AeroSafety WORLD

CRIMINALIZATION CONFLICT
Presenting a united front

MU-2B EXAMINED, AGAIN
Training, operating rules proposed

SAFETY ROADMAP STRATEGY
Implementation details

FEATHERED RISKS
Bird strikes soar

737 PRESSURIZATION CRASH
HELIOS CREW MISSED OPPORTUNITIES

THE JOURNAL OF FLIGHT SAFETY FOUNDATION

JANUARY 2007

Connections

As a young man, I dreamed of being the pilot who saves the day with his spectacular airmanship, the controller with the brilliant flight assist or the mechanic who discovers a hidden defect and saves hundreds of lives. In those days, we never talked about systems; safety was all about the individual or the latest safety technology.

But our industry has grown up, and we now understand, more than ever, the importance of systems. I've outgrown the idea of the spectacular individual save and realize that the best shot at improving safety today is to plug a few gaps by connecting people and systems together. That is why I want to talk about the importance of connections.

There are many important connections in our industry, but this month I am going to focus on the connection between the regulator and the operator.

A safety management system (SMS) deals with critical connections between operators, management systems and production systems, but it doesn't deal with the new relationship that must exist between the regulator and the operator. That new relationship is one of the major motivations behind the creation of the new International Civil Aviation Organization Standards and Guidance material.

Under those standards, which are now in effect, it is not good enough just to say, "My airline has an SMS." The regulator and the airline have to be able to stand together and talk about how their systems connect from the regulator, through management, to the operation. I was responsible for those standards when I was with ICAO, so I can tell you firsthand that was the intent. It is a change for all of us and a big opportunity for lasting progress. Those standards can be found at <www.icao.int/anb/safetyManagement/Documents.html>.

It doesn't do much good to talk about a new system of connections if you don't have a plan to get there. That is what the ICAO/Industry Global Aviation Safety Roadmap is about. You can read more about the Roadmap in this issue of *AeroSafety World* (see page 28). Let me tell you about the philosophy that drove its creation.

A large cross section of the aviation industry realized that progress in terms of safety systems and connections depends on all of us working together. So we wrote a plan that shows how to systematically develop implementation strategies for regions, operators and governments in a way that finally will bring together all the pieces and forge lasting connections that will serve safety for decades.

Not only did this broad cross section of industry devote considerable time and resources to the creation of this plan, they actually committed to follow it. It will become the guiding document that ICAO and the aviation industry refer to when safety improvements are contemplated. The first priorities for the industry will be those investments and activities that support the coordinated development of safety systems around the world, as outlined in this plan. This is a big step. Historic competitors and groups with diverse interests have put aside old differences to make real commitments to act as one. They are doing this to create the connections that will define our future.

William R. Voss
President and CEO
Flight Safety Foundation

AeroSafetyWORLD

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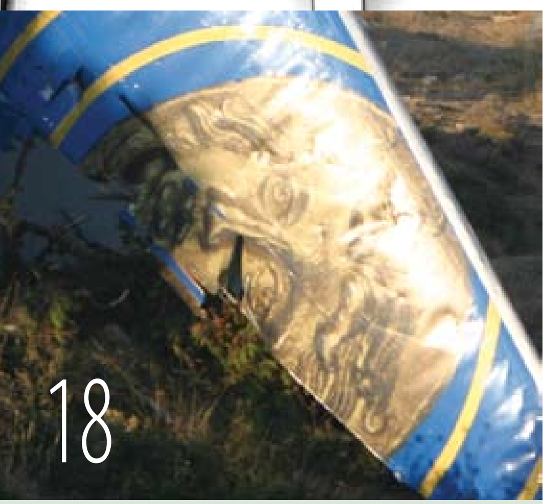

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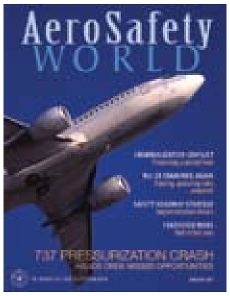

About the Cover
Misset controls doomed a Helios 737.
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If you have an article proposal, manuscript or technical paper that you believe would make a useful contribution to the ongoing dialogue about aviation safety, we will be glad to consider it. Send 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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Flight Safety Foundation

FLIGHT SAFETY FOUNDATION
SINCE 1947

Serving Aviation Safety Interests for More Than 50 Years

Flight Safety Foundation is an international membership organization dedicated to the continuous improvement of aviation safety. Nonprofit and independent, the Foundation was launched officially in 1947 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce positive influence on aviation safety. Today, the Foundation provides leadership to more than 1,000 member organizations in 143 countries.

MemberGuide

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A SLIGHT Adjustment

When *Aviation Safety World* debuted in July, I predicted the publication would evolve as we learned how to handle the new format. Now, seven months down the road, you might have noticed a change when you picked up this journal: We have a new name, *AeroSafety World*. This isn't the sort of change I had in mind.

In many ways the situation that created our need to alter the name was similar to a classic accident scenario, the one that begins with the crew becoming distracted by a minor problem that takes up more and more of the crew's attention until there isn't enough left over to fly the airplane.

In our case so much effort was put into creating a title that had wide acceptance that when consensus finally was achieved everyone relaxed and considered the job done.

Several months after we began publishing the journal, we received a short letter from a publishing firm informing us that they owned a registered trademark on the name "Aviation Safety" and that we were violating that trademark. And, oh, yes, please stop using that title.

A quick check with legal minds expert in the arcane ways of the trademark world confirmed their claim and we started looking for a new name. Thanks to the generosity of the name's owners we were able to continue publishing for several months under the original title while we conducted a proper search, with legal vetting, to make sure the new title was conflict-free.

From its earliest days Flight Safety Foundation was very much a cockpit and aircraft-focused organization. However, as our understanding grew about aviation system impact on safety, the Foundation has given increased attention to issues outside the cockpit. This is one of the reasons that *Flight Safety Digest* did not morph into *Flight Safety World*. "Flight" has a strong association with aircraft and the operation of aircraft. We looked at "aviation" as having a wider scope than "flight," to include air traffic control, airports and the whole aviation system. On this count, we believe "aero" to be nearly synonymous with "aviation."

An additional attribute of the word "aero" is its international flavor. The Foundation has had a global view of aviation safety for many decades, yet the perception persists that it is a North American-centric organization. This is simply not true, and we hope that the story mix in *ASW* helps us drive that fact home.

This new year will bring more changes to *ASW* as we seek an audience beyond the FSF membership base. Probably the first such change will be the launch of an electronic version of the journal, allowing us to expand readership at minimal cost. This expansion will bring *ASW*'s safety messages to a larger number of readers, a good thing in its own right, while making the publication more attractive to advertisers wishing to reach an operations-focused aviation community around the world.

Now that the magazine is up and running we must turn our attention to selling and servicing advertisements, generating revenue to offset the cost of producing a publication of *ASW*'s quality. However, our intention is to maintain advertising opportunities at a level below that commonly seen in commercial publications, where ads often outnumber the editorial pages. In *AeroSafety World*, the safety message will always take precedence over commercial considerations.

Feline Graphics

I just love your new magazine. From a graphics standpoint, it's the "cat's meow." From cover to cover, this is the best aviation safety magazine out there! Every article is great and chock-full of valuable information. Your article "Chilling Effects" [September, page 26] — excellent!

My compliments to your graphic designer for highest quality product. I don't see how you can improve on it, but I will be reading every issue just watching to see it evolve.

Vicki Grimmett
Aviation Graphics
Seattle

Sight and Sound in Passenger Safety Briefings

A fine piece on the question of the effectiveness of cabin safety briefings and passenger attention as reported by Rick Darby based on the Australian Transport Safety Bureau (ATSB) study [November, page 25]. All of us in our air travel no doubt have second-guessed what can be done to get more passengers to pay more attention to briefings and what could enhance them.

An area the study surprisingly does not touch is my pet peeve — the disconnect between the safety briefing information sequence, whether live or video, and the safety briefing/features card.

I'm talking about the sequence of what is being said or demonstrated versus the flow of information on the card. Cards are one page with usually one or two folds with information on both sides. Passenger attention is usually directed to the card by a flight attendant at the start of the briefing and passengers are asked to follow along.

I have yet to find a perfect match, to say the least, and in most cases one has to several times quickly search the card for the item being described in the briefing, scanning among the folds of the card or turning it over and invariably losing the synchronization with the briefing flow.

The result is understandable passenger frustration with the whole briefing procedure, a definite turn-off for giving future attention to safety briefing presentations.

Yes, there could be some graphic difficulty in fitting the ideographs or diagrams in lock-step progression with the briefing but nothing that can't be handled.

The problem could lie in a further disconnect within the airline between the flight operations/cabin service department and the media support group or contractor producing a video or card. Who would have the internal final say on the developed product or procedure? One would expect it to be flight operations/cabin service, but why then does this unsatisfactory situation exist in most airlines?

Bart Crotty
Aviation safety/security consultant
(Former FSF director of aviation safety services)

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

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

FEB. 6–7 (Hong Kong), **FEB. 9** (Nagoya, Japan) ➤ **Asian Business Aviation Conference & Exhibition (ABACE).** National Business Aviation Organization. <convention@nbaa.org>, <www.abace.aero>, +1 202.783.9000.

FEB. 6–7 ➤ 2nd Annual Airline Engineering & Maintenance Conference for the Indian Sub-Continent. Aviation Industry Conferences. Mumbai, India. Daisy Munro, <daisym@aviation-industry.com>, <www.aviationindustrygroup.com>, +44 (0)20 7931 7072.

FEB. 7–11 ➤ Aero India 2007. Ministry of Defence, Government of India; Federation of Indian Chambers of Commerce and Industry; Farnborough International. Bangalore, India. <aeroindia@ficci.com>, <www.aeroindia.in>, +91 11 23357082.

FEB. 12–15 ➤ Annual International Aircraft Cabin Safety Symposium. Southern California Safety Institute. Torrance, California, U.S. Christine Schmitz, <Christine.schmitz@scsi-inc.com>, <www.scsi-inc.com>, +1 310.517.8844, 800.545.3766.

FEB. 13–15 ➤ ATC Maastricht 2007. CMP United Business Media. Maastricht, Netherlands. Sam Weller, <sweller@cmpi.biz>, <www.atcmaastricht.com>, +44 (0)20 7921 8544.

FEB. 13–15 ➤ Safety-Critical Systems Symposium 2007. Centre for Software Reliability. Bristol, England. Joan Atkinson, <joan.atkinson@ncl.ac.uk>, +44 (0)1912 227996.

FEB. 14–16 ➤ 10th Hamburg Aviation Conference. German Airports Association. Hamburg. <www.hamburg-avation-conference.de>, +49 (0)40 50753627.

FEB. 15–17 ➤ 18th Annual Women in Aviation Conference. Women in Aviation International. Orlando, Florida, U.S. Connie Lawrence, <www.wai.org>, +1 937.839.4647.

FEB. 21–22 ➤ 3rd Annual European Airline Engineering & Maintenance Conference. Aviation Industry Conferences. Zurich, Switzerland. Alice Macklin, <alicem@aviation-industry.com>, <www.aviationindustrygroup.com>, +44 (0)20 7931 7072.

FEB. 26–MARCH 1 ➤ CMAC 2007, Civil Military Air Traffic Management Summit. Civil Air Navigation Services Organisation. Bangkok, Thailand. <info@canso.org>, <www.canso.org>, +31 (0)23 568 5380.

MARCH 1–3 ➤ Heli-Expo 2007 Conference & Exhibition. Helicopter Association International. Orlando, Florida, U.S. Marilyn McKinnis, <marilynmckinnis@rotor.com>, <www.heliexpo.com>, +1 703.683.4646.

MARCH 12–14 ➤ 19th annual European Aviation Safety Seminar (EASS): "Staying Safe in Times of Change." Flight Safety Foundation and European Regions Airline Association. Amsterdam, Netherlands. Namratha Apparao, <apparao@flightsafety.org>, <www.flightsafety.org>, +1 703.739.6700, ext. 101.

MARCH 13–14 ➤ 13th Annual Middle East Airline Engineering & Maintenance Conference. Aviation Industry Conferences. Abu Dhabi, United Arab Emirates. Daisy Munro, <daisym@aviation-industry.com>, <www.aviationindustrygroup.com>, +44 (0)20 7931 7072.

MARCH 20–22 ➤ Aviation Industry Expo. National Air Transportation Association and the Professional Aviation Maintenance Association. Orlando, Florida, U.S. Jill Hilgenberg Ryan, <jill.hilgenberg@cygnusexpos.com>, <http://aviationindustryexpo.com>, +1 952.894.8007, 800.827.8009, ext. 3349.

MARCH 20–25 ➤ Australian International Airshow. Aerospace Australia. Victoria, Australia. <expo@airshow.net.au>, + 61 3.5282.0500.

MARCH 26–30 ➤ Worldwide Symposium on Performance of the Air Navigation System. International Civil Aviation Organization Air Navigation Bureau. Montreal. <perf2007@icao.int>, <http://www.icao.int/icao/en/anb/meetings/perf2007/index.html>, +1 514.954.5831.

MARCH 26–29 ➤ 34th Annual International Operators Conference. National Business Aviation Association. San Diego. Dina Green, <dgreen@nbaa.org>, <web.nbaa.org/public/cs>, +1 202.783.9357.

MARCH 27–29 ➤ Aerospace Testing Expo 2007. UKIP Media and Events. Munich, Germany. Ben Drew, <bendrew@ukintpress.com>, <www.aerospacetesting-expo.com>, +44 (0)1306 743744.

MARCH 28–31 ➤ Aircraft Electronics Association 50th Annual Convention & Trade Show. Reno, Nevada, U.S. <info@aea.net>, <www.aea.net>, +1 775.789.2000, 800.501.2651.

APRIL 2–4 ➤ Maintenance Management Conference. National Business Aviation Association. San Diego. Dina Green, <dgreen@nbaa.org>, <web.nbaa.org/public/cs>, +1 202.783.9357.

APRIL 2–5 ➤ 58th Annual Avionics Maintenance Conference. ARINC. Phoenix, Arizona, U.S. Roger S. Goldberg, +1 410.266.2915.

APRIL 4–5 ➤ 8th Annual Airline Line Maintenance Conference. Aviation Industry Conferences. Lisbon, Portugal. <amandap@aviation-industry.com>, <www.aviationindustrygroup.com>, +44 (0)207 931 7072.

APRIL 15–18 ➤ FAA Tech Transfer Conference and Exposition. American Association of Airport Executives, U.S. Federal Aviation Administration, et al. Atlantic City, New Jersey, U.S. Tom Zoeller, <tom.zoeller@aaae.org>, <www.aaae.org>, +1 703.824.0500.

APRIL 16–17 ➤ ACI–NA Public Safety & Security Spring Conference. Airports Council International–North America. Spokane, Washington, U.S. Amy Peters, <apeters@aci-na.aero>, <www.aci-na.org>, +1 202.293.8500.

APRIL 17–19 ➤ MRO 2007 Conference & Exhibition. Aviation Week. Atlanta. Lydia Janow, +1 212.904.3225, 800.240.7645.

APRIL 18–19 ➤ ERA Regional Airline Conference. European Regions Airline Association. Lisbon, Portugal. Paula Bangle, <paula.bangle@eraa.org>, <www.eraa.org/inside-era/RAC07.php>, +44 (0)1276 856495.

APRIL 24–26 ➤ 9th Annual Canadian Airport Management Conference. Airports Council International–North America and Canadian Airports Council. Ottawa. <meetings@aci-na.aero>, <www.aci-na.org>, +1 202.293.8500.

MAY 7–9 ➤ 4th International Aircraft Rescue Fire Fighting Conference. *Aviation Fire Journal.* Las Vegas. <www.aviationfirejournal.com/vegas/contact.htm>, +1 914.962.5185.

MAY 8–10 ➤ 52nd annual Corporate Aviation Safety Seminar (CASS): "Safety — The Foundation for Excellence." Flight Safety Foundation and National Business Aviation Association. Tucson, Arizona, U.S. Namratha Apparao, <apparao@flightsafety.org>, <www.flightsafety.org>, +1 703.739.6700, ext. 101.

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

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

Coping With 'Core Lock'

The U.S. National Transportation Safety Board (NTSB), citing its continuing investigation of a 2004 accident in which a Bombardier CRJ200 crashed near Jefferson City, Missouri, U.S., has issued several safety recommendations regarding "core lock," a rare condition that can freeze an engine core after an in-flight flameout and prevent a windmill restart (see *Aviation Safety World*, July 2006, p. 44).

The captain and first officer — the only people in the airplane during the Oct. 14 Pinnacle Airlines (a subsidiary of Northwest Airlines) repositioning flight from Little Rock, Arkansas, to Minneapolis — were killed, and the airplane was destroyed.

The NTSB investigation has determined that the pilots tried unsuccessfully to restart the General Electric (GE) CF34-3 turbofan engines after a stall and dual-engine flameout at 41,000 ft. The flight crew attempted a windmill restart, which requires airspeed of at least 300 kt; recorded flight data showed that the maximum airspeed during the restart attempt was 236 kt. The core engine speed remained at zero during the attempted windmill restart and during subsequent restart attempts at 13,000 ft using the auxiliary power unit.

As a result of the investigation, NTSB said that the U.S. Federal Aviation Administration (FAA) should, for airplanes with CF34-1 or CF34-3 engines, "require manufacturers to perform high-power, high-altitude sudden engine shutdowns; determine the minimum airspeed required to maintain sufficient core rotation; and demonstrate that all methods of in-flight restart can be accomplished when this airspeed is maintained."

NTSB also recommended that FAA ensure that the flight manuals for CRJ100, 200 and 440 models and for other airplanes with CF34-1 or CF34-3 engines state the consequences of failing to maintain the minimum airspeed required for engine core rotation after a high-power, high-altitude sudden engine shutdown.

Other NTSB recommendations called for a review of the design of other turbine engines to check for susceptibility to core lock. If engines are found to be susceptible, tests should be conducted to determine the minimum airspeeds required to maintain sufficient core rotation to enable an engine restart; the issue should be discussed in airplane flight manuals, NTSB said. If restart is impossible with a core rotation speed of zero, other design or operational means should be provided to enable flight crews to restart the engines. In addition, certification requirements should be established to "place upper limits on the value of the minimum airspeed required and the amount of altitude loss permitted for windmill restarts," NTSB said.

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NTSB Seeks Expanded CRM Training

Crew resource management (CRM) training should be required for on-demand operators that conduct dual-pilot operations, the U.S. National Transportation Safety Board (NTSB) said as it issued its annual "Most Wanted List of Safety Improvements."

"The [NTSB] has investigated several fatal aviation accidents involving Part 135 on-demand operators … where the carrier either did not have a CRM program or the CRM program was much less comprehensive than would be required for a Part 121 [air carriers and commercial operators] program," NTSB said.

NTSB said that although the U.S. Federal Aviation Administration (FAA) has agreed with the basic principles of the recommendation, "no discernable progress has been made."

Other Most Wanted items affecting aviation deal with runway incursions, flammable fuel/air vapors in fuel tanks, aircraft icing and the use of audio, data and video recorders to provide information to accident investigators.

The Most Wanted list was first issued in 1990; since then, it has been revised annually.

Steps Taken to Improve Emergency Communications

The evacuation of a Boeing 717-200 following an engine fire that broke out as the crew prepared for departure from Hobart, Tasmania, Australia, prompted changes in training procedures intended to improve emergency communications, the Australian Transport Safety Bureau (ATSB) said.

The final ATSB report on the incident said that a starter on the right engine had failed, resulting in smoke and sparks, and prompting the captain to order an evacuation of 26 passengers on May 17, 2005. Eleven people were injured during the evacuation, which was completed in 64 seconds.

The report said that "problems with communication involving the pilots, ground crew and cabin crew … created potential risk and [have] led to improved safety action for the future."

As a result of the incident, the operator ordered several changes, including "improved aircraft maintenance procedures relating to markings on door slide brackets, defined phraseology to be used in emergency communications between aircraft dispatchers and pilots, door closure procedures for engine starts, improved policy on cockpit discussion restrictions after door closure and improved cabin crew procedures and training."

ATSB said that copies of the investigation report would be distributed to all high-capacity regular public transport operators in Australia and that a briefing about the safety issues identified during the investigation would be delivered to an operator that was acquiring the fleet of 717s.

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Warnings Issued on Fuel Filter Monitors

Some older models of aircraft fuel filter monitors may be ineffective, warned the Energy Institute, a London-based organization representing individuals and businesses in the energy industry.

The institute said that fuel filter monitors "qualified to IP 1583 fourth edition or earlier editions cannot be regarded as fail-safe devices for preventing water [from] being delivered to aircraft" during fueling operations.

In addition, water-absorbent polymers from the fuel filter monitors may migrate downstream into aircraft fuel systems — a process that can clog fuel filters and can result in other related problems.

The institute said that fuel filter monitors should always be used according to manufacturer instructions and should never be used in fuel containing any fuel system icing inhibitor — known as diethylene glycol monomethylether (DiEGME) or Prist — or in areas in which free water in the fuel may contain high concentrations of salt.

Safeguards Urged to Limit Post-Impact Fires

Post-impact fires are a major cause of fatalities and injuries in otherwise-survivable accidents involving aircraft weighing 5,700 kg/12,500 lb or less, and actions should be taken to reduce related risks, the Transportation Safety Board of Canada (TSB) said in a 2006 report.

The report said that post-impact fires present significant risks to occupants of small aircraft because of the volatility of aviation fuel and its proximity to the occupants, limited escape time, limited energy-absorption characteristics of the airframes, the propensity for immobilizing injuries and the inability of rescue workers to suppress post-impact fires in time to prevent related injuries and deaths.

"Considering the propensity for rapid propagation and the catastrophic consequences of fuel-fed [post-impact fire], the most effective defense … is to prevent the fire from occurring at impact, either by containing fuel or preventing ignition or both," the report said.

The report said that fuel system technologies have been developed in land vehicles and helicopters to lessen the chances of post-impact fires and that a requirement for similar engineering changes in small aircraft could "significantly increase the rate of occupant survival."

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Runway Overrun Prompts Safety Recommendations

The U.S. National Transportation Safety Board (NTSB) has issued four safety recommendations as a result of its investigation of an accident in which a Bombardier Challenger CL-600-1A11 overran a runway and continued across a six-lane highway in Teterboro, New Jersey, U.S.

The airplane was destroyed in the Feb. 2, 2005, accident, and two pilots and two people on the ground were seriously injured. NTSB said that the probable cause was the pilots' "failure to ensure the airplane was loaded within weight-and-balance limits, and their attempt to take off with the center of gravity … well forward of the forward takeoff limit, which prevented the airplane from rotating at the intended rotation speed."

The safety recommendations call on the U.S. Federal Aviation Administration to:

- Disseminate guidance to U.S. Federal Aviation Regulations Part 135 (commuter and on-demand) operators and principal inspectors to describe appropriate methods by which a certificate holder can show that it has "adequate operational control over all on-demand charter flights conducted under the authority of its certificate";
- Review agreements between Part 135 certificate holders and others to identify agreements that allow "a loss of operational control by the certificate holder" and to require revision of these agreements;
- Require that Part 135 certificate holders "ensure that seatbelts at all seat positions are visible and accessible to passengers before each flight"; and,
- Require any Part 135 cabin personnel who "could be perceived by passengers as equivalent to a qualified flight attendant" to undergo basic, FAA-approved training in preflight briefing and safety checks, emergency exit operations and emergency equipment use.

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In Other News …

The **Civil Air Navigation Services Organisation** (CANSO) is being added to the list of organizations invited as observers to meetings of the Council of the International Civil Aviation Organization (ICAO). ICAO President Roberto Kobeh González said that CANSO's contributions would be vital in the implementation of a comprehensive worldwide air traffic management system. … The **Civil Aviation Safety Authority** of Australia (CASA) has proposed a new set of regulations covering aircraft maintenance. The proposed regulations are intended to "achieve a better focus on safety outcomes," CASA said. … The **Directorate General for Civil Aviation** and the **Airports Authority of India** have signed an agreement with the **U.S. Federal Aviation Administration** for help in modernizing India's civil aviation infrastructure. Among the first issues being considered are air traffic control training and procedures, and aviation safety standards and regulations.

Compiled and edited by Linda Werfelman.

Battling Accident Criminalization

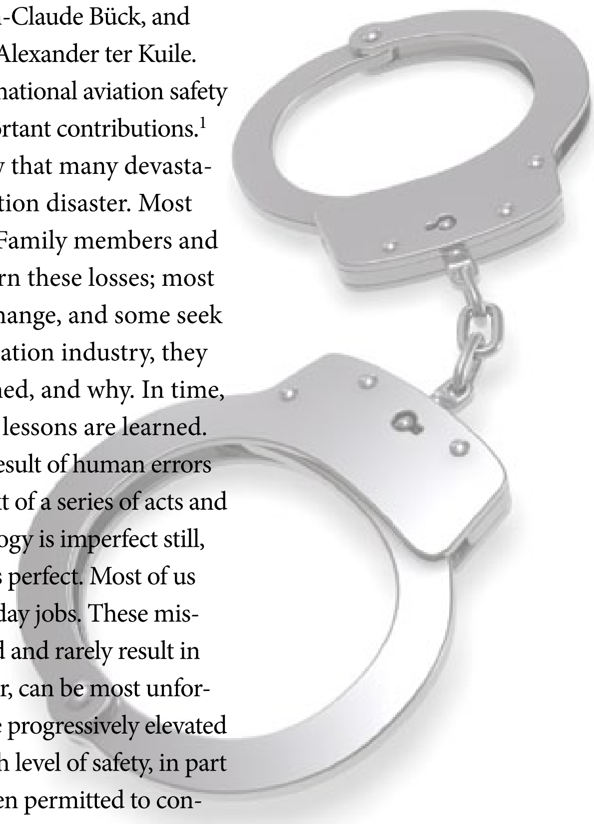
BY KENNETH P. QUINN

The Joint Resolution Regarding Criminalization of Aviation Accidents became fact Oct. 17, 2006, when Flight Safety Foundation (FSF) announced that it had achieved consensus with the Royal Aeronautical Society (RAeS) in London, the Académie Nationale de l'Air et de l'Espace (ANAE) in Paris and the Civil Air Navigation Services Organisation (CANSO) in Geneva (see page 13). This resolution was the culmination of a tremendous effort by many individuals in these organizations, based on consultation with leading experts in aviation accident investigation.

That effort began at the May 18, 2006, meeting of the FSF Board of Governors. Board members discussed a growing tendency of prosecutors and judges to seek criminal sanctions in the wake of aviation accidents, even when the facts do not appear to support findings of sabotage, criminal negligence or willful misconduct.

In response, FSF Chairman Edward W. Stimpson formed the Criminalization Working Group to look into the matter and report findings and recommendations. As group chairman, I quickly realized that the problem was quite complex. The apparent increasing tendency to turn aviation accidents into potential crime scenes is so widespread globally that no one person or group could deal effectively with the problem. We immediately saw an expanding net of potential defendants: air traffic controllers, regulators, pilots, designers, airport directors and corporate managers. Cases arose in Athens, Greece; Milan, Italy; Zurich, Switzerland; Miami; Colmar, France; and Sao Paulo, Brazil. For five months, we reviewed these cases and the traditional legal standards associated with "corporate manslaughter" and other charges.

We were assisted by an assortment of international experts, led by our new Foundation CEO and President William R. Voss, our past President and CEO Stuart Matthews, RAeS CEO Keith Mans, ANAE President Jean-Claude Bück, and CANSO Secretary General Alexander ter Kuile. Other members of the international aviation safety community also made important contributions.[1]



From the start we knew that many devastations occur in a single aviation disaster. Most importantly, lives are lost. Family members and friends of the victims mourn these losses; most seek answers, many seek change, and some seek revenge. Like the entire aviation industry, they want to know what happened, and why. In time, and with hard work, many lessons are learned.

Most accidents are the result of human errors and often arise in the context of a series of acts and omissions. Aviation technology is imperfect still, and individuals are even less perfect. Most of us make mistakes in our everyday jobs. These mistakes normally go unnoticed and rarely result in real harm. Aviation, however, can be most unforgiving. For decades, we have progressively elevated the system to its current high level of safety, in part because the industry has been permitted to conduct thorough investigations and collect complete information about the causes of accidents.

In recent years, however, prosecutors and willing judges around the world have turned the powerful weapons of criminal prosecution against what are simply tragic accidents, the result of mistakes, not willful actions. In some cases, the prosecutions dragged on for more than a decade, causing enormous damage to reputations, careers and finances. Prosecutions turned into persecutions and chilled the free admission of mistakes — even the direct testimony of witnesses or

We recognized that in extreme cases … criminal investigation, and even prosecution, is appropriate.

participants. "Guilty by investigation" wreaked unnecessary havoc on lives.

We recognized that in extreme cases — rising to the level of willful misconduct or particularly egregious reckless conduct, or intentional acts such as terrorism or sabotage — criminal investigation, and even prosecution, are appropriate.

More often than not, however, we found that criminal prosecutions occurring around the globe were not responses to intentional, malicious acts. Instead, we saw verdict-hungry prosecutors pursuing actions against members of the aviation community based on nothing more than their involvement in unfortunate accidents. Without accountability through administrative remedies, such as civil penalties and license suspensions or revocations, or civil justice/tort remedies, usually in the form of compensation, one might argue that criminal prosecution in some situations would be reasonable. However, administrative and civil remedies nearly always exist, and we found almost no adequate basis, other than willful misconduct, for punishing individuals and companies further by subjecting them to the risk of imprisonment or the equivalent of a corporate death sentence, particularly in an industry where safety reputations mean everything.

Recognizing the value to international aviation safety of a complete and thorough accident investigation, our team rapidly reached consensus: "Increasing safety in the aviation industry is a greater benefit to society than seeking criminal punishment for those 'guilty' of human error or tragic mistakes."

Certainly, it is human nature to crave retribution when innocents are killed or seriously injured. However, when considering the chilling impact the threat of prosecution can and does have on safety investigations, it becomes clear that the future of aviation safety depends on unhindered communication between investigators, witnesses and those involved in accidents.

In several countries, individuals are being prosecuted in criminal courts many years after an aviation accident. Several of these examples are outlined in the joint resolution. If those with information to explain the "what" and "why" of an accident are discouraged from speaking openly to investigators because they fear the threat of criminal prosecution, investigators may have difficulty gathering pertinent facts. When determining causation, complete disclosure is imperative to prevent future incidents. The best way to honor victims of tragedy is to make sure we obtain all relevant information that might prevent future accidents. If individuals are not helpful to investigators out of fear of being prosecuted and sentenced to jail, investigators may never discover the truth.

Stated differently, we found that the risk that the threat of criminal prosecution places on the future safety of air travel greatly outweighs any societal benefit in satisfying the inherent human desire for revenge or punishment in the wake of a terrible loss.

Shortly after adoption of our joint resolution, the French court in the Air Inter crash cited in the resolution rendered its verdict: All six individuals were acquitted, but the aircraft manufacturer and airline were required to pay damages. Without expressing an opinion about whether the civil liability aspects of the case were right or wrong, we applaud the French court for at least seeing the wisdom of avoiding criminal sanction and punishment in this case.

Hopefully, this case represents a watershed event, after which prosecutors and judges will exercise restraint about bringing criminal investigations. Perhaps our joint resolution will persuade eager prosecutors to step back and see the wisdom in preserving an existing aviation safety system that has worked remarkably well in reducing aviation accidents.

As we stated, the paramount consideration in a safety investigation should be finding the facts and determining the causal factors of the accident, not criminally punishing those who made errors of judgment or mistakes that may have produced tragic consequences. We are very grateful to the many aviation professionals who took part in the preparation of this joint resolution and look forward to engaging in a dialogue with other groups and individuals on this topic in the months and years ahead. ●

Kenneth P. Quinn is general counsel and secretary of Flight Safety Foundation. He is a partner at the law firm of Pillsbury Winthrop Shaw Pittman LLP in Washington. He is editor-in-chief of The Air & Space Lawyer *of the American Bar Association, and former U.S. Federal Aviation Administration chief counsel.*

Note

1. The Criminalization Working Group, gathering facts and seeking ideas, turned to FSF Board of Governors members: Robert T. Francis, former vice chairman of the U.S. National Transportation Safety Board; William G. Bozin, vice president of safety and technical affairs, Airbus; Steven M. Atkins, vice president product integrity, Boeing; Clay Foushee, formerly with FAA and the U.S. National Aeronautics and Space Administration; Carol Carmody, former NTSB vice chairwoman; and Pierre Caussade, vice president of flight operations standards, support and development, Air France. Also sought out for their knowledge were leading aviation and disaster lawyers: Gerard Forlin of Grays Inn Square in London; Sean Gates of Gates and Partners, in London; John Balfour of Beaumont & Son — Aviation at Clyde & Co. in London; and Daniel Soulez-Larivière and Simon Foreman of Soulez Larivière & Associés in Paris. I consulted extensively with my RAeS counterpart, Charles Haddon-Cave, QC, Chairman of the Air Law Group in London.

Joint Resolution Regarding Criminalization of Aviation Accidents

Recognizing the importance in civil aviation accident investigations in securing the free flow of information to determine the cause of accidents and incidents and to prevent future accidents and incidents;

Recognizing the actions taken recently by the International Civil Aviation Organization in promoting amendments to Annex 13 – *Aircraft Accident and Incident Investigations* to the Convention on International Civil Aviation, encouraging contracting states to adopt by November 2006 certain actions to protect the sources of safety information;

Recognizing the importance of preventing the inappropriate use of safety information, including the increasing use of such information in criminal proceedings against operational personnel, managerial officers, and safety regulatory officials;

Recognizing that information given voluntarily by persons interviewed during the course of safety investigations is valuable, and that such information, if used by criminal investigators or prosecutors for the purpose of assessing guilt and punishment, could discourage persons from providing accident information, thereby adversely affecting flight safety;

Recognizing that under certain circumstances, including acts of sabotage and willful or particularly egregious reckless conduct, criminal investigations and prosecutions may be appropriate;

Concerned with the growing trend to criminalize acts and omissions of parties involved in aviation accidents and incidents;

Noting that:

a. law enforcement authorities in the September 29, 2006, mid-air collision between an Embraer Legacy 600 executive jet and a Gol Linhas Aéreas Inteligentes Boeing 737-800 have opened a criminal investigation and threatened involuntary manslaughter charges and interrogated pilots, while a magistrate revoked the pilots' passports;

b. the French Supreme Court on September 20, 2006, rejected a request to dismiss charges in the July 2000 Air France Concorde crash where three people, a former French civil aviation authority official and two former aircraft manufacturing officials, are currently under investigation for criminal charges;

c. a French court is expected to issue its verdict soon in the 1992 Air Inter crash in Strasbourg, France, wherein the designer of the Airbus A320, two retired Air Inter executives, the former director general of civil aviation, the retired civil servant who was national head of certification, and an air traffic controller were investigated and prosecuted 14 years after the crash and face negligent homicide charges;

d. Swiss prosecutors in August 2006 charged eight Swiss Skyguide air traffic controllers with negligent homicide arising out of the DHL Boeing 757 mid-air collision with a Bashkirian Tu-154 on July 1, 2002, over Überlingen in Southern Germany;

e. the Swiss Federal Prosecutor's Office has an ongoing criminal investigation for negligent manslaughter of the former chief executive of Swiss International Airlines, along with the head of Switzerland's Federal Office of Civil Aviation, and the operations chief and chief trainer at Crossair in connection with the November 2001 Crossair plane crash near Zurich, which the Swiss Aircraft Investigation Bureau concluded was the result of pilot error;

f. an Italian court on July 7, 2006, affirmed the convictions for manslaughter of five aviation officials, including an air traffic controller, the former director of Milan Linate airport, and the chief executive and a former director-general of ENAV, the Italian air traffic control agency, arising out of the October 2001 runway accident between an SAS aircraft and Cessna jet in Milan, where authorities found an inoperative ground radar system contributed to the accident;

g. an ongoing Greek quasi-judicial investigation exists of the 2005 Helios Boeing 737-300 crash near Athens, Greece, wherein a draft accident report has been leaked and authorities have indicated it will be used directly in a quasi-judicial investigation to determine criminal liability;

h. U.S. federal and Florida state prosecutors brought criminal charges, including 220 counts of murder and manslaughter, against a maintenance company, several mechanics, and a maintenance manager arising out of the 1996 ValuJet Flight 592 crash in the Florida Everglades, with nearly all charges later dismissed, withdrawn, or dismissed on appeal, and all tried individuals acquitted; and,

f. Greek prosecutors brought negligent manslaughter, negligent bodily injury, and disrupting the safety of air services charges against the captain and first officer in connection with the 1979 Swissair crash in Athens, with the pilots receiving sentences of four years imprisonment, which was later converted into a fine.

Recognizing that the sole purpose of protecting safety information from inappropriate use is to ensure its continued availability to take proper and timely preventative actions and to improve aviation safety;

Considering that numerous incentives, including disciplinary, civil and administrative penalties, already exist to prevent and deter accidents without the threat of criminal sanctions;

Being mindful that a predominant risk of criminalization of aviation accidents is the refusal of witnesses to cooperate with investigations, as individuals invoke rights to protect themselves from criminal prosecution, and choose not to freely admit mistakes in the spirit of ICAO Annex 13 for the purpose of preventing recurrence;

Considering that the vast majority of aviation accidents result from inadvertent, and often multiple, human errors;

Being convinced that criminal investigations and prosecutions in the wake of aviation accidents can interfere with the efficient and effective investigation of accidents and prevent the timely and accurate determination of probable cause and issuance of recommendations to prevent recurrence;

BE IT THEREFORE RESOLVED, that the below organizations:

1. Declare that the paramount consideration in an aviation accident investigation should be to determine the probable cause of and contributing factors in the accident, not to punish criminally flight crews, maintenance employees, airline or manufacturer management executives, regulatory officials, or air traffic controllers. By identifying the "what" and the "why" of an accident, aviation safety professionals will be better equipped to address accident prevention for the future. Criminal investigations can and do hinder the critical information-gathering portions of an accident investigation, and subsequently interfere with successful prevention of future aviation industry accidents.
2. Declare that, absent acts of sabotage and willful or particularly egregious reckless misconduct (including misuse of alcohol or substance abuse), criminalization of aviation accidents is not an effective deterrent or in the public interest. Professionals in the aviation industry face abundant incentives for the safe operation of flight. The aviation industry every day puts its safety reputation and human lives on the line, and has a remarkable safety record which is due in large measure to the current willingness of operators and manufacturers to cooperate fully and frankly with the investigating authorities. The benefit of gaining accurate information to increase safety standards and reduce recurring accidents greatly outweighs the retributive satisfaction of a criminal prosecution, conviction and punishment. Increasing safety in the aviation industry is a greater benefit to society than seeking criminal punishment for those "guilty" of human error or tragic mistakes.
3. Urge states to exercise far greater restraint and adopt stricter guidelines before officials initiate criminal investigations or bring criminal prosecutions in the wake of aviation disasters. Without any indicia of proper justification for a criminal investigation or charges, the aviation system and air disaster victims and their loved ones are better served by resort to strong regulatory oversight and rigorous enforcement by national and international aviation authorities, and by pursuit of claims through civil justice systems to obtain compensation.
4. Urge states to safeguard the safety investigation report and probable cause/contributing factor conclusions from premature disclosure, and use directly in civil or criminal proceedings. Although use of official accident reports may save criminal investigators the considerable expense of conducting an entire separate investigation, a considerable and serious risk exists of diverting these reports from their original purpose, as technical causes often cannot be equated to legal causes necessary when establishing either civil or criminal liability. In addition, use of relatively untrained and inexperienced technical "experts" by prosecutorial or judicial authorities, as compared to official accident investigating authorities, can result in flawed technical analyses and a miscarriage of justice, while interfering with the official accident investigation.
5. Urge national aviation and accident investigating authorities to: (i) assert strong control over accident investigations, free from undue interference from law enforcement authorities; (ii) invite international cooperation in the accident investigation under Annex 13; (iii) conduct professional investigations to identify probable cause and contributing factors and develop recommendations in a deliberative manner, avoiding any "rush to judgment;" (iv) ensure the free and voluntary flow of essential safety information; (v) provide victims' loved ones and their families with full, accurate and precise information at the earliest possible time; and (vi) address swiftly any acts or omissions in violation of aviation standards.

DATED: October 17, 2006

William R. Voss, President and CEO
Flight Safety Foundation

Keith Mans, Chief Executive
Royal Aeronautical Society

Jean-Claude Bück, President
Académie Nationale de l'Air et de l'Espace

Alexander ter Kuile, Secretary General
Civil Air Navigation Services Organisation

Auditing for **Best Practices**

BY DAROL HOLSMAN

The September 2006 *Aviation Safety World* article in this series described the FSF Audit Team's most frequent findings related to flight monitoring, training and personnel. Let's look at the team's recommendations for best practices in these areas.

Flight crew altitude awareness callouts were inconsistent in six of 20 audits (30 percent) conducted in 2004. The FSF Audit Team recommends that operators develop a flight crew altitude awareness program based on the December 1995 *Flight Safety Digest* article, "Altitude Awareness Programs Can Reduce Altitude Deviations."

Flight departments should stress pilot readback/hearback procedures when air traffic controllers assign altitude changes. Flight crew recording of the altitude assignment is a best practice.

Departments should establish an altitude assignment procedure that requires the pilot monitoring (PM) to select a new altitude in the altitude alerter and challenge the pilot flying (PF) with the new altitude while pointing at the alerter setting. The PF should repeat the new altitude while pointing at the alerter to confirm that the correct altitude has been set.

The FSF Audit Team recommends a policy that requires the PF to make the altitude callouts. This pilot is actually controlling the aircraft, so it is critical that he or she is keenly aware of the altitude. The role of the PM is to back up and challenge the PF if the callout is not made. Altitude callouts should be made prior to the sounding of the altitude alerter's "1,000 ft to level-off" tone.

An effective altitude awareness program should discourage crewmembers from doing nonessential tasks (such as paperwork, eating or searching for the next destination approach chart) at times when altitude callouts must be made.

Another way that operators can foster improvement in this area is to conduct standardization or route checks at least annually, in the simulator or with a third pilot in the aircraft, to ensure the altitude awareness standard operating procedures (SOPs) are being followed.

Improperly organized and inconsistent pilot training records were found in six of 20 audits by the FSF Audit Team.

Pilot training records are necessary to validate the training provided for pilots. Following an accident or significant incident, the investigating agency, such as the U.S. National Transportation Safety Board (NTSB), will request copies of the training records for the crewmembers involved.

The ready availability of complete and accurate records is paramount to ensure that the company, as well as the individual crewmember, receives proper credit for training during the investigation.

Detailed training records can be augmented by a computer-based tracking/recording system to monitor the required training. This system can document a list of the pilot record contents and provide next-due information. The NTSB and U.S. Federal Aviation Administration (FAA) now accept copies of computer-based tracking/recording documents.

In reviewing many different operators' training records, the FSF Audit Team has examined many methods of compiling and arranging such files. In the team's opinion, the most effective training record files consist of a five-part folder, with categories of training and personal data separated as follows:

Licenses (Photocopies)

- Airline Transport Pilot (ATP) rating, with second page showing aircraft type ratings, which is mandatory;
- Flight instructor, if applicable;
- Advanced ground instructor, if applicable; and,
- Airframe and powerplant (A&P), if applicable.

Certificates (Photocopies)

- First- or second-class medical certificate;
- Random drug-testing document — verification, not the results; and,
- Radiotelephone operator's permit, an International Civil Aviation Organization requirement.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Qualification Documentation (Originals or Photocopies)

- Flight crew company qualification authorization letter; and,
- Flight time records.

Supplemental Documents (Photocopies)

- Passport — first two pages; and,
- Driver's license — current.

Flight Training Verification Documents (Originals)

Simulator Training Documents

- Primary and secondary aircraft initial training documents with instructor comments; and,
- Primary and secondary aircraft recurrent training — most current attendance with the listing of the areas covered.

Pilot supplemental training issues were a finding in another six of 20 audits by the FSF Audit Team.

Pilot supplemental training is not mandated in any specific regulatory document for U.S. Federal Aviation Regulations (FARs) Part 91 operators. Part 135, 121, 125 and 129 operators have a clearly defined training regimen that is spelled out in the regulations. The team has established the following guidelines for Part 91 operators and noted the authority for the training requirements, if applicable.

Professional Supplemental Training
(Originals or Photocopies on File)

- Instrument landing system (ILS)/precision runway monitor (PRM);
- International procedures;
- Reduced vertical separation minimum (RVSM)/required navigation performance (RNP)-10/RNP-5/minimum navigation performance specifications (MNPS);
- Crew resource management (CRM) — initial and then recurrent every 36 months;
- Cardiopulmonary resuscitation (CPR)/automated external defibrillator (AED) and first aid — initial and then recurrent every 24 months;

- Minimum equipment list (MEL) use and application — annual review;
- High altitude training/oxygen physiology — every three to five years;
- Hazardous materials familiarization — every 24 months;
- Winter operations — aircraft surface contamination training, with an annual review because of frequent changes;
- Mountain operations — every 24 months;
- Aircraft upset/advanced maneuvering — every three to five years;
- Aircraft emergency evacuation — every 24 months or change of aircraft type;
- Ditching — every 36 months;
- Survival — every 36 months; and,
- Fire — every 24 months.

Fire training should include actually extinguishing a fire with an aircraft-type fire extinguisher every 24 months, as recommended for flight crewmembers by the National Fire Protection Association.

NTSB has recommended to FAA that all pilots be required to have annual weather refresher training. FAA has not adopted this recommendation as of November 2006.

Personnel factors were cited in the findings of six of 20 audits.

Although employee background checks have become routine since the Sept. 11, 2001, terrorist attacks, the FSF Audit Team still finds some operators whose human resources or personnel departments have not established this requirement or conduct inadequate checks.

Operators should verify that the corporate human resources or personnel department has established an employee background check procedure and ensure that an FAA license verification and an accident/incident record review is completed.

The key members of the flight operation leadership team, such as the director/manager and chief pilot, should be fully aware of the contents of the employee background check.

Current copies of the prospective employee's FAA license and medical and flight-hour records should be on file and verified before indoctrination and aircraft type training. Prospective employees should be advised that any falsification of a pilot record is cause for immediate termination.

Medical certification was the subject of findings in six audits. In those audits, ATP rated pilots maintained only an annual second-class medical certificate.

When exercising the privileges of an ATP rating, a pilot must hold an FAA first-class medical certificate in accordance with Part 61.23 (a)(1).

If an operator has an established policy that a captain/pilot-in-command must be ATP rated to operate a company aircraft, a first-class medical certificate should be an ongoing requirement.

The practice of maintaining a second-class medical certificate or annually completing a first-class medical review and then letting it lapse to a second-class medical certificate during the second six-month period should be discontinued. Maintaining a first-class medical certificate as an ATP is an industry best practice.

Alternatively, an operator establishing a requirement for a first-class medical certificate annually and having its personnel also complete a more extensive company management–level medical review is also an industry best practice. ●

This article extends the discussion of the aviation department problems most frequently found by the FSF Audit Team, based on the final reports submitted to clients that contracted for operational safety audits during 2004, detailing the observations, findings and recommendations identified during the review (Aviation Safety World, September 2006, page 46). Observations are documented policies, procedures and practices that exceed the industry best practices; findings identify areas in which the team advises the client to adopt better policies, procedures or practices to parallel industry best practices; and recommendations describe actions that could be taken by the client to meet industry best practices. The recommendations cited in this story are the opinions of the FSF Audit Team.

Fire training should include actually extinguishing a fire with an aircraft-type fire extinguisher every 24 months.

BY MARK LACAGNINA

MISSED

The pilots did not notice a misset pressurization mode selector and misidentified a warning about cabin altitude. After hypoxia struck, autoflight systems kept the 737 flying until the fuel ran out.

opportunities

The Helios Airways Boeing 737-300 was climbing through 16,000 ft after departing from Larnaca, Cyprus, on Aug. 14, 2005, when the captain reported a takeoff configuration warning to operations personnel. The warning horn that the captain heard was actually for a problem with the cabin-pressurization system, according to the Hellenic Air Accident Investigation and Aviation Safety Board in Greece. Unaware of the problem, the pilots were incapacitated by hypoxia, and the aircraft, on automatic control, continued toward Athens, entered a holding pattern and plunged to the ground after the engines flamed out. None of the 121 occupants survived.

In its final report, the board said that the direct causes of the accident were:

- "Nonrecognition that the cabin pressurization mode selector was in the 'MAN' (manual) position during the performance of the 'Preflight' [checklist] procedure, the 'Before Start' checklist and the 'After Takeoff' checklist;
- "Nonidentification of the warnings and the reasons for the activation of the warnings (cabin altitude warning horn, passenger oxygen masks deployment indication, master caution); [and,]
- "Incapacitation of the flight crew due to hypoxia, resulting in the continuation of the flight via the flight management computer and the autopilot, depletion of the fuel and engine flameout, and the impact of the aircraft with the ground."

The 737-300 pressurization system was designed to maintain a cabin altitude of 8,000 ft at the aircraft's maximum certified ceiling, 37,000 ft. The mode selector, which is in an overhead panel above the first officer's seat, has three positions: "AUTO" (automatic), "ALTN" (alternate) and "MAN" (photo, page 21). With the system in automatic mode, which normally is selected for flight, the crew selects the planned cruise altitude and destination altitude in the appropriate windows on the mode selector, and a cabin pressure controller positions the outflow valve to maintain a programmed cabin-pressure schedule. The alternate mode is selected to change from one cabin pressure controller to the other. With the system in manual mode, the flight crew has "direct" control of pressurization, using a toggle switch to position the outflow valve. "Manual control is primarily used as a backup to automatic control," the report said.

There are four annunciator lights above the pressurization control panel. An amber "AUTO FAIL" light indicates a failure of the automatic mode. An amber "OFF SCHED DESCENT" light illuminates if the aircraft descends before reaching the planned cruise altitude set in the "FLT ALT" window. A green "ALTN" light indicates that the system is in the alternate mode. A green "MANUAL" light indicates that the system is in the manual mode.

Unscheduled Leak Check

The mode selector had been set to manual for a pressurization-system check the morning before the accident. The unscheduled maintenance was performed in response to a technical log entry by the flight crew that had landed the aircraft in Larnaca at 0425 after a flight from London. The technical log entry stated that an inspection of the aft galley service door was required because the door seal "freezes, and hard bangs are heard during flight."

After conducting a visual inspection of the door and the pressurization check, a ground engineer (maintenance technician) wrote in the technical log that no defects were found and that no leaks or abnormal noises occurred. The report said that although the airplane maintenance manual included no specific requirement to return the mode selector to "AUTO" after the check, it would have been prudent for the ground engineer to have done so.

The report also noted that a rapid decompression of the accident aircraft's cabin had occurred during a flight from Warsaw, Poland, to Larnaca on Dec. 16, 2004. The decompression occurred when the aircraft was at Flight Level (FL) 350 (approximately 35,000 ft) and near the point at which the flight crew had planned to begin descent. The crew conducted an emergency descent and landed the aircraft at the destination. The Cyprus Air Accident and Incident Investigation Board, which investigated the incident, concluded that the decompression likely occurred either because the outflow valve opened due to an electrical malfunction or the aft galley service door opened due to an improperly positioned handle. Maintenance actions included adjustment and rigging of the door and replacement of the no. 2 cabin pressure controller and the chemical oxygen-generator cylinders in the passenger service units. Technical log entries indicated that no abnormalities were found during a cabin pressure leak check and outflow valve test.

A Mode Overlooked

The accident occurred during a scheduled flight to Prague, Czech Republic, with an en route stop in Athens. The captain, 59, was a native of Germany. He had 16,900 flight hours, including 5,500 flight hours as a 737 captain. He had been employed by Helios Airways from May 2004 to October 2004 and had flown for two other aircraft operators before returning to Helios Airways in May 2005. "According to interviews of his peers at [Helios Airways], during the first period [of employment], he presented a typical 'command' attitude, and his orders to the first officers were in command tone," the report said. "During the second period, his attitude had improved as far as his communication skills were concerned."

The first officer, 51, was a native of Cyprus. He had 7,549 flight hours, including 3,991 flight hours in type. "He had expressed his views several times [to family, colleagues and friends] about the captain's attitude," the report said. "He had also complained about the organizational structure of the operator [and its] flight scheduling, and he was seeking another job." The report said that a review of his training records "disclosed numerous remarks and recommendations made by training and check pilots referring to checklist discipline and procedural (SOP [standard operating procedure]) difficulties."

The flight crew did not reset the pressurization mode selector to automatic before departure. "The fact that the mode selector position was not rectified by the flight crew during the aircraft preflight preparations was crucial in the sequence of events that led to the accident," the report said.

The challenge for the pertinent item on the "Preflight" checklist refers to both the air-conditioning and pressurization systems. The response is: "Pack(s), bleeds on, set." The report said that the pressurization mode selector rarely is positioned to a setting other than automatic, and many pilots interviewed during the investigation said that they typically respond "set"

Boeing 737-300

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The Boeing 737 was designed to use many components and assemblies from the 727. Deliveries of the first production model, the 737-200, which has Pratt & Whitney JT8D engines, began in 1967. The larger 737-300 was introduced in 1984 with quieter and more fuel-efficient CFM International CFM56 engines, rated at 20,000 lb (9,072 kg) thrust.

The 737-300 can accommodate 128 to 149 passengers and 1,068 cubic ft (30 cubic m) of cargo. Maximum standard takeoff weight is 124,500 lb (56,473 kg). Maximum landing weight is 114,000 lb (51,710 kg). Maximum operating speed is Mach 0.82. Cruising speed is Mach 0.75.

Production ceased in 2000 after 1,113 737-300s were built.

Source: *Jane's All the World's Aircraft* after checking only that the cruise altitude and landing altitude are set correctly.

The aircraft departed from Larnaca at 0907. The first item on the "After Takeoff" checklist is to check the pressurization system. "This was the second missed opportunity to note and correct an earlier error," the report said.

About 0910, the flight crew was cleared to climb to FL 340 and to fly directly to the Rhodos (Rhodes) VOR (VHF omnidirectional radio). The captain's acknowledgement of the clearance was the last recorded communication between the flight crew and air traffic control (ATC).

Warning Horn

The aircraft was climbing through 12,040 ft, and cabin altitude was slightly below 10,000 ft, at 0912, when the warning horn sounded. Activation of the warning horn in flight indicates a problem with cabin pressurization, the report said. On the ground, the warning horn sounds when the throttles are advanced and the aircraft is not in the correct takeoff configuration — that is, with trim, flaps and/or speed brakes set incorrectly.

According to the quick reference handbook, among the actions that the flight crew should take in response to a cabin altitude warning or rapid depressurization are to don their oxygen masks and stop the climb. That neither action was taken is one indication that the crew reacted to the warning horn as if it were a takeoff configuration warning. The report noted that the crew did not silence the horn, and the loud noise that it produced likely increased their stress.

The captain established radio communication with a dispatcher in Helios Airways' Operations Center about 0914 and reported a "takeoff configuration warning." About one minute later, the "MASTER CAUTION" and "OVERHEAD" lights illuminated on the flight deck annunciator panel. On the overhead panel, the "PASS OXY ON" light, indicating that the passenger oxygen masks had deployed, and the equipment-cooling system "OFF" lights also had illuminated. The report noted that nine technical log entries about the equipment-cooling system had been

Hellenic Air Accident Investigation and Aviation Safety Board

The pressurization system mode selector was in the manual, "MAN," position during the accident flight and was moved beyond that position by impact forces.

made in the two months preceding the accident. "The crew became preoccupied with the equipment-cooling-system situation and did not detect the problem with the pressurization system," the report said.

The equipment-cooling system includes fans and ducts that direct cool air to and warm air away from electronic equipment on the flight deck and in the electrical and electronic bay. "Loss of airflow (mass flow) due to failure of an equipment cooling fan or low air density associated with excessive cabin altitude results in illumination of the related equipment cooling 'OFF' light," the report said.

Communication Difficulties

The captain told the dispatcher about the equipment-cooling problem, but the dispatcher did not understand what he was saying and suggested that he talk with the on-duty ground engineer — the same person who had conducted the unscheduled maintenance before departure. The dispatcher did not tell the ground engineer what the captain had reported before handing him the microphone.

The ground engineer told investigators that the captain asked for the location of the cooling fan circuit breakers and that he replied that the circuit breakers were behind the captain's seat.

The ground engineer also told investigators that he did not understand the nature of the problem that the captain was experiencing. The report said that the communication difficulties likely arose because "the captain spoke with a

German accent and could not be understood by the British engineer. … Moreover, the communication difficulties could also have been compounded by the onset of the initial effects of hypoxia."

Off the Air

Helios Airways' training program did not specifically require that flight crewmembers and cabin crewmembers be trained to recognize the symptoms of hypoxia. The report said that the lack of this training is "a common situation in the airline industry."

The aircraft was climbing through 28,900 ft about 0920, when the flight data recorder recorded the keying of the no. 2 VHF radio, which was tuned to an ATC frequency. "This marked the last known attempt of radio communication by the flight crew," the report said. Attempts by the airline's Operations Center and ATC to re-establish radio communication with the flight crew were unsuccessful.

The aircraft continued to climb at an average rate of 3,030 fpm. The pressurization outflow valve remained about 12 percent open during the flight, and the average cabin altitude rate of climb was 2,300 fpm. Cabin altitude reached a maximum of about 24,000 ft.

"The aircraft leveled off at FL 340 [about 0923] and continued on its programmed route," the report said. The aircraft crossed the Kéa VOR about 1021 and "began what appeared to be a standard instrument approach procedure for landing at Athens International Airport, Runway 03L, but remained at FL 340," the report said. The aircraft flew over the airport about 1029 and turned right, toward the Kéa VOR, in accordance with the missed approach procedure (Figure 1). The aircraft crossed the VOR about 1037 and entered the published holding pattern.

The F-16 pilot saw a man who was not wearing an oxygen mask enter the flight deck, sit in the captain's seat and don headphones.

F-16 Intercept

Two Greek air force F-16s intercepted the aircraft during its sixth circuit of the holding pattern. The F-16 pilots observed no external structural damage, smoke or fire. "One of the F-16 pilots observed the aircraft at close range and reported at [1132] that the captain's seat was vacant [and] the first officer's seat was occupied by someone who was slumped over the controls," the report said. The captain likely had vacated his seat to check the cooling fan circuit breakers. The F-16 pilot also saw oxygen masks dangling from passenger service units and three passengers sitting motionless, wearing oxygen masks.

The investigation did not determine what actions the cabin crew took or whether they attempted to communicate with the flight crew after the passenger oxygen masks deployed. The cockpit voice recorder (CVR) provided data only for the last 30 minutes of the three-hour flight. The report said that the F-16 pilot's observations indicated that few passengers had donned their masks.

The passenger-oxygen system was designed to supply oxygen for 12 minutes. "In order to retain consciousness after the depletion of the oxygen from the passenger oxygen system, a person on board would have had to make use of one of the [four] portable oxygen bottles," the report said. The valves in three of the bottles were found open. The report said that at least one of the bottles likely had been used by a cabin attendant.

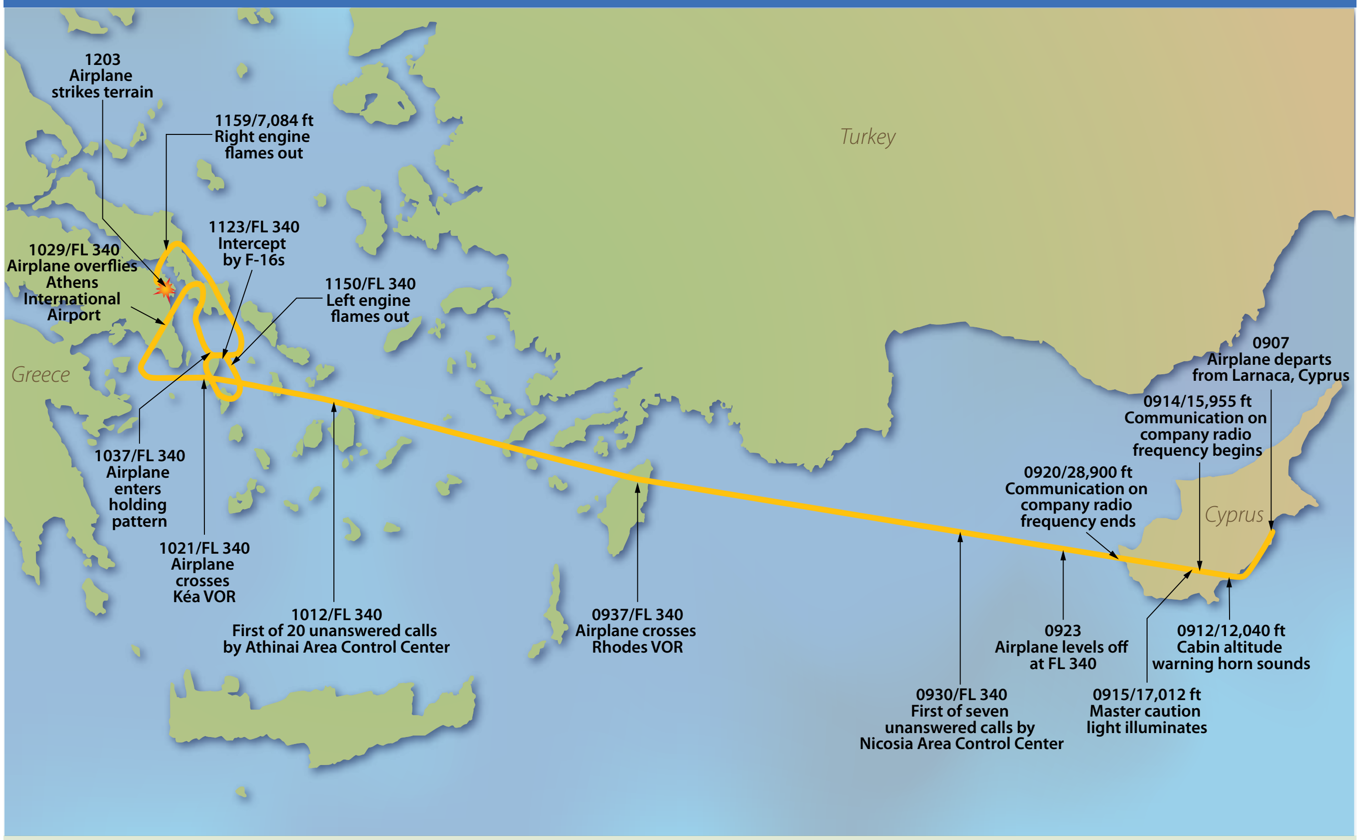
The aircraft was on its tenth circuit of the holding pattern about 1149, when the F-16 pilot saw a man who was not wearing an oxygen mask enter the flight deck, sit in the captain's seat and don headphones. From the F-16 pilot's description of the man's clothing, investigators concluded that the person likely was the cabin attendant who had used one of the portable oxygen bottles. "The F-16 pilot may not have been able to observe an oxygen mask on the person's face because the portable oxygen bottle mask was clear in color," the report said.

The CVR recorded sounds of an oxygen mask being removed from its stowage box and oxygen flowing through the mask. The F-16 pilot tried to attract the cabin attendant's attention, but he did not respond.

Attendant Attempts Control

About 1150, the left engine flamed out due to fuel starvation. The aircraft turned steeply left

Flight Path of Helios Airways Boeing 737, Aug. 14, 2005



FL = Flight level VOR = VHF omnidirectional radio

Times are local.

Source: Hellenic Air Accident Investigation and Aviation Safety Board

Figure 1

to a northerly heading and began to descend. The report said that recorded fluctuations in airspeed and altitude indicated that the cabin attendant, who held a commercial pilot license issued by the United Kingdom, was making an effort to control the aircraft.

CVR data indicated that he attempted to transmit two radio messages about 1154. The first was: "Mayday, mayday, mayday. Helios Airways Flight 522 Athens" followed by an unintelligible word. The second message, spoken a few seconds later in what was described by the report as a very weak voice, was: "Mayday, mayday." Neither message was transmitted, however, because the microphone key had not been depressed.

The 737 was descending through 7,084 ft about 1159, when the right engine flamed out and the heading changed from northerly to southwesterly. About this time, the cabin attendant appeared to acknowledge the presence of the F-16. "He made a hand motion," the report said. "The F-16 pilot responded with a hand signal for the person to follow him on down towards the airport. The [cabin attendant] only pointed downwards but did not follow the F-16."

Although the cabin attendant was a licensed pilot, investigators concluded that anyone with similar flight experience likely would not have been able to control the 737 with both engines inoperative and in the existing conditions of hypoxia and extreme stress. The report said, however, that the cabin attendant apparently attempted to level the aircraft before it struck hilly terrain near Grammatiko, about 33 km (18 nm) northwest of the airport, about 1203.

The remains of 118 occupants were recovered and examined by a forensic pathologist; the bodies of the other three occupants are believed to have been consumed by the post-accident fire. "According to the pathologist's report, the cause of death for all on board was determined to be multiple injuries due to impact, in addition to the extensive burns for 62 of them," the report said. The pathologist's report also said that the occupants likely were "in deep, nonreversible coma due to their prolonged exposure (over 2.5 hours) to the high hypoxic environment" when the impact occurred.

Latent Causes

The report said that the following were latent causes of the accident:

- "Operator's deficiencies in the organization, quality management and safety culture;
- "Regulatory authority's … inadequate execution of its safety oversight responsibilities;
- "Inadequate application of crew resource management principles; [and,]
- "Ineffectiveness of measures taken by the manufacturer in response to previous pressurization incidents in the particular type of aircraft."

Helios Airways was established in 1999 and had begun operating the accident aircraft in May 2004. At the time of the accident, the airline also was operating two 737-800s and an Airbus A319 from Cyprus to 28 destinations in 11 countries. The airline had 228 employees, about one-third of whom were part-time, seasonal employees.

Cyprus contracted with the U.K. Civil Aviation Authority (CAA) to assist in overseeing three airlines in the country. CAA audits of Helios Airways had found several deficiencies. "Management pilots appeared to be insufficiently involved in their managerial duties," the report said. "Training and duty records were found to be incomplete. Manuals were found to be [partially] deficient; they did not always adhere to regulations, and on some issues they were out of date. In the two months before the initiation of the first flight operations with the [accident aircraft], the airline appeared to be effectively scrambling to piece together manuals and paperwork. This suggested that an underlying pressure was prevalent to proceed with little regard for the required formalities." Moreover, flight crew training records indicated that no follow-up action had been taken in response to the first officer's record of insufficient checklist discipline and ineffective performance in abnormal situations.

The report said that the Cyprus Department of Civil Aviation (DCA) appeared to be completely dependent on the U.K. CAA for safety oversight and that the DCA's Safety Regulation Unit was understaffed and lacked leadership and oversight. There was no record that the DCA took action to ensure that airlines responded to deficiencies and issues considered by CAA auditors to require urgent attention.

Previous Problems

Investigators reviewed several previous occurrences worldwide involving aircraft pressurization problems. "Of interest and relevance to the [Helios Airways accident were] nine reports of pressurization problems directly attributed to the crews' failure to set and verify the proper position of the pressurization mode selector to 'AUTO,'" the report said. "Seven of these concerned Boeing 737 aircraft, while the other two events concerned McDonnell Douglas aircraft. These nine reports all referred to aircraft that took off with the pressurization selector inadvertently set to 'MAN.'"

The report said that Boeing had taken or was in the process of taking several actions before the accident to reduce the likelihood of 737 pressurization incidents. Among actions underway was a revision of the *B737 Flight Crew Training Manual* to include information on distinguishing between a cabin altitude warning and a takeoff configuration warning. "A number of remedial actions had been taken by the manufacturer since 2000, but the measures taken had been inadequate and ineffective in preventing further similar incidents and accidents," the report said.

Among actions taken in response to the findings of the accident investigation was Airworthiness Directive (AD) 2006-13-13, issued in June 2006 by the U.S. Federal Aviation Administration. The AD required revision of the 737 airplane flight manual (AFM) "to advise the flight crew of improved procedures for preflight setup of the cabin pressurization system, as well as improved procedures for interpreting and responding to the cabin altitude/configuration warning horn," the report said. The AD also required that the following message be inserted in the AFM: "For normal operations, the pressurization mode selector should be in 'AUTO' prior to takeoff." ●

This article is based on Hellenic Air Accident Investigation and Aviation Safety Board Aircraft Accident Report 11/2006, "Helios Airways Flight HCY522, Boeing 737-31S, at Grammatiko, Hellas, on 14 August 2005." The 198-page report contains illustrations and appendixes.

Committing to automation

Technologies influence hand-flying skills, ATC safety nets, airport moving maps and runway-debris detection.

BY WAYNE ROSENKRANS | FROM PARIS

Alan Bond

Complications often emerge when commercial air transport adopts new automated systems, several presenters said at Flight Safety Foundation's International Air Safety Seminar (IASS) Oct. 23–26 in Paris. Among examples cited were difficulties for airline pilots compelled to hand-fly transport jets in response to "automation exceptions," air traffic control (ATC) systems that generate unwarranted/nuisance short-term conflict alerts (STCAs) and runway surface radar that occasionally misreports the presence of debris that could cause foreign object damage (FOD).

Automation Exceptions

Flight crews accustomed to "glass" flight decks can counteract subtle degradation of their basic instrument flying skills by periodic hand-flying practice during line operations under approved conditions, said Capt. Dennis Landry of the Air Safety Committee and Northwest Airlines Master Executive Council of Air Line Pilots Association, International. "Exclusive use of automation during normal operations can result in degradation of the ability to precisely maneuver the aircraft without automation," Landry said in a proposal to the industry. Initial practice six times a month, then 15 to 30 minutes once or twice per month should be sufficient, he said.

Although flying without the autopilot, autothrottles and flight director — for example, during climb from 10,000 ft until entry into reduced vertical separation minimum airspace in visual meteorological conditions

Speakers from left, Landry, Bourdais and Patterson

Photos: Wayne Rosenkrans

— sharpens skills and "control feel" for takeoff and landing, the primary objective is to establish a practice regime of rule-based behaviors that helps pilots effectively allocate attention to flight-path issues. Landry defines automation exceptions as events that may compel pilots to revert to operating the airplane either without automation or contrary to automation-directed flight paths. These situations include "flight management and guidance computer systems or flight management systems that are not operationally stable or require pilots to create workarounds for system deficiencies [such as faulty software modifications]; go-arounds that are not flown as programmed; partial or full pitot-static system failures; traffic alert and collision avoidance system resolution advisories; precision radar monitor instrument approach system breakout maneuvers; [terrain awareness and warning system] escape maneuvers; 'slam dunk' [visual] approaches; abbreviated instrument approaches initiated from altitudes considerably above the normal descent profile; rapid-decompression descents; and ATC instructions requiring divergence from planned or assigned flight paths."

Correct action is essential if the flight crew confronts an automation exception, he said. Without awareness and practice, "blind over-reliance" on automation can generate subconscious complacency, reluctance or unwillingness to override guidance displayed by the flight director. "Disregarding or eliminating the automation … often presents the best, if not the only, option available," he said. Landry said that the airline industry and regulators would have to conduct formal research and development, and create policies and guidance to establish the proposed practice regime.

Ground-Based Safety Nets

Nuisance STCAs have inhibited efforts by 60 European air traffic service providers to employ four ground-based "safety nets" — that is, system safety defenses based on automation — to reduce the risk of midair collisions, said Martin Griffin, ATC domain manager for Eurocontrol. In addition to STCA, the most mature safety net, others are the minimum safe altitude warning (MSAW), approach path monitor and airspace penetration warning systems. STCA has been mandated, and standardized implementation has been expedited as a pan-European safety objective for 2007–2011.

"The main challenge is to find the optimum balance for a particular local situation between minimizing the number of nuisance alerts and maximizing the warning time when tuning the different STCA parameters," Griffin said. "There is also a dire lack of training for controllers on STCA. This occurs because we have no standard for STCA or safety nets in Europe. Sometimes controllers didn't even realize that they had STCA functionality [or they] had it turned off." Other air traffic controllers have reset STCA parameters so that this radar software functions only as an ATC decision-support tool for routine operations. Particularly troubling from a 2004 survey of air traffic service providers were vague decision-making processes and lack of purpose regarding safety nets among ATC safety managers. "Safety nets come in almost 'automatically' when ATC systems are renewed or upgraded," Griffin said.

Some survey respondents suggested downlinking resolution advisories (RAs) from airborne collision avoidance systems (ACAS) to ATC facilities; Eurocontrol so far has verified the technical feasibility of doing this via data link but with an eight-second delay. Related studies were pending at the end of 2006. "While STCA and ACAS are typically expected to be complementary, dependent on conflict geometry, they sometimes necessarily operate in the same [five-second] time frame, which can be dangerous," Griffin said. "Controllers often are oblivious that an RA has been given to the pilot." Eurocontrol's Safety Nets Planning Implementation and Enhancements Task Force, which conducted an international workshop in October 2006, believes that safety net improvements can be achieved primarily through standardization by the end of 2008.

Airport Moving Maps

Automation that displays guidance to airline flight crews for precise all-weather taxiing was introduced in 2003 by a few airlines to help reduce runway incursions. This airport moving map technology will be standard on all-new airliners such as the Airbus A380 and Boeing 787, and will be available for retrofitting other types, said André Bourdais, an Airbus navigation engineer. Airport data for about 300 air

Alan Bond

carrier airports already are available. As with selection of appropriate automation modes/functions for flight-path control, however, airport moving maps require correct mode selections. After a mode has been selected, a range can be selected for a strategic or detailed view of the airplane's surroundings.

"Installations are either done as an additional mode on the [forward-facing] navigation display (ND) or as a function on the [side-facing] electronic flight bag (EFB)," Bourdais said. Airport moving maps are being designed as the "cornerstone" of coming software enhancements for display of taxi routing, collision avoidance and weather overlays, he added.

"[Improved situation awareness] is achieved by an adapted depiction of a digital airport map [an assembly of several geometrical figures (points, lines or polygons)] merged with aircraft current position and heading," he said. Any airport database compliant with recently adopted standards can generate accurate displays at any desired size or resolution, with intelligent decluttering that helps the flight crew view and interpret only the graphical objects, labels and symbols relevant to the immediate task. "Runway labels are made to always be visible on the map to promote maximum awareness so that pilots can anticipate arrival at intersections and know they are close to a runway," Bourdais said. "Smooth transitions [between different modes and ranges] ensure that pilots never lose visual contact during all taxiing phases."

When automatic dependent surveillance-broadcast (ADS-B) becomes available, upgraded airport moving maps probably also will enable flight crews to observe real-time movement of surrounding aircraft and vehicles, perform evasive maneuvers and receive ground-conflict resolution advisories. ATC clearances involving the airport surface also could be data-linked to the display.

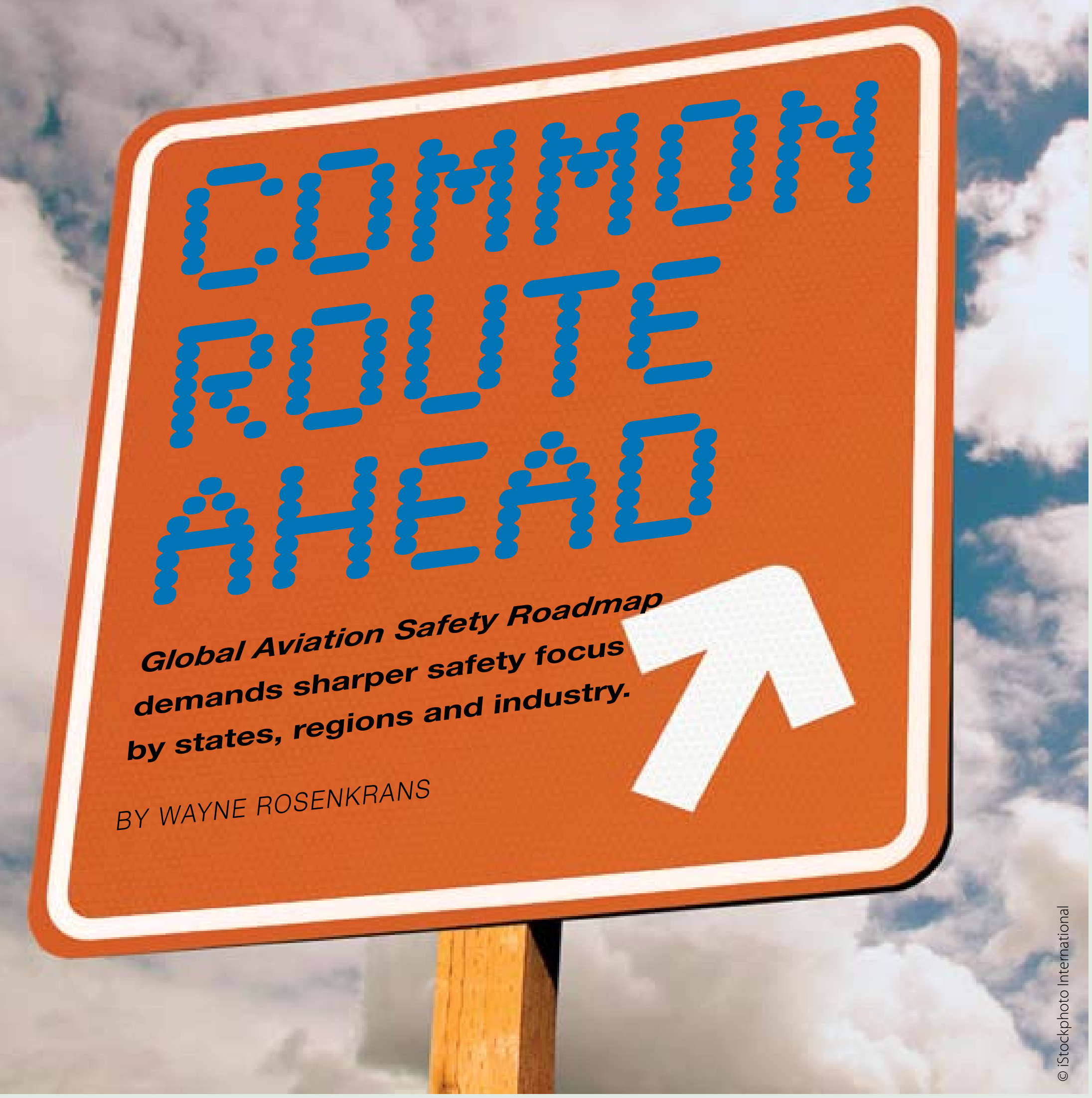
Fine-Tuned Debris Alarm

In 2001, Vancouver (British Columbia, Canada) International Airport Authority and radar specialists at QinetiQ decided to adapt millimetric wave radar and automation to remotely detect debris as small as the cap of a ballpoint pen on paved surfaces. But the potential for false alarms — defined as "any time a FOD retrieval person responded to reported [debris] coordinates and found no debris" — was an early concern, said Brett Patterson, the airport's director of operations safety planning. False alarms have been caused by things such as hangar doors opening and helicopter rotor-blade scintillation. Two incidents involving debris on runways in 2000 — one involving large pieces of an Airbus A330 engine cowling and the other a large aluminum tube from a de Havilland Dash 8 — had convinced the authority to pursue a technologically advanced runway debris-detection method.

Investigators found that human factors reduce the effectiveness of conventional surface-inspection methods. These include individual attentiveness, variations in basic visual acuity, non-uniform visual sampling, inadequate sensitivity to visual contrasts and poor visibility of debris during nighttime and adverse conditions of all-weather operations in Vancouver. "[A] relatively small area of focus, coupled with the fact that the individual performing the runway check is in a moving vehicle, makes a comprehensive scan very difficult," Patterson said. Even adhering to the international recommendation to inspect each runway every six hours, Vancouver's runways are "known to be clear for only 0.5 percent of any 24-hour period."

In 2006, each of two parallel runways received two radar sensors positioned approximately one-third of the total runway length from each threshold. Called QinetiQ Tarsier, the system was in initial operating capability mode at the end of the year. Each sensor has power output equivalent to a mobile phone and has no effect on other airport systems. Employees in the airport operations center advise ATC and request runway closure only if a visual/audible alarm occurs. After debris removal, radar confirms that the runway is clear before reopening.

"FOD radar has consistently identified [runway debris] before pilots or airport personnel, even during daylight, and it provides responding personnel with the latitude and longitude coordinates of the [debris] to within 3.0 m [9.8 ft]," Patterson said. Short-term plans call for software versions that distinguish large versus small FOD-radar targets, improve record keeping and control the lens of a video camera at each radar sensor antenna tower — based solely on radar-generated position coordinates — to transmit sharp magnified video images for risk assessment. ●



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A strategic action plan detailing preferred practices for states and industry to address high-priority safety deficiencies has been delivered to the International Civil Aviation Organization (ICAO) by the Industry Safety Strategy Group (ISSG).[1] Titled *Implementing the Global Aviation Safety Roadmap,* the plan distills the ISSG's consensus on 2006–2014 priorities into one document and represents an industry commitment to tightly coordinate future safety initiatives through one process.[2]

Published in December 2006, the plan provides a common framework to match limited resources to almost unlimited needs, according to R. Curtis Graeber, Ph.D., senior technical fellow, aviation safety, for Boeing Commercial Airplanes. Presenting the plan this past October at the International Air Safety Seminar in Paris, Graeber said on behalf of the ISSG, "Future industry support in global and regional safety initiatives will be tied to the *Roadmap* — if you want some help, show us how [your request] is tied to the *Roadmap* and we'll have the discussion. If it's something that's really different, it goes to the back of the line. Organizations were pulled in different directions without the *Roadmap.* Regions can use the [*Roadmap*] objectives and best practices to engage international stakeholders [and] to develop a regional safety plan."

The *Roadmap* identified areas where national governments need improvement: inconsistent implementation of international standards; inconsistent regulatory oversight; impediments to reporting errors and incidents; and ineffective incident and accident investigation. Regions need to improve coordination of regional programs, the *Roadmap* said. The focus areas for industry are: impediments to reporting and analyzing errors and incidents; inconsistent use of safety management systems (SMSs); inconsistent compliance with regulatory requirements; inconsistent adoption of industry best practices; nonalignment of industry safety strategies; insufficient number of qualified personnel; and gaps in use of safety-enhancing technology.

Roadmap Origins

The ISSG was formed after the ICAO Air Navigation Commission (ANC) invited industry representatives to a May 2005 meeting to discuss methods of integrating disparate efforts, ensuring consistency and reducing duplication. The ISSG prepared and received the ANC's approval of *Global Aviation Safety Roadmap, Part 1,* seven months later, and the *Roadmap* was endorsed by the Directors General of Civil Aviation Conference on a Global Strategy for Aviation Safety in March 2006. The Council of ICAO in June 2006 asked the ISSG for the *Roadmap* implementation plan to help update its Strategic Objective on Safety.

Coming in time to be considered during the early 2007 revision of ICAO's Global Aviation Safety Program (GASP), the plan also has been advanced as "the primary guide to how states and industry work together," Graeber said. The ISSG will coordinate any further activity with the ANC GASP Ad Hoc Working

Group; ICAO Technical Cooperation Bureau; Cooperative Development of Operational Safety and Continuing Airworthiness Programs (COSCAPs); and ICAO regional offices.

In 2007, the ISSG's outreach will include industry segments not explicitly part of the current ISSG or ICAO activities, such as cargo, on-demand and corporate operators. "While regional differences will dictate different implementations of best practices at different levels of maturity, there is much benefit that can be gained by sharing what works — and what doesn't — in various regions that share common challenges," the plan says. In the *Roadmap*, the ISSG considers best practices to be collective lessons learned by the commercial aviation community.

The plan provides the following detailed elements to regions, states and industry:

- Twelve defined *Roadmap* focus areas;
- Acceptable objectives for regional safety teams that choose to work on any *Roadmap* focus area;
- Best practices for identifying and analyzing gaps between the current safety status and the targeted status;
- Technical knowledge, methods and information sources to correct safety deficiencies, including processes for developing regional action plans. In one of the appendixes to the *Roadmap* strategic action plan, the ISSG demonstrates a completed regional assessment template for Sub-Saharan Africa with entries based on sources such as the ICAO Universal Safety Oversight Audit Program (USOAP) results for states;
- Guidance on acceptable metrics for evaluating the effectiveness of corrective actions; and,
- A "best practice maturity model" that enables classification of a state, region or company overall or with respect to any focus area. The model provides criteria for assigning one of four maturity levels from "developing" to "highly evolved" as a method of comparing relative performance over time.

Basis for Safety Initiatives

Although inherently reactive, planning based on accident data still provides an acceptable basis for mapping safety initiatives. "It is absolutely essential that the lessons learned from … accidents remain at the forefront of safety-enhancement activities," the plan says. "Analysis of recent accidents in regions with poorer safety records shows that nearly all were caused by previously well-understood factors with equally well-understood mitigating actions."

Beyond reactive methods, however, the plan urges consideration of prognostic/predictive approaches to risk assessment such as flight data monitoring and periodic auditing of civil aviation authorities, airlines, airports, air navigation service providers (ANSPs), maintenance organizations and training organizations. Best practices for these methods include using metrics from standards of the USOAP and the IATA Operational Safety Audit (IOSA), ICAO annexes and safety oversight/management manuals, and products developed by the international consensus of specialists, such as the Flight Safety Foundation *Approach-and-Landing Accident Reduction (ALAR) Tool Kit.*

A closely related objective is designed to help states, regions and industry apply risk-assessment principles. It says, "The intention of [programs that collect and analyze data] is to both derive appropriate metrics/measures for identifying the precursors to safety incidents so that they can be managed in day-to-day operations [and] identify and reinforce those behaviors that have a positive effect on safety performance."

To develop a regional action plan, the recommended steps are: select the region for analysis, working from the ISSG's categorization of countries or subsets if possible; include and engage all affected stakeholders; outline existing strengths and enablers, i.e., local factors that support the safety of aviation; identify current and future risks/factors in the operating environment; conduct a gap analysis for the majority of the organizations, establishing their current maturity levels relative to their counterparts and to *Roadmap* best practices; develop prioritized recommended actions; and assign this action plan to industry organizations or government entities responsible for correcting safety deficiencies.

Straight Talk

The plan is unequivocal about the role of the global commercial aviation community as a potent force for change wherever standards have not been implemented, and a catalyst for universal adoption of best practices. This translates into several best practices, including one that says, "States apply coordinated initiatives to ensure that noncompliant states do not engage in activity which could be seen as unacceptably increasing the risk of operation."

Also among the plan's recurrent themes are adoption of "just culture"

principles including "open reporting" of incidents by all aviation professionals, sharing and analysis of data at regional and worldwide levels and free exchange of lessons learned from operations. The plan says, "[Just culture is] defined as an atmosphere of trust in which people are encouraged and even rewarded for providing essential safety-related information, even if self-incriminating, [so that hazards and risks may be more clearly understood] but in which all parties clearly understand which types of behaviors are acceptable or unacceptable … and persons reporting need not fear reprisal." Open reporting "encourages reporting … beyond that which is mandated [and is] also confidential in that the reporter's identity is protected," the plan says.

SMSs Everywhere

Although the value of an SMS in risk reduction cannot be overestimated, the ISSG says that this potential has not been realized yet. "To maintain the safety of the whole aviation system, it is important to ensure consistency in the use of SMS across all sectors and disciplines of the aviation industry," the plan says. "ICAO [SMS requirements do] not yet extend to all … [suppliers of goods and services such as] aircraft maintenance, aeronautical information services and meteorology." Audit processes of industry organizations should include SMSs. "To be truly effective, the interface with other SMSs must also be recognized and managed," the plan says.

Leaders of states, regions and industry must have "both detailed knowledge of current best practices and an organizational commitment to adopt them in a timely manner," the plan says. Designated individuals should take responsibility for researching, updating and disseminating best practices, recommending which to adopt and following up on line managers who ideally will have been empowered to ensure implementation of safety-critical items. Quantitative and qualitative assessments of threats and technology by regional specialists — with early involvement of regulators — also are appropriate to avoid "piecemeal solutions that do not recognize system issues."

Graeber

Wayne Rosenkrans

Considerable Technology

The plan highlights current technologies designed to enable aircraft operators, ANSPs, airports and others to address approach-and-landing accidents, loss of control, controlled flight into terrain (CFIT), rejected-takeoff accidents, fuel-related forced landings, midair collisions, ground accidents, in-flight fires, severe weather, turbulence encounters, wind shear avoidance, and aircraft maintenance risks. Appendixes recommend sources of ICAO standards and recommended practices, industry best practices, standard operating procedures (SOPs) and education/training. A few examples show how *Roadmap* recommendations would address some of these accident types.

To reduce the risk of approach-and-landing accidents, aircraft operators should consider how to facilitate stabilized approaches by providing "aircraft capability to fly constant-angle/constant-slope final approaches [including] flight path target or flight path director, other vertical flight management system (FMS)/autopilot/flight director modes [or] both; aircraft capability to fly area navigation (RNAV) and required navigation performance (RNP) RNAV approaches; head-up displays (HUD) for enhanced situational awareness during visual approaches at night or in marginal daytime visual meteorological conditions; [and] auto-land capability."

Operators also should facilitate "optimum use of braking devices such as anti-skid systems … autobrake system; [and] thrust reversers." ANSPs should consider methods of "preventing unstabilized approaches by gaining an enhanced understanding of modern aircraft performance characteristics, e.g., deceleration characteristics; [FMS] reprogramming requirements [for flight crews responding to ATC instructions]; and SOPs." They also should consider implementing the minimum safe altitude warning (MSAW) capability of terminal/approach radars.

Airports should consider implementation of "visual approach slope indicator/precision approach path indicator at each runway end … ; the installation of a visual glide slope indicator at each runway end … ; runway-remaining markings/runway-edge lighting; [and an] EMAS (engineered material arresting system) … bed at each runway end where the terrain configuration does not allow for the provision of a runway [end] safety area." The FSF *ALAR Tool Kit* is among the plan's recommended resources.

To reduce the risk of CFIT, operators should consider "horizontal situation display/navigation displays (NDs); terrain awareness and warning systems [TAWS], in association with GPS [global positioning system] navigation; radio altimeter or TAWS automatic altitude callouts, with standardization across the fleet to maximize effectiveness; primary flight displays (PFDs) with vertical situation displays for enhanced terrain awareness and enhanced awareness of applicable minimum safe altitude; aircraft capability and operating policy for the conduct of constant angle/[constant] slope final approaches for all types of approaches; aircraft capability and operating policy for the conduct of RNP RNAV approaches; [and] aircraft capability for the conduct of approaches with FMS-based or GPS-based vertical guidance (e.g., FMS landing system and global navigation satellite system landing system approaches)."

To reduce the risk of loss of control, operators of aircraft without full flight envelope protection[3] should consider providing a "stall warning system … ; excessive pitch attitude warning; excessive bank-angle warning (e.g., as provided by certain models of TAWS); low-speed protection or warning … ; flight envelope warning; [and] PFD with speed, attitude, etc., warning symbols." ANSPs should consider "gaining an enhanced understanding of performance characteristics of modern aircraft (e.g., maneuvering and go-around characteristics, systems-reconfiguration requirements and SOPs)."

Work Force Realities

The plan projects a 15-year passenger-traffic growth of 4.1 percent annually — a demand for air transport by as many as 7 billion passengers by 2020 — requiring all industry sectors to take action without delay. "Even today, some sectors in some regions are experiencing significant shortages of suitable technical staff," the plan said. "As a result, the industry is witnessing significant migration of professional staff from one region to another to meet this need. This relocation is to the [safety] detriment of certain regions.

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"A major challenge faced by all sectors of the aviation industry concerns the recruitment, training and retention of technically qualified staff, including those engaged in regulatory oversight functions. The failure to recruit and retain a core of well-trained, competent staff has considerable safety implications."

A corresponding objective for states and regions is to "actively encourage a sufficient number of people to enter accredited training institutions." Additional suggested strategies include routinely auditing the quantity and quality of human resources; "promoting the acceptance of licenses and qualifications issued by other regulatory authorities/civil aviation authorities; [and] providing incentives to attract potential candidates into the industry."

Small, deliberate steps are the most likely path to success under these *Roadmap* concepts, according to the ISSG. "Otherwise, an attempt [at] the immediate implementation of all best practices may detract from the basic obligations of states and industry organizations to correct those infrastructure and other deficiencies that are already identified," the plan says. "No region of the world has attained the highest level of focus area maturity by all of their states, airlines/operators and other constituents." ●

Notes

1. The Industry Safety Strategy Group (ISSG) comprises Airbus, Airports Council International, Boeing Commercial Airplanes, Civil Air Navigation Services Organisation, Flight Safety Foundation, International Air Transport Association (IATA), and International Federation of Air Line Pilots' Associations.

2. ISSG. *Implementing the Global Aviation Safety Roadmap.* Dec. 4, 2006. The complete document is available at <www.flightsafety.org/pdf/roadmap2.pdf>.

3. Full flight envelope protection is recommended by the U.S. Commercial Aviation Safety Team. Various systems that directly and automatically operate an airplane's flying controls can provide this protection, including the high-incidence protection system, which prohibits the airplane from stalling by limiting the angle of attack at which the airplane can be flown during normal low-speed operation, and the alpha-floor system, which increases thrust to the operating engines under unusual circumstances where the airplane pitches to a predetermined high angle of attack or bank angle.

DANGEROUS?

New questions about the safety of the MU-2B have been answered with proposed special requirements for those who fly the complex, speedy twin-turboprop.

BY MARK LACAGNINA

Despite political pressure to ground the Mitsubishi MU-2B in the United States, the Federal Aviation Administration (FAA) has found, again, that the airplane is not inherently unsafe but that special experience, training and operating requirements are needed for pilots, instructors and examiners.[1]

On Sept. 28, 2006, the FAA published a notice of proposed rule making (NPRM) for a special federal aviation regulation (SFAR) that would impose the following key requirements:

- A minimum of 100 hours of experience as pilot-in-command (PIC) of multiengine airplanes to act as PIC of an MU-2B;
- FAA-approved initial or transition training for pilots who have not flown an MU-2B in two years;
- Approved requalification training for pilots who have flown an MU-2B in the previous two years but have not received the approved training;
- Approved differences training for pilots who operate more than one model;
- Approved recurrent training every 12 months;
- Mandatory use of MU-2Bs by pilots, designated pilot examiners and check airmen to accomplish biennial flight reviews and conduct the landings required to meet recent flight experience standards;
- Manipulation of controls only by pilots who meet the SFAR requirements;
- A minimum of 2,000 hours as PIC, including at least 800 hours as PIC of multiengine airplanes and 300 hours as PIC of MU-2Bs to provide flight instruction in the airplane. At least 50 of the 300 hours of required PIC time would have to be logged in the previous 12 months;
- At least 100 hours as PIC of MU-2Bs for designated pilot examiners and check airmen; and,

- A "functioning" autopilot aboard the airplane for flight under instrument flight rules or in instrument meteorological conditions or nighttime visual meteorological conditions.

Accident Spikes

As with special certification reviews (SCRs) of the MU-2B conducted by the FAA in 1983–1984 and 1996–1997, an increase in accidents was cited as the reason for the recent "safety evaluation" (Figure 1).

Lacking activity, or flight hour, estimates, the FAA compiled accident rates based on the number of airplanes on the U.S. registry. The agency found that the MU-2B's accident rate from 1966 through September 2005 is twice as high as similar twin-turboprop airplanes — Beech 90 and 100 series King Airs, Cessna 425 and 441 Conquests, Commander 680s and 690s, and Piper PA-31T Cheyennes. Analyses of data, including those shown in Table 1 (page 34), indicated that the frequency of fatal MU-2B accidents involving loss of control is 3.5 times greater than airplanes in the comparison group.

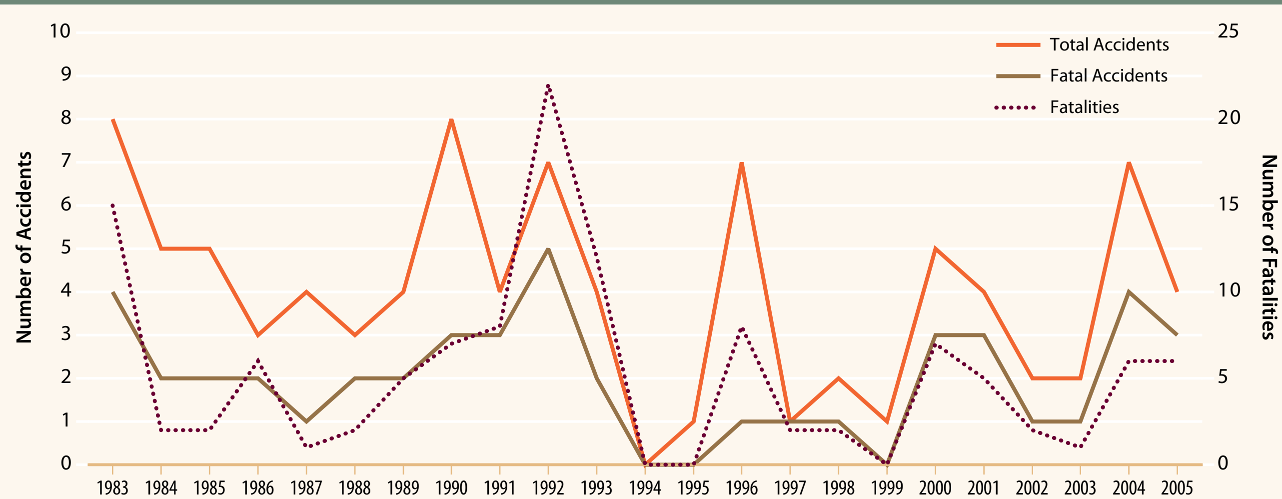
"The most frequent and fatal type of accident … involves uncontrolled descent from altitude during and after flight in reported or suspected icing conditions," the FAA said.

Under the Microscope

The safety evaluation was launched in July 2005 and focused on certification, maintenance, operations and training. The evaluation concluded that the airplane meets its certification requirements and that current maintenance requirements are sufficient. However, a flight standards information bulletin for airworthiness was issued in November 2005, directing FAA aviation safety inspectors to ensure that proper procedures and equipment are used by maintenance technicians during critical procedures,

or just different?

Mitsubishi MU-2B Accidents in the United States, 1983–2005



Source: U.S. Federal Aviation Administration

Figure 1

Comparative U.S. Fatal Accident Data, 1966–September 2005

	MU-2B			Contemporary Twin-Turboprop Airplanes						
				Commander		Beech		Cessna	Piper	
Accident Type	Short Body	Long Body	Total	680	690	90	100	425/441	PA-31T	Total
Loss of control	27	26	**53**	10	33	54	12	20	24	**153**
CFIT	1	10	**11**	3	1	7	1	3	4	**19**
Emergency maneuver	4	4	**8**	1	0	2	0	0	3	**6**
Ramp	1	3	**4**	0	0	2	1	0	0	**3**
Midair collision	1	1	**2**	0	3	1	0	1	2	**7**
Ground collision	0	0	**0**	0	0	1	1	1	0	**3**
Missing/unknown	0	2	**2**	0	0	0	0	0	0	**0**
Other	0	1	**1**	0	2	0	0	0	1	**3**
Total	**34**	**47**	**81**	**14**	**39**	**67**	**15**	**25**	**34**	**194**

CFIT = Controlled flight into terrain

Source: U.S. Federal Aviation Administration

Table 1

including the adjustment and rigging of fuel controls, propeller blade angles and flaps.

A flight standardization board (FSB) was convened to study training requirements. The board reviewed 20 existing training programs and found little standardization. "Only a few emphasized the different handling characteristics of the MU-2B or specialized operational techniques," the FAA said. A standardized training program developed by Mitsubishi Heavy Industries America (MHIA) was adopted after being revised by the FAA to meet the proposed SFAR requirements.

FSB flight test data analyzed by human factors personnel at the Civil Aerospace Medical Institute showed that use of an autopilot significantly reduces workload and stress, and improves pilot performance. The resulting proposed requirement for a functioning autopilot during specific operations was adopted in lieu of proposing a requirement for a second flight crewmember. The SFAR does not require that the autopilot be *used*, just that it be available to reduce pilot workload. The FAA and MHIA both recommend that the autopilot *not* be used in icing conditions because it could mask detrimental effects of icing on the airplane's performance and handling characteristics.

The FAA also considered requiring a type rating, which long has been recommended by MHIA, but concluded that the requirement would not ensure that pilots receive recurrent training in the MU-2B. During the evaluation, the FAA surveyed and held meetings with MU-2B pilots, operators, training providers and special-interest groups. "All participants agreed that something needed to be done to improve the safety record of the MU-2B," the FAA said. "Everyone supported mandatory type-specific, recurrent, standardized training for pilots."

Many participants said that the airplane flight manuals (AFMs) need to be reviewed and revised, and that a standardized cockpit checklist be developed for the airplane. The FAA agreed, and the proposed SFAR includes requirements to have and use an AFM that is up-to-date with revisions and a standardized cockpit checklist developed by MHIA.

Political Pressure

Two fatal accidents in 2004 — on May 14 and Dec. 10 (see appendix, page 36) — prompted numerous congressional inquiries about the safety of the MU-2B. The FAA's Web site includes 13 letters from members of the U.S. Congress, most of whom forwarded correspondence from constituents — relatives of pilots killed in the accidents — and requested information about the airplane.[2] At least six letters said that the airplane should be grounded until its safety record is thoroughly analyzed.

In the NPRM, the FAA said that it found no justification to ground the airplane. "The airplane meets its original type certification basis as found in three type certification analyses," the agency said.

After the NPRM was published, Tom Tancredo, a representative from Colorado, called on President George Bush to replace the FAA administrator and the chairman of the U.S. National

Transportation Safety Board because they "consistently failed to take appropriate action on this issue." Tancredo also introduced legislation that would force the FAA to ground the airplane until it "certifies that the aircraft is safe and a law is enacted approving the certification." However, proposed legislation such as this rarely becomes law.

Bird of a Different Feather

The MU-2B was certified in the United States under Civil Aviation Regulations (CAR) 10, which included CAR 3 standards for normal category airplanes and special conditions applicable to turboprop airplanes. Mitsubishi Heavy Industries produced 764 MU-2Bs between 1965 and 1986. The most significant model change came in 1970, with the introduction of the "long-body" MU-2B.[3]

The FAA estimates that there are 397 of the airplanes — 194 short-body models and 203 long-body models — and about 600 MU-2B pilots in the United States. There once were 675 MU-2Bs on the U.S. registry; the FAA said that 213 have been "withdrawn from use or written off" and 65 have been registered in other countries.

Initially popular among corporate/business aircraft operators, most MU-2Bs in the United States today are being operated for personal use under Federal Aviation Regulations (FARs) Part 91. The FAA estimates that 64 MU-2Bs are being flown by 18 Part 135 operators, primarily for on-demand cargo service.

Tancredo

"This shift to air-taxi and personal-flight operations increased the exposure of the MU-2B to certain known hazards: more frequent night flights; a significantly higher number of hours flown than in previous operations; an increase in single-pilot operations; and operation by pilots who may not be getting the level and frequency of training that corporate pilots typically receive," the FAA said.

The 2005–2006 safety evaluation concluded that the MU-2B is "a complex airplane requiring operational techniques not typically used in other light turboprop airplanes but more similar to those of turbojet aircraft that require a type rating."

Double-slotted Fowler flaps along the full span of the trailing edge of the wing provide short-field takeoff and landing capability. Spoilers provide roll control, and the outboard flap section on each wing incorporates a trim aileron. Wing loading is relatively high — 59 lb/sq ft (288 kg/sq m) for the short-body models and 65 lb/sq ft (317 kg/sq m) for the long-body models — compared with about 39 lb/sq ft (191 kg/sq m) for the F90 King Air, Conquest II, Commander 690 and Cheyenne II. Several pilots who participated in the safety evaluation said that because of the high wing loading and other design characteristics, the airplane must be "flown by the numbers" — that is, according to the AFM.

Feedback

The FAA received about 70 public comments on the NPRM. Most said that the proposed compliance time — 180 days after publication of the SFAR — should be extended to at least one year. MHIA, which provides spare parts and technical services, administers service centers and conducts free Pilot's Review of Proficiency seminars, said that an extension is necessary to train more instructors.

The proposed requirement that only SFAR-qualified pilots manipulate the controls was roundly criticized. Many comments said that a multiengine- and instrument-rated pilot should be allowed to manipulate the controls under the supervision of a qualified PIC.

Several commenters, including two of the largest fleet operators — American Check Transport and Bankair, cited the difficulty of maintaining the original autopilots and called for retention of the current master minimum equipment list provisions for operating the airplane with an inoperative autopilot.

The potential economic impact was criticized by several commenters who called for less burdensome requirements, such as training to proficiency instead of a set number of hours. Epps Air Service, which operates 10 MU-2Bs, said that the market value of the airplanes has dropped substantially since publication of the NPRM and that because of the high turnover in the employment of Part 135 pilots, training costs will be higher than estimated by the FAA.

Many commenters applauded the FAA for resisting the political pressure to ground the airplane. According to U.S. legal requirements, the agency has until April 2008 to publish a final rule or withdraw the proposed SFAR. ●

Notes

1. The recent safety evaluation of the MU-2B by the U.S. Federal Aviation Administration (FAA) followed special certification reviews (SCRs) conducted in 1983–1984 and

1996–1997. The first SCR focused on the airplane's engines, fuel system, autopilot, flight control system and handling characteristics during approaches in instrument meteorological conditions and with one engine inoperative. The second SCR focused on flight in icing conditions. All three reviews concluded that the airplane complies with the regulatory standards under which it was certified.

2. The letters are included in the FAA's "MU-2 FOIA [Freedom of Information Act] Reading Library," which can be accessed by conducting an Internet search for "MU-2." The safety evaluation docket can be accessed by conducting a keyword search for "MU-2" on the U.S. Department of Transportation's docket management system site, <dms.doc.gov>.

3. Mitsubishi Heavy Industries (MHI) produced about 13 different models of the MU-2. The prototype, which had the marketing designation MU-2A, first flew in 1963 with Turbomeca Astazou engines but was not produced. Production models have Honeywell — formerly Garrett AiResearch — TPE331 engines. The first production model, the MU-2B, was introduced in 1965. Although "MU-2B" is the generic name for the production airplanes, subsequent models have series identifications as well as marketing designations: for example, the MU-2B-10/MU-2D, which was introduced in 1968 with wet-wing tanks replacing fuel bladders. The first of the "long-body" models, the MU-2B-30/MU-2G — which is slightly more than 6 ft (2 m) longer and has what MHI calls "bulges" to house the main landing gear — was introduced in 1970, joining the "short-body" MU-2B-20/MU-2F. In 1978, the models were renamed the MU-2B-60 "Marquise" and the MU-2B-40 "Solitaire." Production ended in 1986.

Appendix

Mitsubishi MU-2B Fatal Accidents, United States, 2004–2005

Date	Location	Aircraft Model	Aircraft Damage	Fatalities
March 11, 2004	Napa, California	MU-2B-40	destroyed	2
The aircraft crashed during an approach in visual meteorological conditions (VMC) to Napa County Airport at 2030 local time. The preliminary report by the U.S. National Transportation Safety Board (NTSB) said that the wreckage was found in a river 3 mi (5 km) south of the airport seven days after the accident.				
March 25, 2004	Pittsfield, Massachusetts	MU-2B-36	destroyed	1
The aircraft was on a cargo flight in VMC when it descended rapidly from 17,000 ft. Several witnesses said that the aircraft was in a flat spin with the engines operating when it struck terrain at 0533. The pilot had about 6,500 flight hours, including more than 2,000 flight hours in type. NTSB said that the probable cause of the accident was "the pilot's loss of aircraft control for undetermined reasons."				
May 14, 2004	Ferndale, Maryland	MU-2B-60	destroyed	1
The pilot, who had more than 6,800 flight hours, was conducting a nighttime cargo flight to Baltimore–Washington International Airport and was cleared to land on Runway 33R. The report said that the pilot attempted to reverse course after entering a "modified downwind" for Runway 15L. Witnesses saw the aircraft enter a steep left bank at about 700 ft and descend to the ground. NTSB said that the probable cause of the accident was "the pilot's failure to maintain airspeed during a sharp turn, which resulted in an inadvertent stall."				
Dec. 10, 2004	Englewood, Colorado	MU-2B-60	destroyed	2
Soon after departing from Runway 35R at Centennial Airport for a nighttime cargo flight, the pilot told the tower controller that he needed to return to the airport. The aircraft was on downwind for Runway 35R when the pilot reported that he had shut down one engine. The aircraft overshot the turn to final, entered a steep left bank and descended to the ground. NTSB said that the probable cause of the accident was "the pilot's failure to maintain minimum controllable airspeed [V_{MC}]." The pilot had 2,496 flight hours, including 364 flight hours in type. The report said that a pilot-rated passenger was aboard to receive aircraft-familiarization training.				
May 24, 2005	Hillsboro, Oregon	MU-2B-25	destroyed	4
After takeoff, the pilot was conducting a steep climb at an airspeed below V_{MC} when a partial power loss occurred in the left engine. The aircraft rolled into a steep left bank, pitched nose-down and spun to the ground. NTSB said that "the pilot's failure to obtain minimum controllable airspeed" was the probable cause of the accident and that "the pilot's lack of recent experience and recurrent training in type" was a factor.				
Aug. 4, 2005	Parker, Colorado	MU-2B-60	destroyed	1
The preliminary report said that the aircraft struck terrain after descending below the glideslope during an instrument landing system (ILS) approach to Centennial Airport. The accident occurred at 0206 in instrument meteorological conditions. The pilot had more than 4,800 flight hours, including 1,200 flight hours in type.				
Sept. 22, 2005	West Memphis, Arkansas	MU-2B-36	destroyed	1
About 20 minutes after departing from West Memphis for a positioning flight in nighttime VMC, the pilot told air traffic control that he needed to return to the airport "to have something checked out," the preliminary report said. A witness, a professional pilot, saw the aircraft flying "way too low" and "excessively slow" before it struck a large earthmoving vehicle and terrain near the airport. The pilot had 12,600 flight hours, including 1,900 flight hours in type.				

Source: U.S. National Transportation Safety Board

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RISKS on Feathered Wings

As air traffic and wildlife populations increase, collisions between aircraft and wildlife — especially birds — are increasingly likely.

BY LINDA WERFELMAN

Wildlife strikes at airports around the world destroyed more than 163 aircraft and killed more than 194 people from 1988 through 2005, and the threat to human health and safety is increasing, a 2006 report by the U.S. Federal Aviation Administration (FAA) says.[1]

The report warned of an increase in the "risk, frequency and potential severity of wildlife-aircraft collisions" during the next decade, primarily as a result of three factors:

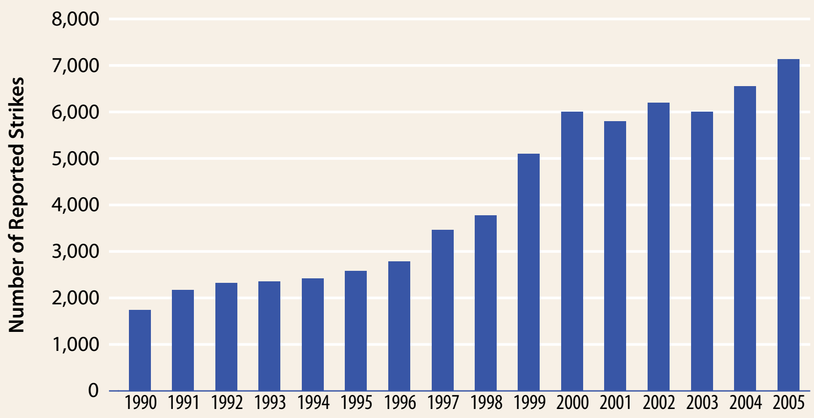
- The replacement of older aircraft with three or four engines with quieter, two-engine aircraft "increases the probability of life-threatening situations resulting from aircraft collisions with wildlife, especially with flocks of birds," because of the reduction in engine redundancy. In addition, research indicates that birds "are less able to detect and avoid modern jet aircraft with quieter engines than older aircraft with noisier engines" — one of the reasons that bird strikes damage engines more often than any other aircraft component.

  As an example of the extent of the change, in 1969, 75 percent of the 2,100 passenger aircraft in the United States had three or four engines; by 2008, only about 10 percent of the 7,000 passenger aircraft in the United States will have three or four engines.

- The populations of many species most commonly involved in strikes — and many bird species with the largest body weights — have increased dramatically in recent years. For example, the Canada goose population in Canada and the United States increased about 7.9 percent a year from 1980 through 2005, and the population of white-tailed deer — estimated at 350,000 in 1900 — increased to at least 17 million in 1997.

- As wildlife populations have increased, so has air traffic — 29.9 million aircraft

Wildlife Strikes Involving U.S. Civil Aircraft, 1990–2005



Source: U.S. Federal Aviation Administration

Figure 1

movements in the United States alone in 2005, compared with 17.8 million in 1980, the report said. Growth is expected to continue to increase by at least 2 percent each year through the end of the decade.

New Technologies

As wildlife strikes increase, airport authorities are turning to a variety of programs to remove birds and other wildlife from the paths of aircraft.

Among the new technologies is a laser bird repellent, the TOM500, developed by Lord Ingénierie for the French Direction Générale de l'Aviation Civile and being tested at Montpellier Airport in France.

The device uses a green laser beam — safe for the human eye — to scan runways and frighten away birds. Several months after installation of the TOM500 at Montpellier Airport, birds no longer appeared in the runway area; no bird strikes have occurred at the airport with the device in operation.[2]

Another new system is DeTect's Merlin radar system, being tested at Dallas/Fort Worth International Airport in Texas and Kennedy International Airport in New York. This system detects birds but does not scare them away and often is paired with other bird-scaring technologies.[3,4]

Millions in Damages

The FAA report included an estimate that aircraft strikes of birds and other wildlife cost the U.S. civil aviation industry US$557 million a year, plus 580,029 hours of aircraft down time.

The data showed a dramatic increase in reported wildlife strikes in the United States in recent years — a trend that is likely to continue, the report said. From 1990 through 2005, authorities received reports of 66,392 wildlife strikes involving civil aircraft in the United States (Figure 1). Of these, 97.5 percent involved birds. In the final year of the period, 7,136 wildlife strikes were reported — more than quadruple the 1,744 strikes reported in 1990.

The report said that the increase probably was a result of several developments: Aircraft operations and wildlife populations both increased, leading to an increase in the actual number of wildlife strikes, and awareness of the problem increased, leading to an increase in reporting of the events.

Nevertheless, the report estimated that less than 20 percent of wildlife strikes for the 16-year period were reported to FAA; in addition, information about the extent of damage and cost estimates often was incomplete.

Of the wildlife strikes reported during the 16-year period, 144 involved reports of injury or death to humans — nine deaths and 172 injuries. Waterfowl and birds of prey were most frequently identified as the types of birds involved, and deer were the most frequently identified terrestrial mammals (land-based mammals, excluding bats).

Engines Incur Most Damage

The report said that commercial aircraft were involved in 84 percent of the reported wildlife strikes in the 1990–2005 analysis. Reports were received from throughout the United States, including some from U.S. territories, and from other countries if U.S.-registered aircraft were involved.

Of the bird strikes, 51 percent occurred between July and October, and 63 percent occurred during daytime. About 59 percent of bird strikes occurred during the landing phase of flight, and 38 percent occurred during takeoff and climb; 60 percent occurred 100 ft above ground level or lower.

Of the terrestrial mammal strikes, 58 percent occurred between July and November — 33 percent of deer strikes occurred in October and November. Sixty-three percent occurred during nighttime, 55 percent during the landing roll and 34 percent during the takeoff roll; 8 percent occurred when the aircraft was in the air — for example, when an aircraft's landing gear struck a deer.

Aircraft engines were the components most often damaged by bird strikes, accounting for 32 percent of all damaged components, the report said. Of the 8,750 reported bird strikes involving aircraft engines, more than 400 involved more than one engine: 421 events involved strikes to two engines, 10 involved strikes to three engines, and five involved strikes to four engines. Of the engines that were struck, 3,011 were damaged: 2,822 events involved damage to one engine, 93 involved damaged to two engines, and one involved damage to three engines.

Of the reported terrestrial mammal strikes, the components most often reported as damaged were the landing gear, propeller and wing/rotor.

Of the 64,734 bird strike reports, 53,309 discussed the extent of damage to the aircraft. Less than 1 percent of the aircraft were destroyed, 4 percent incurred substantial damage, 8 percent incurred minor damage, and 85 percent were not damaged.

Of the 1,420 terrestrial mammal strikes reported, 1,022 reports discussed the extent of damage to the aircraft. Of these, 2 percent of the aircraft were destroyed, 5 percent incurred an undetermined amount of damage, 28 percent incurred substantial damage, 29 percent incurred minor damage, and 36 percent were undamaged.

Overall, the report said, strikes involving terrestrial mammals resulted in damage to 64 percent of the aircraft, and strikes involving birds damaged 15 percent of aircraft.

Of the reports that discussed economic loss, the average was $113,000 per incident; of those that discussed aircraft down time, the average was 163.9 hours per incident. Many reports, however, did not discuss losses, so the actual numbers are estimated to be considerably higher, the report said.

In some instances, losses totaled millions of dollars.

For example, the cost of repairs was estimated at $9.5 million for an Airbus A310 that had multiple bird strikes to an engine during an attempted takeoff from Subic Bay, Philippines, on June 24, 2005 (see appendix, page 40). The engine and cowling were replaced, and the airplane was out of service for four days. The birds were identified as Philippine ducks.

Repairs cost about $1.5 million after a Dec. 30, 2005, strike in which a vulture crashed through the windshield of a Bell 206 near Washington, Louisiana, U.S., injuring the pilot, who experienced difficulty with his vision as he conducted a precautionary landing because the bird's blood was in his eyes.

The report said that, to fight the problem of wildlife strikes, airport authorities first must assess wildlife hazards on their airports and then "take appropriate actions, under the guidance of professional biologists trained in wildlife damage management, to minimize the problems," the report said.

"The aviation community must also widen its view of airport wildlife management needs to consider habitats and land uses in proximity to the airport. Wetlands, dredge spoil containment areas, waste-disposal facilities and wildlife refuges can attract hazardous wildlife. Such land uses are often incompatible with aviation safety and should either be prohibited near airports or designed and operated in a manner that minimizes the attraction of hazardous wildlife."

The report also urged more comprehensive reporting of wildlife strikes to enable analysts to more precisely determine the extent of related safety issues and the economic costs of the problem.●

Notes

1. Cleary, Edward C.; Dolbeer, Richard A.; Wright, Sandra E. *Wildlife Strikes to Civil Aircraft in the United States, 1990–2005*. Federal Aviation Administration (FAA) National Wildlife Strike Database, Serial Report No. 12. Washington, D.C. June 2006.
2. Lord Ingénierie. *Bird Strike: Laser Bird Repellent TOM500*. <www.lord-ing.com/eng/newpr.htm>.
3. DeTect. *Merlin*. <www.detect-inc.com/radar/?p=radar>.
4. Schofield, Adrian. "New Birdstrike Technology Trials Under Way at U.S., French Airports." *Airports*. Oct. 17, 2006.

How to Report a Strike

The Federal Aviation Administration (FAA) asks that wildlife strikes in the United States and those involving U.S.-registered aircraft in other countries be reported using FAA Form 5200-7 or via the Internet at <http://wildlife-mitigation.tc.faa.gov>.

Bird species that cannot be identified locally often can be identified by mailing feathers and other remains in a sealed plastic bag, along with Form 5200-7, to:

Feather Identification Laboratory
Smithsonian Institution,
Division of Birds
P.O. Box 37012
NHB, E610, RC 116
Washington, DC 20013-7012

These items also may be sent by express mail services to:

Feather Identification Laboratory
Smithsonian Institution
NHB, E610, MRC 116
10th and Constitution Ave. NW
Washington, DC 20560-0116

Envelopes should identify the contents as "safety investigation material."

— LW

Appendix
Selected U.S. Wildlife Strikes, 2005

Date	Location	Aircraft Type	Phase of Flight	Components Damaged
Jan. 7	Bowerman, Washington	Raytheon Hawker 1000	climb	no. 1, 2 engines
During climb, the pilot pulled the airplane's nose up to avoid birds, possibly dunlins, but they were ingested into both engine cores. A post-landing inspection found that the landing gear also was covered with small birds. The area is a wildlife refuge, but no specific warning had been issued.				
Jan. 12	Tokyo	Boeing 747	takeoff	engine, wing
During takeoff, the crew saw two birds on the runway centerline and other large birds under the airplane's nose and to the left, and then heard a loud bang. The airplane yawed left. An inspection showed that two fan blades had broken through the cowling, and others had been damaged. A bird ingested into the engine was identified as a hooded crow.				
Feb. 18	Oakland, California	McDonnell Douglas MD-10	climb	engine
During climb, a bird of an unidentified species was ingested into the no. 2 engine. An inspection showed that two blades had separated from the inlet fan and one blade had cut through the acoustic panel.				
Feb. 20	Miami	Cessna Citation Ultra	climb	none
The airplane struck a turkey vulture during climb. The crew believed that the impact was not hard and saw no indications of major damage. After landing, a hole with a 1.0-ft (0.3-m) diameter was found in the airplane's tail.				
Feb. 27	Orlando, Florida	Boeing 737-300	takeoff	engine
A gull struck an engine during takeoff. The strike had no apparent effect on engine operation, but a post-landing inspection found that several fan blades were dented.				
March 4	San Jose, California	Boeing 757-200	climb	engine
As the crew rotated the airplane for takeoff, a flock of gulls and small birds landed on the runway. At least one bird was ingested into the left engine. The crew returned to the airport and taxied to the gate. An inspection found that several fan blades were bent.				
March 30	Miami	Swearingen SA 227	landing roll	propeller, fuselage
During landing, a white-tailed deer — the last deer in a group of eight — was struck by a propeller blade, which separated and punctured the fuselage.				
April 1	Oakland, California	Boeing 757-200	climb	engine
During climb, a common loon was ingested into an engine. The crew declared an emergency and landed at a nearby airport. An inspection found that fan blades and the nose cowling had been damaged.				
April 9	Chicago	Boeing 737-300	climb	radome, horizontal stabilizer, engine
During climb, the airplane struck several birds of an unknown species, and one bird was ingested into the no. 2 engine.				
April 17	Brentford, South Dakota	Bell 407	en route	windshield
As the helicopter was being flown to the site of a vehicular accident, three blue-winged teal ducks struck the windshield, which shattered. Blood from the ducks temporarily blinded the pilot, who was directed by his crew to a safe landing site.				
April 20	between Denver and San Francisco	Boeing 777	en route	engine
A bird strike involving an unknown species occurred while the airplane was en route. A post-flight inspection found blade damage.				
April 24	New York City	Boeing 747	takeoff	engine
As the airplane was rotated for takeoff, it struck several gulls. The no. 2 engine was shut down because of vibration, and the crew dumped 18,700 lb (8,482 kg) of fuel before landing. Several fan blades were damaged.				
May 9	Brownwood, Texas	Rockwell NA265	takeoff	engine
The captain rejected the takeoff after hearing a loud bang and losing directional control of the airplane. Bird residue from an unknown species was found in the left engine.				
May 31	Kauai, Hawaii	Boeing 757	takeoff	engine
During takeoff, the pilots saw a barn owl on the right side of the airplane and felt vibration in the right engine. They conducted a precautionary landing at a nearby airport. An inspection found damage to the engine.				
June 10	Kansas City, Missouri	McDonnell Douglas DC-9	climb	engine
During the takeoff roll, the first officer saw a small bird, later identified as an American kestrel, fly in front of the airplane and disappear to the left. As the airplane was rotated, it vibrated and rolled left, and loud banging noises were heard. The crew conducted an emergency landing. An inspection found damage to several fan blades and the fan case.				
June 24	Subic Bay, Philippines	Airbus A310	takeoff	engine, cowling, wing
A loud bang was heard during the takeoff roll, followed by vibration and a "pull" to the right. An inspection found damage to fan blades, the nose cowling and a fan cowling. The bird was identified as a Philippine duck.				

Continued on next page

Appendix
Selected U.S. Wildlife Strikes, 2005

Date	Location	Aircraft Type	Phase of Flight	Components Damaged
Aug. 4	Refugio, Texas	Cessna 421	landing	nose landing gear, propellers
The airplane struck a deer while landing.				
Aug. 17	Merritt Island, Florida	Cessna 421	descent	wing, tip tank, electronics
During descent, a collision with a black vulture "ripped the wing," tore a hole in a fuel tank and damaged an annunciator light that would have confirmed whether the landing gear had been extended. The pilot conducted an emergency landing.				
Aug. 23	Phoenix	MD Helicopters MD 520	en route	windscreen, rotor blades
During cruise at 400 ft above ground level, a bird — an American coot — hit the windscreen, shattering the left side. In addition, the rotor blades were scratched.				
Sept. 1	Lorain County, Ohio	Falcon 20	climb	engines, tail, wings, fuselage, landing gear
After rotation, the airplane hit a flock of birds, later identified as mourning doves, and the no. 1 engine flamed out. After the crew retracted the landing gear, the airplane struck another flock, and no. 2 engine speed decreased. The crew could not maintain airspeed or altitude, and the airplane crashed into a ditch and an airport perimeter fence.				
Sept. 3	Cleveland	Boeing 757	climb	engines
Just after rotation, the crew saw a large flock of European starlings and tried to avoid hitting the birds. They heard several birds strike the airplane. Engine instrument indications were normal, and the flight was continued to its destination. An inspection found damage to both engines.				
Sept. 13	Fort Worth, Texas	McDonnell Douglas DC-10	landing	engine
During landing, between 15 and 20 rock pigeons were ingested into the no. 3 engine.				
Sept. 30	unknown	McDonnell Douglas DC-10	unknown	engine
During maintenance, technicians found indications that a wood duck had struck the no. 1 engine.				
Oct. 16	Ogdensburg, New York	Raytheon Beech 1900	takeoff	engines, propellers, landing gear, nose, fuselage
During the takeoff run, the airplane struck a coyote, causing the nose landing gear to collapse and propeller blades to cut through the airplane's skin.				
Oct. 17	Vacaville, California	Raytheon Beech 400	landing	engine, landing gear, fuselage, pitot tube
During the landing rollout, the airplane struck about 20 wild turkeys, including one that was ingested into an engine.				
Nov. 1	Sioux Falls, South Dakota	Airbus A300	climb	engine
While the airplane was climbing through 6,000 ft, a large bird, later identified as a mallard, struck the no. 2 engine. The crew felt engine vibrations and heard related noise. They returned to the departure airport, where an inspection found damage to several fan blades and other parts of the engine.				
Nov. 30	Denver	Boeing 747	approach	engines, wing
During approach, Canada geese struck the no. 1 and no. 2 engines. The engines appeared to continue to function normally, although a subsequent inspection found core ingestion and damage to fan blades in both engines. Holes were found in both flaps, with "a leg with webbed foot" protruding from one hole.				
Dec. 13	Harrisburg, Pennsylvania	Embraer 145	approach	engine
During approach, the crew saw "a streak" outside the left window and felt a jolt. They detected an odor, turned off the air-conditioning pack and reduced power to idle. When they tried to increase power, violent compressor stalls occurred. Investigators said the airplane struck a Canada goose.				
Dec. 28	Chicago	Boeing 737-300	climb	engine
During climb, a large bird — later identified as a snowy owl — was ingested into the no. 2 engine, and the crew performed a precautionary landing. An inspection found that the engine was destroyed.				
Dec. 28	Sacramento, California	Boeing 737-500	climb	engine
The crew saw a large white bird of an undetermined species fly by the left side of the airplane and heard a loud pop before the engine began vibrating. The crew returned to the airport for a precautionary landing. All fan blades were replaced.				
Dec. 30	Washington, Louisiana	Bell 206	en route	destroyed
During cruise at 50 ft above ground level, a large vulture crashed through the windscreen, and the pilot was temporarily unable to see because of wind and the bird's blood in his eyes. The pilot tried to land in a bean field, but the left skid hit the ground and the helicopter tipped onto its side.				

Source: Cleary, Edward C.; Dolbeer, Richard A.; Wright, Sandra E. *Wildlife Strikes to Civil Aircraft in the United States, 1990–2005*. Federal Aviation Administration National Wildlife Strike Database, Serial Report No. 12. Washington, D.C. June 2006.

Conclusions from the analyses of six approach and landing incidents that might have resulted in controlled flight into terrain but for timely warnings by TAWS.

BY DAN GURNEY

LAST LINE OF DEFENSE

Learning From Experience

Most flight crews on most days manage the threats and avoid error-prone behavior that can occur in flight operations, as presented in this series of "TAWS saves" analyses. However, in some situations, threats and opportunities for error can overcome human defenses, and a technological solution is required. If the threats involve terrain or obstacles, then terrain awareness and warning system (TAWS) warnings and prompt, correct action by the flight crew serve as the last line of defense against controlled flight into terrain.[1]

Threats

The threats that were identified in the incident analyses can be placed in two groups:

- Threats arising from pre-existing conditions that can be encountered in most operations, including: false visual cues during a "black hole approach"; instrument approach charts that lack altitude/range tables, are cluttered and difficult to decipher, or depict ambiguous procedures; nonprecision approach procedures; and approach procedures incorporating distance measuring equipment (DME) offset from the runway threshold or primary navaid.[2]

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- Situational threats arising from particular flight conditions and situations, including: nighttime and/or instrument meteorological conditions; a late change of plan; and failure to react, or react correctly, to alerts and warnings.

In isolation, these threats may pose no undue risk; but when they combine, the risk of catastrophic error increases significantly.

All the pre-existing conditions can be identified by management audit and crew vigilance. The risk-assessment process should identify conditions that might act as risk multipliers.[3] For example, runways that are prone to black hole conditions should be considered as significant risks at night. Similarly, nonprecision approaches and instrument approach procedures depicted on cluttered or ambiguous charts should be considered as particularly high risks.

Whenever threat conditions are identified, they should be reported and either eliminated, mitigated or avoided. Flight crews must recognize situational threats. This requires focused attention, instrument-scan patterns that help maintain good flight path awareness and sound decision making to avoid or mitigate the risks presented by the threats.

Photo: BAE Systems

This altimeter was in a BAe 146 that struck a mountain 120 ft below the summit on approach to Melilla, Spanish Morocco, on Sept. 25, 1998. The flight crew did not respond immediately to a GPWS warning, and all 38 people aboard were killed.

Errors

The errors identified in the incident analyses appear to have originated from circumstantial conditions or from unidentified or mismanaged threats, with the following results:

- Inadequate situational awareness when the flight crew believed that they understood the situation but did not. This led to errors that included: succumbing to visual illusions or misidentifying visual cues; misinterpreting procedures depicted by instrument approach charts or incorporated in standard operating procedures (SOPs); and failing to understand a procedure or to have a shared mental model of the procedure. These are errors that originate in the cognitive process — that is, what we think about, how and on what we focus our attention, and why we believe that something is important.

- Selection of a wrong course of action, an error that often involved simple slips, mistakes or memory lapses. Typically the result of inadequate training or poor discipline, this type of error originates from weaknesses in cognitive control — that is, the way we control our thinking through self-discipline, double-checking, managing time, avoiding preconceptions and not rushing to conclusions.

All the errors could have been — and should have been — detected before the TAWS warnings occurred through self-monitoring and cross-crew monitoring not only the aircraft's flight path but also individual and crew behavior. Such monitoring requires application of crew resource management (CRM) skills involving communication for developing a shared mental model and cross-checking facts and common understandings.

An error is a source for learning and an opportunity to gain experience. When errors are detected in normal operations, they should be reported so that the circumstances can be identified and assessed, and safety actions taken if warranted. Confidential reporting systems increasingly are being used to bring errors to light. However, crews also should openly debrief errors to identify the contributors and the mechanisms of detection and recovery. The crew should pay attention to the good points as well as the not-so-good, what was interesting and previously not known, and why.

Moreover, it is essential for each pilot to conduct a self-debriefing to clarify his or her understanding of any error, the situational threats under the circumstances and/or the beliefs and behavior that may have led to the error.

Threat and Error Management

Monitoring is an essential element in threat and error management. Yet, in each of the incidents, monitoring failed for one reason or another. In some incidents, the crews either lacked information, such as altitude/range tables, or failed to use information that was available, such as electronic flight information system (EFIS) maps. The solution to these problems requires organizational action to provide vital information and procedures, and personal commitment to use them.

The monitoring process must be accurately defined in SOPs, trained and practiced to enable skillful application. To be effective, monitoring must be truly independent; there is little value in both pilots using the same source as a cross-check. Independent cross-checking also is important for flight path control; there is no point in the pilot monitoring calling out altitudes and ranges for the pilot flying to follow during the approach if the pilot monitoring has misidentified the information or the information is incorrect.

"Monitoring independence" starts with the approach briefing. Each pilot should monitor the briefing by cross-checking the details on his chart and ensuring that he understands the plan for the approach. An approach briefing is a "flight plan for the mind" and provides a master pattern for subsequent comparisons. The crew must have a common understanding, a shared mental model that is correct for the situation. Most pilots think in pictures but communicate with words; both processes can be taught and improved.

Situational Awareness

In each incident, the flight crew lost awareness of the aircraft's position relative to the runway in terms of altitude, distance and time.

Humans tend to build internal models, or patterns, of the way things should be, both in the sense of an "ideal" current situation and for future events. Crews need to guard against short-term tactical thinking in which response to what is expected often dominates the sound assessment and judgment of strategic thought. Pilots must control their thinking, consider early what a situation could become, consider options and alternatives, and, if in doubt, ask questions.

The most important element in decision making is the objective. When the objective is a safe landing on the runway, the situation-assessment process must include attention to the location of the runway and a continual updating of the shared mental model of the aircraft's position relative to the runway. Crews should use all their tools: display the runway position on the EFIS; pay attention to vertical displays; and select the terrain map for all approaches, as well as for departures.

Taking Action

A TAWS warning can create surprise and stress due to the unexpected nature of the event. Generally, pilots experience the need to understand the situation before taking action and, thus, begin a new assessment process. This delays action. Stress also increases difficulties in perceiving information and thinking, which also delays action.

A TAWS warning requires immediate action without thought, an automatic behavior. To gain this skill, crews need to practice their pull-up technique in response to a TAWS warning in surprising, stressful training situations. For example, simulator instructors can place a "glass mountain" in the aircraft's flight path to surprise the pilots and enable them to hone their pull-up reaction. During the debriefing, the crew might argue that the warning was out of context, they "knew where they were" and there was no real terrain threat. The counter argument is that this is precisely the mindset that the incident crews might have had. They likely were convinced that they knew where they were and that the TAWS warning was wrong, not them. Fortunately, except for hesitation by one crew, the incident crews reacted correctly, pulled up and avoided impending collisions with terrain or obstructions.

Training must overcome the doubting mindset and the compulsion to understand the situation before responding to a TAWS warning. A pull-up must be conducted without hesitation.

Moreover, the use of conditional phrases in TAWS procedures should be avoided. There is no need for the "if visual" and "if certain of position" phrasing that often was included in previous ground-proximity warning system (GPWS) procedures to prevent reaction to inappropriate warnings. TAWS is significantly more reliable than GPWS and is not prone to generating inappropriate warnings (Figure 1). When a TAWS warning is generated, there is no time for thinking and assessment; the crew must react immediately. After climbing to the minimum safe altitude, the crew must determine the reason for the warning before descending again. Remember that most TAWS warnings are the result of human error.

Building Defenses

All six incidents involved aircraft with modern technology, "glass" flight decks and equipment that should have enhanced situational awareness. Yet, all the incidents involved close encounters with terrain or obstacles. The aviation industry was "lucky" that accidents were avoided and a good safety record was maintained — but just how lucky?

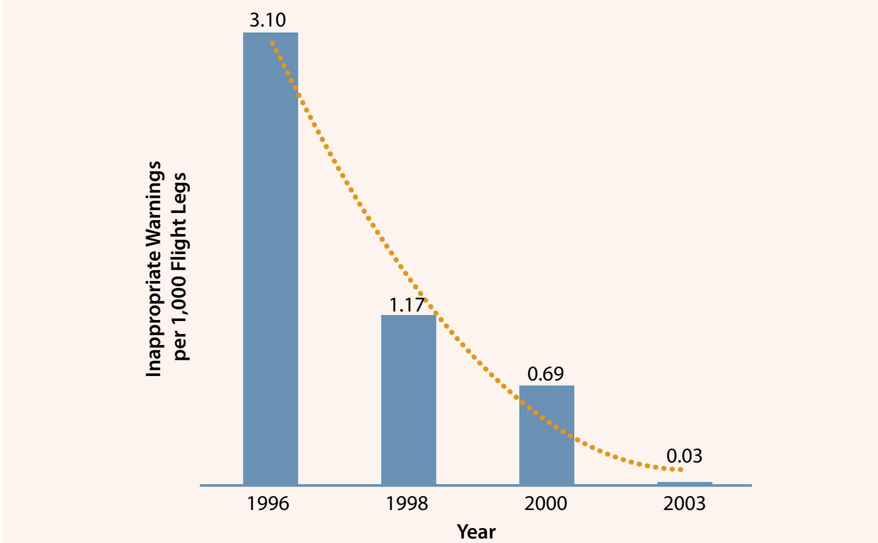
In the majority of the incidents, the flight crews apparently were unaware of the aircraft's position relative to the runway, either in space or time, or both. In two incidents, the aircraft were at very low altitudes, with crews preparing to land, yet were still 1.5 nm (2.8 km) from the runways. The single incident in which an obstacle warning was generated involved the only aircraft in the operator's fleet that had the TAWS obstacle mode activated.

Luck in these incidents could be defined as having defenses that just matched the hazard or risk. However, in an industry that seeks defense in depth and considering that all of the incidents involved the last defense — the crew pulling up following a TAWS warning —"luck" is unacceptable. We cannot expect that the last line of defense will always hold; in one incident, the crew failed to react immediately and correctly to a warning.

In-depth defenses should be based on active threat and error management at all managerial and operational levels. This requires constant vigilance to identify threats and errors, risk assessment and timely decisions to select corrective courses of action. These processes depend on thinking skills, which are the foundations of airmanship, leadership and professional management.

As of Nov. 1, 2006, more than 35,000 aircraft had been fitted with TAWS. Aircraft equipped with the system had flown 300 million flight sectors without a controlled-flight-into-terrain accident. This is a major success for the industry, and every effort must be made to continue and protect this achievement. ●

Frequency of Inappropriate TAWS Warnings



TAWS = Terrain awareness and warning system

Source: Dan Gurney, from Honeywell

Figure 1

[This series, which ran in *Aviation Safety World* from July through December 2006, is adapted from the author's presentation, "Celebrating TAWS Saves, But Lessons Still to Be Learned," at the 2006 European Aviation Safety Seminar, the 2006 Corporate Aviation Safety Seminar and the 2006 International Air Safety Seminar. Don Bateman, Yasua Ishihara and the Honeywell EGPWS safety team contributed to the research and preparation of the paper.]

Dan Gurney served in the British Royal Air Force as a fighter pilot, instructor and experimental test pilot. He is a co-author of several research papers on all-weather landings. Gurney joined BAE Systems in 1980 and was involved in the development and production of the HS125 and BAe 146, and was the project test pilot for the Avro RJ. In 1998, he was appointed head of flight safety for BAE Systems. Gurney is a member of the FSF CFIT/ALAR Action Group, the FSF European Advisory Committee and the FSF steering team developing the "Operators Guide to Human Factors in Aviation."

Notes

1. *Terrain awareness and warning system* (*TAWS*) is the term used by the International Civil Aviation Organization to describe ground-proximity warning system (GPWS) equipment that provides predictive terrain-hazard warnings; *enhanced GPWS* (*EGPWS*) and *ground collision avoidance system* (*GCAS*) are other terms used to describe TAWS equipment.
2. A *black hole approach* typically occurs during a visual approach conducted on a moonless or overcast night, over water or over dark, featureless terrain where the only visual stimuli are lights on and/or near the airport. The absence of visual references in the pilot's near vision affects depth perception and causes the illusion that the airport is closer than it actually is and, thus, that the aircraft is too high. The pilot may respond to this illusion by conducting an approach below the correct flight path — that is, a low approach. In the extreme, a black hole approach can result in ground contact short of the runway.
3. A checklist designed for assessing such risks, the *Approach-and-landing Risk Awareness Tool*, is part of the FSF *Approach-and-landing Accident Reduction (ALAR) Tool Kit*. Information about this and other resources for preventing ALAR and controlled flight into terrain is available at <www.flightsafety.org>.

‘Over in a Flash’

How Airbus emptied a packed A380 12 seconds faster than necessary.

BY WAYNE ROSENKRANS

When 873 people jumped out of an Airbus A380-800 onto slides in 78 seconds last March, two pursers and 16 flight attendants helped validate the airplane’s new evacuation technology, procedures and training. Although this full-scale emergency evacuation demonstration in Hamburg, Germany, was certified within days by the European Aviation Safety Agency (EASA) and the U.S. Federal Aviation Administration (FAA), cabin safety researchers likely will spend years analyzing the data.

At Flight Safety Foundation’s International Air Safety Seminar (IASS) in Paris in October 2006, an Airbus official added details of how a Lufthansa cabin crew guided about 11 passengers per second off the airplane, which has 16 doors, through the eight doors on the right side. Francis Guimera, A380 program safety director, said, “Without a doubt, cabin crew are the most important element in case of an emergency [or] an evacuation demonstration. … Never before have so many people been safely evacuated from an aircraft. Because of the double-deck configuration, a single-shot [demonstration] — both decks at the same time — was requested by EASA and FAA to identify any possible slide interference.”

The A380-800 — which received joint EASA/FAA type certification on Dec. 12, 2006 — is an all-new four-engine jet transport airplane that typically is expected to have 555 passenger seats in three classes with two aisles per deck, but can be configured to carry more than 800 passengers in high-density seating. A passenger seating configuration of 110 seats is allowed by EASA/FAA regulations for each pair of Type A exits.[1] The A380 is equipped only with Type A exit doors, with the eight pairs designated forward to aft on the main deck as M1, M2, M3 (overwing), M4 and M5, and on the upper deck as U1, U2 and U3. This airplane preferably will be evacuated as two separate cabins, and forward and aft staircases will offer a potential secondary escape route. The demonstration established a maximum passenger-seating capacity of 853 with the minimum 18 flight

Airbus

attendants. Another demonstration would be required to raise that seating number.

The demonstration’s purpose was to determine if this airplane type can be evacuated in a timely manner, that is, within 90 seconds, as required by Part 25.803 and Appendix J to Part 25 of the EASA Joint Aviation Requirements and the U.S. Federal Aviation Regulations (FARs). The demonstration also is intended to confirm the adequacy of emergency procedures and the effectiveness of crew training.

Engineering innovation was critical for evacuation to be feasible. “For an aircraft of such size, you find it necessary first to imagine the appropriate evacuation means,” Guimera said. Overall, the evacuation system comprises eight door-mounted slides and two fuselage-mounted overwing slides for the main deck, and six fuselage-mounted slides for the upper deck. Beside each door is a door-and-slide indication panel that helps any crewmember to correctly handle the powered-door operation and to confirm that slides are fully inflated. Briefing cards and

Airbus

After the demonstration, hangar lighting reveals evacuation system equipment — including predeployed upper deck slides — that had been visually concealed beforehand from volunteer passengers and crewmembers.

placards inform passengers how to operate the system.

Because the upper deck door sills are 7.87 m (25.80 ft) above the ground, the corresponding slide/ramps provide integral blinder walls and a curved ramp to mitigate passenger fear of heights. Each of these slides is 14.7 m (48.25 ft) long. They are designed so that the maximum velocity of a person arriving at the ground is no faster than that for a person descending from a current single-deck aircraft.

Manufacturer Goodrich's Tribrid gas-generator module — along with new slide fabrics, adhesion methods and light-emitting diode (LED) exterior lighting — exemplify the new technology developed for the system. A reservoir within the module for each slide contains carbon dioxide in liquid form as a coolant, and a gaseous mixture of carbon dioxide and nitrogen. "The [electrically fired squib and solid] propellant provide the energy to expand the primary gases that transform the liquid coolant into a mixed gas discharged into [slides]," Guimera said.

Another evacuation innovation is the "intelligent" slide for each M1 door, i.e., a ramp extension operated automatically by aircraft-attitude sensors. This means that if an A380 is sitting on the ground in a tail-low attitude with the main gear extended — causing the door sill to exceed the normal 5.1 m (16.7 ft) height — an electrically actuated cutter releases an additional length of ramp that will rest on the ground.

In preparation for the demonstration, a pool of 42 Lufthansa cabin crewmembers trained in Toulouse, France, completing a three-day subset of the full A380-800 cabin crew curriculum. They also spent a half-day visiting the demonstration aircraft. "We addressed only topics that were relevant," Guimera said. "[We told them,] 'Make yourself heard, help those in the vicinity of the [assigned cabin] area and verify that no occupants are still remaining in the aircraft.' In stair management, we were very interested to see if there was any possibility of migration between the upper deck and the main deck. We succeeded [during the demonstration] … there was no movement of people between the upper deck and the main deck."

In Hamburg on the morning of the demonstration — Sunday, March 26 — 18 cabin crewmembers from the 42 on standby were called to the Airbus hangar. They received a briefing about the on-site safety plan, in which 80 slide assistants would handle all evacuees as they reached the ground. Otherwise, this briefing was highly restricted in its content per EASA/FAA regulations. Afterward, recalling his experience with the volunteer passengers, Lufthansa flight attendant Stefan Kaiser said, "It was all over in a flash. All we had to do was dictate the pace for them to jump."

Airbus photos of before-and-after demonstration activities do not show the low level of illumination that evacuees actually experienced. At the evacuation signal, normal cabin lighting changed to floor-proximity emergency escape path lighting and outside illuminated slides — yellow LEDs integrated into railings — outlined the escape route. Forty infrared-sensitive video cameras were used, and two videos were shown and discussed at the IASS.

Table 1 shows that the upper deck was evacuated in the same amount of time as the main deck. The rate at every door — ranging from about 1.3 to 1.8 evacuees per second — exceeded the theoretical average rate of 1.2 evacuees per second per door required to evacuate the occupants within 90 seconds.

Airbus A380-800 Emergency Evacuation Demonstration[1]

Door Designation	Evacuation Start Time[2]	Door Begins to Open[3]	First Evacuee on Slide	Last Evacuee on Ground	Time Elapsed From Start (Seconds)	Rate (Evacuees per Second)	Passenger Evacuees	Crew Evacuees[4]	Total Evacuees
Five Main Deck Doors Used – Right Side									
M1	16:27:37	16:27:42	16:27:50	16:28:49	72	1.5	105	3	108
M2	16:27:37	16:27:42	16:27:50	16:28:48	71	1.4	98	3	101
M3 (overwing)	16:27:37	16:27:41	16:27:48	16:28:55	78	1.4	106	3	109
M4	16:27:37	16:27:42	16:27:49	16:28:54	77	1.8	137	2	139
M5	16:27:37	16:27:42	16:27:50	16:28:52	75	1.3	92	2	94
Main deck subtotal							538	13	551
Three Upper Deck Doors Used – Right Side									
U1	16:27:37	16:27:43	16:27:49	16:28:51	74	1.4	101	1	102
U2	16:27:37	16:27:43	16:27:47	16:28:52	75	1.3	94	4	98
U3	16:27:37	16:27:43	16:27:49	16:28:55	78	1.6	120	2	122
Upper deck subtotal							315	7	322
Total							**853**	**20**	**873**

Notes

1. These unofficial data are based on two exterior infrared video recordings presented by Airbus at Flight Safety Foundation's International Air Safety Seminar in Paris in October 2006. Accuracy is subject to screen resolution of the videos, a limited view of the M3 overwing slide and other factors.
2. These are local times in Hamburg, Germany, on March 26, 2006. Sudden darkness in the cabin, except for emergency lighting, signaled the evacuation start time.
3. Each time represents the first visible motion of the door on the videos. Only a very low level of exterior illumination was allowed during the demonstration.
4. Crewmembers comprised two pursers, 16 flight attendants and two pilots. They were unaware of which doors to use until the evacuation signal.

Source: Flight Safety Foundation

Table 1

The fastest time, at the M2 door, appeared to be about seven seconds better than slowest time at the M3 overwing and U3 doors.

Evacuees at the upper deck doors appeared to show no hesitation. On the main deck, however, one passenger at M5 stepped through this door toward the slide, grabbed the right door frame, turned back and climbed toward the door before turning again and jumping onto the slide. For about four seconds, other evacuees jumped around this passenger without delay.

Guimera noted that one video shows a crewmember at the U1 door taking about 10 seconds to jump after the last person from his area had jumped. "An interesting thing to see is the delay because [this flight] attendant was checking that all of his area was free of passengers," Guimera said.

Crowding on the M3 overwing slide for about 17 seconds caused its inflated barrier to fold down and outward so that about a half dozen passengers appeared to lose their balance and/or fall onto the slide before they descended. "It was a concern, so we had to reinforce the barrier on the M3 overwing slide," Guimera said.

Videos shot inside the cabin show pursers and flight attendants shouting commands and assertively directing the evacuees to the best alternate exit whenever crowding slowed the flow at the exit the crewmember was monitoring, he added. Guimera cited a few examples of how Airbus interpreted the videos, measuring a "normal rate" of 1.85 evacuees per second. "We have five [aft] slides so it was more crowded," he said. "[For the M4 door,] we have an excellent report — 137 passengers were evacuated within 75 seconds."

Injuries during evacuation demonstrations for airplane certification long have been a concern. One of FAA's most cited figures is that 269 (4.6 percent) of 5,797 evacuees were injured in 19 demonstrations conducted from 1972 to 1991 — a rate that FAA called "unacceptable" in 2004 while advocating safer alternatives. Thirty-three passengers and no crewmembers were injured during the A380 demonstration; Airbus categorized the injuries as minor and cited one fractured femur, friction abrasions, sprained knees and bruises.

In addition to standard EASA and FAA certification requirements, the agencies created various special conditions for "novel or unusual design features," a standard term in certification regulations. Special conditions relevant to evacuation addressed the A380's full double-deck passenger cabins and very large seating capacity; forward and aft staircases connecting the main and upper decks; method of outside viewing from closed doors; slide/rafts for all upper deck doors for ditching; performance of escape systems installed in nonpressurized compartments after cold soak from a long flight and with 25-kt wind from the critical angle; the unique slide-inflation subsystem; and escape and/or removal of crewmembers from crew rest compartments.

The demonstration was one of many forms of extensive evacuation-related testing. Goodrich alone expected to conduct up to 2,500 tests of the A380 evacuation system, as one example. "This also was the first time that the authorities have requested that the manufacturer simultaneously inflate all the slides on one aircraft [using only battery power]," Guimera said, referring to a test completed successfully in June 2006.

Another special condition noted by Guimera was FAA's requirement for satisfactory slide operation at minus 55 degrees C (minus 67 degrees F). "This new requirement is setting a new standard," Guimera said. "[A380 certification] was also the first time that the authorities were not satisfied to demonstrate the slide/raft capability only by a simple analysis." So Airbus conducted full-scale tests in the Pacific Ocean in which one A380 slide/raft was inflated and boarded adjacent to a floating platform, then detached into open water for a sea trial.

A380 evacuation tests continued after the March 26 demonstration. Three days later, for example, Airbus conducted a full-scale migration test. "We installed 150 passengers on the main deck forward part and 70 on the upper deck," Guimera said. "We opened only … the forward left door [on the main deck] … to evaluate the crowding of people coming from the upper deck to the main deck. Finally, we succeeded in evacuating 220 people within two minutes … with no [adverse] interaction."

Guimera also addressed questions about computer simulation of evacuations. "Unfortunately, evacuees may create bottlenecks and confusion at the top of slides," he said. "[Software does not yet] simulate such anticipation [or how] migration between decks is to be avoided by appropriate gestures and correctly positioning [cabin] crew during the preflight briefing. We cannot support the idea to have a demonstration done only by simulation — the real test is certainly more revealing." ●

Note

1. A Type A exit is a floor-level exit with a rectangular opening of not less than 106.7 cm (42 in) wide by 182.9 cm (72 in) high with corner radii no greater than one-sixth of the width of the exit.

Swiss Watch

Accidents and incidents involving large Swiss-registered aircraft increased in 2005, but there were no fatalities for the fourth year in a row.

BY RICK DARBY

For the fourth consecutive year, large Swiss-registered aircraft — with maximum takeoff weights greater than 5,700 kg/12,500 lb — were involved in no fatal accidents in 2005, the Swiss Aircraft Accident Investigation Bureau said.[1] The rate of accidents and serious incidents[2] in the category increased compared with 2004, and was the third highest in the 1996–2005 period (Table 1).

The accident and serious incident rate for 2005 was 2.90 per 100 aircraft, compared with 1.61 for 2004 and an average of 2.09 for the previous nine years.[3] The spike in fatality rates in 1998 is attributable to the accident involving Swissair Flight 111 on Sept. 2, 1998, near Peggy's Cove, Nova Scotia, Canada. That event killed all 229 occupants after a fire began above the McDonnell Douglas MD-11's cockpit ceiling and spread rapidly, resulting in loss of control while the flight crewmembers were attempting an emergency landing.

Nevertheless, as Table 1 shows, the overall rate of accidents and serious incidents in the year of the Swissair Flight 111 accident was among the lowest in the 1996–2005 period, and the average of 2.68 from 1999 through 2005 has exceeded the average of 0.98 for 1996 through 1998.

The number of accidents and serious incidents involving Swiss-registered airplanes in the medium category of 2,250 kg–5,700 kg (4,960 lb–12,500 lb) increased from two in 2004 to three in 2005 (Table 2). The number of helicopter accidents and serious incidents in 2005, four, was half that of 2004.

Among accidents and serious incidents involving all types of Swiss-registered aircraft — airplanes, helicopters, gliders, balloons and airships — airplanes in the large category nearly doubled their proportion, from 13 percent in 2004 to 24 percent in 2005. Airplanes in the medium category represented 6 percent of the total in 2004 and 10 percent in 2005. Helicopters, involved in 25 percent of the total number of accidents and serious incidents in 2004, were involved in 14 percent of 2005's total.

The distribution of accidents and serious incidents by flight phase is shown in Table 3

Rate Up in 2005

Accidents, Serious Incidents, Fatalities and Rates, Swiss-Registered Aircraft,* 1996–2005

Year	Registered Aircraft	Accidents and Serious Incidents	Accidents and Serious Incidents per 100 Aircraft	Fatalities
1996	232	2	0.86	0
1997	229	2	0.87	0
1998	246	3	1.22	229**
1999	256	7	2.73	0
2000	285	7	2.46	31
2001	306	11	3.59	26
2002	304	6	1.97	0
2003	257	9	3.50	0
2004	248	4	1.61	0
2005	241	7	2.90	0

* Aircraft with maximum takeoff weight greater than 5,700 kg/12,500 lb

** Fatalities in 1998 resulted from the accident involving Swissair Flight 111.

Source: Swiss Aircraft Accident Investigation Bureau/Flight Safety Foundation

Table 1

Helicopter Accidents and Serious Incidents Down 50 Percent

Accidents and Serious Incidents Involving Swiss-Registered Aircraft in Switzerland and Abroad, and Non-Swiss-Registered Aircraft in Switzerland, 2004–2005

	Accidents and Serious Incidents Involving Swiss-Registered Aircraft				Accidents and Serious Incidents Involving Swiss-Registered Aircraft				Accidents and Serious Incidents Involving Non-Swiss-Registered Aircraft			
	In Switzerland				Abroad				In Switzerland			
	Total		Persons Injured		Total		Persons Injured		Total		Persons Injured	
	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004
Airplanes with MTOW 2,250 kg (4,960 lb)–5,700 kg/12,500 lb	2	0	1	0	1	2	0	1	0	0	0	0
Airplanes with MTOW > 5,700 kg/12,500 lb	3	1	0	0	4	3	0	0	0	1	0	0
Helicopters	4	8	2	5	0	0	0	0	0	0	0	0
Total	**9**	**9**	**3**	**5**	**5**	**5**	**0**	**1**	**0**	**1**	**0**	**0**

MTOW = Maximum takeoff weight

Source: Swiss Aircraft Accident Investigation Bureau

Table 2

(page 52). For airplanes in the large and middle categories, those during landing increased in 2005 from the previous year, but for helicopters they decreased. In four of five phases, from "starting and climb" through "landing," helicopters had fewer accidents and serious incidents in 2005 than in 2004.

The report indicated the numbers of airprox incidents[4] investigated by the bureau annually between 1998 and 2005 (Figure 1, page 52). The nine airprox incidents for 2005 were the lowest number since the two in 1998, a 36 percent reduction from the 14 in 2004 and a 53 percent reduction from the 19 in 2003.

Fewer Helicopter Accidents, Incidents in Most Flight Phases

Flight Phase, Accidents and Serious Incidents Involving Swiss-Registered Aircraft in Switzerland and Abroad, and Non-Swiss-Registered Aircraft in Switzerland, 2004–2005

	Ground and Rolling, Hovering Flight		Starting and Climb		Cruise		Descent and Approach		Landing	
	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004
Airplanes with MTOW 2,250 kg (4,960 lb)–5,700 kg/12,500 lb	0	0	0	1	0	0	0	0	3	1
Airplanes with MTOW > 5,700 kg/12,500 lb	2	1	2	1	1	2	1	1	1	0
Helicopters	1	0	1	2	1	2	1	3	0	1
Total	**3**	**1**	**3**	**4**	**2**	**4**	**2**	**4**	**4**	**2**

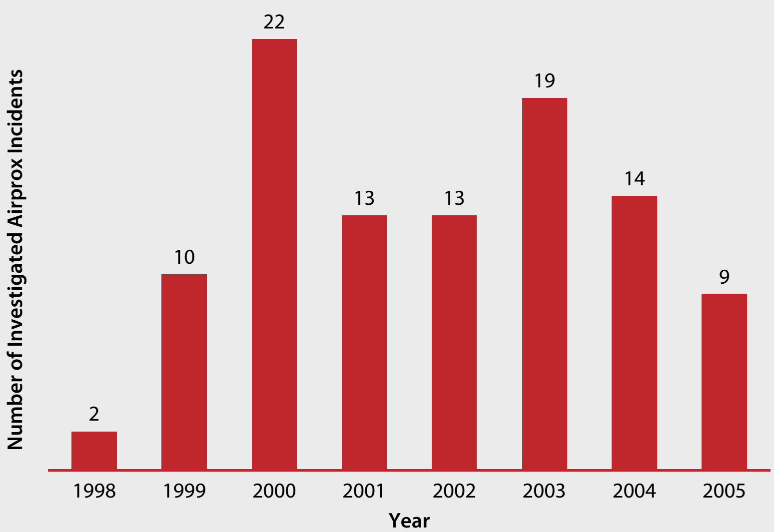
MTOW = Maximum takeoff weight

Source: Swiss Aircraft Accident Investigation Bureau

Table 3

Airprox Incidents Down

Investigated Airprox Incidents, Switzerland, 1998–2005



Airprox incident is defined as "a situation in which, in the opinion of a pilot or of the air traffic control personnel, the distance between aircraft moving under their own power as well as their relative positions are such that the safety of the aircraft involved could be endangered in flight or on the ground in the aircraft-moving area."

Source: Swiss Aircraft Accident Investigation Bureau

Figure 1

Notes

1. Swiss Aircraft Accident Investigation Bureau. *Statistics Concerning Accidents and Serious Incidents Involving Swiss-Registered Aircraft in Switzerland and Abroad and Foreign-Registered Aircraft in Switzerland.* Available via the Internet at <www.bfu.admin.ch/en/html/statistiken_tabellen.html>.

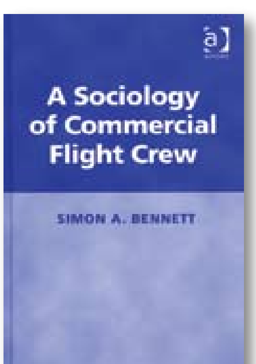
2. A *serious incident* is defined as an "occurrence associated with the operation of an aircraft under circumstances which nearly led to an accident."

3. The numbers of accidents and serious incidents, and of registered aircraft, were published in the report. Flight Safety Foundation calculated the rates. The accident investigation bureau stopped publishing flight hours after 1999; therefore, the only rates that could be derived for the whole period were the ratios of accidents and serious incidents to registered aircraft.

4. An *airprox incident* is defined as "a situation in which, in the opinion of a pilot or of the air traffic control personnel, the distance between aircraft moving under their own power as well as their relative positions are such that the safety of the aircraft involved could be endangered in flight or on the ground in the aircraft-moving area."

Pilot Project

A sociological study of airline pilots finds that most report satisfaction in their jobs, but some are alienated from management and have safety-related concerns.



BOOKS

A Sociology of Commercial Flight Crew

Bennett, Simon A. Aldershot, England, and Burlington, Vermont, U.S.: Ashgate, 2006. 224 pp. Tables, appendixes, bibliography, index.

This study looks at airline pilots from an angle that Bennett says has been more or less bypassed previously — how pilots are affected by the social environment they inhabit.

A pilot, Bennett says, is "a social actor. That is, someone with a history; a work life; a home life; a social life; someone caught up in numerous social and economic networks." Six in-depth interviews and questionnaire responses were designed to give a coherent picture of pilots' interactions with their profession.

One reason for the study, the author says, is that "the success of commercial aviation is due … to the imagination, ambition and dedication of its employees. In my opinion, commercial aviation's future prosperity depends in large part on developing more subtle understandings of those who work in the industry. Only if the industry understands its key resource can it be nurtured and used to best effect."

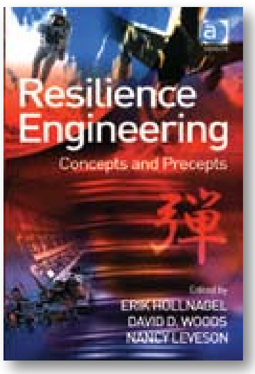
The social setting in which pilots work also has safety implications. "The introduction of crew resource management … has served to flatten (but not eliminate) the flight deck's authority gradient," Bennett says. "To improve safety margins, much of the imperiousness of the rank of captain has been engineered away. First officers (and flight attendants) are encouraged to contribute to the management of the flight and to seek clarification from the captain if, on the basis of a piece of information known only to themselves, they believe a decision to be ill-advised."

Pilots' responses to the questionnaire and in interviews yielded primary data, mostly *verbatim* comments. Concerns included how interaction with management at their airlines potentially affects safety, although it cannot be determined from the sample group how representative such concerns are among airline pilots.

One pilot said that commercial pressures created a "hidden culture of short cuts." The pilot said, "Turnaround [between-flight] issues revolve around safety and blame. Nobody minds working fast to get the job done, but there can be perceived pressure to take short cuts. It is as much about perceived pressure [as] of actual pressure. The airline will be very sure to leave a good audit trail of its procedures to show on paper that everything is being done correctly, but it is not the projected culture that counts, it is the hidden culture, the whispers between pilots, discussions over coffee, chats during turnarounds."

Another pilot said, "We need more respect from the management group, nonpartisan safety departments, and rules and regulations that do not contain the words 'where possible'; 'may'; [and] 'taking into account all the factors.'" Another cited "commercial pressure; a management attitude that finance is everything; performance-related pay awards when a human resources desk jockey tells me how I am flying my airplane, and consequently what my pay raise will be."

Nevertheless, to judge from the *verbatim* quotes, most pilots still enjoy, and some even get a thrill, from what they do. "Sense of achievement," "financial security" and "camaraderie" are frequently reported phrases. One said, "As a pilot, you feel part of the plane. There's nothing to beat climbing up through the cloud first thing in the morning on a gray day with dawn breaking and seeing all those wonderful colors. I love what I do, and even if I won the lottery tomorrow, I'd go on flying."



Resilience Engineering: Concepts and Precepts

Hollnagel, Erik; Woods, David; Leveson, Nancy (editors). Aldershot, England, and Burlington, Vermont, U.S.: Ashgate, 2006. 409 pp. Tables, figures, bibliography, index, appendix.

The concept of resilience in systems design has received considerable attention in recent years (*Aviation Safety World*, December 2006, page 54). Resilience is among the latest generation of risk management principles that go beyond reactivity. The trouble with a reactive method — looking at past accidents to find ways to keep the same sort of accident from happening again — is that it is ill suited to today's understanding of accident causation as the result of a complex interaction of human, mechanical and institutional factors, rather than single-point operator errors or chains of causation.

Hollnagel and Woods say that "failure, as individual failure or performance failure on the system level, represents the temporary inability to cope effectively with complexity. Success belongs to organizations, groups and individuals who are resilient in the sense that they recognize, adapt to and absorb variations, changes, disturbances, disruptions and surprises — especially disruptions that fall outside of the set of disturbances the system is designed to handle."

The book explores many aspects of resilience as the ability of systems to anticipate and adapt to failure. "Resilience engineering is a paradigm for safety management that focuses on how to help people cope with complexity under pressure to achieve success," Hollnagel and Woods say. "It strongly contrasts with what is typical today — a paradigm of tabulating error as if it were a thing, followed by interventions to reduce this count. A resilient organization treats safety as a core value, not a commodity that can be counted. … Rather than view past success as a reason to ramp down investments, such organizations continue to invest in anticipating the changing potential for failure because they appreciate that their knowledge of the gaps is imperfect and that their environment constantly changes."

Resilience engineering begins, they say, with a focus on methods and tools:

- To analyze, measure and monitor the resilience of organizations in their operating environment;
- To improve an organization's resilience vis-à-vis the environment; and
- To model and predict the short- and long-term effects of change and line management decisions on resilience and, therefore, on risk.

REPORTS

Fire Safety of Advanced Composites for Aircraft

Mouritz, A.P. Australian Transport Safety Bureau (ATSB). B2004/0046. April 2006. 36 pp. Figures, tables, references. Available via the Internet at <www.atsb.gov.au/publications/2006/grant_20040046.aspx> or from ATSB.*

"Without careful management and strict safety regulations, the risk of aircraft fires could increase with the growing use of fiber-reinforced polymer composite materials in aircraft," the report says. "Many polymer composites rapidly ignite when exposed to fire and generate high amounts of heat, blinding smoke and choking fumes. The careful selection of fire resistant composite materials is essential to aircraft safety."

Researchers performed a comprehensive review of the scientific literature to develop a database of the fire properties of many polymer composites, which are used both structurally and in cabins. Properties included time to ignition, limiting oxygen index, peak and average heat-release rates, total heat release, flame-spread rate, smoke and combustion gases. Tables present the composite materials, ranked from best to worst in fire safety terms. Currently used composites and others that may be used in future designs are included.

Glass-reinforced phenolic composites are the most common of those used in cabins, and the database shows their excellent fire reaction performance. Carbon-reinforced epoxy composites, those with the most frequent structural applications, have poor fire resistance, according to the data.

Color and Visual Factors in ATC Displays

Xing, Jing. U.S. Federal Aviation Administration (FAA) Office of Aerospace Medicine. DOT/FAA/AM-06/15. Final report. June 2006. 22 pp. Figure, tables, references, appendixes. Available via the Internet at <www.faa.gov/library/reports> or through the National Technical Information Service.**

Current computer technology makes it easy to use color for identification or differentiation on the digital displays used by air traffic controllers. FAA has no requirement for how color should be used on air traffic control (ATC) displays. The variety of color designs suggests that manufacturers, in creating unique color schemes, disagree with one another or have not seriously considered the human factors aspects of color choices for the ATC environment, the author says. Furthermore, some ATC displays allow individual users to configure the color coding to suit themselves.

As a result, the color stylization of the same information can vary from one ATC facility to another or even within the same facility, with a resulting potential for confusion, the report says. Also a matter for concern, it adds, is that using color symbolism has drawbacks as well as benefits, and those drawbacks are not widely understood.

The researcher visited nine ATC facilities to learn how controllers used computer displays and color information in performing their tasks, to identify color usage and relevance to ATC tasks, to determine the purposes of color use and to discuss with facility representatives the advantages and problems involving colors on displays.

"In this report, we described the benefits of color use in ATC displays," the researcher says. "We also derived a rationale for how to achieve these benefits based on accumulated vision and cognitive research. We also identified several drawbacks of color use in ATC displays and presented the potential consequences of inappropriate use of colors in the domain of perceptual and cognitive information processing."

An example of misjudged color design, the report says, is using the same color for different purposes, or in contradiction to a convention that controllers have assimilated through experience.

"For example, red is usually the top choice to convey warning and alert messages," the report says. "Controllers would naturally infer that a red code conveys urgent information, and the attention to red reduces awareness of other information. Problems arise when the color is used to encode an aircraft's destination, even though the destination is no more important than that of any other aircraft. When two meanings are associated with the same color code (e.g., urgency, destination), the brain has to exert extra effort to suppress one meaning to correctly interpret the meaning of that code."

The report also says that adding more colors reaches a point of diminishing returns, and that although controllers generally prefer color displays, studies indicate that colors make their job seem easier but do not improve efficiency.

WEB SITES

Air Data Research, <www.airsafety.com>

This organization offers a weekly *Air Safety Newsletter* delivered by e-mail that alerts readers to newly released and revised accident reports from numerous countries and accident investigation boards. Internet links to the reports are provided.

The newsletter may also contain news, data and other information released by the U.S. National Transportation Safety Board and the U.S. Federal Aviation Administration.

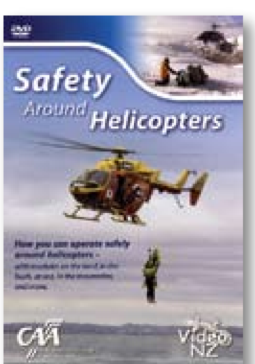
Its publisher says that *Air Safety Newsletter* addresses research needs of aviation safety investigators and analysts, and that "distribution is provided at no charge to persons actively employed in the fields of aviation accident investigation, analysis or litigation."

Flight Safety Information (FSINFO), <www.fsinfo.org>

Aviation enthusiasts who follow news from around the world may find *Flight Safety Information Newsletter* helpful. FSINFO compiles a daily newsletter of aggregated global aviation news from newspapers, Web sites and other sources. The newsletter is delivered by e-mail one or more times daily at no charge. Issues contain a combination of original and summarized text, with links to electronic sources.

Visit the Web site to register for the newsletter. While at the Web site, readers can peruse an online library that lists full-text articles, magazines like *Flight Safety Information Journal* and reports.

A bonus to receiving the electronic newsletter is its Web links to original news sources. Readers following breaking news about a particular aviation event may find a link to local or national media near the event. For example, a news article about an aviation event in Singapore may contain a link to a local source, such as *The Straits Times* newspaper, where additional information is available.



AUDIO-VIDEO

Safety Around Helicopters

Civil Aviation Authority of New Zealand (CAA) and Video New Zealand. DVD. 70 minutes. June 2006. Available on loan from CAA*** or by purchase from Video New Zealand.****

The video is divided into modules. The first, "Introduction," is appropriate for everyone who operates in or around helicopters. It includes basic operational information and best practices for approaching an aircraft and using doors and seat belts. Other modules are mission-specific.

"Going Bush" describes safety requirements for transporting hunters. "The Mountains" includes the safety briefing and embarking and disembarking procedures for transporting skiers and snowboarders. "Industry" shows how to prepare a helicopter site, including checking for dangerous wires. "All at Sea" is about methods for safe retrieval of a person from a boat. "Corporate and Tourism" discusses passenger briefings that vary with the helicopter type and destination. "Rescue on the Land" shows how an injured farm worker is rescued.

"Helicopter Identification" includes the main types of helicopters being used in New Zealand, with information such as the location of doors.

There is no regional code, and any functional DVD player can read the disc. ●

Sources

* Australian Transport Safety Bureau
P.O. Box 967, Civic Square
ACT 2608
Australia
Internet: <www.atsb.gov.au>

** National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161 U.S.A.
Internet: <www.ntis.gov>

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— Rick Darby and Patricia Setze

Crew Continues Takeoff After Engine Surges at V_1

After shutting down the engine and dumping fuel, the Boeing 777 crew returned to the airport for a single-engine landing.

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 on aircraft accidents and incidents by official investigative authorities.

JETS

Compressor Liners Found Eroded

Boeing 777-300. Minor damage. No injuries.

The aircraft was departing from Melbourne (Australia) Airport at 0104 local time Aug. 25, 2004, when the left engine surged at V_1, which informally is called takeoff decision speed. The flight crew continued the takeoff and then shut down the engine because of repeated surges, or compressor stalls. The Australian Transport Safety Bureau (ATSB) report said that the cockpit voice recorder recorded a loud bang 0.8 seconds before the automatic V_1 callout and 57 more bangs before the engine was shut down 70 seconds later.

"Due to forecast turbulence, the crew maintained an altitude of approximately 3,000 ft above ground level [AGL] to dump fuel and reduce the aircraft's weight for landing," the report said. "Air traffic services vectored the aircraft over Port Phillip Bay for the fuel dump, which took approximately one hour." The flight crew then returned to the airport and conducted a single-engine landing. None of the 300 occupants was injured.

Investigators found debris on the runway from a composite core panel that had broken and separated from the Rolls-Royce Trent 800 engine when it began to surge. The report said that a detailed examination of the engine found that erosion of the high-pressure compressor (HPC) casing liners had reduced compressor efficiency. Rolls-Royce told investigators that proper clearance between the HPC casing and rotor blades is critical for engine-airflow control at takeoff thrust settings.

The engine's total service time was 15,614 hours, during which it had undergone 4,527 cycles. Twenty-one days before the incident, a borescope examination of the engine was performed in response to an engine-condition-monitoring alert about a change in turbine gas temperature. Minor damage that was within acceptable limits was found on a few of the HPC blades, and the engine was returned to service. "The borescope inspection only permitted limited examination of the HPC casing liner material in the immediate vicinity of the borescope inspection port," the report said.

Eroded HPC casing liners were found in two other Trent 800 engines, which subsequently were removed from service. Among actions taken by Rolls-Royce after the incident was a change in condition-monitoring procedures to include a detailed review of engine-parameter data if troubleshooting prompted by an alert finds no explanation for the alert.

Birds Strangle a Falcon

Dassault Falcon 20D. Substantial damage. One minor injury, one uninjured.

The airplane was 15 ft above the runway during takeoff from Lorain County (Ohio, U.S.) Regional Airport for an on-demand cargo flight at 1950 local time Sept. 1, 2005, when flocks of birds rose from both sides of the runway. Several birds were ingested by the engines, said the U.S. National Transportation Safety Board (NTSB) report. The right engine surged and lost power. About 10 seconds later, the copilot observed that the left-engine fan speed, N_1, was decreasing below 50 percent.

The stall-warning horn sounded, and the pilot landed the airplane gear-up on the runway about 3,000 ft (915 m) beyond the point of rotation. The airplane overran the 5,000-ft (1,525-m) runway, struck a fence, crossed a road and came to a stop in a cornfield. The pilot was not injured; the copilot received minor injuries.

The stall-warning horn sounded, and the pilot landed the airplane gear-up on the runway.

Turbulence Closely Follows Seatbelt Sign

Boeing 737-800. No damage. One serious injury, two minor injuries.

Light turbulence persisted during the climb after the airplane departed from Hamilton, Bermuda, on Oct. 22, 2005, for a flight to Boston. The flight crew decided to leave the seatbelt sign illuminated. The turbulence subsided when the airplane was about 230 nm (426 km) northwest of Hamilton at Flight Level 340 (approximately 34,000 ft).

"However, more turbulence was forecast for [an area] about 150 miles [278 km] ahead of the airplane," the NTSB report said. "The captain announced to the passengers that the seatbelt sign would be turned off for 10 minutes to allow them an opportunity to move about the cabin but would be turned on again due to the upcoming turbulence."

About three minutes after the crew turned the seatbelt sign back on, the airplane encountered moderate turbulence. Two passengers and a flight attendant fell while attempting to return to their seats. The two passengers received minor injuries; the flight attendant suffered a fractured pelvis. The other 147 occupants were not injured.

Control Lost on Wet Runway

Cessna CJ1. Substantial damage. Seven uninjured.

Visual meteorological conditions (VMC) prevailed for the business flight to Murfreesboro, Tennessee, U.S., on May 16, 2006, but a weather front was approaching the airport. The automatic terminal information service said that the winds were from 240 degrees at 3 kt and the runway was wet. The approach controller cleared the pilot to conduct a visual approach to Runway 18.

The pilot said that as he landed the airplane on the first third of the 3,900-ft (1,190-m) runway, heavy rain began to fall and wind direction and velocity changed. The pilot lost directional control of the airplane after the tires began to hydroplane at midfield. "The pilot stated that there was insufficient runway remaining for him to initiate a go-around," the NTSB report said. "The airplane went off the runway sideways, collapsed the left main landing gear and came to a complete stop."

No Training, No Protection

Douglas DC-9. Minor damage. One fatality.

Passengers were being boarded at Norfolk, Virginia, U.S., on Sept. 12, 2003, when an airline employee drove a tractor toward the airplane in preparation to push it back from the gate. The NTSB report said that the employee had been assigned to baggage-room duties that day and was not qualified or authorized to conduct push-back operations. She had not received training in push-back operations since 1992.

"Another airline employee on the ramp saw the tug driver maneuver the tug toward the towbar connected to the airplane's nosegear, heard a loud noise and saw the towbar buckle and 'go into the air,'" the report said. "The tug struck the radome of the airplane, and the airline employee who was driving the tug was fatally injured after being trapped between the tug and the airplane."

NTSB said that the absence of a protective enclosure over the cab of the tug was a factor in the accident.

Clogged Fuel Vent Downs a Homebuilt

Velocity Jet 900. Destroyed. One minor injury.

The pilot was conducting his first flight in the homebuilt airplane at Millbrook, New York, U.S., on May 24, 2006. The NTSB report said that he had no prior experience and had received no training in turbine airplanes. After liftoff, the airplane climbed above the traffic pattern altitude at a rate of 4,000 to 5,000 fpm and accelerated above 200 kt on the downwind leg.

The pilot reduced power to flight idle. He told investigators that the airplane was low on base leg, but the engine did not respond when he advanced the throttle. "I got too slow, lost control and crashed 100 feet short of the runway," he said.

An examination of the airplane found that the fuel tank vent was clogged with dirt and insect remains. NTSB said that the probable cause of the accident was "the pilot/owner's inadequate preflight [inspection of the airplane]."

TURBOPROPS

Pitch Trim Runaway

Embraer EMB-110P2 Bandeirante. No damage. No injuries.

The company's chief pilot was conducting a private flight on Sept. 1, 2005, to re-establish recent flight experience in the aircraft and to practice newly adopted flight crew procedures. Two other company pilots were aboard: one was serving as copilot/supervisory pilot; the other was observing.

On initial climb from Bankstown Airport in New South Wales, Australia, the aircraft pitched nose-down. The pilot used the manual pitch-trim system and the electric pitch-trim system but was unable to reduce the nose-down pitch forces. "The [pilot] indicated to the copilot that he was having control difficulties," the ATSB report said. "The copilot assisted the [pilot] by applying back-pressure on the right control column." However, the pilots were not able to maintain a climb.

The copilot observed that the elevator-trim indicator was in the full nose-down position. He attempted unsuccessfully to apply nose-up elevator trim. The pilot reduced power, and the nose-down pitch forces decreased but still required opposing control inputs by the pilots. "The pilots reported that the aircraft descended to about 150 ft AGL during the incident," the report said.

The copilot declared an urgency condition, pan-pan, and advised the airport tower controller of the problem and the crew's intention to return for a landing. He then released the control wheel and, "in desperation," used both hands to apply back-pressure to the pitch-trim wheel. "The copilot reported that after using 'excessive force,' the trim wheel released from the nose-down position and was moved towards the neutral position," the report said. "The pilots regained control of the aircraft and landed shortly after."

Investigators found that when the elevator-trim switch on the left control wheel was moved left to the "DOWN" position or moved right to the "UP" position and released, it did not return to the center, neutral, position. "With electrical power on, selection of 'UP' or 'DOWN' produced a noise consistent with operation of the trim servo motor but did not result in movement of the trim tab," the report said. Debris, a "sticky substance" and corrosion were found in the trim-switch mechanism, and the trim servo motor clutch did not slip, or disengage, properly at design torque limits because of inadequate lubrication.

The pilots did not pull the electric trim system circuit breaker during the incident, as called for by the emergency checklist. "Given that the electric trim was probably driving when the crew were having control difficulties, pulling the electric trim servo circuit breaker would have deactivated the electric trim servo motor and … allowed the pilots to regain manual trim control," the report said.

Similar to an accumulation of ice on the airframe, thickened deice/anti-ice fluid also degrades the aerodynamic performance of the aircraft.

Crew Uses Wrong Takeoff Speeds

Dornier 328-110. No damage. No injuries.

Before departing from Ronaldsway Airport on the Isle of Man, U.K., on Nov. 28, 2005, the aircraft was treated with a heated mixture of Type II+ deice/anti-ice fluid and water to remove an accumulation of frost. The flight crew selected a V_1/V_R (takeoff decision speed/rotation speed) of 109 kt based on the aircraft's takeoff weight, 12,300 kg (27,117 lb). However, when the commander pulled the control column aft at that speed, the aircraft did not rotate. The commander rejected the takeoff and stopped the aircraft on the runway. None of the 19 occupants was injured.

In its report, the U.K. Air Accidents Investigation Branch (AAIB) said that the V_1/V_R speed selected by the crew was for normal conditions and was incorrect for the situation. "Contamination must have been present on the tail surfaces because the aircraft would not rotate at the 'normal' rotation speed for its configuration and load, but it was not possible to determine whether the contaminant was ice or thickened [deice/anti-ice] fluid," the report said.

In addition to providing V_1/V_R speeds for normal takeoff conditions, the Dornier 328 airplane flight manual (AFM) includes V_1/V_R speeds that are about 20 kt higher to provide an additional margin above stall speeds during takeoff in icing conditions and/or after the aircraft has been treated with thickened deice/anti-ice fluids such as Type II or Type IV fluids. The report noted that, similar to an accumulation of ice on the airframe, thickened deice/anti-ice fluid also degrades the aerodynamic performance of the aircraft. The AFM specified a V_1/V_R speed of 128 kt for the incident conditions. The higher speed increases accelerate/stop distance by 330 m (1,083 ft) to 1,350 m (4,429 ft); the usable length of the runway was 1,613 m (5,292 ft).

Icing Triggers Stall on Approach

Cessna 425 Conquest I. Destroyed. One fatality.

Dark nighttime instrument meteorological conditions (IMC) prevailed at the destination, Gallatin Field in Bozeman, Montana, U.S., on Nov. 29, 2005. On arrival, after almost four hours of flying, the pilot was instructed by air traffic control (ATC) to enter a holding pattern at 11,000 ft — about 6,500 ft AGL. The NTSB report said that the pilot had about 1,987 flight hours and had logged nine hours of flight time in actual IMC in the six months preceding the accident flight; however, he had not flown at night during that period.

Soon after entering the holding pattern, the pilot was cleared to conduct an instrument landing system (ILS) approach. Two minutes after he acknowledged the clearance, ATC lost radio contact with the pilot.

Search efforts were terminated that night because of the weather conditions and darkness. The next morning, the wreckage of the airplane was found about 2.8 nm (5.2 km) from the airport. "The airplane impacted terrain in a vertical descent and flat attitude," the report said. "Evidence of forward velocity and/or leading-edge deformation was not observed on the wings or fuselage. Mixed ice was noted along the leading edges of both wings."

NTSB said that the probable cause of the accident was "the pilot's failure to maintain airspeed during the approach, which resulted in an inadvertent stall."

GPU Strikes Rotating Propeller

De Havilland Canada Dash 8. Substantial damage. No injuries.

The aircraft was parked at a stand and was being prepared for departure from Aberdeen (Scotland) Airport on Oct. 7, 2005. A ground power unit (GPU) was used to provide electrical power for starting the aircraft's engines. Soon after the GPU cables were disconnected from the aircraft, the GPU began moving forward, toward the aircraft. Nobody was in the cab, and the GPU struck the rotating propeller on the right engine and came to rest against the fuselage. The flight crew shut down the engines, and all 54 occupants exited through the cabin door.

All four blades on the propeller and the propeller hub were damaged, and the fuselage was dented. The aircraft operator determined that the right engine required a complete overhaul. The GPU also was substantially damaged.

An examination of the GPU found that, because of worn engine-governor components, the engine idling speed was significantly higher than normal and sufficient to override the parking brake. The AAIB report concluded that the GPU's "FORWARD-NEUTRAL-REVERSE" selector had been moved to the "FORWARD" position, most likely because of "human intervention." However, the gate in the selector was found to be worn, and the report said that the selector might have moved to the "FORWARD" position when it was jolted as the GPU cab door was closed.

PISTON AIRPLANES

Missing Dipstick Causes Oil Loss

Piper Chieftain. Destroyed. Two fatalities.

The passenger arrived at Ankeny (Iowa, U.S.) Regional Airport at 0900 local time Nov. 8, 2005, but because the charter flight had not been confirmed by the customer, the operator had not assigned a pilot to the flight. The flight scheduler called several company pilots before finding one who could accept the assignment, the NTSB report said. The pilot arrived about 1005. A witness said that the pilot spent about two minutes in the office before he walked directly to the airplane, boarded and started the engines.

While servicing the airplane, a lineman had placed the oil-quantity dipstick on the right wing while adding oil to the right engine at 0930. He did not replace the dipstick in the oil-filler tube. The lineman also left the engine-cowling dipstick-access door open.

"The pilot taxied the airplane forward about 5 ft [2 m] and abruptly stopped and shut down both engines," the report said. The pilot exited the airplane, closed the dipstick-access door, reboarded the airplane, restarted the engines and resumed taxiing. About three minutes after departing from Runway 18, the pilot told ATC that he needed to return to the airport due to an oil leak. He reported on the Unicom frequency that he was shutting down the right engine.

The report said that the airplane was at 550 ft AGL when it overflew the airport on a southerly heading. "The airplane continued to fly south past the airport, entered a left turn and turned back to the north," the report said. The airplane stalled and descended to the ground about 2.5 nm (4.6 km) north of the approach end of Runway 18.

NTSB said that the probable causes of the accident were "the pilot's failure to preflight the airplane, the pilot's improper in-flight decision not to land the airplane on the runway when he had the opportunity and the inadvertent stall when the pilot allowed the airspeed to get too low," and that a contributing factor was "the lineman's improper servicing of the airplane."

'Unchecked Descent' Below Minimums

Pilatus Britten-Norman Islander. Destroyed. Two fatalities.

The pilot, who had been on leave and had not flown for 32 days, conducted a brief solo flight at the Glasgow, Scotland, airport to regain currency on March 15, 2005. He then landed the aircraft to board a paramedic for an air ambulance flight to Campbeltown Airport in Argyll.

The pilot had been assigned the flight at 2136 local time; he had been awake since 0645. "The task was to collect a 10-year-old patient who was suffering from suspected appendicitis and fly him to Glasgow for hospital treatment," the AAIB report said.

The airplane departed from Glasgow at 2333. ATC services were not available at Campbeltown Airport. At 0008, the pilot established radio communication with an airport flight information service (AFIS) officer, who reported that visibility was 4,500 m (2.8 mi) in rain, broken clouds were at 400 ft and 900 ft AGL, and surface winds were from 240 degrees at 15 kt. The pilot said that he would conduct the VOR/DME (VHF omnidirectional radio/distance measuring equipment) approach to Runway 11 and "hopefully break visual" for a circling approach to Runway 25. Published minimums for the straight-in approach are 380 ft — 341 ft above runway elevation — and 1,300 m (0.8 mi).

The report said that the aircraft's descent rate was 1,050 fpm when it descended below 1,540 ft, the minimum altitude for the outbound segment of the procedure turn. ATC radar contact then was lost. About 0018, the pilot reported that the aircraft was inbound on the procedure turn, which is conducted over water northwest of the airport. The AFIS officer said that visibility had decreased to between 1,500 m and 2,500 m (0.9 mi to 1.6 mi) and asked the pilot to report when he had the airport in sight. The pilot did not acknowledge the request or reply to further radio transmissions by the AFIS officer. "The aircraft was subsequently located on the seabed 7.7 nm [14.3 km] west-northwest of the airport," the report said. The paramedic's body was found in the wreckage. The pilot's body was found about nine months after the accident by the crew of a fishing vessel.

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AAIB said that the following were causal factors of the accident:

- "The pilot allowed the aircraft to descend below the minimum altitude for the aircraft's position on the approach procedure, and this descent probably continued unchecked until the aircraft flew into the sea;
- "A combination of fatigue, workload and lack of recent flying practice probably contributed to the pilot's reduced performance; [and,]
- "The pilot may have been subject to an undetermined influence such as disorientation, distraction or a subtle incapacitation which affected his ability to safely control the aircraft's flight path."

Internal Debris Causes Engine Failure

Cessna 320E. Destroyed. Two serious injuries.

The airplane was between 100 and 200 ft AGL during departure from Missoula, Montana, U.S., for an aerial-mapping flight on June 21, 2005, when the right engine lost power. The NTSB report said that the airplane, which was about 83 lb (38 kg) over maximum gross weight, descended into a gully when the engine failure occurred and climbed slowly after the pilot feathered the propeller and secured the engine. The pilot was conducting a left turn to avoid trees when the airplane struck a hill. The pilot and passenger exited the airplane before it was consumed by fire.

Investigators found pieces of paper lodged between the impeller and housing of the turbocharger, which had separated from the right engine on impact. "An examination of the pieces of paper extracted from the turbocharger revealed that they were from an air-filter instructional sheet," the report said. "It was also determined that the replacement air filter had been installed on the right engine approximately four months prior to the accident." The airplane had been operated about 54 hours after the air filter was installed.

The report said that when the manufacturer packages new air filters, the instruction sheet is folded and inserted inside the canister, and the canister is placed in a plastic bag. Maintenance personnel failed to remove the instruction sheet from the canister when the air filter was installed in the accident airplane, the report said.

Beaver Stalls While Crossing Ridge

De Havilland DHC-2. Destroyed. One fatality.

After completing a flight in the float-equipped aircraft to two wilderness camps, the pilot was returning to the company's base camp at Squaw Lake, Quebec, Canada, on the afternoon of Sept. 1, 2005, when deteriorating weather conditions forced him to conduct a precautionary landing on Elross Lake, which is 15 nm (28 km) northwest of the base camp, said the report by the Transportation Safety Board of Canada.

About 1630 local time, the pilot reported to a company dispatcher by VHF radio that there "seemed to be a break in the weather" and that he intended to continue the flight to the base camp. Another company pilot told the accident pilot that the weather at Squaw Lake was poor and that the flight should not be attempted. The report said that an airport near the base camp was reporting 2 mi (3,200 m) visibility, 600 ft vertical visibility and surface winds at 18 kt.

"Rescue efforts were initiated in the evening when the aircraft did not arrive at the base camp," the report said. The wreckage of the aircraft was found on a mountain ridge 4 nm (7 km) from Elross Lake the next day. "The severity and type of the damage, and the angle at which the aircraft contacted the terrain indicate the aircraft was in an aerodynamic stall at the time of impact," the report said. "In an attempt to cross the [ridge], the pilot perhaps lost visual reference to the ground and subsequently control of the aircraft, and/or he encountered moderate to severe turbulence and strong updrafts causing the aircraft to stall … at an altitude from which recovery was not possible."

HELICOPTERS

Air Ambulance Strikes Sea During Approach

Sikorsky S-76A. Extensive damage. No injuries.

Nighttime VMC prevailed for the air ambulance flight on Sept. 18, 2004. The helicopter, with five crewmembers aboard, departed from Gotland, Sweden, to pick up a patient with an acute heart condition on the island of Häradsskär.

"The weather was judged to be good, and the sortie was viewed by the crew as a routine mission," said the report by the Swedish Accident Investigation Board. As the helicopter neared the island, the crew observed lights in the windows of the patient's house. "Apart from this, the only external reference point in the area was the light from the lighthouse," the report said. "The commander decided, after passing the island, to make a right turn and then approach it from the north and into the wind."

The commander told the other crewmembers that he would conduct a relatively steep approach. "He felt that the initial glide towards the island was without problems even though he lacked visual contact with the ground and the strong light from the lighthouse at times masked the weaker light from the house windows," the report said.

Soon after the copilot called out a radio altitude of 100 ft, the winch operator observed that the helicopter was rapidly approaching the water and that the waves were going in the wrong direction. The winch operator shouted, "We're moving backwards." The report said that the helicopter struck the water before the commander could react. Water rapidly filled the helicopter, but all five crewmembers exited before it sank. They later were rescued by the crew of a military helicopter.

Investigators found that the pilots had not used the radio altitude warning system, the radar system or the global positioning system during the approach. "The investigation has revealed that the pilots underestimated the difficulty of landing under the circumstances then prevailing and that the procedures and the technical equipment available for them to be able to perform a safe landing were not employed," the report said.

Spatial Disorientation Cited in Control Loss

Robinson R44. Substantial damage. No injuries.

Visibility was reduced by low fog and flat light conditions during the charter flight from Iliamna, Alaska, U.S., to a remote site on March 12, 2006. About 10 nm (19 km) from Iliamna, "the pilot was unable to discern any topographic features on the snow-covered terrain, and he elected to make a precautionary landing to wait for better visibility," the NTSB report said. "After about 10 minutes, he decided to continue to his destination."

As the helicopter moved forward after takeoff, the pilot's vision again was affected by blowing snow and the flat light conditions. The pilot attempted to establish a stable hover. He told investigators that he believed the aircraft was not moving when the right skid struck the ground. The helicopter rolled right, and the main rotor blades struck the ground. "As the main rotor blades struck the ground, the helicopter rolled onto its right side," the report said. The pilot and passenger were not injured.

NTSB said that the probable causes of the accident were "the pilot's continued flight into adverse weather conditions and his spatial disorientation and loss of control during a subsequent landing attempt." ●

Preliminary Reports

Date	Location	Aircraft Type	Aircraft Damage	Injuries
Nov. 6, 2006	Piacenza, Italy	Piper Cheyenne I	destroyed	2 fatal
Nighttime visual meteorological conditions (VMC) prevailed when the airplane crashed in a forest during a flight from Malta to Milan.				
Nov. 7, 2006	Corozol, Belize	Cessna 207A	NA	6 NA
The airplane was on a 30-nm (56-km) flight to Corozol from Orange Walk when engine problems occurred. The pilot ditched the airplane 4 nm (7 km) from shore. The six occupants were rescued by the crew of a marine vessel.				
Nov. 8, 2006	Takhli Air Base, Thailand	Learjet 35A	destroyed	7 fatal
The Thai air force airplane was 150 ft above ground level on takeoff when the captain reported an engine problem. The airplane stalled and struck an empty hangar during the emergency landing.				
Nov. 8, 2006	Alamogordo, New Mexico, U.S.	Cessna 337C	destroyed	1 fatal
Daytime VMC prevailed when the airplane veered right off the runway on landing, crossed a taxiway and struck a hangar.				
Nov. 9, 2006	Walikale, Democratic Republic of Congo	Let L-410UVP	destroyed	1 fatal, 4 minor
Engine problems occurred soon after the airplane took off from a road used periodically as a runway. The road had been reopened for traffic when the flight crew returned for an emergency landing. The airplane struck several vehicles, killing a passenger in one vehicle, before veering off the road, striking several houses and stopping in a field.				
Nov. 12, 2006	Rottnest Island, Australia	Partenavia P.68B Victor	destroyed	6 minor
The airplane crashed on a salt lake bed soon after takeoff.				
Nov. 13, 2006	South Bend, Indiana, U.S.	Cessna T303 Crusader	destroyed	5 fatal
The airplane climbed in instrument meteorological conditions to about 5,700 ft after takeoff, entered a spiraling left turn and struck a cornfield in an 80-degree nose-down attitude.				
Nov. 14, 2006	Big Bear Lake, California, U.S.	Cessna 421B	destroyed	3 fatal
A witness saw dark smoke emerge from the left engine after the airplane lifted off. The airplane yawed left, and the landing gear remained extended. The airplane crashed on the shore of a lake about 7 nm (13 km) from the airport.				
Nov. 15, 2006	Progreso, Mexico	CASA 212 Aviocar 400	substantial	7 none
Both engines flamed out about five hours after the Mexican naval airplane departed from Cancún for a maritime patrol mission. The flight crew ditched the airplane 1.9 nm (3.5 km) offshore. All seven occupants escaped before the airplane sank.				
Nov. 17, 2006	Ocumare del Tuy, Venezuela	Cessna 207	NA	3 fatal
The pilot encountered engine problems soon after takeoff for a cargo flight. During an attempted landing on a city street, the airplane struck a telephone pole and a bus. The pilot and two occupants of the bus were killed.				
Nov. 17, 2006	Puncak Jaya, Indonesia	De Havilland Canada DHC-6	destroyed	12 fatal
The Twin Otter was on a charter flight from Mulia to Ilaga when it struck a mountain at 10,500 ft.				
Nov. 18, 2006	Leticia, Colombia	Boeing 727-23F	destroyed	5 fatal
Nighttime VMC prevailed with patches of fog when the cargo airplane struck a 150-ft antenna about 2 nm (4 km) from the airport during a visual approach. The three flight crewmembers and two passengers were killed.				
Nov. 19, 2006	Kingstown, St. Vincent and the Grenadines	Rockwell 500S	NA	2 fatal
Radio contact was lost soon after the pilot reported over Bequia Island and four minutes from landing in Kingstown. The next day, debris from the airplane was found on the ocean.				
Nov. 22, 2006	Cunday, Colombia	Cessna 208 Caravan	destroyed	3 fatal
The Colombian air force airplane struck a mountain during an approach in low visibility to Tolemaida Air Force Base.				
Nov. 27, 2006	Tehran, Iran	Antonov 74T-200	destroyed	36 fatal, 2 serious
The Iranian air force airplane crashed on takeoff from Mehrabad Airport.				
Nov. 29, 2006	Mindelheim–Mattsies, Germany	Grob G.180 Spn	destroyed	1 fatal
The test pilot was killed when the prototype business jet struck terrain during a demonstration flight.				

NA = not available

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

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