San Juan, Puerto Rico (SJU)</td><td>Diversion, unscheduled landing</td><td>Smoke in cockpit and cabin</td><td>Embraer EMB-190</td><td>JetBlue Airways</td></tr>
<tr><td colspan="7">Climbing through 10,000 ft, the crew reported an odor and visible indication of smoke in the cockpit and cabin. The aircraft was returned to SJU and an evacuation was accomplished. Maintenance technicians removed and replaced Pack 1.</td></tr>
<tr><td>March 9</td><td>Descent</td><td>Chicago (ORD)</td><td>Emergency landing, unscheduled landing</td><td>Smoke in cockpit</td><td>Embraer EMB-145LR</td><td>American Eagle Airlines</td></tr>
<tr><td colspan="7">During the descent, the crew reported the odor of smoke in the cockpit. The crew performed the procedures for cockpit smoke and fumes and aircraft operating manual procedures. The crew declared an emergency and the aircraft was landed at ORD without incident. The crew canceled the emergency while inbound after parking checks determined that the circuit breaker for the engine indicating and crew alerting system was tripped.</td></tr>
<tr><td>March 27</td><td>Cruise</td><td>—</td><td>Unscheduled landing</td><td>Fumes in cockpit</td><td>McDonnell Douglas DC-8</td><td>Air Transport International</td></tr>
<tr><td colspan="7">After 10 minutes of running the right recirculation fan, the crew sensed an electrical ozone odor. The right recirculation fan was turned off and the circuit breaker was tripped; the smoke and smell dissipated. Maintenance technicians replaced the right recirculation fan.</td></tr>
<tr><td>April 4</td><td>Cruise</td><td>Madison, Wisconsin (MSN)</td><td>Emergency landing, unscheduled landing</td><td>Smoke in cabin</td><td>Embraer EMB-145LR</td><td>American Eagle Airlines</td></tr>
<tr><td colspan="7">A flight attendant reported an electrical odor followed by smoke coming out of a passenger reading light. Other reading lights were flickering. The crew declared an emergency and diverted to MSN. Maintenance workers found a ballast with shorted connector and burning odor.</td></tr>
<tr><td>April 5</td><td>Cruise</td><td>—</td><td>Diversion, unscheduled landing</td><td>Smoke in cockpit and cabin</td><td>Boeing 737</td><td>Southwest Airlines</td></tr>
<tr><td colspan="7">An equipment cooling "OFF" light illuminated. Heat and smell dissipated immediately in the cockpit but smoke lingered in the cabin. Maintenance personnel found a normal equipment-cooling blower with a bad check valve. Maintenance removed and replaced the blower, check valve and high efficiency particulate arrestor filter.</td></tr>
<tr><td>April 15</td><td>Cruise</td><td>—</td><td>Diversion, unscheduled landing</td><td>Fumes in cabin</td><td>Boeing 757</td><td>United Airlines</td></tr>
<tr><td colspan="7">Fumes were reported in the cabin, and the flight was diverted. Maintenance technicians found that the equipment-cooling no. 1 supply fan had tripped the circuit breaker. Maintenance technicians replaced the cooling fan.</td></tr>
<tr><td>April 17</td><td>Cruise</td><td>—</td><td>Diversion, unscheduled landing</td><td>Smoke in cockpit and cabin</td><td>Airbus A320</td><td>United Airlines</td></tr>
<tr><td colspan="7">A smoke odor was detected in the no. 1 galley and cockpit. The crew accomplished the "Smoke–Cabin" procedures in the quick reference handbook and diverted. The crew turned off the avionics blower and extract fans. Smoke and vibration dissipated. Maintenance personnel found the avionics extract fan inoperable and replaced it.</td></tr>
<tr><td>April 25</td><td>Climb</td><td>Savannah, Georgia (SAV)</td><td>Emergency descent, diversion</td><td>Fumes in cockpit</td><td>Learjet 45</td><td>Corporate/charter</td></tr>
<tr><td colspan="7">During climb, a "R BLEED OVHT" amber light illuminated twice for several seconds and then extinguished. At Flight Level 450, a "PACK OVHT" amber light illuminated, preceded by fumes in the cockpit. The crew declared an emergency and diverted to SAV. Maintenance removed and replaced the right high-pressure valve and air cycle machine turbine.</td></tr>
<tr><td colspan="7">Source: Safety Operating Systems <www.safeopsys.com><br>Edited and compiled by Rick Darby.</td></tr>
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