AeroSafety WORLD

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ICAO auditors find faults

IMPROVE BRAKING REPORTS
Using what's known

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TECHNICALLY SIMPLE
MAINTENANCE ENGLISH MADE EASIER

THE JOURNAL OF FLIGHT SAFETY FOUNDATION

AUGUST 2007

THE Bell Tolls

"Any man's death diminishes me, because I am involved in mankind; and therefore never send to know for whom the bell tolls; it tolls for thee."
— John Donne, 1624

Forgive me for resurrecting a famous old quote, but it kept coming to mind last month as I flew back from a difficult trip to Indonesia. Anybody following the aviation industry has been hearing the bells toll for Indonesia, where there have been three major crashes in just the first half of 2007. Its 10-year accident rate is 3.1 per million departures, at least triple the global accident rate.

Safety there has not been good for some time, and it's not getting better. The most recent crash compelled the U.S. Federal Aviation Administration to review Indonesia's status under its International Aviation Safety Assessments Program. The agency found that Indonesia fell short of International Civil Aviation Organization standards and downgraded the nation to Category 2. The E.U. followed, blacklisting all Indonesian airlines.

Just seven years ago, Indonesia had five airlines that carried approximately 10 million passengers in that year. In 2006, 25 airlines carried 30 million passengers, a 200 percent increase in passenger traffic in six years. The Indonesian government expects passenger traffic to reach 70 million by 2010. That rate of growth is almost unmanageable but it is low compared with other countries in the region.

It gets worse. The airlines I spoke with in Indonesia have lost about 30 percent of their pilots to other regions of the world. The regulator has lost about 30 percent of its inspectors and has about half of the inspectors required for today's needs. The great aviation personnel shortage has hit Indonesia hard, and its body count proves it.

How does a young democracy with more than 230 million people cope? So far, not very well. Structural reforms to deal with this growth are overdue. Inspector pay is a fraction of what it needs to be to retain good people, and yet the growth continues. The country's highest-ranking officials know what to do, and they are committed to doing it. It will be painful, it will take time, and it may not happen soon enough to avoid further disasters, but it must succeed.

This is just an early battleground; the same dynamics linger below the surface throughout Asia, Eastern Europe and elsewhere. If those of us who have the answers ignore this problem, we are going to have front row seats when the balloon goes up.

Our industry must find a better way to manage itself. Investment bankers with wildly optimistic cash-flow models are going to keep buying airplanes and starting airlines. The aviation industry needs to reach out to these emerging carriers and help them to see a way to profitability that follows a path of safely managed growth. Governments that have waited decades for prosperity are not inclined to say "no" to growth. They need good advice and positive reinforcement. Clearly, I see a role for the Foundation. When I call for help, I hope some of you will answer.

William R. Voss
President and CEO
Flight Safety Foundation

AeroSafetyWORLD

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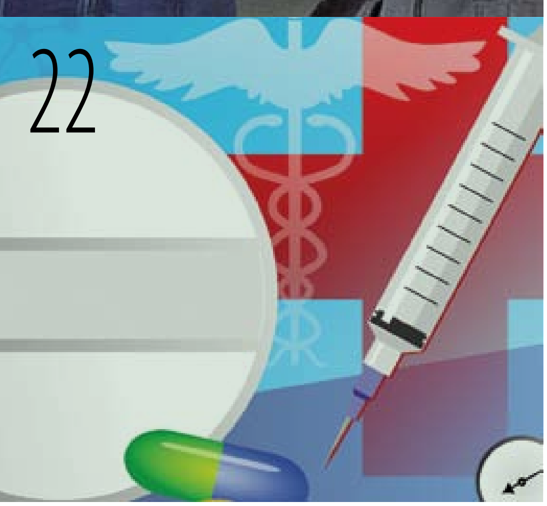

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There are guidelines for making English easier to understand in maintenance documents.
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If you have an article proposal, manuscript or technical paper that you believe would make a useful contribution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

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Serving Aviation Safety Interests for More Than 50 Years

Flight Safety Foundation is an international membership organization dedicated to the continuous improvement of aviation safety. Nonprofit and independent, the Foundation was launched officially in 1947 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce positive influence on aviation safety. Today, the Foundation provides leadership to more than 1,000 member organizations in 142 countries.

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GROWTH AND Consequences

The chief executive for United Breweries Limited, an Indian company, came to the 2004 Farnborough Air Show to explain why his company was buying A320s and starting Kingfisher Airlines. Among India's one billion-plus people, he said, is a middle class of more than 200 million able to afford air travel, or about the same number of middle class travelers that live in Europe. These people wanted to fly, he said, but they had few opportunities. The capacity just wasn't available.

That, to me, was a stunning bit of news. Only a few years earlier the Indian government had opened the door to new airlines; before that, the nation's incumbent airlines had a fleet of fewer than 200 jets. Here were 200 million people who had fought to get a better life only to discover that the travel available to others was not available to them.

This was and remains a politically untenable state of affairs. As the standard of living continues to rise around the world, more and more people have the time and the money to travel, and they demand that their leaders allow more air service, competitively priced. So quality airlines like Jet Airways and Air Asia spring up and packed airplanes quickly turn sleepy terminals into hot destinations, and there is no turning back. The increased travel spreads and energizes commerce, spurring even more travel and, sometimes, the birth of carriers of dubious quality.

Thus we arrive at a troubling crossroad, reached through the happy success of world development creating a rising demand that threatens to push the aviation industry into increasingly dangerous territory, the growth straining infrastructure and the abilities of regulators, as Bill Voss discusses in his President's Message (p. 1).

Restraining growth either by direct edict or indirectly, by refusing to expand airports and related infrastructure, is not only politically unpopular, it works against that economic growth and prosperity thing that everyone believes is so good.

Manufacturers' market forecasts agree that huge growth in air travel will continue. Even if a state here and there throttles its own traffic, they eventually will be swept along with the tide by their neighbors' activity.

Thanks to the Global Aviation Safety Roadmap, the path to safe, responsible growth is clear. But that leaves one final piece that must be set into place to make it all work: money.

Nations struggling to provide their people with the bare necessities find it difficult to redirect scarce funds to aviation. However, a well-trained and well-paid inspector force is an essential part of any aviation safety system, especially when dealing with a lot of start-up airlines and flight personnel with minimal experience, as is often the case in developing countries. Wayne Rosenkrans describes in this issue inspector force problems uncovered by International Civil Aviation Organization audits (p. 30). We must restate the importance of funding an empowered, trained and sustainable inspector force in a way that does not involve payment directly from the operator.

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

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Sharing Global Safety Knowledge

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Joint meeting of the FSF 60th annual International Air Safety Seminar **IASS**, IFA 37th International Conference, and IATA

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March 10–12, 2008

Flight Safety Foundation and European Regions Airline Association 20th annual European Aviation Safety Seminar **EASS**

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April 29–May 1, 2008

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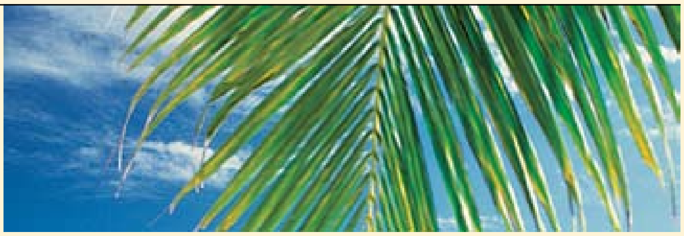

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AUG. 6–9 ➤ 53rd Annual Air Safety and Security Week and the Air Safety and Security Forum. Air Line Pilots Association, International. Washington, D.C. <https://crewroom.alpa.org/safety/Default.aspx?tabid=2427>, +1 703.689.2270.

AUG. 6–9 ➤ Unmanned Systems North America. Association for Unmanned Vehicle Systems International. Washington. <info@auvsi.org>, <www.auvsi.org/symposium>, +1 703.845.9671.

AUG. 9–11 ➤ Latin American Business Aviation Conference and Exhibition (LABACE2007). National Business Aviation Association and the Associação Brasileira de Aviação Geral. São Paulo, Brazil. Dan Hubbard, <dhubbard@nbaa.org>, <www.labace.aero>, +1 202.783.9360.

AUG. 27–30 ➤ ATA Non-Destructive Testing Forum. Air Transport Association of America. Orlando, Florida, U.S. <ata@airlines.org>, <www.airlines.org/operationsandsafety/events/2007+NDT+Forum+Web+site.html>, +1 202.626.4000.

AUG. 27–30 ➤ ISASI 2007, 38th International Seminar. International Society of Air Safety Investigators. Singapore. Chan Wing Keong, <chan_wing_keong@isasi07.org>, <www.isasi07.org>, +65 6541 2800.

SEPT. 3–6 ➤ Asian Aerospace 2007. Reed Exhibitions. Hong Kong. <www.asianaerospace.com/index.html>, +852 2824 0330.

SEPT. 5–6 ➤ 19th FAA/ATA International Symposium on Human Factors in Maintenance and Ramp Safety. U.S. Federal Aviation Administration and Air Transport Association of America. Orlando, Florida, U.S. <ata@airlines.org>, <www.airlines.org/operationsandsafety/events/2007+HF+Symposium+Web+site.htm>, +1 202.626.4000.

SEPT. 10–13 ➤ Bird Strike 2007 Conference. Bird Strike Committee Canada and Bird Strike Committee USA. Kingston, Ontario, Canada. Carol Liber, <events@theplanner.net>, <www.birdstrikecanada.com/2007conf.htm>, +1 604.276.7471.

SEPT. 11–15 ➤ 17th ACI Africa Annual Assembly, Regional Conference and Exhibition. Airports Council International. Arusha, Tanzania. <events@aci-africa.aero>, <www.aci-africa.aero/en/index.php?idp=4&>.

SEPT. 11–12 ➤ Crisis Management for the Aviation Industry. Quaynote Communications. London. <info@quaynote.com>, <http://www.quaynote.com/ankiti/www/?code=uk13&f=home>, +44 (0)207 074 0241.

SEPT. 12–13 ➤ CFIT/Approach and Landing Action Group ALAR Workshop. Flight Safety Foundation and Flight Safety Foundation International. Baku, Azerbaijan. Farkhan Guliyev (Baku), <farkhan.guliyev@azans.az>, +99 450 333 20 30; Rafail Aptukov (Moscow), <fsfi@fsfi.civilavia.ru>, +7 495 155 6869; Jim Burin (United States), <burin@flightsafety.org>, +1 703.739.6700, ext. 106.

SEPT. 13 ➤ De/Anti-Icing Seminar. National Air Transportation Association. Denver. <www.nata.aero/events/event_detail.jsp?EVENT_ID=1021>.

SEPT. 16–20 ➤ 55th International Congress of Aviation and Space Medicine. International Academy of Aviation and Space Medicine. Vienna, Austria. <icasm2007@imperial-tours.com>, <www.icasm2007.org>, +43 1 535 69 70.

SEPT. 17–19 ➤ Air Medical Transport Conference. Association of Air Medical Services. Tampa, Florida, U.S. Natasha Ross, <nross@aams.org>, <www.aams.org/Content/NavigationMenu/EducationMeetings/AMTC2007/default.html, +1 703.836.8732.

SEPT. 17–19 ➤ 8th Annual Aviation Industry Suppliers Conference. SpeedNews. Toulouse, France. <conferences@speednews.com>, <www.speednews.com/Conference/euroconference.html>, +1 310.203.9603.

SEPT. 17–19 ➤ World Low Cost Airlines Congress. Terrapinn. London. Caroline Thoresen, <Caroline.Thoresen@terrapinn.com>, <www.terrapinn.com/2007/wlca/Custom_16556.stm>, +44 (0)207 092 1230.

SEPT. 19–21 ➤ Russian International Business Aviation Exhibition. JetExpo. Moscow. <info@jetexpo.ru>, <www.jetexpo.ru>, +7 495 739 55 22.

SEPT. 19–22 ➤ 12th Aviation Expo/China 2007. General Administration of Civil Aviation of China. Beijing. <www.cpexhibition.com/aviation/aviation.html>.

SEPT. 25–27 ➤ NBAA2007: Helping Businesses Take Flight. National Business Aviation Association. Atlanta. Donna Raphael, <draphael@nbaa.org>, <web.nbaa.org/public/cs/amc/2007>, +1 202.478.7760.

SEPT. 26–27 ➤ 7th Annual CIS, Central and Eastern European Airline Engineering and Maintenance Conference. Aviation Industry Group. Prague, Czech Republic. Ruth Martin, <ruthm@aviation-industry.com>, <www.aviationindustrygroup.com/index.cfm?pg=247&archive=false&offset=1>, +44 (0)207 931 7072.

OCT. 1–2 ➤ UKFSC Annual Seminar: Technical Innovation and Human Error Reduction. U.K. Flight Safety Committee. Heathrow. <admin@ukfsc.co.uk>, <www.ukfsc.co.uk/annual%20seminar.htm>, +44 (0)1276 855193.

OCT. 1–4 ➤ 60th Annual International Air Safety Seminar. Flight Safety Foundation, International Federation of Airworthiness, and International Air Transport Association. Seoul, Korea. Namratha Apparao, <apparao@flightsafety.org>, <www.flightsafety.org/seminars.html#iass>, +1 703.739.6700, ext. 101.

OCT. 2–4 ➤ Helitech 2007. Reed Exhibitions. Duxford/Cambridge, U.K. Sue Bradshaw, <sue@helitech.co.uk>, <www.helitech.co.uk>, +44 (0)20 8439 8894.

OCT. 10–13 ➤ CAMA Annual Scientific Meeting. Civil Aviation Medical Association. San Diego. James L. Harris, <Jimlharris@aol.com>, <www.civilavmed.com/Meeting_Events.htm>, +1 405.840.0199.

OCT. 15–19 ➤ Accident Investigation Orientation for Aviation Professionals. U.S. National Transportation Safety Board. Ashburn, Virginia. <TrainingCenter@ntsb.gov>, <www.ntsb.gov/Academy/CourseInfo/AS301_2007.htm>, +1 571.223.3900.

OCT. 15–16 ➤ European Aviation Training Symposium. Halldale Media Group. Berlin. Chris Lehman <chris@halldale.com>, <www.halldale.com/eats>, +44 (0)1252 532000.

OCT. 17–19 ➤ Wildlife Hazard Management Workshop. Embry-Riddle Aeronautical University, Center for Professional Education. Seattle-Tacoma International Airport, Seattle. Billy Floreal, <florealb@erau.edu>, <www.erau.edu/ec/soctapd/seminar_progs.html>, +1 386.947.5227.

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

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

Safety News

Hurry-Up Call for Europe's Single Sky

A European Commission task force is calling for acceleration of the Single European Sky (SES) initiative as one means of improving safety regulation across the region.

The High Level Group for the Future of European Aviation Regulations included the accelerated delivery of SES as one of its 10 recommendations for enhancing aviation safety and efficiency throughout Europe.

The High Level Group has endorsed the European Commission's target date of 2020 for completing the SES initiative, as well as other major changes in the aviation system. However, the Group said in its final report that it has identified 2014 as the year by which its proposals must be implemented to ensure that aviation in Europe remains "safe, competitive and environmentally responsible."

The final report said that fragmented regulation is "a major bottleneck in improving the performance of the European aviation system" and that the problem cannot be dealt with one country at a time.

"This can only be addressed at the European level," the report said. "Strengthen the role of the European Community and the Community method as the sole vehicle to set the regulation agenda for European aviation by eliminating overlaps between EU [the European Union] and other regulatory processes, ensuring independent structures for regulation and service provision, and ensuring that safety regulatory activities are conducted independently from other forms of regulation."

The report said that EU member states should be required to systematically implement existing commitments, especially a commitment to end fragmentation of the aviation system — a subject addressed in the SES initiative.

"States should address inconsistent guidelines for [air navigation service providers], performance shortfalls in oversight, bottlenecks in airport capacity and safety management, and the new challenges of mitigating and adapting to climate change," the report said.

The European states also should "deliver continuously improving safety," the report said. "Require states to apply safety management principles consistently and, in particular, facilitate the uniform application of 'just culture' principles. … Ensure that states' safety oversight is harmonized and that cooperation between national authorities is stimulated to achieve overall higher levels of performance."

The report said that the European Aviation Safety Agency (EASA) should become "the single EU instrument for aviation safety regulation" and that Eurocontrol should play a key role in delivering SES and a related air traffic management initiative.

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TCAS Requirements

Operators of large commercial aircraft in Canada have been given two years to comply with a new requirement to install airborne collision avoidance systems.

Laurence Cannon, minister of transport, infrastructure and communities, said that the action is intended as a safety backup to previously existing ground-based air traffic control systems. The new requirement is described in an amendment to the Canadian Aviation Regulations that took effect July 1.

The amendment calls for operators to install one of two types of traffic-alert and collision avoidance systems (TCAS), which indicate when another aircraft presents the risk of a midair collision.

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Night Vision

The Civil Aviation Safety Authority of Australia (CASA) is proposing to establish standards for the use of night vision goggles (NVGs) by helicopter pilots in some types of flight operations.

Under the proposal, at least initially, NVGs would be limited to operations involving search and rescue, law enforcement, aerial fire fighting and support, emergency medical services, marine pilot transfer, and training providers who plan to conduct NVG training.

A final rule will be adopted after a review of public comments on the proposal, which were due in July.

NTSB Urges Greater Access to Legal Records

Aviation medical examiners should have greater access to legal records involving drunken driving arrests of individuals applying for medical certificates, the U.S. National Transportation Safety Board (NTSB) says.

In three safety recommendations, the NTSB noted that the U.S. Federal Aviation Administration (FAA) already requires applicants for medical certification to report convictions for driving while intoxicated, impaired or under the influence of alcohol or drugs. Applicants also must report administrative actions that result in a loss of driving privileges or attendance at a required educational or rehabilitation program.

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The NTSB said that the FAA also should take steps to ensure that applicants be required to provide complete copies of their arrest records and/or court records before their next aeromedical examination. The NTSB also recommended that the complete medical records, including the arrest and/or court records, be made available to any physician who performs an aeromedical examination on these applicants and that all pilots who are diagnosed with dependence on alcohol or drugs be required to undergo special follow-up examinations as long as they hold their medical certificates.

The NTSB said the recommendations resulted from investigations of a number of aircraft accidents — all associated with a pilot's substance dependence — in which the FAA should have been aware of the pilot's problem.

As an example, the NTSB cited a July 23, 2006, accident in which a Raytheon Bonanza crashed on landing at Bullhead City, Arizona, U.S., killing the pilot and one passenger and seriously injuring a second passenger. The NTSB said that the probable cause of the accident was the pilot's incorrect judgment of distance and speed, which resulted in a long landing, and his inadequate recovery from a bounced landing, "all due to the effects of impairment from alcohol consumption."

The NTSB said, "The pilot had previously reported a [driving under the influence] conviction to the FAA, but the FAA did not obtain records of that offense. The [NTSB] subsequently obtained the arrest records, which noted that the pilot had a blood alcohol level of 0.28 percent more than an hour after his traffic stop. The records also detailed that the pilot had been actively controlling his vehicle, was completely conscious and was conversing with the arresting officer. At a blood alcohol level of 0.28, non-tolerant individuals would be unconscious or nearly so."

The NTSB said that, because of his alcohol tolerance, the pilot would have met the FAA definition of substance abuse. If the FAA had considered his arrest records as part of the process of applying for medical certification, the pilot would not have been issued a medical certificate, the NTSB said.

SMS Expansion

Transport Canada (TC) has proposed including airports and air traffic services providers among those required to implement a safety management system (SMS). Airlines have been required to have SMSs since 2005.

The proposed regulatory amendments are intended to "increase accountability in the aviation sector," a TC statement said.

"Safety management systems are methods a company can use to integrate safety throughout its organization," TC said. "They are based on the operator's in-depth knowledge of its organization and integrate safety into policies, management and employee practices and procedures. As each organization integrates safety into daily operations, management and employees can continuously work to identify and overcome potential safety hazards."

The proposed amendments were published July 7; final action will be taken after a 30-day period for public comment.

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Confusing Paint Jobs

Inconsistency in aircraft paint schemes is causing confusion among pilots receiving local traffic information from air traffic control (ATC), Eurocontrol says.

"Where the aircraft in question's livery is not entirely consistent with a livery which would be expected for a particular aircraft operating agency, confusion and ambiguity can result," Eurocontrol said in a safety reminder message distributed to aviation safety personnel.

The inconsistencies are a result of paint schemes that may reflect an affiliation with an airline alliance rather than the identity of an individual airline.

"ATC must take particular care, when describing aircraft in local traffic information, particularly as regards the use of conditional clearances," Eurocontrol said. "Therefore, where it is deemed necessary, as a means of providing additional clarity, to refer [to] an aircraft's operating agency name or radiotelephony designator in either local traffic information or during coordination between control positions in the aerodrome control tower, ATC should ensure (preferably by visual observation) that the aircraft's livery is in fact consistent with the livery that would be expected for the aircraft in question."

© Star Alliance

In Other News …

The **Civil Aviation Safety Authority of Australia** (CASA) has adopted new principles intended to prevent unnecessary costs associated with new aviation safety regulations. CASA CEO Bruce Byron said that the principles specify that, among other things, any proposed aviation safety regulations "must not impose unnecessary costs or unnecessarily hinder high levels of participation in aviation and its capacity for growth." … Less than 10 percent of pilots in China meet international aviation English standards, according to news reports. The reports quote officials of the **General Administration of Civil Aviation of China** as complaining that too many pilots are delaying learning English, despite English proficiency standards from the International Civil Aviation Organization. … The **African Civil Aviation Agency** has designated Windhoek, Namibia, as the home of the new organization.


Civil Aviation Safety Authority of Australia

Byron

No Thanks

Australian pilots and air traffic controllers are engaging in what may be the "inappropriate" use of pleasantries — such as "thank you" and "g'day" — in radio communications, according to a study by the Australian Transport Safety Bureau (ATSB).

Researchers reviewed tapes of readbacks on the surface movement control (SMC) frequency at the Sydney airport to determine whether there was a relationship between verbose readbacks and frequency congestion, the report said. They found no such relationship.

Instead, they found that users of the frequency were "well-disciplined in reading back [air traffic control] instructions and clearances," the report said. The tapes also revealed "a frequent use of pleasantries such as 'good morning,' 'thank you' and 'g'day'.

"Although these phrases are not endorsed by the [Aeronautical Information Publication], their use appeared to have little adverse effect on frequency congestion. But in times of high traffic density, it seems inappropriate."

Compiled and edited by Linda Werfelman.

C-FOQA takes root

Foundation introduces a powerful corporate aviation safety tool.

BY MARK LACAGNINA

Following the completion of a successful demonstration project, Flight Safety Foundation has implemented a program to enable corporate aircraft operators to receive the safety and economic benefits of flight operational quality assurance (FOQA).

FOQA, also called flight data monitoring outside the United States, involves the collection and analysis of data recorded during flight operation to detect unsafe practices or conditions outside of desired operating procedures early enough to allow timely intervention to avoid accidents and incidents.[1] Among other benefits, FOQA also allows the identification of maintenance issues and the improvement of operational efficiencies.

British Airways and TAP Air Portugal pioneered flight data monitoring (FDM) in the early 1960s. The more descriptive term, FOQA, was coined by the Foundation in the early 1990s when it led efforts to encourage greater use of the program by airlines in the United States.[2] Today, more than 100 airlines worldwide have FDM/FOQA programs.

"There is no question that FOQA is one of the most powerful safety tools available to the airlines," said Bob Vandel, FSF executive vice president. "FOQA brings previously unknown problems to light before they can cause accidents or incidents, and it helps the air carriers to confirm and quantify problems that they had only suspected. Tremendous savings — in maintenance and fuel costs, for instance — also are achieved through the use of FOQA."

The FSF Corporate Advisory Committee (CAC) in 2002 began to study the feasibility of

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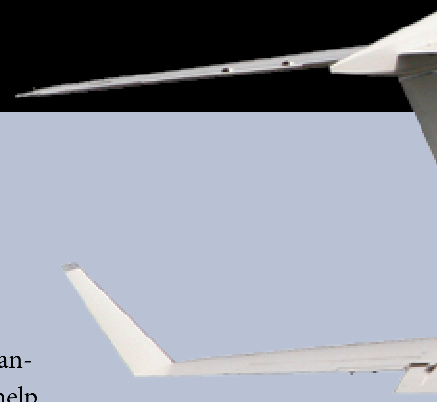

using this tool to help improve corporate aviation safety. With the help of the National Business Aviation Association (NBAA) Safety Committee, the CAC launched the corporate FOQA (C-FOQA) demonstration project three years ago. The results, announced at this year's Corporate Aviation Safety Seminar (CASS), were a resounding thumbs-up: C-FOQA works and shows great promise for making corporate aviation even safer.

Teething Pains

The demonstration project was challenging. Operators of 22 airplanes signed up to participate, but most decided not to proceed because of hardware and installation issues, unresolved questions about data protection and resistance by pilots (*ASW*, 8/06, p. 45). Not coincidentally, these are among the factors that have impeded even greater voluntary use of FOQA by airlines, especially in the United States.

The C-FOQA demonstration project ultimately was launched with the participation of the aviation departments at Altria Corporate Services and Merck & Co. "We were disappointed by the number of operators that dropped out," said Ted Mendenhall, CAC vice chairman and C-FOQA program coordinator. "But even with a small sample, our two operators saw some items of great interest to them, which indicates that they benefitted from the opportunity to look at that data."

Adapting a basically airline-oriented program for use in corporate aviation was difficult. "Certainly, we were new to the game," Mendenhall said. "We learned a lesson that we had been told by the airlines, that it takes longer than you expect to get things up and running. Just due to the multiple parties involved, the legal agreements that we had to work out — that took time. Finding the right people to talk to at the manufacturers took us a while. We are in a better position now because we have some good contacts at the manufacturers, which will help operators get QARs installed in their airplanes."

A QAR — quick access recorder — facilitates data collection and retrieval by tapping into the airplane's digital data stream and recording data similar to the parameters gathered by the digital flight data recorder (DFDR). Total cost for the equipment required to participate in the FSF C-FOQA program is about US$10,000 to $13,000. This includes a QAR with a one-gigabyte storage capacity; an installation kit consisting of a wiring harness and supplemental type certificate (STC); and software to convert the QAR data to a format suitable for downloading. Installation performed by an outside avionics shop costs about $2,000.

Both demonstration project participants found QAR installation and certification to be time-consuming. "Installation actually is very simple, requiring only about four man-hours per airplane, with half of that time dedicated to paperwork," said Jeff Sands, director of flight operations and financial and administrative services for Altria Corporate Services. Altria had two of its three airplanes, a Gulfstream GIV-SP and a G300, in the demonstration project.

Steve Thorpe, assistant chief pilot, airplanes, and C-FOQA program manager for Merck & Co., said, "Our maintenance folks had to work closely with the Duncan Aviation avionics installers to get the QAR installed and running properly." Merck operates a Dassault Falcon 50EX and 900EX, and three Sikorsky S-76 helicopters. The company equipped the 900EX, which has a DFDR, for the demonstration project. "It did take a while to get things running properly," Thorpe said. "Our QAR was the first, or at least one of the first, installed on a Dassault airframe."

Any airplane with a data bus that provides a recordable digital data stream theoretically can be

Data are downloaded from a quick access recorder by a direct or wireless PC connection, or by removing a storage device.

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equipped for C-FOQA, but unless the airplane already has a DFDR installed, the process might be cost- and time-prohibitive. U.S.-registered multiengine turbine airplanes with 10 or more passenger seats built since 1991 are required to have DFDRs.

"It would have been preferable to have both of our airplanes in the program, but it looked like it would have involved a lot of downtime for the Falcon 50EX, which does not have a DFDR, and significant cost just to put a QAR in," Thorpe said. "We decided to put a QAR in the airplane that was equipped for it and to see how it goes."

Mike DelMastro, director of flight operations for Merck, said, "We plan to have any subsequent aircraft we purchase equipped to participate in the FSF C-FOQA program."

Ones and Zeros

Collecting flight data is one thing; making sense of the data is quite another. "All you get from a QAR is a bunch of ones and zeros," Mendenhall said. "To make sense of this data, you need what is called a data map."

Simply stated, a data map shows what parameters are recorded on each channel of the DFDR, the sequence in which they are recorded and the frequency at which each parameter is recorded. Depending on when they were manufactured, DFDRs record either 57 or 88 parameters, including time, airspeed, altitude, heading, vertical and longitudinal acceleration, roll and pitch attitude, engine power, rate of climb/descent, and flight control position. Many other variables can be derived through analysis of these parameters.

The data map for each DFDR installation is developed by the airplane manufacturer and is essential for FOQA data processing. Some corporate airplane manufacturers consider their data maps as proprietary information and initially were reluctant to provide them to the Foundation. "They thought it was a secret we could not have," Mendenhall said. "For the airplanes used in the demonstration project, Austin Digital, the data-processor that we chose for the project, had to sign releases [nondisclosure agreements] for the manufacturers saying that it would not do anything with the data maps other than the intended purpose of processing the data for C-FOQA." Austin Digital is among several data-processing vendors that will be available to participants in the FSF C-FOQA program. Aerobytes, Flight Data Services and Sagem are among other data processors with FOQA capability.

The operator periodically downloads data from the QAR by removing a storage device or by using a cable or wireless connection to a personal computer. Software provided by the data-processing vendor for the operator's personal computer compresses and encrypts the downloaded data and manages the transmission of the data to the vendor's secure server. Mendenhall says that transmission time depends on the operator's Internet connection; typically, transmission of four months worth of data takes about 20 minutes.

Spotting Variations

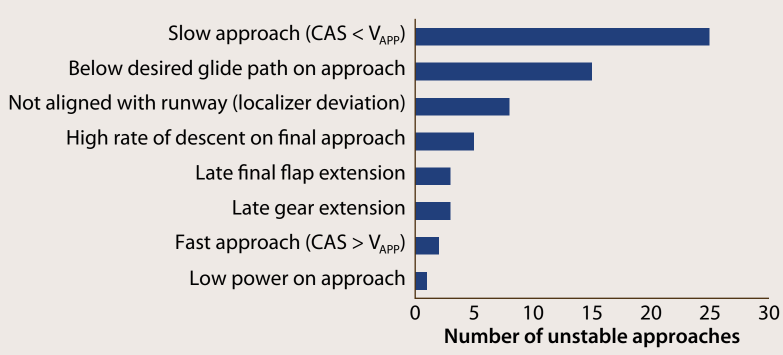
Data analysis is highly automated. Basically, the data-processing vendor's software is programmed to detect variations from normal parameters established by regulation, the airplane flight manual or industry best practices. In reference to the latter, Mendenhall said that among industry best practices of primary concern during the demonstration project was approach stabilization.

Figure 1 and Figure 2 (p. 14) are hypothetical examples of what an operator might find in a quarterly report provided by a data-processing vendor. The examples were among several in a presentation on C-FOQA by Sands at this year's CASS. Figure 1 shows hypothetical deviations from stabilized approach criteria. Figure 2 shows a hypothetical breakdown of deviations from the target approach speed.

What can be gleaned from C-FOQA data analysis is limited only by the user's imagination. Data-processing vendors can, for example, provide computer animations of an event to help the operator understand what happened (photo, p. 15).

The results of the automated analyses of flight data must, however, be screened for "false positives." Sands provided an example. One of the quarterly reports he received during the demonstration project indicated that a flight crew might have climbed above their assigned altitude. This was detected from data showing that the indicated altitude overshot the selected altitude. Looking at other data recorded

Deviations From Stabilized Approach Criteria



CAS = calibrated airspeed V_{APP} = target approach speed

Figure 1

Distribution of Deviations From Target Approach Speed

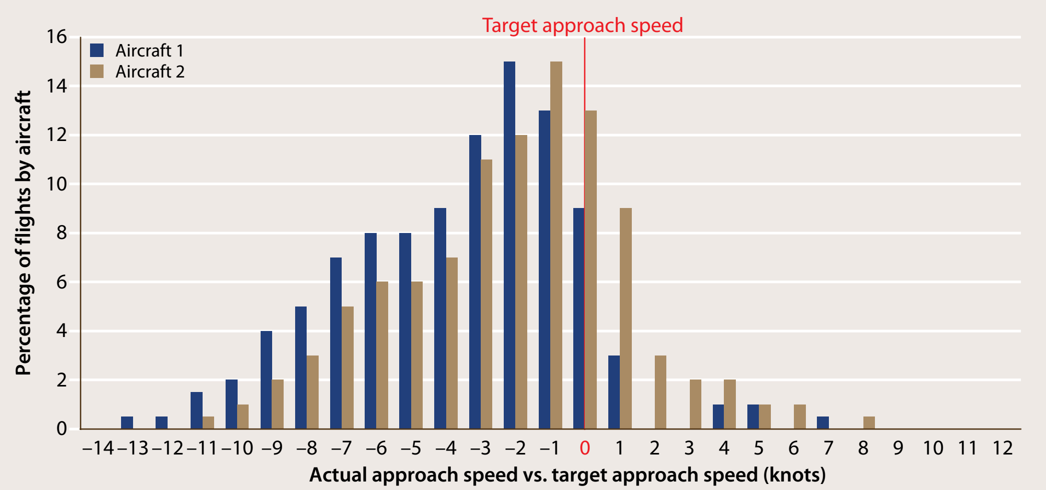


Figure 2

during the event, Sands found that the selected altitude was changed at or near the time of the reported altitude bust. "It was apparent that the airplane was proceeding as cleared to the assigned altitude when the controller amended the crew's climb clearance to a lower altitude; because of the late altitude-clearance revision, what appeared to be an overshoot was, in fact, a non-event," he said.

Thorpe provided another example of a false positive. "We had a few departures flagged for having less than the proper flap setting for takeoff," he said. "It turned out that the departures were from Toluca, Mexico, where the field elevation [8,458 ft] makes that flap setting the normal procedure for takeoffs."

False positives also can be triggered by faulty sensors and other hardware problems in the airplane. During the demonstration project, Mendenhall screened all reports for false positives before they were sent to Altria or Merck. "We will continue to have a review process," he said. "But, quite honestly, the review team could miss something that will be picked up by the operator, who might have a better understanding of the event."

Thus, screening for false positives is also one of the duties of the operator's *gatekeeper*. The gatekeeper, typically a pilot with operational experience in the airplane(s), has overall responsibility for the aviation department's C-FOQA program. Because the gatekeeper has access to non-deidentified data for a specific period — to enable him or her to talk to the flight crew, if necessary, to gain a better understanding of an event — he must be trusted by his colleagues.

Shutting Out Big Brother

Pilot support is essential for the success of any safety-improvement effort. As administrator of the C-FOQA program, the Foundation secures legal agreements that specify the data-processing vendor's responsibilities and prohibit the operator from using the data for punitive purposes.

A former chairman of the NBAA Safety Committee, Sands is a longtime advocate of FOQA and began discussing the program with his pilots years before the C-FOQA demonstration project was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launched. "We were fortunate to have one pilot on staff who previously had flown for an airline with a FOQA program," he said. "She was very helpful in describing the safety benefits that such a program offers and its nonpunitive nature."

Said Thorpe, "I am sure there were concerns among our pilots at first. I tried to be very open about the process; it was so important to convince them that the program is a very important safety tool and not a 'big brother' enforcement tool or a means to gather information to send to the FAA [U.S. Federal Aviation Administration]."

Sands and Thorpe said that participation in the demonstration project resulted in substantial safety benefits. For example, Sands noted that some deviations from stabilized approach criteria showed up in the first quarterly report. Following a discussion of the findings with his pilots and minor refinement of the aviation department's training program to emphasize certain points, later reports showed that deviations from stabilized approach criteria had dropped to zero. "That, alone, was a significant safety improvement," he said.

The More, the Merrier

Compared with the airlines, corporate aviation departments have relatively few airplanes and more widely mixed fleets; thus, the opportunity to identify trends is limited. The solution is for the Foundation to aggregate the data collected under the C-FOQA program.

"With only two operators and two types of airplanes, we could not aggregate data," Mendenhall said. "But that is what we want to do as we go forward. We generated quite a bit of interest in C-FOQA at the CASS, and several operators have expressed serious interest in the program. A number of them have given us verbal commitments to the program and are now trying to acquire QARs."

Vandel said that as the program matures, the Foundation also will examine aggregate data to identify trends affecting specific aircraft types, airports, air traffic control procedures, phases of operation — approach and landing, for example — and events such as unstabilized approaches. Information on identified trends will be issued as advisories or alerts to the industry. ●

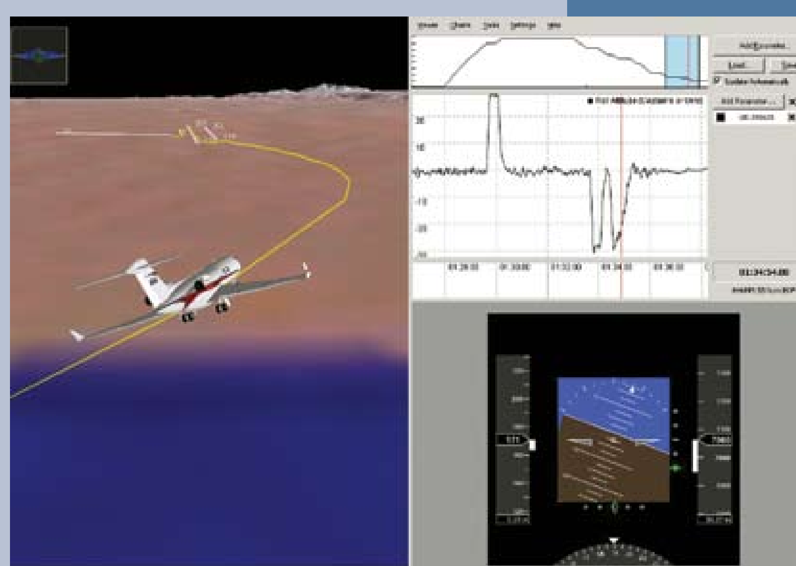
For more information about the FSF C-FOQA program, contact Bob Vandel at +1 703.739.6700, ext. 110, <vandel@flightsafety.org>, or Ted Mendenhall at +1 936.449.5875, <mendenhe@consolidated.net>.

Notes

1. FSF Editorial Staff. "Aviation Safety: U.S. Efforts to Implement Flight Operational Quality Assurance Programs." *Flight Safety Digest* Volume 17 (July–September 1998).

2. FSF Editorial Staff. "Wealth of Guidance and Experience Encourage Wider Adoption of FOQA." *Flight Safety Digest* Volume 23 (June–July 2004).

FOQA data can be used to create a computer animation that helps the operator understand how an event occurred.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Word lists and writing rules take the confusion out of aviation maintenance documents.

Simplifying the

Technicalities

BY LINDA WERFELMAN

English is the international language of aviation — and therefore the language most frequently used in technical and maintenance documents — but often it is not the native language of the maintenance personnel who use these documents.

As a result, complex technical instructions can be misunderstood, especially by those without strong English language skills — and occasionally by native-English speakers — and the misunderstandings can lead to accidents.

The International Civil Aviation Organization (ICAO) said in a 1996 article in the *ICAO Journal* that language errors had become more prevalent, partly because air carrier airplanes were being manufactured in many different countries, where many different languages are spoken.

"Sometimes, the technical language of the manufacturer does not translate easily into the technical language of the customer, and the result can be maintenance documentation that is difficult to understand," ICAO said.[1]

"Anecdotal evidence suggests a case where a certain maintenance procedure was 'proscribed' (i.e., prohibited) in a service bulletin. The technician reading this concluded that the procedure was 'prescribed' (i.e., defined, laid down) and proceeded to perform the forbidden action."

The International Federation of Airworthiness (IFA) cited another example involving a Japanese operator's airplane, in service for five days without batteries for the emergency exit door operation auxiliary system.[2]

"During maintenance, the battery cases were replaced," the IFA report said. "Seven of the eight [replacement] cases did not contain batteries. Another mechanic who should have checked the existence of the batteries had reportedly misread the English manual."

These and other examples illustrate how difficult a language English can be, said the Aerospace and Defence Industries Association of Europe (ASD), which has developed rules for the use of English in aviation maintenance documents.

"Many readers [of technical maintenance documents] have a knowledge of English that is limited, and are easily confused by complex sentence structures and by the number of meanings and synonyms which English words can have," the ASD said.

Pattern of Errors

A study conducted for the U.S. Federal Aviation Administration (FAA) on language errors within the worldwide maintenance repair and overhaul (MRO) market found that the most common errors involve both written English and spoken English.[3] The study identified the most frequent language-related errors as involving one of the following three scenarios, in which a maintenance employee:[3]

- Was unable to communicate verbally at the level required for adequate performance;
- Did not realize that a person he or she was speaking with had limited English ability; or,
- Did not fully understand written documentation in English, such as a maintenance manual or a work card.

"Language errors of many types are possible, although only a few are frequent, with a language-error-prone activity having consistent characteristics: complex task instructions; poorly designed document, in English; users with low ability in English and low familiarity with the task to be performed; and time pressure to complete the task," said one of several reports on the study, which included surveys of 941 maintenance personnel in Asia, Europe, Latin America and the United States, along with task-card comprehension tests and group discussions of scenarios involving language errors.

"When listed in this way, language errors appear to have all of the usual human factors ingredients for error, not just language error. … The implication is that if the 'usual' error-shaping factors are present, then the 'usual' interventions should be effective (e.g., training, documentation design [and] organization design.)"

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The study identified a similar pattern in the most frequently cited factors that could prevent language errors:

- "The mechanic or inspector is familiar with this particular job;
- "The document follows good design practice;
- "The document is translated into the native language of the mechanic or inspector;
- "The document uses terminology consistent with other documents; [and,]
- "The mechanic or inspector uses the aircraft as a communication device, for example, to show the area to be inspected."

Although the study found language errors to be a "potential problem," it also identified two frequent factors in the discovery of an error: the mechanic or inspector either "asked for assistance or clarification" or "appeared perplexed." Both factors rely on "feedback from the message recipient to the message sender," the report said, and both typically occur early in the maintenance process.

"Detection of language errors is typically reported well before any maintenance/inspection errors have been committed, or [before] the aircraft is released for service," the report said.

The study found that younger maintenance personnel and those with better reading skills experienced fewer language errors.

"Increasing mastery of English will have a significant impact on comprehension and is a vindication of the English language training programs invested in by many of the MROs we visited," the report said.

'Strong Case' for Simplification

ICAO said in its 1996 article that the preponderance of maintenance information published in English made a strong case for the use of simplified technical English, a "controlled language" — that is, a language specifically adapted to eliminate ambiguity and complexity by using only selected words and applying grammar rules in very specific ways.

Others in the aviation industry have shared that belief. Efforts to address maintenance problems associated with misunderstandings of written English began on a large scale in the late 1970s, when the Association of European Airlines asked the European Association of Aerospace Industries (AECMA) — as the ASD was then known — to develop its first version of simplified technical English suitable for use in aviation maintenance documentation. AECMA's first product, *AECMA Simplified English*, has been revised several times; the current document is *ASD Simplified Technical English, Specification ASD-STE100*, which combines writing rules and a dictionary of "controlled vocabulary" (see "Writing to Rule").[4]

"Clear and unambiguous maintenance instructions are the scope of the specification," said Orlando Chiarello, chairman of the ASD STE Maintenance Group and product support manager for Secondo Mona, an Italian manufacturer of aircraft fuel systems and other components. "Although sometimes difficult for the writer, the unique scope of ASD-STE100 is to give to whoever does maintenance in whichever part of the world a text which must be technically correct and simple to understand. The user does not have to learn ASD-STE100; she/he has simply to read an English text that is clear and easy."

Since 1987, the use of ASD-STE100 has been a requirement of international standards for aircraft maintenance documents.

With its beginnings in Europe and North America — home to most manufacturers of aircraft, aircraft engines and other components — simplified technical English has remained more prevalent on those continents than elsewhere in the world, Chiarello said. Nevertheless, manufacturers in Africa, Asia, Australia and South America also use ASD-STE100, he said. In addition, in Russia, one manufacturer has requested permission to adapt ASD-STE100 to the Russian language with the development of Simplified Russian. Originally developed for civilian aviation, ASD-STE100 has been incorporated into standards for production of military aircraft.

"Theoretically, all manufacturers who write maintenance procedures in accordance with [the international standards] should mandatorily use ASD-STE100," Chiarello said. "How correctly it is used is difficult to say, and there are many factors that may have influence on the correct usage."

Although ASD-STE100 results in the use of simplified English for the readers of maintenance documents, it is "not a simplified version of English for the writers," he said, noting that those who use the specification to prepare aviation maintenance documents in technical English must have a good command of written English and thorough training in the use of ASD-STE100.

The ASD-STE100 dictionary contains about 1,000 "general vocabulary" words, although writers using the specification may add the technical names and technical verbs required to describe various maintenance procedures, said Richard Wojcik, associate technical fellow for Boeing Phantom Works, a research and development unit at Boeing. There are, however, 20 categories that must be applied to determine whether a word qualifies as a technical name and 11 categories of technical verbs, Wojcik said.

Writing to Rule

Simplified technical English in general — and Specification ASD-STE100, developed by the Aerospace and Defence Industries Association of Europe, in particular — is intended specifically for people who use English language technical documents in the aerospace industry.[1,2]

The primary components of simplified technical English are a set of writing rules for style and grammar, and a dictionary containing about 1,000 approved words. Also included are a thesaurus and guidelines for adding words to the approved technical vocabulary.

Among the rules:

- Write in the active voice (i.e., "The pilot flew the airplane," rather than "The airplane was flown by the pilot");
- Avoid long compound words and long sentences; and,
- Be consistent in your choice of words.

— LW

Notes

1. Aerospace and Defence Industries Association of Europe (ASD). *Simplified Technical English*. <www.simplifiedenglish-aecma.org/Simplified_English.htm>.
2. Boeing. *Simplified English Checker.* <www.boeing.com/phantom/sechecker/se.html>.

When the technical names and technical verbs are included, "you have potentially thousands and thousands of words," he said, adding that, to some extent, "it's up to the judgment of the writing establishments within the companies which words they're going to allow for their companies as technical names."

The ASD says that the specification emphasizes the principle of "one word — one meaning." Therefore, in situations in which several English words mean approximately the same thing, the dictionary includes only one and excludes the synonyms.

"For example, 'start' was chosen instead of 'begin,' 'commence,' 'initiate' or 'originate,'" the ASD says. "When there are several possible definitions of a word in English, the specification selects one of these definitions to the exclusion of the others. For example, 'to fall' has the definition of 'to move down by the force of gravity,' not 'decrease' (Table 1)."

Wojcik cited another example: the word "interference," which according to the rules may not be used "when it means things knocking together" but is permitted in describing electrical interference, which is "not an event but rather an environmental condition."

"Many of the rules in simplified technical English are designed just to clarify — they're the same rules that any good technical writer would apply," Wojcik said. "In general, it's a clarifying standard. ... It just forces people to take out the double-talk, the unnecessary wording, the circumlocution, all the things that people will put into a document because they want to sound educated or because they just aren't thinking very carefully about how the reader is going to understand what they're saying."

Several companies produce the software typically used to implement ASD-STE100, including Boeing, whose Simplified English Checker tells writers if they have used unapproved words or violated writing rules. The program does not automatically correct what it identifies as errors, however; instead, it provides writers with information and allows them to determine whether what they have written makes sense.[5]

Simplification

STE:	"Stop the power supply."
Non-STE:	"Turn off the power."
Explanation:	"'Turn' is approved when you use it to 'move something around its axis.' If you do not 'turn' something to stop the power supply … do not use the word 'turn.'"
STE:	"Continue the test."
Non-STE:	"The test can be continued by the operator."
Explanation:	"Use the active voice" — rather than the passive voice in choices of verbs and sentence structure.
STE:	"Set the rotary switch to INPUT."
Non-STE:	"Rotary switch to INPUT."
Explanation:	"Do not omit verbs [to make sentences shorter]. The reader will not know what the action is."
STE:	"When the landing gear retracts: (1) The door-operating bar on the leg touches and turns the latch. (2) This causes the roller to move out of the slot. (3) The second roller holds the door-operating bar."
Non-STE:	"During the final movement of the landing gear retraction, the door operating bar located on the leg contacts and turns the latch, withdrawing the roller from the slot and the second roller entraps the door operating bar."
Explanation:	"The tabular layout of text … with standard punctuation can help to show the relationship between two or more complex actions or events. This is clearer than writing long sentences."
STE:	"Make sure that the oxygen tubes are fully clean. This will help to prevent contamination and explosions."
Non-STE:	"Extreme cleanliness of oxygen tubes is imperative."
Explanation:	"Be specific in a warning or caution. You must tell the users exactly what they must do and what can happen, to get their attention immediately."

STE = standard technical English

Source: Aerospace and Defence Industries Association of Europe. ASD-STE100, *Simplified Technical English*. Issue 4. January 2007.

Table 1

Changing Practices

Philip Shawcross, vice president of the International Civil Aviation English Association, said that standardization of language used by maintenance personnel has become increasingly necessary because of the substantial changes in maintenance practices over the past 20 years, including:

- Expansion of the role of computers in the maintenance environment;
- Fewer translations of documents from English to a native language;
- Increased use of manufacturer-generated standardized training materials — written in English;
- More alliances among airlines, many of which are in countries that have no common language; and,
- An increasingly mobile, multicultural work force.[6]

"All these trends have something 'invisible' in common: a much increased reliance upon language and upon a single language — English," said Shawcross, who also is in charge of training curriculum design for Aviation English Services, which provides training and testing in aviation-specific English.

"The regulations set by civil aviation authorities represent only one of the pressures exerted on operators to ensure that their maintenance staff [attains] a given level of proficiency in English," Shawcross said. "Operational, technical, safety, financial and commercial pressures are probably more effective in the way they drive for efficient communication. … Translation is costly and slow. Computer-assisted translation for technical texts is still very far from being reliable. … Using the single universally recognized aviation language competently also makes good business sense."

Simplified technical English is not perfect, Shawcross said, noting that critics sometimes complain about its rules and/or choices of words.

However, it "does embody a considerable amount of common sense and good practice and has provided editors worldwide with a single framework within which to write," he added. "As a result, maintenance documents from all the main manufacturers are much more uniform and accessible than many were 20 years ago."

Nevertheless, authors of the FAA language-error study said they were surprised to find that simplified technical English "had no consistent effect" in limiting language errors among non-native speakers of English outside the United States. Earlier findings had shown that simplified technical English was effective for non-native English speakers in the United States.[7]

"Perhaps [simplified technical English] is less useful when applied in a setting where the native language is other than English," their report said. "Similarly, neither the interventions of a bilingual coach or a glossary produced any significant results, despite their widespread use as interventions at MRO sites."

The report added that translation of information from English into the native language was "the only consistent significant intervention" in preventing misunderstanding. Partial translation, with technical terms left in English, was as effective as full translation.

As a result of the study's findings, the report recommended training for maintenance personnel in written and spoken English and use of good design practices in work documents, as well as recognition of "the symptoms of imperfect communication" and the harmful effects of time pressures.

Proficiency Requirements

Although ICAO moved in 2004 to establish a baseline for English language proficiency for pilots and air traffic controllers, with proficiency testing set to begin in 2008, maintenance personnel were not included.

Elizabeth Mathews, a specialist in applied linguistics and leader of the international group that developed ICAO's English language proficiency standards, said that maintenance personnel require skills in reading, writing and speaking/listening to English. Detailed studies would be required before the appropriate proficiency levels for maintenance personnel could be determined, she said. ●

Notes

1. International Civil Aviation Organization (ICAO) Secretariat. "Awareness Grows of Importance of Human Factors Issues in Aircraft Maintenance and Inspection." *ICAO Journal*. January–February 1996.
2. International Federation of Airworthiness (IFA). "Human Factors: New Technology Adds a New Dimension to Documents." *IFA News*, 2006.
3. Drury, C.G.; Ma, J.; Marin, C. "Language Error in Aviation Maintenance: Findings and Recommendations." Included in *Aviation Maintenance Human Factors Program Review, Fiscal Year 2005*, July 2006. The study was conducted for the U.S. Federal Aviation Administration, which was especially interested in maintenance, repair and overhaul facilities that were engaged in contract maintenance for major airlines.
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5. Boeing. *Simplified English Checker*. <www.boeing.com/phantom/sechecker/se.html>.
6. Shawcross, Philip. "Reading and Writing English in Engineering and Maintenance." Presentation to the 20th conference of the International Airline Language and Communication Organisation. Feb. 3–4, 2005.
7. Drury; Ma; Marin.

Further Reading From FSF Publications

FSF Editorial Staff. "High Stakes in Language Proficiency." *Flight Safety Digest* Volume 25 (January–February 2006).

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Accepting a trip while ill would fly in the face of safety principles.

BY WAYNE ROSENKRANS

Cabin Fever

Concerns about flight attendants and pilots flying while ill deserve attention from aviation safety professionals and regulators, say recent reports to safety reporting systems from crewmembers in the United Kingdom and the United States. Concepts of illness tend to fall along separate lines for crewmembers, airline managers and aeromedical specialists, says Heidi Giles, vice president of global response services for MedAire, a company that provides services such as assistance during emergency in-flight medical events, airline crew support, airline passenger-assistance services, medical evacuations and airport medical fitness assessments.

Medical *fitness to fly* means whether people can be sustained as healthy, viable human beings in an aircraft at an 8,000-ft cabin pressure altitude. *Fitness to operate* as crewmembers means that they are deemed to be "physically capable, mentally alert and able to complete all the functions required primarily of their safety duties, and secondarily of all their service duties," Giles said. "On the airplane, there is no limited duty."

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Illness, like fatigue, is fraught with complexity for airlines and crewmembers because it involves self-assessment, social interactions, labor-management contracts and performance expectations. The airline industry recognizes that crewmembers make more errors when they are fatigued, but a direct correlation between illness and in-flight errors has not been researched as thoroughly. "When people call and say they are 'just fatigued,' our nurse case managers will ask a lot of questions to make sure that that is all it is," Giles said. "Most difficult is that when people are fatigued, they are very emotional and not necessarily able to express themselves the way they might were they well rested."

The U.S. Federal Aviation Administration (FAA) *Aeronautical Information Manual (AIM)* — available at <www.faa.gov/airports_airtraffic/air_traffic/publications/ATpubs/AIM> — is a pilot-oriented reference that some cabin safety specialists also consider informative for flight attendants. The *AIM* says, "Even a minor illness suffered in day-to-day living can seriously degrade performance of many piloting tasks vital to safe flight. Illness can produce fever and distracting symptoms that can impair judgment, memory, alertness and the ability to make calculations. Although symptoms from an illness may be under adequate control with a medication, the medication itself may decrease pilot performance. The safest rule is not to fly while suffering from any illness. If this rule is considered too stringent for a particular illness, the pilot should contact an aviation medical examiner for advice."

Common Illnesses

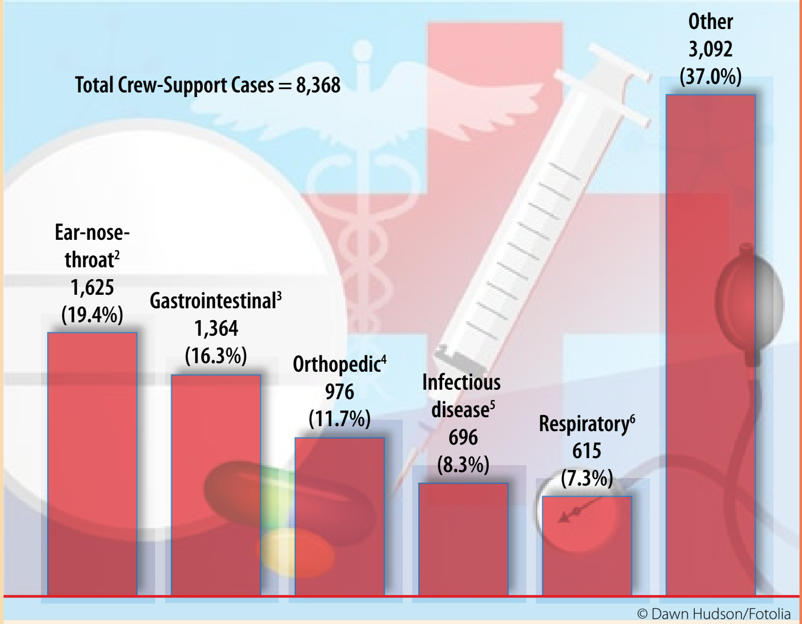
MedAire's MedLink in-flight medical advice — currently provided to 74 airlines worldwide — during the past decade has become known primarily for assisting passengers. The company in 2006 had 17,310 in-flight medical advice cases involving all types of aircraft occupants, but cases involving pilots and flight attendants have not been separated from those involving passengers. Based on 42 months of data from its crew-support program, which generated 15 cases a day among 10 airlines, MedAire has identified in its data the five most common illnesses affecting flight attendants and pilots on layovers (Figure 1), and extrapolated its rate to estimate that worldwide, "nearly 1,000 crewmembers are experiencing a health-related issue on duty every day."[1]

Among 5,600 crew-support cases handled in 2006, 747 (13.3 percent) were in the gastrointestinal illness category; 648 (11.6 percent) were ear-nose-throat, including barotrauma; 471 (8.4 percent) were orthopedic including muscle sprain/strain; 357 (6.4 percent) were dental care, including damaged tooth/filling and dental pain; and 281 (5.0 percent) were respiratory, including upper respiratory infections. Generally, the gastrointestinal calls were prompted by diarrhea and incessant vomiting. The ear-nose-throat calls sought to prevent extreme pain from blocked ears. The sprain/strain calls involved concern about ability to operate flight controls, to push a cart or operate a jump seat harness. The dental calls aimed to prevent extraordinary pain from an exposed nerve. And upper respiratory infection calls primarily involved infections that caused pain in the sinuses because of gas expansion and bubble formation.

Illnesses that are not on this list also can be serious. "A good example is any gynecological issue," Giles said. "Usually something can seem to be fairly minor to crewmembers during layover, but they will wait until it becomes bad enough before they call because of heavy bleeding, pain or fever. With minor nausea, they will still fly. But they cannot be actively vomiting and serving meals or flying an airplane. They also cannot get up out of the cockpit to go to the lavatory every two minutes."

Among the in-flight medical advice cases in 2006, 5,955 (34.4 percent) were in the neurological/neurosurgical illness category, including fainting; 3,289 (19.0 percent) were gastrointestinal; 1,800 (10.4 percent) were

Five Leading Categories of Airline Crewmember Illnesses/Injuries Affecting Flight Duty[1]



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Notes:

Crew-support cases from January 2003 through June 2006 were categorized.

1. Each case involved one or more calls in which MedAire-affiliated physicians and nurse case managers assisted pilots and flight attendants employed by 10 airlines, typically during a layover period.
2. The typical diagnosis was barotrauma such as ear block.
3. The typical diagnosis was gastroenteritis (inflammation of the stomach and/or intestines).
4. The typical diagnosis was musculoskeletal injury such as a muscle strain/sprain.
5. Diagnoses varied, including illnesses such as influenza.
6. The typical diagnosis was upper respiratory infection.

Source: MedAire

Figure 1

respiratory, including upper respiratory infections; 1,298 (7.5 percent) were cardiac; and 692 (4.0 percent) were orthopedic, including muscle sprain/strain.

Flight Level Illnesses

A U.K. pilot, describing in 2005 the circumstances of a missed approach and diversion, said, "I had been sick on the previous day, and I had advised operations that I would be unable to fly due to a heavy cold. Despite this, I was awakened by a telephone call from the operations officer who persuaded me to report for duty (in five hours time). … The sixth sector was back into the home base and the weather had deteriorated significantly. … By this time I was feeling very ill indeed."[2]

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In 2005, the U.S. captain of an Airbus A320 said, "Prior to departure, we were informed that we had an ill flight attendant on board, and incorrectly assumed that this flight attendant was a deadheading flight attendant. About one hour into the flight, the purser called up to inform us that the flight attendant was on oxygen and later reported that she spent a significant amount of time vomiting in the [lavatory]. I inquired, and was told that she had called crew scheduling the previous night and called in sick. Crew scheduling informed her that she would have to work the flight to Chicago O'Hare International Airport or it would have to be canceled, and she would be replaced at O'Hare. She was either ordered or coerced to work while ill."[3]

A U.S. A320 captain in 2006 said, "During the flight, it became readily apparent after we departed that the first officer was recovering from an illness. As he used the radio to communicate with air traffic control, he coughed uncontrollably. It was at this point that I realized that he should have taken some time off via the sick list to recover more fully. It was obvious by our discussion that he was intimidated by the flight office and the chief pilot via the absence-management program, which tracks and punishes pilots for [inappropriately] using sick leave. This policy placed me in an uncomfortable situation, as I do not have the expertise to diagnose a person's illness."[4]

Another U.S. captain in 2006 said, "When I attempted to brief the flight attendants, it was painfully obvious that [the purser, with laryngitis] had almost no voice at all. … She relayed to me that she really did not want to call in sick because of the sick leave policy. She stated that she did not really feel that bad, but she was also worried about her voice and ability to give commands during an evacuation if necessary. … The supervisor told her that she should just let someone else do the communications with the cockpit and public address system announcements."[5]

Precedents for Pilots

In the United States, airline pilots and flight attendants are safety-sensitive employees subject to FAA drug- and alcohol-testing requirements and flight time limitations. To operate, however, only the pilots must have a first-class or second-class medical certificate that must be renewed every six or 12 months for an airline transport pilot or commercial pilot, respectively, by an FAA-designated aviation medical examiner. The U.S. Federal Aviation Regulations (FARs) concerning medical certification also prohibit a pilot from operating with a known medical deficiency except as authorized by the FAA.[6]

Pilots readily can receive FAA advice on prescription and nonprescription medications. This guidance in part says, "For example, any airman who is undergoing continuous treatment with anticoagulants, antiviral agents, anxiolytics, barbiturates, chemotherapeutic agents, experimental hypoglycemic, investigational, mood-ameliorating, motion sickness, narcotic, sedating antihistaminic, sedative, steroid drugs, or tranquilizers must be deferred [medical] certification unless the treatment has previously been cleared by FAA medical authority. … During periods in which the foregoing medications are being used for treatment of acute illnesses, the airman is under obligation to refrain from exercising the privileges of his/her airman medical certificate unless cleared by the FAA."[7]

In a reminder about fitness to operate, the Air Line Pilots Association, International said in 2007: "Crewmembers will keep themselves physically and psychologically fit for duty. Flight crewmembers will not report for duty when ill, under serious mental stress or while having a known medical deficiency that would render them unable to meet the requirements for a current medical certificate."[8]

In some countries, fitness to operate for flight attendants is not so explicit, however. Since Dec. 10, 2004, U.S. flight attendants have been required to hold a flight attendant certificate of demonstrated proficiency, but this does not require medical certification.

Cabin Crew Perspectives

One U.S. cabin safety specialist, with 20 years of experience as a flight attendant, believes that industry perceptions of flight attendants have led some airlines to see this aspect of cabin safety as a malleable commodity. "Although we are required on board the aircraft for safety purposes, a manager asking 'How sick are you?' or saying 'If you report sick, we are going to have to cancel a flight, and all these people are going to be stranded' sometimes conveys to the flight attendants who report sick to 'take the trip, you are not operating the aircraft' or 'if push comes to shove, a passenger will open those doors if you cannot,'" said Candace Kolander, coordinator, Air Safety, Health and Security Department of the Association of Flight Attendants–Communications Workers of America.

"I hear those stories more often than stories of a manager being supportive and saying 'You really should *not* get back on that flight' — especially if the crewmembers are on the fence — they are not bedridden, they don't have uncontrollable heaving, but they are also not 100 percent — they've got an illness that is questionable," Kolander said. Except for crew resource management training about pilot in-flight incapacitation, discussions of the safety aspects of crewmember illness often are absent in recurrent training, she said.

Some sickness-absence management programs also neglect to mention the links among illness, fitness to operate and safety. "Very rarely have I seen stand-alone memos that say 'Do not fly when you are sick,'" she said. Instead of being inserted at the bottom of reminders about investigation procedures for suspected sick leave abuse, they could say, "Your job as a safety professional is really important, and in order to do your job well, you need to be 100 percent," Kolander said.

Nurse case managers handle airline crew-support calls at the MedAire Global Response Center in Tempe, Arizona, U.S.

© MedAire

Feel-Good Solutions

Calls for medical advice from crewmembers ill on layover typically have one recurrent theme. Essentially, the callers to MedAire want to stem their rising tide of symptoms if possible. "They ask, 'What can I get over the counter at a pharmacy in Frankfurt that is going to make me feel better enough to get on the airplane, go home and take care of this?'" Giles said.

Neither Kolander nor Giles has been able to gauge accurately whether the percentage of crewmembers reporting for duty while ill has been

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increasing, except from their respective anecdotal vantage points. "If crewmembers have an illness or an injury that might compromise safety, the majority of them would not come to work," Giles says. "They take it very, very seriously. They do not want that reputation on the line either — of showing up ill or slacking."

For an individual, getting a grip on illness status without medical expertise also may be tricky. "Sometimes, even though someone may have the ability to assess their own illness, their ability to reason decreases in certain circumstances," Giles said. To a crewmember, an illness could be happening for the first time, but that contrasts sharply with the perspective of a nurse case manager involved in basically the same scenario 200 times a year.

The initial phone call to a nurse case manager generates preliminary information — expressed on a scale of low, medium or high probability of fitness to operate on a specific flight — for the airline to project ability to operate and to identify potential scheduling problems, and a decision on whether the crewmember is assessed/treated by a health care professional.

Complicating some scenarios can be a crewmember's refusal to acknowledge an illness. One flight attendant in July 2007 claimed that she was feeling well, Giles said. "She was not, she was in an altered state, either as a result of a substance that she was taking or some emotional situation, but her ability to judge the situation was impaired as well," she said. "So the entire crew stood up and said, 'We refuse to fly with this person' — and good for them. Neutral care givers with experience as critical care nurses or emergency room nurses know how to hold hands over the phone. So they were able to reason with her and get her to a point where she was willing to see a medical professional who would put illness in the context of personal medical condition, as opposed to work, reputation, all those things that get entwined."

Some crewmembers feel relieved to experience third-party input rather than have an argument about the seriousness of their illness. "We have had situations where the airline station manager was pressuring the crewmember, saying, 'Come on, you need to fly, we've got to leave on time. Come on, this is our last leg,'" Giles said. "The crewmember was really torn until we stepped in and said, 'No, you can't operate.' Then the crewmember could say, 'MedAire says I can't fly.'"

The company primarily uses its data about crewmember illness to produce a regular report to each airline, pointing out trends involving specific geographic areas or illnesses. This has included epidemiological studies of problems such as environmental contamination at a crew hotel. The data also have prompted development of educational materials for crews such as guidance on proper hand washing techniques, Giles said. ●

Notes

1. Garr, Jennifer. "Managing Crew Illness and Injury." A presentation to the 24th annual International Aircraft Cabin Safety Symposium, Feb. 12–15, 2007.
2. U.K. Confidential Human Factors Reporting Programme (CHIRP) report no. 325227, October 2005.
3. U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) report no. 658580, May 2005.
4. NASA ASRS report no. 688279, February 2006.
5. NASA ASRS report no. 696801, May 2006.
6. U.S. Federal Aviation Regulations Part 61.53, "Prohibition on Operations During Medical Deficiency," prohibits pilots from operating in circumstances when they would not meet the requirements of the medical certificate held.
7. FAA. *Version V of The Guide For Aviation Medical Examiners.* April 25, 2007.
8. Air Line Pilots Association, International. "Master Executive Council Code-A-Phone Update." May 14, 2007. <crewroom.alpa.org>.

Heating up in Paris

BY J.A. DONOGHUE | FROM PARIS

While not global warming, the hot pace of orders at the Paris Air Show creates concerns about coping with a rapidly expanding world fleet.

Paris Air Show 2007 displayed the energetic expansion of nearly every aspect of the global aviation industry, with tens of billions of dollars in sales commitments being announced, a development that was both encouraging and worrisome. While the vigorous economic health of the industry certainly is welcome, the infrastructure and training challenges that will accompany the delivery of the thousands of ordered aircraft must be considered with a degree of concern.

Airbus, to a much greater degree than Boeing, targets the show as a stage from which to announce major sales, and this year the European manufacturer outdid itself with 728 orders and options announced during the show's five days, with additional orders trickling in during the following days. Boeing and Airbus together got 545 firm orders during the show. Others announced sales as well, money changing hands so quickly that, by show's end, the value of sales tallied by just the three major

J.A. Donoghue

Dassault displayed its newly certificated Falcon 7X to the crowd.

Photos: J.A. Donoghue

engine manufacturers exceeded US$20 billion, with Rolls-Royce alone claiming sales of more than $15 billion.

Continuing a trend several years in the making, most of the orders came from the developing world, including the Middle East, Asia and Latin America. With many orders coming from new or rapidly growing airlines, most of these aircraft will be fleet additions, not replacements. Given today's shortage of pilots and other skilled aviation professionals, the source of additional crews for these new aircraft seems important to figure out.

Canadian simulator builder CAE Inc., which also has a training arm, estimates that 16,000 pilots need to be trained each year for the next 20 years to meet the demand in both the airline and corporate aviation markets. The company is expanding the capabilities of its global network of 24 civil training centers to handle corporate and airline training.

Alteon, Boeing's training subsidiary, forecasts an even greater demand, predicting the need for an average of 18,000 new pilots every year, plus 480,000 new mechanics during that 20-year period.

Europe-based Thales is making simulators for a wide range of new customers, including four full flight simulators for Rudradev Aviation's new airline training center in Chennai, in southern India; just before the air show, Thales announced orders for additional A320 simulators for Sichuan Airlines' new training center in Chengdu, China.

Avionics news at the show included the announcement by ACSS, the joint venture of L-3 Communications and Thales, that it had concluded development of its SafeRoute system, with certification by the U.S. Federal Aviation Administration (FAA) expected soon. Using automatic dependent surveillance-broadcast (ADS-B) technology, SafeRoute has two functions: surface area movement management (SAMM) and merging and spacing (M&S).

In the SAMM function, SafeRoute displays the equipped aircraft's own-ship position on a moving map of the airport surface, plus the position of any other transponder-equipped aircraft. The M&S mode allows airborne aircraft to line up behind and follow another aircraft at a precise interval.

Nicholas Sabatini, FAA associate administrator for aviation safety, said at the show that SafeRoute will enhance pilot "situational awareness and allow air crews to separate themselves." Sabatini also credited the work of UPS and Karen Lee, UPS operations director, for working with ACSS to develop the system, "leading edge stuff, way out there in front," he said.

Lee said the certification testing was "flawless in high density traffic," and she hoped to get SafeRoute into UPS service this month.

ACSS's SafeRoute simulates how an aircraft approaching an occupied runway would be warned (left). Gulfstream's PlaneView cockpit would use the primary flight display on the left for the synthetic vision presentation.

© ACSS


© Gulfstream

The system will be installed in class 3 electronic flight bags (EFBs) on 107 UPS 757s and 767s for use to control spacing approaching its hub in Louisville, Kentucky, U.S., from the west. Tests have shown that this ability will increase airport capacity by 10–15 percent, cut local noise 30 percent and reduce emissions 34 percent below 10,000 ft, Lee said. UPS's plan is to expand use of the system in Louisville, and it is considering using SafeRoute for its Cologne, Germany, hub, she added.

The SAMM function, Lee told ASW, not only will increase pilot situational awareness on the ground, but, with a glance at the display taking the place of following "a finger on the [airport] map," creates a more head-up taxi environment.

Use of SAMM on a class 2 EFB seems likely to get FAA approval, which will dramatically cut the cost of equipping with the system, Lee said, but FAA "is still not confident about [approving] M&S" on a class 2 EFB.

Gulfstream, which pioneered the use of enhanced vision systems (EVS) in civil aircraft five years ago — 294 EVS-equipped Gulfstreams are now in service — plans to certificate a synthetic vision system this year. Pres Henne, senior vice president for programs, engineering and test, said, "We're looking for things that represent a difference, an advantage for our customers." The synthetic vision view of what the world in front of the cockpit should look like, taken from a simplified version of an earth database, will be displayed behind the primary flight display (PFD) graphics, showing terrain, obstacles, airport layouts and other significant features, providing pilots "a significant increase in situational awareness," Henne said.

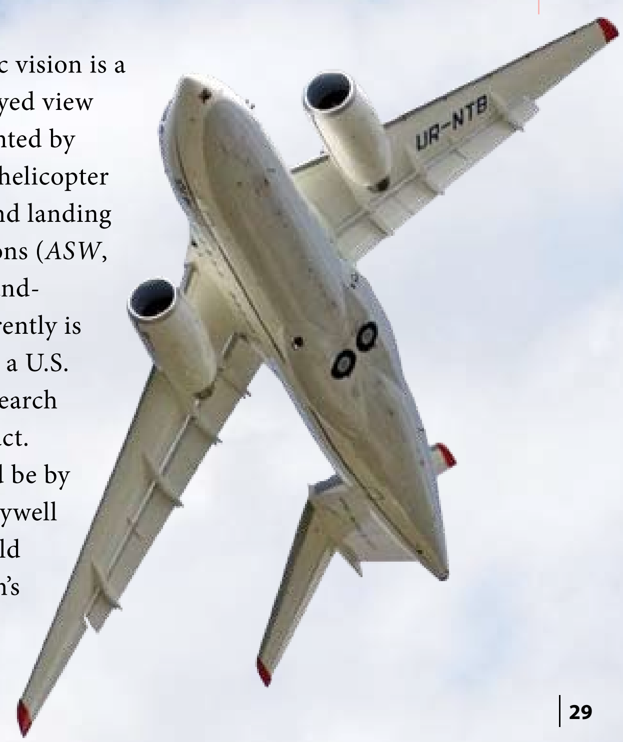
The next generation head-up guidance system (HGS) Gulfstream will adopt, a Rockwell Collins system Henne called HUD2, will integrate the EVS with synthetic vision in the HGS display.

Jeffrey A. Standerski, Collins vice president and general manager, air transport systems, said the HGS for Gulfstream, which Collins calls the 5860, will be the first HGS with active matrix liquid crystal display, and will have a wide field of view. Standerski foresees in the very near future the combination of EVS, synthetic vision, weather radar, traffic information and more on the HGS plate. Collins also builds the 2200 HGS for both pilot positions in the Boeing 787, using the same technology on its Embraer and Dassault installations.

Also using synthetic vision is a Honeywell PFD-displayed view of the world supplemented by radar sensors to guide helicopter pilots during takeoff and landing in "brownout" conditions (*ASW*, 12/06, p. 44). Called Sandblaster, the system currently is being developed under a U.S. Defense Advanced Research Projects Agency contract. While initial use would be by the U.S. military, Honeywell expects civil users would benefit from the system's capabilities. ●

The Antonov An-148, recently certificated, flew daily at the show.

Photos: J.A. Donoghue



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BY WAYNE ROSENKRANS

Inspector

Aviation safety inspectors fielded by some nations have problems complying with the standards and recommended practices (SARPs) of the International Civil Aviation Organization (ICAO). As inspectors face booming aviation system growth and increasing cross-border interdependence[1] — with their work redefined by forces ranging from globalization of aircraft maintenance to proliferation of safety management systems (SMSs) — auditors for ICAO continue to push for accelerated compliance through their Universal Safety Oversight Audit Program (USOAP).

Compliance deficiencies[2] found by the auditors appear in excerpts from ICAO contracting states' first-generation audits based on the USOAP's original auditing approach from 1999 to 2001, follow-up missions from 2001 to 2004, and post-2004 audits using ICAO's current comprehensive systems approach (*ASW,* 2/07, pp. 39-41). These excerpts are incomplete and anecdotal; they provide general insights about a specific time but do not show the extent of any deficiency involving inspectors, and many deficiencies are now resolved. By mid-2007, about half of the 190 ICAO states had authorized posting of the excerpts from their USOAP audit results on a publicly accessible table in the Flight Safety Information Exchange (FSIX) area of the ICAO Web site <www.icao.int/fsix/auditrep1.cfm>. Of these states, excerpts from 10 audits reflect the comprehensive systems approach. Releasing current audit summaries becomes mandatory March 23, 2008. In brief, these reports show that ICAO wants civil aviation authorities to provide enforcement power and credentials to their inspectors, a competitive salary, enough inspectors for the workload, and training, procedures and tools that enable them to be effective and efficient.

Findings about inspectors typically were accepted by civil aviation authorities, the reports showed. But not always. In the Czech Republic, for example, the auditors found training deficiencies, but the civil aviation authority responded that because its flight inspectors formerly held flight crew licenses, had as many as 15,000 flight hours in air transport and received simulator training, they were "adequately competent to carry out en route checks, including planning, pre-flight inspection, in-flight inspection, post-flight inspection, etc., according to [the inspector's handbook]."

In several states, auditors found that inspection teams did not have a dangerous goods specialist. In others, there was no formal system for the civil aviation authority to send airworthiness information, such as malfunction reports, to manufacturers and other states.

Authoritative Credentials

The enforcement power represented by an aviation safety inspector's badge and/or other credentials played a critical role in effective safety oversight, according to some of the reports. Inspectors in some states had neither a badge nor other credentials, however. When provided, some credentials were inconsistent in their purpose. Regarding Bulgaria, a favorable report said, "Under the current regulations, as reflected in their credentials, the aviation inspectors have the authority to propose the suspension, termination, revocation and limitation of the rights under the issued licenses, permissions, certificates and approvals, and to take immediate and independent action to address safety-critical findings."

Enforcement power without credentials — and credentials without power — are not acceptable situations, auditors say. Auditors visiting Estonia, for example, found that the credentials carried by inspectors did not confer upon them any legal power of access; right to inspect aircraft, facilities, manuals, certificates, licenses or files; power to detain an aircraft; or — for just cause — authority to immediately prevent an aviation professional from exercising the privileges of a license or certificate. A similar report for Hungary said that this gap caused "difficulty ensuring compliance with aviation laws and regulations due to this lack of empowerment [and] few examples of enforcement actions taken by the [civil aviation authority]."

The opposite was found in other states; for example, the inspectors in the Marshall Islands were "fully empowered [but] not issued a government credential to identify their [official duties and] authority." The airworthiness inspector had,

Scrutiny

ICAO auditors expect states to commit enough resources for effective oversight.

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instead of a government credential, only an airport identification card granting access to airport property. Some civil aviation authorities, such as in Sweden, initially objected to these findings, however, arguing that such amendments were unnecessary because no inspector in the past had been denied access.

Exercising authority also implies clear definition of inspectors' privileges and ready access by inspectors to domestic aircraft, foreign aircraft, operator buildings/installations, air traffic organizations, airports, maintenance and repair organizations, training institutions, paper documents and digital data. Auditors' follow-up comments were favorable when Bulgaria not only spelled out how inspectors can initiate statements for administrative violations but formally documented the authority of inspectors to issue written guidelines for corrective actions by operators or other organizations.

At the civil aviation authority in Moldova, auditors found that monetary penalties and imprisonment could be imposed by law for violation of aviation regulations. Records showed only that aircraft had been grounded and certificates had been suspended temporarily. Yet no enforcement methods less severe than these four sanctions were in place for situations in which inspectors routinely identified a safety discrepancy and simply wanted a timely correction.

Inspectors' oversight of designated examiners, line check pilots and contractors also involved deficiencies. The main issues were insufficient random checks of certificate candidates and insufficient quality control of testing procedures, leading to entirely "self-monitoring by the air operators."

Government-issued vehicles and credentials that confer rights of access are considered essential for all aviation safety inspectors.


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Competitive Salaries

Low inspector salaries is one theme echoing through a number of reports. Auditors focused on the safety-related consequences, such as chronically unfilled positions, high turnover of inspectors, oversight delays or backlogs caused by the shortage of inspectors, difficulty attracting highly qualified professionals from industry, insufficient travel funds for inspection/training missions and inability to schedule inspector training, especially recurrent training on the aircraft types operated under the state's air operator certificates (AOCs).

Related issues were the civil aviation authority's ability to provide stable long-term employment and whether the ministry of transportation arbitrarily established inspectors' salaries. "[Senior operations and airworthiness inspectors] are on a yearly renewable contract due to government policy, and no provision is available to reinforce the technical capacity of the [civil aviation authority] by offering them long-term contracts," said a report on Lesotho. A report on the Czech Republic noted, "[Inspectors' classification under civil servant law] means that their salary can reach, on average, a maximum of one-third of the salary of qualified line pilots [of an] air company."

Poland's civil aviation authority said that recent operations inspector vacancies had been filled by pilots retired from the state airline industry. Hiring was difficult due to "low inspector salaries which remain approximately one-tenth of those provided to similarly qualified people in industry."

Sometimes, the civil aviation authority's response was to deny that low salary was a safety concern. The civil aviation authority in the Netherlands told ICAO, "This has no direct impact on the recruitment of flight operations inspectors [or] on existing competency and experience among the team of inspectors for the

European Civil Aviation Conference and Joint Aviation Authorities SAFA Program

present level of activity of the [civil aviation authority]. The government has already launched a study which will allow additional compensation for the entire organization." In some cases, however, the ICAO follow-up mission found that as soon as the civil aviation authority increased salaries, inspector turnover ceased to be a problem.

The solution in Poland was for the minister of transport to index the inspector salary scale to a maximum of 80 percent of the salary received in comparable positions in the industry, and to amend a law to "require maintenance of inspector salaries at that level."

Sufficient Staffing

Low salary sometimes led to insufficient inspector staffing, which some auditors simply called "too much workload." In response to this finding, the civil aviation authority of Ireland held on to its belief that it employed a satisfactory number of inspectors but agreed to add inspectors to reduce dependence on external contractors.

In Switzerland, the safety consequence of an acute shortage of operations inspectors was that "subsequent to the issue of an [AOC], only a few operations inspections on some commercial air transport operators are conducted." Some civil aviation authorities — such as in Singapore — responded to such findings by refining the workload parameters and formulas they use to calculate the required number of flight operations inspectors.

Other auditors identified failures by civil aviation authorities to meet their own schedules of en route flight deck/cabin inspections and station inspections for scheduled air operators. "Neither the state regulations nor the [inspector's] handbook [specifies] the minimum number of inspections that should be performed for each operator during the year," said a report on Poland. "Inspections are planned according to the manpower presently available. Due to this lack of regulations and the shortage of operations inspectors, the division is accomplishing less than the minimum number of inspections recommended by ICAO guidance material." In Oman, the civil aviation authority's audit plan "indicated that most of the scheduled audits have not been performed due to a shortage of flight operations [inspectors] and airworthiness/maintenance inspectors."

Civil aviation authorities of various sizes reported difficulty enabling operations inspectors, as a group, to stay current as pilots on all aircraft types flown by the state's AOC holders. A report about the civil aviation authority in Finland said, "Although the [civil aviation authority] tries to have all the aircraft expertise within its own staff, it also has to use the expertise of [designated] company check pilots to complement its capabilities and to conduct type-specific inspections not covered by its inspector work force. … [The civil aviation authority's] inspectors perform all operations system inspections, route checks covering non-type-specific elements, [operators' crew] training and ramp inspections. They also review the work done by the designated check pilots."

Acute shortages of inspectors in some countries have limited inspections of air carriers.

The civil aviation authority in Denmark said, addressing a related audit finding, that "it would not be physically possible for the relatively few inspectors employed by a small unit … to be qualified and current in each aircraft type used by the … operators." The solution was a commitment by the civil aviation authority to adhere to SARPs and Joint Aviation Authorities procedures "as far as possible" and to "use adequately qualified and authorized line check commanders,


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acceptable to [the civil aviation authority], for specific type-related checks. … The minimum experience requirements, which are identical for [civil aviation authority] inspectors and designated check pilots, are mandated by regulation."

In Hungary, agreements with airlines enabled operations inspectors to fly a minimum of 200 hours per year as line pilots. But ICAO auditors also found that this arrangement required the inspectors to be absent from their inspection duties for long periods of time. The operations inspectors in Switzerland were authorized to maintain currency in their pilot ratings within the industry by flying 20 percent of their working hours.

Procedures, Checklists and Training

Deficiencies in establishing proper procedures for inspectors were prominent in reports about some states. Auditors' concerns about checklists also generated findings, such as: inspector checklists that were not comprehensive; inspectors conducting inspections without any checklists; and use of unapproved checklists or job aids.

Some of the most comprehensive inspector training programs found by auditors comprised initial indoctrination, on-the-job training, recurrent training, a pilot currency system, advanced courses and detailed files of inspector training. Absence of such files was noted for a number of civil aviation authorities, however.

ICAO auditors also questioned the appropriateness of civil aviation authorities taking cues from operators on when to conduct inspections. "In practice, inspections are conducted on an irregular basis or when requested by the industry," said a report about Bahrain. "Any deficiencies identified during an inspection are handled informally." This civil aviation authority could not produce acceptable evidence of the inspections, deficiencies or follow-up actions under this system.

Tools of the Trade

Deficiencies in office facilities and equipment also affected inspectors. For example, findings in the Marshall Islands were addressed by purchasing a photocopier, microfiche and microfilm reader, mobile telephones, a laptop computer and a government vehicle for surveillance and on-site inspections. In other states, the inspectors lacked long-distance telephone service, Internet access, facsimile equipment, slope and distance measuring equipment and photo/video cameras.

ICAO auditors also found, however, that a civil aviation authority's acquisition of computer hardware, software and Internet access by itself did not translate into adequate access to, or control of, essential technical materials. They favored a dedicated technical library — digital, paper or both — to quickly access material such as mandatory continuing airworthiness information, master minimum equipment lists and manufacturers' technical publications.

The civil aviation authority of Iceland told ICAO that it "does not require nor have the necessary means or resources to obtain, store and maintain current, technical documentation as detailed in the [audit] recommendation, except when design organizations can provide that data in digital format." Instead, its practice was for inspectors to obtain information from an external organization — such as an aircraft operator or maintenance and repair organization — that is required by law to maintain updated documentation.

The traditional method of airworthiness surveillance, sometimes called "100 percent checking," is being abandoned by some civil aviation authorities — with the endorsement of ICAO and other international safety specialists — in favor of SMSs. For example, noting the current environment of inspectors, a USOAP audit report for Bulgaria said, "The regulatory staff rely extensively on prescriptive checklist methodology and have not yet embraced and introduced the broader regulatory audit regime,


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and concepts such as SMS, including risk assessment."

Top-Flight Practices

USOAP audits also furnish insights about best practices and innovations. For example, the civil aviation authority's inspection-activity database in Bulgaria consolidated "all the data, checklists and photographs collected by the inspectors during their audits and inspections, all aircraft and maintenance records, status of life-limited parts, checklists relating to renewals of certificates of airworthiness, and records of certificates issued."

The civil aviation authority in Finland based its inspector training plan on one-year, three-year and five-year forecasts and factored in regionwide inspector training requirements. The authority in the Czech Republic applied software to automate its process of requesting a corrective action plan from an operator, monitoring implementation and prompting inspectors to ensure that every corrective action item is cleared.

In Canada, the civil aviation authority built incentives for commercial aircraft operators into continuous airworthiness surveillance through a national program. "The certificate of airworthiness remains valid as long as all airworthiness requirements are fulfilled and an annual airworthiness information report is completed and signed by the owner or an authorized delegated person and submitted," the report said. "The audit is conducted within intervals of six to 36 months, covering all large commercial air transport operators and maintenance organizations and manufacturers as well as any approval holder … targeted as high risk. The [program] also includes a follow-up of the findings identified during the audit, which are required to be [cleared] in the following two years."

The civil aviation authority in the United Kingdom committed to a fully digital solution for its own documents, introducing an Internet-based format for its inspector's manual with accessibility to all staff. "No hard [printed] copies (except for a master copy) have been published," the report said.

The civil aviation authority in Australia described to auditors how its conventional inspection processes had been superseded by a "system safety analysis approach" backed by comprehensive training for flight operations inspectors.

"The [civil aviation authority currently] relies on a system where the prime responsibility for airworthy aircraft remains with the owner-operator," a report about Sweden said. "Aircraft certificates of airworthiness are renewed based on declarations from maintenance organizations in conjunction with random inspections, including spot-checking of [airworthiness directives]."

As such shifts of responsibility to operators occur under SMSs, the traditional inspector role in some cases can expand to include on-site participation in risk analysis conducted by the operator. As a result, a new type of audit finding under ICAO's comprehensive systems approach has emerged. Auditors who assessed Bulgaria, for example, said, "[Inspectors] are not participating in the periodic meetings of air operators, during which the effectiveness of their reliability programs is monitored. Consequently, the inspectors are not informed of any degraded levels of safety to justify any decision taken, [or] to initiate or impose special operational restrictions."●

Notes

1. Scovel, Calvin L. III. "Aviation Safety: FAA Oversight of Foreign Repair Stations." Testimony of the inspector general of the U.S. Department of Transportation before the Committee on Commerce, Science and Transportation; Subcommittee on Aviation Operations, Safety and Security; U.S. Senate. June 20, 2007. This document describes changes occurring worldwide in the role of aviation safety inspectors, including the effects of conducting maintenance of large commercial jets outside their country of registry and the introduction of safety management systems within civil aviation authorities.

2. When auditors from the Universal Safety Oversight Audit Program of the International Civil Aviation Organization identified inspector-related deficiencies within civil aviation authorities, they typically referred to standards and recommended practices cited in Document 8335, *Manual of Procedures for Operations Inspection, Certification and Continued Surveillance,* and Document 9734, *Safety Oversight Manual, Part A — The Establishment and Management of a State's Safety Oversight System.*

BY ODDVARD JOHNSEN

Improving Braking Action Reports

Using performance data from landing aircraft would eliminate current inaccuracies.

The accuracy of braking action reports can be improved substantially by basing them on flight data derived from landing aircraft, research in Norway has shown. This technique could eliminate discrepancies between the braking action measured and reported by airport personnel and the braking action actually experienced by flight crews, as in the following examples:

In December 1999, a Premiair McDonnell Douglas DC-10-10 with 399 people aboard was traveling at about 30 kt when it overran the 2,950-m (9,679-ft) runway at Oslo International Airport in Gardermoen, Norway. The airplane came to a halt about 305 m (1,000 ft) beyond the end of the runway. The DC-10 was moderately damaged, but there were no injuries. To the pilots, the landing had appeared to be normal during the initial phase. It was not until just before they prepared to turn off the runway — at a groundspeed of about 50 kt — that they were caught by surprise by braking action that was described by the captain as "nil." The runway friction measurement that had been provided to the pilots on approach was five hours old and had indicated that braking action was good. Special friction measurements taken about 20, 30 and 40 minutes after the accident also indicated that braking action was good. The investigation determined that these reports were "unrealistic." The temperature was at freezing, and visibility was down to 800 m (1/2 mi) in drizzle and fog.[1]

In December 2005, a Southwest Airlines Boeing 737 with 103 people aboard overran the runway at Chicago Midway Airport and struck two automobiles when it came to a stop on an off-airport road. Preliminary information indicates that the aircraft touched down fast and long, and that the thrust reversers were deployed only seconds before the aircraft left the runway. Although braking action had been reported as good, based on a runway friction measurement taken 30 minutes before the accident, the pilots had used either a medium or maximum autobrake setting. Less than 10 minutes after the accident, another friction measurement was taken, and it too indicated that braking action was good.[2]

Recent discussions have focused on the use of a reverse thrust credit in calculating landing distance. A question that might remain unanswered until the final report on the Midway overrun is issued is whether the 737's thrust reversers, if used and functioning properly, would have provided enough force to prevent the accident.

Deceleration Factors

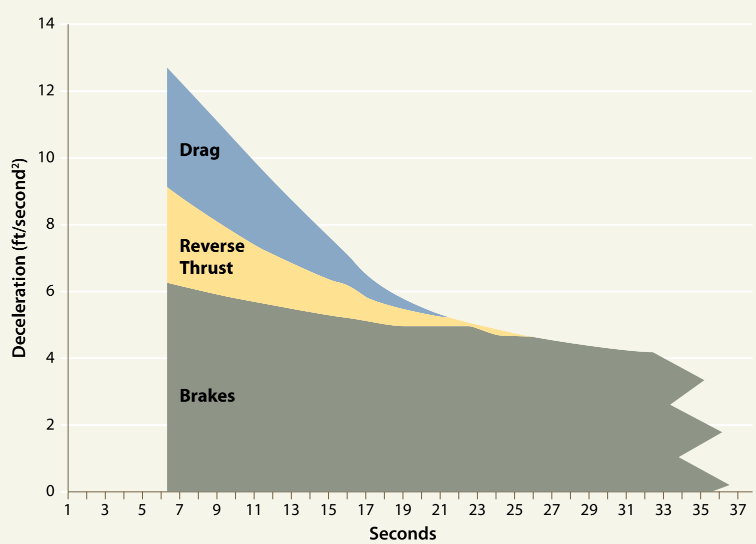
Before discussing the various methods of assessing runway friction and braking action, it is important to understand the fundamentals for the landing distances published by aircraft manufacturers in advisory material such as the airplane flight manual (AFM) and the quick reference handbook (QRH). AFM data are the foundation for on-board performance computations (*ASW*, 2/07, p. 22).

Landing distance theoretically is a function of the maximum available negative acceleration (deceleration) at any given time until the aircraft stops. Deceleration comprises three major factors that vary over time: aerodynamic drag, reverse thrust and braking.

Figure 1 shows the approximate distribution and relationship among these factors throughout a landing run. These relationships are not constant. Deceleration from aerodynamic drag and reverse thrust diminishes quickly. Although these factors influence performance throughout the landing run, for practical purposes, aerodynamic drag and reverse thrust may be disregarded at speeds below 60 to 50 kt; at these lower speeds, wheel braking is the factor that really counts.

Aircraft manufacturers use the term *airplane braking Mu*, which must not be confused with the same term used by the International Civil Aviation Organization (ICAO) for friction measurement. Airplane braking Mu is in many ways an expression of an average sustainable level of deceleration, when aerodynamic drag and reverse thrust are factored out. Table 1 and Figure 2 (p. 38) show the relationships developed by Boeing between braking action reports and airplane braking Mu. The curve in Figure 2 illustrates the dynamic nature of this. The non-linearity of the relationships is important, because it differentiates airplane braking Mu

Deceleration Factors



Source: Oddvard Johnsen

Figure 1

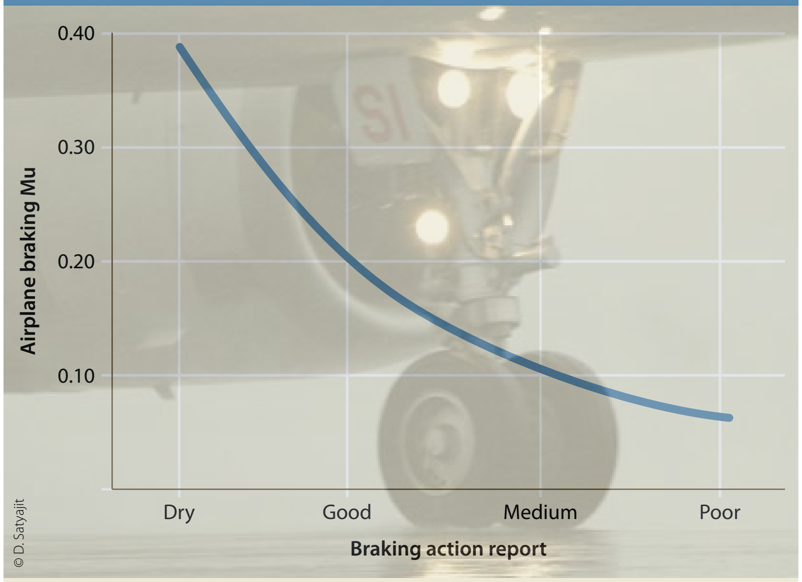
Relationship Between Braking Coefficients and Reports

Braking action report	Dry	Good	Medium/Fair	Poor/Nil
Airplane braking Mu (approximate)	0.38	0.20	0.10	0.05

Source: Oddvard Johnsen, from Boeing

Table 1

Relationship Between Braking Coefficients and Reports



Source: Oddvard Johnsen, from Boeing

Figure 2

Reference Landing Distance, Boeing 737-700*

Landing distance per QRH	1,690 m
Air distance	305 m
Safety margin 15%	253 m
Net landing distance	1,132 m
Average deceleration for landing run	1.89 m/s^2
Average g force for landing run	0.19 g
Airplane, medium braking action	0.10 g
Deceleration attributed to aerodynamic drag, reverse thrust, etc.	0.09 g

QRH = quick reference handbook

*Medium/Fair braking action

Source: Oddvard Johnsen

Table 2

from the commonly used ICAO terminology for mechanical braking-action testing devices.

Reference landing distances found in the QRH incorporate non-runway items such as aerodynamic drag and reverse thrust. The QRH does not indicate how much each factor contributes to deceleration and, thus, landing distance; however, there are ways to estimate their contributions. Table 2, for example, shows reference data for medium/fair braking action for the 737-700.

After factoring out the air distance included in QRH landing distance values and a 15 percent safety margin, the net landing distance is 1,132 m (3,714 ft). By using the landing reference speed, VREF, and a full-stop configuration, we can derive an estimated average deceleration for the landing run of about 0.19 g. By comparing this to corresponding airplane braking Mu for medium/fair, which is 0.10, we see that approximately 0.09 g is attributed to factors that are not dependent on the runway. The challenge is to extract the airplane braking Mu portion from a landing run.

Current Methods

Current methodologies for assessing braking action can be broken down to the following major groups: visual/qualitative, subjective and mechanical.

Table 3 is from Safety Alert for Operators (SAFO) 06012, *Landing Performance Assessments at Time of Arrival (Turbojets)*, issued by the U.S. Federal Aviation Administration (FAA) on Aug. 31, 2006. It illustrates how qualitative braking action reports are related to runway contaminants. Today, we know that simple descriptions of contaminants do not easily convert into braking action. There are a multitude of factors influencing braking action, such as the status of the runway micro texture and the weather history, to mention a few examples.

The subjective method is simply pilot reports. The pilot's

Relationship Between Braking Action Reports and Runway Contaminants

Braking Action	Dry (not reported)	Good	Fair/Medium	Poor	Nil
Contaminant	None	Wet Dry snow (< 20 mm)	Packed or compacted snow	Wet snow Slush Standing water Ice	Wet ice

Source: U.S. Federal Aviation Administration

Table 3

assessment of braking action is a personal judgment that is influenced by a number of factors; given the same conditions and aircraft, two pilots likely will judge the conditions differently. Various factors affect the pilot's perception. Braking action on a long runway, for example, might be perceived as better than braking action on a shorter, marginal runway where the end seems to approach substantially faster. A pilot with experience in harsh winter conditions will most likely judge braking action to be better than a pilot with little experience in such conditions.

Particularly in Northern Europe and North America, airports use various types of mechanical devices to measure runway friction. Although the devices produced by different manufacturers vary somewhat in design, they all follow the basic principle of braking a wheel against the pavement at a constant ratio and at a constant speed. The friction scale begins at 0 and goes to 1. ICAO has assigned measured coefficients to braking action estimates (Table 4). Although there is no correlation to airplane braking action — and aircraft manufacturers state that the coefficients should not be confused with airplane braking Mu — these numbers are still applied as a foundation for in-flight performance analysis.

In particular, the visual/qualitative and mechanical methods are applied in a uniform manner, regardless of aircraft type. However, we know that the same ambient conditions can have substantially different effects on a light turboprop airplane compared with a heavier and faster jet.

Relationship Between Runway Friction Measurements and Braking Action Reports

Measured Coefficient	Estimated Braking Action	Code
0.40 and above	Good	5
0.39 to 0.36	Medium to good	4
0.35 to 0.30	Medium	3
0.29 to 0.26	Medium to poor	2
0.25 and below	Poor	1

Source: Oddvard Johnsen, from International Civil Aviation Organization

Table 4

We also know that snow contaminants can produce considerably different degrees of "slipperiness" in one geographic region, compared with another. One factor is the salt content of the environment; qualitatively, the same contaminant produces a different slipperiness in a coastal environment than in an inland environment.

Little Progress

Because of the complex interactions among ambient factors, as well as their interactions with various elements of aircraft dynamics, a definitive determination of braking action is impossible. The current methods of assessing braking action are indirect. With the exception of subjective pilot reports, none of the methods actually uses the aircraft as a reference.

© Morten Nelson

A Braathens 737-700, like the one shown here, was used in braking performance information tests in Tromsoe, Norway.

Furthermore, there has been little or no progress in the development of effective measures to improve the quality of information associated with operating on contaminated runways. Although effort and resources have been devoted to national and international programs to improve the understanding of braking action, practical results have been few.

The work that has been done has failed for several reasons, primarily because it has been stuck to "old tracks" without renewed thinking. The approach has been too academic, with little understanding of actual airline operations.

Tromsoe Experience

In 1999, I was assigned by the Norwegian Aircraft Accident Investigation Board (AAIB) to serve on the team formed during the investigation of the Premiair DC-10 accident to examine the ability of modern aircraft to provide essential braking action information. The test program involved the collection of flight data from 2000 through 2005. The tests were conducted with a Braathens 737-700, and the bulk of the information was collected at the Tromsoe airport in northern Norway, where winter conditions are common.

Among the results of the tests and subsequent analyses was a method to derive airplane braking Mu from flight data after a landing run. This method uses the aircraft as a reference and essentially factors out the aerodynamic drag and reverse thrust elements of the landing run. Data recorded in the velocity interval between 60 and 30 kt are used to compute peak levels of deceleration. The computations result in braking action measurements that are very much in line with QRH and AFM data.

Although this method represents a way of calculating braking action that is still an estimate, it is more directly derived than the methods used today. Furthermore, it uses the dynamic scale of airplane braking Mu, which is the foundation for aircraft performance advisory information found in the QRH/AFM.

Using aircraft data to calculate braking action is a more objective and consistent method. Today, data can be transmitted more easily from aircraft after landing — for example, via a data link or wireless ground link. The frequency at which braking action information is collected — a function of the number of aircraft landing — also is much greater than the intermittent methods currently used.

Grouping Data

The tests at Tromsoe pertained only to the 737-700, and the results were developed with reference to Boeing advisory material, including the definitions of airplane braking Mu and braking action. Similar reference material has not been analyzed for other types of aircraft.

The founding principle for current braking action reports is that they should apply to all aircraft types. Flight data calculations, however, must conform to the basic data in the AFM/QRH. We know that the same ambient conditions can provide different braking action for two different aircraft. However, it would be impractical and cumbersome to develop a reference system for each and every aircraft model. "One size fits all" is not the way to go either. But creating groups of similar aircraft would make this aircraft-data method more workable.

The question that will always remain is: What about the first flight in the morning? The answer might be a ground vehicle that can be fitted with a data recorder and dynamic calculation systems harmonized to a set of predetermined aircraft groups.

Commercial aviation safety no longer depends on pilots' local knowledge, experience and intuition; we are now in a digital world with "boxes" to be filled. The result is that inaccuracies are amplified when runway conditions are critical. There is no quick fix, but by using the appropriate tools and making use of today's ability to acquire, compute and transfer data worldwide in an instant, it is possible to counter the trend of increased runway excursions.●

A retired airline captain, Oddvard Johnsen has served for the past 35 years as an advisor to the Norwegian AAIB on runway conditions and installations. He is a former vice chairman of the International Federation of Air Line Pilots' Associations (IFALPA) Airworthiness Study Group and participated in the Halla Banor (Slippery Runways) Program, conducted by IFALPA and the Aeronautical Research Institute of Sweden in the 1970s. Johnsen also participated in the Joint Winter Runway Friction Measurement Program, conducted by the FAA and Transport Canada in the 1990s.

Notes

1. Norwegian Aircraft Accident Investigation Board report no. 5/2001, *Report of Aircraft Accident at Oslo International Airport, Gardermoen Runway 19L, December 6, 1999.* Pertinent portions of the report were translated into English by Oddvard Johnsen for *ASW*.

2. U.S. National Transportation Safety Board preliminary report no. DCA06MA009; Aviation Safety Network <http://aviation-safety.net/database/record.php?id=20051208-0>.

InSight is a forum for expressing personal opinions about issues of importance to aviation safety and for stimulating constructive discussion, pro and con, about the expressed opinions. Send your comments to J.A. Donoghue, director of publications, Flight Safety Foundation, 601 Madison St., Suite 300, Alexandria VA 22314-1756 USA or donoghue@flightsafety.org.

A Moveable View

Head-up displays are paving the way for head-worn displays designed to provide information and flight guidance.

BY SHARON D. MANNING AND CLARENCE E. RASH

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Head-worn displays will enable pilots to keep flight information in sight while looking outside the aircraft.

As head-up displays (HUDs) gradually become standard equipment in commercial jets worldwide, researchers are looking toward what many believe will be one of the next developments in flight deck technology: head-worn displays (HWDs).

HWDs — in use since the 1980s in the military, where they are known as helmet-mounted displays (HMDs) — are like HUDs in that they not only duplicate the information on instrument displays but also play the role of flight guidance systems by providing additional flight cues and indicators.

But HWDs have unique advantages. The most significant is that they give pilots an almost unlimited see-through field of vision, enabling them to look anywhere without losing sight of the head-up flight information that HWDs provide. This look-around capability opens the way for increased use of enhanced vision systems (EVS) and synthetic vision systems (SVS) — advanced vision systems that provide pilots with greater situational awareness during low visibility takeoff and landing conditions.[1]

In HWDs, the reflective surface of the HUD design is moved from the transparent glass or plastic plate mounted inside the windshield to a "beam-splitter" located in front of a pilot's eyes — or often in front of one eye. To accomplish this, the beam-splitter — an optical device that reflects imagery while also enabling see-through vision — is attached to some form of headgear. In military HMDs, the flight information and imagery are projected onto either a visor or a beam-splitter located in front of the eyes, with both monocular and binocular applications.

An HWD has four basic components:


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Helmet-mounted displays — military precursors of head-worn displays — have been used for years by pilots in the armed forces.


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- A mounting platform, which can be as simple as a headband or as sophisticated as a full flight helmet. In addition to serving as an attachment point, it must provide the stability to maintain the critical alignment between a pilot's eyes and the HWD viewing optics;

- An image source for the information imagery that is optically presented to the pilot's eyes. Advances in miniature displays have produced a wide selection of small, lightweight and low-power choices at moderate cost, while meeting the demands of high luminance and resolution;

- Relay optics, which relay to the eyes the information produced by the image source. Relay optics typically consist of multiple elements, usually lenses. The last element is the beam-splitter. Initial designs for commercial aviation are expected to be monocular with the beam-splitter in front of one eye; and,

- A head-tracker, which is optional if the HWD is used only to present information with symbols but required if EVS and SVS imagery is to be presented. With this equipment, the pilot's directional line of sight must be recalculated continuously and used to point the sensor in the EVS forward-looking infrared (FLIR) camera in the same direction or to select SVS data that correlates with the pilot's line of sight. Presentation of FLIR or synthetic imagery requires a preflight procedure called boresighting, which aligns the sensor's line of sight with the pilot's line of sight.

As with standard HUDs, HWDs can present virtually any type of informational format: numerical data, such as altitude and airspeed values; pictorial or color symbols; maps; and video information.[2] The first three formats currently are more common, but the video format is expected to become popular because of the increasing availability of EVS and SVS imagery.

Advantages of HWDs

HWDs offer all of the advantages of HUDs, including — most importantly — increased situational awareness. By centralizing critical flight information within a pilot's line of sight, operational safety is enhanced. Transitioning from heads-down instrument flight to visual flight can be problematic. As with all HUDs, however, HWDs offer pilots the advantage of monitoring critical aircraft status data without having to repeatedly look down to scan flight instrument displays.

Another proven benefit of HUDs, and also of HWDs, is that, with the ability to keep their eyes fixed to the outside world, pilots are more likely to detect important changes within the field-of-view[3] — an advantage important in identifying runway incursions.

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Potential Problems

Most of the disadvantages of HWDs are well known because they are common to all HUDs. First is the phenomenon of "attention capture" — or tunneling — which is the unwanted tendency for pilots to pay too much attention to the HUD and not enough attention to events in their field of vision outside the airplane.[4,5]

Attention capture with HUDs mounted just inside a windshield has been blamed for undetected runway incursions — one of the types of events that HUDs are intended to prevent. Numerous studies have attempted to understand attention capture and how it can be mitigated. Most disturbing is a developing consensus that HUDs limit a pilot's ability to simultaneously process information derived from HUDs and from the real world.[6]

Most HUD symbols are not "conformal" — that is, they are not overlaid in a one-to-one relationship to match shapes and features in the real world. Therefore, the HUD symbols are perceived as different from the scene outside an aircraft's windows. This causes pilots to deliberately shift their attention to view either the symbols or the outside scene. The transition to conformal symbology may mitigate the attention capture problem.[7] This conformity must be required for video imagery presented in HWDs.

A second disadvantage is the possibility that HUD symbols or other imagery could obscure critical objects in the outside scene.[8] This problem can be reduced by keeping the number of symbols presented to a minimum and within the recommended size. Reducing the clutter caused by too many symbols also can decrease the potential for attention capture.

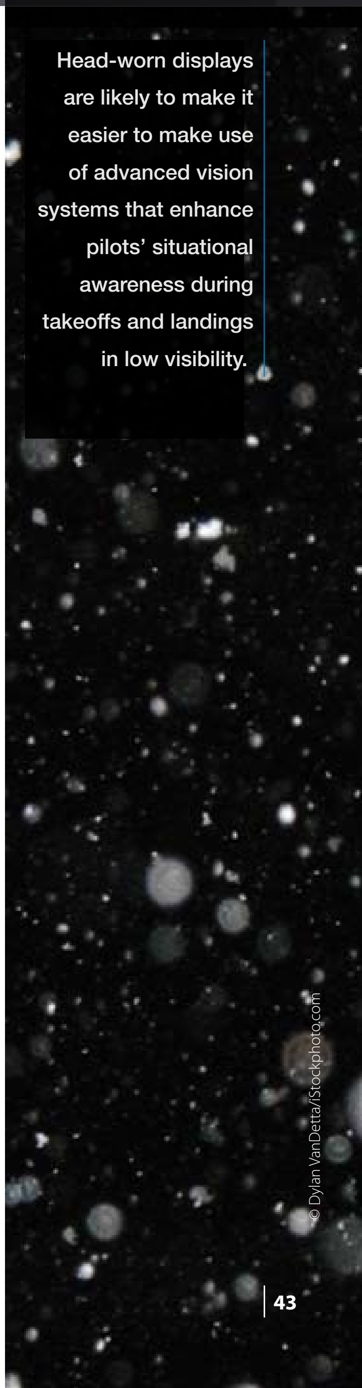
In addition to these general HUD-related disadvantages, other concerns are unique to HWDs — and unique to the concept of mounting the display to the head. The first of these is user acceptability, which is important when any new technology is introduced; without user acceptance, the technology will not be used. The primary factors affecting acceptance are the head-supported weight, center-of-mass offset, required modification in head movement and display lag.

Many pilots are not accustomed to wearing more than a headset on their heads. Current headsets are generally lightweight, typically 12 to 18 oz (340 to 510 g).[9] HWDs will increase head-supported weight by at least 16 oz (454 g).

Because the HWD's display source and optics must be placed in front of the eye, the HWD's added weight will be above and forward of the human head's natural center of mass — a factor that, as a flight progresses, may result in muscle fatigue.

For HWDs to present FLIR and synthetic imagery that represent what a pilot is seeing, the HWD must incorporate head-tracking. The need for head-tracking increases the cost and the complexity of HWDs.

The head-tracking process of determining the pilot's head position, relaying this position



Head-worn displays are likely to make it easier to make use of advanced vision systems that enhance pilots' situational awareness during takeoffs and landings in low visibility.

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to the sensor, the sensor's movement to the correct line of sight, the sensor's acquisition of the scene, and transmitting and presenting the final imagery on the HWD takes time.[10] This time is called system latency. Latency times are typically hundreds of milliseconds. The largest contributor is the "slew rate" of the sensor, or the time for the sensor to move to the new head position. Studies have shown that total system-latency times approaching one-third of a second or longer (300 or more milliseconds) are unacceptable from a performance standpoint.

These latency times have been blamed for motion sickness. The onset and severity of motion sickness symptoms are difficult to predict, and such occurrences in commercial aviation would be unacceptable. Studies by the U.S. National Aeronautics and Space Administration (NASA) have documented the need for improvement in image alignment, accuracy and bore-sighting of HMDs to help mitigate this problem.[11]

Taxiing Tests

Under NASA's Aviation Safety Program (AvSAFE), various HUD types and data formats are being evaluated for improvement of commercial aircraft taxi operations.[12] In a recent study, experienced commercial flight crews evaluated two HWD concepts and a baseline head-down display for acceptance and usability. In the study, pilots compared the three configurations while performing a series of taxi scenarios at O'Hare International Airport in Chicago. All of the taxiing tasks involved exiting the runway and taxiing to the airport terminal area.

Participating pilots described the HWDs as easy to use. They found no difference in workload between head-down designs and HWD designs. However, motion sickness was reported by 25 percent of the participating crews. Symptoms typically arose during the first HWD trial and worsened over time.

The Future

HWDs will be required if pilots are to take full advantage of EVS and SVS advanced vision systems. However, HWDs are not problem-free and will face pilot acceptance issues. Their implementation ultimately may be determined by whether they make flight tasks easier and safer by reducing workload and improving safety.

The debut of HWDs into commercial jet aviation will be easier than the introductions of many previous technologies. The military has been using HMDs for almost three decades and already has resolved most of the technical, ergonomic and human factors issues associated with their design, manufacture and use.●

Sharon D. Manning is a safety and occupational health specialist at the Aviation Branch Safety Office at Fort Rucker, Alabama, U.S., and has more than 15 years experience in aviation safety. Clarence E. Rash is a research physicist at the U.S. Army Aeromedical Research Laboratory at Fort Rucker with more than 25 years of experience in aviation safety, operational performance and human factors issues.

Notes

1. An enhanced vision system (EVS) is a sensor system that extends the visual range of pilots — for example, in darkness, fog, smoke or haze. The U.S. Federal Aviation Administration (FAA) uses the term enhanced flight vision system (EFVS) to describe a sensor system used in combination with a head-up display to enable an aircraft to be landed in situations involving low visibility. A synthetic vision system (SVS) uses databases containing terrain, obstacle-clearance and runway information to provide pilots with a computerized three-dimensional view of the area surrounding their airplane.

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8. Foyle; McCann; Sanford; Schwirzke.

9. Rash, C.E. "Shutting Out the Noise." *AviationSafety World* Volume 1 (November 2006): pp. 42–45.

10. Rash, C.E. (Editor) *Helmet-Mounted Displays: Design Issues for Rotary-Wing Aircraft*. Bellingham, Washington, U.S.: SPIE Press. 2001.

11. Bailey, R.; Arthur III, J.; Prinzel III, L.; Kramer, L. "Evaluation of Head-Worn Display Concepts for Commercial Aircraft." *Proceedings of SPIE*, Volume 6557, pp. 65570Y-1 to 16. 2007.

12. Ibid.

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FSF Editorial Staff. "Head-Up Displays in Civil Aviation: A Status Report." *Flight Safety Digest* Volume 21 (December 2002).

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Gaylord Entertainment Co.
Geico Corp.
General Dynamics
General Electric Co.

**Members as of 7/07.*

General Mills
General Motors Corp.
Georgia-Pacific Corp.
Group Holdings
H. Beau Altman Corp.
H.J. Heinz Co.
Halliburton Co.
Harley-Davidson Motor Co.
Harris Corp.
H. E. Butt Grocery Co.
The Hershey Co.
Hewlett-Packard Aviation
Hillenbrand Industries
Hilton Hotels Corp.
The Home Depot
Honeywell
Huntsman
IBM Flight Operations
IMS Health
Imperial Oil
Interlaken Capital Aviation Services
International Paper
JCPenney Co.
JP Morgan Chase
Jeld-Wen
Jeppesen
Jet Aviation
Jetport
Johnson & Johnson
Johnson Controls
K-Services
KB Home
KaiserAir
Kellogg Co.
KeyCorp Aviation Co.
Koch Business Holdings
Kraft Foods Global
The Kroger Co.
Level 3 Communications
Liberty Global
Limited Brands
Lucent Technologies
M&N Aviation
Marathon Oil Co.
The Marmon Group
Masco Corp. Flight Department
McCormick & Company
McDonald's Corp.
The McGraw-Hill Cos.
McWane
MedAire
Mente
Merck & Co.
MGM Mirage
Milliken & Co.
Monsanto Aircraft Operations
Motorola
MP Air
Mutual of Omaha
NetJets International
Nissan Corporate Aviation
Norfolk Southern Corp.
Northern Jet Management
Novartis
Office Depot Aviation
Owens Corning
Owens-Illinois General
PetSmart
PPG Industries
Parker Drilling Co.
Parker-Hannifin Corp.
Pentastar Aviation
PepsiCo
Pfizer
Pfizer AirShuttle
The Pictsweet Company
Pioneer Hi-Bred International
Principal Financial Group
Printpack
Procter & Gamble
Progress Energy
Quest Diagnostics
Quizno's Aviation Department
RJ Reynolds Tobacco Co.
Raytheon Co.
Richmor Aviation
Robinson Aviation (RVA)
Rosemore Aviation
Sanofi-Aventis
S.C. Johnson
SCANA Corp.
Sizeler Realty Co.
Schering-Plough Corp.
The Schwan Food Co.
Sears Holdings Corp.
Shamrock Aviation
Shaw Communications
Shaw Managed Services
Shell Oil Company
Signature Flight Support
Sky River Management
Skyservice Airlines
Sony Aviation
Sprint Nextel
Starr Aviation
Steelcase North America
SunTrust Banks
Sunoco
Supervalu
Tag Aviation Holding
Target Corp.
TeamLease
Tennessee Valley Authority
Texas Instruments
The Timken Co.
TransCanada
Travelers
Tudor Investment Corp.
USAA
The United Co.
United States Steel Corp.
Universal Underwriters Group
Universal Weather & Aviation
UnumProvident Aviation Dept.
Valero Engery Corp.
Vecellio Group
Verizon
Victory Aviation
W.W. Grainger
Wachovia Corp.
Waitt Media
Wal-Mart Aviation
Whirlpool Corp.
Whiteco Industries
The Williams Cos.
Wyvern Aviation Consulting
Xerox Corp
Yum! Brands Aviation
Zeno Air

Charter

Access Air
Addison Jet Management dba Imaginaire
Air Serv International
Bombardier Skyjet
Chantilly Air
Cloud Nine Aviation
Corporate Jets
DC Global Aviation
Epps Air Service
ExcelAire Service
Global Aviation
Heritage Flight
Jackson Air Charter
Key Air
Knollwood Aviation
Million Air Richmond
Rainin Air
Trans-Exec Air Service
USAirports Air Charters
Universal Jet Aviation
World Class Aviation
World Class Charters
Xpress Air

Academia

Air Routing International
Airbus North America Customer Services
Airline Training Associates
Atlanta Technical College
Averett University
Aviation Technical Library
Bowling Green State University
CAE SimuFlite
Central Georgia Technical College
Central Missouri State University
Corporate Aviation Systems
Daniel Webster College
Dudley Knox Library Serials
Embry-Riddle Aeronautical University–Mesa, Arizona
Embry-Riddle Aeronautical University–Prescott, Arizona
Embry-Riddle Aeronautical University–Daytona Beach, Florida
Embry-Riddle Aeronautical University–Albuquerque, New Mexico
Embry-Riddle Aeronautical University–Oklahoma City, Oklahoma
Embry-Riddle Aeronautical University–Randolph AFB, Texas
FlightSafety International
Florida Memorial College Library
GT Baker Aviation School
Middle Tennessee State University
Mission Safety International
Mountain Reading Service
National Center for Atmospheric Research
Northwestern University Library
Purdue University
Renton Technical Library
Rochester Institute of Technology
Saint Louis University
Southeastern Oklahoma State University
Southern Alberta Institute of Technology
Southern California Safety Institute
Southern Methodist University
St. Philips College LRC
University Aviation Association
University of North Dakota
University of Oklahoma
University of Southern California
Vaughn College of Aeronautics
V1 Aviation Training

Government/CAAs

120G-AIS
39 AS-SEF
Aero Club Kadena AFB
Alberta Government, Air Transportation Services
Army Aero-AOBC NJ
DA-COLLECT ALBAT-Defence Dept.
Defence Department Regional Library
Drug Enforcement Administration–Aviation Division
National Defence Headquarters–Canada
Nav Canada
Navy Air Test & Evaluation Squadron
Transportation Safety Board of Canada
Transport Canada
U.S. Army Flight Training Department
U.S. National Aeronautics and Space Administration–Langley Research Center
U.S. Naval Safety Center
U.S. Air Force Safety Center
U.S. Coast Guard–Washington, DC
U.S. Federal Aviation Administration (FAA)
U.S. National Transportation Safety Board
USDA Forest Service
Washington Airports Task Force

Insurance

AIG Aviation
Global Aerospace
Liberty Mutual Group
Nationwide Insurance
United States Aviation Underwriters
Willis Global Aviation

Aviation Associations

American Association of Airport Executives
Air Canada Pilots Association
Air Line Pilots Association, International
Air Transport Association of America
Air Transport Association of Canada
Airline Professional Association, Teamsters Local 1224
Allied Pilots Association
Canadian Business Aviation Association
Ebsco Subscription Service
Frontier Airline Pilots Association
General Aviation Manufacturers Association
Helicopter Association International
Independent Pilots Association
International Society of Air Safety Investigators
Maintenance and Ramp Safety Society
National Aeronautic Association of the USA
National Air Traffic Controllers Association
National Air Transportation Association
National Association of Flight Instructors
National Business Aviation Association
Office of Air and Marine Operations (ATTSS)
Professional Aviation Maintenance Association

Rand Corporation
Regional Airline Association
Southwest Airlines Pilots' Association
Swets Information Services

Consulting/Vendors

Alertness Solutions
Aviation Mobility
Aviation Personnel International
Engineered Arresting Systems Corporation
Farragut International
Flightscape Incorporated
IHS
The Metropolitan Aviation Group
PAR Tech Travel
R Cubed Consulting
SAE International
Safegate Airport Systems
Safety Focus Group
Safety Operating Systems
The VanAllen Group
Virtual Flight Surgeons

Individuals

Malcolm B. Armstrong
Sid Baker
Donald Baldwin
Karl Bancroft
Michael S. Baum
Sylvain Beaudet
Kenneth Beaupre
Larry E. Beck
Lewis H. Bias
Kevin Boardman
Fredric R. Boswell
John Bradley
J. Jeffrey Brausch
Gregory Brown
Jodie Brown
Capt. Mike Bruno
William Buehler
William L. Buttenwieser
Thomas J. Byrne
Fred A. Calvert
Dennis Caudle
Richard Chan
Joseph J. Cottrell
James J. Coulas Jr.
Ron Craik
Alan Cruce
Sushant Deb
Joseph M. Del Balzo
Anthony Destefano
Capt. Thomas A. Duke
Randy Duncan
A. Michael Evans Jr.
Thomas A. Farrier
Teri Fisher
Steve Gaudreau
Walter Gezari
Orin Godsey
John Goglia
Eric Goodman
Ken Gray
Marianne Guffanti
CC Hsin
Todd Hubbard
Eric Hube
Poch F. Iliscupides
Jennifer Kooren
Daniel Johnson
Margaret A. Johnson
William B. Johnson
Christopher Kelsey
Jennifer Kniffin
John A. Kolmos
Capt. Paul Lambeth
Steve Lee
Randy Lewis
W.R. Long
Scott I. Macpherson
Bruce Mayes
Bill McCabe
Larry McCarroll
Michael W. McKendry
Nazrul Mozumder
Aaron Parker
James Prince
Robert L. Prince
Ken R. Qualls
Andy Repke
Erik Rigler
David Robertson
S. Harry Robertson
Dr. Paul Robinson
Roberto Sarmiento
Ronald Schleede
Douglas Schwartz
Rusty Scioscia
Seven Stars Group
Glenna Sharratt
Alexander Sidlowski
Capt. Timothy Soderstrom
Victor J. Solis
Jason Starke
Raymond Stebler
G. Kent Thompson, P.E.
Ted Thompson
Scott Thurner
Joseph P. Tompkins
Jane K. Toth
Edward Turkovich
Richard Vacar
Carl W. Vogt
David Vornholt
Mark Winns
Terry Yaddaw

Mexico & Central America

Airlines

ABC Aerolineas S.A. de C.V.
Aeromexpress
Aeroméxico
Aviateca
Concesionaria Vuela Compania de Aviacion S.A. de C.V.
COPA
Estafeta Carga Aérea
LACSA–Lineas Aereas Costarricenses
MasAir Cargo Airline
Mexicana Airlines
TACA International Airlines

Regional Airlines

Aero California
Aviacsa Airlines Líneas Aéreas Azteca
Líneas Aéreas Azteca
Transportes Aeromar

Aviation Associations

ASPA de México
Colegio de Pilotos Aviadores de México

Individuals

Mynor Pelaez

Caribbean & West Indies

Airlines

Air Jamaica
BWIA West Indies Airways
Cayman Airways
Cubana
LIAT (1974)

Airports

Crown Point International Airport
Piarco International Airport

Academia

Inter American University of Puerto Rico

Government/CAAs

Bahamas Civil Aviation Authority
Cayman Islands Civil Aviation Authority
Trinidad and Tobago Civil Aviation Authority

South America

Airlines

Aerolíneas Argentinas
AeroRepublica
Austral
Avianca Airlines
Lan Airlines
Lan Argentina
Lan Ecuador
Lan Chile Cargo
LanPeru
Lloyd Aéreo Boliviano
PLUNA Lineas Aereas Uruguayas
Pantanal Linhas Aéreas
Surinam Airways
TAM Brazilian Airlines
TAME
Tampa Cargo
TANS–Transportes Aereas Nacionales de la Selva
Transportes Aéreos del Mercosur
VARIG Brazilian Airlines
VASP Brazilian Airlines
Varig Logistica

Regional Airlines

Aeropostal Alas de Venezuela
Gol Linhas Aereas
Southern Winds

Airports

INFRAERO

Manufacturers

Embraer

Corporate

Carbones del Cerrejon

Charter

Morro Vermelho Taxi Aereo

Government/CAAs

CENIPA–Brazil
Guyana Civil Aviation Authority

Aviation Associations

Sindicato Nacional das Empresas de Táxi Aéreo
Sindicato Nacional dos Aeronautas

Consulting/Vendors

Inter Assessoria Aeronautica

Individuals

Dr. Sam Slattery
Torong Guyana

Europe & North Atlantic

Airlines

Adria Airways
Aer Lingus
Aeroflot– Russian Airlines
AeroSvit Airlines
Air Atlanta Icelandic
Air Contractors
Air Europa
Air France
Air Malta
Alitalia
Armavia
Armenian International Airways
Austrian Airlines
Azerbaijan Airlines
Belavia–Belarusian Airlines
Blue Wings
BMED
bmi
Britannia Airways
British Airways
British European
Cargolux Airlines International
Carpatair
Cat Aviation
Compagnie Aérienne Corse
Contact Air Flugdienst
Croatia Airlines
Czech Airlines
Denim Air
DHL Air
Estonian Air
European Air Express
European Air Transport
Finnair
FlyNordic
GB Airways
Germanwings
Hahn Air Lines
Hapag-Lloyd Flug
Hifly
Iberia Airlines of Spain
Iberworld Airlines
Icelandair
Jat Airways
JSC Siberia Airlines
JSC Volga-Dnepr Airlines
KLM Royal Dutch Airlines
LOT Polish Airlines
LTU
Lauda Air–Austria
Lithuanian Airlines
Lufthansa Cargo
Lufthansa German Airlines
Luxair
Macedonian Airlines–Macedonia
Malév Hungarian Airlines
Malmo Aviation
Martinair Holland
MK Airlines
Montenegro Airlines
MyTravel Airways–U.K.

Olympic Airlines
Pulkovo Aviation Enterprise
Royal Air Maroc
SAS Braathens
SATA
Samara Airlines
Scandinavian Airlines System
Sterling Airlines
Sundt Air, Norway
Swiss Air Ambulance
Swiss International Air Lines
TAP Portugal
TAROM–Romanian Air Transport
TNT Airways
Thomas Cook Airlines
Transaero Airlines
Transavia.com
TUI Airlines (Arkefly, Corsairfly, Hapagfly, Jetairfly, Thomsonfly, TUI Airline Management)
Turkish Airlines
Ukraine International Airlines
Virgin Atlantic Airways
Volare Airlines

Low Cost Carriers

Air Baltic
Meridiana
Ryanair

Regional Airlines

Aegean Airlines
Air Astana
Air Austral
Air Berlin
Air Bosna
Air Iceland
Air Moldova
Air Nostrum
Air One
Albanian Airlines
Alpi Eagles
Atlasjet International Airways
Binter Canarias Unipersonal
Blue Panorama Airlines
Blue1
Cimber Air
Cirrus Airlines
CityJet
Corsair
Eastern Airways
easyJet
Eurowings Luftverkehrs
Falcon Air
First Choice Airways
Helios Airways
Hellas Jet
Hemus Air
KLM Cityhopper
Lufthansa CityLine
Malmo Aviation
Norwegian Air Shuttle
Portugália Airlines
Regional
SN Brussels Airlines
Skyways Express
Spanair
Vladivostok Air
Wideroe's Flyveselskap

Helicopter

ANWB Medical Air Assistance–The Netherlands
Basis Koksijde–Belgium
Bristow Helicopters
CHC Europe
Luxembourg Air Rescue
Norsk Helikopter

Airports

Amsterdam Airport Schiphol
Athens International Airport
Budapest Airport
Dubrovnik Airport
Fraport
Vienna International Airport

Manufacturers

Air Support
Antonov Design Bureau
BAE Systems
Dassault Aviation
Eurocopter Deutschland
Pilatus Aircraft
SNECMA
Saab Aircraft AB
Sagem Défense Sécurité
Thales Aerospace

Maintenance & Repair

Air Atlanta Aero Engineering
Fokker Services

Corporate

Aerobytes
DaimlerChrysler Aviation
Dasnair
Dunell Aviation International
Eurojet Holdings
Jetflite
NATS
Netjets Transportes Aereos
PrivatAir–Switzerland
Rabbit-Air

Charter

Mediterranean Aviation Co.
Zimex Aviation

Academia

British Library
Cranfield University
Horizon Swiss Flight Academy
Institut Français de Sécurité Aérienne (DCI-AIRCO)
KTHB Aero Library–Sweden
London Metropolitan University
Lund University
Sabena Flight Academy
Solavia

Government/CAAs

Accident Investigation Board–Norway
Agenzia Nazionale per la Sicurezza del Volo
Air Accidents Investigation Branch, UK
Air Corps Library
Air Traffic Services Authority–Bulgaria
BEA France
Central Joint Aviation Authorities
Denmark Aircraft Accident Investigation Board
Denmark Civil Aviation Administration
Deutsches Zentrum fuer Luft- und Raumfahrt
DGAC–Direction du Contrôle de la Sécurité, France
ENAC–Ente Nazionale Aviazione Civile
Embassy of France (DGAC)–U.S.
Estonian Civil Aviation Administration
Federal Office of Civil Aviation –Switzerland
Finland Accident Investigation Board
Finnish Civil Aviation Authority
Hellenic Air Accident Investigation Board
Hellenic Civil Aviation Authority
Icelandic Civil Aviation Administration
Instituto Nacional de Aviação Civil
Irish Aviation Authority
Luftfahrt-Bundesamt
Malta Department of Civil Aviation
Marinevliegkamp de Kooy–The Netherlands
NAVIAIR
National Aerospace Laboratory–The Netherlands
Netherlands Civil Aviation Authority
Norway Civil Aviation Authority
Poland Civil Aviation Office
RAF Centre of Aviation Medicine–UK
Royal Norwegian Air Force
STK Skandinavisk Tilsynskontor
Statens Haverikommission
Swedish Civil Aviation Authority
U.K. Civil Aviation Authority
VERVOER-BEDRIJFSERKENNING–Belgium

Insurance

Avicos Insurance Co.
Inter Hannover
LMA (Lloyd's Market Association)
La Réunion Aérienne
Marsh
Partner Reinsurance Co.
SPL Swiss Pool for Aviation Insurance
Swiss Reinsurance Company–FSBG

Aviation Associations

ANPAC (Associazione Nazionale Piloti Aviazione Commerciale)
The Air League–United Kingdom
Airports Council International
Association of European Airlines
Associação dos Pilotos Portugueses de Linha Aérea
Dutch Airline Pilots Association
Eurocontrol
EuroPress Polska
European Regions Airline Association
Flight Safety Foundation International (Moscow)
Guild Air Pilots & Navigators
Hellenic Airline Pilots Association
IFSC–Italian Flight Safety Committee
International Federation of Air Line Pilots' Associations
International Federation of Airworthiness
International Transport Workers Federation
Sindicato Nacional das Empresas de Táxi Aéreo
Sindicato Nacional de Pessoal de Voo da Aviacao Civil–Portugal
SwissALPA–AEROPERS
Vereinigung Cockpit–German Air Line Pilots' Association

Consulting/Vendors

CEFA Aviation
Flight Data Services
HTS Worldwide
T. Consulting (Transport System Advisory Services)
Saferflight
Superstructure Group

Individuals

Nuno Aghdassi
Angel Arroyo
Bart Bakker
John Barrass
Michael Chamberlain
Nicolas Charlemagne
Gennadily Cosí
Tom Curran
Katia DeFrancq
J. de Lange
Panagiotis Droumpounetis
Frank Frimor
Michael R.O. Grueninger
Capt. Frank M. Hankins
Holger Hoffmann
Mike Holtom
Wim Huson
Srecko Jansa
Dr. B. M. Lawrence
Olga Marin
Dr. Kjell Mjos
Frank Moloney
Dhamseth Pallawela
Robert Guitton Ropp
Christiane Schreibert
Werner Schweizer
Juan Sendagorta
Liam Sisk
Raul Sosa
Gary Tarizzo
NS Travers-Griffin
Tom Verbruggen
John Vincent
Anthony Walker
Ian Wigmore
Urs Wildermuth
Frank Wright

Middle East

Airlines

AMC Airlines
Aero Asia
Afriqiyah Airways
Ariana Afghan Airlines
Arkia Israel Airlines
Caspian Airlines
Cyprus Airways
DHL International
EgyptAir
EgyptAir Cargo
Egyptian Aviation Services
El Al Israel Airlines
Emirates
Etihad Airways
Gulf Air
Iran Air
Iraqi Airways
Kuwait Airways
Libyan Arab Airlines
Middle East Airlines–AirLiban
Midwest Airlines
NetJets Middle East
Oman Air
Pakistan International Airlines
Palestinian Airlines
Qatar Airways

Royal Flight of Oman
Royal Jordanian Airlines
Saudi Arabian Airlines
Sri Lankan Airlines
Syrianair
Tunisair
Yemenia, Yemen Airways

Regional Airlines
C.A.L. Cargo Airlines
Iran Aseman Airlines
Israir Airline and Tourism
Kish Air
Mahan Airlines Services Co.
Trans Mediterranean Airways

Helicopter
Petroleum Air Services

Manufacturers
Israel Aircraft Industries
Sirocco Aerospace International

Corporate
Saudi Aramco

Charter
Jordan Aviation Airlines
National Air Services
Royal Jet

Academia
Egyptian Aviation Academy– EAA
M&M Aviation Consultancy

Government/CAAs
Air Force Academy–Dundigal, India
Amiri Flight–Abu Dhabi
DGCA–Director General of Civil Aviation, India
Egyptian Meteorological Authority
International Airport Projects–Saudi Arabia
Kuwait Directorate General of Civil Aviation

Individuals
Dr. Montaser Fayek El-khaldy
Mustafa Fetouri
Shabnam Kinkhabwala
Kamal C. Mututantri
Narinder Pal Yadav

India

Airlines
Air India
Indian Airlines
Kingfisher Airlines
Sahara Airlines

Regional Airlines
Jet Airways

Aviation Associations
Skycare Aviation Safety Society

Individuals
Shabnam Kinkhabwala
P.K. Misra
Capt. Ananthakrishnan Ranganathan

Africa

Airlines
Aero Zambia
AfriJet Airlines
érie
Air Botswana
Air Gabon
Air Madagascar
Air Malawi
Air Mauritius
Air Namibia
Air Senegal International
Air Seychelles
Air Tanzania Co.
Air Zimbabwe
Cameroon Airlines
Commercial Airways
Ethiopian Airlines
Inter Air
Kenya Airways
Liñhas Aeréas de Moçambique
Precision Air Services
Royal Swazi
Rwandair Express
Safair
Sierra National Airlines
Solomon Airlines
Sudan Airways
South African Airways
TAAG–Linhas Aereas de Angola
Tassili Airlines
Virgin Nigeria Airways

Regional Airlines
Air Gemini
Bellview Airlines
Nationwide Airlines
SA Airlink
Zambian Airways

Corporate
Anglo Operations
Charter
Solenta Aviation (Pty)
Sonair

Government/CAAs
Ghana Civil Aviation Authority
South African Civil Aviation Authority

Aviation Associations
Air Traffic Navigation Services

Individuals
Olumide Aiyegbusi
James Attoh
Raymond Barske
Jacobus H. de Jager

Australia & New Zealand

Airlines
Air New Zealand
BHP Billiton
Qantas Airways

Low Cost Carriers
Virgin Blue Airlines

Regional Airlines
Air Nelson
Cobham Flight Operations & Services (Australia)

Helicopter
Telstra Childflight

Academia
Raaf College Library
RMIT Carlton (TAFE) Library
Trace University
University of New South Wales

Government/CAAs
Airservices Australia
Australia Civil Aviation Safety Authority
Australian Directorate Defence Aviation & Air Force Safety
Australian Transport Safety Bureau
Defence Library Service–Albatross
Defence Library Service–Canberra
Defence Library Service–Oakey
Defence Library Service –Williams
Department of Transport & Regional Services–Australia
New Zealand Civil Aviation Authority
New Zealand Civil Aviation Authority –Librarian Information Services
New Zealand House of Representatives
New Zealand Transport Accident Investigation Commission

Aviation Associations
Australian Federation of Air Pilots
Aviation Safety Foundation–Australia
Flight Attendants' Association

Individuals
Richard Bucknell
Robert Courtenay
James Harris
Richard Hodge
David McBrien
David Platten
David George Prior

Asia & Pacific

Airlines
Air China International Corp.
Air Koryo
Air Macau
Air Marshall Islands
Air Niugini
Air Pacific
Air Tahiti Nui
Air Vanuatu
AirAsia
Airfast Indonesia, PT
All Nippon Airways
Asiana Airlines
Biman Bangladesh Airlines
Cathay Pacific Airways
China Airlines
China Cargo Airlines
China Eastern
China Southern Airlines
Dragonair
EVA Airways Corp.
Far Eastern Air Transport Corp.
Garuda Indonesia
Hainan Airlines Co.
JAL Express
JALways Co.
Japan Airlines International
Japan Asia Airways
Korean Air
MIAT Mongolian Airlines
Malaysia Airlines
Mandarin Airlines
Nippon Cargo Airlines
Philippine Airlines
Polynesian Airlines
Royal Brunei Airlines
Shanghai Airlines
Shenzhen Airlines
Simrik Air
Singapore Airlines
Thai Airways International
Turkmenistan Airlines
Vietnam Airlines

Regional Airlines
Air Caledonie
Air Japan Co.
Air Nippon Co.
Air Tahiti
Bangkok Airways
Japan TransOcean Air
Phuket Airlines
Shandong Airlines
Sichuan Airlines
SilkAir
Singapore Airlines Cargo
TransAsia Airways
Xiamen Airlines

Helicopter
Aero Asahi Corp.

Airports
PT(Persero) Angkasa Pura II

Manufacturers
Ishikawajima-Harima Heavy Industries Co.

Corporate
Samsung Techwin Co.

Academia
Air Force Academy, Education & Training Center for Aviation Safety
Aletheia University
Hanseo University
Institute of Transportation, MOTC

Government/CAAs
Brunei Department of Civil Aviation
Civil Aviation Authority of Singapore
General Administration of Civil Aviation of China, Center of Aviation Safety & Technology
Hong Kong Civil Aviation Department
Republic of Korea Air Force
Republic of Singapore Air Force
Taiwan Civil Aeronautics Administration

Aviation Associations
Air Line Pilots Association–Singapore
Association of Asia Pacific Airlines
Association of Air Transport Engineering & Research–Japan
Aviation Safety Council
Flight Safety Foundation–Taiwan
Japan Aeronautical Engineers' Association
Japan Aircraft Pilots Association
Polyspring Enterprises Co.

Individuals
Lo Sheng-Chiang
Yea Fuh Hwang
Lee Chi Lien
Robin Low
Tashi Phuntsho
Hiroshi Sogame
Minseok Song
Jun Sato
John Trevett
Steven Khoo Hock Yew
Wang Yi-Fen

Cold Comfort in Accident Reports

Antihistamines used by pilots for relief from colds or allergies were associated with 338 fatal U.S. civil aviation accidents in a 16-year period.

BY RICK DARBY

There was an increasing trend in the use of a certain class of antihistamines — which can cause sedation and impair cognitive function — among U.S. civil aviation pilots killed in accidents during the 1990–2005 period, according to a new study.[1] Ninety percent of the accidents occurred in general aviation operations, and the analysis suggests that pilots have disregarded warnings.

Antihistamines, usually consumed in the form of tablets or capsules, are drugs used to alleviate symptoms of allergy and the common cold. They are typically sold "over the counter" as nonprescription medicines, but some formulations are marketed as prescription drugs. "The first-generation antihistamines have been reported to be associated with significant sleepiness and impaired performance on flight tasks, resulting in slowed reaction times, memory difficulties and impaired vigilance," the report says.

The study considered the presence of 13 of the most commonly used first-generation antihistamines known as H_1 receptor antagonists — hereafter called, for simplicity, antihistamines — in the remains of pilots in fatal accidents.[2] The researchers examined the U.S. Federal Aviation Administration Civil Aerospace Medical Institute (CAMI) Toxicology Database for reports indicating the association of antihistamines, sometimes combined with other drugs or alcohol, with pilot fatalities during the 16-year study period. Only the records for pilots-in-command — no copilots or first officers — were studied.

Of 5,281 fatal accidents from which results of a post-mortem examination were recorded in the database, there were 338 accidents in which the pilots' remains indicated the presence of antihistamines. Of the 338 accidents, 304 (90 percent) were general aviation accidents.[3] Table 1 shows the breakdown according to operational type.

Of those 338 pilots who tested positive for antihistamines, the certificates held included 175 private pilot, 88 commercial, 48 airline transport pilot, 20 student, and one non-U.S. type; six were non-certificated. Among the 88 commercial pilots, 72 were conducting general aviation

Operational Category Distribution

Fatal U.S. Civil Aviation Accidents Reported in CAMI Toxicology Database, 1990–2005

Operational Category	Aviation Accidents	Pilot Fatalities	Antihistamine-Related Pilot Fatalities
General aviation (FARs Part 91)	4,734	4,655	304
Air taxi and commuter (FARs Part 135)	271	265	15
Air carrier (FARs Part 121)	27	20	1
Agricultural (FARs Part 137)	157	157	8
Rotorcraft (FARs Part 133)	30	29	2
Ultralight vehicle (FARs Part 103)	47	47	4
Public use	69	66	2
Other categories	48	42	2
Total	**5,383**	**5,281**	**338**

CAMI = U.S. Federal Aviation Administration Civil Aerospace Medical Institute FARs = U.S. Federal Aviation Regulations

Notes: Includes fatal accidents of registered and unregistered aircraft from which post-mortem biological samples were submitted for toxicological evaluation.

Because only toxicological results of the pilot-in-command were considered in each accident, the number of antihistamine-related pilot fatalities equals the number of accidents.

Source: U.S. Federal Aviation Administration

Table 1

operations, five air taxi and commuter operations, seven agricultural operations, one helicopter operation, two public use operations, and one was classified "other." Among the 48 airline transport pilots, 35 were conducting general aviation operations, 10 air taxi and commuter operations, one air carrier operation, one agricultural operation, and one helicopter operation.

Thirty-five of the 338 pilots held first-class medical certificates, 107 second-class medical certificates and 182 third-class medical certificates. The other pilots did not have medical certificates.

Of the 338 pilots, 94 had consumed only one antihistamine, but 244 tested positive for at least two types of antihistamine, other drugs, alcohol or a combination of those substances (Table 2, page 52). Other drugs identified by the toxicology reports included amphetamines, analgesics (narcotic and non-narcotic), antidepressants, barbiturates, benzodiazepines, cardiovascular medicines, cocaine and several others.

"The use of the antihistamine(s) by pilots was determined to be the probable cause or a contributing factor in 63 of the 338 accidents," the report says. "There were 13 accidents in which the use of antihistamine(s) was determined to be the cause of the accidents. In one pilot fatality [among the 63], only one antihistamine was found. However, other drugs and/or ethanol [alcohol] were also present in 12 fatalities. Of these, five had two antihistamines and one had three antihistamines.

"In 50 accidents, the use of antihistamine(s) was determined to be a contributing factor. This group of accidents entailed seven fatalities in which only one antihistamine was found."

The antihistamine-involved pilot fatalities as a percentage of total pilot fatalities during the 16-year period "clearly suggested a steady increase in the number of fatalities with these medications," the report says (Figure 1, page 52). "For example, the antihistamine-associated fatalities/aviation accidents were approximately 4 [percent] and 11 percent in 1990 and 2004, respectively." The difference in the percentages of antihistamine-associated accidents by years was statistically significant ($p < 0.001$).

"Pilots are not only cautioned for the medical conditions that might interfere with flight safety, but also against the potential impact of some

"The use of the antihistamine(s) by pilots was determined to be the probable cause or a contributing factor in 63 of the 338 accidents."

Double Trouble

Antihistamines and Other Substances Involved in 338 Fatal U.S. Civil Aviation Accidents, CAMI Toxicology Database, 1990–2005

Substance(s)	Pilot Fatalities
One antihistamine	94
Two antihistamines	9
One antihistamine plus drugs and/or alcohol	209
Two antihistamines plus drugs and/or alcohol	25
Three antihistamines plus drugs and/or alcohol	1
Total	**338**

CAMI = U.S Federal Aviation Administration Civil Aerospace Medical Institute

Note: Includes only pilots-in-command, tested post-mortem.

Source: U.S. Federal Aviation Administration

Table 2

drugs, even when pilots feel better by taking them," the report says. "Among these drugs, the most important are the ones that alter CNS [central nervous system] functions. Although [antihistamines] are not CNS-specific drugs, as such, they have major side effects on the CNS. Because of this very reason, the package labeling of these medications contains precautionary statements, warning users against activities involving motor skills, such as operating a vehicle or machinery. However, patients — including aviators — do not appear to take these warnings seriously." ●

Notes

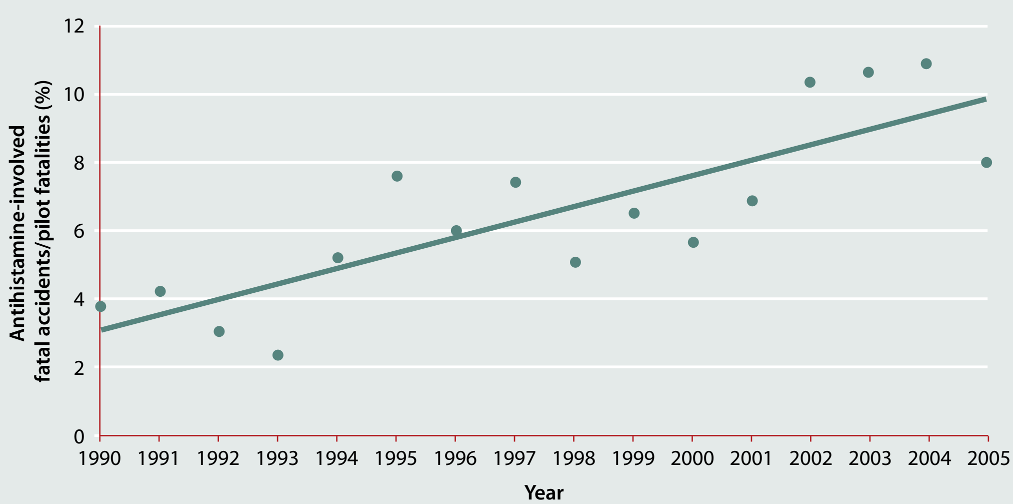
1. U.S. Federal Aviation Administration Office of Aerospace Medicine, Civil Aerospace Medical Institute. "First-Generation H_1 Antihistamines Found in Pilot Fatalities of Civil Aviation Accidents, 1990–2005." DOT/FAA/AM-07/12. May 2007.
2. Another class of antihistamines, known as second-generation H_1 antagonists, is considered to cause no sedative effect or cognitive impairment. Some of the second-generation drugs are approved by aeromedical authorities.
3. Because the data were accident-dependent, no conclusions can be drawn about how frequently antihistamines were used by pilots in general aviation compared with pilots in other types of operations.

Further Reading From FSF Publications

Mohler, Stanley R. "Allergy Symptoms May Interfere With Pilot Performance." *Human Factors & Aviation Medicine* Volume 48 (September–October 2001).

Trending Higher

Percentage of Fatal U.S. Civil Aviation Accidents Involving Antihistamine, CAMI Toxicology Database, 1990–2005



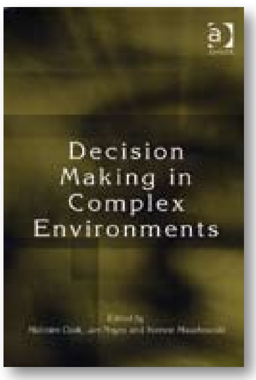
CAMI = U.S. Federal Aviation Administration Civil Aerospace Medical Institute

Source: U.S. Federal Aviation Administration

Figure 1

Decision Management

The vast amount of information available to today's decision makers is being studied to find out how it can be optimally used.



BOOKS

Decision Making in Complex Environments

Cook, Malcolm; Noyes, Jan; Masakowski, Yvonne (editors). Ashgate: Aldershot, England, and Burlington, Vermont, U.S., 2007. 458 pp. Figures, tables, references, index.

Decision making is not what it used to be. It's a great deal more complicated. In our globalized, technologically linked world, information is constantly changing and increasing almost faster than anyone can keep up with it. Decisions tend to affect more people in a larger sphere of influence.

"Today, we are inundated with a plethora of information, e-mails and ever-changing software," Masakowski says. "It is imperative that we master the critical components of knowledge management and decision making that will enhance and empower the individual and/or nation."

Automation, as usual, has both helped and created its own concerns. "There has been significant progress made in the development of technologies that serve to modify data, reduce the clutter and present information/knowledge in a manner in keeping with human information processing," Masakowski says. "However, there is still a need to be aware of the trade-offs involved between the human decision maker and those automated technologies that support their decision maker. Currently, we are faced with an abundance of information that challenges our attention and cognitive capacities, as well as placing increased demands on time management."

Besides several chapters on general characteristics of complex decision making, the book considers its application in several fields. A number of them by various contributors are relevant to aviation. Examples of those chapters include the following, with brief samples of observations made in them:

- "Human Information Processing Aspects of Effective Emergency Incident Management Decision Making": "Effective incident commanders functioned as if they had a good practical understanding of the limitations of their information processing system. … They had developed a rich network of decision rules organized in schemas [tentative internal representations of the outer world] which enabled them to use, mostly, fast, rule-based, robust *recognitional* decision processes rather than slow, vulnerable, knowledge-based analytical problem solving processes, which involve heavy demand [on] working memory capacity."

- "Air Traffic Controller Strategies in Holding Scenarios": "The difference in pattern matching [of two randomly selected controller groups in an experiment] highlighted one of the main differences between the sequencing of simple or complex traffic flows. The controllers sequencing the simple traffic flow mainly ordered the traffic according to patterns of traffic in a plan view. The controllers viewing the complex traffic flow considered the flight level of the aircraft more important and sequenced traffic according to the vertical view of the aircraft."

- "The Flight Deck of the Future: Field Studies in Data Link and Free Flight": "Data link has the potential to offer the 'permanence' of information in a way that buffers the vulnerability of working memory. This would allow air traffic control officers to devote their cognitive resources to other demanding cognitive tasks, for example, solving conflicts and so on."

- "The Flight Deck of the Future: Perceived Urgency of Speech and Text": "From the findings it is clear that both speech and text commands in expected or unexpected situations have their relative merits. It is likely that in routine, low-workload communications, such as a request for a change in [altitude] as stated on the flight plan, the use of data link could avoid errors that may occur due to mishearing, low radio quality or perceptual confusion between two similar flight numbers. However, for non-routine situations, such as a pilot running low on fuel, the potential impact of data link could be more critical."

REPORTS

Understanding Safety Culture in Air Traffic Management

Eurocontrol Experimental Centre. EEC Note 11/06. September 2006. 50 pp. Figures, tables, annexes. Available via the Internet at <www.eurocontrol.int/safety/gallery/content/public/EEC_note_2006_11.pdf>.

Safety culture is important in air traffic management (ATM) even when other elements of a safety management system (SMS) are already in place, according to this report based on a survey of 52 staff members of European air navigation service providers (ANSPs). "The results suggest that whilst a good SMS is necessary, it may not be sufficient," the report says.

Although the term "safety culture" has been used over the past few years in ATM, it is not always clear what it means in that context. The report is intended to clarify the concept, based on the results of the survey, which was administered by interviewers. "The various interview results were pooled to generate a large list of issues," the report says. "Several of the analysts were involved in clustering these into a set of comprehensive safety culture elements."

Safety culture elements, which were also categorized into sub-elements, comprised "safety management commitment," "trust in organizational safety competence," "involvement in safety," "ATCO [air traffic controller] safety competence" and "a just, reporting and learning culture." Analyzing statements extracted from the interviews, the researchers found examples of practices that "enable" or "disable" safety culture in each sub-element.

For example, in the sub-category of "communication about changes," disabler examples include "new procedures are issued by staff notice"; "there is only one accessible computer with the information and no verification that controllers understand"; and "people sometimes forget to do the computer-based briefing before [a] shift."

In the same sub-category, enabler examples include "safety briefing by station manager with team outlines new staff notices, new activities, restrictions, etc."; "for big changes, controllers are given training in simulations"; and "maintenance engineers communicate with controllers before touching a system."

Birdstrike Risk Management for Aerodromes

U.K. Civil Aviation Authority, Safety Regulation Group. CAP 772. First edition. March 2007. 48 pp. Figures. Available via the Internet at <www.caa.co.uk/docs/33/CAP772.pdf> or from The Stationery Office.*

"The bird strike risk is not uniform across all types of aerodromes and flight operations, and therefore it is essential that the most appropriate measures are identified and adapted to suit the local situation," the report says. "Effective techniques in risk assessment, bird control, habitat management and safeguarding exist that can reduce the presence of birds on aerodromes and the risk of a bird strike."

Risk identification is an important prerequisite to risk reduction. "The level of ambient bird strike risk, which is the level and type of bird activity that would occur in the absence of any monitoring or control measures, should be determined," the report says. Without this baseline measurement, it is hard to gauge the effectiveness of risk reduction techniques.

The assessment process typically involves, among other things, identifying bird species and habitats in the area; the probability of a strike with each species, considering current mitigation procedures and seasonal factors; the size and numbers of each species, including whether the birds are solitary or in flocks; and the frequency of serious strikes involving multiple birds. Taking all factors into account, the acceptability of the level of risk can be plotted on a matrix with scales for severity and probability, both ranging from very low to very high.

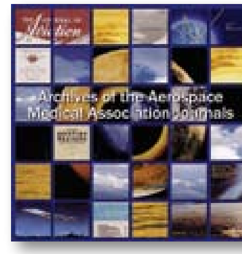
The chapter on risk reduction includes sections on habitat management, bird dispersal and safeguarding — keeping an eye on new or proposed land-use development outside the airport perimeter that could attract birds to the area.

Managing the habitat that offers birds food or security can in some cases be as important as dispersion. The report calls management of grass areas "the most effective habitat control measure," with both short and tall grass attracting birds, and recommends maintaining grass at a height of 100 to 200 mm (4 to 8 in). Management might include eliminating or reducing the fruit- and berry-producing plants that attract birds. Other techniques include clearing out buildings or structures that invite roosting, draining standing water, piping water streams underground, and blocking landfill and sewage sites from birds.

Noise can be useful in dispersal, but the noise must be one that the birds do not become quickly habituated to, the report says. Birds have their own "language" for warning one another, and effective sounds include recorded signals from other birds that indicate danger or distress, such as when captured by a predator. Distress cries are usually most effective when they come from a bird's own species, the report says. Waterfowl are mostly immune from dispersal through sound: "They feel secure on the water and, if threatened, tend to remain there."

For those whose bird knowledge could use a boost, the final chapter, "Aerodrome Ornithology," offers guidance in identification, biology and behavior by species.

ELECTRONIC MEDIA



Archives of the Aerospace Medical Association Journals

This DVD contains 73 years (1930–2002) of full-text articles from three magazines — *Aviation, Space, and Environmental Medicine* and its two preceding titles, *Aerospace Medicine* and *The Journal of Aviation Medicine.* All have been published by the Aerospace Medical Association.

Special features help researchers quickly access the 16,691 titles: an index for browsing by publication date, article title, author and magazine, plus basic and advanced search capability. Articles may be printed, saved or read on the computer monitor. Articles include tables, figures and references as they appeared in print.

The DVD is priced separately for members, nonmembers and institutions. Order information is available at the association's Web site, <www.asma.org>, or from Sheryl Kildall at <skildall@asma.org>.

WEB SITES

Aerospace Medical Association (AsMA), www.asma.org

AsMA is an international organization with a "membership [that] includes aerospace medicine specialists, flight nurses, physiologists, psychologists, human factors specialists and researchers in this field. Most are with industry, civil aviation regulatory agencies, departments of defense and military services, the airlines, space programs, and universities."

AsMA describes aerospace medicine as a "branch of preventive medicine that deals with the clinical and preventive medical requirements of man in atmospheric flight and space." This description, an overview of major issues affecting those who function in the "abnormal environment encountered in aviation and space," and information about a career in this unique

field of medicine are available to members and nonmembers in "This Is Aerospace Medicine," a 63-slide presentation, posted on the Web site.

The publications section of the Web site contains other items free to nonmembers. Some are written for travelers; some, such as *Medical Guidelines for Airline Travel* (second edition, May 2003, 22 pp.) are directed to medical professionals. AsMA says the document was written for "physicians [who] need to understand the world of commercial flight, environmental and physiological stresses, and vaccination requirements in order to properly advise patients." The guidelines address specific medical conditions that may be pre-existing or manifest in flight.

Portions of AsMA's peer-reviewed journal, *Aviation, Space, and Environmental Medicine,* are available free to nonmembers — tables of contents and abstracts of monthly issues, plus selected full-text articles. *Medical News*, a section of the journal that informs readers about organizational and medical news, is also online at no charge.

Links to constituent and affiliated organizations with purposes and objectives similar to those of AsMA, such as the Aviation Medical Society of Australia and New Zealand, and related professional and commercial organizations are included at the Web site. Its multi-media online bookstore sells items of interest to members and nonmembers.

(Editorial note: Dr. Russell B. Rayman, executive director of the Aerospace Medical Association, is a member of the *AeroSafety World* editorial advisory board.)

Halldale Media Group, www.halldale.com

Halldale publishes products for the training and simulation industry that serves aviation. The Halldale Web site provides several aviation products free and online.

Current and archived full-text issues of *CAT: The Journal for Civil Aviation Training* are available in digital format and can be read online or printed. Halldale says that *CAT* has a regional and international focus in its reporting on "training challenges and solutions" for commercial aviation.

The World and Regional Aviation Training Conference and Tradeshow (simultaneous programs focusing on airline pilot, cabin crew and maintenance training, referred to within the industry as WATS/RATS) "brings together leading aviation training companies to discuss the evolution of training equipment, regulations and processes," according to the Web site. In addition to providing information about upcoming events, the site provides complete presentations from the previous conference. Two examples of agenda items from the 2007 event are "Pilot Technology-Driven Training: The New Aircraft and System Challenges" and "WATS/RATS Pilot Air Carrier Training Insights."

Presentations from the same conference addressing cabin crew subjects such as "Safety, Egress/Emergency Evacuation Training" are offered online to be read or downloaded. Some presentations contain audio and video clips. Proceedings from the 2007 maintenance conference are also available.

Likewise, there are full-text presentations from the 2006 European Aviation Training Symposium, which focused on suppliers of training products to the European air transport market. "Safety and Unexpected In-Flight Events" and "Advances in Flight Training Technology" were two of several session topics discussed.

Free international directories and guides to providers of simulation equipment, training products and services are provided through the <halldale-directories.com> Web portal and on CD.●

Source

* The Stationery Office
P.O. Box 29
Norwich NR3 1GN, United Kingdom

— *Rick Darby and Patricia Setze*

In-flight Depressurization

Cargo door seal was installed incorrectly.

BY MARK LACAGNINA

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

JETS

Crew Conducts Emergency Descent

Airbus A330-300. No damage. No injuries.

Soon after departing from Dublin, Ireland, at 1241 local time on Aug. 18, 2005, for a flight to Shannon International Airport, the flight crew observed an "ENG 1 BLEED LOW TEMP" warning on the electronic centralized aircraft monitor (ECAM). "The ECAM actions were carried out, but the indication remained," said the report by the Irish Air Accident Investigation Unit (AAIU).

As the aircraft climbed through 10,000 ft, the captain noticed that cabin altitude was an unusually high 4,900 ft. He decided to continue the flight at 10,000 ft rather than climb to 16,000 ft, as planned. The aircraft was landed without further incident at 1317.

A postflight report (PFR) generated by the aircraft maintenance computer indicated a no. 1 engine bleed problem and a cross-bleed problem. "There was no reference on the PFR to a pressurization problem," the AAIU report said. A test of the bleed management computer for the no. 1 engine revealed a fault that subsequently had been cleared. Nevertheless, the bleed management computer was replaced. After the engine bleed, cross-bleed and pressurization systems were checked by engineers, the aircraft was released for service. "The engine bleed and pressurization systems were again checked by the flight crew, and all indications were normal, with the aircraft pressurizing normally," the report said.

The aircraft then departed from Shannon, at an unspecified time, with 237 occupants for a scheduled flight to New York. While climbing to cruise altitude, the crew observed cabin altitude increasing through 7,500 ft and reduced the rate of climb. As the aircraft was being leveled at Flight Level (FL) 350 (approximately 35,000 ft) over the Atlantic Ocean, cabin altitude increased through 8,500 ft. The crew changed the pressurization mode from automatic to manual but were unable to control cabin altitude. At about 1515, they requested and received clearance from air traffic control (ATC) to descend and return to Shannon.

Cabin pressure then increased to nearly 10,000 ft, and an ECAM warning was generated. The crew donned their oxygen masks, declared PAN and conducted an emergency descent to 10,000 ft. "On completion of the checklists, the flight crew conducted a full [analysis] of the situation and, having considered all options, including burning off fuel, etc., decided to prepare for an overweight landing at Shannon and to land as soon as possible," the report said.

The crew requested and received vectors from ATC for a long final approach to Runway 24, and landed the aircraft uneventfully at 1623. "Neither the passengers nor the crew reported any ill effects," the report said.

The door seal had been installed "inside out and upside down."

Engineers visually inspected the cabin pressure outflow valve and found no abnormalities. Then they inspected the aft cargo door seal, which had been replaced two days before the incident flight by the airline's maintenance contractor in Dublin. The report said they found that the door seal had been installed "inside out and upside down," preventing inflation of the seal by pressurized air in the cargo hold. Pressurized air normally enters through 2-mm (0.1-in) holes in one side of the seal; because of the incorrect installation of the seal in the incident aircraft, the holes faced the outside of the aircraft. This resulted in a pressurization leak through the unsealed cargo door.

Windshield Emits Smoke and Flames

Bombardier CRJ200. Minor damage. No injuries.

The aircraft was climbing through 17,000 ft after departing from Asheville, North Carolina, U.S., for a scheduled flight with 30 passengers to Covington, Kentucky, on March 19, 2006, when the captain smelled smoke. "A few seconds later, flames and smoke started shooting out of the lower left [side of the] windshield," said the U.S. National Transportation Safety Board (NTSB) report.

The captain told the first officer to turn off the windshield heating system. This eliminated the flames, but the smoke persisted. The crew declared an emergency and returned to Asheville Regional Airport, where the aircraft was landed without further incident.

Postflight examination of the aircraft revealed overheat damage to the windshield near a terminal block for the windshield heating system. "The overheat damage was the result of an improperly installed fastener that resulted in arcing between the terminal block lug, the aircraft wiring eyelet, and the fastener and lock washer that secure the two components together," the report said. "The arcing progressed over time, degrading the solder junction between the terminal block and the windshield heating system braid wire [and resulting] in heat damage to the sealant and the subsequent flame."

Catering Vehicle Struck During Pushback

Boeing 737-700. Substantial damage. No injuries.

The aircraft was being prepared for departure from Chicago for a scheduled flight with 105 passengers to Tampa, Florida, U.S., the morning of July 8, 2005. The driver of a catering vehicle that had serviced the 737's aft galley was awaiting marshalling assistance to back the vehicle away from the aircraft, the NTSB report said.

The driver of another catering vehicle parked behind the aircraft and exited the vehicle to assist the driver who had serviced the 737. He then returned to the vehicle and prepared to drive it away from the aircraft.

Meanwhile, however, the operator of the pushback vehicle, who was not aware of the catering vehicle behind the aircraft and who had not received the "clear for pushback" signal from the aircraft marshaller (wing walker), began the pushback. The marshaller, who was in sight of the pushback vehicle operator, gave the hand signal to stop the pushback. "I put up the stop signal and yelled 'stop,' but the plane kept on being pushed," he said.

The section of the aircraft near the auxiliary power unit (APU) door struck the catering vehicle and tipped it over onto its side; the driver was not injured. The flight crew said that they "did not feel any jolts or unusual aircraft movement" when the impact occurred. However, after noticing that the APU had stopped operating, they discontinued the engine-start procedure and halted the pushback.

NTSB said that the probable cause of the accident was "the pushback tow driver not maintaining visual lookout for the wing walker's visual signal."

No Explanation for Cockpit Blackout

British Aerospace BAe 146-300. No damage. No injuries.

The aircraft was en route from London to Inverness, Scotland, with 71 passengers aboard on the night of Nov. 8, 2006. Soon after the APU was started during descent, there was a loss of electrical power to the primary flight displays, navigation displays and cockpit lighting, said the U.K. Air Accidents Investigation Branch (AAIB) report.

The flight crew declared an emergency and reported the situation to ATC. They flew the aircraft in visual meteorological conditions (VMC) above the clouds while troubleshooting the problem.

"The commander 'worked backwards' and switched the APU off," the report said. "Generator 1 (GEN 1) and Generator 4 (GEN 4) were then reset, and electrical power to all the flight deck displays returned to normal." The cabin crew reported that galley power had been lost momentarily but the cabin lights had remained illuminated. "At no stage were any circuit breakers found to be tripped," the report said.

The flight crew conducted an instrument landing system (ILS) approach and landed without further incident at Inverness. "On the ground, the only fault which could be identified was a possible problem on the ground service bus," the report said. Replacement of the no. 1 generator control unit eliminated the problem. "The aircraft was returned to service, from which time it has continued to operate without any recurrence," the report said. The AAIB and the aircraft manufacturer were unable to determine conclusively what caused the loss of electrical power.

Smoke Enters Flight Deck — Twice

Avro 146 RJ100. Substantial damage. No injuries.

The aircraft was descending to land at Edinburgh, Scotland, the night of Sept. 20, 2006, when smoke began to fill the flight deck. The crew observed low oil pressure in the no. 2 engine and shut down the engine, the AAIB report said.

After the Avro was landed and the 51 passengers were deplaned, the aircraft was ferried to the airline's maintenance base in Birmingham, England, where the no. 2 engine was replaced. During departure, smoke again filled the flight deck after the flight crew shut down the APU and selected engine air. "Engine air was quickly turned off and APU air selected," the report said. "The APU was then restarted, and, as the APU air entered the aircraft, the smoke started to clear very rapidly." The crew returned to Birmingham and landed without further incident.

"It was concluded that, on the first occasion, a bearing failure led to seal damage and contamination of the air conditioning system," the report said. "It appeared that residual oil in the system, resulting from the initial failure, had not been eliminated during the rectification and was responsible for the second event."

Aluminum Plate Strikes Tail During Taxi

Boeing 737-300. Substantial damage. No injuries.

The airplane was being taxied for departure from La Guardia Airport in New York on June 8, 2006, when the right horizontal stabilizer was struck by an aluminum plate. The NTSB report said that the plate, which measured 25 in by 60 in (64 cm by 152 cm) had been left on the taxiway by workers performing taxiway maintenance.

"The plate was supposed to have been a thicker and, hence, heavier steel plate to prevent it from being affected by the jet blast from taxiing airplanes," the report said. "Guidance to the construction company regarding the use of such plates was provided by the FAA [U.S. Federal Aviation Administration] and the airport authority."

Controller Error Blamed for Incursion

Airbus A330-300, Boeing 737-300. No damage. No injuries.

Operations on intersecting runways were being conducted in VMC at Boston Logan International Airport the afternoon of June 9, 2005. The local east controller (LCE) was responsible for operations on Runway 04R and Runway 09, and the local west controller (LCW) was responsible for operations on Runway 04L and Runway 15R, the NTSB report said. Runways 04L and 04R were being used for landings, and Runways 09 and 15R were being used for departures.

Because Runway 15R intersects the other three runways, the LCW was required to receive a release from the LCE before clearing an aircraft to take off on Runway 15R. After providing a release, the LCE was required to

"As the APU air entered the aircraft, the smoke started to clear very rapidly."

cease operations on the other runways until the aircraft departed from Runway 15R.

The LCW received a release from the LCE before clearing the Airbus, which had 340 people aboard, for takeoff on Runway 15R. Five seconds later, the LCE cleared the Boeing, which had 108 people aboard, for takeoff on Runway 09. The 737 first officer said that he had just called "V_1" when he saw the A330 rotating near the intersection. "He told the captain to 'keep it down' and pushed the control column forward," the report said. "He further stated: 'The Airbus passed overhead our aircraft with very little separation, and once clear of the intersection, the captain rotated, and we lifted off towards the end of the runway. I reported to departure control that we had a near miss, at which time [a flight crewmember aboard the A330] reported, 'We concur.'"

The LCE told investigators that he had been very busy and had forgotten that he had given the LCW a release for the A330's departure. NTSB said that the probable cause of the runway incursion was the LCE's failure to follow standard operating procedures.

Engine Surges Involved in Control Loss

Gates Learjet 35. Substantial damage. No injuries.

Nighttime VMC prevailed on March 22, 2006, when the flight crew began a "standing-start" takeoff from Runway 27L at Philadelphia International Airport for a cargo flight. The pilot held the wheel brakes until the engines spooled up to 70 percent N_2, high-pressure rotor speed, then released the brakes and increased power.

The NTSB report said that the pilot disengaged the nosewheel steering system when the copilot called out "airspeed alive" at about 60 kt. Airspeed was about 95 kt when the airplane began to turn right. "The copilot noticed fluctuations with the engine indications and called for an abort," the report said. "The pilot reduced the power to idle and corrected back to the left using left rudder pedal and light braking. The airplane then turned to the right again, and the pilot corrected once again to the left. The airplane continued to turn left and departed the left side of the runway, tail-first, at a 45-degree angle." The right main landing gear collapsed, and the right wing-tip tank struck the ground before the Learjet was stopped.

NTSB said that surging of the left engine during takeoff and the flight crew's subsequent loss of control of the airplane resulted from the operator's inadequate maintenance of the engine's fuel computer harness. Company maintenance records indicated that the harness had been checked six days before the accident. However, investigators found several discrepancies, including deteriorated and missing shielding, corrosion, a worn ground wire and a broken connector pin.

TURBOPROPS

Barrel Roll During Missed Approach

Beech King Air A90. Destroyed. No injuries.

Daytime instrument meteorological conditions prevailed on Aug. 22, 2006, when the pilot flew his King Air from Weston, Ireland, to Knock to practice instrument approaches and gain familiarity with an integrated avionics system that had been installed in the airplane. The pilot had 743 flight hours, including 95 flight hours in type. His passenger had about 2,000 flight hours in multiengine airplanes, had previously owned a King Air and was familiar with the avionics system.

The AAIU report said that weather conditions worsened as the airplane neared Knock. Visibility was 4,400 m (2 3/4 mi) with light rain, and ceilings were broken at 100 ft and overcast at 500 ft. ATC cleared the pilot to conduct an ILS approach to Runway 27. The pilot told the controller that he would discontinue the approach 600 to 700 ft above the airport and go around for another approach. The controller told the pilot to initiate the missed approach with a right turn and climb to 3,000 ft while navigating directly to the initial approach fix.

The pilot hand-flew the ILS approach to 1,400 ft, about 735 ft above the airport, and began the missed approach. He said that he retracted the landing gear, partially retracted the flaps and was climbing straight out at about 140 kt when he felt a sudden jolt and the aircraft rolled right, beyond 90 degrees of bank, and did not respond to aileron input. "He said that he did not believe he had become distracted and that he was very conscious of what he was doing," the report said. "The [passenger] joined [the pilot] on the controls during the upset, and he let him take control, as [the passenger] was a much more experienced pilot."

The passenger said that he had been examining a chart when he glanced up and noticed the excessive bank angle; he did not feel a jolt or any significant turbulence. He said that application of left aileron had little effect, and he decided to continue the right roll. "Due to his position in the cockpit, he was unable to reach the throttles, which were at a high power setting," the report said. "As the aircraft rolled inverted … he could see the roof of the canopy getting darker as they neared the ground. He continued the roll until brightness showed in the canopy again, applying full back pressure to the controls." The passenger said that during recovery, airspeed increased to between 280 and 300 kt, and aerodynamic loading reached about 5 g.

The King Air was flown back to Weston and landed without further incident. The pilot said that he did not see anything wrong with the aircraft and was surprised when his mechanic later told him about the damage, which included buckled skin on the wings and empennage. The report said that the underlying structural damage likely was beyond economic repair.

Weather Below Approach Minimums

Swearingen Merlin. Destroyed. One fatality, four minor injuries.

The pilot was conducting a private flight from Beaumont, Texas, U.S., to Craig Airport in Jacksonville, Florida, the morning of Nov. 27, 2003. His four children were aboard as passengers. The pilot knew before departure that weather conditions were below the approach minimums at Craig Airport and, nearing Florida, was told by an air traffic controller that the fog at the airport was not expected to lift for at least an hour and a half, the NTSB report said.

The pilot also learned that the airport in nearby St. Augustine was reporting clear skies and 2 mi (3,200 m) visibility, and that aircraft were landing at Jacksonville International Airport, which had a runway visual range (RVR) greater than 6,000 ft (1,800 m). The pilot told ATC that he would "take a look at Craig" and that he had the current automatic terminal information service information, which included a vertical visibility of 100 ft and 1/4 mi (400 m) horizontal visibility. He requested and received vectors for the ILS approach to Runway 32, which had a decision height of 241 ft and a minimum visibility of 1/2 mi (800 m).

Recorded ATC radar data indicated that the Merlin descended below the ILS glideslope during final approach. The airplane struck trees, rolled right and struck the ground 1.8 nm (3.3 km) from the airport at 0752 local time. The pilot was killed; the passengers received minor injuries.

Power Loss Traced to Gearbox Malfunction

British Aerospace Jetstream 32. Substantial damage. No injuries.

The aircraft was on a scheduled passenger flight from Mount Gambier, South Australia, to Adelaide the afternoon of Dec. 23, 2005. During a shallow turn at FL 120, about 93 km (50 nm) east of Adelaide, the right engine surged twice and then stopped, said the report by the Australian Transport Safety Bureau (ATSB).

The flight crew secured the engine and requested and received clearance from ATC to fly directly to Adelaide and to descend to 10,000 ft. Before beginning the descent, the crew attempted an automatic and a manual restart. "During these attempts, the engine would rotate and the propeller would unfeather, but the engine would not start," the report said. The crew conducted a single-engine landing without further incident.

"The engine would rotate and the propeller would unfeather, but the engine would not start."

Examination of the engine revealed two damaged gears in the propeller reduction gearbox. A tooth on one gear was fractured, and several others were worn; all the teeth on the gear to which it mated were missing.

The report said that the operator had purchased the engine from the manufacturer and installed it on the Jetstream on Dec. 20, 2005. The gear with the lesser damage had been installed new by the manufacturer during a continuing airworthiness maintenance inspection in October 2005; the gear with the stripped teeth had been in the gearbox since the engine was manufactured. The engine had accumulated 6,258 operating hours since manufacture, including 16 operating hours since its installation on the Jetstream.

ATSB said that accelerated tooth wear on the more extensively damaged gear likely resulted from "the mating of new and worn components," but it could have been initiated by a foreign object in the gearbox.

PISTON AIRPLANES

Hypoxia Likely Caused Control Loss

Cessna 404. No damage. No injuries.

The unpressurized aircraft departed from San Pedro Airport, Cape Verde Islands, at 1855 local time for a private flight to Dakar, Senegal, on Dec. 16, 2006. The U.K. AAIB report said that the pilot did not continuously use supplemental oxygen above 10,000 ft during the climb to, and initial cruise at, FL 210. The passenger said that the pilot took off his oxygen mask several times. The pilot told investigators that he took off his oxygen mask to respond to a perceived engine problem at about 1930.

"He was probably suffering from hypoxia when he attempted to adjust his engine controls, and this resulted in vibration and an uncontrolled descent," the report said. The passenger said that he heard a change in engine noise and felt the vibration before the aircraft began to descend at high speed and in a spiral. He called the pilot twice on the intercom system. The aircraft was descending through 5,000 ft when the pilot responded to the passenger's second call.

After regaining control of the airplane, the pilot requested and received clearance from ATC to divert to Amilcar Cabral Airport, Cape Verde Islands. He landed there without further incident at 2005. The pilot said that he likely began experiencing hypoxia during the climb and that the perceived engine problem probably had resulted from the engine controls being improperly set for cruise flight.

Cannabis Consumption Noted in CFIT Probe

Piper Seneca II. Destroyed. Three fatalities.

The airplane was chartered for a sightseeing flight from Ardmore to Kerikeri to Taupo, on New Zealand's North Island, the morning of Feb. 2, 2005. Although the operator told the two passengers that weather conditions were not good, they elected to take the flight as planned, said the report by the New Zealand Transport Accident Investigation Commission.

The pilot conducted two instrument approaches to Kerikeri but was unable to land because of the weather conditions. He requested and received clearance from ATC to proceed to Taupo, which was reporting 50 km (31 mi) visibility and a broken ceiling at 4,000 ft. Before the pilot began the descent, the controller asked which instrument approach procedure he intended to fly. The pilot said that he would conduct the NDB/DME (nondirectional beacon/distance measuring equipment) approach.

Before beginning the approach, the pilot was told by an airport Unicom operator that the weather was "closing in a bit." Visibility was 7,000 m (4 mi), and there were a few clouds at 1,000 ft and a broken ceiling at 2,000 ft. The minimum descent altitude for the circling approach was 1,940 ft, and minimum visibility was 2,800 m (1 3/4 mi).

After turning inbound, the aircraft's ground track deviated increasingly left of the intermediate and final approach tracks. When the pilot reported crossing the final approach fix — his last radio transmission — the Seneca was about 6 km (3 nm) left of the fix. The aircraft was at 2,600 ft about 30 seconds later when it struck a mountain 8 km (4 nm) from the airport.

Investigators found no anomalies with the navigation aids, and no likely sources of signal interference were identified. "No obvious cause for the accident could be determined," the report said. "Autopsy reports showed the pilot had consumed cannabis [marijuana], probably between 12 and 24 hours before the accident. While cannabis can adversely affect a person's ability to operate an aircraft, its effects can vary greatly; so, this could not be conclusively identified as a cause of this accident."

Icing Triggers Stall on Departure

Cessna T310R. Destroyed. One fatality.

Moderate icing conditions prevailed on the pilot's normally scheduled cargo route in Arizona, U.S., on Dec. 7, 2004. The pilot landed in Flagstaff, which had 1 1/2 mi (2,400 m) visibility and a 300-ft overcast, at 1826 local time and requested that the airplane be deiced. The line service technician who deiced the 310 said that there was a substantial amount of ice on the airplane and that light snow continued to fall at the airport until the airplane departed more than an hour later.

Witnesses said that the airplane rotated about 5,000 ft (1,524 m) down the 7,000-ft (2,134-m) runway and that one or both of the engines sounded very rough. The airplane was descending in a wings-level and slightly nose-high attitude when it struck a highway embankment 2 nm (4 km) from the airport. Elevation of the accident site was 6,798 ft — 200 ft lower than airport elevation.

The NTSB report said that the operator kept a truck on standby at the airport to transport the cargo if it could not be flown because of weather conditions or a mechanical problem. However, entries in the pilot's journal indicated that he perceived considerable pressure to operate the 310, which did not have deicing boots, in icing conditions. "There was insufficient information from which to determine whether the company culture condoned or encouraged this behavior," the report said.

NTSB said that the probable cause of the accident was the pilot's decision to attempt flight in known adverse weather conditions and with ice and snow that had accumulated on the airplane while it was on the ground.

HELICOPTERS

External Line Strikes Tail Rotor

Messerschmitt-Bolkow-Blohm BO 105. Destroyed. One serious injury.

After completing 27 cargo flights from a coast guard vessel to a lighthouse in Bella Bella, British Columbia, Canada, on May 7, 2005, the helicopter was returning to the ship with less than 40 kg (88 lb) of gear in the bonnet (sling). The bonnet, which was attached to the helicopter by a 33-m (108-ft) external line, had been lashed closed with a polypropylene rope, said the report by the Transportation Safety Board of Canada.

The helicopter was being flown at about 60 kt when the rope apparently slid up the external line and the bonnet opened. The report said that the bonnet then flew forward, into the helicopter's flight path, and the external line struck and disabled the tail rotor. The pilot was unable to deploy the emergency flotation system before the helicopter struck the water and sank.

The report noted that the pilot was wearing his lap belt but not the upper-body restraints; his helmet, which was fractured during the impact, protected his head from severe injury. "The pilot was able to exit the sunken helicopter but remained face down in the water," the report said. "He was wearing an uninflated lifejacket. The pilot was rescued within three minutes and revived, but remained in critical condition for several days."

Unattended Helicopter Rolls Over

Bell 206B. Substantial damage. No injuries.

While preparing the helicopter to pick up passengers for a sightseeing flight in Boulder City, Nevada, U.S., the morning of Nov. 11, 2006, the pilot started the engine and completed the preflight checks. After checking generator load, he left the engine running at 100 percent rpm to charge the battery, the NTSB report said.

"The pilot exited the helicopter with the engine running and the rotors turning to disconnect the APU and to move it away from the helicopter," the report said. "While moving the APU, the pilot heard the engine sound change, turned around and saw the front skids lifting off the ground." The helicopter then moved backward and rolled down an embankment. ●

Preliminary Reports

Date	Location	Aircraft Type	Aircraft Damage	Injuries
June 1, 2007	Zurich, Switzerland	Gulfstream G-V	minor	9 none
The nose landing gear did not extend on approach, and the flight crew conducted a go-around. Attempts to extend the nose gear were unsuccessful, and the crew landed the G-V with the nose gear retracted.				
June 3, 2007	Kashira, Russia	Robinson R44	substantial	1 fatal, 2 serious
The helicopter crashed under unknown circumstances during a local flight from Moscow. The pilot was killed.				
June 4, 2007	Milwaukee	Cessna Citation II	destroyed	6 fatal
Soon after departing on an air ambulance flight, the flight crew declared an emergency, reporting a runaway trim condition. The crew was attempting to return to Milwaukee when the airplane struck Lake Michigan.				
June 5, 2007	Simiti, Bolivar, Colombia	Bell 206L-3	substantial	2 fatal, 4 serious
Instrument meteorological conditions (IMC) prevailed when the helicopter struck mountainous terrain at 1,000 ft. The pilot and copilot were killed.				
June 10, 2007	Santa Barbara, California, U.S.	Dassault Falcon 900	substantial	15 none
The captain said that although he eventually pulled the control column back to his chest, the airplane did not rotate. The crew rejected the takeoff, but the Falcon overran the runway.				
June 13, 2007	Guipuzcoa, Spain	Bell 212	destroyed	2 fatal
IMC prevailed when the helicopter struck terrain during a positioning flight from Santander to Alicante.				
June 16, 2007	Chelinda, Malawi	Cessna U206F	destroyed	6 fatal
The airplane was on a sightseeing flight when it struck high terrain in visual meteorological conditions (VMC).				
June 26, 2007	Placitas, New Mexico, U.S.	Beech 58 Baron	destroyed	1 fatal
VMC prevailed when the Baron struck a mountain at about 10,000 ft during a business flight from Torrance, California, to Clinton, Oklahoma.				
June 18, 2007	Blenheim, New Zealand	Beech 1900D	substantial	17 none
The crew reported an unsafe landing gear indication on approach to Wellington. They diverted to Blenheim and conducted an intentional wheels-up landing.				
June 20, 2007	Boston	Embraer 135	minor	41 none
The crew observed a "landing gear lever disagree" warning during the flare and rejected the landing at Logan International Airport. The flaps were damaged when the airplane contacted the runway, gear-up, during the go-around. The crew manually extended the gear and landed at Logan without further incident.				
June 21, 2007	Kamina, Democratic Republic of Congo	LET 410	substantial	1 fatal, 24 NA
The airplane struck terrain on takeoff and came to a stop upside down in a swamp.				
June 23, 2007	Naryn, Kyrgyzstan	Yakovlev 40	destroyed	13 NA
Engine problems occurred after takeoff from Ysykkul Airport. The crew shut down two of the three engines and conducted an emergency landing in a field. There were no fatalities.				
June 25, 2007	Sihanoukville, Cambodia	Antonov An-24RV	destroyed	22 fatal
The airplane struck a mountain at 1,640 ft during approach.				
June 25, 2007	Treviso, Italy	Boeing 737-800	NA	181 none
The crew heard a loud bang during the landing. The nose landing gear axle had fractured, and the left nosewheel had separated.				
June 28, 2007	M'banza Congo, Angola	Boeing 737-200	destroyed	6 fatal, 73 NA
The 737 touched down about halfway down the 1,800-m (5,906-ft) runway, overran the runway and struck vehicles and buildings. The fatalities included one person on the ground.				
June 30, 2007	Saltillo, Mexico	North American Sabreliner 40	substantial	4 NA
The airplane landed long and overran the runway onto rocky soil. There were no fatalities.				
June 30, 2007	Conway, Arkansas, U.S.	Cessna Citation	destroyed	1 fatal, 1 NA
The Citation landed long on the 4,875-ft (1,486-m) runway, and the pilot attempted to go around. The airplane overran the runway and struck a building, killing the pilot.				

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.

International Federation of Airworthiness

Flight Safety Foundation

International Air Transport Association

Joint meeting of the FSF 60th annual International Air Safety Seminar IASS,
IFA 37th International Conference, and IATA

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