AeroSafety WORLD

UAS OUTLOOK
Unmanned vehicles may rule

UPSET INNOVATION
Integrating technology into training

FLIGHT ATTENDANT INJURIES
Risk greater on short-haul flights

TURBULENCE
COOPERATE AND AVOID

THE JOURNAL OF FLIGHT SAFETY FOUNDATION

MARCH 2014

FOCUS Areas

Let me start with a heartfelt "Thank you!" to Kevin Hiatt. As you may know, Kevin has assumed the lead safety and operations role with the International Air Transport Association (IATA). Under Kevin's leadership, Flight Safety Foundation continued to expand its safety footprint and to skillfully execute its mission as the leading independent, impartial and international voice of aviation safety.

It is now my honor to serve as the Foundation's acting CEO and president while the search is under way for a permanent new leader. While leadership transition is a time of change, it is not a time to be stagnant or stationary. The Foundation's temporary leadership, supported by the full Board of Governors, is committed to carrying on our vital mission, and, to that degree, has dedicated considerable time to setting the 2014 priorities for the advancement of safety. Your continuing support of the Foundation allows for work to advance in the following areas:

Unstable approaches and go-arounds — The past year provided several vivid reminders of what can happen if pilots make the wrong decisions and continue unstable approaches. This is not a new concern, but rather one the Foundation has been engaged with since 1992. Many would say that the FSF *Approach and Landing Accident Reduction Tool Kit* is our best-known product. More than 40,000 tool kits have been produced and distributed in the last two decades, and dozens of workshops on the subject have been conducted. But times change, technology changes, and thinking needs to be updated. So the Foundation and its experts have been revisiting the go-around process in order to update best practices. We've studied recent events, updated guidance and provided status reports at recent conferences, and we will do the same in 2014. In fact, we are a primary sponsor for the Regional Airline Association's Approach and Go-Around Safety seminar scheduled for March in Orlando.

Safety data sharing and protection — We have demonstrated the need, business process and safety value for expanded sharing of industry safety data, with a focus on gathering, analysis and dissemination. We are convinced of the utility of data sharing as a means to improve safety and are committed to its expansion across the globe. The Foundation is uniquely positioned to bring together states, regulators, operators and data analysis experts to facilitate the rapid development of safety improvements. In 2014, we will continue extending our reach to a broader international community and to other sectors of aviation. With this expansion comes a need for greater understanding of the principles of safety data protection. Our goal is to make data protection concerns a thing of the past.

Advancing safety in challenging operations — This is perhaps the least known of our activities, but also one of our fastest-growing safety improvement opportunities. The Foundation, in concert with some of the largest natural resource companies in the world, has embarked on an effort to reduce the risks of flying in support of mineral and mining operations, oil and gas production and specialty air charters. We have invested heavily in our Basic Aviation Risk Standard (BARS) products, which include worldwide best practice audit standards and training programs. Hundreds of audits have been accomplished, and we are poised for further growth into the humanitarian-support arena. This is some of the most immediately impactful work in which the Foundation engages.

Flight Safety Foundation is poised in 2014 to expand its safety presence in the areas noted above and many others. Thank you for your continued membership, endorsement and commitment to aviation safety on all fronts.

Kenneth J. Hylander
President and CEO (Acting)
Flight Safety Foundation

AeroSafety WORLD

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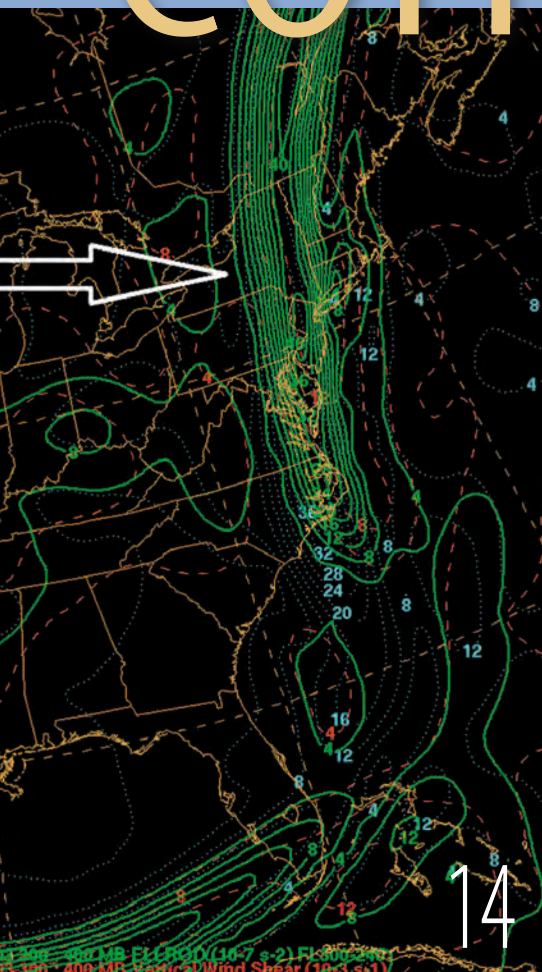

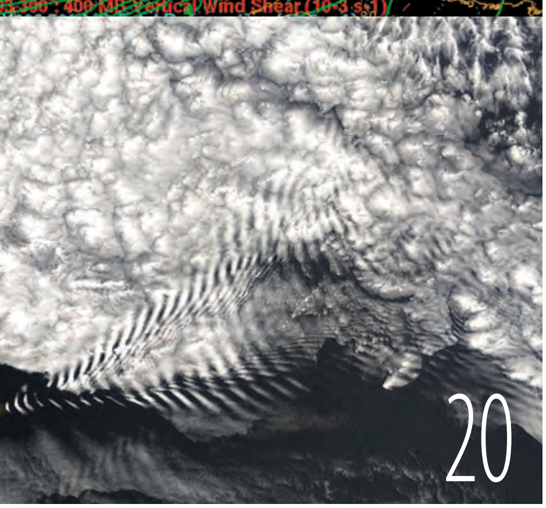

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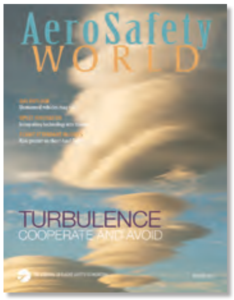

About the Cover
Standing lenticular clouds warn of possible strong, mountain-wave turbulence.

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BY THE Numbers

It now is apparent that 2013 will go down as one of the safest years in aviation history, particularly in terms of the number of fatalities in commercial air transport operations. According to preliminary data released by the International Civil Aviation Organization (ICAO), the number of fatalities suffered in scheduled commercial operations fell by more than 50 percent in 2013 from the previous year, despite the fact that the number of fatal accidents remained the same year over year (see "Another Record Year," p. 44).

The numbers don't match up exactly because different organizations include or exclude different types of aircraft from different types of operations in tabulating accidents and calculating accident rates, but the European Aviation Safety Agency (EASA) had a similar message: the number fatalities suffered worldwide last year was down significantly from the yearly average for the period 2003–2012. While EASA's calculations also had the number of fatal accidents declining last year, the relative decrease in fatalities far outpaced the drop in fatal accidents.

We haven't done an in-depth statistical analysis, but I think there is growing evidence that supports the idea that when fatal accidents occur, more passengers and crew are surviving those accidents than ever. In part, this likely is due to the type of accidents that are occurring. Crashes on approach and landing are more survivable than controlled flight into terrain (CFIT). According to ICAO, seven of the nine fatal accidents it counted last year were during the approach or go-around phases of flight. But credit also is due to the way airplanes are designed, built and certificated, from the strength of the seats, to the materials used in the cabin, to the training of crews.

Unfortunately, the decline in fatalities is not shared evenly across all operational types. In his "Year in Review" article in the February issue of *AeroSafety World*, Foundation Fellow Jim Burin noted that the 22 major turboprop accidents in 2013 were about average for that sector of the industry and represented a modest regression from 2012's record year. In releasing limited data on the safety performance last year of its member carriers, the Association of Asia Pacific Airlines (AAPA) said that turboprop operations maintained a good safety record but "continue to experience somewhat higher accident rates compared to larger jet aircraft operations."

Andrew Herdman, AAPA director general, went as far as to say that "… greater attention also needs to be focused on turboprop aircraft operations. We need firm regulation to ensure that all carriers operate to the highest international standards, including wide deployment of automated terrain awareness warnings systems (TAWS) for all commercial operations."

According to Burin, over the past several years, there have been 38 CFIT accidents involving 14 turbojet airplanes and 24 turboprops. Of those 38 aircraft, only three were equipped with operating TAWS and in those three cases, the system provided 30 seconds or more of warning of the impending collision with the ground.

Frank Jackman
Editor-in-Chief
AeroSafety World

Serving Aviation Safety Interests for More Than 65 Years

Since 1947, Flight Safety Foundation has helped save lives around the world. The Foundation is an international non-profit organization whose sole purpose is to provide impartial, independent, expert safety guidance and resources for the aviation and aerospace industry. The Foundation is in a unique position to identify global safety issues, set priorities and serve as a catalyst to address the issues through data collection and information sharing, education, advocacy and communications. The Foundation's effectiveness in bridging cultural and political differences in the common cause of safety has earned worldwide respect. Today, membership includes more than 1,000 organizations and individuals in 150 countries.

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MARCH 4–5 ➤ Air Charter Safety Symposium. Air Charter Safety Foundation. Ashburn, Virginia, U.S. Bryan Burns, <bburns@acsf.org>, <acsf.aero>, +1 703.647.6401.

MARCH 4–6 ➤ World ATM Congress 2014. Civil Air Navigation Services Organisation. Madrid, Spain. Rugger Smith, <rugger.smith@worldatmcongress.org>, <worldatmcongress.org>, +1 703.299.2430.

MARCH 6–8 ➤ 25th annual International Women in Aviation Conference. Women in Aviation International. Orlando. <wai.org>.

MARCH 12–15 ➤ AEA 57th annual International Convention & Trade Show. Aircraft Electronics Association. Nashville, Tennessee, U.S. Debra McFarland, <debbiem@aea.net>, +1 816.347.8400.

MARCH 13–14 ➤ 2Gether 4Safety Seminar & Expo. AviAssist Foundation. Entebbe, Uganda. <events@aviassist.org>, <2gether4safety.org>.

MARCH 18–19 ➤ Approach and Go-Around Safety. Regional Airline Association. Orlando. Stacey Bechdolt, <bechdolt@raa.org>, <raa.org>.

MARCH 18–20 ➤ African Aviation MRO Africa Conference & Exhibition. African Aviation. Johannesburg, South Africa. <www.africanaviation.com>.

MARCH 19–21 ➤ ARSA Annual Repair Symposium and Legislative Fly-In. Aeronautical Repair Station Association. Arlington, Virginia, U.S. <www.arsa.org>.

MARCH 25–26 ➤ Aircraft Commander in the 21st Century: Decision-making — Are We on the Right Path? (Flight Operations Group Conference). Royal Aeronautical Society. London. <conference@aerosociety.com>, +44 (0) 20 7670 4345.

MARCH 26–27 ➤ Safety in Aviation Asia. Flightglobal. Singapore. Alex Aubrey, <alex.aubrey@rbi.co.uk>, <flightglobalevents.com/safetyasia14>, +44 (0) 20 8652 4724.

MARCH 31–APRIL 2 ➤ 10th annual CHC Safety & Quality Summit. CHC Helicopter. Vancouver, British Columbia, Canada. <www.chcsafetyqualitysummit.com>.

MARCH 31–APRIL 2 ➤ IATA Ops Conference 2014. International Air Transport Association. Kuala Lumpur, Malaysia. <www.iata.org>.

APRIL 1–3 ➤ World Aviation Training Conference and Tradeshow (WATS 2014). Halldale Group. Orlando, Florida, U.S. Zenia Bharucha, <zenia@halldale.com>, <halldale.com/wats#.Ub4RyhYTZCY>, +1 407.322.5605.

APRIL 1–3 ➤ ERAU Unmanned Aircraft Systems Workshop. Embry-Riddle Aeronautical University. Daytona Beach, Florida, U.S. Sara Ochs, <case@erau.edu>, <daytonabeach.erau.edu/usa>, +1 386.226.6928.

APRIL 7–9 ➤ Flight Operational Forum Norway. FoF Norway. Oslo, Norway. <manager@fof.aero>, <fof.aero>, +47 911 84182.

APRIL 8–10 ➤ MRO Americas. Aviation Week. Phoenix. Helen Kang, <helen_kang@aviationweek.com>, <www.aviationweek.com>, +1 212.904.6305.

APRIL 15–17 ➤ Asian Business Aviation Conference & Exhibition (ABACE2014). Shanghai. Shanghai Airport Authority and U.S. National Business Aviation Association. Dan Hubbard, <dhubbard@nbaa.org>, <www.abace.aero/2013/news/abace2014/>, +1 202.783.9360.

APRIL 16–17 ➤ 59th annual Business Aviation Safety Summit (BASS 2014). Flight Safety Foundation and National Business Aviation Association. San Diego. Namratha Apparao, <apparao@flightsafety.org>, <flightsafety.org/bass>, +1 703.739.6700, ext. 101.

APRIL 22–23 ➤ Civil Avionics International Forum. Galleon (Shanghai) Consulting Co. Ltd. Shanghai. <marketing@galleonevents.com>.

MAY 8–9 ➤ 3rd Air Medical & Rescue Congress China 2014. China Decision Makers Consultancy. Shanghai. <cdmc.org.cn/2014/amrcc/>.

MAY 9 ➤ Search & Rescue Forum China 2014. China Decision Makers Consultancy. Shanghai. Patrick Cool, <Patrick@pyxisconsult.com>, <cdmc.org.cn/2014/isrfc/>.

MAY 12–15 ➤ Unmanned Systems 2014 Conference. Association for Unmanned Vehicle Systems International. Orlando. <membership@auvsi.org>, <www.auvsishow.org/auvsi2014/public/enter.aspx>, +1 703.845.9671.

MAY 12–16 ➤ SMS Expanded Implementation Course. The Aviation Consulting Group. Honolulu, Hawaii, U.S. Bob Baron, <bbaron@tacgworldwide.com>.

MAY 13–15 ➤ RAA 39th annual Convention. Regional Airline Association. St. Louis, Missouri, U.S. David Perez-Hernandez, <www.raa.org>, +1 312.673.4838.

MAY 20–22 ➤ Cabin Operations Safety Conference. International Air Transport Association. Madrid. Mike Huntington <COSCSales@worldtek.com>, <www.iata.org/events/Pages/cabin-safety.aspx>, +1 514.874.0202.

MAY 21–22 ➤ Asia Pacific Aviation Safety Seminar (APASS 2014). Association of Asia Pacific Airlines. Bangkok, Thailand. C.V. Thian, <cvthian@aapa.org.my>, +603 2162 1888.

MAY 24–25 ➤ Rotortech 2014. Australian Helicopter Industry Association. Sunshine Coast, Queensland, Australia. <secretary@austhia.com>.

JUNE 4–5 ➤ RTCA 2014 Global Aviation Symposium. RTCA. Washington. <symposium@rtca.org>, +1 202.833.9339.

JUNE 10–11 ➤ 2014 Safety Forum: Airborne Conflict. Flight Safety Foundation, Eurocontrol, European Regions Airline Association. Brussels, Belgium. <tzvetomir.blajev@eurocontrol.int>, <skybrary.aero>.

JUNE 24–25 ➤ 6th annual Aviation Human Factors & SMS Seminar. International Society of Safety Professionals. Dallas. <isspros.org>, +1 405.694.1644.

JUNE 30–JULY 2 ➤ Safe-Runway Operations Training Course. JAA Training Organisation. Abu Dhabi, United Arab Emirates. <jaato.com>, +31 (0) 23 56 797 90.

JULY 3 ➤ Technology: Friend or Foe? The Introduction of Automation to Offshore Operations (Annual Rotorcraft Conference). Royal Aeronautical Society. London. <conference@aerosociety.com>, +44 (0) 20 7670 4345.

JULY 14–20 ➤ 49th Farnborough International Airshow. Farnborough International. Farnborough, Hampshire, England. <enquiries@farnborough.com>, <farnborough.com>, +44 (0) 1252 532 800.

NOV. 11–13 ➤ 67th annual International Air Safety Summit. Flight Safety Foundation. Abu Dhabi, United Arab Emirates. Namratha Apparao, <apparao@flightsafety.org>, +1 703.739.6700, ext. 101.

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

If you have a safety-related conference, seminar or meeting, we'll list it. Get the information to us early. Send listings to Frank Jackman at Flight Safety Foundation, 801 N. Fairfax St., Suite 400, Alexandria, VA 22314-1774 USA, or <jackman@flightsafety.org>.

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

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BARS

BASIC AVIATION RISK STANDARD

FLIGHT SAFETY FOUNDATION

UPDATE

Greg Marshall,
BARS Program Managing Director

Ninety-one audits were conducted in 19 countries last year under the auspices of Flight Safety Foundation's Basic Aviation Risk Standard (BARS) Program, bringing to 252 the number of audits conducted or planned in 29 countries since BARS was launched in 2010, according to data provided by the BARS program office in Melbourne, Australia.

The 2013 audits resulted in 44 P1 (highest priority) findings, 1,381 P2 findings and 140 P3 findings, and the average closure rate was 98 percent for P1, 92 percent for P2 and 45 percent for the P3 findings, which are recommendations for improvement only. The BARS program office published 87 initial audit reports and 85 final audit reports. Seventeen operators achieved "gold" status and 16 achieved the new "silver" status, which was introduced in 2013.

The silver level recognizes aircraft operators that have maintained continuous registration for two years and have closed out all of their findings by the originally planned due date. "The introduction of this status level recognizes aircraft operators that have placed considerable effort in acquitting their findings in a complete and timely manner," BARS Managing Director Greg Marshall said last year in announcing the silver level. Aircraft operators that proceed to their third-year audit and close their findings in the same manner progress to gold status.

In reviewing the program's other 2013 achievements, Marshall said BARS currently has 23 member organizations and that three more are expected to join in the first quarter of 2014. Two auditor accreditation courses were conducted in 2013, an updated *BARS Procedures Manual* was released, as was an updated *BARS Auditor Guide*. Other releases included the BARS Aerial Work audit category and protocol and Volumes 1 and 2 of the *BARS Implementation Guidelines*.

Two new courses were developed and made available last year — the *Aviation Coordinator for Offshore Personnel* course and the *Helicopter External Load Operations for Ground Personnel* course.

In addition to the BARS member organizations expected to join this year, Marshall said the introduction of new audit protocols and additional tools and guidance materials — all designed to assist organizations with the management of aviation risk for their employees — are on tap for 2014.

For example, the operational review tool is newly available as an application through Apple's App Store. The tool, which can be used with iPads and iPhones, includes built-in checklists that can be used by auditors or other personnel when conducting field reviews to verify procedures, the existence of equipment and the adequacy of facilities.

In May, Version 5 of the *BAR Standard* is expected to be released, as are the two volumes of the Version 5 *BARS Implementation Guidelines*. A new suite of documents, tailored to specific user groups, will be produced to replace the current *BARS Procedures Manual* format.

The protocols expected to be released include the BARS Maintenance and Repair Organization audit category and protocol, and a new aerodrome audit category and protocol.

BARS was established by Flight Safety Foundation, in conjunction with the global natural resource sector, to improve safety in operations involving remote and hazardous environments. The program aims to raise aviation safety standards by assisting resource companies with the management of aviation risk for their personnel. The International Council on Mining and Minerals supports the use of BARS to improve safety.

Safety News

Category 2 Rating for India


Jennifer Moore

India has been downgraded to a Category 2 rating under the U.S. Federal Aviation Administration's (FAA's) International Aviation Safety Assessment program.

The rating, which signifies that India's oversight of civil aviation safety "does not currently comply with the international safety standards set by the International Civil Aviation Organization (ICAO)," means that Indian carriers will not be permitted to begin any new service to the United States. Existing service may continue, however.

The FAA said it would work with India's Directorate General for Civil Aviation to identify actions that must be taken to regain a Category 1 safety rating, which signifies compliance with ICAO safety standards.

The Indian government has begun addressing the issues identified during the FAA's September 2013 assessment of Indian aviation safety oversight, the FAA said, noting that 75 additional full-time inspectors have been hired.

The FAA's International Aviation Safety Assessment program evaluates the civil aviation authorities in all countries where air carriers operate to the United States to determine whether those authorities meet ICAO safety oversight standards.

NTSB Pushes Helicopter Safety

An "unacceptably high" number of helicopter accidents has prompted the U.S. National Transportation Safety Board (NTSB) to add improving helicopter safety to its annual "Most Wanted" list of transportation safety improvements.

"In the last 10 years, 1,470 accidents occurred involving helicopters used as air ambulances, for search and rescue missions and commercial helicopter operations such as tour flights," the NTSB said, adding that the accidents killed 477 people and caused serious injuries to 274 others. "Safety improvements to address helicopter operations have the potential to mitigate risk to thousands of pilots and passengers each year."

The NTSB reiterated its call for implementation of sound risk management practices, especially for inspection and maintenance; flight risk evaluation programs and formal dispatch and flight-following procedures for emergency medical services helicopters; and improved training that includes scenarios involving inadvertent flight into instrument meteorological conditions.


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Continuing Risks

The Transportation Safety Board of Canada (TSB) has reiterated its call for action to reduce the risks of runway collisions, citing its new report on an Aug. 29, 2011, occurrence in which a passenger airplane was taxied across an active runway as a twin-engine turboprop was taking off.

No one was injured, and damage was minor, but the TSB said that it was "concerned that unless better defenses are put in place to reduce these occurrences, the risk of a serious collision between aircraft remains."

The agency noted that the risk of collisions on runways is cited on its Watchlist of transportation safety issues that present the greatest risks to Canadians.

The TSB said that the 2011 occurrence followed the landing of a Sky Regional Airlines Bombardier DHC-8-402 with 29 people aboard at the Montreal/Pierre Elliott Trudeau Airport.

"The ground controller gave the crew taxi instructions to the gate, which included stopping before Runway 28 until instructed to cross it," the TSB said. "The DHC-8 flight crew read back the instruction correctly, meaning that they understood and would comply. Meanwhile, the air traffic controller cleared a Beech King Air with three crewmembers aboard to take off on Runway 28.

"Two minutes later, the DHC-8 entered Runway 28 without stopping, while the King Air was nearing takeoff speed. The King Air aborted the takeoff and while slowing down, veered right on the runway centerline and passed about 40 ft [12 m] behind the DHC-8."

The King Air received minor mechanical damage that the TSB said was related to the airplane's rapid deceleration. There was no damage to the DHC-8.

Using criteria established by the International Civil Aviation Organization, Transport Canada and Nav Canada, the TSB characterized the occurrence as "extremely serious," noting that it would have resulted in a collision if the King Air crew had not rejected their takeoff and veered to the right.

Data show that between 2001 and 2009, there were 4,140 runway conflicts across Canada. "Not all 4,140 occurrences involved a risk of high-speed collision," the TSB said. "However, in those that did, the outcomes could have been catastrophic."

Changes implemented after the occurrence included improved signage on the taxiway on both sides of the runway and the creation of a local runway safety committee. In addition, Sky Regional modified its checklist to limit distractions during taxiing, the TSB said.

Night Flight Review

Spurred by the fatal 2011 crash of a Eurocopter AS355 F2 in dark night conditions in South Australia, the Australian Civil Aviation Safety Authority (CASA) has begun a review of regulations concerning night visual flight rules (VFR) flight.

CASA said its primary focus is "the need for a defined external horizon to be visible for aircraft attitude control."

CASA's review follows the issuance by the Australian Transport Safety Bureau (ATSB) of a report on an Aug. 18, 2011, crash 145 km (78 nm) north of Marree that killed the 16,000-hour pilot and his two passengers. The ATSB said the pilot probably was spatially disoriented and that factors contributing to his disorientation probably included the dark night conditions that prevailed at the time (*ASW*, 2/14, p. 23).

In describing its project, CASA noted that the ATSB report had characterized dark night visual meteorological conditions (VMC) as "effectively the same" as instrument meteorological conditions.

"The only real difference," the ATSB said, "is that, if there are lights on the ground, they can be seen in VMC. In remote areas, where there are no lights or ambient illumination, there is no difference. Pilots cannot see the ground and have no external cues available to assist with their orientation."


Australian Transport Safety Bureau

CASA said that its review is intended to clarify the term "visibility" in dark night conditions and to develop additional guidance material that emphasizes "the importance of maintaining a discernible external horizon at night."

In a separate discussion of accidents that occur during flight under night VFR, the ATSB said that pilots could effectively manage the risks inherent in night VFR flight, in part by ensuring that they remain current and proficient and by ensuring that the aircraft is appropriately equipped.

"Always know where the aircraft is in relation to terrain, and know how high you need to fly to avoid unseen terrain and obstacles," the ATSB said. "Remain aware of illusions that can lead to spatial disorientation — they can affect anyone. Know how to avoid and recover from illusions by relying on instrument flight."

European–Asian Pact

The European Commission and the Association of Southeast Asian Nations (ASEAN) say they are taking steps to enhance cooperation on aviation safety and other related issues.

A February summit meeting in Singapore included discussion of aviation safety regulations and the potential for cooperation between ASEAN and the European Union.

"ASEAN is developing, by 2015, an ASEAN single aviation market, which will have many similarities to the single aviation market that the EU has successfully created over the past two decades," the EU said. "The summit will offer an excellent opportunity to explore the potential for a closer cooperation between the two regions, including the prospect of an 'open skies' agreement."

The EU noted that air traffic between the EU and ASEAN totaled 10 million passengers in 2012, and projections indicate that half of the wordwide growth in air traffic over the next 20 years will involve operations in the Asia-Pacific region.

The agenda included discussion of air traffic management issues and the possibility of a comprehensive air transport agreement between the EU and ASEAN.


Jet Request/wikimedia

Proposed Penalty

The U.S. Federal Aviation Administration (FAA) has proposed a $150,000 civil penalty against Talon Air for allegedly violating Federal Aviation Regulations when it allowed four pilots to fly the company's Hawker 4000 "without proper training or examinations."

The FAA says that the pilots flew at least 64 times in 2011 and 2012 while they were not qualified to serve as crewmembers.

The company has 30 days from its receipt of the FAA enforcement letter to respond.

R44 Fuel Tank Retrofitting

Citing seven accidents in the United States and Australia involving Robinson R44 helicopters, the U.S. National Transportation Safety Board (NTSB) says owners and operators of R44s should be required to implement fuel tank retrofitting outlined in a manufacturer's service bulletin.

The NTSB said that, in each of the seven accidents, "impact forces were survivable for the occupants, but fatal or serious injuries occurred because of a post-crash fire that resulted from an impact-related breach in the fuel tanks."

The most recent accident, still under investigation, involved an R44 II that struck a fueling structure at Corona (California, U.S.) Municipal Airport on Nov. 25, 2012; fire and an explosion followed. The pilot was killed.

The NTSB said that since 2008, it has investigated three other R44 accidents involving a breach of the fuel tanks, followed by leaking fuel and a fire. Since 2011, three similar R44s were involved in similar accidents in Australia, the NTSB said.

All of the accidents should have been survivable, "with minor or no injuries to the occupants," the NTSB said. "However, the accidents in the United States … resulted in two fatalities and two serious thermal injuries, and the accidents in Australia resulted in eight fatalities and one serious injury."

Robinson Helicopter Co. issued Service Bulletin (SB) 78 in 2010, advising owners and operators of R44s with all-aluminum fuel tanks to retrofit the helicopters with bladder-type fuel tanks that are "designed to contain fuel and prevent it from spilling out of the tank after a survivable impact." The SB said the corrective action should be taken by Dec. 31, 2014.

Later, Robinson moved up the completion date to April 30, 2013. In December 2013, the U.S. Federal Aviation Administration issued Special Airworthiness Bulletin SW-13-11 to inform R44 owners and operators about the revision and the availability of bladder-type fuel tanks.

dhnikkel/wikimedia

Robinson said that, although a number of retrofits have been completed, some owners have delayed having the work done, sometimes citing the absence of a formal requirement.

The Australian Civil Aviation Safety Authority issued an airworthiness directive in 2013 (AD/R44/23) requiring operators to comply with a revised service bulletin, SB-78B.

In Other News …

The European Commission has published rules for **operational suitability data (OSD)**, intended to ensure that data needed for safe aircraft operations is available to — and used by — aircraft operators. Types of data in the OSD category include aircraft reference data to support qualification of simulators, a minimum syllabus for training in pilot type ratings, and the master minimum equipment list. … The U.K. Civil Aviation Authority (CAA) has merged its **airspace and safety** functions, now under the jurisdiction of the Safety and Airspace Regulation Group.

Correction A note in a figure accompanying a December 2013–January 2014 *ASW* article about line operations safety audits (LOSA; "Intentionally Noncompliant," p. 17) incorrectly stated the number of airlines involved in the LOSA observations discussed in the article. The note in Figure 1 should have said that the observations took place at more than 70 airlines. Additionally, James Klinect, chief executive officer of The LOSA Collaborative, said, in a clarification after publication of the article, "It's not really how a flight crew responds to intentional noncompliance (INC) errors that dictates INC mismanagement. It's the outcome, regardless of how a crew responds. … In LOSA we call bad outcomes, regardless of response, mismanagement."

Compiled and edited by Linda Werfelman.

Smooth Operators

BY WAYNE ROSENKRANS

Airlines by now should be benefiting from both meteorological forecasts of atmospheric turbulence and today's actionable intelligence about the real-time effects of that turbulence on large commercial jets. Unfortunately, say several turbulence-detection pioneers in the United States, the industry is still missing a key piece — enough airline participation — needed to accelerate progress in reducing, if not eliminating, unexpected encounters with in-flight turbulence. Such encounters still take a steady toll in injuries and, in the rarest cases, fatalities (see "Bumpy Ride Ahead," p. 20).

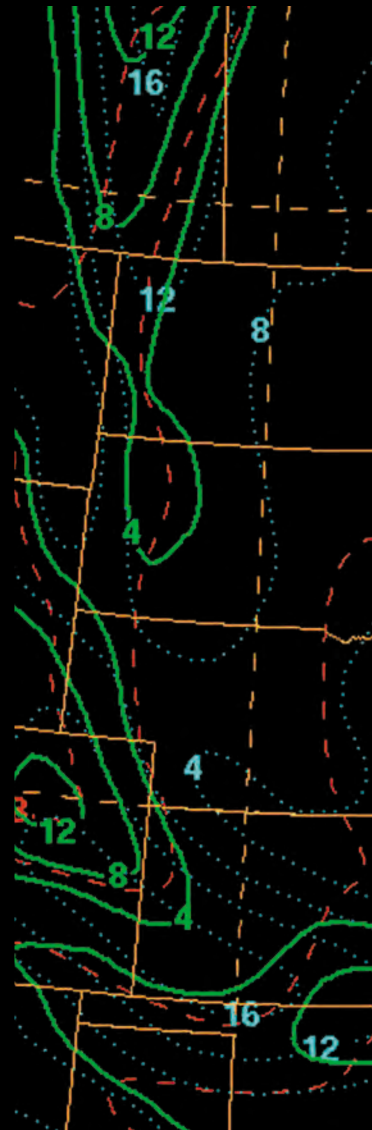
In February, specialists from American Airlines, WSI Corporation and AeroTech Research briefed *ASW* about their perspectives of related technology, experiences of pilots and dispatchers, and lessons learned in this safety quest while gaining operational efficiencies as air traffic grows.

Eight years ago, an *ASW* article (*ASW*, 9/06, p. 20) described several new technologies that had become mature enough for operational use, a point made then by the U.S. Federal Aviation Administration (FAA) in Advisory Circular (AC) 120–88A, *Preventing Injuries Caused by Turbulence*. A major theme of the AC is the importance of constantly communicating turbulence information. The AC said, "In the past, the practice of rerouting has been met with limited air carrier acceptance, primarily because of the inaccuracy of first-generation turbulence forecast products, the subjectivity inherent in pilot weather reports (PIREPs), if available, and the operational costs of rerouting. … The most promising way to capture and convey [real-time] information is through a comprehensive program of reports from aircraft in flight. That program would be founded on automated turbulence reporting supplemented by human reports PIREPs."

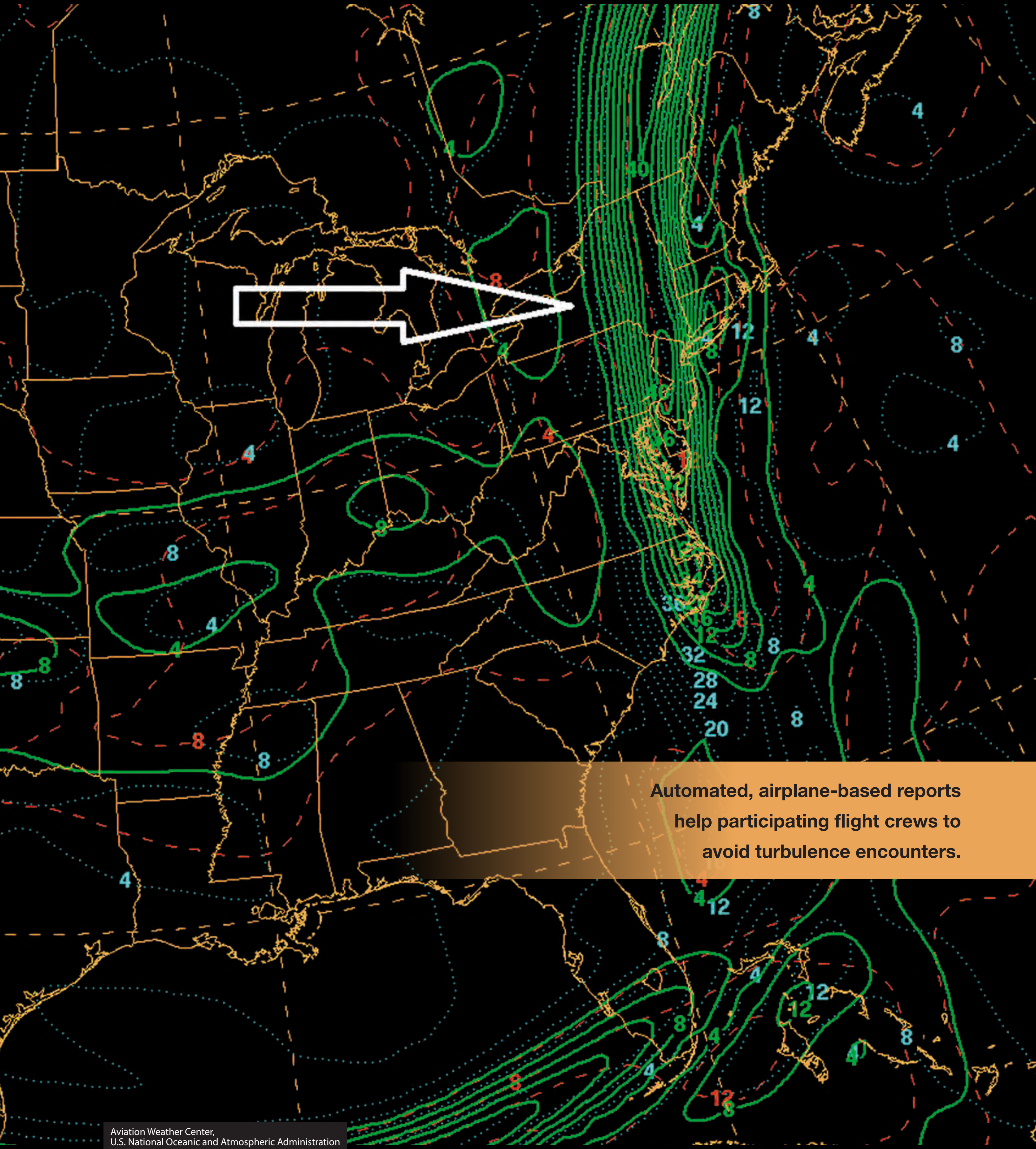
Among its recommendations, the AC said that U.S. Federal Aviation Regulations Part 121 air carriers should consider the installation of the Turbulence Auto-PIREP System (TAPS). (Product names were removed in November 2007.) TAPS was developed by Paul Robinson and his AeroTech Research staff under the U.S. National Aeronautics and Space Administration's Turbulence Prediction and Warning System project.

Robinson describes TAPS as a robust, onboard technology that uses the same vertical accelerometer that sends data to the digital flight data recorder and ties into the aircraft's existing aircraft communications addressing and reporting system (ACARS). Essentially, reports now are generated, transmitted to airline dispatch, further processed for different users and retransmitted to ACARS printers on nearby aircraft based on which flight crews would benefit from the information.

In the 2006 article, *ASW* called TAPS "a new system now in limited use that automatically reports turbulence encounters to ground stations, with the promise that eventually the reports routinely will be data-linked into flight decks." A new generation of aircraft turbulence-detecting radars then coming on the market, using software patented by AeroTech Research called ETURB, also was ready to complement TAPS. Today, WSI exclusively licenses TAPS, and it forms part of a WSI commercial product called Total Turbulence, an integrated suite of turbulence awareness, forecasting, detection and mitigation technology

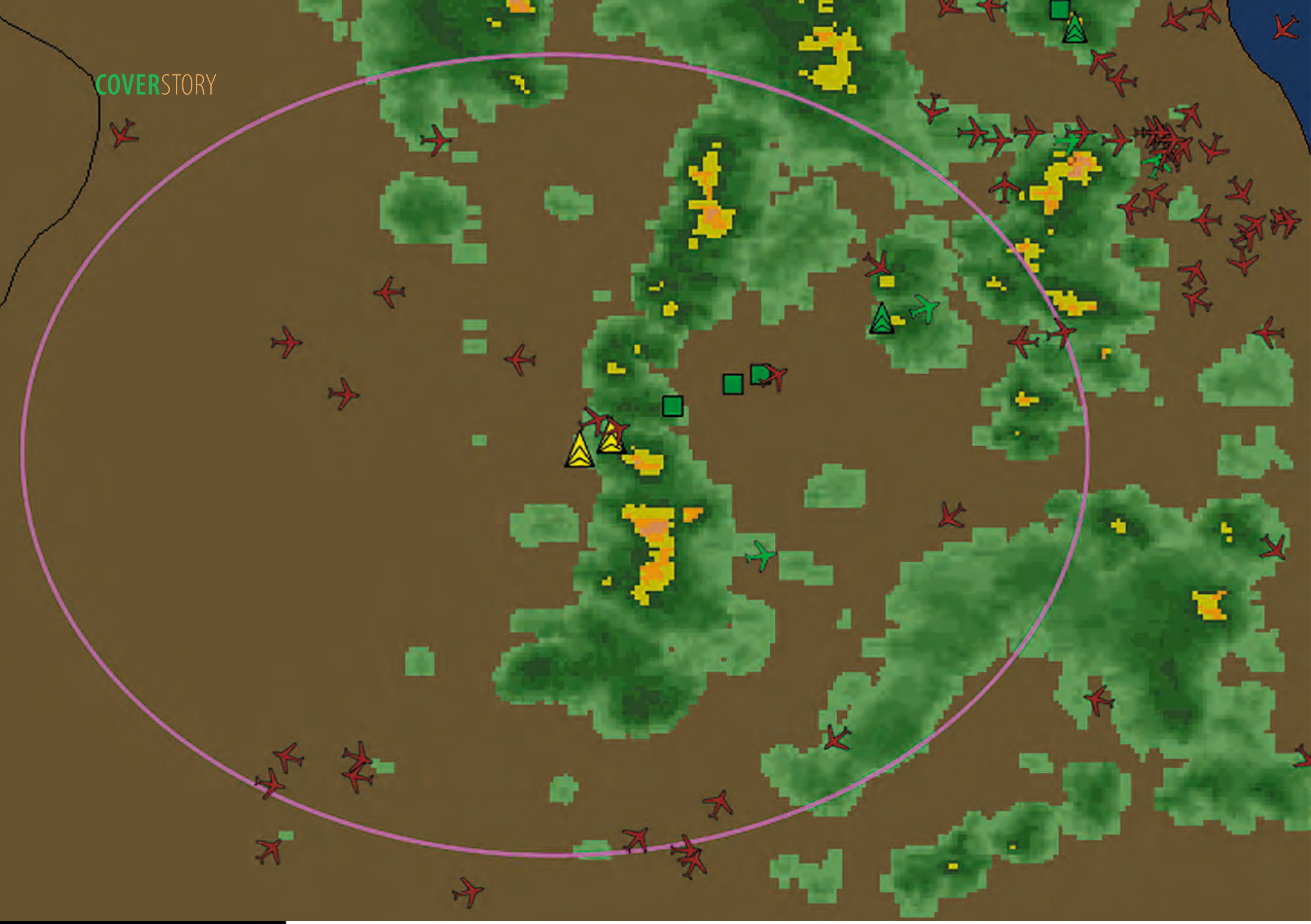


Aviation Weather Center's Ellrod Index graphical forecast shows (at white arrow) a possible area of severe turbulence at about Flight Level 220; a U.S. widebody jet encountered severe turbulence here over Vermont, U.S., at FL 330 on Jan. 16, 2014, resulting in minor injuries to five unsecured flight attendants.



Aviation Weather Center,
U.S. National Oceanic and Atmospheric Administration

Automated, airplane-based reports help participating flight crews to avoid turbulence encounters.



Just west of Chicago O'Hare International Airport, Total Turbulence–equipped aircraft are green and non-equipped aircraft are red on a moderately convective day; two non-equipped aircraft encounter TAPS moderate-turbulence reports (yellow stacked chevrons) inside of a WSI turbulence advisory area (purple ring).

© WSI Corporation

to the various people responsible for airline turbulence-safety programs.

American Airlines' Experience

David H. Clark, a captain with American Airlines and manager of American's Connected Aircraft Program, said the company implemented the Total Turbulence product as the launch partner in November 2012 and, as of November 2013, had 364 of its Boeing airplanes equipped with this product, including the TAPS feature. This strategic safety and business decision essentially was test results–driven, he said. "At a high level, the key factors were that during testing, we had looked at the rate of events for turbulence, especially severe turbulence," Clark said. "Our rate of severe turbulence events had gone down, especially with the aircraft that have TAPS. We got a more timely alert for that type of activity, and therefore avoided it. When the rate went down, we attributed that at least in part to TAPS information. We validated that functionality. TAPS is additive to the preflight forecast information so, therefore, we are flight-planning our routes around known and predicted areas of turbulence or significant weather — as we have for many years — with some very sophisticated tools. They are generally very accurate, but the weather system and the environment are very fluid, so there are still opportunities for unexpected change."

The airline's most significant improvements in turbulence avoidance have occurred in transoceanic flying, a result attributed to the capability of Total Turbulence to compensate for sparse real-time data available over the ocean, compared with during U.S. domestic operations. "Even domestically, it's helped," he said. "Not only are our aircraft reporting turbulence events back to our dispatch, but then we can retransmit those occurrences to aircraft in the vicinity, sometimes well before they're known. TAPS reports come to the ACARS printer, and often pilots can change altitude to try to avoid that area."

The latest version offers a color graphical interface and increased flight deck functionality through an electronic flight bag (EFB) application called WSI Pilot Brief on Apple iPads, according to WSI. A number of U.S. airlines are in discussions with the FAA to gain operational approval of these and similar capabilities, Clark said. "That is the plan we're working on now," he said. "All parties involved — the regulatory agencies, the airlines and manufacturers — are working well together, and I think we're in agreement. It's just a matter of working out the details. The concept is to have connectivity airborne such as traffic flow information on top of that. It really helps to see that real-time turbulence picture in addition to the text of aircraft reports. Graphical user interface would be an option; I think that would be a fair way to put it. I would hesitate to say that it will entirely replace ACARS; for the foreseeable future, we will continue to have ACARS for other reasons."

At the industry level, this technology would become optimally effective if more aircraft and more airlines would report and disseminate this quality of turbulence information, Clark said, adding, "That's the real vision. Although we're a WSI launch partner to test the concept and the initial rollout, as airlines around the world adopt the technology, that's when we'll really maximize the value. I look forward to increased participation from other carriers because more participation means more data, better data — and that will be of benefit to all participants. But it takes time and money to equip."

A Typical Flight

In everyday use, exploiting enhanced turbulence-avoidance intelligence has proved straightforward for American Airlines flight crews operating 364 Total Turbulence–equipped flight decks of Boeing 737s, 757s and 767-300s. A now-typical scenario is a 777 flight crew returning from Tokyo Narita Airport to Dallas-Fort Worth International Airport during a normally convective time of the year.

"Another equipped Boeing 777, in an area of unexpected moderate or severe turbulence, sends a TAPS report, and that report ultimately can be shared with all aircraft in the vicinity," Clark said. "That gives us a heads-up alert that we would like to avoid that area. So the reporting aircraft is 100 nm [185 km] ahead at the same altitude, same course. The flight crew says, 'Let's talk to our dispatcher.' The dispatcher says, 'I think your best bet now, based on that report, is to climb 2,000 ft. So they do. There's never a guarantee that will avoid the moderate or severe turbulence encounter, but at least we have additional tools to improve the chance that we'll avoid it or at least minimize the impact of turbulence."

In the airline's experience, flight crews normally have sufficient time to obtain air traffic control (ATC) clearance to respond to a turbulence threat. "Generally it works out — most of the time, yes, not all the time," he said. "The Atlantic crossing has become very congested, so there are times where it takes some time to coordinate a course or altitude change. Therefore, the more notice we have, the better."

American Airlines has not specifically studied how Total Turbulence affects a flight crew's use of seat belt signs or public address system announcements to cabin crews as an adjunct to its fundamental policy and emphasis that all occupants wear seat belts/harnesses at all times while seated. Nevertheless, pilots have been able to infer intuitively that the more information they have about turbulence and the earlier TAPS alerts reach them, the more effectively they are able to seat the passengers and flight attendants and reduce the risk of injuries.

"That is a standard policy, and, believe me, it works," Clark said. "Clear air turbulence is most difficult to avoid but doesn't happen very often. We do, unfortunately, run through unexpected choppy air, and a lot of our passengers are glad they did have their seatbelt on."

Flight crews also are trained to use all the turbulence-mitigation tools available, and to take the conservative approach by turning on the seatbelt signs, at a minimum, and/or asking flight attendants to take their seats if the captain

The more information they have about turbulence and the earlier TAPS alerts reach them, the more effectively they are able to seat the passengers and flight attendants and reduce the risk of injuries.

considers that warranted. "These flight crew actions may be caused simply by hearing another aircraft crew on the radio reporting that they are in turbulence," Clark said. "TAPS gives us a lot more specific detail in terms of where they're located."

As to U.S. flight crews' obligation to provide turbulence PIREPS to ATC, that has not changed because of TAPS equipage. "For the foreseeable future, I don't think it will," Clark said. "There could be a point in time where all aircraft around the world are equipped and we share this data in a real-time environment. What's important is that ATC still gets those reports because TAPS reports right now are going to a dispatcher and back to the airplane, not necessarily being shared with air traffic controllers."

WSI representatives expressed to *ASW* interest in, one day, widely disseminating TAPS reports, including to ATC. "I hope that happens," Clark said. "I think it will someday. That would really make this capability so much more useful."

Although Total Turbulence has features useful for post-flight analysis of turbulence encounters — such as archived-data replay after the event, including the objective measurement of vertical accelerations and their duration — American Airlines has not adapted these yet into company processes. "We aren't formally using TAPS reports for maintenance inspections at this time," Clark said. "One post-flight use was just to tweak the system's sensitivity so we don't get nuisance reports." Another post-flight advantage has been the opportunity to compare what occurred per the accelerometer's empirical digital data with other information sources, he said.

"You may hit a very light bump — very quick, it only lasts a second — but due to the sensitivity of the equipment, the system may register an alert that this was moderate or even, theoretically, severe. The duration was too short to really call it 'severe,' but it registers that way. A crewmember would say, 'I don't even remember that.'"

For the pilots of encounter aircraft, another value of TAPS during flight is improved calibration of the pilot's subjective judgment of whether moderate or severe areas of turbulence were encountered. "As you consider the length of a 777, what may feel like light turbulence to me as captain could be fairly significant with that center of gravity moment arm to passengers and flight attendants," he said. "So it has also helped them calibrate — or even better, to verify — turbulence impressions." In a post-flight conversation with a dispatcher who can access the raw TAPS data, the captain often may learn that what he or she reported as severe turbulence empirically registered as moderate turbulence.

As to the value of turbulence-avoidance resources provided to the aviation community at no cost by the U.S. National Oceanic and Atmospheric Administration's Aviation Weather Center <www.aviationweather.gov/adds/>, Clark said his perspective is that that resource can be considered complementary. "WSI is our partner and our provider for weather services," he said. "They combine government and proprietary information and analyses into the best, most accurate picture that they can — and then relay that to us. The government also provides weather information and has some unique capability, so it's additive for the total picture."

WSI's Perspective

WSI has responded to prospective client requests for prognostic, in-flight and post-flight tools and for immediate expertise to support the improved turbulence identification and forecasts, according to Mark D. Miller, the company's senior vice president and general manager for aviation. The company became more deeply involved in the turbulence aspects of aviation weather services in recent years partly because of the prevalence of turbulence-related injuries among North American air carriers and Asia-Pacific air carriers that face related geographic and climatological challenges, Miller said.

The technical merits of TAPS, as documented in scientific literature, described in the FAA AC and assessed by WSI's and American Airlines' due diligence processes, drove WSI's decision to make it a core capability of Total Turbulence. As of January 2014, three WSI-client airlines (including American Airlines) were operating 465 Boeing and Airbus aircraft equipped with TAPS.

"In terms of the core reporting capability, we felt very confident in the technology in terms of a sensible measure of turbulence, automatically and objectively reporting turbulence that the aircraft was experiencing," Miller said. "But to be useful and valuable to the airline, [we] needed to put [integrated] information into the hands of the people who can basically take positive action to reduce the impact. [TAPS] technology is proven and very versatile in terms of its ability to be used across a wide range of fleet types and avionics types."

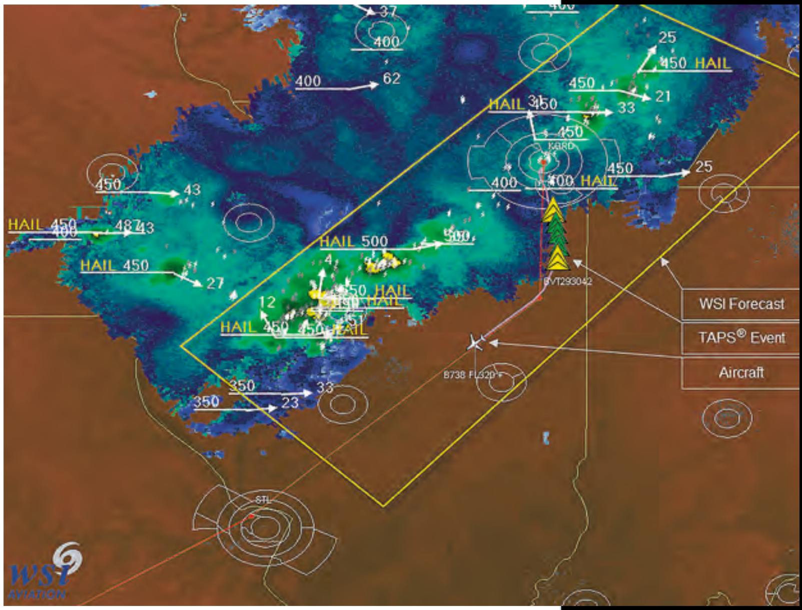
When a significant turbulence event, such as an accident or incident, occurs, the company also conducts forensic debriefings of airline personnel, including how everyone responded to the information they had at the time.

"[This] highlights one of our tools in terms of what we do," Miller said.

"In a maintenance context, when we talk about Total Turbulence, [event replay is partly] why it's more than just an observation coming off an aircraft. Fusion Replay is basically a warehouse where we [store for up to 92 days] all of these data from all of the TAPS reports, PIREPS, all of the National Weather Service guidance, and all of our own guidance." In combination with the airlines' own flight data monitoring programs, this facilitates "post-event analysis … as a tool to train and inform, so that going forward, they can continue to improve their policy and procedures around these types of events," he added.

Total Turbulence is available in the WSI Fusion component, a real-time flight management platform used by dispatchers. "As soon as there's [a TAPS-reported] event, the dispatcher gets an alert for not only the flight that's been impacted but any other flights that may be traversing that area," he said. "So within a minute or two [dispatchers, for example] get a list up on their screen showing three other flights that they're responsible for and that will soon be in that area of reported turbulence. They can immediately send an ACARS message up to the aircraft notifying the crews. [The] text message basically has the pertinent details, closes that communication loop between the dispatcher and the pilot, and informs them what action to take to reduce the impact."

WSI also ingests all TAPS reports and alerts into its forecasting operation. "Our meteorologists are continually monitoring and issuing our own SIGMETS [significant meteorological information] based on transport category aircraft around the globe for turbulence … convection, volcanic ash, icing and dust in certain areas where dust is an issue. … They basically compare [alerts] against any guidance they already have issued like SIGMETs or even forecast guidance, called *flight planning guidance*. … They … continually improve the guidance [with amendments] delivered through a platform like WSI Fusion or WSI Pilotbrief to keep the pilots and dispatchers on the same page … a common situational awareness or common operating picture."



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A graphical display of en route turbulence hazards — including a polygonal area of WSI-forecasted turbulence — includes superimposed TAPS reports of moderate turbulence (yellow stacked chevrons) and light turbulence (green stacked chevrons) that immediately help flight crews avert the hazards and also improve forecast-service accuracy.

Miller concurs with Clark about the evolving resources the U.S. government now has arrayed against the threat of hazardous turbulence encounters. "They clearly do good work in the Aviation Weather Center, and some of the products and research they do [in their mission] are exceptional," Miller said. "WSI draws on this foundation for the tools we provide our own meteorologists."

Subscriber airlines get access to reports generated by their own aircraft and deidentified aircraft of other operators that are participating and contributing to the network, he added. "Once we can work through some [integration] challenges, our vision would be that all the stakeholders would have access to [TAPS] information," Miller said. "Definitely our vision is to get many aircraft equipped and to enable the use and display of this data to all the critical stakeholders … to make this data available to ATC and also contribute … through Aviation Weather Center."

Since the American Airlines deployment, WSI, as noted, has added two other airlines — one an unidentified large U.S. carrier that has deployed Total Turbulence and the other an Asia-Pacific-based carrier that is in the final stages, he said. "I fully expect the number of aircraft flying with TAPS to double this year," Miller said. "With a network, we're trying to get as many observations as we can."

Bumpy RIDE AHEAD

BY ED BROTAK

Unforeseen turbulence encounters carry risk of serious incidents.

On March 5, 1966, British Overseas Airways Corp. (BOAC) Flight 911, a Boeing 707, departed from Tokyo's Haneda Airport for Hong Kong Kai Tak International Airport. In clear skies, the flight crew attempted to fly over Mount Fuji (approximate elevation 12,400 ft). But with strong winds and an approach to the mountain from the leeside, the airplane encountered a particularly severe mountain wave over Gotemba City at 16,000 ft. The turbulence encounter was so extreme that the aircraft experienced in-flight structural breakup. All 124 people aboard were killed.

Even though today's jetliners benefit from newer designs to withstand turbulence, pilots still are expected to avoid conditions where severe or extreme turbulence is possible. And although crashes primarily caused by turbulence have become rarer since the Flight 911 accident, they still occur, and serious incidents are common. The U.S. National Transportation Safety Board (NTSB) estimates that nearly three-quarters of all weather-related accidents/incidents are due to turbulence. The U.S. Federal Aviation Administration (FAA) reports that dozens of airline passengers have been injured in recent years by turbulence encounters. Turbulence is the number one cause of injuries to passengers — and especially to flight attendants — in nonfatal accidents. In a typical year, U.S. pilot reports (PIREPS) of moderate or greater turbulence average 65,000, and reports of severe or greater turbulence average 5,500.[1]

What do we mean by turbulence? In terms of airflow, meteorologists focus on laminar flow and turbulent flow. Laminar flow is a flat, regular, smooth flow of air that moves in the same direction at the same speed. Turbulent flow is chaotic, with air moving in random directions and at varying speeds.

In the real world, we see both occurring at the same time. When the turbulence becomes more dominant, then there are problems. In terms of aerodynamics, turbulence is a sudden change in airflow that abruptly affects the altitude and/or attitude of the aircraft.

For this article, we are concerned only with the vertical variations in airflow. The term *turbulence* often also is used in conjunction with rapid variations in horizontal wind speed — that is, wind gusts. Also, by limiting this article to naturally occurring turbulence, we will not address similar problems such as wake turbulence, jet engine blast or helicopter rotor downwash.

Refresher on Basics

Turbulence can occur anywhere in the atmosphere, from ground level to near the upper limits of standard high-level en route charts, typically above Flight Level (FL) 350 (approximately 35,000 ft). To give pilots a better idea of what they are dealing with, turbulence is described in terms of intensity for reporting and forecasting. Light turbulence causes just brief and slight changes in altitude and/or attitude. Moderate turbulence is of greater intensity and also may cause changes in airspeed, but the aircraft remains in control at all times. Severe turbulence can cause large, abrupt changes in altitude and/or attitude and can cause large changes in airspeed. The aircraft may be temporarily out of control. With extreme turbulence, an aircraft can be tossed about violently and may incur structural damage.

In the United States, pilots are urged, in the common interest of safety, to report encounters with moderate or greater turbulence to air traffic control (ATC) in a PIREP. According to FAA guidance, ATC expects turbulence reports to include location, altitude or range of altitudes, and aircraft type, and should include whether the aircraft was operating in clouds or clear air. In this system, the reported turbulence intensity (light, moderate, severe or extreme) and duration (occasional, intermittent or continuous) are determined subjectively by the pilot (see “Smooth Operators,” p. 14).

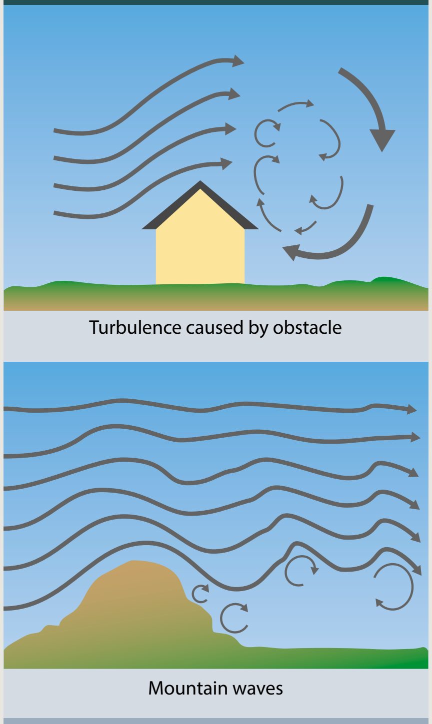
Turbulence can be broken down into three major categories by cause: mechanical, convective and wind shear.

Mechanical turbulence occurs when airflow encounters a physical impediment (Figure 1). The air flows around, over and, if the object is off the ground, under the obstacle. But when the air is forced around an object, the flow often becomes more turbulent. Waves and even vortexes can form downwind of the object. Depending on the wind direction and speed, buildings at an airport, for example, can cause turbulence that can affect aircraft takeoff/landing performance on a runway, or — if surface winds exceed 50 kt — flight at altitudes greater than 3,000 ft above ground level (AGL).

Mountain waves, such as the one that destroyed Flight 911, fall into the category of mechanical turbulence. On the windward side of a mountain, the air is forced upward. It will then sink on the leeside. Often vertical waves are formed. These waves can break like ocean waves and generate significant turbulence. Although single mountains can produce waves, mountain ranges have greater effects on airflow and are more prone to significant mountain waves. The waves can propagate a great distance from the mountain source, up to 100 mi (160 km) or more downwind. At times, a set, or train, of waves is established in the lee of the mountain. And the induced waves can extend higher than the mountains that produced them. Sometimes these waves are marked by visually striking cloud formations, such as lenticular clouds or roll clouds. At other times, the air may be deceptively clear.

Convective turbulence can be as innocuous as a faint updraft on a warm day or as potentially destructive as the violent updrafts and downdrafts in a thunderstorm. For many operational purposes, convection — caused by vertical currents (thermals) that develop in air heated by a warm surface below — can be simply considered warm air rising and cool air sinking. Glider pilots, for example, know where to find the rising thermals that help keep their aircraft aloft. Cumulus clouds are convectively produced. Airliner occupants may experience a bumpy ride from the minor vertical motions, even through a small “fair weather” cumulus cloud, but prolonged flight in these conditions would be considered an undesirable ride-quality event.

Mechanical Turbulence



Source: Ed Brotak

Figure 1

U.S. National Aeronautics and Space Administration

Frontal zones, where two differing air masses collide, are frequent breeding grounds for turbulence, so much so that "frontal turbulence" is often included as a separate category to emphasize its importance. With colder air being denser, the warmer air is forced up over it, often producing vertical waves and vortexes that generate turbulence. Fast moving cold fronts are usually the most turbulent.

The turbulence within thunderstorms is well documented. Professional pilots, even those operating large commercial jets, know to avoid the associated turbulence. The updrafts and downdrafts in the strongest thunderstorms can exceed 100 mph (160 kph). The turbulence generated can structurally damage even the strongest aircraft. Don't be misled by the "hurricane hunter" missions you hear about. The tropical convection, even in a powerful tropical cyclone, isn't nearly as strong as in midlatitude thunderstorms.

Disturbingly, there still are numerous accidents with pilots miscalculating the danger of the destructive turbulence within these storms. For example, on March 25, 2010, the experienced pilot of a Eurocopter AS350 B3 on an emergency medical services flight, attempted to outrun an approaching line of thunderstorms and return to base in Brownsville, Tennessee, U.S. The squall line, moving at 61 kt groundspeed, apparently overtook the helicopter. The aircraft crashed in an open field 2.5 mi (4.0 km) from its destination, killing the pilot and two nurses aboard. NTSB investigators looked at weather data and concluded "the helicopter likely encountered severe turbulence from which there was no possibility of recovery, particularly at low level" (*ASW*, 3/12, p. 45).

Turbulence caused by thunderstorms is not restricted to the area within the cloud itself. Strong downdrafts can extend below the cloud base and often reach the ground, where the winds become horizontal, creating a threat of wind shear. These rapid changes in wind speed and direction were associated with a number of major aircraft accidents in the 1960s and 1970s. With widely used automated detection of wind shear and escape-maneuver education, pilots and ATC personnel should now be well aware of the risks, and wind shear–monitoring equipment such as Doppler radar and lidar (light detection and ranging) have become standard at many larger airports.

Dangerous turbulence also can occur above thunderstorm clouds. United Airlines Flight 967, a Boeing 777-200, was en route from Washington to Los Angeles on July 20, 2010. Flying over an area of developing thunderstorms in Kansas, the plane hit severe turbulence while cruising at 38,000 ft, seemingly well above the storms. The flight crew landed the airplane in Denver, where 21 people were taken to hospitals for their injuries. Meteorologists who studied the event believe a gravity wave (*ASW,* 2/10, p. 32) generated by the storms may have been the cause of the turbulence.

Jet Stream Factors

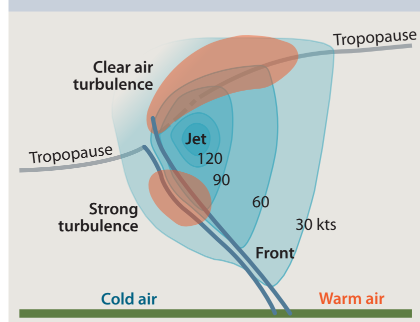
Although not as severe as thunderstorm turbulence or strong mountain waves, conditions known as clear air turbulence (CAT) pose a much greater threat for air travelers. Typically, these encounters occur above 15,000 ft AGL. As the name implies, CAT usually is not associated with cumuliform clouds and is, thus, unable to be detected in advance using the pilots' eyesight. It doesn't show up on conventional on-board weather radar. Often, it isn't forecast. And the worst incidents associated with CAT have occurred at FL 300 or higher. Of all turbulence-related incidents, two-thirds occur at or above this level. This is a typical cruising altitude for longer flights and often a flight phase when the seat belt signs are not illuminated, and where the passengers and cabin crew are not wearing seat belts and may well be moving around the cabin. Technically, CAT also can be present in nonconvective clouds.

A major cause of turbulence at these upper levels is the jet stream. This fast-moving river of air often is concentrated between 30,000 and 35,000 ft above sea level. Wind speeds in the core of the jet stream can exceed 200 mph (320 kph) and may approach 300 mph (480 kph) in some cases. The turbulence in these situations is generated by the wind itself, and is a result of wind shear.

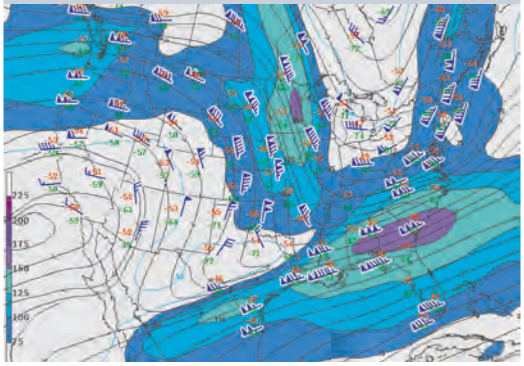
For flight operations, we often think of wind shear as a low-level phenomenon. Often in that case, it's a quick, unexpected change in wind speed and/or direction associated with a thunderstorm downdraft. Technically though, wind shear is the change in the vertical component of wind speed or wind direction.

A jet stream, however, is a three-dimensional weather system. It's not just a flat ribbon of strong winds at one level in the atmosphere. It has a vertical extent, and strong winds may reach down thousands of feet below the jet stream core. But as you move away from the core of the jet, the wind speeds decrease. This sets up the wind shear. Once again,

Cross section of jet stream showing areas of turbulence.



A 250-mb chart (~34,000 ft) shows the polar jet stream to the north and the subtropical jet stream to the south. Teal and purple shading indicates stronger winds and locations of jet streaks.



National Weather Service, U.S. National Oceanic and Atmospheric Administration

the jet's flow can become turbulent, with waves and even vertical vortexes. These can contain the abrupt vertical motions that induce the turbulence that can affect aircraft even some distance away from the jet itself. In fact, the worst turbulence isn't within the core of the jet stream but rather away from the core, so that is where the wind shear is strongest. And this can occur both above and below the jet core and to the sides of it.

One of the worst cases of jet stream turbulence effects occurred Dec. 28, 1997, when United Airlines Flight 826, a Boeing 747-122, en route from Tokyo to Honolulu encountered severe CAT over the Pacific Ocean about 870 nm (1,610 km) east-southeast of Tokyo. One passenger was killed and 171 passengers were injured, 15 seriously. Nine crewmembers also were injured, three seriously. The plane plummeted 1,000 ft when it encountered the turbulence at FL 330. The woman killed wasn't wearing a seat belt and apparently was thrown against the ceiling. (Technically, the ceiling hit her.) The flight crew returned to Tokyo and made an uneventful landing. The accident pilot had reported visual meteorological conditions with no clouds. Turbulence had not been forecast. A 140-kt jet stream was in the area with its core centered near 39,000 ft.

There are two major jet streams at upper levels of the atmosphere above Earth's Northern Hemisphere — the polar jet and the subtropical jet. The polar jet is tied in with the polar front, the dividing line between warm, tropical air and cold, polar air. Seasonally, the polar jet moves well north in summer, often poleward of 45 degrees latitude. In the winter, it follows the cold air toward the equator. It can dip down as far as 25 degrees latitude.

The polar jet is highly variable in both location and strength. It can move far down into midlatitudes with outbreaks of polar and even arctic air. But it can also surge back poleward as warm air pushes up ahead of major storm systems. Although typically found near 30,000 ft, the core of the polar jet can drop to 25,000 ft or even lower.

The subtropical jet, often centered near 35,000 ft, is found at lower latitudes, usually between 20 degrees and 30 degrees. It typically affects the southern United States and Mexico, the Mediterranean region, and Southeast Asia up to Japan. Both jets are much stronger and more important to aviation in the winter.

Often the jet stream is depicted as a solid arrow following the airflow above the ground below. This gives the impression that jet stream winds are continuously strong along the jet axis (the drawn arrow). They are not. Wind speeds vary greatly along the jet axis with areas of weaker winds separating areas of stronger winds. The areas of stronger winds are called "jet streaks." This is where temperature contrasts at upper levels are strongest, the so-called "upper-level fronts." These streaks would be associated with the strongest wind shear and maximum turbulence. The jet streaks themselves also move or propagate along the jet axis. But they move at much slower speeds than the winds themselves, usually at 20 to 40 kt. Closer to Earth's surface, low-level jets (*ASW,* 11/12, p. 32) could also produce turbulence.

To forecast turbulence in the United States, the online Aviation Weather Center <www.aviationweather.gov> of the National Weather Service provides turbulence products for aviation. For example, all PIREPS containing turbulence data are displayed on a map. SIGMETs (significant meteorological information) for turbulence and convection are available. There are also maps showing areas forecast to have turbulence. One of the center's latest developments is called Graphical Turbulence Guidance, an automatically generated turbulence product that predicts the location and intensity of turbulence over the continental United States.

In the future, will global warming affect turbulence? In an article published in *Nature Climate Change*, researchers from the University of Reading in England say that it will.[2] Looking specifically at air routes over the North Atlantic, they predict that winds above 10 km (33,000 ft) from Earth's surface will strengthen. This could lead to a 10 percent increase in events involving moderate or greater turbulence, they said.

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

Notes

1. U.S. National Center for Atmospheric Research (NCAR), Research Applications Laboratory. *Aviation Turbulence.*
2. See <www.bbc.co.uk/news/science-environment-22063340>.

Occupational Hazard

Flight attendants working primarily on short-haul trips may be more prone to workplace accidents than their long-haul colleagues.

BY LINDA WERFELMAN

Susan Reed based on image by Torsten Henning

Dutch researchers may have found a connection between frequent work on short-haul flights and an increased risk of on-the-job accidents involving cabin crewmembers.[1,2]

Conversely, frequent assignments to long-haul flights may have a negative association with occurrences of occupational accidents, according to the study, published in the December issue of *Aviation, Space, and Environmental Medicine*.

The researchers noted that studies of workers in other industries have identified an increased rate of work-related injuries among those who work long hours or irregular schedules — two situations that are common in the airline industry. Other studies also note a connection between irregular schedules and fatigue, poor sleep quality and quantity, and a disruption of circadian rhythm — also situations common among workers in the airline industry.

The researchers said that their work suggested a similar link between short-haul scheduling of cabin crewmembers and work-related accidents.

"Because cabin crewmembers fly fewer short-haul hours compared to long-haul hours on average per year, the presumable increased incidence of accidents during short-haul flights may be explained by the specific characteristics of the short-haul operation," the report said. "Short-haul is quite different from long- and medium-haul because the operation is characterized by a relatively high workload: a high frequency of on-board services (e.g., serving beverages or meals) and short turnaround times between flights."

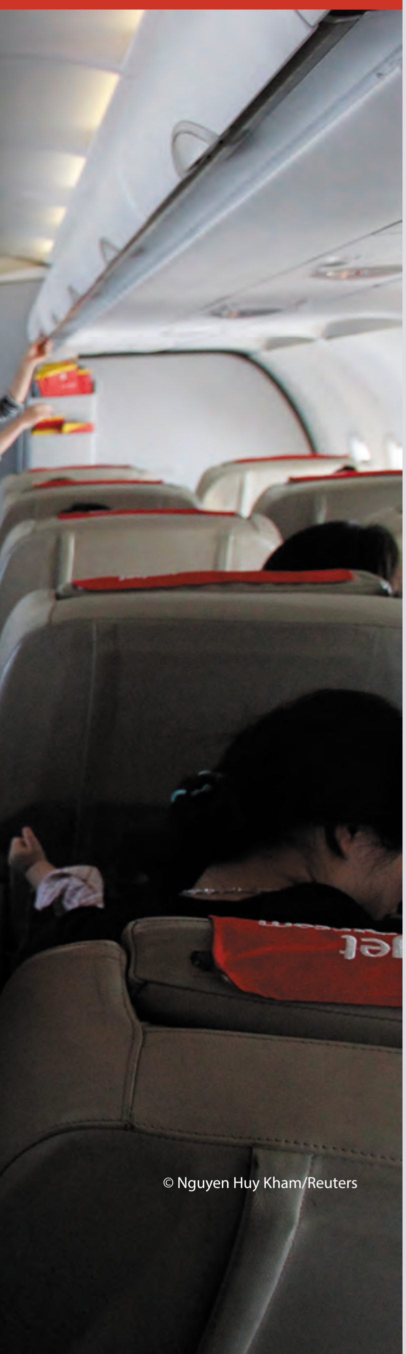
The report was based in part on data gathered through the Monitoring Occupational Health Risks in Employees (MORE) cohort, an expansive study designed to analyze the occupational health risks facing the employees of a large airline. The MORE cohort data included all medical and human resource records, as well as work schedules, for airline employees since Jan. 1, 2005. The occupational accident study reviewed the MORE records of 6,311 cabin crewmembers — all of the cabin crewmembers who were working for the company on Jan. 1, 2005, except for female cabin crewmembers who became pregnant after Jan. 1, 2009, and were excluded.

The occupational accident study also reviewed reports of all occupational accidents that involved cabin crewmembers in 2009 and that were reported to the airline's occupational health service. A total of 289 cabin crewmembers had reported at least one accident that year, the report said, calculating an annual accident rate of 4.5 per 100 cabin crewmembers. The report also noted a mean number of accidents of 0.012 per 100 flight hours.

Of the 6,311 cabin crewmembers included in the study, 81 percent were women, 54 percent were 41 years old or younger, 56 percent were unmarried, and 60 percent had children. Almost all — 95 percent — lived in the Netherlands. Twenty-seven percent were full-time employees, and 12 percent had more than one employer.

Results showed that male cabin crewmembers had "significantly fewer" accidents than female crewmembers per 100 flight hours, that younger cabin crewmembers were more likely than their older counterparts to report an occupational accident, and that those with children were more likely to report than those without children.

The report said that this study was the first to investigate links between exposure to flight schedules and the occurrence of on-the-job accidents. Its conclusion was that "the number of short-haul flights proved to be predictive for the occurrence of accidents. … The more exposure to short-haul flights, the higher the risk to cabin crewmembers of experiencing an occupational accident, and the more exposure to long-haul flights, the lower their risk of experiencing an occupational accident."



'The components of the short-haul duty days … trigger fatigue among the crew.'

These accidents were primarily falls, slips and tripping, and the resulting injuries typically were sprains, strains, bruises and burns, the report said.

Data did not show what type of flight each crewmember was working on when an accident occurred, the report said. Nevertheless, the report added, "It can be hypothesized that they predominantly occurred during short-haul flights."

Data showed that 71 percent of the involved employees said that their accidents were related to on-board customer service. Other causes were reported as "the landing or taking off of the airplane (6 percent) and turbulence during the flight (3 percent)."

In addition, other workload factors, "such as time on task, lack of rest breaks and stressful work," were identified as contributing to an increased risk of on-the-job accidents.

"Since the results of this study indicate that the risk of experiencing an accident increases with increased exposure to short-haul flights, it can also be hypothesized that the cumulative exposure to short-haul flights might lead to more fatigue accumulation, compared to cumulative exposure to long-haul flights," the report said.

At the airline that was the focus of the study, the long-haul schedule for cabin crewmembers involved several duty days, including at least one layover, followed by several days off. Short-haul schedules involved three or four duty days, followed by one or two days off.

"It is known that the components of the short-haul duty days (up to four flights a day, long working hours, early starts and late finishes) trigger fatigue among the crew," the report said, citing earlier research on fatigue in short-haul operations. "It is, therefore, possible that the days off in between are not sufficient to recover from the days on duty, thereby inducing a cumulative fatiguing effect and increasing the risk of accidents over successive duty days."

The researchers said their study had several limitations, including the voluntary nature of reporting on-the-job accidents, which may have allowed for underreporting; and the scarcity of information about circumstances surrounding the reported accidents.

"Information on which type of flight the accident happened and at what time during the flight it occurred was not available," the report said. "Further, although the characteristics of the short-haul operation might have played a role in the reported accidents, there was no objective information available about the involved workload (the number of on-board services or the number of rest breaks during these flights)."

The report said additional research is needed to determine what types of changes in short-haul scheduling — such as a reduction in duty times or numbers of flights or an increase in the number of days off — might reduce the number of accidents. Research also should examine gender and other factors to determine whether they might explain differences in accident occurrence.

Because so many of the accidents occurred while cabin crewmembers were involved with on-board services, accident-reduction efforts should be focused on that area, with goals of developing more specific accident-prevention strategies, the report said.

Notes

1. Van Drongelen, Alwin; Boot, Cecile R.L.; Pas, L. Willemijn et al. "Flight Schedules and Occupational Accidents Among Cabin Crew: A Longitudinal Study." *Aviation, Space, and Environmental Medicine* Volume 84 (December 2013): 1281–1285.
2. The report defined short-haul flights as lasting less than four hours, medium-haul flights as lasting at least four hours but less than eight hours, and long-haul flights as lasting eight hours or longer.

Further Reading From FSF Publications

FSF Editorial Staff. "Study of Airline's Flight Attendants Finds More Than Half of Injuries Affect Muscles and Bones in Back, Neck, Shoulders." *Cabin Crew Safety* Volume 37 (July–August 2002).

FSF Editorial Staff. "Working in, Around Aircraft Cabins Requires Awareness of Fall Prevention." *Cabin Crew Safety* Volume 35 (January–February 2000).

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May 5-9 2014

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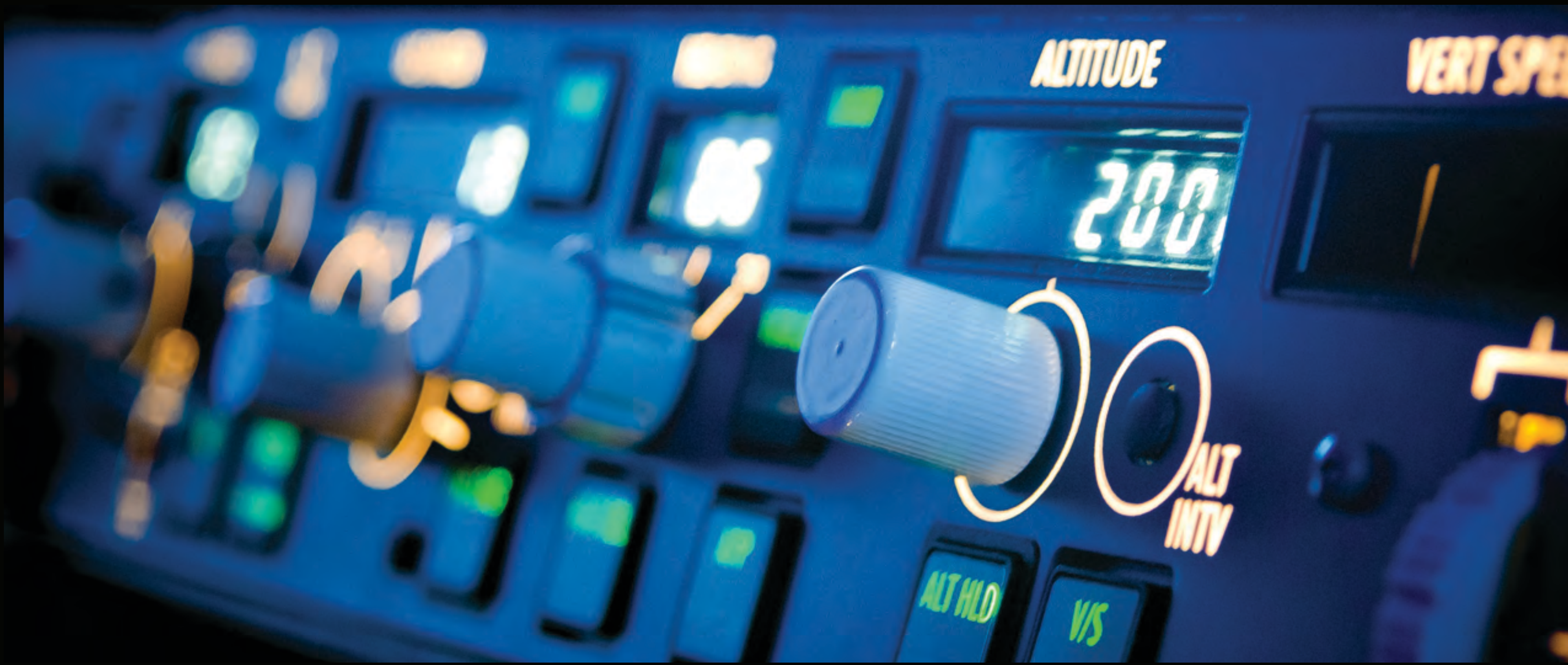


Behind the Scenes

BY WAYNE ROSENKRANS

Delivering airline pilot training to mitigate the risk of loss of control–in flight (LOC-I) partly depends on technical innovations that mesh precisely with new regulations, standards and expert guidance (*ASW*, 7/13, p. 27, and 8/13, p. 34). Behind-the-scenes details provide evidence of progress to date on these innovations, as seen by some of the international specialists involved, and offer insights on what constitutes acceptable results from key hardware-software solutions, and their limitations.

For many years, the effectiveness of existing engineered solutions for accident prevention was the subject of wide-ranging debate, some specialists told the 8th International Flight Crew Training Conference, held in September 2013 in London by the Royal Aeronautical Society. Overall, the specialists voiced confidence in current or imminent technical capability to support this training.

Michael Varney, a captain and senior director, flight crew training, Airbus, told the conference, "The fact is that over decades, we have looked at these sorts of statistics [for LOC-I, controlled flight into terrain, ground collisions and runway excursions] and fixed the problems on an engineering basis instead of looking behind what the root causes of the problems are. … As we design-out known problems and we improve the reliability of our already very reliable system, failures are much less likely. Nevertheless, when we put human beings in the cockpit, there are all sorts of potential, possible interactions and some things that we cannot predict by design. … We can create, with help from our simulator manufacturers, a really immersive environment where the pilots feel 90 percent that they're really in the airplane — and that they really have to deal with the situation."

Technical Solutions

Analyses of technological possibilities have clarified the research and development priorities and the benefit-to-cost ratios, said Jeff Schroeder, chief scientific and technical adviser, flight simulation systems, U.S. Federal Aviation Administration. He spoke as chairman

Upset prevention, recognition and recovery specialists identify critical technical enhancements.

of the Research and Technology Group of the International Committee for Aviation Training in Extended Envelopes. The committee, a four-year initiative of the Royal Aeronautical Society, disbanded in late 2013.

There's no longer a question that conducting high-altitude stall prevention training in flight simulation training devices (FSTDs) offers the highest benefit-to-cost ratio for operators, he said. This has been the flight regime where stalls in transport category airplanes have happened recently, and where recovery is the most challenging. Practice applying the most effective response — based on first reducing angle-of-attack — instills confidence and reinforces the current procedure, he said.

"Because of the roll damping, the ensuing recovery to get back to safe flight can expose some deficiencies with a rare number of pilots," Schroeder said. "In the United States, we have to do full-stall training and, based upon some recent experience, it looks like that appears to be feasible in simulators. … No airplane stalls the same way twice, and … our proposed modeling specification [has] a component of randomness that goes into the models so that it's consistent with the variation [flight crews] will see in the airplane."

The group first sought expert opinion — often from test pilots highly experienced in stalling the same aircraft types — to rate the realism created by new software algorithms installed in an FSTD, then conducted technology demonstrations, evaluations and experiments. In November 2010, for example, the group assessed a new representative stall model algorithm that, unlike typical algorithms, was not based on flight test data (see "Configurable Model," p. 30).

"[In 2013,] we did an experiment that involved looking at four different types of stall models, one being an unmodified [algorithm] that is delivered with the simulator now," Schroeder said. "Ten test pilots — nine of whom had stalled an actual [Boeing] 737 airplane, one over 500 times — evaluated [these] so we had a lot of confidence [in] the opinions that we were getting on the model fidelity. In another part of the experiment, I had 40 747 line pilots come in and get trained on the various stall models, and then we checked them after they had trained to proficiency in recovering from several [stall] scenarios on the type-specific stall model developed by The Boeing Co."

False Success

Mismatching a technology to a training element may create the risk of a negative transfer of training, he said. Another committee concern was that a pilot might attempt to recover from a high-altitude stall when the aircraft actually was not stalled. Such a scenario might be prompted inadvertently by activation of the stick shaker during moderate turbulence.

"The pilot misconstrues that as a stall condition and then places the nose down, executes a full recovery in the sparse air [but then gets] into pilot-induced oscillations in the recovery, varying in [g loads, the positive or negative multipliers of normal gravitational acceleration]," Schroeder said. "The worst case that we saw went between 0.2 g and 2.2 g. If you're not paying attention to the barber pole [minimum-speed amber and red bands on a Boeing speed tape, for example] going up and down and oscillating — your angle-of-attack is changing, your lift is changing and your load factor is changing — you might think this was a pretty good recovery. And it wasn't."

Accurately simulating recovery from a full stall is one of the areas where simulation engineers still need to spend time, he said. Further work also is needed to improve the buffet realism so that buffeting progressively changes to reflect depth of entry into the stall region of the aerodynamic envelope; the feedback to instructors; the mathematical modeling of recovery; and the modeling of the effects of icing on stall.

"Roughly, we have about 50 different aircraft [variants] that we probably have to make models for … in the United States, across about 300 simulators in the air carriers," he said. "Most of the [upset prevention, recognition and recovery training] can be done today, especially on the prevention side, with our existing tools. … By 2018, everybody in the United States that flies [Federal

Aviation Regulations] Part 121 [air carrier] operations will have to comply."

Enter the Matrix

A key factor in the group's progress in closely aligning technical capabilities with the committee's 176 training elements was a comprehensive training matrix (Table 1, p. 31), said Dennis Crider, chief technical adviser, vehicle simulation, U.S. National Transportation Safety Board (NTSB). "The matrix contains training elements necessary for the pilots to [acquire] skills to recognize and recover from in-flight upsets," he said. They also cover, for stall in icing conditions, the types of automation mismanagement, stalls-without-warning and aircraft nose-below-horizon scenarios commonly seen in NTSB accident data, he added.

Airline pilots have long needed to be trained on "what lies beyond the stick shaker," Crider said. If this training is effective, the various cues to imminent stall and stall can be transformed — by qualified instructors using appropriate technology — from sources of confusion to familiar inputs that rapidly trigger the correct response.

Configurable Model

Wind tunnel experiments for modeling high-altitude stall have proven to be equally or more important than relying on flight test data to create a new configurable simulation, according to one conference presentation. "What we're trying to do, working with the U.S. Federal Aviation Administration, is to postulate the potential of configuration geometry types to simplify the stall model deployment," said John Ralston, president of Bihrle Applied Research. "The reason for doing this is to try to minimize the amount of model-specific work that needs to be done in order to accomplish this. This also gives us an approach to [modeling] where we might not have available the original equipment manufacturer [flight test] data to support the stall model development."

The wind tunnel experiments aimed to develop a stall model configurable for most of the aircraft that have a "swept low wing, low tail, underwing-engine configuration," he said. "We wanted to identify the requisite model architecture that would capture the stall features [and type-specific baseline data,] configuration-representative reductions in the static and dynamic stability in both longitudinal and lateral directional axes; reductions in control effectiveness; [enhanced buffet;] and an asymmetric behavior that also characterizes rolloff," Ralston said. This is not a generic model but rather a model that can be adjusted in real time inside an engineering simulator based on a subject matter expert's recommendations.

Nonlinear characteristics such as stable-versus-unstable roll damping have been relatively difficult to identify from flight test data but can be readily identified in the wind tunnel; nevertheless, wind tunnel test data also have limitations, he said.

An enhanced stall model demonstration of the technology, using a Sim Industries Boeing 737-800 device, was conducted for the Research and Technology Group of the Royal Aeronautical Society's committee, said Dave Gingras, vice president, Bihrle Applied Research. The enhanced modeling was implemented by transitions between existing and new algorithms as necessary, and running the blended simulation externally on modern computer hardware so that the relatively low computing power of legacy flight simulation training devices would not be an issue.

— WR

The group also did an exhaustive fidelity-requirement analysis, deciding the specific level for every combination of device and training element. Each task was characterized as practical, academic or both, and separately assigned to mitigation levels within upset awareness; recognition and prevention; and/or recovery stages, said David Shikany, associate technical fellow, aerodynamics stability and control, flight simulation, The Boeing Co.

"We took each training task, and we looked at it from the point of view of the cues that were required," Shikany said. "The awareness and the alerting cues were relevant to the control forces, the instruments and the audio cueing that is associated with [the all-attitude exposure] training task. The control forces and the motion cueing both play a role in the pilot's ability to control the aircraft in order to be able to carry out the training task. And motion cueing has a major physiological effect in the all-attitude exposure training task. So we carried this out for all of the 176 tasks, and once we'd done that, we then felt that we could go back and link [each required cue] to the FSTDs."

He cited the *awareness* level of training for high-altitude stall as an example. "There's going to need to be a representative level of fidelity in the flight model — in the control forces in the cockpit, for example — to be able to meet the learning objective … to understand the relationship between high alpha [angle-of-attack] and increased induced drag," Shikany said. A diagram produced by the group shows that the industry already has devices that meet that level of fidelity.

'Genetic Code'

In parallel with the fidelity work, the group assigned a code to each detail

'Genetic Code' Examples From FSTD Feature-Fidelity Analysis

	Academic	Practical	Device level	Cockpit layout and structure	Flight model	Ground handling	Aeroplane systems	Flight controls and forces	Sound cue	Visual cue	Motion cue	Environment – ATC	Environment – navigation	Environment – weather	Environment – aerodromes	Miscellaneous – IOS	
				Feature of Flight Simulation Training Device													
Training Element Example				**Fidelity Level Needed for Training Element**													**Learning Objective**
High-AOA performance considerations	X	X	FTD	R	R	N	R	R	R	R	N	N	N	N	N	N	Understanding of the relationship between high AOA and increased induced drag
High-altitude stall	X	X	FFS	S	S1	N	S	S	R	R	R2	N	N	N	N	S1	Demonstration of stall recoveries, altitude loss, recovery with reduced thrust/power and other performance differences associated with high-altitude flight
New FSTDs Example				**Fidelity Level Needed for Proposed Device**													**Legend for ICAO Fidelity Codes**
Type VII+				S	S1	S	S	S1	R	S	R2	N	S	R2	R	S1	
Type GAD				G	R	N	G	R	G	R2	R3	N	N	N	N	S1	Lowest Fidelity → Highest Fidelity
Type SPD				S	S2	S	S	S	R	S	R3	N	S	R	R	S1	N------- G -------R------- R1------- R2------- R3-------R4 ------- S ------- S1 -------S2
Type SDD				G	G	N	G	G	G	R2	R4	G	S	G	G	G	

ATC = air traffic control; AOA = angle-of-attack; FFS = full flight simulator; FSTD = flight simulation training device; FTD = flight training device (other); g = standard gravitational acceleration; ICAO = International Civil Aviation Organization; IOS = instructor operating station; N = none or fidelity not applicable; G = generic fidelity (ICAO's lowest level of required fidelity for a given FSTD feature); R = representative fidelity (ICAO's intermediate level of required fidelity); S = specific fidelity (ICAO's highest level of required fidelity); GAD = g-awareness device (proposed); SPD = spin device (proposed); SDD = spatial disorientation device (proposed); VII+ = Proposed enhancement of ICAO Type VII FSTD (for full stall); X = training element relates to this kind of training

Note: These two training elements are examples of 176 in the training matrix prepared by a committee of the Royal Aeronautical Society. All were analyzed partly to identify the needed level of FSTD-feature fidelity to achieve upset prevention, recognition and recovery learning objectives. Similarly, feature-fidelity levels for these four additionally recommended device specifications were identified by the committee's Research and Technology Group.

Source: Research and Technology Group, International Committee for Aviation Training in Extended Envelopes

Table 1

of the capabilities of commonly used FSTDs, said Joris Field, training systems specialist, National Aerospace Laboratories Netherlands.

"[We took] all the fidelity requirements for the various features and essentially aligned them into a device," Field said. "Unfortunately, the 176 tasks that are in that matrix resulted in over 40 unique 'genetic codes.' … [Instead of] standardizing down to seven devices, you would [have to] turn all those unique genetic codes into 40 different devices." The solution in some cases was to "roll up" similar sets of codes into what he called "a common genetic code or set of fidelity requirements that could satisfy a number of the tasks" first by using today's ICAO Type II, Type V and Type VII FSTDs.

"Then we found that we had to essentially come up with four new devices," he said, describing how the group distilled the desirable leftover codes into a Type VII+ device, a g-awareness device, a spin device and a spatial disorientation device. "For the Type VII+ device, there were 18 [codes] primarily associated with training tasks related to the stall. … The Type VII+ device does require some additional enhancements to the flight model primarily for stall, control forces, flight control forces, stick pusher, motion buffet, environment, weather and the IOS [instructor operating station]. … One of the things we'll have to be aware of [is that if] the training objectives change, those device requirements will have to change also. … Over three-quarters of the training in that matrix can be accomplished with today's devices plus some enhancements. … There always will be a subset of those training objectives that will be required to be performed on the airplane due to psychological or physical effects."

"How do we simulate all this?" asked Itash Samani, head of global FSTD regulations, CAE. "The level of the [current standard Type VII, a 'Level D+'] device is our starting point [and] what is commonly out there."

In the near future, the industry also can look forward to accurate representation of stall behavior in icing conditions with new Type VII models instead of today's unrepresentative, artificial increases in aircraft weight and drag as a proxy. New models will include loss of lift; increasing drag; change in the stall angle-of-attack, which prevents normal stall warnings; changes in the pitching moment of the aircraft; and decreased control effectiveness, and changes in control forces, he said.

Over the Horizon

BY LINDA WERFELMAN

Industry experts foresee a day when UAS will rule the skies.

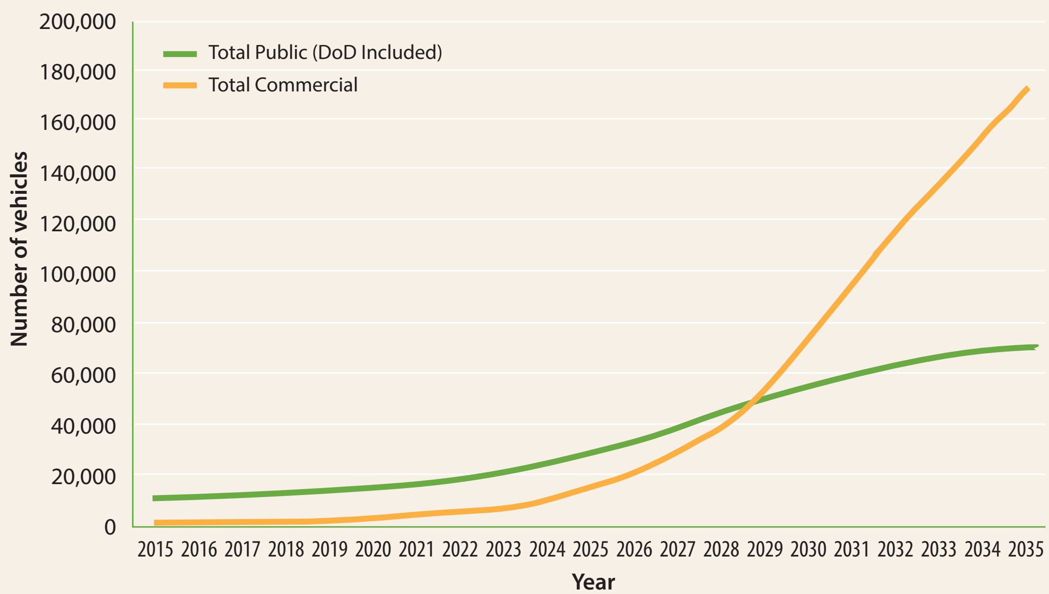
Flights of unmanned aircraft systems (UAS) are likely to outstrip those of manned commercial aircraft in the United States by 2035, with projections calling for expanded UAS roles in new areas such as the transportation of cargo, package delivery and flight crew augmentation.

Those roles, however, will only be possible after the industry deals with numerous challenges, including crowded skies and other safety concerns; regulatory and policy issues; privacy and related social considerations; and environmental issues such as noise and emissions.

A collection of reports issued in recent months by the U.S. Department of Transportation (DOT) John A. Volpe National Transportation Systems Center, the U.S. Joint Planning and Development Office (JPDO) and the U.S. Federal Aviation Administration (FAA) describe the tasks likely to be taken on by UAS and the challenges that the industry must overcome.[1,2,3]

Historically, UAS have been military aircraft, used primarily in war zones and in restricted airspace, and U.S. Department of Defense (DoD) data indicate that, by 2035, the armed forces expect to have 14,000 UAS, along with 5,000 additional aircraft equipped with UAS

Unmanned Aircraft Systems — Total Forecast 2015–2035



DoD = U.S. Department of Defense

Source: John A. Volpe National Transportation Systems Center

Figure 1

technology that will allow for "pilot augmentation or optional pilot replacement." Unmanned aircraft will represent 70 percent of the U.S. military's fleet in 2035, up from 25 percent today, the Volpe report said.

The report forecast an even more sweeping expansion in non-military use of UAS by federal, state and local governments (Figure 1).

Today, federal agencies — including the Central Intelligence Agency, Department of Homeland Security, and National Aeronautics and Space Administration (NASA) — operate about 125 UAS. As the FAA resolves its existing regulatory challenges within the coming months, other federal agencies — including those within the Department of Agriculture, Department of Commerce and Department of Energy — will begin acquiring UAS, pushing the federal fleet to about 10,000 by 2035.

By 2015, U.S. states and territories probably will operate a few hundred UAS, but those numbers will expand to 10,000 by 2035, and municipalities — especially their police departments and other first responders — will add about 34,000.

The greatest surge in UAS numbers, however, is forecast in the commercial market, which by 2035 is expected to be fielding 175,000 unmanned aircraft.

"The majority of these vehicles will be low-cost and dedicated to specific new and emerging tactical market applications," the Volpe report said. "The source of supply of these vehicles will come initially from the radio controlled (RC) type vehicle makers, as opposed to the suppliers of DoD and public agency aircraft. After an initial surge or upswing in commercial sales, reduced growth is expected, as needs for early adopters and innovators are met. As UAS usage becomes more mainstream, DoD suppliers are expected to seriously enter the commercial market, which will encourage changes in business models … . These changes should again accelerate market growth through 2035."

Many of these public and commercial unmanned aircraft will be among the smallest UAS vehicles — from the *nano*, *micro* and *small* categories — weighing anywhere from less than 1 lb (0.5 kg) to 55 lb (25 kg, see "UAS Categories," p. 36).

Laying the Groundwork

The FAA continued laying the groundwork for the eventual merger of UAS into the National Airspace System (NAS) with its selection in December 2013 of six UAS test sites to be used for research into certification and operational requirements (*ASW*, 2/14, p. 9).

The sites — which will focus on a range of research topics, including standards for unmanned aircraft categories, necessary changes in air traffic control operations, UAS sense-and-avoid capabilities, failure mode testing and system safety requirements — were selected because of their ability to provide "valuable information about how best to ensure the safe introduction of this advanced technology into our nation's skies," U.S. Transportation Secretary Anthony Foxx said.

The FAA's near-term role will be to aid in the establishment of a safe testing environment and to provide safety oversight for operations in the test sites.

Crew Augmentation

As UAS move into the commercial fleet, they will take on a number of new roles, some of which have their roots in military operations.

For example, Kaman's Unmanned K-MAX has been used to resupply U.S. troops in Afghanistan, and is operated remotely, picking up and delivering slinged cargo pallets, the Volpe report said, adding that, in commercial civilian operations, such aircraft could be used in making deliveries to remote locations, logging operations and some types of lifting and hauling.

Routine power line and pipeline inspections, crop dusting and livestock tracking and herding all are potential uses for UAS, along with augmented flight assistance — a field presenting a range of possibilities, from "transfer of technology from UAS experience to the cockpit to provide the pilot with a pilot's assistant, to optionally piloted aircraft (OPA) where the aircraft is capable of human-piloted and autonomous flight," the Volpe report said.

"Using an automatic flight control system, UAS technology can be integrated into existing manned aircraft. Servos manage the throttle, control flight surfaces, raise and lower gear, apply braking and tie all of these functions into a navigation system and autopilot."

General aviation aircraft presumably would be the first civilian aircraft to undergo these modifications, the report said, adding, "The addition of a UAS operating package capable of autonomous landing will create a significant safety capability change, not unlike adding a parachute to the [Cirrus] aircraft line. With a UAS safety package, the pilot and passengers can enjoy the confidence of assistance in the case where the pilot is incapacitated. Likewise, if the pilot can shift from manned operations to UAS, the workload can be significantly reduced and the pilot becomes the safety observer."

Eventually, the report said, "two-person flight crews could be reduced to single-pilot operations … . In this concept, the automatic flight control system augmentation provides the necessary redundancy and can assume greater workload than the second manned pilot."

Expanding Uses

The first use of unmanned aircraft came during World War I, and UAS have played an

Texas A&M University–Corpus Christi

Researchers at Texas A&M–Corpus Christi prepare one of their UAS vehicles for flight. The university is operating one of the six UAS test sites authorized by the FAA.

increasingly prominent role in military operations. Public, non-military UAS, however, have operated on a limited basis in the NAS since the early 1990s, gradually taking on missions in such areas as agricultural monitoring, border surveillance, search and rescue, and disaster response.

With a combination of technological advances, increased interest in using UAS and a 2012 law that included provisions for the phased expansion of UAS operations, the FAA and other government agencies have begun working toward developing a complete picture of what will be involved in integrating UAS into NAS operations.

UAS Categories

Globally, civil aviation authorities have not agreed on how to classify unmanned aircraft systems (UAS), but a report by the U.S. Department of Transportation's (DOT's) John A. Volpe National Transportation Systems Center recommends several categories that it says are consistent with those used by U.S. military and research personnel.[1]

Three of these recommended categories are expected to be covered by the notice of proposed rulemaking (NPRM) that the U.S. Federal Aviation Administration plans to issue later this year:

- *Nano* refers to the smallest UAS vehicles, those that weigh less than 1 lb (0.5 kg) and are less than 1 ft (0.3 m) long. They would fly below 400 ft above ground level (AGL) at less than 25 mph (40 kph) and have an endurance of one to two hours. Nano devices could perform surveillance in urban areas, transmitting video or images of camera views to an operator.
- *Micro* UAS vehicles, weighing between 1 lb and 4.5 lb (2 kg) and less than 3 ft (0.9 m) long, would have speeds up to 25 mph and could be flown below 3,000 ft AGL. They, like nano UAS vehicles, also could be used for surveillance.
- *Small* UAS vehicles, weighing between 4.5 lb and 55 lb (25 kg) and less than 10 ft (3 m) long, can fly higher (up to 10,000 ft), faster (50 to 75 mph [80 to 121 kph]) and longer (one to four hours) than nano and micro UAS vehicles. Besides surveillance, they could be used for product deliveries.

Heavier UAS vehicles — in several categories ranging up to 12,500 lb (5,670 kg) or more — will be the subject of later NPRMs.

— LW

Note

1. DOT, John A. Volpe National Transportation Systems Center. *Unmanned Aircraft System (UAS) Service Demand, 2015–2035*, DOT-VNTSC-DoD-13-01. Report prepared for the U.S. Air Force. September 2013.

Comprehensive Plan

That complete picture is presented in the JPDO's *Comprehensive Plan* — a collaborative effort involving the Departments of Transportation, Defense, Commerce and Homeland Security, NASA, the FAA and industry representatives.

"The continued safe integration of UAS in the NAS and increased NAS access for UAS will be driven by incremental advances in research and development … (including test ranges), rulemaking (including operational approval and airworthiness standards) and development of UAS-related technologies," the plan said. "Safe integration will lead us from today's need for accommodation of UAS through individual approvals to a time when standardized/routine integration into the NextGen [the Next Generation Air Transportation System, the ongoing upgrade of the NAS] environment is well defined."

The plan outlined six goals aimed at facilitating the safe integration of the smallest UAS vehicles into the NAS.

Two of these goals call for routine operation of small — less than 55 lb — UAS vehicles in visual line-of-sight flights. Public UAS — those operated by various non-military federal, state and local government entities — would be the first to begin operations, followed by civil UAS. The FAA expects to issue a notice of proposed rulemaking later this year concerning regulations.

Two additional goals call for routine operation of larger UAS vehicles, again with the public UAS beginning operations before their civil counterparts. Another goal calls for establishing acceptable levels of automation in UAS, and the sixth goal calls for fostering U.S. leadership in UAS capabilities and in standards development.

The *Comprehensive Plan* said that, although it sets forth "the overarching interagency goals, objectives and approach to integrating UAS into the NAS," each department or agency involved in development of the plan will work toward those goals and some may develop complementary agency-specific paths toward achieving the common goals and objectives.

The FAA's *Integration of Civil UAS in the NAS Roadmap* is one such individual plan, discussing the agency's proposals for achieving its goals in connection with UAS development.

"Ultimately, UAS must be integrated into the NAS without reducing existing capacity, decreasing safety, negatively impacting current operators or increasing the risk to airspace users or persons and property on the ground any more than the integration of comparable new and novel technologies," the roadmap said, noting the FAA's key roles in developing regulations, guidance material and training requirements.

"The process of developing regulations, policy, procedures, guidance material and training requirements is resource-intensive," the roadmap said, calling on government agencies and industry stakeholders to support the continuing evolution of UAS operations.

The FAA said that its plans call for an incremental approach to implementing the regulations that will guide the industry.

"The FAA expects to gain experience in applying the existing airworthiness regulations during the type certification process with early UAS adapters," the report said. After that, the agency will revise airworthiness regulations as necessary for UAS safety.

Sense-and-Avoid

The FAA will focus research on sense-and-avoid systems, control and communications, and human factors, the report said, adding that this research will aid in establishing performance limits and in evaluating technologies and procedures for NextGen.

Sense-and-avoid research is directed at developing ground-based and airborne systems, although actual use of an airborne system is considered a long-term goal.

Human factors research involves both pilots and air traffic control (ATC) "and how they will interact to safely operate unmanned aircraft," the FAA report said. "In the near term, data will be collected to permit analysis of how pilots fly UAS, how controllers provide service involving a mix of manned aircraft and UAS and how pilots and controllers interact with each other, with the goal of developing pilot, ATC and automation roles and responsibilities concepts."

On the same subject, the JPDO report suggested research topics that included effective human-automation interaction and UAS operational and technical risks such as inability to avoid a collision and/or maintain positive control of a UAS vehicle.

'Early Adapters'

Overall, the Volpe report said, commercial market use of UAS will begin after the regulatory policies are implemented, perhaps sometime in 2015, with micro UAS vehicles — similar to the RC vehicles now used by hobbyists — being deployed by "innovative users and early adapters."

As noted, the second accelerated influx of UAS into U.S. airspace is not likely until around 2022, as manufacturers that have been accustomed to producing devices for the military expand to the commercial market.

By then, the FAA and others will have conducted further research on risks associated with very small UAS vehicles, including the risks of collision in the air or on the ground.

"A Micro vehicle of foam and balsa construction weighing less than 4.5 lb [2 kg] traveling less than 20 mph [32 kph] poses little, if any, collision risk to airborne aircraft or persons or property on the ground," the report said.

Early Incidents

In their early years, however, UAS have been involved in a handful of incidents and non-fatal accidents investigated by the U.S. National Transportation Safety Board (NTSB).

The NTSB issued its first investigative report on a UAS crash in 2007, combining its findings on the April 25, 2006, accident involving a General Atomics Aeronautical Systems Predator B with 22 safety recommendations (*ASW*, 12/07, p. 42).

Changes in accident investigation procedures as more UAS enter the NAS — and as more of them are involved in accidents — probably will be minimal, NTSB Member Robert Sumwalt said.

"There will be differences, but the methodology used is essentially the same," he said, noting that — just as in investigations of manned aircraft accidents — the most frequently cited probable causes of the early UAS occurrences involve human factors.

Notes

1. DOT, John A. Volpe National Transportation Systems Center. *Unmanned Aircraft System (UAS) Service Demand, 2015–2035*, DOT-VNTSC-DoD-13-01. Report prepared for the U.S. Air Force. September 2013.
2. JPDO. *Unmanned Aircraft Systems (UAS) Comprehensive Plan: A Report on the Nation's UAS Path Forward*. September 2013. The JPDO's members represent several U.S. government departments and agencies involved in development of NextGen.
3. FAA. *Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap*, First Edition. November 2013.

Disappearing Act

BY MARIO PIEROBON

Shortages of qualified safety inspectors increasingly inhibit regulators.

In its 2013 annual report on the Universal Safety Oversight Audit Programme (USOAP), the International Civil Aviation Organization (ICAO) noted that of the eight critical elements laid out in the program, technical personnel qualifications and training ranked last in terms of satisfactory implementation by ICAO contracting states. The civil aviation authorities (CAAs) in a variety of countries, both developed and developing, have found that hiring, training and retaining qualified aviation safety inspectors is an ongoing challenge.[1]

The ineffectiveness of aviation safety oversight in some states and regions of the world has led North American and European authorities to act essentially as watchdogs of global aviation safety oversight. For instance, on Jan. 31, 2014, the U.S. Federal Aviation Administration (FAA), under its International Aviation Safety Assessment (IASA) program, announced that it had downgraded India to a Category 2 rating, signifying "that India's civil aviation safety oversight regime does not currently comply" with the international standards set by ICAO. In its September 2013 IASA assessment, FAA identified 33 problem areas — mainly related to staff shortage and training issues. India's Directorate General of Civil Aviation (DGAC) subsequently hired 75 new safety inspectors.

In May 2013, the European Commission (EC) updated for the 22nd time the European Union (EU) air safety list, better known as the EU blacklist, of airlines that are subject to an operating ban or operational restrictions within the European Union (EU). Decisions to ban foreign carriers or subject them to operating restrictions are based on the unanimous opinion of the EU Air Safety Committee (ASC), which consists of aviation safety experts from the EC, from each of the 28 EU member states, as well as from Norway, Iceland, Switzerland and the European Aviation Safety Agency (EASA). The Commission's decisions about changing the list also must be supported by the European Parliament and the Council of Ministers before they can take effect.

"The considerations of the ASC are derived from the EU Safety Assessment of Foreign Aircraft (SAFA) check findings and ICAO's USOAP reports," says Silvano Manera, a former director general of Italy's Ente Nazionale per l'Aviazione Civile (ENAC), the CAA.

"The SAFA program is targeted to actual operations, while ICAO's USOAP is directed to states and the ban is activated when evidence exists that ICAO standards are not met either by a carrier or the respective civil aviation authority. Some cases exist when a carrier meets high industry standards such as IOSA (the International Air Transport Association's [IATA's] Operational Safety Audit), but it is still banned because its registry state is deemed unable to provide acceptable oversight, with staffing inadequacies normally being one of the main issues," says Manera.

The shortage of oversight staff actually represents a threat for the whole aviation industry. In the growing air transport system of the Asia Pacific region, aviation safety oversight can be anywhere in the USOAP range of 10 percent effectiveness to 100 percent effectiveness. Most states within the Asia Pacific region have been rated 50 to 60 percent effective from the standpoint of personnel and the capability for them to do their oversight, says Kim Tretheway, chief technical adviser of ICAO's Co-operative Development of Operational Safety and Continuing Airworthiness Programme, Southeast Asia.[2]

More mature aviation markets also are having a hard time filling all budgeted aviation safety inspector slots. In late 2012, for example, senior officials at Transport Canada said they were having a difficult time filling all 880 budgeted safety inspector positions and that there were around 100 vacancies.[3] Also, an audit by Canada's auditor general found that Transport Canada had failed to conduct planned inspections of hundreds of aviation companies designated as "higher risk" operations, according to a published report. In addition, the audit found that 67 percent of air carriers, maintenance companies and large airports were inspected as scheduled under annual surveillance plans in 2010–2011.[4]

The global shortage of aviation safety inspectors led the U.S. delegation to ICAO to present an item related to this matter at the ICAO 38th Assembly, held in late September and early October 2013. "A global shortage of qualified aviation safety inspectors has become evident as ICAO member states continue to enhance their capabilities in aviation safety oversight. This shortage is evident through a high number of inspector vacancies and the movement of trained and qualified inspectors to other authorities or to private industry. Inspectors perform a core function of an aviation authority and have direct impact on aviation safety," says an ICAO working paper.[5]

Causes of Shortage

Manera says there are two parallel macro socio-economic reasons why there is this shortage of inspectors. "On the one hand, there are aeronautically developed countries where attrition/retirement rates cannot be matched by new hiring because of [a] shortage of public funding. Budget cuts due to the economic downturn do not allow the hiring of enough skilled people," he said, adding that "training costs are a factor, too."

On the other hand, there are aeronautically *developing* countries in places like Africa, Asia and South America where hiring locally cannot keep pace with rapid aviation growth, according to Manera.

And then there is the issue of public sector salaries. "Inspectors are mostly on civil service pay scales, significantly lower than in the private sector, making it extremely difficult to attract recruits or lure professionals away from airlines."[6]

"Retention of qualified inspectors has been an issue due to the lack of salaries commensurate with industry counterparts or similar inspector positions at other authorities in the region, as well as early retirement requirements set by the national government," says the ICAO working paper.[7]

In addition to financial reasons, some observers suggest that staff shortages at aviation safety inspectorates may also be caused by a stronger workplace dynamism in the private sector. The theory is that aviation safety professionals may be stimulated by a relatively fast-changing and less bureaucratic work environment in private-sector, market-competitive organizations. Manera says that in a bureaucracy, dynamism can be inversely proportional to the state's level of economic development —and this may partially explain why sufficient aviation safety inspectors can be difficult to hire in aeronautically developing countries.

But focusing only on remuneration and working conditions as reasons for inspector shortages would be too limiting, says Manera. The shortage of qualified aviation safety inspectors also is caused by difficulty in ensuring adequate levels of training. "Authority inspectors need different and additional skills, other than what can be found in the private sector. In aeronautically developed countries, it is often the case that training is needed even for highly skilled people," he said.

Some authorities "face the challenge of maintaining a training program to ensure that inspectors have initial and recurrent training, and that inspectors [may not] use the latest requirements and practices due to a lack of knowledge or resources."[8]

Francesco Gaetani, former manager of regulations at Alitalia, added that flight operations inspectors usually have non-flying status, which may contribute to fewer candidates being willing to engage in a pure oversight role.

Applying Pressure

All ICAO member states and signers of the Convention on International Civil Aviation (known as the Chicago Convention) are obligated to implement the organization's aviation safety requirements. To fulfill its ICAO obligations, each CAA, and especially its operations and continuing airworthiness inspectorate, is responsible for implementing the ICAO requirements on behalf of the national government.[9]

There are no supranational bodies that can supersede or can discharge national responsibilities when it comes to ensuring that state or regional CAAs have adequately staffed operations and airworthiness inspectorate activities. "ICAO sets and recommends standards; sometimes it 'urges' contracting states to provide local actions to reach those standards, but legislative and executive powers reside within national bodies, which are set up by the states," says Manera.

"IATA and other industry bodies … propose international standards for the whole industry. They foster the spreading of those standards, too. But due to the [cited] reasons, such industry standards and bodies cannot, although appreciated, substitute state legislation [or for] the role of local CAAs," adds Manera.

However, some regulatory entities are capable of pressuring national governments. For example, Gaetani said that EASA, on behalf of the EC, is responsible for the oversight of EU states' CAAs. "Several kinds of [EASA] inspections are made to assess the uniform implementation of rules on regulation of aviation safety in Europe. One of the items inspected, similar to those in ICAO's USOAP, is the adequacy of a CAA's ability to perform its oversight function: the availability and qualification of inspectors are verified according to the complexity of a member state's civil aviation system," says Gaetani.

Numerous auditing programs also are in place to ensure that aviation safety inspectorates' staffing levels are adequate: USOAP, IOSA, ISAGO (IATA Safety Audit for Ground Operations), SAFA and FAA's IASA. "The existing auditing programs contribute to target the whole aviation system of a given country: starting from high-level state legislations down to actual operations, existing programs help to define what the gaps are, where they are and what should be done to overcome negative outcomes," says Manera.

"On a global scale," adds Gaetani, "ICAO performs inspections of contracting states within the framework of USOAP. Recently EASA and ICAO have agreed to share concerns and join resources to conduct USOAP activities. This program is especially helpful to emerging countries with a developing civil aviation system."

An industry feedback mechanism on inspectors' activities could also be helpful to raise the bar with regard to inspectors' qualifications. "Airline industry bodies could provide a constructive feedback to authorities by commenting on inspectors' oversight activities, in particular when inspectors are found to be lagging behind both technological and operational progress. In addition, such organizations could organize dedicated forums for inspectors (similar to the one on the SAFA program organized by IATA) where operational issues and developments are discussed in a friendly and productive environment," says Gaetani.

Sharing Expertise

An important step toward alleviating the lack of inspectors could be mutual inspection recognition between states.

"The FAA and EASA conduct regular meetings to deepen mutual recognition, but they have not been able, up to now, to find a legally suitable and acceptable form of 'role substitution' for the discharging of responsibilities," says Manera. "On the one side, there is a synergy in certification activities across the Atlantic, but, on the other side, both entities (the United States and the EU) require 're-certification' of third country operators, worsening and increasing the need of inspection activities."

Regulators need to collaborate more, share expertise and work toward avoiding duplication of inspections. CAAs not only inspect their own country's aircraft but also those of foreign airlines that operate in the state; as a result, the aircraft are subject to multiple inspections. This could be avoided if states recognized each other's approvals, says Alan Foo of the CAA of Singapore.[10]

Regulators need to collaborate more, share expertise and work toward avoiding duplication of inspections.

Changing Contract Provisions

In an article published in late 2012, Foo wondered about the possibility of attracting proficient inspectors by turning safety regulatory bodies into statutory entities not tied to government pay scales, thereby narrowing the disparity between government salaries and airline salaries.

Aviation safety regulators "need to be governed bodies, but having them separated as corporate entities means they can have different pay scales and not be subject to the overall government budgetary framework," he said in the article. "The money is available there, either through channelling it from passenger service charges or having certification costs. It's got to be paid for."

The CAA of Singapore itself became a statutory body in 1984; as such, it is not tied to government pay structures, and it says that it can offer more competitive salaries, especially to its flight operations inspectors.[11]

Another possible solution could include the contracting of outsourced personnel. "An easy-to-implement solution is that of contracting qualified industry personnel with flexible contracts. For instance, inspectorate capacity can be increased through the part-time use of active auditors from the industry," says Manera.

"With the use of contracted personnel, advantages could be double-ended: You pay them only when you employ them, and the rest of the time, they keep themselves current working in the front line as part of a permanent job."

Standards for Employment

The general qualifications for initial employment of aviation safety inspectors are outlined in ICAO *Airworthiness Manual* (Doc 9760), Part II.[12]

"Talking about the validity of ICAO's documents, we should keep in mind that rules require a lot of time to be produced, approved and become binding. ICAO's rule-making process is lengthy due to its own nature, with around 200 member states contributing to rule making," says Manera.

The standards outlined in the *Airworthiness Manual* are provided for reference. Additional considerations should guide the hiring, training and retention of inspectors.

The manual was designed to provide "guidance to states on how they could meet, at a minimum, the ICAO airworthiness standards. Guidance is provided in the manual for the expected minimum qualifications and experiences of an inspector but states have the responsibility to hire and train inspectors. Similarly, success in retaining inspectors depends on state-level activity and is not within the scope of ICAO's mission and role," reported an ICAO spokesperson.

"In order to save time and resources and to prioritize actions, authorities and states ought to fully apply the same logic that they expect from the industry when rules are imposed by governmental bodies. A strong and efficient analysis of data flowing in towards authorities could drive 'limited' resources in inspecting 'first things first' and to perform short quality-driven inspections instead of quantity-driven ones," says Manera.

A Self-Evaluating Industry

Aviation safety inspectors typically are expected to accomplish many of the daily technical and safety functions of a CAA as required by ICAO. They represent the national government, and their role is critical to maintaining international aviation safety standards. As a result, some experts conclude that lack of qualified aviation safety inspectors directly impacts aviation safety.[13]

The global scarcity of aviation safety inspectors also coincides with the implementation of safety management systems (SMS) worldwide. Can SMS implementation be considered a tool, at least in part, for reducing potential aviation risks associated with less frequent CAA inspections? In the long run, this may be the case.

"The introduction of systemic methods of self-evaluation of safety performance, like SMS, is a strategic decision taken by aviation legislators in order to change the logic of an authority inspection, evolving from a 'single item' (or process) evaluation to a 'system' evaluation. This change would save a significant amount of human resources, but it [still has a long way] to come," says Manera. "Recently produced European Aviation Safety Regulations (i.e., third-country operator regulations) still envisage on-site document (paper) checks even when more reliable databases are available in house."

Gaetani says an SMS is a powerful tool when properly used, but that full implementation is needed for an SMS to produce results, and this can take years in complex organizations such as international airlines. "There might be a period of time ahead of us where a less-mature SMS could compel authorities to believe that safety performance is being improved while it is actually not. The underlying reason is that operational risk assessment is hard to perform effectively and even harder to verify by inspectors [who] are not adequately qualified and up-to-date. Even if one of the SMS's elements is the requirement of a thorough documentation of the SMS's activities, the suitability of an operational risk assessment cannot be easily assessed by inspectors without an in-depth knowledge of the organization's operational activities," concludes Gaetani.

Notes

1 ICAO. Assembly 38th Session Technical Commission, Agenda Item 31: Aviation Safety — Emerging Issues Global Shortage of Aviation Safety Inspectors, A38-WP 101 TE/32, 16 August 2013.

2 Ballantyne, Tom. "Poor pay key to inspector shortage," *Orient Aviation* October 2012.

3 Schmidt, Sarah. "Transport Canada admits to shortage in civil aviation inspectors," <Canada.com>, published on 27 November 2012 [<o.canada.com/news/national/transport-canada-admits-to-shortage-in-civil-aviation-inspectors/> accessed December 2013].

4 Ibid.

5 ICAO.

6 Ballantyne.

7 ICAO.

8 Ibid.

9 Ibid.

10 Ballantyne.

11 Ibid.

12 ICAO.

13 Ibid.

BY FRANK JACKMAN

Another Record Year

2013 will go down in history as one of the safest years in commercial aviation.

Both the International Civil Aviation Organization (ICAO) and the European Aviation Safety Agency (EASA) have released preliminary analyses of worldwide accident data showing 2013 to be one of the safest years in airline history.

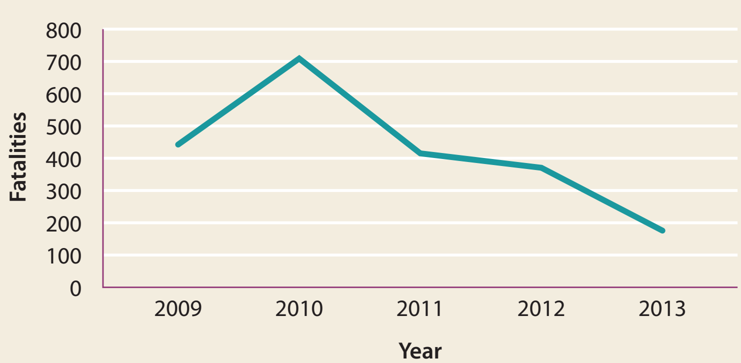
The statistics indicate that 2013 "was the safest year ever recorded" in terms of fatalities in scheduled international air transport operations, according to ICAO. While the number of fatal accidents involving scheduled commercial operations remained steady at nine, the number of people who died in those accidents declined dramatically from 2012. According to ICAO data, there were 372 fatalities in 2012, but that number dropped 53.5 percent to 173 last year (Figure 1). Of the nine total fatal accidents worldwide in 2013, seven occurred during the approach or go-around phases of flight, ICAO said.

The ICAO statistics refer to scheduled commercial operations involving aircraft having a maximum takeoff weight of more than 5,700 kg (12,500 lb).

"These results are no surprise given the level of commitment our sector demonstrates, year-in and year-out, to improving the safety of the global air transport network," ICAO Secretary General Raymond Benjamin said in releasing the report in January. "Recent years have seen a tremendous increase in the level of cooperation and partnership on aviation safety priorities and we are now seeing the fruits of these efforts borne out by these remarkable 2013 outcomes."

Over the past five years (2009 through 2013) fatalities have increased once, spiking to approximately 700 in 2010 from fewer than 500 in 2009, ICAO data show. Since then, the number

Global Fatalities Trend in ICAO Data, 2009–2013



ICAO = International Civil Aviation Organization

Source: International Civil Aviation Organization

Figure 1

of fatalities has decreased three consecutive years and fallen more than 75 percent overall.

According to ICAO, 60 percent of all fatalities in 2013 were attributed to accidents in narrowbody jet airplanes, while 37 percent were attributed to accidents involving turboprop aircraft and three percent were attributed to accidents involving widebody jets.

When broken down by ICAO regional aviation safety group (RASG) areas of responsibility, the statistics show that the Pan American region (RASG-PA) had the most fatal accidents with five, but that Europe (RASG-EUR) had the most fatalities with more than 60 (Figure 2). The Middle East region (RASG-MID) did not have any fatal accidents in 2013. Africa (RASG-AFI) and the Asia/Pacific region (RASG-APAC) had one each, and Europe had two.

Effective implementation of ICAO's safety oversight critical elements by member states under the Universal Safety Oversight Audit Programme increased to 61.7 percent in 2013 from 61.1 percent in 2012, ICAO said. RASG-AFI, RASG-MID and RASG-PA saw increases in effective implementation, while RASG-APAC and RASG–EUR had small decreases.

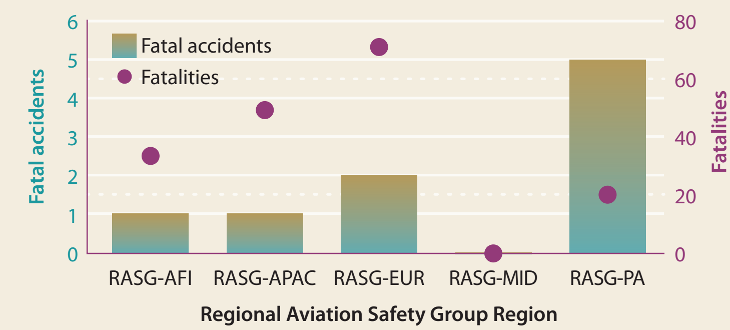
The steady state of the rate of fatal accidents in 2013 compared with 2012 comes against a backdrop of what ICAO described as a "marginal" increase in scheduled commercial air transport departures in 2013 over the previous year. According to figures released by ICAO in mid-December, the number of departures last year reached 33 million, establishing a new record and surpassing 2012's figure by more than one million flights. Scheduled passenger traffic grew 5.2 percent in 2013 over the previous year.

According to the data released in January by EASA, there were 17 fatal accidents involving large commercial air transport airplanes worldwide in 2013, which is fewer than in any other year in the past decade by this count, but more than announced by ICAO, which counted only scheduled operations. The annual average since 2003 is 27 fatal accidents, EASA said (Figure 3).

EASA also noted a "significant reduction" in the number of fatalities worldwide, with 224 in 2013, which declined about 68 percent from the yearly average of 703 between 2013 and 2012.

"Europe continues to have one of the strongest safety records in the world, however this positive picture cannot be taken for granted," said Patrick Ky, EASA's executive director. "As traffic over European skies and worldwide increases, we need to continue our efforts to maintain and even improve aviation safety," he said in releasing the EASA numbers.

Fatal Accidents and Fatalities by ICAO Region, 2013

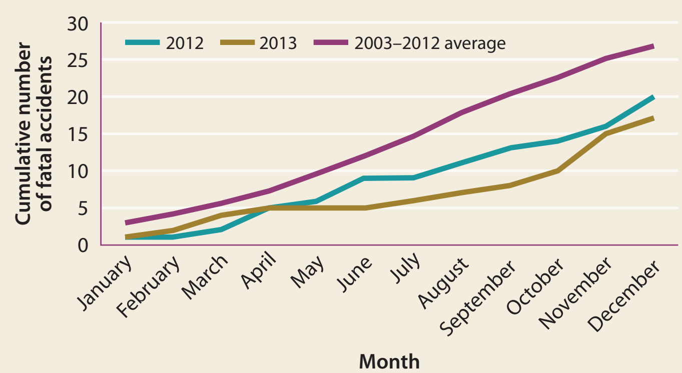


AFI = Africa; APAC = Asia/Pacific; EUR = Europe; ICAO = International Civil Aviation Organization; MID = Middle East; PA = Pan American; RASG = Regional Aviation Safety Group;

Source: International Civil Aviation Organization

Figure 2

European Fatal Accidents per Month, 2012 and 2013



Source: European Aviation Safety Agency

Figure 3

There were no fatal accidents involving large commercial air transport airplanes in EASA member states in 2013, a year in which those states performed approximately 6 million commercial air transport flights and carried more than 800 million passengers, the agency said.

Asia Pacific Carriers Count 2013 as Safe Year

The Association of Asia Pacific Airlines (AAPA) also has weighed in with an assessment that 2013 was the safest year ever in terms of commercial airline jet fatalities. AAPA, which is the trade association for scheduled international airlines based in the Asia Pacific region, said there were seven major accidents involving large Western-built commercial airline jets in 2013, and that those accidents resulted in 115 fatalities. According to AAPA calculations, that represents a loss rate of one major accident for every four million flights.

Asia Pacific carriers suffered three major accidents involving large Western-built commercial airline jets in 2013, resulting in 24 fatalities, AAPA said. The organization went on to say that turboprop operations maintained a good safety record, but experienced somewhat higher accidents rates compared to jet aircraft operations. AAPA also said that many of the turboprop operations "are carried out in more challenging environments and conditions, which can be considered a contributory factor." The association did not provide statistics on turboprop accidents or fatalities.

Andrew Herdman, director general of AAPA, said that greater attention needs to be focused on turboprop aircraft operations. "We need firm regulation to ensure that all carriers operate to the highest international standards, including wider deployment of automated terrain awareness warning systems for all commercial operations."

U.S. GA Fatal Accident Rate 'Flattens Out'

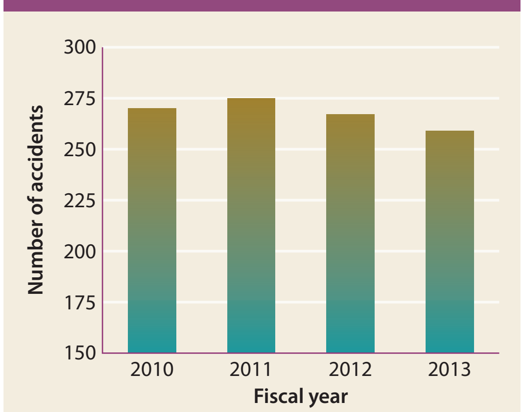
General aviation (GA) in the United States — which includes some business aviation activity — suffered 259 fatal accidents resulting in 449 fatalities in 2013, according to data released by the U.S. Federal Aviation Administration Jan. 27, 2014, when Administrator Michael Huerta met with general aviation leaders to "jump start efforts for this year's flying season." According to FAA, Huerta and GA leaders agreed to work together to raise awareness to prevent weather-related accidents for the upcoming period of highest activity. FAA also said it is working with industry on a prototype program to use de-identified GA operations data in its Aviation Safety Information Analysis and Sharing program to help identify risks before they become accidents.

The number of fatal GA accidents had gone down over the past decade, but so have total GA flight hours, likely due to economic factors, according to FAA. Fatal accidents from controlled flight into terrain have been reduced by more than 50 percent over the past three years when compared with the previous three-year period, the agency said.

FAA preliminarily estimated the GA fatal accident rate for fiscal year 2013 (the year ended Sept. 30, 2013) at 1.07 per 100,000 hours flown, with 259 fatal accidents and 449 fatalities. In fiscal 2012, the GA fatal accident rate was 1.09 per 100,000 hours flown and there were 267 fatal accidents (Figure 4).

According to FAA, the five leading causes of fatal GA accidents in the 2001–2011 period —more recent data were not available — were loss of control–in flight, controlled flight into terrain, system component failure–powerplant, low-altitude operations and "unknown or undetermined." The next five causes on the list were "other," fuel-related, system component failure—nonpowerplant, midair collisions and windshear or thunderstorm.

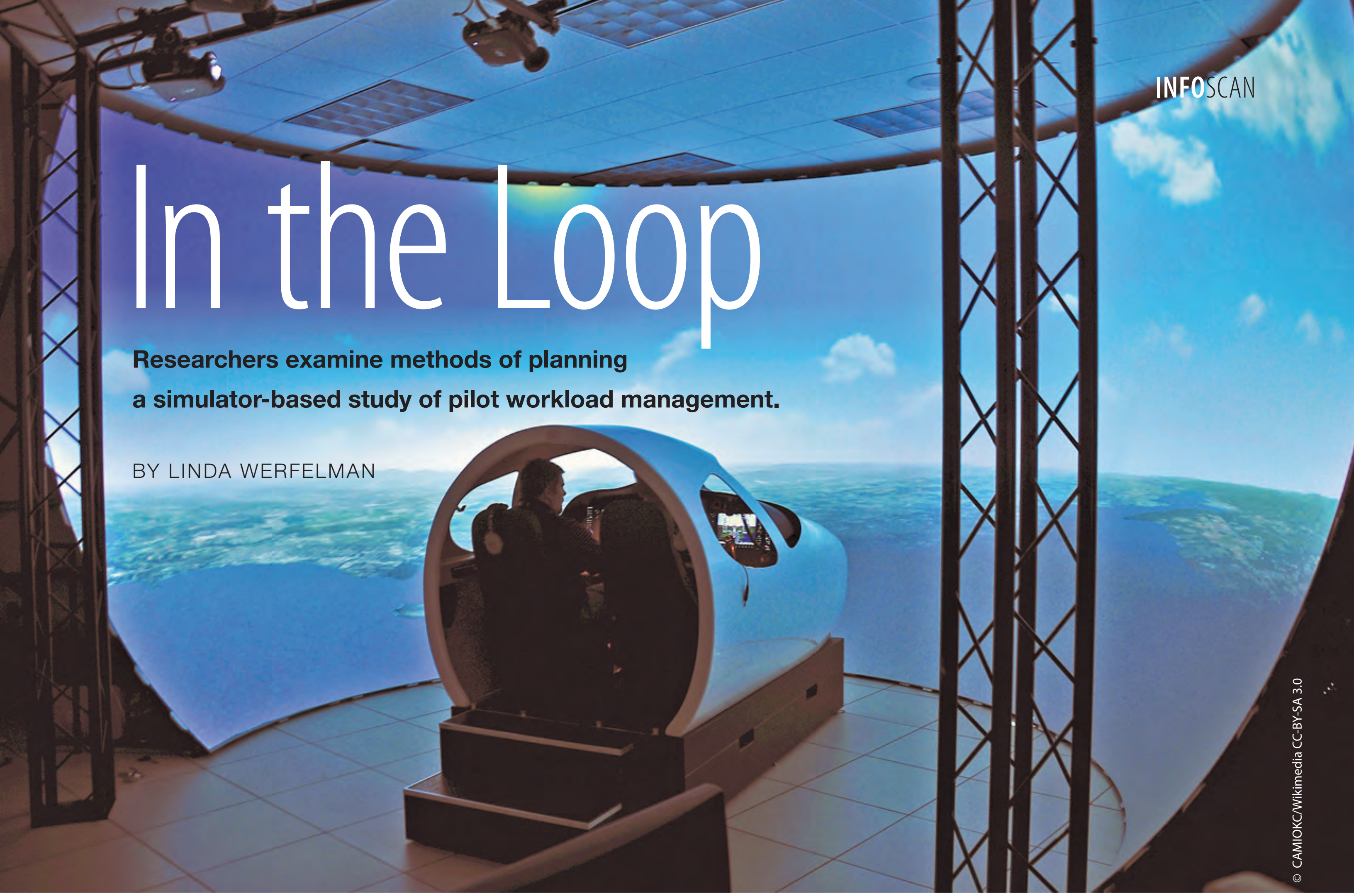
U.S. General Aviation Fatal Accidents, 2010–2013



Notes: U.S. government fiscal year is Oct. 1 through Sept. 30.

Source: U.S. Federal Aviation Administration

Figure 4

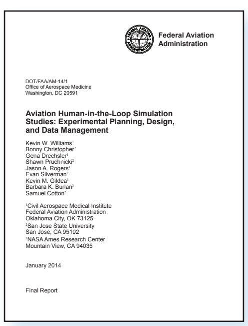


In the Loop

Researchers examine methods of planning a simulator-based study of pilot workload management.

BY LINDA WERFELMAN

REPORTS



Federal Aviation Administration

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Aviation Human-in-the-Loop Simulation Studies: Experimental Planning, Design, and Data Management

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Final Report

Aviation Human-in-the-Loop Simulation Studies: Experimental Planning, Design, and Data Management.

DOT/FAA/AM-14/1. Williams, K.; Christopher, B.; Drechsler, G. et al. U.S. Federal Aviation Administration (FAA) Office of Aerospace Medicine. 80 pp. Appendixes, figures, photos, tables. Available from the FAA at <www.faa.gov/go/oamtechreports>.

This report describes "human-in-the-loop" flight simulations as part of a task and workload-management study involving single pilots of very light jets. Information gathered through the study also will be used as baseline data in upcoming studies related to development of the Next Generation Air Transportation System, known as NextGen.

The study was conducted in a Cessna Citation Mustang flight training device and with data collection methods that included voice analysis; instantaneous self-assessment of perceived workload; U.S. National Aeronautics and Space Administration (NASA) tools for measuring workload; and questionnaires involving cockpit set-up preferences, demographics and automation experiences.

"Researchers have a need to measure the workload of the pilot during the flight because automation and advanced technology can provide a great benefit to pilots in terms of reducing some types of workload and making increased situation awareness possible, particularly when flying single-pilot operations," said the report on the study, conducted by researchers from the NASA Ames Flight Cognition Lab and the FAA Aerospace Human Factors Research Lab at the Civil Aerospace Medical Institute.

"Guidance is needed so designers can reduce the cognitive complexity of these systems, to minimize the likelihood of human error and to better support pilots managing the workload and resources of advanced automation."

The report focused on the researchers' discussion of how they designed their human-in-the-loop simulation study and the methods used to collect and analyze the results. An earlier report discussed the observations recorded during the simulator study, which the authors said produced baseline data that will be used in future NextGen research (*ASW*, 11/13, p. 47).

In this report, the researchers said that they chose to use the instantaneous self-assessment device to allow for a measurement of the workload "at any pre-determined point during the flight, and post-hoc workload measures can be administered as required."

Although use of the device "has the possibility of making the flight seem less real, actually adding to the workload being measured and potentially interrupting other tasks," they nevertheless wanted to gather pilots' observations while they were still fresh. Waiting until after the flight, they said, could mean that pilots' memories of the experience would become inaccurate.

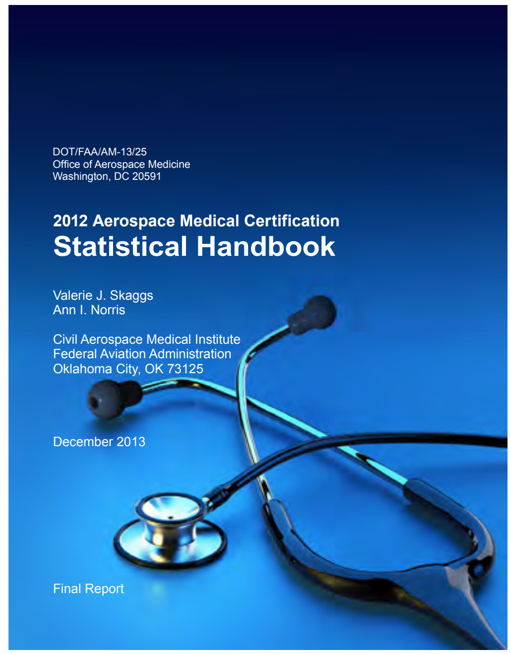
"Achieving the necessary balance between gathering the most useful data and maintaining the fidelity of the simulation requires careful planning and execution of the study," the report said. "There are numerous background materials that must be developed and multiple data sources that must be considered."

Overall, the report said, human-in-the-loop flight simulation studies can collect "literally, thousands of variables, many times a second over the duration of a flight that could last several hours." The amount of time spent planning, analyzing and reporting study details can far outstrip the time spent actually conducting the study, the report said.

"When pilots perform flights in the real world, they do not simply show up at the airport, jump in the plane, start the engine and take off," the report added. "There are many steps involved in planning and executing the flight. The safety of the flight depends critically on the performance of these steps. When conducting a flight simulation study, one intention of the researcher is to make the flight experience as realistic as possible so that the performance and decision-making activities of pilots match what would be found if they were flying an actual aircraft."

2012 Aerospace Medical Certification Statistical Handbook

DOT/FAA/AM-13/25. Skaggs, V.J.; Norris, A.I. U.S. Federal Aviation Administration (FAA) Office of Aerospace Medicine. December 2013. 42 pp. Figures, tables. Available from the FAA at <www.faa.gov/go/oamtechreports>.



This is the most recent of the FAA's annual statistical handbooks of aerospace medical certification data — a compilation of "the most recent and most widely relevant" data collected about active pilots and aviation medical examiners (AMEs).

The handbook's data on FAA-certificated pilots were derived from the FAA's medical certification records from 2007 through 2012; medical data were taken from the most recent medical examinations, and only pilots with current medical certificates were included in the data set.

Data on AMEs were selected from the Aviation Medical Examiner Information System.

The handbook shows, in a series of figures and tables, each certificated pilot's age, date of issuance of medical certificate, height, weight, body mass index (BMI), gender, selected medical conditions, special issuances and FAA region of residence.

The findings, as of Dec. 31, 2012:

- Some 581,850 pilots, all at least 16 years of age, held FAA medical certificates — 32.7 percent had Class 1 certificates, 21.6 percent had Class 2 certificates, and 45.7 percent had Class 3 certificates;

- Seven percent of certificates required a special issuance;
- The most common medical condition was "hypertension with medication," reported by 11.3 percent;
- The average age of these pilots was 42.9 years, 93.5 percent were men;
- The mean BMI for male certificate-holders was 27.2, and the mean female BMI was 24.1.

The handbook also includes data on 3,427 active AMEs, about half of whom were family practitioners. Nearly 90 percent were men, their average age was 60.2 years, and 52.6 percent did not themselves have a pilot's license.

FAA Made Limited Progress in Implementing NextGen Provisions of the FAA Modernization and Reform Act of 2012

AV-2014-027. U.S. Department of Transportation Office of Inspector General (OIG). Jan. 28, 2014. 19 pp. Appendix, exhibits. Available from the OIG online at <www.oig.dot.gov/node/6298>.

This audit report, an examination of the Federal Aviation Administration's (FAA's) progress in implementing portions of a 2012 law dealing with the Next Generation Air Transportation System (NextGen), finds that the FAA has yet to implement key provisions of the law intended to accelerate NextGen technologies.

The report said that the FAA has implemented, or is on target to implement, 11 of 24 provisions of the law that were singled out by the OIG, including completion of the multiagency NextGen Integrated Work Plan. In other areas, however, progress has been slow, according to the report, requested by the aviation subcommittee of the U.S. House Committee on Transportation and Infrastructure.

Two areas were singled out by the OIG.

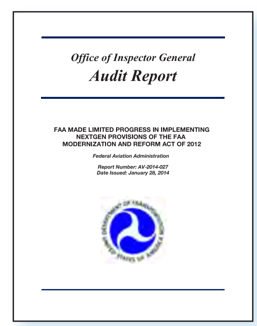
First, the report said that the FAA has not initiated "rulemaking activities requiring use of the [automatic] dependent surveillance–broadcast (ADS-B) In system for enhanced satellite-based air traffic surveillance." The ADS-B In system shows pilots information being transmitted by ADS-B ground stations and other aircraft.

In addition, the agency "has not established a public-private incentive program for installing NextGen avionics equipment on aircraft," the report said.

The report added that the FAA also has failed to meet a number of deadlines for submitting reports and plans involved in NextGen implementation.

The FAA's problems in meeting the law's requirements can be attributed in part to programmatic and organizational challenges, the report said.

"According to FAA officials, the act's provisions are difficult to execute, as they require coordination among multiple programs, resolution of complex technical and operational issues and collaboration with industry stakeholders," the report said. "For example, FAA's delays with issuing guidelines and regulations for ADS-B In are due, in part, to the need to finalize requirements for displaying traffic information in aircraft cockpits, modify the systems that controllers rely on to manage traffic, develop and deploy new procedures for separating aircraft using satellite-based technology, and assess potential system security vulnerabilities. As a result, FAA will not likely be ready to mandate the use of the technology by 2020, as required by the act."


Office of Inspector General
Audit Report

FAA MADE LIMITED PROGRESS IN IMPLEMENTING NEXTGEN PROVISIONS OF THE FAA MODERNIZATION AND REFORM ACT OF 2012

Federal Aviation Administration

Report Number: AV-2014-027
Date Issued: January 28, 2014

The OIG repeated its conclusion, outlined in a 2012 report, that users have been "concerned" about equipping their aircraft with ADS-B avionics "because FAA has not clearly defined what benefits will be achieved and when."

The report included recommendations calling on the FAA to develop a process for delivering regular updates on its progress in meeting the law's NextGen requirements and to communicate its plans to Congress and other NextGen stakeholders.

In the FAA's response, included in the report, the agency agreed with both recommendations and noted that it has used multiple processes to share information on NextGen progress.

Undetected Touchdown Leads to Tail Strike

Perceiving that the A320 was still airborne, the crew decided to go around.

BY MARK LACAGNINA

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

JETS

Rapid Pitch-Up

Airbus A320-200. Substantial damage. No injuries.

The A320's main landing gear contacted the runway at Japan's Sendai Airport so softly on the morning of Feb. 5, 2012, that none of the usual sensory cues was clearly evident. Believing that the aircraft was floating too far down the runway, the captain decided that it would be safer to go around than to continue the landing.

The captain had progressively increased back-pressure on his sidestick to maintain the flare attitude, and he moved the stick fully aft while initiating the go-around. As a result, the A320 pitched up substantially and the tail struck the runway, said the Japan Transport Safety Board in its final report on the accident. Damage to the rear fuselage was substantial, but none of the 166 occupants was hurt. The crew subsequently landed the aircraft without further incident.

Visual meteorological conditions (VMC), with light surface winds from the southeast, prevailed at Sendai, and the flight crew had decided to conduct a visual approach, backed up by the instrument landing system (ILS), to Runway 27. Inbound from Osaka, the aircraft neared Sendai from the south, over the Pacific Ocean. The tower controller advised the crew that the winds were from 160 degrees at 2 kt.

The A320 was 1,000 ft above the ocean when the captain began a left turn onto final approach to Runway 27. The first officer subsequently called out a radio altitude of 500 ft as the aircraft descended on the ILS glideslope, and the captain replied "stabilized," indicating that all performance parameters were within the limits for a stabilized approach and that the aircraft was configured properly for landing.

The aircraft crossed the runway threshold at 50 ft and at 138 kt — about 3 kt above the target airspeed. The captain initiated the flare at about 30 ft, as prescribed by standard operating procedures, and brought the throttles to idle.

Recorded flight data indicated that the aircraft "floated" about 10 ft above the runway before the main landing gear touched down about 2,297 ft (700 m) from the threshold of the 9,843-ft (3,000-m) runway. The touchdown was soft, with a change in vertical acceleration of 0.06 g, compared with an average of 0.19 g recorded for the last 13 landings. No sounds typical of touchdown were captured by the cockpit voice recorder. The first officer was looking out the windshield and did not notice the instrument panel indication of automatic spoiler deployment.

Believing that the aircraft was still airborne, the captain said "oh, no good" and then announced "go around." With the application of go-around power, spoiler retraction and full-aft sidestick, the pitch angle increased rapidly from 1.8 to 12.7 degrees.

During the subsequent climb-out, a purser told the crew that a loud sound had been heard and that an unusual impact had been felt in the cabin. Suspecting a tail strike, the captain decided to enter a holding pattern while the runway was checked for debris. Airport personnel found a large white scrape mark about 3,740 ft (1,140 m) from the approach threshold.

During the brief hold, the crew detected "no particular body vibrations or other irregularities [and] decided to land at Sendai Airport as planned," the report said. An examination of the A320 revealed a large abrasion on the lower rear fuselage and deformation of the rear pressure bulkhead.

Afterward, both pilots said that never before had they been unable to recognize when an airplane touched down on landing.

Smoke, Sparks Prompt Evacuation

Boeing 737-300. Minor damage. No injuries.

The six crewmembers were preparing the 737 for a ferry flight from London Gatwick Airport the morning of March 1, 2013, when the senior cabin crewmember saw smoke and sparks near a forward overhead locker.

"After ordering the cabin crew to leave the aircraft, the flight crew carried out the QRH [quick reference handbook] drills and declared a mayday before leaving the aircraft," said the report by the U.K. Air Accidents Investigation Branch (AAIB).

Examination of the 737 revealed that the smoke and sparks had originated from electrical arcing across the pins of a spare galley connector that was receiving electrical power although its circuit breaker was pulled and collared. The report noted that the connector "was positioned close to damp sound-insulation material."

A similar incident had occurred a year earlier to another aircraft in the operator's fleet. Maintenance action was ordered, "but the operator's maintenance systems allowed the task to be closed prior to completion of the rectification work" on the aircraft involved in the 2013 incident, the report said. Following that incident, "the connector was removed from the aircraft and the wires capped and stowed."

'Surreal' Approach

Airbus A319-132. No damage. Two minor injuries.

Inbound from Vienna, Austria, with 152 passengers and five crewmembers the night of Dec. 19, 2010, the flight crew was turning base for a landing at Köln/Bonn (Germany) Airport when they detected a "strange, strong and unpleasant" odor. They queried the purser, who reported that there was no abnormal odor in the cabin.

"A short time later, during intercept of the extended centre line, both pilots noticed an adverse effect on their physical and cognitive performance," said the report on the serious incident published by the German Federal Bureau of Aircraft Accident Investigation (BFU) in December 2013.

The pilot-in-command (PIC), 35, said that his first sensation was an "intense prickling in his hands and feet." He then experienced tunnel vision and severe dizziness. The copilot, 26, said that nausea "hit him like a punch to his stomach." His arms and legs began to feel numb, and he could not think clearly.

After donning oxygen masks, the PIC's condition improved somewhat. "He felt physically ill [and] was at the upper limit of what he thought he could do while manually flying the airplane with the assistance of the flight director," the report said. The copilot's condition worsened. "He did not feel capable to actively influence the course of events and just hoped it would be a successful landing," the report said. "Both pilots described their condition shortly before touchdown as surreal and like a dream."

The landing was successful, and the pilots subsequently were taken by ambulance to a hospital for medical treatment. "In the hospital, both pilots were examined and released after about two hours," the report said. "Blood and urine tests were not made."

The PIC resumed flying duties four days after the incident; the copilot said that he remained unfit to fly for seven months due to illness and post-traumatic stress disorder. The pilots' symptoms were analyzed by the German Airforce Institute of Aerospace Medicine. Possible causes included inhalation of carbon monoxide, insecticide or deicing fluid; ingestion of contaminated food or drink; lack of oxygen; and cardiological disease. Further analysis of possible factors such as oil, hydraulic fluid and rain repellent leaks, and electrical system malfunctions was performed by the BFU. However, no definitive conclusion was reached about the cause of the pilots' illness.

Maintenance technicians who examined the airplane shortly after it was parked detected a "strange odor" although the cockpit windows had been opened. "The technicians estimated it was highly likely caused by deicing fluid," the report said. "The technicians definitely ruled out oil, fuel and electrical smell." (The A319 had been deiced prior to its departure from Vienna.)

However, further inspections of the airplane and a functional check flight did not reveal the source of the odor that had partially incapacitated the flight crew.

TURBOPROPS

Attention Lapse on Landing

Fairchild Metro III. Substantial damage. No injuries.

The flight crew was conducting a cargo flight the morning of March 7, 2013, to Dublin (Ireland) Airport, which had about 1,200 m (3/4 mi) visibility in fog and an overcast at 300 ft. The pilots said that the Metro broke out of the clouds at about 650 ft during the ILS approach to Runway 10.

"As per normal procedure after landing, the first officer, who was the pilot flying, gave the controls to the captain … so that he [the first officer] could complete the 'Leaving the Runway' checklist," said the report by the Irish Air Accident Investigation Unit (AAIU). "This checklist is completed from memory and included booster pump and flap-to-zero selections."

The captain was applying wheel braking and the indicated airspeed was below 90 kt when the nose landing gear suddenly collapsed. Both propellers struck the runway, and the aircraft came to an abrupt stop resting on its nose. Neither pilot was injured.

The AAIU determined that the first officer likely had inadvertently retracted the landing gear, rather than the flaps, during the landing roll. "Whilst it is not possible to be definitive as to why the landing gear selector was moved to the 'UP' position, the [first officer] described feelings of tension and stress associated with the limits approach he flew into [Dublin] due to the poor weather conditions," the report said.

"It is possible that following the successful landing, and the associated relief of tension and stress, the [first officer] may have relaxed, leading to a reduced level of task attention as he went through his checks prior to leaving the runway. This reduced level of task attention probably facilitated the lapse whereby the landing gear selector was incorrectly moved to the 'UP' position."

High Speed Leads to Excursion

Cessna 425. Substantial damage. Three minor injuries.

The pilot conducted a global positioning system (GPS) approach the morning of March 28, 2011, to Runway 22 at Hemphill County Airport in Canadian, Texas, U.S., which had surface winds from 140 degrees at 5 kt, 5 mi (8 km) visibility and an overcast at 600 ft.

"The airplane broke out of the clouds directly over the end of the runway," said the report by the U.S. National Transportation Safety Board (NTSB). "The pilot then remained clear of clouds and executed a no-flap circling approach to the opposite-direction runway."

Investigators determined that the approach airspeed was excessive and that the tire on the right main landing gear burst during the hard touchdown. The airplane then bounced and veered off the runway after the left main gear collapsed. Four passengers sustained minor injuries; the pilot and two other passengers were not hurt.

'Complacency' Cited in CFIT

Rockwell 690A. Destroyed. Six fatalities.

Night VMC prevailed when the Commander departed from Falcon Field in Mesa, Arizona, U.S., for a visual flight rules (VFR) flight to Safford, Arizona, on Nov. 23, 2011. "There was no moon, and the direction of flight was toward sparsely lit terrain," the NTSB report said. "The pilot did not request VFR flight-following or minimum safe altitude warning (MSAW) services" for the 110-nm (204-km) flight.

Due to inbound traffic, the tower controller kept the airplane on the northeasterly runway heading for about two minutes before clearing the pilot for his requested right turnout. There was no further radio communication with the Commander.

Radar data showed that the airplane turned directly toward Safford and climbed to 4,500 ft. About four minutes later, it struck a 5,057-ft mountain about 15 nm (28 km) southeast of the airport, killing all six occupants.

"This controlled flight into terrain (CFIT) accident was likely due to the pilot's complacency (because of his familiarity with the flight route and because he selected a direct route, as he had previously done, even though he turned toward the destination later than he normally did) and lack of situational awareness," the report said.

The cruise altitude likely had been chosen to keep the airplane below the 5,000-ft floor of Phoenix Class B airspace. The direct track between the Mesa and Safford airports passed about 3 nm (6 km) south of the mountain, but "the delayed right turn from [Mesa] put the airplane on a track that intersected the mountain," the report said. "The pilot did not adjust his flight track to compensate for the delayed right turn to ensure clearance from the mountain."

The report noted that six years before the crash, passenger seating had been reduced from six to five by removing a seat belt from the aft divan; the modification rendered the Commander exempt from the requirement to be equipped with a terrain awareness and warning system (TAWS).

PISTON AIRPLANES

Engine Fire on Takeoff

Convair 340. Substantial damage. No injuries.

The captain suspected that the spark plugs were fouled when the left engine backfired during the run-up for a cargo flight from San Juan, Puerto Rico, to Saint Thomas, Virgin Islands, the morning of Jan. 17, 2011. "An additional engine run resulted in no further backfiring, and the captain decided to depart," the NTSB report said.

Nearing the destination, the left engine backfired again, but the freighter was landed without further incident. No maintenance was requested or performed before the subsequent departure for the return flight to San Juan.

"During the takeoff, the local controller noted black smoke trailing the left engine and advised the flight crew," the report said. "However, the captain attributed the smoke to normal operation for the airplane type and decided to continue the flight."

After the flight crew switched radio frequencies to San Juan Approach, the local controller at Saint Thomas saw bright orange and red flames emerge from the Convair's left engine. The information was relayed by the approach controller to the crew. "They immediately executed the fire checklist and shut down the left engine," the report said. "However, the fire continued because it was located in an area where fire-suppression bottles could not reach."

The crew turned back to Saint Thomas. The fire had damaged the left brake line, and after touching down, the airplane veered off the right side of the runway, crossed a taxiway and a perimeter road, went through the perimeter fence and came to a stop with the nose section over a public road.

Examination of the left engine revealed that two of the 18 pistons did not move in their cylinders when the propeller was rotated. "This discrepancy could result in unburned fuel or oil entering the exhaust system and igniting in the exhaust or augmentor tubes," the report said.

Inadvertent Gear Retraction

Beech Duchess. Substantial damage. No injuries.

The Duchess was taking off from Bournemouth (England) Airport for an instrument instructional flight the afternoon of Feb. 6, 2013, when the landing gear partially retracted. "The aircraft was brought to a rest on the runway with a collapsed nose gear and partially collapsed main gear," the AAIB report said. The pilot, the flight instructor and the passenger were not injured.

Investigators determined that while making rudder inputs to maintain directional control in a brisk crosswind, the pilot's knee likely had struck and dislodged the gear selector knob, which is at the bottom right side of the panel. "A detent system designed to prevent inadvertent operation of the gear lever was not effective," the report said.

Fuel Leak Causes Fire

Cessna 310K. Substantial damage. No injuries.

Shortly after starting the left engine in preparation for a flight from Olive Branch, Mississippi, U.S., the morning of March 7, 2012, the pilot saw smoke emerge from the nacelle and from below the panel. He shut down both engines and exited the airplane.

"Local personnel responded and extinguished the fire," the NTSB report said. Subsequent examination of the left engine revealed that the fire likely was caused by the ignition of fuel that had leaked from the fuel strainer onto electrical connections for the battery and starter solenoid.

HELICOPTERS

'Fast-Changing Weather'

Eurocopter AS350-B3. Destroyed. Four fatalities.

The pilot had conducted three charter flights in Papua, New Guinea, the morning of March 16, 2012, and was en route with three passengers from Wanagon to the company's base in Timika when he received a radio call from the company asking him to pick up another passenger in West Gully.

"The pilot flew to West Gully and attempted to land twice but was unsuccessful due to poor visibility," said the report by the Indonesian National Transportation Safety Committee (NTSC).

The pilot resumed the flight to Timika but found that the weather conditions there also precluded a landing. He radioed the company that he was diverting to Landville. The report noted that the remote, mountainous area is subject to fast-changing weather and that Landville was an oft-used alternate because it generally has better visibility than the heliports at higher elevations.

There was no further radio communication with the pilot. An emergency locator transmitter (ELT) signal was detected, but the search was delayed by a false report that the helicopter had landed at Landville and was subsequently hampered by adverse weather conditions.

The wreckage of the helicopter was found the next morning at 8,000 ft. The NTSC determined that the helicopter was in level cruise flight when it struck the steep mountain slope. The accident was categorized as CFIT.

Unapproved Fuel

Hughes 500D. Substantial damage. No injuries.

The pilot was conducting a positioning flight to Aiken, South Carolina, U.S., the afternoon of March 20, 2012, when the tailwind changed to a headwind. The pilot realized that the reduced groundspeed would prevent him from reaching the destination, so he diverted to McCormick, South Carolina.

Finding that no fuel was available at the airport, the pilot repositioned to a nearby automobile station, where the helicopter was refueled with 25 gal (95 L) of 87-octane gasoline. "The pilot did not know what the approved alternate fuel was for the turbine engine," the NTSB report said. "According to the engine manufacturer, automotive fuel is not an approved fuel on the list."

Shortly after departing from the station, the helicopter was about 200 ft above the ground and at 70 kt when the engine lost power. "The pilot lowered the collective pitch as much as possible to clear a power line and reach an open field," the report said. "Once clear of the power line, he lowered the collective pitch to the full-down position."

The helicopter touched down hard in a tail-low attitude. The tail boom separated, and the helicopter rolled over on its right side.

The 500D flight manual lists several types of jet fuels as "primary" fuels for the helicopter and notes that aviation gasoline can be used in an emergency. The report said that the probable cause of the accident was "the pilot's decision to use automotive fuel instead of [an] approved alternate fuel."

Preliminary Reports, December 2013

Date	Location	Aircraft Type	Aircraft Damage	Injuries
Dec. 2	La Alianza, Puerto Rico	Fairchild Metro III	destroyed	2 fatal
The Metro was nearing San Juan International Airport on a cargo flight in night visual meteorological conditions (VMC) when it made a steep right turn, entered a descent that ranged from 12,000 to 21,000 fpm and crashed in a pasture.				
Dec. 2	Walton, Indiana, U.S.	Cessna Citation 560	substantial	3 none
The Citation was descending through 17,000 ft on approach to Chicago Midway Airport when the right engine cowling separated and struck the horizontal stabilizer. The airplane subsequently was landed without further incident.				
Dec. 3	London, England	Airbus A320-214	substantial	64 none
A tail strike occurred when the A320 touched down hard at London Heathrow Airport and bounced into a nose-high attitude.				
Dec. 4	Novo Progresso, Brazil	Britten-Norman Islander	destroyed	5 fatal
The Islander struck wooded terrain shortly after taking off for a medevac flight.				
Dec. 4	Abuja, Nigeria	Boeing 747-200	substantial	6 NA
No fatalities were reported when the 747 freighter veered off the runway on landing and struck construction equipment and several vehicles.				
Dec. 5	Madrid, Spain	Boeing 767-300ER	substantial	203 none
The right rear wheel and tire on the right main landing gear burst on takeoff, and debris punctured the left wing. A hydraulic system failure prevented the flight crew from retracting the landing gear. They declared an emergency and returned to the airport for a landing.				
Dec. 8	Jacksonville, Florida, U.S.	Cessna 310R	substantial	3 fatal
Night instrument meteorological conditions (IMC) prevailed when the Cessna struck terrain during a missed instrument landing system approach. Visibility was 2.5 mi (4,000 m) in mist and the ceiling was overcast at 200 ft.				
Dec. 10	Guayaramerín, Bolivia	Fokker F-27	substantial	25 none
A bird strike shortly after takeoff damaged the right engine and wing. The flight crew returned to the airport for a landing.				
Dec. 10	London, England	Gulfstream G550	NA	NA
The Gulfstream struck an antenna when it touched down short of Runway 04 at London Stansted Airport.				
Dec. 11	Kalaupapa, Hawaii, U.S.	Cessna 208B	substantial	1 fatal, 3 serious, 5 minor
The engine lost power shortly after the Caravan took off for an air taxi flight. One passenger was killed, and the pilot and two passengers were seriously injured during the subsequent ditching. The survivors donned life vests and were rescued 80 minutes later. The Caravan floated for about 25 minutes before sinking.				
Dec. 11	Eau Claire, Wisconsin, U.S.	Beech King Air E90	minor	1 none
The King Air was on a positioning flight at 19,000 ft when the inner ply of the right windshield cracked. Windshield heat was not being used at the time. The pilot diverted to Eau Claire for a precautionary landing.				
Dec. 14	Vargas Island, British Columbia, Canada	Cessna 421B	destroyed	2 fatal
The 421 struck terrain under unknown circumstances during approach to Tofino Airport on Vancouver Island.				
Dec. 17	Atlanta, Georgia, U.S.	Raytheon Premier I	destroyed	2 fatal
Shortly after departing from Fulton County Airport in VMC, the pilot radioed that he had a problem and was returning to the airport. The airplane struck trees and terrain while turning onto final approach to Runway 26.				
Dec. 19	Viña del Mar, Chile	Beech King Air 90	substantial	2 none
Shortly after taking off for a night positioning flight, the flight crew encountered a technical problem and turned back to the airport. The King Air touched down short of the runway and slid to a stop against a fence.				
Dec. 26	Irkutsk, Russia	Antonov 12	substantial	9 fatal
Night IMC prevailed with 1,700 ft (about 500 m) visibility in smoke and mist, and a 200-ft overcast, when the cargo airplane crashed into a military storage facility during approach.				

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.

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International SOS

WorleyParsons resources & energy

OZ MINERALS

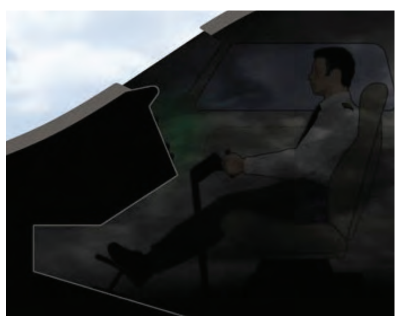
GOLD FIELDS

PATRONS

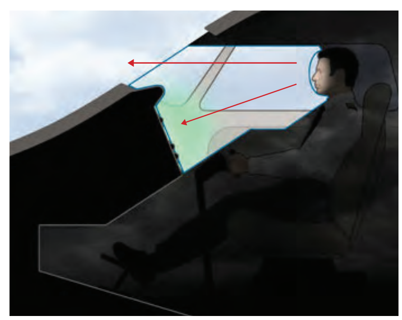
WFP World Food Programme

Gulfstream A GENERAL DYNAMICS COMPANY

Normal cockpit view



Smoke-filled view without EVAS™



Smoke-filled view with EVAS™