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THE JOURNAL OF FLIGHT SAFETY FOUNDATION

SEPTEMBER 2014

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INTERNATIONAL AIR Safety Summit

In November, more than 300 aviation safety professionals from around the world will gather in Abu Dhabi for Flight Safety Foundation's 67th annual International Air Safety Summit (IASS). Already, we have higher-than-usual registration and representation from a wide range of companies and sectors from every corner of the globe.

It's not hard to understand why. We've paired one of the most respected and important safety events with a region of the world that is home to one of the aviation industry's highest rates of growth. According to some reports, growth in the Middle East is expected to outpace the rest of the world for the next 20 years. It's no wonder that this is turning into a hot ticket.

As the agenda for this event takes shape — and you can access it at <flightsafety.org/IASS2014> — it promises to address some of the most timely issues in aviation and aviation safety. We'll have updates about aircraft tracking and about operations above areas of armed conflict, directly from the individuals who are leading those efforts. Results of the Foundation's go-around project are scheduled for release in time for IASS, and the summit will feature several presentations about approach and landing safety and go-arounds. Accident investigators from the U.S. National Transportation Safety Board will present information about the crash of Asiana Flight 214. This is just a sample of what is on the agenda.

The major sponsor for IASS is Etihad Airways, which will be hosting a luxury opening reception the first night of IASS for all attendees.

In conjunction with IASS 2014, we will be holding our second annual Benefit Dinner. Last year, we raised more than $75,000 to assist with FSF programs, and we are aiming to increase that amount this year. The dinner, including a reception and silent auction, will be held at the Monte-Carlo Beach Club on Saadiyat Island in Abu Dhabi.

This will be my first IASS as president and CEO, but the reputation of this event precedes it. I know that it will be an important week of sharing safety information, networking with colleagues from all around the world and learning about the latest safety technologies. If there is one safety conference to go to, it is IASS.

I hope to see you there.

Jon L. Beatty
President and CEO
Flight Safety Foundation

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TEST OF Resilience

When, in my last Editor's Message of 2013, I looked ahead to 2014, I didn't foresee an airliner missing for months, or one getting shot down as it flew a scheduled flight from Europe to Asia. But that's the reality the global aviation industry faces following the dual tragedies of Malaysia Airlines MH370 and MH17. Hundreds of passengers and crew are dead, or missing and presumed dead, and the industry is left searching for answers as to what happened and how to mitigate the risk of either happening again.

To that end, two industry task forces have been convened to study the relevant issues and make recommendations. The first, the Aircraft Tracking Task Force (ATTF), is being led by the International Air Transport Association (IATA) and comprises subject matter experts from IATA, the International Civil Aviation Organization (ICAO), airlines, equipment manufacturers, air navigation service providers, labor groups and Flight Safety Foundation, among others. The ATTF, working with an aggressive schedule, is expected to be in a position to deliver draft options for "enhanced global aircraft tracking" to ICAO in September, leading to presentation to industry before year's end.

The second group is the Task Force on Risks to Civil Aviation Arising from Conflict Zones (TF RCZ), which was convened by ICAO following the loss of MH17 over eastern Ukraine and which met for the first time in mid-August. The group's mandate is to "refine the roles and procedures relating to the mitigation of conflict zone risk in civilian airspace," ICAO said. David McMillan, chairman of the Foundation's Board of Governors, was elected as TF RCZ chairman. "We're looking for urgent, practical measures to address these new risks," McMillan said. The group's preliminary findings are expected in October.

Of course, work continues on many of this year's "expected" issues, including more effective pilot monitoring, improved upset prevention and recovery training, integration of unmanned aircraft systems into the U.S. National Airspace System and more realistic approach and go-around practices and procedures. And that highlights one of the industry's core strengths and a primary reason for its stellar safety record: resiliency.

The Merriam-Webster definitions for resilience include "the ability to recover from or adjust easily to misfortune or change." It usually is not easy, but the aviation industry, because of the professionals it employs, has a finely honed ability to effectively and efficiently mitigate new safety threats without giving up ground on previous issues. I am confident this resilience will carry the day once more.

Frank Jackman
Editor-in-Chief
AeroSafety World

SEPT. 3–5 ➤ ALTA Aviation Law Americas 2014. Latin American and Caribbean Air Transport Association. Miami. <www.alta.aero>, +1 786.388.0222.

SEPT. 8–12 ➤ 5th Pan American Aviation Safety Summit 2014. Latin American and Caribbean Air Transport Association. Curaçao. <www.alta.aero>, +1 786.388.0222.

SEPT. 13–19 ➤ 2014 National Safety Council Congress and Expo. National Safety Council. San Diego. <congress.nsc.org>.

SEPT. 22–24 ➤ Air Medical Transport Conference 2014. Association of Air Medical Services. Nashville, Tennessee, U.S. <www.aams.org>, +1 703.836.8732.

SEPT. 23–24 ➤ Asia Pacific Airline Training Symposium (APATS 2014). Halldale. Bangkok, Thailand. <halldale.com/apats>.

SEPT. 23–25 ➤ International Flight Crew Training Conference 2014. Royal Aeronautical Society. London. <conference@aerosociety.com>, +44 (0) 20 7670 4345.

SEPT. 28–OCT. 1 ➤ 59th ATCA Annual Conference and Exposition. Civil Air Navigation Services Organisation (CANSO). Washington. Anouk Achterhuis, <events@canso.org>, +31 (0) 23 568 5390.

SEPT. 29–OCT. 3 ➤ Aircraft Accident and Incident Investigation: ICAO Annex 13 Report Writing. Singapore. Singapore Aviation Academy. <saa@caas.gov.sg>, <saa.com.sg>, +65 6543.0433.

OCT. 6–9 ➤ Bombardier Safety Standdown USA 2014. Wichita, Kansas, U.S. Bombardier Aerospace. <info@safetystanddown.com>, <safetystanddown.com>.

OCT. 6–9 ➤ 2014 Public Safety and Security Fall Conference. Airports Council International–North America. Arlington, Virginia, U.S. <aci-na.org>.

OCT. 9–10 ➤ CANSO Africa Runway Safety Seminar. Civil Air Navigation Services Organisation (CANSO) and National Airports Corp. Ltd. Livingstone, Zambia. Anouk Achterhuis, <events@canso.org>, +31 (0) 23 568 5390.

OCT. 13–17 ➤ ISASI 2014 Seminar. International Society of Air Safety Investigators. Adelaide, Australia. <www.isasi.org>.

OCT. 15–16 ➤ 2014 EASA Annual Safety Conference. European Aviation Safety Agency (EASA). Rome. <asc@easa.europa.eu>.

OCT. 21–23 ➤ NBAA2014 Business Aviation Convention and Exhibition. National Business Aviation Association. Orlando, Florida, U.S. <info@nbaa.org>.

OCT. 26–OCT. 30 ➤ CANSO Global ATM Safety Conference. Civil Air Navigation Services Organisation (CANSO). Amman, Jordan. Anouk Achterhuis, <events@canso.org>, +31 (0) 23 568 5390.

OCT. 28–29 ➤ European Airline Training Symposium (EATS 2014). Halldale. Berlin. <halldale.com/eats>.

NOV. 2–3 ➤ Offshore/Onshore Aviation Conference and Exhibition. Middle East and North Africa (MENA) Helicopter Safety Team. Abu Dhabi, United Arab Emirates. Alison Weller, <alison@accessgroup.aero>, +971 5 6116 2453.

NOV. 3–5 ➤ 52nd annual SAFE Symposium. SAFE Association, Orlando, Florida, U.S. <safe@peak.org>, <www.safeassociation.com/index.cfm/page/symposium–overview>, +1 541.895.3012.

NOV. 8-9 ➤ Aviation Training Congress China 2014. Pyxis Consult, China Decision Makers Consultancy. Zhuhai, China. Sharon Liu, <Sharon@pyxisconsult.com>, +86 21 5646 1705.

NOV. 9–10 ➤ International Flight Operations Congress China 2014. Pyxis Consult, China Decision Makers Consultancy. Zhuhai, China. Sharon Liu, <Sharon@pyxisconsult.com>, +86 21 5646 1705.

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

NOV. 20–21 ➤ AVM Summit USA. Aviation Maintenance Magazine. Orlando, Florida, U.S. Adrian Broadbent, <abroadbent@aerospace-media.com>, <avm-summit.com>.

NOV. 24–27 ➤ ICAO Regional Aviation Safety Group Asia and Pacific Regions (RASG-APAC) Meeting. International Civil Aviation Organisation. Hong Kong. <icao.int>.

DEC. 7–9 ➤ AAAE Runway Safety Summit. American Association of Airport Executives (AAAE). Salt Lake City, Utah, U.S. <aaaemeetings.aaae.org>.

FEB. 10–11 ➤ Approach and Landing Accident Reduction (ALAR) Info Exchange. Flight Safety Foundation. Singapore. Namratha Apparao, <apparao@flightsafety.org>, +1 703.739.6700, ext. 101.

FEB. 12–13 ➤ Maintenance and Engineering Safety Forum. Flight Safety Foundation. Singapore. Namratha Apparao, <apparao@flightsafety.org>, +1 703.739.6700, ext. 101.

FEB. 17–18 ➤ 1st International Human Factors Conference. Lufthansa Flight Training. Frankfurt/Main, Germany. <human-factors-conference@lft.dlh.de>, <human-factors-conference.com>, +49 69 696 53061.

MARCH 2–5 ➤ HAI Heli-Expo 2015. Helicopter Association International. Orlando. <rotor.org>.

MARCH 10–11 ➤ Air Charter Safety Symposium. Air Charter Safety Foundation. Dulles, Virginia, U.S. <acsf.aero>.

MARCH 10-12 ➤ World ATM Congress 2015. Civil Air Navigation Services Organisation (CANSO). Madrid, Spain. Anouk Achterhuis, <events@canso.org>, +31 (0) 23 568 5390.

MAY 13–14 ➤ Business Aviation Safety Summit 2015 (BASS 2015). Flight Safety Foundation. Weston, Florida, U.S. Namratha Apparao, <apparao@flightsafety.org>, +1 703.739.6700, ext. 101.

MAY 19–21 ➤ 2015 European Business Aviation Convention and Exhibition (EBACE2015). National Business Aviation Association. Geneva. <nbaa.org>.

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

MOVING TOWARD RATIONAL FAA REGULATION OF Unmanned Aircraft Systems

BY MARION C. BLAKEY

Even though Congress has mandated a deadline in 2015 for integrating unmanned aircraft systems (UAS) into U.S. airspace, that deadline will probably not be met. However, increasing attention from many sources outside the U.S. Federal Aviation Administration (FAA) is focused on how safety concerns will be addressed.

Typically, the safety conversation boils down to how to avoid collisions between conventionally piloted aircraft and UAS, and UAS crash landings. That's a fair departure point for thoughtful discourse, but as someone who had responsibility for safety at the U.S. National Transportation Safety Board and the FAA, I believe we need to consider the broader picture. UAS have tremendous life-saving potential when lost people need to be found; when wildfires develop; when tornadoes hit; and when power lines, oil rigs and bridges need close inspection. Almost every day, there is news of a new idea about how to gain valuable social benefits from this technology without having to put humans in dangerous positions. We need to balance our safety concerns about UAS with the safety gains we can realize from those operations.

Achieving that balanced approach to UAS regulation means recognizing the need for prudent first steps to get a number of these systems into the airspace. In addition to the immediate benefits, we can obtain useful operational data that will help us enhance UAS safety and allow this industry to develop and grow. Dragging our feet on developing a rational regulatory regime that provides clarity for the public, hobbyists and more sophisticated UAS developers and users will stifle innovation, delay the safety improvements that come with operational experience and postpone the benefits this technology promises. We will also see an increase in flights by those who fly UAS illegally, ignoring the FAA's restrictions and potentially creating unsafe conditions.

In developing new regulations, the entire UAS community — government and industry alike — must also take on the challenge of informing and educating the public about how real safety risks are being addressed and mitigated. A recent *Washington Post* report, for instance, erroneously used examples of selective and outdated military UAS accidents in hazardous flying conditions to paint a dire picture of what problems might be engendered by UAS activities in the domestic airspace. That kind of sensational journalism doesn't promote the clear-eyed and rational discussion we should have on regulating UAS.

Currently, we have an unstable regulatory environment, with only a handful of licensed operators, plus those who are exempt because they are in the hobbyist category. Without clear guidance, this is a recipe for trouble until the FAA publishes its small UAS proposed rule and moves on to other UAS categories. And while we appreciate the technical expertise that is going into the development of new regulations, we believe the Obama administration needs to designate an official who will take a more global policy approach to safety but one expeditiously deriving the potential benefits of widespread UAS applications.

On the positive side, the FAA's Small Unmanned Aircraft System Aviation Rulemaking Committee has proposed a smart step-by-step approach to full UAS integration. The FAA's six designated test sites will help us obtain valuable data to enhance the safety of UAS technical systems and to pinpoint potential safety issues. And the recent action by the FAA to entertain license exemptions for filmmakers prior to the issuance of the small UAS rule is a welcome step. AIA supported the applications for those exemptions through a joint letter with the Motion Picture Association of America to FAA Administrator Michael Huerta. Furthering progress requires us to keep taking these kinds of steps.

We should not forget that there's a global competition ongoing to develop UAS applications. A decade after the Wright brothers flew, the United States found that it was lagging far behind European aviation capabilities and had to make a concerted effort to catch up. For the sake of the U.S. economy and society, that historic mistake should not be repeated by needlessly slowing the safety regulatory process for UAS.

Marion C. Blakey is president and chief executive officer of the Aerospace Industries Association.

The opinions expressed here are those of the author and not necessarily those of AeroSafety World *or the Flight Safety Foundation.*

Safety News

Asiana Recommendations

Boeing should be required to enhance training for pilots of 777s to "improve flight crew understanding of autothrottle modes and automatic activation system logic," the U.S. National Transportation Safety Board (NTSB) says.

The recommendation is one of 27 included in the NTSB's final report on the July 6, 2013, crash of an Asiana Airlines 777 when it struck a seawall during approach to San Francisco International Airport. The crash killed three of the 307 people in the airplane, and 49 others were seriously injured. The airplane was destroyed.

The NTSB said the probable cause of the crash was the flight crew's "mismanagement of the airplane's descent during the visual approach, the pilot flying's unintended deactivation of automatic airspeed control, the flight crew's inadequate monitoring of airspeed and the flight crew's delayed execution of a go-around."

The NTSB's investigation of the accident prompted its issuance of 15 safety recommendations to the U.S. Federal Aviation Administration (FAA), including one that calls on the FAA to require Boeing to develop the enhanced 777 training and another that says the agency should require operators and trainers to provide the training to 777 pilots.

Other recommendations to the FAA said that the agency should require Boeing to include in the 777 crew training manual "an explanation and demonstration of the circumstances in which the autothrottle does not provide low-speed protection" and convene a panel of experts to identify the most effective methods of training flight crews in using automated systems for flight path management.

Other recommendations — among them, dealing with the need to comply with standard operating procedures, the need to give Asiana pilots more opportunities for manual flight and the need for improved emergency communications — were issued to Asiana, Boeing, the Aircraft Rescue and Firefighting Working Group and the city and county of San Francisco.

A full discussion of the NTSB final report will be included in the October issue of *AeroSafety World*.

Basil D. Soufi | Wikimedia Commons

Proposed Penalty

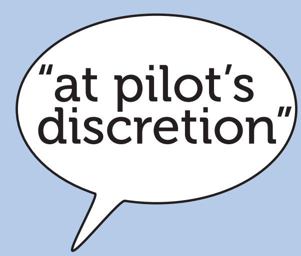
Southwest Airlines is facing a proposed $12 million civil penalty because of the U.S. Federal Aviation Administration's (FAA's) charge that it failed to comply with federal regulations in making repairs on three Boeing 737s.

Southwest has 30 days from its notification of the FAA's proposed action to respond.

The FAA said in a statement released in late July that Southwest had conducted "extreme makeover" alterations beginning in 2006 to eliminate the potential for cracks in the skin of 44 airliners. The airline's contractor, Aviation Technical Services (ATS), did not comply with required procedures in replacing fuselage skin and in stabilizing the airplanes on jacks, the FAA said.

The agency also said that the airplanes were returned to service and operated on flights in 2009 while not in compliance with U.S. Federal Aviation Regulations. In addition, the FAA said that Southwest did not properly install water drain mast ground wires on two 737s in compliance with an airworthiness directive; these airplanes were operated on more than 20 passenger flights after the airline became aware of the problem and before it was corrected.

Double Meaning



Eurocontrol is warning pilots and air traffic controllers that confusion could result from use of the phrase "at pilot's discretion," which is common in the United States but not understood globally.

"In the United States, the meaning of 'at pilot's discretion' in radio telephony voice communications related to climb/descent clearances is promulgated to include the option for pilots to level off at intermediate levels," Eurocontrol said in a safety reminder message issued in late July.

"However, the meaning of this phrase … is not understood globally, and there is a risk that its use outside the U.S. could lead to adverse safety outcomes if non-U.S. based controllers unwittingly approve pilot requests to climb/descend at their own discretion."

Eurocontrol said its advisory was intended to caution controllers in countries other than the United States that their use of the phrase in response to a request from a U.S. pilot could result in "a situation where they approve the request for 'own discretion' (to climb/descend) without recognizing the potential of an unexpected outcome — i.e., a possible intermediate level off."

Use of the phrase "when ready," as prescribed by the International Civil Aviation Organization, does not imply that an intermediate level-off is acceptable and precludes misunderstanding, Eurocontrol said.

Undetermined Cause

Limited access to the Antarctic site of the Jan. 23, 2013, crash of a de Havilland DHC-6-300 Twin Otter and the absence of data from the airplane's cockpit voice recorder (CVR) left accident investigators unable to determine the accident's cause, the Transportation Safety Board of Canada (TSB) says.

The three crewmembers — the only people aboard the airplane — were killed when it struck Mount Elizabeth, perhaps after flying into clouds during a repositioning flight from South Pole Station, with an intended landing site of Terra Nova Bay, the TSB said in its final report on the accident, released in June.

Weather conditions kept rescue personnel from reaching the site for two days and prevented accident investigators from thoroughly examining the wreckage, the report said. Investigators also found that the CVR had not been functioning the day of the accident.

The report noted that after the accident, the operator implemented actions intended to mitigate flight risks, including improving the accuracy of Antarctic aviation navigational charts, developing visual flight rules routes for longer flights, altering pre-start checklists "to confirm that an adequate oxygen supply is on board the aircraft and that the [CVR] is functional," and amending global positioning system operating procedures to ensure correct data input.

Michael Studinger | NASA

© Chameleonseye | istockphoto

Coping With Armed Conflicts

The International Civil Aviation Organization (ICAO) has established a task force — headed by David McMillan, chairman of the FSF Board of Governors — to address issues stemming from the July 17 downing of a Malaysia Airlines Boeing 777 over eastern Ukraine, killing all 298 people aboard.

Authorities say the airplane, en route at 33,000 ft, was struck by a missile fired from an area where pro-Russian separatists had been fighting Ukrainian government forces.

The Task Force on Risks to Civil Aviation Arising From Conflict Zones will review methods that might be used to improve the gathering of information about armed conflicts and how they might endanger civil aviation.

The task force will focus on methods of effectively collecting and disseminating "information and intelligence that might affect the safety of our passengers and crew," ICAO said, adding that ICAO member states have been "reminded … of their responsibilities to address any potential risks to civil aviation in their airspace."

McMillan, a former director general of Eurocontrol, said that the industry must "apply lessons learned from the tragedy of [Malaysia Airlines Flight 17] … to fill any gaps that may exist to better assess and share risks from and near regional conflict zones."

ICAO said the aviation community asked it to address "fail-safe channels for essential threat information to be made available to civil aviation authorities and industry" and "the need to incorporate into international law, through appropriate [United Nations] frameworks, measures to govern the design, manufacture and deployment of modern anti-aircraft weaponry."

An ICAO safety conference, including all 191 ICAO member states, will be held in February 2015, in part to discuss these issues.

IATA said that "clear, accurate and timely information on risks is critical."

IATA Director General and CEO Tony Tyler added, "We were told that flights traversing Ukraine's territory at above 32,000 ft would not be in harm's way. We now know how wrong that guidance was. It is essential that airlines receive clear guidance regarding threats to their passengers, crew and aircraft. Such information must be accessible in an authoritative, accurate, consistent and unequivocal way. This is the responsibility of states. There can be no excuses."

Upgrade for Serbia

Serbia has received a Category 1 safety rating from the U.S. Federal Aviation Administration (FAA), signifying that its civil aviation authority is operating in compliance with International Civil Aviation Organization safety standards.

The rating, based on an FAA assessment conducted earlier this year, represents an upgrade from the Category 2 rating that Serbia has held since 2006. A Category 2 rating signifies that a country's civil aviation authority is deficient in one or more areas, including relevant legislation or regulations, technical expertise, trained personnel, record keeping or inspection procedures.

The FAA conducts safety reviews of all countries that have air carriers flying to and from the United States, and of those that have applied for such flights.

Serbian airlines currently do not fly to the United States, but the rating change means that they may apply to the FAA and U.S. Department of Transportation for authority to do so.

In Other News …

Air Methods could face a $428,000 **civil penalty** proposed by the U.S. Federal Aviation Administration (FAA), which said the emergency medical services (EMS) operator flew helicopters without conducting required inspections of night vision imaging system–compatible lighting filtration installations. The company has 30 days from receipt of the FAA's enforcement letter to respond. The agency has proposed a $110,000 civil penalty against another EMS operator, Air Evac EMS, for operating a Bell 206 on several passenger flights even though its chin bubble window — a window at the front of the helicopter that allows the pilot to see below — was not installed in accordance with the manufacturer's instructions. The FAA says the company has discussed the matter with the agency. … New pilot **licensing regulations** take effect in Australia in September, and over the next four years, some 40,000 licenses that have been issued under Civil Aviation Regulations Part 5 will be reissued under the new Part 61. New requirements also will be implemented for flight reviews and proficiency checks, the Australian Civil Aviation Safety Authority says.

Compiled and edited by Linda Werfelman.

Reality CHECK

Reports of unauthorized commercial flights by small remotely piloted aircraft — outside hobbyists' domain — raise concern about disregard of rules.

BY WAYNE ROSENKRANS

© Tyler Olson | Dreamstime.com

Throughout 2014, observations and media-derived awareness of potentially hazardous flights by small unmanned aircraft systems (sUAS), called *remotely piloted aircraft* at the international level, have prompted consternation for some U.S. aviation safety professionals. At issue, two UAS subject matter experts told *AeroSafety World*, is whether unauthorized commercial sUAS flights, in particular, pose a significant risk to air transport, business aviation and other aviation activities.

Such flights are prohibited by the U.S. Federal Aviation Administration (FAA) unless the operator is one of a select few to have received an exemption from the Federal Aviation Regulations. The experts who spoke to *ASW* offered different approaches to address the risk that they see.

FAA Viewpoints

Insights into relevant FAA positions surfaced in the briefing by John Hickey, deputy associate administrator for aviation safety, at an Air Line Pilots Association, International Safety Forum in August. "I think that, to some degree, [operating non-segregated UAS] is not going to be as soon as some people tend to think it is," he said. "We're still many years away from what you would see as safe integration in the very busiest airspace in our system. … As the public sees … that we will not allow these UAS to come into the system until we are completely sure that they are safe, that's a great step to educating the public."

Perceptions also may be influenced by developments such as the September 2013 announcement of the FAA issuing its first-ever commercial, type-approved, restricted-category aircraft authorization for corporate UAS flights in the Arctic airspace of Alaska. "We've been very engaged in providing exemptions to a limited group of commercial operations as a result of … Section 333 of [the 2012 FAA funding] reauthorization bill," Hickey said. "Exemptions allow certain entities in certain isolated airspace to operate a business venture [such as] the Motion Picture Association of America, and we granted an exemption to them."

As for sUAS (aircraft less than 55 lb [25 kg], often flown with direct, line-of-sight control by the pilot), the FAA has scheduled for late 2014 the publication of its notice of proposed rulemaking (NPRM) for this category, he said.

AUVSI Perspectives

Ben Gielow, general counsel and senior government relations manager, Association for Unmanned Vehicle Systems International (AUVSI), told *ASW* editors, "We're obviously very concerned with the possibility of [an sUAS operator] going out there and flying recklessly and dangerously, which is why we … have been asking the FAA for years to regulate us, to pass the safety rules — we actually want the regulations.

"[Those] flying in downtown New York City over people, or flying around the very busy airports there, certainly are not members of ours. … There's not a whole lot that can be done right now to stop or prohibit them from just going out and buying the systems online. [Some] don't know anything and just are flying them, and don't realize the safety risks that they could be posing."

The association has called for intensified FAA enforcement of current restrictions and implementing enforceable regulations as the most important risk mitigations. "Until they do, they're on legal 'thin ice' in punishing people for flying a [radio control (RC)] model aircraft, a Raven, as [a] commercial unmanned aircraft," Gielow said.

AUVSI foresees problems if regulations emerge with uniform treatment of all sUAS flights that have in common solely their commercial purposes. "Unmanned aircraft are not commercial [air] carriers, they are not carrying people, and often they only weigh a couple pounds [0.9 kg]," he said. "So although they may be taking pictures and those pictures may be sold commercially, they shouldn't have to meet the same level of safety requirements across the board. … Everyone in the industry anticipates that [the new sUAS] regulations will be, or at least should be, different based on size, weight, performance and airspace that they fly in."

While the industry awaits the sUAS NPRM, speculation abounds regarding the extent to which FAA requirements — such as provisions for personnel certification — will be carried over from or inspired by manned aircraft experience. "Everyone wants to know 'What are the pilots' qualifications?" he said. "Do they really need to build up all the hours in a manned aircraft just to prove that they know the airspace?"

Benefits from the FAA's sUAS rulemaking, he said, typically are described in terms of investments, competitive advantage beyond U.S. borders and exports. Yet safety meanwhile is affected in that, Gielow said, "the reality is we need the FAA to write these rules. We've been reading more and more about folks … just going out there and flying [sUAS commercially] today — either [not] knowing the FAA prohibitions or knowing them … but doing it anyway, then challenging the FAA to come after them. So we're at a dangerous time because if the FAA does not hurry up and come out with something soon, more … will go out there and fly, and if this 'horse gets out of the barn,' I don't see it coming back in."

Unauthorized commercial flying arguably generates a drag on limited FAA enforcement resources and a distraction. "The FAA does not have the money or the manpower to track down every reported use of a 4-lb [1.8-kg] quadcopter, whether it's flying inside of a fireworks display or over a farm field," Gielow said. "It doesn't make sense that the only thing different between a model aircraft and an unmanned aircraft is the intent of the pilot, which has nothing to do with the actual safety of the aircraft or airspace." The focus on detecting illegal commercial operations consumes part of air safety inspectors' time, he added.

"Once the rules are out, the FAA … will have leveled the playing field so that responsible parties will then hold nonresponsible parties accountable," he said. "Then I think there will be an industry effort to ensure that everyone is safe. But right now, [sUAS operations are] basically turning into the Wild West — folks … doing whatever they want."

'The FAA does not have the money or the manpower to track down every reported use of a 4-lb [1.8-kg] quadcopter, whether it's flying inside of a fireworks display or over a farm field.'

The association, which primarily represents interests of manufacturers of large UAS, in recent years has been collaborating closely on safety issues with the sUAS community, the RC model aircraft community, the commercial air transport sector, the business aviation sector, helicopter operators, general aviation associations, air traffic controllers and other stakeholders, he said. For example, the association rounded up executives from 32 aviation associations to sign an April letter urging the FAA to expedite its second attempt at sUAS rulemaking in part because of discomfort about the "safety vacuum" of the status quo.

Regarding RC model aircraft hobbyists, Gielow said, "On the safety front, there is a lot that we learn from their community because, for the very small [sUAS aircraft] — operating under restrictions of [see-and-avoid] line-of-sight, at less than 400 ft, away from people — [such] commonsense safety restrictions could greatly enable the [sUAS] industry to take off."

Small-Scale Risk Mitigation

The safety culture that has evolved across several generations of RC model aircraft hobbyists focuses on reducing the risk of injury or property damage — to themselves or others — in the United States, says Richard Hanson,

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director, public relations and government affairs, Academy of Model Aeronautics (AMA).

AMA protects members under a group insurance program that provides $2.5 million liability coverage for each. The insurance claim records kept by the program have helped AMA to monitor the safety of members' activities and adjust safety policies, flight operations procedures, member education and flying rules effectively enough to essentially avoid the need for government regulation of the hobby, he said.

Most of the injuries captured in these records have involved AMA-member hobbyists who have been injured by their own aircraft, with typical injury severity being a cut finger and the rarest being five cases in which the modeler flying was killed by his own aircraft. "For the most part, [events involved] mishandling of their aircraft, or something that went awry, and they got hit in the knees, hit in the lower legs [while] taxiing or something like that," Hanson said. "As far as injuries to people outside the hobby, those are very rare but there have been some instances. … As far as property damage, we've had a few instances where the aircraft was going out of control and was going back [to the operator] and hit vehicles in the parking lot and broke windshields, those types of things. It's a very rare occasion where the aircraft actually leaves the flying site."

Flying of model aircraft predates manned aviation, and the institutional knowledge of the AMA — founded in 1936 — preserves awareness of the five member fatalities and the death of a bystander who, in 1979, was observing an RC model aircraft demonstration at a flying field, he said. The AMA in recent years received anecdotal reports of minor injuries — but no fatal injuries — caused to nonmember operators and bystanders struck by multi-rotor sUAS–type aircraft in flight.

"[AMA's] more traditional, core members … design, build, fly and compete with these model aircraft for the personal pleasure of watching them fly, learning how to fly and becoming good at flying the aircraft," Hanson said. "That is the motivation, the purpose for their participation in the hobby." Yet, about 30 percent of AMA members who responded to an informal AMA survey also expressed strong interest in owning and flying sUAS. "[They] have some interest in this technology — either for their personal use — to extend their hobby into this area or with the idea, somehow, of making a business or at least creating some revenue stream from it. … The most prevalent one is aerial photography, but there are literally thousands of other applications."

Like the FAA, the AMA recognizes that the distinction of flying a traditional model aircraft versus commercially flying an sUAS involves serious safety concerns. "Even though they are very similar in nature, the fact that [the sUAS] can perform a function and have a purpose lends them to being introduced in environments [beyond] where you would typically find a model aircraft," Hanson said. "Our safety guidelines for model aircraft are that you fly at a location away from persons that can get hurt or property. By the nature of doing something purposeful, with [sUAS] you are around people and around things … so we … have been working about a year with that community and coming up with a unique set of safety guidelines for that aspect of operating this equipment."

During the past year, in the absence of new FAA regulations, AMA decided to actively engage in public education to fill the vacuum

'Even though they are very similar in nature, the fact that [the sUAS] can perform a function and have a purpose lends them to being introduced in environments [beyond] where you would typically find a model aircraft.'

of knowledge about sUAS risks and benefits.

Those in the AMA who favored this issue engagement — as opposed to the alternative of officially drawing a line between model airplanes and UAS, and disavowing any responsibility for sUAS safety — prevailed. "The general public doesn't know … the distinction between a UAS and a model airplane. … [We're] reaching out to [the sUAS] community, finding people who want to fly safely and responsibly, and teaching them how to do so. … Then the true outliers, [the people who] choose to operate irresponsibly, can be dealt with by regulation, local ordinances and so forth."

AMA has productive, longstanding working relationships with many of the associations representing industry segments in the domain of manned aviation, including safety specialists from commercial air transport and business aviation, he said. "But what we find, by and large, is that they [typically] have very little knowledge about or understanding of the hobby and how it operates," Hanson said. "There haven't been model-airplane [vs.] manned-aircraft incidents of any significant numbers. You can literally count them on one hand. … [They're] not seeing model aircraft getting ingested into engines. [They're] not seeing model aircraft striking the windscreens of full-scale aircraft. By and large, [they're] not seeing model aircraft anywhere in the manned aircraft environment."

Unfamiliar Newcomer Traits

Hanson links the spate of 2014 reports alleging that an sUAS operator created risks for a manned aircraft operation to the emergence of newcomers to the technology who have not "grown up in the model aircraft culture" and who, because of ignorance, fail to operate safely. Changing the behavior of those people, he believes, requires a human factors–centered strategy unlike the relatively complex culture, practices and assumptions of manned aviation.

If efforts to instill safe flying behavior among today's new sUAS owners prove ineffective, several consequences seem likely, according to Hanson's interactions with them so far. "Basically, some of them will quit because they don't want to be viewed as operating irresponsibly," he said, noting that others will continue flying without regard to overly complex safety rules if those rules do not make sense to them. Still others will continue flying their sUAS contrary to safety rules and guidance "because they don't care," he said.

"A lot of [sUAS] depend highly on GPS [global positioning system] signals, and if that signal is lost — whether due to some circuitry or other issue with the aircraft — the people don't know how to fly the aircraft any other way. They can't manually fly the aircraft and keep [their operation] safe. So there are some unique educational training and safety challenges with this community."

The AMA has been accustomed to modelers adhering to its rules for the identification of owners of RC model aircraft to enable retrieval of an aircraft that inadvertently flies away from the designated flying field, and to show legal and ethical accountability for the consequences of the operator's actions and/or system malfunctions. The sUAS community should have an equivalent method — perhaps a formal registration program with a registration number for each sUAS aircraft, Hanson said.

"We also believe that this community — because of the potential for flying in more sensitive areas — needs to be more accountable in terms of their education and training," he said, suggesting perhaps a universally recognized endorsement program.

Underestimating sUAS

AMA staff and members who fly sUAS at noncommercial, public awareness and educational demonstrations under AMA rules have encountered many people in the audience who say they see no need to learn how to fly such aircraft because the aircraft always will fly itself. "That's absolutely wrong," Hanson said. "The technology is not bulletproof. It's no more reliable than the technology your cell phone has. It's built on the same [location-sensing] circuitry that's in your cell phone, and we all know how many times a phone tells you you've got 'GPS lock lost' and [you have to reboot] because an application software locked up. People need to know how to handle emergent situations when they occur."

Because of an exemption in the FAA Modernization and Reform Act of 2012, AMA members' activities with traditional RC model aircraft essentially will continue in isolation from the forthcoming FAA regulatory changes focused on sUAS, he said. The language of the law refers in part to applicability to any organization that has a proven community-based safety program and a long track record of effective safety management.

AMA is concerned that no matter how often the FAA places official policy-interpretation announcements in the *Federal Register* prohibiting commercial operation of the sUAS that people already possess, both the defiance of rules and ignorant behavior seem poised to continue and potentially to increase the risk for other airspace users.

"They're being sold by the thousands," Hanson said. "We believe we need education [now] — not in 2016 — so we're going forward with that education."

Moving IN

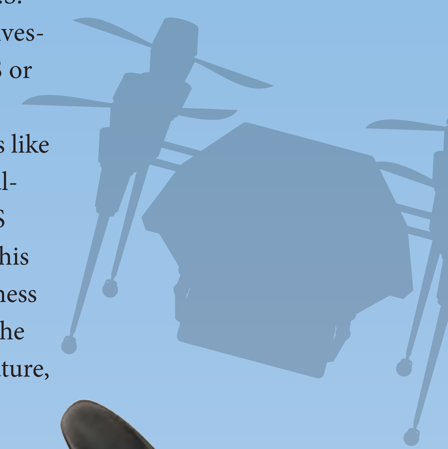
BY LINDA WERFELMAN

As UAS — authorized and unauthorized — work their way into the airspace, accidents and incidents are increasing.

A small unmanned aircraft systems (UAS) vehicle came so close to a US Airways Bombardier CRJ200 near Tallahassee, Florida, U.S., one day last March that the airline pilot was convinced the two aircraft had collided.

The pilot reported what he thought was a near midair collision to air traffic controllers, who had no information about UAS — also sometimes known as remotely piloted aircraft, unmanned aerial vehicles (UAVs) or drones — operating in the area. Ultimately, the U.S. Federal Aviation Administration (FAA) investigated but was unable to identify the UAS or its pilot.

In this instance, and a number of others like it in recent months, danger did not materialize, Jim Williams, manager of the FAA UAS Integration Office, said in remarks earlier this year to the Small Unmanned Systems Business Exposition in San Francisco. Nevertheless, he added that, in similar occurrences in the future,



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U.S. National Transportation Safety Board

NTSB accident investigators examine the wreckage of a General Atomics MQ-9 Predator B that crashed near Nogales, Arizona, in 2006.

the results "could be catastrophic," especially if a small UAS aircraft is ingested into a jet engine.

"What kind of injuries or damage could be caused by one of these aircraft?" he asked. "More than you might think, even though they may weigh only a few pounds."

As an example, he cited an incident in late 2013 when an unauthorized small UAS aircraft — an open-rotor hexacopter — that had been hired to film an event at the Virginia Motor Speedway in Jamaica, Virginia, crashed into a spectator stand, causing several minor injuries. The operator told the FAA that he believed the crash resulted from a malfunctioning battery.

With a growing number of UAS — authorized and unauthorized — in the skies, the number of reported accidents, incidents and near-midair collisions is slowly increasing.

An investigation earlier this year by *The Washington Post* found that registered UAS operators in the United States, including law enforcement authorities and universities, had reported 23 accidents and 236 unsafe incidents between November 2009 and June 2014.[1]

A search of U.S. National Transportation Safety Board (NTSB) records reveals only a handful of final reports on UAS occurrences, including three non-fatal, non-injury accidents and three incidents between 2006 — when the first UAS accident in the United States was recorded — and 2009. In each case, the aircraft was either being flown on a demonstration or test flight, or being operated by a U.S. government agency on a public use flight.[2]

The NTSB's 2007 final report on the first accident concluded that the probable cause was "the pilot's failure to use checklist procedures" when switching from one ground control console that was inoperable because of a "lockup" to another console at the same ground control station. In the process, the fuel valve on the General Atomics Aeronautical Systems MQ-9 Predator B was inadvertently shut off, causing the engine to lose power; the aircraft crashed in a remote area near Nogales, Arizona, on April 25, 2006 (see Table 1).

Lost Communication

A preliminary report has been issued in a more recent occurrence — a July 26, 2013, event in which a Sensor Integrated Environmental Remote Research Aircraft (SIERRA) operated by the U.S. National Aeronautics and Space Administration (NASA) Ames Research Center, struck the surface near Prudhoe Bay, Alaska.

Preliminary information indicated that, about four hours into the planned six-hour flight to assess sea ice during the melting season, the aircraft briefly lost its Iridium satellite communication link. When the connection was reestablished, RPM and alternator warning lights were illuminated on the ground control display, and the aircraft entered a controlled glide until impact, the NTSB said. A preliminary report, which said that the aircraft probably struck the ice, added that there were no plans for recovery. The investigation was continuing.

Numerous pilot and controller reports to NASA's Aviation Safety Reporting System (ASRS) also discuss encounters with UAS that air carrier pilots characterized as uncomfortably close.

For example, the captain of a Bombardier CRJ200 described an experience during approach to Newport News/Williamsburg (Virginia) International Airport in March 2013:[3]

> *We were issued a clearance to descend to 4,000 ft. At that moment, I saw a target on our TCAS [traffic-alert and collision*

avoidance system] about 4 mi [6 km] ahead at 4,000. I told … approach about the target, and they said they weren't talking to that traffic. ... Then we caught the target visually at 12 o'clock. I first thought it was a hawk circling because it was very small and maneuvering mostly in circles. A few seconds later, [it] took shape of an aircraft with wings. We told approach we were going to turn right to avoid hitting the aircraft. As we were turning, we got within 2 ½ mi [4 km] and the same altitude as it went from our 12 o'clock position, and for about five seconds, it seemed to chase us … before suddenly turning back to our 12 o'clock position. As it passed by … we observed it flying extremely erratically, in fact, so erratically that we pilots believe it was a drone, due to the excessive g [gravity] forces required to pull those maneuvers that were almost continuous rolls, loops, etc.

Air traffic control (ATC) was unable to give the captain any information about the small aircraft, and could not confirm whether it was a UAS aircraft and, if so, if it was civilian or military.

One month earlier, the first officer on a corporate jet was flying an approach to Leesburg (Virginia) Executive Airport when, as he said in his ASRS report, "we got a TA [traffic alert] followed by an RA [resolution advisory] climb. … The captain spotted the unannounced aircraft closing on us from below and to the left. The distance on the TCAS indicated 200 ft at the closest readout.[4]

U.S. UAS Accidents and Incidents, 2006–2013

Date	Location	Aircraft Type	Event Severity
01/27/14	Point Loma, California	General Atomics MQ-9	unavailable
The aircraft was operated by CBP. No further information was available in the NTSB database on this occurrence.			
07/26/13	Prudhoe Bay, Alaska	SIERRA	unavailable
The aircraft, operated by NASA to evaluate the condition of sea ice, struck the surface after briefly losing its satellite communication link, according to a preliminary report. The investigation is continuing.			
05/10/13	Cocoa Beach, Florida	General Atomics MQ-9 Predator	unavailable
The CBP aircraft experienced a bounced landing and runway excursion. The NTSB said the probable cause was an "improper flare, leading to a nosewheel-first touchdown, which resulted in a pilot-induced oscillation."			
02/19/09	Sierra Vista, Arizona	General Atomics MQ-9 Predator	nonfatal
The CBP aircraft touched down hard and porpoised several times during a training flight. The NTSB cited the student pilot's "improper flare while landing with a tailwind and the instructor pilot's delayed response."			
11/06/08	Sierra Vista, Arizona	General Atomics MQ-9 Predator B	nonfatal
The CBP aircraft bounced several times while landing during a training evaluation mission. The NTSB said the probable cause was the pilot's "failure … to timely flare the aircraft to the appropriate attitude."			
9/24/08	Whetstone, Arizona	Raytheon Cobra	incident
The U.S. Army Corps of Engineers aircraft was testing a mapping camera and related technology when it crashed after losing engine power. The NTSB cited an overheated piston and the pilot's "failure to send a proper command to the UAS."			
07/28/08	Colorado Springs, Colorado	Raytheon Cobra	incident
The aircraft was on a Raytheon demonstration flight when it overshot final approach and crashed into a stadium light. The NTSB cited "the flight team's failure to program the UAS with flight-tested parameters that could tolerate the high density altitude and tailwind conditions … and the existence of an undiscovered software anomaly."			
08/24/07	Whetstone, Arizona	Raytheon Cobra	incident
The aircraft was one of two UAS aircraft being operated by Raytheon at an airstrip used for UAS test flights when it dove into the ground. The NTSB cited the "student pilot's failure to follow proper procedures … which resulted in a loss of aircraft control."			
04/25/06	Nogales, Arizona	General Atomics MQ-9 Predator B	nonfatal
The aircraft was being flown by CBP for border surveillance when it crashed in a remote area. The NTSB's probable cause was the pilot's "failure to use checklist procedures" when switching operational control from one ground control console to another.			

CBP = U.S. Customs and Border Protection; NASA = U.S. National Aeronautics and Space Administration; NTSB = U.S. National Transportation Safety Board; SIERRA = Sensor Integrated Environmental Remote Research Aircraft

Source: U.S. National Transportation Safety Board

Table 1

The captain questioned ATC about whether the other aircraft might have been a UAS aircraft, and in response, "a supervisor came on line to answer questions and only acknowledge that they were tracking via radar a VFR [visual flight rules] target but didn't say where it was."

Reckless Flying?

A number of recent near collisions involving UAS aircraft also have been reported, including a July occurrence in which two men were accused of operating a UAS aircraft that nearly struck a New York City police helicopter near the George Washington Bridge[5] and a May report that crews of two airliners had spotted a UAS aircraft flying nearby at 6,500 ft as they approached Los Angeles International Airport.[6]

The UAS story that may have garnered the most attention was the FAA's reckless-flying penalty against Raphael Pirker, who in October 2011 used a small UAS (with an aircraft weighing less than 5 lb [2.3 kg]) in making a promotional video for the University of Virginia.

The FAA assessed a $10,000 civil penalty, based in part on video that showed the UAS aircraft's flight under bridges and over the heads of pedestrians on the Charlottesville campus. However, the penalty was dismissed by the NTSB administrative law judge who had jurisdiction in the matter and who said that the FAA did not have authority over small UAS. The FAA is appealing the ruling.

A senseFly eBee similar to this one was being used for aerial photography over a mining site in Australia when it had a close encounter with an agricultural spraying aircraft.

© senseFly

'Sweeping Changes'

In Australia, the "rapid growth in the popularity of so-called drones and a corresponding rise in the number of safety incidents" have prompted the Civil Aviation Safety Authority (CASA) to begin a review of its rules for safe recreational flying of remotely controlled model aircraft.

In 2002, Australia became one of the first nations to regulate UAS operations, and since then, "technology has seen sweeping changes in the types of remotely controlled aircraft that are available," CASA said. "There is concern some people are flying their remotely controlled aircraft irresponsibly and are putting the public and other airspace users at risk."

The regulatory review will focus on sections of the Civil Aviation Safety Regulations that discuss non-commercial UAS operations, CASA said. Separate regulations deal with commercial UAS.

Separation Anxiety

In recent months, the Australian Transport Safety Bureau (ATSB) has issued a handful of UAS-related reports — most notably, three reports that discuss in-flight separation issues.

The first of the three occurred Sept. 12, 2013, while the pilot of an Ayres S2R was engaged in aerial agricultural spraying near Horsham, Victoria. About the same time, the pilot of a senseFly eBee arrived at a neighboring mine site to conduct an aerial photography survey.[7]

The UAS pilot completed his pre-flight preparations and conducted a risk assessment, and then heard an aircraft operating about 1 km (0.5 nm) away. The UAS pilot "broadcast on the area frequency advising his intention to conduct unmanned aerial photography operations over the … mine site" and specifically addressed his message to the "ag aircraft operating northeast of [the] mine site."

Hearing no response, he asked the mine manager to contact the farmer and request that he advise the agricultural pilot of the UAS operation.

The farmer complied, telling the pilot that "there would be an 'aircraft' conducting aerial photography" near one of the fields where he would be working, the report said. "The pilot assumed that this would be a fixed-wing aircraft operating at or above 500 ft AGL [above ground level]. Accordingly, he intended to remain at or below 350 ft to ensure separation."

In Australia, UAS aircraft must be operated at or below 400 ft AGL, unless special approval has been granted for operations at higher altitudes; in those cases, notices to airmen (NOTAMs) are filed with Airservices to inform other pilots of the operations.

At one point, the UAS operator put his aircraft in a holding pattern to avoid the crop duster, which was operating between 100 and 150 ft AGL, the ATSB report said.

Although the two aircraft came within 100 m (328 ft) of each other, the Ayres pilot told investigators that he never saw the UAS aircraft and was unfamiliar with UAS procedures.

He also said that he believed that UAS aircraft "present an additional hazard to those already encountered by pilots conducting agricultural operations, particularly as they are very difficult to see." He added that a collision with the UAS aircraft "may potentially have resulted in aircraft damage due to ingestion into the engine, windscreen damage or pilot distraction."

The UAS operator said he considered it unlikely that a collision with his eBee — a foam, carbon fiber and composite structure with a 96 cm (3 ft) wingspan and takeoff weight of less than 700 g (1.5 lb) — would have caused damage.

The ATSB said the incident "highlights the challenges associated with having a diverse mix of aircraft operating in the same airspace and the need for all pilots and operators to remain vigilant and employ see-and-avoid principles."

The UAS operator said that in the future, he would insist on speaking directly to the pilot of any aircraft known to be operating in the same area where he plans to fly — an action endorsed by the ATSB, which said all pilots "need to recognize that small UAVs may be difficult to see."

The other two Australian incidents, both of which occurred in March 2014, were characterized as near collisions. Both were categorized as serious incidents involving "interference from the ground."

In the March 19 incident, a de Havilland DHC-8 was in controlled airspace at 3,800 ft AGL on approach to Perth Airport when the crew saw "a bright strobe light directly in front of the aircraft," the ATSB final report said. "The light appeared to track towards the aircraft, and the crew realised that the light was on an unknown object, possibly [a UAS aircraft]. The pilot took evasive action, turning towards the west to avoid a collision." The gray cylindrical object passed within 100 ft vertically and 20 m (66 ft horizontally) of the airplane.[8]

The airspace below 3,500 ft above mean sea level was military airspace, but the Australian Defence Force said there were no military UAS operations at the time. There was no alert from the airplane's TCAS, the ATSB said.

Three days later, on March 22, a Bell 412 had just taken off from a Newcastle, New South Wales, hospital bound for a helipad 2 nm (4 km) away when "a steady white light," identified as a UAS aircraft, appeared and crossed in front of the helicopter, then made two abrupt turns — first flying away from the helicopter and then back toward it. As the helicopter began descending toward the helipad, the pilot saw the UAS aircraft "hovering in position" just above it, the ATSB said. The pilot's transmissions during the incident on the common air traffic advisory frequency netted no responses.[9]

The ATSB's final report quoted CASA as saying the UAS aircraft probably was a first person view vehicle equipped with a camera that "enables the operator to fly it remotely whilst looking through either a pair of goggles or at a screen. … Use of these goggles does not provide a line of sight vision of the UAV."

Notes

1. Whitlock, Craig. "Close Encounters: As Small Civilian Drones Get More Popular, the Near Misses Stack Up." *The Washington Post*. June 24, 2014.
2. Individual NTSB accident reports are available at <www.ntsb.gov/aviationquery/month.aspx>.
3. ASRS. Report no. 1072844. March 2013.
4. ASRS. Report no. 1067656. February 2013.
5. NBC New York. "NYPD Helicopter Nearly Struck by Drone Near George Washington Bridge: Police." <www.nbcnewyork.com>.
6. Whitlock.
7. ATSB. Aviation Occurrence Investigation AO-2013-167, *Aircraft Separation Issue Involving an Ayres S2R, VH-WBK and an Unmanned Aerial Vehicle*. Sept. 12, 2013.
8. ATSB. Aviation Occurrence Investigation AO-2014-052, *Near Collision Between an Unknown Object and a de Havilland DHC-8, VH-XFX*. March 19, 2014.
9. ATSB. Aviation Occurrence Investigation AO-2014-056, *Near Collision Involving an Unmanned Aerial Vehicle and a Bell 412, VH-WSR*. March 22, 2014.

Shoved Into a Black Hole

A strong tail wind and an absence of visual cues led to an overrun on a wet runway in Jamaica.

BY MARK LACAGNINA

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The flight crew of an American Airlines Boeing 737-800 could not stop the aircraft on the remaining runway after it touched down far beyond the approach threshold at the airport in Kingston, Jamaica, the night of Dec. 22, 2009. Fourteen passengers were seriously injured and the aircraft was destroyed when it overran the runway onto a rocky beach.

In a recently published report on the mishap, the Jamaica Civil Aviation Authority (JCAA) concluded that "the flight crew's decision to land on a wet runway with a 14-knot tail wind, their reduced situational awareness and failure to conduct a go-around after the aircraft floated longer than usual contributed to the accident."

The report said that in the last seconds of the approach to Runway 12 at Kingston's Norman Manley International Airport, the captain might have been affected by a visual illusion that caused him to perceive that the aircraft was too low and to make control inputs that prolonged the touchdown.

Contributing to this "black hole" illusion were the isolated location of the airport; darkness and heavy rain; the absence of runway approach lights, touchdown zone lights and centerline lights; and the nonreflective paint that had been used for the runway markings at the airport.

Moreover, the crew had decided to conduct a straight-in ILS (instrument landing system) approach to Runway 12 despite the tail wind and rainfall. The decision was based primarily on the reported ceiling, which was close to the minimum altitude prescribed for a circling approach and a landing into the wind on Runway 30.

The pilots were not aware that a suitable global positioning system (GPS) approach was available to Runway 30. The report noted that the chart for the GPS approach was in the flight deck library and that the procedure was in the flight management system database. Investigators found "no obvious reason" why the crew was not aware of the approach.

Fatigue Suspected

Another possible factor was fatigue: "Although the flight crew had just had three days' rest and their flight/duty/rest times were within the required limits at the time of the accident, they were at the end of the third flight of a long duty day," the report said.

The pilots had flown a round-trip between Miami and Baltimore and had changed aircraft in Miami for the flight to Kingston.

"The flight crew had been on duty for nearly 12 hours and awake for more than 14 hours, and it was almost 'bedtime' in their recent diurnal cycle," the report said. "The flight crew [was] possibly fatigued; however, the extent to which this affected their performance could not be determined."

The captain, 49, had 11,147 flight hours, including 2,727 hours in type. After earning an aeronautics degree, he worked as a flight instructor and then as a pilot and operations director for a charter company. He was employed by American Airlines in 1986 as a 727 flight engineer. He progressed as a 727 and McDonnell Douglas MD-11 first officer, and then as a 727 and 737 captain.

"He was familiar with Caribbean routes and had landed at Kingston on Runway 12 before during rainy weather," the report said.

The report did not specify the first officer's age but noted that he had 6,120 flight hours, including 5,027 hours in type. After graduating from an aviation college, he worked as a flight instructor and charter pilot. He was employed by American Eagle as an ATR 72 copilot in 1994 and was hired by American Airlines in 1998 as a 727 flight engineer. He then progressed as a 727 and 737 first officer.

"The first officer said he had been to Kingston many times before," the report said. "He had landed there at night and in the rain."

Lights Out

The 737, being operated as American Airlines Flight AA331, departed from Miami at 0122 coordinated universal time (UTC; 2022 local time) with 148 passengers and six crewmembers. The captain was the pilot flying.

The flight proceeded uneventfully until turbulence was encountered at 37,000 ft over Cuba. The pilots described the turbulence as "fairly rough" and "real bumpy." In-flight service was suspended several times, and the captain told the cabin crew to prepare early for landing. However, the turbulence subsided as the 737 neared Jamaica.

Scattered thunderstorms and rain had been forecast for Kingston. The airport had a single, 8,911-ft (2,716-m) runway that straddled a thin peninsula jutting into the Caribbean Sea south of Kingston. Neither Runway 12 nor Runway 30 had a runway end safety area.

The approach lights for Runway 12 had been out of service for a month due to an underwater electrical system fault. "There was not much peripheral lighting around the runway because of its location across a peninsula with sea at both ends and the absence of a nearby settlement," the report said. "A commercial power outage had caused the airport to be operating on its standby power generator. The outage resulted in even less than normal peripheral lighting around the airport."

At 0248 UTC, the crew received an aircraft communications addressing and reporting system (ACARS) message containing a special weather observation for Kingston that was 20 minutes old. The observation included surface winds from 310 degrees at 9 kt, 5,000 m (about 3 mi) visibility in thunderstorms and moderate rain, and a broken ceiling at 1,400 ft.

The first officer, who was handling the radios, then asked the approach controller for an update on the weather conditions at the airport. The information provided by the controller was similar to that in the ACARS message, except that the ceiling had dropped to 1,000 ft. When asked about recent arrivals, the controller said that one aircraft had landed within the past hour and "didn't have any problems coming in."

Alternate Closed

Jamaica's Montego Bay Sangster International Airport had been filed as the flight's primary alternate, but the runway at the airport was scheduled to be closed for maintenance shortly after the 737's estimated time of arrival at Kingston. Thus, the aircraft was carrying extra fuel for the possibility of diverting to the secondary alternate, Grand Cayman in the Cayman Islands, about 270 nm (500 km) northeast of Kingston.

"This brought the calculated landing weight on arrival at Kingston very close to the aircraft's maximum landing weight," the report said.

Complicating the situation was that the departure from Miami had been delayed by the necessities of offloading baggage belonging to a passenger who had not boarded the aircraft and then, after leaving the gate, of coordinating with maintenance personnel on deferring a malfunctioning air-conditioning pack temperature controller according to the provisions of the minimum equipment list.

Thus, the flight was behind schedule. Just before beginning the descent to Kingston, the crew was told by company dispatch that Montego Bay had closed. "Because of the fuel needed to fly to [Grand Cayman], the crew discussed making one approach into Kingston, and, if this approach missed, they would proceed directly to their alternate," the report said.

'Better Option'

While briefing for the arrival at Kingston, the crew decided that due to the reported 1,000-ft ceiling, conducting a straight-in ILS approach to Runway 12 with the tail wind was a better option than circling to land on Runway 30. The published decision height for the straight-in approach was 278 ft, and the minimum decision altitude for circling was 1,150 ft (1,140 ft above airport elevation).

During post-accident interviews, the first officer told investigators that both the captain and he had conducted the ILS approach to Runway 12 many times. "In their interviews, both [pilots] said there was no instrument approach to Runway 30 at Kingston," the report said.

The aircraft configuration chosen by the crew did not follow the recommendations of the 737 operating manual, the report said. The manual states that a flaps 40 setting should be used when landing with a tail wind, but the crew decided to use flaps 30. They also decided initially to use the autobrake 2 setting, although the conditions at Kingston dictated using either the maximum autobrake setting or manual braking.

Landing performance data provided by the operating manual for a flaps 30 landing show that at maximum landing weight, the 737-800 requires 6,795 ft (2,071 m) on a dry runway, 7,814 ft (2,382 m) on a runway reported as wet or as having good braking action, 8,440 ft (2,573 m) when braking action is fair or medium, and 11,090 ft (3,380 m) when braking action is poor.

The data also indicate that each knot of a tail wind component increases landing distance by about 191 ft (58 m). Thus, a 14-kt tail wind would increase landing distance by 2,674 ft (815 m).

'Serious Warning'

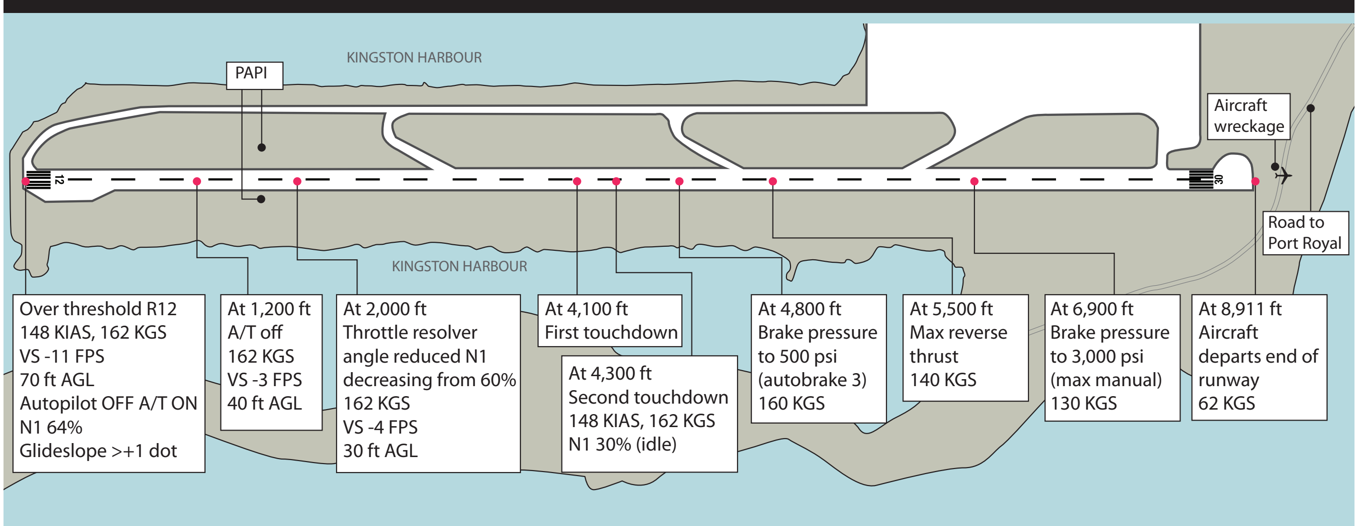
At about 0304, the approach controller told the crew, "You may have to circle to land. The wind, uh, three zero degrees at one zero knots." Notably, the controller did not mention the GPS approach to Runway 30 as an option.

"Understand that," the first officer replied. "We can go ahead and, uh, take a straight-in."

Despite the reports of moderate rain at the airport, the crew at no time requested, and the controllers did not provide, a runway condition report or a braking action report.

The airport "lacked operational procedures for the conduct of runway surface inspections during inclement weather," the report said. "And the lack of agreements between the airport, air traffic service and other users for the furnishing and distribution of inspection results precluded flight crews from being apprised of the most recent runway conditions prior to arrival."

Landing Sequence Key Events



AGL = above ground level; A/T = autothrottle; FPS = feet per second; KIAS = knots indicated airspeed; KGS = knots ground speed; PAPI = precision approach path indicator; PSI = pounds per square inch; VS = vertical speed

Source: Jamaica Civil Aviation Authority Aviation Accident Investigation Report JA-2009-09

Figure 1

At 0314, the approach controller cleared the crew to conduct the straight-in ILS approach to Runway 12 and advised that the runway was wet and that the surface winds were now from 320 degrees at 15 kt. The report noted that this was the crew's second indication of an increasing tail wind.

The controller asked, "Are you able to still land, uh, make a straight-in approach runway one two?"

"We copy the wind, and we can go straight-in to one two," the first officer replied.

The cockpit voice recording contained no discussion between the pilots about the tail wind, the rainfall or the runway conditions. Although the airline required pilots to conduct a landing distance assessment when conditions change or deteriorate after a flight is dispatched, the flight crew did not do so.

Investigators found that pilots arriving from the north generally preferred to land straight-in on Runway 12 because "it afforded a quicker and more convenient procedure … and required less taxi time to reach the terminal building."

Postaccident interviews revealed that the 737 pilots previously had landed with tail winds on wet runways. A factor that might have influenced their decision making was that at no time during the approach did the tail wind exceed the company's limitation of 15 kt. (The limit had only recently been increased from 10 kt.)

"The flight crew was concerned mainly with the tail wind being 15 knots or less, and the controllers appeared more concerned with the tail wind conditions than was the flight crew," the report said. "The tail wind reports … should have triggered a serious warning for the flight crew. … However, they continued the approach without any discussion or extra briefing, and at each wind check from ATC [air traffic control] of less than 15 knots, they immediately responded that they would land with the tail wind, despite the heavy rain and the controllers' querying of the intention to land on Runway 12."

'Wet' Runway

At 0317, the approach controller handed off the flight to the airport tower controller. On initial contact, the crew reported inbound on the ILS at 2,800 ft.

The tower controller reminded the crew that the winds were from 320 degrees at 15 kt and said, "Confirm still requesting runway one two."

"That's affirmative," the first officer said. "Runway one two."

The tower controller cleared the crew to land on Runway 12 and advised that the runway was wet. The report said that this was the first runway-condition advisory received by the crew and likely was based solely on the presence of heavy rain at the airport.

According to International Civil Aviation Organization guidance, a runway reported simply as "wet" means that the "surface is soaked, but there is no standing water." The 737 operating manual indicates that a runway reported simply as being "wet" means that braking action can be considered "good."

However, approach-briefing material provided to the crew contained a caution about the potential for standing water on the runway when it rains at the Kingston airport. Investigators found that neither company dispatchers nor the 737 crew were aware of this.

The report said that braking action at the time of the accident likely corresponded to the airline's characterization of "fair/medium," rather than "wet/good."

Nevertheless, the controller's advisory prompted the first officer to ask the captain if they should use a higher autobrake setting. "Runway's wet," he said. "You want to go to brakes three perhaps?" The captain agreed that they should select the autobrake 3 setting.

'Feeling for the Runway'

The aircraft encountered heavy rain but no turbulence during the approach and broke out of the clouds at about 1,000 ft. The captain disengaged the autopilot at about 550 ft but kept the autothrottles engaged.

Recorded flight data showed that the captain made several nose-up pitch-control inputs as the aircraft crossed the runway threshold at 70 ft radio altitude, or about 20 ft higher than the ideal crossing height (Figure 1).

The autothrottle system was in the speed mode and holding 148 kt (the reference landing speed plus 5 kt), resulting in groundspeed of 162 kt. Flight data recorder (FDR) data confirmed a tail wind component of 14 kt, as well as a left crosswind component of 7 kt.

The captain disengaged the autothrottles at about 35 ft and manually moved the throttles to flight idle about 14 seconds after the aircraft crossed the threshold. At this point, the 737 was 3,800 ft (1,158 m) past the threshold and "floating" down the runway in a shallow rate of descent.

"The FDR showed pitch-control motions indicative of the captain 'feeling for the runway,' and this prolonged the flare," the report said. "The captain did not appear to realize that the landing was going to be long [and] the first officer made no comment."

The 737 touched down 1,130 ft (344 m) beyond the touchdown zone and 4,811 ft (1,466 m) from the end of the runway. The aircraft bounced on touchdown and settled again about 200 ft (61 m) farther down the runway. The spoilers and thrust reversers deployed, and

Boeing 737-800

In 1964, Boeing began design work on a twin-turbine, short-range, narrow-body airliner that could compete with the Douglas DC-9, the British Aircraft Corp. One-Eleven and the Sud Aviation Caravelle. The result was the 737, which shared many components and assemblies with the 727 trijet, and differed from its competitors by having wing-mounted engines, a shorter fuselage and a wider cabin seating six abreast. It was the first Boeing airliner to have a two-pilot flight deck.

The first model, the 737-100, entered service in 1968, followed shortly by the -200, both with Pratt & Whitney JT8D engines. Continuous improvement over the years has increased the airplane's size, power, payload and performance.

The "Classic" series — the -300, -400 and -500 models — was introduced in the 1980s. Boeing then began work on the "Next-Generation" 737s, which have larger wings, higher cruise speeds, transcontinental range, CFM56 engines and glass cockpits. The -600, -700 and -800 models entered service in the 1990s, and the -900 and -900ER models followed in the next decade.

The 737-800 entered service in 1998 with 27,300-lb (12,383-kg) thrust CFM56-7 engines and accommodations for 162 passengers in a two-class cabin configuration or for 189 passengers in single-class. Maximum weights are 174,200 lb (79,017 kg) for takeoff and 144,000 lb (65,318 kg) for landing. Typical cruise speed is 0.789 Mach. Maximum cruise altitude is 41,000 ft, and maximum range is 3,115 nm (5,769 km).

About 7,900 737s had been delivered by the end of 2013. The -600, -700, -800 and -900 models, as well as the business jet version, are currently in production, and a new model called the 737 Max is scheduled to begin service in 2017.

Sources: Boeing, *The Boeing 737 Technical Guide, The Encyclopedia of Civil Aircraft*

the autobrake system activated about 4,311 ft (1,314 m) from the departure threshold.

"The captain stated that the aircraft was not decelerating as expected using autobrake 3, and he overrode the autobrake system, applying maximum manual braking … and selecting maximum reverse thrust," the report said. "He was joined by the first officer simultaneously applying maximum manual braking."

The captain later told investigators that he had considered initiating a go-around when he first perceived that the aircraft was not decelerating properly but expected that it eventually would slow down. There were 2,111 ft (643 m) of runway remaining when maximum braking was applied.

Investigators found no sign that the aircraft hydroplaned before it overran the runway at a groundspeed of 62 kt at 0322. "The aircraft broke through a fence, crossed above a road below the runway level and came to an abrupt stop on the sand dunes and rocks between the road and the waterline of the Caribbean Sea," the report said.

The 737's fuselage broke into three pieces, the nose landing gear and the left main landing gear collapsed, and the right main landing gear and the right engine were torn off the wing. Fuel leaked from the right wing tanks onto the sand, but, probably due to the heavy rain, there was no fire.

The report said that none of the serious injuries to the 14 passengers was life-threatening. The other 134 passengers either were unhurt or sustained minor injuries. "None of the flight crew and cabin crew was seriously injured, and they were able to assist the passengers during the evacuation," the report said.

The JCAA issued several recommendations based on the findings of the accident investigation (*ASW*, 7–8/14, p. 8). Among them was that flight crews of all transport category aircraft should be required to conduct landing performance assessments before each landing and that the assessments should include at least a 15 percent safety margin.

The authority also recommended that operators provide flight and ground training on the hazards of tail wind landings and "firmly discourage" tail wind landings on contaminated runways or when heavy rain is falling.

This article is based on Jamaica Civil Aviation Authority Aviation Accident Investigation Report JA-2009-09, "Runway Overrun on Landing, American Airlines Flight AA331, Boeing 737-823, United States Registration N977AN, Norman Manley International Airport, Kingston, Jamaica, (MKJP), 22 December 2009." The report is available at <jcaa.gov.jm>.

Susan Reed

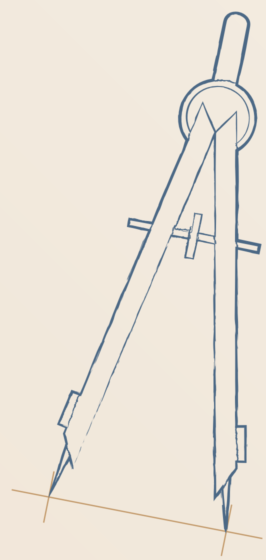
BY CHRISTOPHER M. BROYHILL

Refreshing Metrics

Research constructs aim for better ways of measuring safety culture in business aviation.

While safety culture is a topic of keen interest in business aviation, measuring the health of a safety culture in the operational setting of a specific organization remains a challenge — one that persists partly because academic researchers in this field typically have focused almost exclusively on large, commercial air transport operators and have ignored business aviation operators. Considering that the U.S. Federal Aviation Administration (FAA) predicts that turbine-powered business aircraft will average 12.5 million flight hours annually between now and 2034, the lack of attention seems to be more than a minor oversight.[1] One result is that operators may lack a sound basis for evaluating the quality of the nonpublic, proprietary safety culture measurement tools on the market.

I reached this conclusion after surveying related academic literature and aviation industry sources as part of my planned doctoral dissertation on the effectiveness of the International Standard for Business Aviation Operations (IS-BAO) in the development of healthy safety culture. Essentially, this search for a scientifically designed and validated survey instrument to assess safety culture in business aviation operations produced no results.[2] Moreover, the



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search revealed no peer-reviewed studies on safety culture in business aviation.

This led to a yearlong research project to produce a scientifically tested measurement instrument for the assessment of business aviation safety culture. While the end result was such an instrument, the research also produced some interesting results for students of aviation safety culture in general and of business aviation safety culture in particular: it verified the presence of distinct, measurable constructs that reside within a healthy safety culture. Comprehending these constructs and the questions that define them may help aviation safety managers and other aviation leaders to better assess elements of safety culture in their own organizations.

Safety Culture Defined

The following constructs have been derived from a commonly agreed definition of the term *safety culture*. In a 2002 study commissioned by the FAA, a group of scholars surveyed and compared safety culture across several industries and produced the following definition:

> *"Safety culture is the enduring value and priority placed on worker and public safety by everyone in every group at every level of an organization. It refers to the extent to which individuals and groups will commit to personal responsibility for safety; act to preserve, enhance and communicate safety concerns; strive to actively learn, adapt and modify (both individual and organizational) behavior based on lessons learned from mistakes; and be rewarded in a manner consistent with these values."*[3]

In *Implementing Safety Management Systems in Aviation,* the authors define the term more succinctly. "Safety culture," they say, "can be described as the values, beliefs and norms that govern how people act and behave with respect to safety."[4]

While both definitions provide an overall context, they do not tell us how people in a healthy safety culture act. More importantly, the definitions do not provide a way to measure the health of the safety culture. Hence, I saw the need to focus on research constructs for better insights into safety subcultures.

I saw the need to focus on research constructs for better insights into safety subcultures.

Brief Look Back

This effort wasn't the first to realize that measurement of safety culture required going beyond definitions. One earlier project focused on individual behaviors, or constructs, inside of safety culture to validate a survey of commercial aviation operations in 2006.[5] That instrument, the Commercial Aviation Safety Survey (CASS), was designed to validate a safety culture survey for airline operations based on a five-factor model that included organizational commitment, management involvement, pilot empowerment, reporting systems and accountability systems.

After distributing this instrument to the pilots and managers of a large U.S. airline and analyzing the results, the researchers were forced to revise their model to focus on four main factors within safety culture: organizational commitment, operations interactions, formal safety system and informal safety system.

In 2008, a different research team administered the revised four-factor CASS to the flight operations department of a major European airline.[6] Their analysis confirmed the existence of a positive, effective safety culture within the organization by focusing on the constructs. The same year, two researchers released an FAA-funded report highlighting their revised instrument, now called the Safety Culture Scale Measurement System (SCISMS).[7] Presently, the SCISMS appears, from my literature survey, to be the only industry-validated instrument designed to measure safety culture in aviation organizations.

In a related study, another research team tested a four-factor model using an existing data set from a major international carrier.[8] While this model was unorthodox, their results proved that a four-factor construct fit the data better than a single-factor construct model.[9,10]

Constructs in Subcultures

When I realized there was a need to design an instrument to assess safety culture in business aviation operations, my first step was to turn to the safety subcultures hypothesized by Alan J. Stolzer, Carl D. Halford and John Goglia in their 2008 work, *Safety Management Systems in Aviation*, summarized in Table 1. While the names chosen for these subcultures, their attributes and key behaviors/constructs had appeared previously in other research, most notably the work of risk theorist James Reason, the Stolzer team was the first to grasp the importance of the subculture context and to group the five subcultures as part of a coherent safety culture description. These subcultures provided only the constructs I needed to describe the performance of people inside the safety and a critical component — the measurable behaviors/constructs — needed for safety culture assessment in business measurable aviation operations.

First Instrument

Entire textbooks have been written about how to construct survey instruments that will accurately collect the data they are intended to collect. Question phraseology, question length, the order of questions and the response mechanism for questions must be taken into account, for example. Once the instrument is designed, multiple pretests and evaluations are required to ensure that the instrument generates consistent data. Knowing that opportunities for testing would be limited, rather than develop questions for the entire survey, the majority of my questions were adapted — with attribution — from an open-source version of the SCISMS and the Safety Culture Checklist designed by Reason.

The result was a 40-question survey instrument. Five questions at the beginning collected data on the respondent and five questions at the end asked for the respondent's opinion of the survey itself. The remaining 30 questions were written to assess the five safety culture areas identified by the Stolzer team, five questions per subculture, with an additional five questions

Safety Subcultures

Subculture	Key Attribute	Key Behavior of Members
The Informed Culture	Knowledge	They know what they need to know.
The Flexible Culture	Adaptation	They can adapt when required.
The Reporting Culture	Information	They tell what happened.
The Learning Culture	Growth	They learn from the lessons.
The Just Culture	Expectation	They know what to expect.

Source: Adapted from *Safety Management Systems in Aviation* by A.J. Stolzer, C.D. Halford and J. J. Goglia, 2008. Copyright 2008 by A.J. Stolzer, C.D. Halford and J. J. Goglia; used with permission.

Table 1

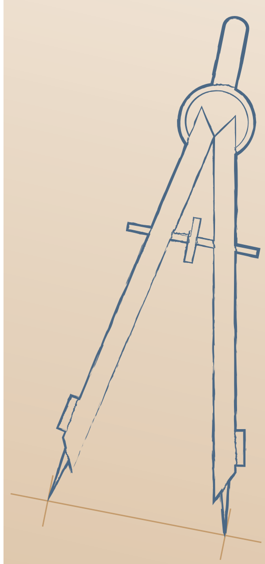
that assessed the respondent's opinion of the organization's leadership. The respondents answered all the safety culture and leadership assessment questions using a Likert scale (1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = neither agree nor disagree, 5 = slightly agree, 6 = agree and 7 = strongly agree).

Test of First Instrument

For the first test of my survey instrument, a sampling frame was derived of the 44 IS-BAO–registered business aircraft operators based in the U.S. states of Illinois, Indiana and Wisconsin. Fourteen operators agreed to participate, but 13 actually completed the survey. The data collection instrument was distributed to 162 respondents affiliated with the 13 participating operators. A total 101 responses were received for a response rate of 62.35 percent.

The first test of the survey instrument was promising in both its validity and its reliability. Nearly all respondents reported no difficulty understanding the questions, and they agreed that the survey was valid in measuring both safety culture and leadership. Measurements of the scale reliability in the subcategory human behaviors/constructs were regarded favorably as well. In every construct area but one, the survey satisfied the research community's reliability criteria.

But most interestingly, when the survey responses were loaded into a principal component analysis, they did not group precisely according to the five subculture areas described earlier. Instead, they grouped into eight distinct areas,



Subculture Grouping from First Survey Test

Subculture	Improvement Culture	Sustainment Culture	Empowered Culture	Flexible Culture	Compliant Culture	Reporting Culture	Open Culture	Just Culture
Number of variables	4	6	3	2	4	3	4	4

Source: Christopher M. Broyhill

Table 2

only some of which aligned with the original researchers' hypothesis. Based on the content of the survey questions, I renamed certain constructs within the model. With these renamed categories, the survey answers (variables) were distributed as depicted in Table 2. Questions devised to assess safety culture leadership factors across three construct areas did not group into one area as expected.

Second Instrument

While the distribution of variables across the new constructs in the first test was instructive, it was not conclusive, largely due to the limited sample size. I was still convinced that the survey variables should group into measurable, understandable constructs. This led to a review of results and a revision of the survey instrument to measure the original research team's five subculture constructs and one additional area, the Empowered Culture, in which members of the business aviation organization are given authority to recommend revisions to safety guidance and procedures, where appropriate. Additionally, I tightened the focus on leadership and used three questions to gather a limited measurement of the respondents' views of their leaders. Rather than an even distribution of questions across measurement areas in the revised survey instrument, I revised it to measure the subculture areas as depicted in Table 3.

Second Test

To test the second version of my survey instrument, I targeted 116 operators in California, New Jersey and New York, as well as three operators from the energy industry not located in those states, for a total of 119 operators. Of these operators, 18 agreed to participate in the survey. Survey links were forwarded to 376 respondents, and 232 responses were received, a response rate of 61.7 percent.

The results for the second instrument were even more encouraging in the area of content validity. The respondents typically reported that the survey measured safety culture and leadership, they said they found the questions were easy to understand and not biased, and they agreed the time required for the survey was optimum. Scale reliability for the behavior measurement areas/constructs was higher as well, although one construct area still did not achieve reliable status. Most encouraging was that a confirmatory factor analysis revealed that the hypothesized distribution relationship in Table 3 held true once the appropriate covariances were taken into account. In other words, the seven culture constructs appeared to accurately represent the latent values inherent in the data.

Results and Application

So what is the takeaway from all this? Safety culture is measurable. Not only is business aviation safety culture measurable from an overall perspective, but the subcategories' individual behaviors/constructs are measurable so that a business aviation organization and its leaders can know the strengths and weaknesses of its safety culture. The descriptions of the final constructs are in Table 4.

Measurement of these constructs requires specifically targeted questions that ask the respondents' opinions about the aspects of their safety culture. Some of the representative questions for each construct are:

The Informed Culture — My organization places high priority on training;

The Flexible Culture — My organization has a mechanism to approve deviations from existing guidance if something unexpected happens;

The Empowered Culture — Line personnel are actively involved in identifying and resolving safety and/or operational concerns in my organization;

Revised Instrument Variable Distribution

Questions	Measurement Area
1–5	The Informed Culture
6–9	The Flexible Culture
10–13	The Empowered Culture
14–18	The Reporting Culture
19–22	The Learning Culture
23–27	The Just Culture
28–30	The Leadership Culture

Source: Christopher M. Broyhill

Table 3

Revised Safety Subcultures		
Subculture	**Key Attribute**	**Key Behavior of Members**
The Informed Culture	Knowledge	They know what they need to know.
The Flexible Culture	Adaptation	They can adapt when required.
The Empowered Culture	Influence	They can make things change.
The Reporting Culture	Information	They tell what happened.
The Learning Culture	Growth	They learn from the lessons.
The Just Culture	Expectation	They know what to expect.
The Leadership Culture	Facilitation	They make the culture flourish.

Source: Adapted from *Safety Management Systems in Aviation* by A.J. Stolzer, C.D. Halford and J.J. Goglia, 2008. Copyright 2008 by A.J. Stolzer, C.D. Halford, and J.J. Goglia; used with permission. Also adapted from *IS-BAO Implementation and Healthy Safety Culture: Refining the Measurement of Perceptions* by C.M. Broyhill. Copyright 2014 by C.M. Broyhill.

Table 4

The Reporting Culture — All personnel can report safety discrepancies without fear of negative repercussions;

The Learning Culture — If a safety issue is raised, it will be communicated to everyone in the organization;

The Just Culture — Standards of accountability are consistently applied to all personnel in my organization; and,

The Leadership Culture — Leadership encourages us to actively identify hazards and safety risks and when we do, leaders take prompt action to investigate and mitigate them as practicable.

As noted above, these questions measure respondents' perceptions/opinions of the area assessed and in this instance, it is perceptions that matter. These constructs are all elements of organizational culture, and according to one of the foremost authorities on the subject, Edgar Schein, organizational culture is largely a function of the perceptions of those involved.

Next Steps

In mid-2014, the International Business Aviation Council (IBAC) was considering incorporating the latest safety culture survey instrument into its safety culture toolkit and distributing this toolkit to IS-BAO–registered operators worldwide for periodic self-assessment. I plan to use the instrument to complete in 2015 research for the doctoral dissertation, as noted, on the effectiveness of IS-BAO implementation and leadership in the development of a healthy safety culture in business aviation operations.

Chris Broyhill is the transportation director at Exelon Corporation and a Ph.D. student. He has held leadership positions in aviation organizations for over 30 years and has been researching safety culture in business aviation for the last three years.

Notes

1. FAA. *Forecast tables, FAA aerospace forecast fiscal* years 2014-2034. Washington, D.C.: FAA, 2014.

2. Due to their limited distribution, often at high cost, and their unavailability to academic researchers, such proprietary tools are unlikely to have been subjected to scientific rigor that would help assure their statistical validity and reliability.

3. Wiegmann, D.A.; Zhang, H.; von Thaden, T.; Sharma, G.; Mitchell, A. Safety culture: A review. (Technical Report no. ARL-02-3/FAA-02-2). Atlantic City, New Jersey, U.S.: FAA, 2002.

4. Stolzer, A.J.; Halford, C.D.; Goglia, J.J. *Implementing safety management systems in aviation* (Kindle edition). Burlington, Vermont, U.S.: Ashgate, 2011.

5. Gibbons, A.M.; von Thaden, T.L.; Wiegmann, D.A. "Development and initial validation of a survey for assessing safety culture within commercial flight operations." *The International Journal of Aviation Psychology*, 16(2), 215–238, 2006.

6. Von Thaden, T.L.; Kessel, J.; Ruengvisesh, D. "Measuring indicators of safety culture in a major European airline's flight operations department." T*he Proceedings of the 8th International Symposium of the Australian Aviation Psychology Association*, Sydney, Australia, April 8–11, 2008.

7. Von Thaden, T.L.; Gibbons, A.M. *The safety culture indicator scale measurement system (SCISMS)*. (Document no. HFD-08-03/FAA-08-2). Atlantic City, New Jersey, U.S.: FAA, 2008.

8. Kelly, T. K.; Meyer, R. C.; Patankar. M. (2012). *Safety culture: Testing the safety culture pyramid with structural equation modeling*. (No. Grant # 08-G-014). St Louis, MO: Center for Aviation Safety Research.

9. Patankar, M. S.; Sabin, E. J. (2010). The safety culture perspective. In E. Salas and D. Maurino (Eds.), *Human Factors in Aviation*, second edition. Chennai, India: Elsevier.

10. The model tested was a pyramid, first hypothesized by Patankar and Sabin in 2008, and it consisted of four distinct, yet interdependent, layers. "The base of the pyramid included safety values and unquestioned assumptions that serve as the foundation of the model," their report said. "The second layer is described as safety strategies and consists of leadership strategies, policies, procedures, organizational norms, history, legends and heroes. The third level of the pyramid [represents] the safety climate of the organization and consists of the short- and near-term set of attitudes and opinions surrounding safety. The apex of the pyramid [represents] safety behaviors and consists of individual and group safety-related behaviors within the organization."

Bad Attitude

A report cites 'troubling evidence' about some approaches to helicopter safety in the North Sea energy industry.

BY LINDA WERFELMAN

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A committee of the British Parliament says it found evidence of a "macho, bullying culture" in the North Sea oil and gas industry, including one report that workers who expressed concern about the safety of the helicopters that transport them to offshore platforms were told they should leave the industry.[1]

Publication of the House of Commons Transport Committee report in July followed the release of two related documents: the U.K. Air Accidents Investigation Branch (AAIB) report on the 2012 ditching of two Eurocopter[2] EC225 LP Super Pumas in the North Sea[3] and the U.K. Civil Aviation Authority (CAA) review of offshore helicopter safety (*ASW*, 4/14, p. 33).[4]

Besides the ditchings in 2012, three additional accidents involving North Sea helicopters — two of them fatal — have occurred since 2009 ("North Sea Helicopter Crashes, 2009–2013," p. 35). All of the accidents involved Super Pumas, which make up about 60 percent of the North Sea helicopter fleet, the report said, adding that their numbers mean that "it is unsurprising that they are involved in more accidents than other models."

The House of Commons Transport Committee opened its inquiry into offshore helicopter safety after the most recent accident — in which four of the 18 people aboard were killed when a Super Puma AS332 L2 crashed into the sea near Sumburgh, Shetland Islands, on Aug. 23, 2013.

During the inquiry, the committee "heard troubling evidence" about the safety culture in the oil and gas industry, the panel's report said.

"We were disturbed to hear that just weeks before the Sumburgh crash, workers who had raised concerns about the airworthiness of Super Pumas were told by officials at the oil company … to put on 'big-boy pants' or quit if they could not deal with the risk of helicopter crashes," the report said. "That insensitive approach further eroded confidence in Super Pumas among the offshore work force."

The report said that, although a labor union characterized the safety culture within the industry as one of "macho bullying that exists with the tacit acceptance of the employers," an official of Oil & Gas UK — an industry organization — described healthy collaboration between the industry and the offshore workers. Nevertheless, the report added that the official agreed that the "big-boy pants" remark "highlighted the need to rebuild work force confidence and to improve communication between workers and managers."

The Transport Committee said in the report that it was "unacceptable that offshore workers were told by an operations manager that they should leave the industry if they were concerned about helicopter safety. In an inherently hazardous industry, operations managers must prioritise safety, which means facilitating a culture of approachability and openness at all levels."

The CAA's review did not thoroughly examine the effects of commercial pressures on helicopter safety, the committee said, adding, "The evidence that we heard was polarised, and commercial sensitivities mean that it is difficult for most external reviews to examine the contractual obligations set by industry."

The committee recommended that the U.K. Department for Transport conduct an inquiry in that area as well as on the role and effectiveness of the CAA in regulating the industry. In addition, the department should commission independent research on safety improvements and threats to safety in the industry, the committee said.

Among the committee's other recommendations was a call for the CAA to ensure that operators regularly review helicopter safety information and ensure that it accurately describes how equipment should be used. The committee's report cited preliminary AAIB information about the August 2013 crash that indicated that preflight briefing material "did not fully represent" the type of underwater emergency breathing system available in the helicopter for use in case of a ditching. As a result, the report said, some crash survivors did not use the breathing equipment.

Gary Watt | Wikimedia Commons

CAA Review

The Transport Committee report cited the CAA's review of offshore helicopter safety, published earlier this year, for proposing dozens of changes intended to bolster safe operations, including prohibiting all but emergency flights during the most severe sea conditions, requiring enhanced underwater breathing equipment for all passengers and establishing the Offshore Helicopter Safety Action Group to implement its recommendations.

Nevertheless, the report added that the CAA should consult with the industry "to ensure its demands are realistic and implemented in a way which continues to allow for maximising economic recovery."

Each accident occurred after a loss of main rotor gearbox oil pressure.

Another Transport Committee recommendation noted that Norway's offshore safety record has improved over the past decade while the U.K.'s record has declined, and that the CAA has said it can find no explanation for the divergence.

The Transport Committee and the CAA agreed, however, that there are differences in the safety reporting culture in each country — differences that the Transport Committee described as "worrying." Since 2008, more occurrence reports have been filed in Norway than in the U.K., the CAA said in its review, adding that this might indicate a greater occurrence rate or a more active reporting culture (Table 1, p. 36). The Transport Committee said that, to find the explanation, the CAA "must undertake a joint review with its Norwegian counterparts to uncover why more occurrences are reported in Norway, despite its smaller fleet."

The committee, noting that the offshore industry "has little appetite for transferring more responsibility for helicopter operations to a European level," also urged the Department for Transport to "push EASA [the European Aviation Safety Agency] to improve its response and implementation times" when it receives safety recommendations from the CAA.

AAIB Final Report

In its final report on the 2012 ditchings — discussed in a single report because their circumstances were so similar — the AAIB said that each accident occurred after a loss of main rotor gearbox oil pressure. In each case, the crew activated the emergency lubrication system on the EC225 LP Super Puma as required.

"Both helicopters should have been able to fly to the nearest airport," the AAIB report said. "However, shortly after the system had activated, a warning illuminated indicating that the emergency lubrication system had failed. This required the crews to ditch their helicopters immediately in the North Sea."

Each ditching was successful, and no serious injuries were reported to any of the 14 people in the first helicopter or 19 people in the second. In each case, the helicopters were flown by

North Sea Helicopter Crashes, 2009–2013

U.K. helicopters used in the North Sea offshore oil and gas industry have been involved in five crashes — two of which resulted in a total of 20 fatalities — since 2009. All five accidents involved variants of the Eurocopter[1] Super Puma, and three were attributed to gearbox problems. The five accidents were:[2,3]

- The Feb. 18, 2009, ditching of an EC225 LP near an oil platform located 125 nm (232 km) east of Aberdeen, Scotland. None of the 18 people in the helicopter was seriously injured. The U.K. Air Accidents Investigation Branch (AAIB) said the accident was a result of the crew's erroneous perception of the "position and orientation of the helicopter relative to the [offshore] platform during the final approach" and an inoperative warning system (*ASW*, 11/11, p. 24).
- The April 1, 2009, crash of an AS332 L2 into the North Sea 11 nm (20 km) northeast of Peterhead, Scotland. All 16 people in the helicopter were killed. The AAIB said the accident was caused by the catastrophic failure of the main rotor gearbox (*ASW*, 2/12, p. 36).
- The May 10, 2012, ditching of an EC225 LP in the water about 34 nm (63 km) east of Aberdeen. There were no serious injuries to any of the 14 people in the helicopter. The AAIB said the accident was caused by a gearbox failure and a wiring/pressure switch configuration problem that led to a faulty warning light illumination.
- The Oct. 22, 2012, ditching of an EC225 LP in the sea 32 nm (59 km) southwest of the Shetland Islands. None of the 19 people aboard was seriously injured. The AAIB said the accident, like the May 10 ditching, was caused by a gearbox failure and a wiring/pressure switch configuration problem that led to a faulty warning light illumination.
- The Aug. 23, 2013, crash of an AS332 L2 into the sea while on approach to Sumburgh Airport in the Shetland Islands. Four of the 18 people aboard were killed. The AAIB investigation is continuing.

— LW

Notes

1. Eurocopter was rebranded in January 2014 as Airbus Helicopters.
2. U.K. House of Commons Transport Committee. *Offshore Helicopter Safety*, Second Report of Session 2014–2015. July 8, 2014. Available at <www.parliament.uk/transcom>.
3. Individual accident reports are available at <www.aaib.gov.uk/publications/formal_reports.cfm> and <www.aaib.gov.uk/publications/special_bulletins.cfm>.

two-pilot crews and were transporting workers from Aberdeen Airport in Scotland to drilling rigs in the North Sea.

Both accidents occurred over the North Sea in daylight — one on May 10, 34 nm (63 km) east of Aberdeen Scotland, and the other on Oct. 22, 32 nm (59 km) southwest of the Shetland Islands.

After each ditching, passengers and crewmembers evacuated into the helicopter's life rafts. They were rescued soon afterward.

The AAIB report said that a fatigue crack in the vertical shaft of the main gearbox bevel gear was to blame for the loss of drive to the oil pumps in both helicopters, which launched the chain of events that led to the ditchings.

The AAIB report said that a fatigue crack in the vertical shaft of the main gearbox bevel gear was to blame for the loss of drive to the oil pumps.

'Incompatibility'

In each case, the investigation determined that the emergency lubrication system had been operating properly, but the system warning light illuminated because of "an incompatibility between the helicopter wiring and the pressure switches," the report said. "This meant the warning light would always illuminate after the crew activated the emergency lubrication system."

U.K. and Norwegian Occurrence Reporting Data, 2003–2012

Year	Number of Events Reported		Hours Flown	
	Norwegian CAA	U.K. CAA	Norway	U.K.
2003	5	223	44,233	73,139
2004	8	149	41,786	69,674
2005	3	148	43,559	76,919
2006	3	208	44,815	71,755
2007	123	229	44,940	73,236
2008	293	224	43,087	70,924
2009	352	319	47,231	67,000
2010	556	293	52,651	69,662
2011	427	253	53,862	77,610
2012	356	216	57,160	86,133

CAA = Civil Aviation Authority

Source: U.K. CAA. CAP1145, *Civil Aviation Authority — Safety Review of Offshore Public Transport Helicopter Operations in Support of the Exploitation of Oil and Gas*, Annex C, Paragraph 8.3.1. February 2014.

Table 1

Nevertheless, because it was impossible for the flight crews to know that the system was working properly, ditching was the appropriate, safe response to illumination of the warning light, the report added.

Grounded

The two accidents prompted a 10-month grounding of the North Sea fleet of Super Pumas, followed by a flurry of alert service bulletins from Eurocopter, and airworthiness directives and safety directives from regulators, outlining the steps required before the helicopters would be permitted to return to the skies.

The ban on flights was rescinded days before the August 2013 fatal crash, which, in turn, prompted a second, shorter suspension of flights. The AAIB was continuing its investigation, but preliminary reports said circumstances surrounding the accident, which destroyed the helicopter, were not similar to those of the 2012 ditchings. The AAIB said that early phases of the investigation revealed no evidence of a technical problem and that investigators were focusing on operational aspects of the flight, "especially on the effectiveness of pilot monitoring of instruments during the approach, operational procedures and the training of flight crews."

Fatigue Cracks

Accident investigators found that the ditching of each of the helicopters involved in the 2012 accidents followed a loss of oil pressure that resulted from "a failure of the bevel gear vertical shaft in the main rotor gearbox, which drives the oil pumps," the report said. "The shafts had failed as a result of a circumferential fatigue crack in the area where the two parts of the shaft are welded together."

Awareness

The pilots of the second accident helicopter had read the preliminary reports on the first accident, and the copilot — a training captain who was using the flight as part of the revalidation of the captain's line training qualification — had incorporated details of the accident into a scenario to be used in simulator training for other flight crews.

The AAIB issued several new safety recommendations, including a call for EASA to review the installation of the type of life raft used in the helicopter to ensure "a high degree of deployment reliability in foreseeable sea conditions."

Other recommendations involved the need for clear instructions on the packing and installation of rescue pack lines and mooring lines during life raft installation. After the second ditching, the left life raft was fully inflated but caught up in tangled rescue pack and mooring lines, which were untangled by the copilot. Occupants of both helicopters cut mooring lines because they feared that the life rafts were too close to the helicopter and might be slashed by the rotor blades.

Notes

1. U.K. House of Commons Transport Committee. *Offshore Helicopter Safety*, Second Report of Session 2014–2015. July 8, 2014. Available at <www.parliament.uk/transcom>.
2. Eurocopter was rebranded in January 2014 as Airbus Helicopters.
3. AAIB. Aircraft Accident Report 2/2014, *Report on the Accidents to Eurocopter EC225 LP Super Puma G-REDW, 34 nm East of Aberdeen, Scotland, on 10 May 2012 and G-CHCN, 32 nm Southwest of Sumburgh, Shetland Islands, on 22 October 2012.*" Available at <www.aaib.gov.uk>.
4. U.K. CAA. CAP 1145, *Civil Aviation Authority — Safety Review of Offshore Public Transport Helicopter Operations in Support of the Exploitation of Oil and Gas.* February 2014. Available at <www.caa.co.uk>.

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AIRBORNE

Fluctuating rates of airproxes and level busts convince European stakeholders to share analyses and refine countermeasures.

Recent increases in reported losses of required minimum in-flight separation of aircraft, known as *airproxes* in a number of European countries, and of altitude deviations from air traffic control (ATC) clearances by flight crews, called *level busts*, generated enough concern that in June, the stakeholders convened a two-day Airborne Conflict Safety Forum in Brussels, Belgium. The numbers for both airproxes and level busts are small relative to traffic volume, but they are viewed as critical safety indicators because of the severity of potential consequences, presenters said.

"In European airspace with prescribed separation minima, there are approximately 150 losses of separation per million flights," says the final report by forum organizers. "Since each flight receives on average 15 executive instructions in the en route environment, this is equivalent to one loss of separation per 100,000 instructions. … IATA [International Air Transport Association] safety data show 0.25 pilot level bust reports per 1,000 flights with 41 percent of these occurring during descent. Other data suggest that approximately 15 percent of level busts may subsequently result in a loss of separation in busy airspace."

The 272 participants heard 23 presentations offering insights at European and global levels, according to Tzvetomir Blajev, coordinator, operational safety improvement initiatives, Eurocontrol; organizer of the safety forum; and chairman of Flight Safety Foundation's European Advisory Committee. The European Regions Airline Association and the Foundation joined Eurocontrol in arranging the event. Forum videos, the agenda, digital slides and the final report are available at no cost at Eurocontrol's SKYbrary website at <www.skybrary.aero/index.php/Portal:Airborne_Conflict>.[1,2]

The report also summarized an informal consensus about key safety-improvement strategies. Participants called for better operational data integrity and use of the most relevant data sources to address these events; measures to increase the probability that every pilot's response to a corrective resolution advisory (RA) from an airborne collision advisory system (ACAS, known in some countries as a traffic-alert and collision avoidance system or TCAS) will conform to the procedures of the system's design; overcoming variations in requirements for ACAS equipage and airspace access; and increasing pilot notifications to air traffic controllers during and after responding to an ACAS RA.

They also aimed to resolve aircraft airworthiness and operational problems that can degrade ACAS effectiveness; expand efforts to identify and mitigate the human errors that may lead to loss of aircraft separation; reemphasize all pilots' adherence to basic "see and avoid" practices in all airspace classes; improve pilots' awareness of the separation-risk implications/factors of flight operations within every airspace

CONFLICT

BY WAYNE ROSENKRANS

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class; improve the functionality of short-term conflict alert (STCA) technology in ATC traffic displays; and reduce risks of misinterpreting ATC instructions by standardizing the responses to controllers from multi-crew flight decks regarding lateral or vertical clearances.

Forum participants urged government and industry to consider reducing the risk of level busts by changing/harmonizing states' designated transition levels (one or more altitudes above which all aircraft barometric altimeters must be adjusted to standard sea level pressure for ATC separation, a procedure prone to errors by pilots not used to the locally applicable aviation regulation); integrate human factors, procedures and technology for a total systems approach to airspace design; apply proactive methods to reduce the risk of pilots or controllers becoming confused by similar aircraft call signs, and improve adherence to professional discipline and mitigating techniques when similar call signs are heard; provide European input to the international developers of ACAS X, the next generation of automated collision-avoidance warning logic; and publicize emerging airborne conflict issues and recommended solutions.

Insights From Data

In an average year, 160 airlines share air traffic management (ATM)–related flight operations data with Eurocontrol's safety researchers, said Dragica Stankovic, EVAIR (European Voluntary ATM Incident Reporting) function manager at the agency. The region's air navigation service providers (ANSPs) and states' safety analysts supplement this with their data and analysis of issues such as call sign confusion and ACAS RAs.

EVAIR recently focused on 2008–2013 level busts and ACAS RAs. "In the data repository, we found 12,000 reports … 0.4 percent of the EVAIR occurrences were identified as level busts and … 12.6 percent … as ACAS resolution advisories," Stankovic said, noting that 11 percent of level busts were followed by an ACAS RA. "It means that a further erosion of the separation minimum was, in fact, prevented by the ACAS resolution advisory," she said. The data showed 57 airlines involved in level busts and 87 involved in ACAS RAs.

For 2012, the year in which the largest number of level busts was reported during the five-year period, the rate was 0.35 reports per 10,000 operations. "So if we have, let's say, in the summer season, 30,000 operations daily, it means that in Europe … we had at least one level bust daily, if not more," Stankovic said. "In 2013, we recorded quite a good decrease of the number of level busts. After drilling down to the base data, we saw that a good contributor to that was the reduction of the call sign similarities … partly a result of the call sign similarity deconfliction tool developed by Eurocontrol [and implemented by] about 20 airlines to date."

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In 49 percent of cases, ATC initiated avoidance action by other aircraft pilots when the level bust occurred. In 53 percent, the aircraft involved were converging from opposite directions; in 42 percent, their tracks crossed.

Most level busts took place at relatively low altitudes, from 2,200 ft to Flight Level 180 (approximately 18,000 ft), and the majority of level busts that generated ACAS RAs occurred in the upper airspace, Stankovic said, suggesting a possibility of improving local airspace design.

"We have 11 percent of the level busts where the traffic was, in fact, maintaining the [ATC-assigned] flight level," she said. "In situations with unstable atmosphere or severe turbulence, we saw [losses] of altitude of more than 400 ft and also the [wake turbulence] impact of the super-heavy traffic."

Eurocontrol strongly encourages flight crews to follow international standards and recommended practices by refraining from high vertical rates when climbing or descending to an assigned flight level, she said.

In 31 percent of level bust reports, there was a direct ATM involvement, and analysis of causal factors showed nearly one-third of those involving problems in air-ground communication, she said.

"Air-ground communication with the hearback [controller's message verification] omitted — [resulting in] misunderstanding and causing confusion — is dominating as a contributing factor" in level busts, she said. Other issues are inadequate traffic information provided by ATC before the pilot selects vertical climb/descent rates, mistakes by planning controllers, and lack of timely information from ATC to pilots about meteorological conditions that increase susceptibility to a level bust.

Global Parallels

Gordon Margison, IATA's assistant manager, Global Safety Information Center analysis, used the association's Safety Trend Evaluation, Analysis and Data Exchange System to compare about 400 level busts. "Indeed we do see an increasing trend," he said. "We have more altitude deviations being reported. … We have had a large increase in the contribution from U.S. [air] carriers." This added information most likely indicates an actual number of level busts not just greater participation in the voluntary reporting of these events under airlines' aviation safety action programs, he said.

"The descent [from cruise] and approach were major phases," Margison said. "[Among] our top event types was 'flight management.' … Usually this was a crew error, … a human factors issue in the cockpit. Also related were … ATM factors as well as weather; TCAS response [as] a contributing factor to some of our altitude deviations … deficiencies in the [flight] documentation and data … provided to the flight crews and [in] their charts."

IATA's analysis found ATC factors such as confusing clearances and changes to clearances early in a flight. In other cases, turbulence was the major factor.

Giancarlo Buono, a captain and IATA's regional director, Safety and Flight Operations, Europe, said air crew flight management, air traffic management and weather, especially turbulence and tailwinds, are now the three main areas of concern. "The majority of the events were successfully managed and did not have any further consequences on the flight," he said. "In terms of immediate effects, we saw that the majority were flight path deviations in the lateral area, but also some avoidance maneuvers."

About 68 percent of level busts happen during short-haul operations, compared with 28 percent during long-haul operations, he said. Pilots who spend most of their flight time in congested air traffic are more prone to altitude deviations. "Most happened during a STAR [standard instrument arrival procedure]. … Only 35 percent showed that the altitude deviations happened below 10,000 ft. … Maybe when the pilots are below 10,000 ft, we have quite robust procedures for maintaining situational awareness such as sterile flight deck," he said.

In 89 percent of events studied by IATA, the autopilot was engaged at the time of the level bust. Anomalies in some automated systems also made a difference, Buono said. "I don't want to get into an issue with manufacturers here, but we still have a lot of airplanes flying where, when you select an altitude on your autoflight panel … and you start playing with the vertical speed selector … the altitude function disarms and then the airplane will not automatically capture the altitude."

In 70 percent of level busts studied, the pilot flying or the pilot monitoring recognized the altitude deviation and took corrective action. "However, in 29 percent, [the level bust only] was recognized by ATC and only in 1 percent [it was detected] by an aircraft automated system's response," Buono said. "These data are quite comforting. … ATC cleared [them] to continue, which means that probably there was no immediate safety issue related to conflict. … Only 0.5 percent of the reports indicated that a reduced separation happened as a result of the altitude deviation."

U.K. Initiatives

Current initiatives to address level busts respond to a "Significant 7" list of safety

Breaking Down a Level Bust

The U.K. Civil Aviation Authority, through Airborne Conflict Safety Forum presenter Jacky Mills, cited the following example of a level bust (called an *altitude deviation* in some countries) for which causal factors subsequently were mitigated.

"[This] level bust in our airspace caused a serious airprox [near miss] between a Cessna Citation departing from London City Airport and a Boeing 777 inbound to Heathrow," Mills said. "The London City DVR 4T SID [standard instrument departure, Dover] track coincides with the base leg turn for aircraft inbound to London Heathrow. The DVR 4T requires an initial climb to 3,000 ft, but, on this occasion, the privately operated Cessna [pilot] read back the clearance for 4,000 ft and, unfortunately, the error was not noticed by the tower controller. With no Mode S downlink of [the pilot's] selected level, the controller was not aware that the Citation was climbing above his cleared level until, unfortunately, it had exceeded 3,000 ft.

"[A Boeing 777 flight crew then] received a [traffic-alert and collision avoidance (TCAS)] "descend" [resolution advisory (RA)] followed by a TCAS "reversal, climb" RA. The 777 [pilot flying] didn't follow the initial "descend" RA but did follow the "reversal, climb" [RA] and only then reported the RA to ATC [air traffic control]. Meanwhile, the Citation [crew] had seen the 777 and — although they thought they would be well above it when they crossed — they subsequently realized that they'd be quite close, so they changed their heading 30 degrees to the left.

"The Citation [pilot flying] was under the impression that the TCAS equipment was serviceable and reported that at about that time, he received a traffic alert. So the [two] aircraft actually passed with a lateral separation of only 0.5 nm [0.9 km] and a vertical separation of only 164 ft. The U.K. Air Accidents Investigation Branch investigated this incident, and they recommended that London City amend all SIDS to terminate [at] 3,000 ft and [the removal of] all step-climb procedures. I'm pleased to say these recommendations have been implemented."

— WR

risks derived from analysis of worldwide fatal accidents and high-risk occurrences that involved large U.K. air transport airplanes, said Jacky Mills, flight operations policy specialist at the U.K. Civil Aviation Authority (CAA). "Unfortunately, airborne conflict is the only Significant 7 risk for which high-severity incidents have not reduced," she said. "There had been a gradual decline in events [from 2009 until late 2013] … when they started to increase, and the trend [has been] going upward for six to seven months since then. This time last year, we were getting an average of 24 level bust events in a month, but by February 2014, this increased to 36 incidents a month. It's leveled off [as of June] but obviously that's an area of real concern."

Based on CAA questionnaires completed by each flight crew following a U.K. level bust, the most frequent scenario is a correct pilot readback (message verification) followed by an incorrect pilot action. Further work is needed to assess causal factors, but pilots' expectations that ATC would assign a particular level to their aircraft, high workload, distraction and conducting weather-avoidance maneuvers were notable.

"Altimeter-setting errors is the next largest [scenario involved in a level bust] followed by failure to follow the cleared SID [standard instrument departure procedure] and then turbulence," Mills said, pointing out the coincidence between days with significantly increased level busts and low atmospheric pressure causing a large difference relative to the standard sea level pressure setting of 1013 mb (29.92 in hg). "With the transition altitudes in the U.K. being lower than in a lot of countries, this can catch pilots out [unaware] if they are not very quick to change their altimeter setting." Unique procedures — such as stepped climbs in SIDs — and unusually low transition altitudes of 3,000, 5,000 or 6,000 ft in U.K. airspace are being harmonized with other European states, but meanwhile they remain a risk factor.

"The U.K. airspace structure is also particularly intricate with heavy traffic loads sharing limited airspace [see "Breaking Down a Level Bust."]," she said. The CAA has been using Google Earth three-dimensional mapping to identify level bust hotspots based on plotting four years' worth of cleared altitudes vs. actual altitudes for events extracted from 740 mandatory occurrence reports.

CAA safety outreach includes a reminder card for pilots and controllers. "An accurate location of the level bust event [in reports] with the precise name of the SID and/or the runway of departure would really help us," Mills said. "Pilots could help us by pressing [their transponder's] IDENT button to register the location of a particular event. I would also like to encourage reports on … altitude deviations which did not result in a level bust."

Related Priorities

Flying with a malfunctioning transponder — or with the transponder turned off or with its standby mode selected in flight — and controller blind spots each led to a significant number of conflicts between adjacent airplanes, according to Eurocontrol's Safety Improvement Subgroup. These are two of the subgroup's current "Top 5" operational safety priorities, said Antonio Licu, head of the Safety Unit in Eurocontrol's Network Operations Management Division of the Network Management Directorate, joined by Mike Edwards, director, Homefield ATM Safety.

"The controllers get it right 99.9999 percent of the time," Edwards said, noting early insights from the beginning of a multi-year research project. "Minor slips of judgment [or] memory [occur in] probably about one out of every 500 [ATC instructions], but they are the kinds of things that nobody else would even notice. … Errors where there was a major requirement to provide separation are perhaps one in every 25,000. … So it is a small problem but, of course, potentially very significant."

By the term *controller blind spot* Eurocontrol means a situation in which a controller issues a climb or descend instruction, for whatever reason, but fails to observe another aircraft positioned in front of the pilot who received the instruction. Researchers so far have attributed 65 percent of actual events studied to a controller almost exclusively focusing attention on the potential for future conflicts. A group of experts first imagined scenarios conducive to such controller behavior.

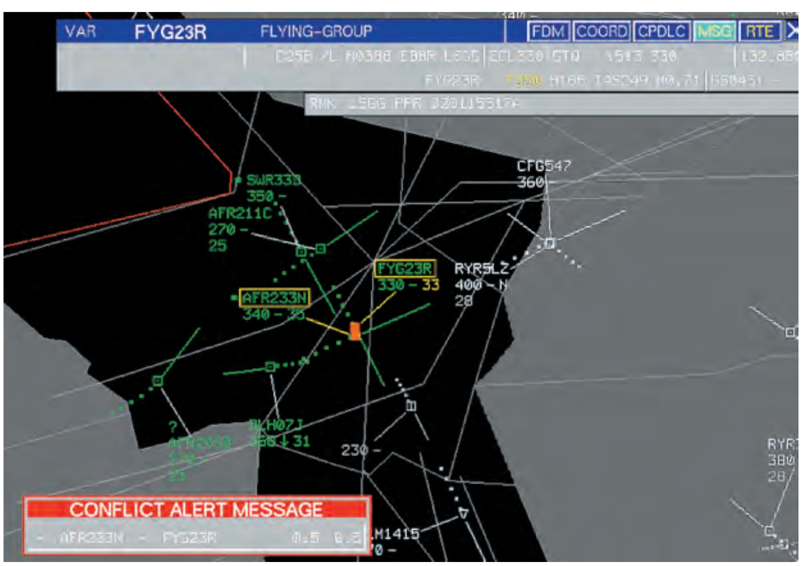
"The first one is *attention grabber* — literally just the controller focusing his attention on something else … without really following the standard pattern of all the things that he should do," Edwards said. "The second is [heavily proceduralized] *constraints.* This is the requirement for an aircraft to leave a sector at a particular level so … [that the controller has] got to get the aircraft to that level. That becomes the primary focus, and he doesn't see the aircraft that's in the way. The third, quite common, is *failure to conflict-detect* when one of the aircraft is not following its flight planned route. … The fourth is *solving a potential conflict,* thinking ahead, but not seeing the one that's right in front. And lastly, [there is a] general sort of … *operational/nonoperational distraction* — talking about staffing or whatever."

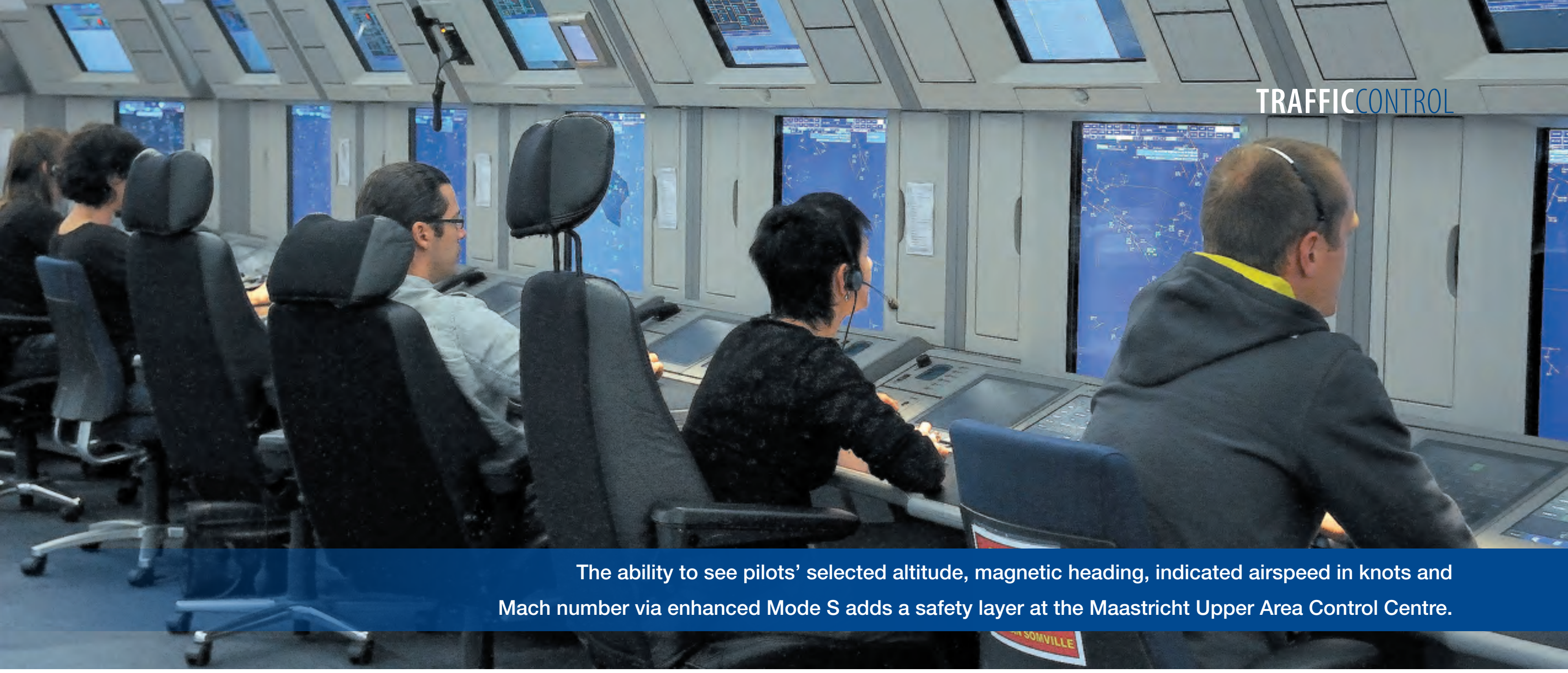
The expert group then looked at actual ATC-error scenarios. Effective risk barriers (safety defenses) observed were standard scanning routines, flight data display systems, proactive colleagues, team resource management, short-term probes querying flight data, separation-alert tools, defensive controlling, efforts at "keeping it simple" and data-block clarity.

"Living in the future — not seeing the [aircraft] right in front of them … not being with the airplanes where they actually are but rather where they're going to be" is related to another controller error called *layered filtering,* in which the controller assumes that the job is done after issuing instructions to the crew of an aircraft in his or her sector, Edwards said. "He's not consciously thinking about that aircraft anymore. … He puts it to the back of his mind and doesn't see it when he needs to," he said.

On the technology side, 60 percent of the events involved ATC flight data displays that either were not updating correctly or were not capable of being updated by the controller. Most involved an aircraft flight crew cleared for direct

The short-term conflict alert system "listens" to pilots' altitude selections through enhanced Mode S and, if mismatched to clearance, stops the typical 10-second "grace period" for pilot response to a clearance, enabling faster controller intervention.





The ability to see pilots' selected altitude, magnetic heading, indicated airspeed in knots and Mach number via enhanced Mode S adds a safety layer at the Maastricht Upper Area Control Centre.

routing. "There may be a need for ANSPs to focus on providing flight data that better supports controllers in potential conflict resolutions," Edwards said.

The technique noted of imagining scenarios and comparing them with actual scenarios was applied to mishandled ATC coordination of aircraft moving between adjacent sectors, including those of other ANSPs. Issues included absent, incomplete or misunderstood coordination; incorrect data entries; premature transfer of an aircraft to the next sector, which precluded further ATC radio communication in case of a conflict (in one-third of events); late transfer of an aircraft after it entered the next sector, which precluded radio communication by the new sector's controller in case of a conflict (in one-third of events); and problems in silent coordination because of flaws in an agreement specifying the procedure.

"Two thirds of such events involved … a failure to correctly apply a standard procedure [and/or a failure] to coordinate," he said. "Separation-predictive tools, airspace incursion tools [and proactive colleagues] could prevent all those if they were deployed and if they were used."

Most disconcerting, he said, was that in 36 percent of airborne conflicts, the executive controller was not talking to the pilot of either closing airplane. "It's almost like the controller's worst nightmare," Edwards said. "The events themselves are so few, I'm pleased to say, [that we're] getting into that difficult area of trying to break down that last little bit of information — and that's a whole new ballgame for us."

ATC Technological Solutions

Europe's ANSPs have been active in sharing their best strategies — including for use of technology — for level-bust risk reduction, said Kris Vermeiren, Eurocontrol operational concepts and validation expert who spoke about the Maastricht Upper Area Control Centre, which is responsible for upper level airspace over Luxembourg, Belgium, Netherlands and northwest Germany.

STCA capability has proved valuable since 1980, he said, but he called the value added by processing transponders' enhanced Mode S data "the best invention since radar."

"For only two years, STCA also has been listening to the pilot-intent [data,] taking into consideration the selected altitude as provided by enhanced Mode S data," Vermeiren said. "This can save valuable seconds to intervene." The extra data — selected flight level, magnetic heading, the indicated speed in knots and Mach number — appear in an extendable label. New color-coded warnings also help controllers to quickly spot discrepancies between pilot actions and their ATC clearances. "Before … it was not guaranteed that you would see all the discrepancies," he added.

The Maastricht center also has eliminated flight control strips, recognizing that controllers have a fast-detection advantage when they can keep their "eyes glued" to the enhanced labels on their displays. A 10-second "grace period" delay between receiving Mode S data and presenting an active alert to the controller allows the pilot time to select the assigned altitude/flight level. Many pilots remain unaware that some controllers now can see these in-flight data in real time, however, he said.

Notes

1. Forum materials include a 16-page report listing 15 safety improvement strategies; findings and recommendations; and basic background, objectives and outcomes of discussions.
2. Sponsoring forum partners were the International Civil Aviation Organization, the International Federation of Air Traffic Controllers' Associations, U.K. CAA, U.K. NATS, IATA, European Cockpit Association and Direction Générale de l'Aviation Civile of France.

BY FRANK JACKMAN

ATSB Report Shows Powerplant Problems Rare

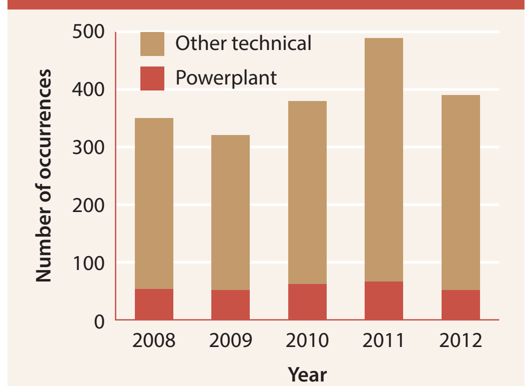
Powerplant problems comprise a relatively small portion of turbofan-powered aircraft technical failures reported to the Australian Transport Safety Bureau (ATSB) between 2008 and 2012, according to an ATSB Transport Safety Report released in June. Of the 20,500 safety occurrences of all types reported to the ATSB by flight crews and operators of Australian civil-registered turbofan-powered aircraft during the five-year period, approximately 1,930 occurrences related to technical failures; of those, only 280 of the technical failures, were classified as powerplant occurrences, the ATSB said in its report (Figure 1).

The report, "Power Plant Failures in Turbofan-Powered Aircraft," is planned to be the first in a series of research investigations examining technical failures reported to ATSB over the five-year period. Other reports in the series will look at airframe and systems issues affecting turbine-powered aircraft, and technical failures involving turboprops, piston-engine fixed-wing aircraft, and piston and turboshaft-powered helicopters, ATSB said.

Under Australia's *Transport Safety Investigation Act and Regulations*, technical issues must be reported to the ATSB if they constitute a transport safety matter, which can include anything that has affected, or has the potential to affect, the safety of an aircraft. Powerplant-related technical issues that occur from the time an aircraft is being prepared for flight until all crew and passengers have disembarked after the flight must be reported when they include: a failure that prevents an aircraft from achieving predicted performance during takeoff or climb; an uncontained or contained engine failure; a malfunction that affects the operation of the aircraft; any technical failure that causes death or serious injury, leads to aircraft control difficulties or seriously affects operation of the aircraft; items that become detached from the aircraft; and a failure that causes fumes, smoke or fire, or leads to crew incapacitation.

During the five-year period reviewed, the number of reported technical failures in turbofan-powered aircraft fluctuated between a

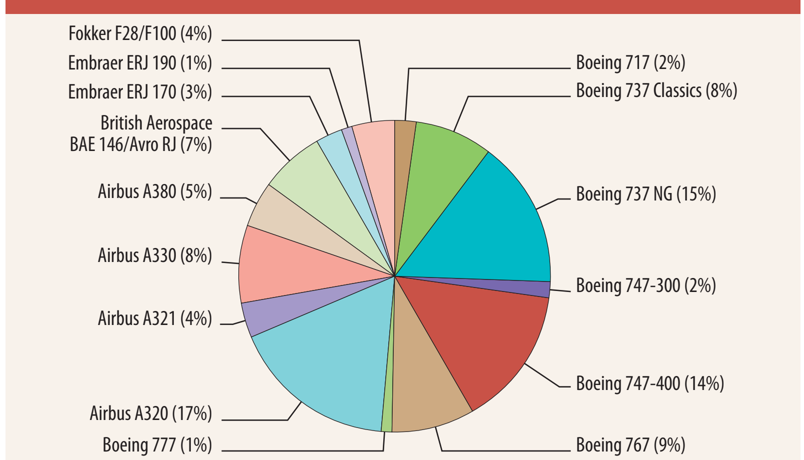
Technical Occurrences Involving Turbofan Aircraft



Source: Australian Transport Safety Bureau

Figure 1

Air Transport High-Capacity Occurrences by Aircraft Type, 2008–2012



Source: Australian Transport Safety Bureau

Figure 2

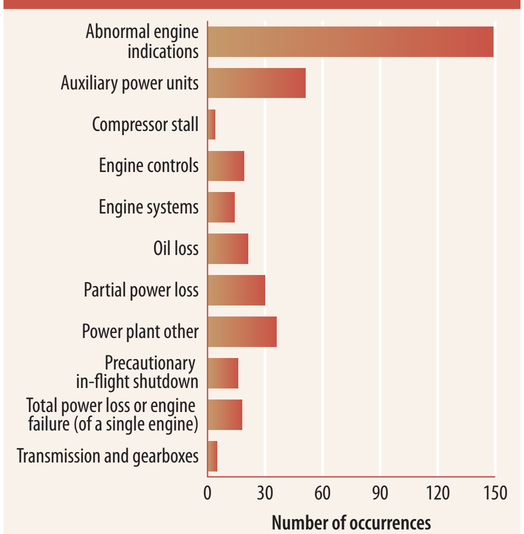
List of Possible Engine/Airframe Combinations in Australian Registered Aircraft

Engine manufacturer	Engine Model	Aircraft
Textron Lycoming	ALF502	British Aerospace BAE 146, Canadair CL-604
Textron Lycoming	LF507	Avro RJ
BMW Rolls Royce Aero Engines	BR700	Boeing 717
General Electric Company	CF34	Embraer ERJ-170, Embraer ERJ-190
General Electric Company	CF6	Airbus A330, Boeing 747, Boeing 767
CFM International, S.A.	CFM56	Boeing 737
Williams International	FJ44-1A	Cessna Citation Jet
General Electric Company	GE90	Boeing 777
Pratt & Whitney Canada	JT15D	Cessna Citation I, V
Rolls Royce Ltd	RB211 (-524 D4, -524 G2, -524H36)	Boeing 747, Boeing 767
Rolls Royce Ltd	Tay 620	Fokker F28/F100
Rolls Royce Ltd	Tay 650	Fokker F28/F100
Rolls Royce Ltd	Trent 900	Airbus A380
Honeywell International Inc.	TFE731	Learjet 31, Cessna Citation III
International Aero Engines	V2500	Airbus A320, Airbus A321

Source: Australian Transport Safety Bureau

Table 1

Powerplant-Related Occurrence Events



Source: Australian Transport Safety Bureau

Figure 3

high of 489 in 2011 and a low of 321 in 2009. The powerplant occurrences remained fairly constant over the period, ranging from 52 to 66 occurrences per year, or 13 to 15 percent of the annual total of technical occurrences.

The powerplant-related occurrences originate from six operation groups: air transport high capacity, which comprise aircraft certified as having a maximum capacity of more than 38 seats, or having a maximum payload capability that exceeds 4,200 kg (9,259 lb); air transport low capacity (38 seats or fewer, or payload capability of 4,200 kg or below); charter operation, which involves the carriage of passengers and/or cargo on non-scheduled flights for trade or commerce; aerial work; flying training; and private.

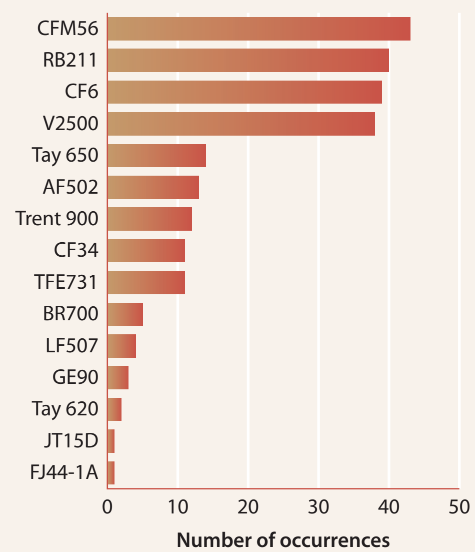
The vast majority (91.4 percent or 256) of the 280 powerplant-related occurrences reported during 2008–2012 originated from high-capacity aircraft. Figure 2 shows how those 256 occurrences break down by aircraft type. The Airbus A320, the Boeing 737 Next Generation (-700 and -800 series) and the Boeing 747-400 accounted for a combined 46 percent of the occurrences, followed by the Boeing 767 at 9 percent, and the Airbus A330 and 737 Classics (-300s and -400s), both at 8 percent.

The turbofan-powered aircraft fleet operating in Australia is varied and represents a number of different possible airframe and engine combinations. For example, variants of the Rolls-Royce RB211 are found on both the Boeing 747 and 767, and variants of the General Electric CF6 are found on both of those airframes, as well as on the Airbus A330 (Table 1).

For the purposes of the study, ATSB categorized the powerplant-related technical failures into one or more of 11 types of occurrence events (Figure 3). The most common type of event (53 percent of the total) related to abnormal engine indications. Reported abnormal engine indications related to any abnormal engine instrument readings, such as engine power output or temperature, as well as engine overspeed or over-torque warnings. Also falling into this category were any general reports of engine problems or observations of abnormal sights or sounds by a crewmember, such as smoke or fumes in the cabin or cockpit, or excessive engine vibration. ATSB said that while many abnormal engine indications can be insignificant or even spurious, 36 did result in air-returns, and 34 of those necessitated a shutdown of the affected engine.

Failures related to auxiliary power units (APUs) were the next most prevalent with 51 occurrences of 18 percent of the total. APUs are not part of the propulsion system on an aircraft; they are turbines and have components,

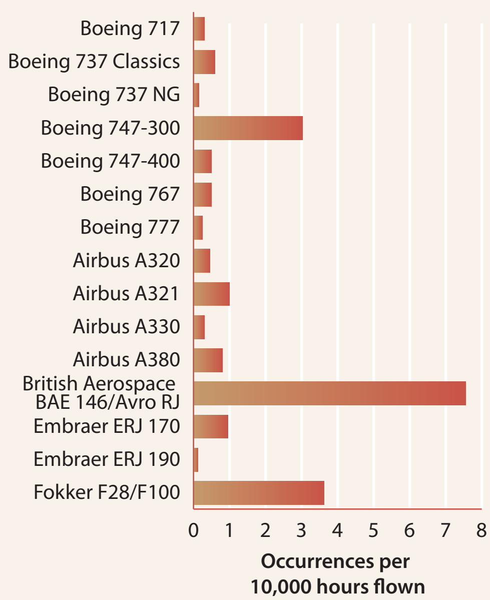
Number of Powerplant Occurrences by Engine Model



Source: Australian Transport Safety Bureau

Figure 4

Rate of Powerplant Occurrences by Aircraft Model



Source: Australian Transport Safety Bureau

Figure 5

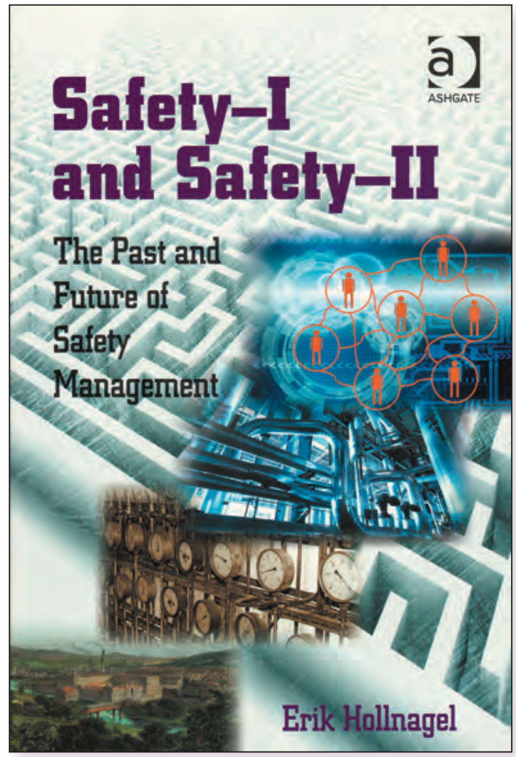
operating temperatures/pressures and failure mechanisms that are similar to turbines used for propulsion. The most common fault associated with APUs was smoke and/or fumes in the cockpit or the cabin, typically as a result of a contamination of the air conditioning as a result of an APU oil leak. These kind of events accounted for 29, or 57 percent, of the 51 APU events, two of which resulted in air-returns.

A total of 18 total power loss/engine failures were reported to ATSB during the study period. Two were the result of fuel starvation in cases with sufficient fuel on board that didn't reach the engine. Both cases were the result of inadvertent selections of the fuel controls. One of the events resulted in an air-return, and in the other case, the fault was recognized, the engine was restarted, and the flight continued. Of the 16 other engine failures, four occurred at start-up, two during takeoff (with both resulting in rejected takeoffs), and 10 in flight. Four of the in-flight shutdowns resulted in air-returns and three in diversions. Two of the occurrences were uncontained engine failures.

ATSB broke down the data into occurrence by engine model (Figure 4), but removed the APU occurrences. The data in Figure 4 do not take into account fleet size or hours flown and do not represent a rate of occurrences. Figure 5, however, shows the rate of powerplant occurrences by aircraft model per 10,000 hours flown. ATSB stressed that the exposure data are expressed in airframe flight hours and not engine hours, and do not take into account the number of engines per aircraft. The 747-300s and -400s, the Airbus A380 and the BAE 146/Avro RJ are four-engine airplanes, and the others are two-engine airplanes. Also, hours flown were not available for the aircraft undertaking charter operations, namely the Learjet 45, 36 and 35A; the IAI 1124; the Canadair CL-604; the Raytheon 400A; Cessna 560 and 525; and Hawker 900XP, so those aircraft are excluded from Figure 5. APUs are included in the rate dataset because it is based on airframe hours flown.

Over the five-year period, the BAE 146/Avro RJ had a rate of occurrences of 7.55 per 10,000 hours flown, which is more than twice as high as any other aircraft in the dataset. The next closest was the Fokker F28/F100, with a rate of 3.63 occurrences per 10,000 hours flown, and the 747 Classics (-300 variant), with a rate of 3.02 per 10,000 hours flown. The ATSB cautioned that the different aircraft models are operated by a wide variety of operators and that higher rates of occurrences could be a result of a better safety-reporting culture.

Ninety-eight percent of the 280 powerplant-related events were classified as low-risk occurrences indicating a low-risk outcome or no accident outcome, four were classified as medium risk, two as high risk and one as very high risk, although none of them resulted in injury to passengers or crew. The very high risk occurrence was Qantas Flight 32, an Airbus A380 bound for Australia from Singapore. One of the Rolls Royce Trent 900 engines suffered an uncontained failure that resulted in significant structural and systems damage (*ASW*, 9/13, p. 10).



BY RICK DARBY

Is there an alternative to studying accidents and incidents?

Right Flight

BOOKS

Work-As-Done

Safety–I and Safety–II: The Past and Future of Safety Management

Hollnagel, Erik. Farnham, Surrey, England, and Burlington, Vermont, U.S.: Ashgate, 2014. 200 pp. Figures, tables, glossary, index. Hardcover, paperback, ebook PDF, ePUB PDF.

Hollnagel, professor at the University of Southern Denmark, argues that it is time for a new strategy in safety management. He distinguishes the new process, which he calls Safety–II, from the traditional one that he names Safety–I.

Here is how he defines the two:

- Safety–I: "Safety is the condition where the number of adverse outcomes (accidents/incidents/near misses) is as low as possible. Safety–I is achieved by trying to make sure that things do not go wrong, either by eliminating the causes of malfunctions and hazards, or by containing their effects."
- Safety–II: "Safety is a condition where the number of successful outcomes is as high as possible. It is the ability to succeed under varying conditions. Safety–II is achieved by trying to make sure that things go right, rather than by preventing them from going wrong."

Safety–I, Hollnagel says, has prevailed in risk management since people started pursuing safety in a disciplined way. He discusses several phases of development.

The Three Ages

In what he calls the *First Age*, "the dominant threats to safety came from the technology that was used, both in the sense that the technology … itself was clunky and unreliable, and in the sense that people had not learned how systematically to analyse and guard against the risks. The main concern was to find the technical means to safeguard machinery, to stop explosions and to prevent structures from collapsing." This prevailed roughly from the beginning of the Industrial Revolution period in the late 18th century through World War II, and for some years afterward.

"The feeling of having mastered the sources of risks so that the safety of industrial systems could be effectively managed was rather abruptly shattered by the disaster at the Three Mile Island nuclear power plant [in central Pennsylvania, U.S.] on 28 March 1979," Hollnagel says. This led to what he calls the *Second Age*, which was marked by the study of a new risk factor — human operators.

While a step forward in some ways, human factors research too often led to another misguided solution, namely, writing the operator out of safety management as much as possible. "In the general view, humans came to be seen as failure-prone and unreliable, and so as a weak link in system safety," Hollnagel says. "The 'obvious' solution was to reduce the role of humans by replacing them by automation, or to limit the variability of human performance by requiring strict compliance." As will be seen in the discussion of Safety–II, it is precisely this variability that is now said to offer a key to further risk reduction.

Belief in the supreme efficacy of human factors design and procedures "lasted barely a decade." Several events, including the space shuttle *Challenger* disaster, the explosion of a nuclear reactor at the Chernobyl power plant in the former Soviet Union, and the taxi-phase collision of two Boeing 747 airliners at Tenerife, Canary Islands, "made it clear that the organisation had to be considered over and above the human factor.

"One consequence was that safety management systems have become a focus for development and research, and even lend their name to the *Third Age*: 'the age of safety management.'"

Meaningless Questions?

Hollnagel is not convinced that the attempts to counter the safety threats revealed in the Second Age and Third Age are adequate. He says, "While we can have some confidence in the answers when the safety of technical systems is assessed, we cannot feel the same way when the safety of the human factor or the organisation is assessed. The reason for that is simply that the questions are less meaningful than for technical systems, if not outright meaningless."

He argues that although technical issues can be analyzed, and defenses against technical failure can be reasonably precise, the same cannot be said about people, still less about organizations.

Safety–I has led to huge success in risk reduction. There is no debate about the steep decline in commercial aviation accident rates, particularly since the beginning of the jet era, or the remarkably good safety record that continues in most regions of the world. Hollnagel does not suggest, however, that progress is being held back by Safety–I practices. He says, "While Safety–II represents an approach to safety that in many ways differs from Safety–I, it is important to emphasise that they represent two complementary views of safety rather than two incompatible or conflicting views."

Greater Complexity

Safety management has vastly expanded in complexity since the early industrial age, when the goal was mainly to see that equipment such as railroad engines did not blow up or otherwise harm people and property. The safety focus now includes operational systems and their interrelationships, maintenance, automation, organizations and human psycho-physiology. As a result, Hollnagel says, in Safety–I, a split inevitably arises between what is called *Work-As-Imagined* (by designers, management and others removed from the task; that is at the so-called "blunt end") and *Work-As-Done* (by maintenance technicians, pilots and others at the "sharp end" of an airplane).

"Seen from the sharp end, it is no surprise that descriptions based on Work-As-Imagined cannot be used in practice and that actual work is different from prescribed work," Hollnagel says. "But this difference is not at all easy to see from the blunt end, partly because it is seen from the outside and from a distance, partly because there is a considerable delay and partly because any data that might exist have been filtered through several organisational layers. …

"We know from a long experience that it is possible to design even extremely complicated [technical] systems in every detail and to make certain that they work, by rigourously ensuring that every component functions according to specifications. Machines, furthermore, do not need to adjust their functioning because we take great care to ensure that their working environment is kept stable and that the operating conditions stay within narrow limits."

Against Variability

People at the sharp end are assumed to be equally capable of performing Work-As-Imagined — and to be motivated by encouragement or threat. Hollnagel says, "According to this way of looking at the world, the logical consequence is to reduce or eliminate performance variability either by standardising work … or by constraining all kinds of performance variability so that efficiency can be maintained and malfunctions or failures avoided."

Hollnagel distinguishes between the terms *tractable* and *intractable* systems:

"A system is tractable if the principles of its functioning are known, if descriptions of it are simple and with few details and, most importantly, if it does not change while it is being described. … A system is intractable if the principles of its functioning are only partly known (or, in extreme cases, completely unknown), if descriptions of it are elaborate with many details and if systems change before descriptions can be completed." The more complicated a system, the more intractable, and the less its aspects involving humans can be fully specified. Some situations can only be resolved by variability determined ad hoc by humans.

The Unexpected

For these reasons, and other issues discussed in the book, Hollnagel concludes that "people always have to adjust work to the actual conditions, which on the whole differ from what was expected — and many times significantly so. This is the performance adjustment or the performance variability that is at the core of Safety–II."

Whereas in Safety–I, the human factor was considered at best an unfortunate necessity and at worst a threat to be damped down, Safety–II acknowledges the following:

- "Systems are not flawless and people must learn to identify and overcome design flaws and functional glitches;
- "People are able to recognise the actual demands and can adjust their performance accordingly;
- "When procedures must be applied, people can interpret and apply them to match the conditions; [and,]
- "People can detect and correct when something goes wrong or when it is about to go wrong, and hence intervene before the situation seriously worsens."

Sensible Adjustments

All these are examples of things that go right, but they usually go unnoticed, even by the people directly involved. Hollnagel says, "It is essential not to wait for something bad to happen, but to try to understand what actually takes place in situations where nothing out of the ordinary seems to take place. Safety–I assumes that things go well because people simply follow the procedures and Work-As-Imagined. Safety–II assumes that things go well because people always make what they consider sensible adjustments to cope with current and future situational demands. Finding out what those adjustments are and trying to learn from them can be more important than finding the causes of infrequent adverse outcomes!"

Every successful operation, such as a safe flight, involves countless actions that go right. But how can those actions be studied? Many national safety authorities scarcely have the resources to investigate accidents and incidents adequately, let alone investigate what seem like non-events.

Hollnagel suggests several techniques, primarily interviewing the people at the sharp end. He believes that this is feasible and likely to bear fruit because asking individuals about their successful procedures avoids any of their tendency toward defensiveness. Interviews can include questions like these, he says:

- "What do you do if something unexpected happens? For example, an interruption, a new urgent task, an unexpected change of conditions [or] a resource that is missing?
- "Is your work usually routine or does it require a lot of improvisation?
- "What do you do if information is missing, or you cannot get hold of certain people? [and,]
- "How often do you change the way you work?"

"A Safety–II perspective will … require methods and techniques on [their] own to be able to look at things that go right, to be able to analyse how things work and to be able to manage performance variability rather than just constraining it," Hollnagel says.

'It is essential not to wait for something bad to happen, but to try to understand what actually takes place in situations where nothing out of the ordinary seems to take place'

Slip of the Tongue

A trainee controller's miscommunication placed two A319s in close proximity.

BY MARK LACAGNINA

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

JETS

Radar Was Inoperative

Airbus A319s. No damage. One minor injury.

An unreliable air traffic control (ATC) radar system necessitating the use of ATC procedures that were unfamiliar to some controllers, as well as thunderstorms prompting course deviations were among the factors that created a high-stress, high-workload environment in which a trainee controller issued instructions that placed converging A319s at the same altitude near the Basel Mulhouse airport in Switzerland the evening of June 29, 2010.

A collision was averted when the flight crews complied with resolution advisories (RAs) generated by their traffic-alert and collision avoidance systems (TCAS). However, a cabin crewmember was slightly injured during abrupt maneuvering by the crew of one aircraft.

The English translation of the final report on the serious loss of ATC separation, published by the Bureau d'Enquêtes et d'Analyses (BEA) in May, said that the radar system problems had originated a few months earlier, when the Basel Mulhouse approach control facility was assigned the responsibility for coordinating air traffic in additional airspace transferred from an adjacent facility.

The central processing units in the Basel Mulhouse facility's computers did not have sufficient capacity to handle the additional traffic. The result was serious display malfunctions that led to the radar system being declared inoperative three days before the incident.

"For three days, air traffic control at Basel Mulhouse had been based on 'procedures' [which were not defined in the report] because of uncertainty about the reliability of the radar display," the report said.

The trainee controller and his instructor had not previously used procedural control methods. And, although the radar system had been declared inoperative, they had their radar display on when the incident occurred. "The simultaneous use of procedural control and an uncertain radar image increased the workload of the controllers and may have helped create confusion about the positions of the aircraft," the report said.

One of the A319s, of French registry, had departed from Runway 15 at the Basel Mulhouse airport for a scheduled flight to Paris and was climbing westbound. The other aircraft, of Swiss registry, was inbound on a flight from Palma, Spain, and was southwest of the airport, descending to land.

The flight crews of both aircraft had requested and received clearance to deviate around thunderstorm cells. The A319s were on converging courses, and the trainee controller had planned to resolve the conflict by instructing the crew of the French aircraft to stop their climb at 10,000 ft and to tell the crew of the Swiss aircraft to stop their descent at 11,000 ft. However, when he issued the instructions within a period of one minute, he inadvertently assigned both aircraft the same altitude: 11,000 ft.

The report said that the trainee believed he had assigned 10,000 ft to the crew of the French aircraft. He did not detect the error when the crew read back the faulty clearance. The trainee's instructor, who was handling additional duties at the time, also did not detect the error.

Several factors complicated the situation. The French aircraft was climbing at 3,000 fpm, which the report called "excessive." In addition, TCAS traffic advisories were generated aboard both aircraft at the same time a short-term conflict alert was generated in the approach control facility.

The trainee reacted to the alert by telling the crew of the French aircraft to stop climbing at 10,000 ft. However, the aircraft already was climbing through 10,600 ft when the pilot flying (PF) disengaged the autopilot and applied a nose-down pitch input in response to the trainee's instruction. Simultaneously, a TCAS "maintain vertical speed" RA was generated aboard the French aircraft. The PF changed from a nose-down to a nose-up pitch control application.

While this was happening, a "monitor vertical speed" RA was generated aboard the Swiss aircraft. The report said that this RA prompted the crew not to climb. However, the PF inadvertently applied a nose-up pitch input while disengaging the autopilot, then applied a nose-down input, changing the pitch attitude from 5.3 degrees nose-up to 5.6 degrees nose-down.

A series of coordinated, corrective RAs then were generated aboard both aircraft. The French aircraft crew received a "descend, descend now" RA while the Swiss aircraft crew received a "climb, climb now" RA.

The report said that the flight control inputs by the pilot of the Swiss aircraft were more abrupt than necessary. "During these manoeuvres, the vertical load factor recorded on [the Swiss aircraft] oscillated between – 0.19 g and 2.04 g," the report said. "The minor injury to [the] cabin crewmember was due to the abrupt manoeuvres."

The A319s came within 0.29 nm (0.53 km) horizontally and 1,760 ft vertically of each other before the flight crews received TCAS "clear of conflict" messages.

The BEA concluded that "the loss of separation that characterized this serious incident was due to an error in speech by the trainee controller … and the non-detection of that error by the instructor controller."

The investigation led to several recommendations, including that the French ATC authority issue clear instructions on the use of radar imagery when it is known to be unreliable or when procedural control is in use, and that the International Civil Aviation Organization study the feasibility of incorporating TCAS resolution maneuvering in aircraft autoflight systems.

Fire Traced to Loose Nut

Embraer 190-100. Minor damage. Eight minor injuries.

A fire erupted in the no. 1 engine cowling as the airplane was rolling out on landing at Nassau (Bahamas) International Airport on Sept. 3, 2009. The flight crew shut down the engine and pulled the fire handle.

Eight of the 84 passengers sustained minor injuries during the subsequent emergency evacuation, said the report by the U.S. National Transportation Safety Board (NTSB).

Investigators traced the fire to a B-nut that had been cross-threaded on a fuel-supply coupling during the original assembly of the General Electric CF34 engine. The improperly seated nut prevented engagement of a metal seal in the high-pressure fitting, leaving an O-ring to act as the primary seal until it failed, causing fuel to be sprayed into the cowling.

Anomalies Prompt Diversion

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

Shortly after departing from Exeter (England) Airport for a cargo flight to Belgium the night of Sept. 19, 2013, the flight crew saw the "Freight Door Unlocked" warning light illuminate and then heard loud noises emanating from the main cargo area.

"The pilots suspected that the two indications were connected and that the aircraft had suffered structural damage," said the report by the U.K. Air Accidents Investigation Branch (AAIB). They declared an emergency, diverted to London Gatwick and landed without further incident.

Investigators found that the anomalies were not related. The warning light was triggered by a freight door latch proximity switch that was out of adjustment. "The noises were probably caused by a flexible duct in the air conditioning bay becoming detached," the report said.

TURBOPROPS

'Inadequate Route Planning'

Beech King Air C90GT. Substantial damage. One fatality.

After deplaning passengers at Nemacolin Airport in Farmington, Pennsylvania, U.S., the morning of June 22, 2012, the pilot departed for a visual flight rules (VFR) positioning flight to Morgantown (West Virginia) Municipal Airport, about 20 nm (37 km) southwest, to refuel the airplane.

"The pilot had chosen a direct flight route near rising terrain and obstructions within a designated mountainous area at his selected cruise altitude of 3,100 feet, which was below the published maximum elevation figure of 3,500 feet depicted on the VFR sectional chart for the area," the NTSB report said.

The King Air was at 3,100 ft when the pilot established radio communication with an approach control facility. The controller assigned a transponder code and advised the pilot that the airplane was in radar contact.

The King Air was about 9 nm (17 km) from the Morgantown airport when the pilot descended to 3,000 ft. Shortly thereafter, the airplane struck a 3,089-ft communications tower and descended to the ground.

"Aeronautical charts found on board the airplane depicted the tower hazard, so the pilot should have had some awareness of the tower's presence," the report said, noting that the collision might have occurred in instrument meteorological conditions. A witness near the accident site described the weather as "cloudy with lightning and thunder."

Investigators found that the terrain-inhibit mode for the airplane's enhanced ground-proximity warning system (EGPWS) had been engaged. This prevented the system from generating any visual or aural warnings.

NTSB concluded that the pilot's "inadequate preflight route planning" was the probable cause of the accident and that contributing factors were his improper use of the EGPWS and the controller's "failure to issue a safety alert regarding the proximity of the tower."

EFIS Goes Blank on Go-Around

Jetstream 41. No damage. No injuries.

The aircraft was on final approach to Wick (Scotland) Airport the morning of Sept. 24, 2013, when the flight crew lost visual reference with the runway. "During the missed approach, momentary blanking of the electronic flight instrument system (EFIS) displays occurred, but the standby instruments continued to operate normally," the AAIB report said.

During the second approach, the copilot's displays went blank, and the crew decided to divert to Aberdeen Airport, where the weather was better. "During the diversion, VHF communication difficulties were experienced, but the aircraft landed without further incident," the report said.

Investigators found that the avionics problems had been caused by unrelated faults. The blanking of the copilot's EFIS displays and the VHF communications difficulties were caused by a loss of electrical power to the right essential bus bar. The transient blanking of the pilot's displays was caused by the failure of transzorbs, which are installed in the windshield heating system and designed to protect avionics equipment from static.

'Don't Pitch Up'

Cessna 208B. Destroyed. One fatality.
Cessna 207. Substantial damage. No injuries.

The Caravan and the 207, operated by different charter companies, departed about the same time from neighboring remote villages for positioning flights on similar routes to Bethel, Alaska, U.S., the afternoon of Sept. 2, 2011.

"While en route, the Cessna 207 pilot talked with the Cessna 208B pilot on a prearranged radio frequency, and the two agreed to meet up in flight for the return to their home airport," the NTSB report said.

The 207 pilot told investigators that she was in cruise flight at 1,200 ft when the Caravan flew into position on the left side. "Then, unexpectedly and unannounced, the pilot of the Cessna 208B maneuvered his airplane above and over the top of her airplane," the report said.

The 207 pilot radioed that she could not see the Caravan and was concerned about its position. The Caravan pilot replied, "Whatever you do, don't pitch up." She then saw the Caravan's wings and cockpit on the right side of the 207 and felt an impact with the right wing.

The Caravan descended steeply in a nearly vertical nose-down pitch attitude and struck terrain near Nightmute, Alaska. The 207 pilot was unable to maintain level flight and conducted an emergency landing on the tundra.

Investigators determined that the Caravan's vertical and horizontal stabilizers had separated from the airplane after striking the 207's wing.

PISTON AIRPLANES

Engines Starved for Fuel

Cessna 421B. Substantial damage. No injuries.

About 10 minutes after departing from Fairhope, Alabama, U.S., for a VFR flight to Selma the afternoon of Sept. 29, 2012, the pilot repositioned the fuel selectors for both engines from the main tanks to the auxiliary tanks. He told investigators that later, when he initiated a descent from 4,500 ft, the right engine started to "cough and lose power."

The pilot said that he repositioned the fuel selector to the main tank, but the engine lost power completely. He was unable to restart the engine. "The pilot did not select the [auxiliary] fuel boost pump to 'low' per the checklist, and as a result the system may have provided too much fuel to the engine for a restart," the NTSB report said.

About two minutes after feathering the propeller on the right engine, the left engine began to lose power. "The airplane continued under partial power on the left engine for about six minutes, when the pilot realized that the airplane had descended down to 800 feet," the report said.

The pilot decided to land the airplane on a dirt road about 6 nm (11 km) from the Selma airport. After touchdown, the 421 crossed a bridge, clipped a tree and came to a stop in a cotton field with substantial damage to the right wing. The pilot and his three passengers escaped injury.

NTSB concluded that the probable cause of the accident was "the pilot's improper fuel management, which resulted in a total loss of engine power on the right engine and a partial loss of engine power on the left engine due to fuel starvation."

Brake Fails on Landing

Piper PA-31P. Substantial damage. No injuries.

The pilot said that shortly after the Pressurized Navajo touched down on the runway at Doylestown (Pennsylvania, U.S.) Airport the morning of Sept. 8, 2013, the left brake pedal "went to the floor."

"He tried pumping the brakes to regain left braking action but was unsuccessful," the NTSB report said. The landing gear collapsed when the Navajo veered off the runway and came to a stop in a grassy area. The pilot, alone in the airplane, was not hurt.

"Post-accident examination confirmed that the left brake was inoperative and revealed a small hydraulic fluid leak at the shaft of the parking brake valve in the pressurized section of the cabin," the report said. "Air likely entered the brake line at the area of the leak while the cabin was pressurized, rendering the left brake inoperative."

'Classic VMC Stall'

Piper Aztec. Destroyed. One serious injury.

The Aztec was about 100 ft off the ground on takeoff from Truckee-Tahoe (California, U.S.) Airport the morning of Sept. 21, 2011, when the left engine lost power. The pilot told investigators that the airplane rolled left and entered a "classic V_{MC} stall." (V_{MC} is defined as the minimum control speed with the critical engine inoperative.)

The Aztec descended onto an airport parking ramp and was destroyed by fire. The pilot sustained serious injuries.

Investigators found that particles of paint clogging a fuel nozzle likely caused the engine problem. "However, even though the left engine may have been running rough and not producing full takeoff power, the right engine was operating properly, and if the pilot had maintained airspeed at or above the airplane's minimum controllable airspeed, he should have been able to maintain control," the report said.

HELICOPTERS

Somatogravic Illusion

Bell 407. Substantial damage. One fatality.

The pilot was engaged in transporting passengers across a lake near Abingdon, Virginia, U.S., on Aug. 24, 2012. Night had fallen when a boater saw the helicopter deplane passengers and then lift off, turn toward the lake and descend along an embankment. The witness said that the landing light was not on when the skids subsequently contacted the water and the helicopter flipped over.

"Security camera video footage revealed that the pilot had successfully conducted this low-level, rapid-acceleration takeoff profile several times during the day, when visual spatial references were plentiful," the NTSB report said. "The pilot's decision to attempt such a takeoff at night without the aid of ambient light or the use of helicopter lights denied him the visual spatial references needed to assure safe terrain and obstacle avoidance."

The report said that the pilot likely experienced a type of spatial disorientation called somatogravic illusion, in which acceleration is perceived as an increasing nose-up pitch attitude and can result in nose-down pitch inputs.

Rotor Blade Separates

Aerospatiale AS355 F1. Substantial damage. One fatality.

The helicopter struck terrain in West Windsor, New Jersey, U.S., after a main rotor blade separated during a positioning flight the afternoon of Sept. 15, 2012. Investigators found that the upper rod end on the fore/aft servo had disconnected due to severely worn threads in its fitting.

The NTSB report said that the helicopter operator's "incorrect maintenance procedures and inadequate inspections" were contributing factors in the accident. Among the maintenance discrepancies was the use of a corrosion-inhibiting compound, rather than the grease specified in the maintenance manual, and an incorrect torque value during installation of the upper rod ends in the servos.

In addition, the inspection procedures provided by the helicopter manufacturer were found to be insufficient. "The 600-hour inspection called for checking the radial play of the end bearings," the report said. "However, there were no instructions to specifically check the threads of the servo end fitting or the torque of the rod end nut."

Crash During Bird Avoidance

Bell 206L-3. Substantial damage. Two minor injuries.

The LongRanger was engaged in a public use flight to check a radiological monitoring system the afternoon of Sept. 7, 2013. The helicopter was in cruise flight about 300 ft above ground level near Amistad, New Mexico, U.S., when the pilot saw several large birds ahead.

The pilot initiated a steep right turn to avoid the birds. "He subsequently noted an increase in main rotor speed and adjusted accordingly," the NTSB report said. "The pilot rolled out on a reciprocal heading, leveled the helicopter and began to slow down. He noticed that the descent rate was not decreasing even though appropriate control inputs had been made."

The helicopter touched down hard, bounced and came to a stop about 300 ft (91 m) from the touchdown point.

Preliminary Reports, June 2014

Date	Location	Aircraft Type	Aircraft Damage	Injuries
June 1	Middletown, Ohio, U.S.	de Havilland DHC-6-200	minor	1 fatal
The Twin Otter was parked with its engines operating, waiting for skydivers to board, when an employee of a fixed base operator was struck by a propeller while walking toward the cockpit.				
June 2	Bahía Solano, Colombia	Beech King Air B200	substantial	3 serious
The King Air was landed gear-up on a prairie after losing power on takeoff.				
June 3	Moscow, Russia	Ilyushin 96-300	destroyed	none
A fire that started in the cockpit eventually consumed the IL-96, which was in storage at Sheremetyevo Airport.				
June 4	Newark, New Jersey, U.S.	Boeing 777-300	substantial	none
The 777 was parked at a gate and was being prepared for a flight with 335 people aboard when it was struck by a catering truck that became wedged beneath the rear fuselage.				
June 8	Olsztyn, Poland	Antonov 2T	substantial	2 serious
The biplane was returning from a skydiving flight when it struck trees on approach.				
June 11	Gulf of Mexico	Bell 206-L4	destroyed	2 fatal
A witness saw the LongRanger spin several times before it descended into the water on approach to an offshore platform.				
June 13	Aruanã, Brazil	Cessna 525	substantial	7 minor
The nose gear collapsed when the CitationJet overran the 1,280-m (4,200-ft) runway on landing.				
June 13	White Plains, New York, U.S.	Piper PA-46-500TP	destroyed	1 fatal
The Meridian struck trees and crashed near a house shortly after taking off in instrument meteorological conditions including 1/4 mi (400 m) visibility in fog and a 200-ft overcast.				
June 15	Fresno, California, U.S.	Lockheed SP-2H	substantial	2 none
The Neptune tanker was returning to Porterville after a fire-fighting mission when the hydraulic system failed. The flight crew diverted to Fresno and manually extended the landing gear. However, the nose gear collapsed on landing.				
June 17	Lydenburg, South Africa	Cessna 208	destroyed	3 fatal, 2 serious
The Caravan was on a training mission for the South African air force when it crashed in the Misty Mountains.				
June 17	Sula, Montana, U.S.	Grumman G-21A	destroyed	1 fatality
A witness at a ski resort located in a mountain pass at 7,000 ft said that visibility was about 1/4 mi (400 m) in snow when she saw the Goose flying just above the trees and then enter a spin and descend vertically into a parking lot.				
June 18	Huntsville, Alabama, U.S.	IAI 1124A Westwind	destroyed	3 fatal
Visual meteorological conditions prevailed when the Westwind entered a steep right turn about 100 ft above the ground on takeoff and descended into a cotton field.				
June 19	Egegik, Alaska, U.S.	Cessna 208B	substantial	1 minor
The Caravan struck a container while taking off from a beach near Egegik.				
June 23	Elpe, Germany	Learjet 35A	destroyed	2 fatal
The Learjet was participating in a training mission with two Luftwaffe Eurofighter Typhoons when it collided with one of the fighters and crashed out of control. The damaged fighter was landed without further incident.				
June 23	Texarkana, Texas, U.S.	Airbus AS350-B2	substantial	4 none
The helicopter was on an emergency medical services flight and was nearing the destination at 1,000 ft when the pilot received a warning about excessive rotor speed. The main rotor blades struck the tail boom when the pilot conducted an autorotative landing in a farm field.				
June 24	Peshawar, Pakistan	Airbus A310-324ET	NA	1 fatal, 2 serious
The A310, inbound on a scheduled flight from Saudi Arabia, was struck by ground fire while landing in Peshawar. A passenger was killed and two cabin crewmembers were injured by bullets.				
June 26	Creve Coeur, Missouri, U.S.	Cessna 414	destroyed	1 minor
The pilot reported a problem with the cargo door shortly after takeoff and turned back to the airport. The 414 stalled and crashed in a wooded area after an engine apparently lost power during the subsequent approach.				

NA = not available

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

Selected Smoke, Fire and Fumes Events, January–March 2014

<table>
<tr><th>Date</th><th>Flight Phase</th><th>Airport</th><th>Classification</th><th>Subclassification</th><th>Model</th><th>Operator</th></tr>
<tr><td>Jan. 4</td><td>Cruise</td><td>—</td><td>Buffets/galleys</td><td>Smoke</td><td>Boeing 737</td><td>Delta Air Lines</td></tr>
<tr><td colspan="7">During flight, smoke and fumes were reported in the cabin and cockpit, and the aircraft was diverted. Maintenance found the forward galley oven with a burned electrical odor, replaced the oven and performed an operations check. The aircraft was approved for return to service.</td></tr>
<tr><td>Jan. 8</td><td>Cruise</td><td>Detroit, Michigan, U.S. (DTW)</td><td>Hydraulic reservoir, main</td><td>Smoke</td><td>Boeing 737</td><td>Southwest Airlines</td></tr>
<tr><td colspan="7">The flight crew declared an emergency on departure, after a flight attendant reported smoke and fumes in the cabin. The crew performed quick reference handbook (QRH) procedures, and the smoke dissipated after the pack was selected “OFF.” The airplane returned to DTW. Maintenance removed and replaced the hydraulic reservoir, air pressure module and left coalescent bag in accordance with the maintenance manual.</td></tr>
<tr><td>Jan. 10</td><td>Cruise</td><td>—</td><td>Humidity control system</td><td>Smoke</td><td>Airbus A300</td><td>Federal Express</td></tr>
<tr><td colspan="7">Smoke appeared in the cockpit with no electronic centralized aircraft monitoring (ECAM) indications, and the aircraft was diverted. During touchdown, an ECAM warning for avionics smoke illuminated and then extinguished. Maintenance personnel found excessive deicing fluid in the main wheel well while accessing the air conditioning pack bay and cleaned the wheel well. Maintenance inspected left and right pack coalescer bags, found both very dirty and replaced them in accordance with the maintenance manual. They ran both engines with both packs operating for 35 minutes with no noticeable fumes or odors noted. They completed the avionics smoke detection system check in accordance with the maintenance manual; the check was normal.</td></tr>
<tr><td>Jan. 11</td><td>Cruise</td><td>—</td><td>Cabin cooling system</td><td>Smoke</td><td>Embraer 145LR</td><td>Atlantic Southeast Airlines</td></tr>
<tr><td colspan="7">The crew reported smoke in the cockpit and cabin during flight. Passengers heard metallic grinding near Row 11 and smelled an electrical burning odor. The aircraft was diverted and landed without incident. Maintenance removed and replaced the no. 2 air cycle machine (ACM). It was operations tested with no defects, and the aircraft was approved for return to service.</td></tr>
<tr><td>Jan. 31</td><td>Cruise</td><td>—</td><td>Cabin cooling system</td><td>Smoke</td><td>Embraer 145LR</td><td>Atlantic Southeast Airlines</td></tr>
<tr><td colspan="7">During flight, the crew reported smoke in the cockpit. The aircraft landed without incident. Maintenance inspected and removed and replaced the no. 2 ACM. It was operations tested with no defects, and the aircraft was approved for return to service.</td></tr>
<tr><td>Feb. 6</td><td>Cruise</td><td>—</td><td>Air distribution system</td><td>Smoke</td><td>Bombardier CL600</td><td>American Eagle Airlines</td></tr>
<tr><td colspan="7">During cruise, a flight attendant reported black dust on the no. 1b overhead bin. This dust later became apparent on the cockpit windshield. The cabin and cockpit had a carbon-like smell. After landing, the dust was noticeable on nearly every overhead bin. Maintenance removed and replaced both recirculation fan filter cartridges in accordance with the maintenance manual. During ground runs, no black dust was noted.</td></tr>
<tr><td>Feb. 7</td><td>Cruise</td><td>—</td><td>Central display</td><td>Smoke</td><td>Embraer 145XR</td><td>Atlantic Southeast Airlines</td></tr>
<tr><td colspan="7">The flight was diverted after an odor of electrical smoke was detected in the cockpit and the no. 4 multifunction display (MFD) went blank. The odor subsided after the MFD circuit breaker was pulled. Maintenance removed and replaced the first officer’s MFD. The operations check was normal, and the aircraft was approved for return to service.</td></tr>
<tr><td>Feb. 8</td><td>Climb</td><td>—</td><td>Air distribution system</td><td>Smoke</td><td>Bombardier CL600</td><td>Sky West Airlines</td></tr>
<tr><td colspan="7">After takeoff, smoke filled more than half the cockpit. The pilots donned oxygen masks, declared an emergency and landed the aircraft uneventfully. Smoke filled the aft cabin but cleared after landing. The crew performed QRH procedures. An operational test of both packs was conducted in accordance with the aircraft maintenance manual, and no smoke was noticed in the cockpit or cabin.</td></tr>
<tr><td>Feb. 18</td><td>Cruise</td><td>Anchorage, Alaska, U.S. (ANC)</td><td>Air distribution system</td><td>Smoke</td><td>Boeing 777</td><td>American Airlines</td></tr>
<tr><td colspan="7">During flight from Dallas/Fort Worth (DFW) to Tokyo Narita (NRT), the crew reported a smoke smell in the cockpit. The lower left cabin recirculation fan overheated. The circuit breaker was pulled, and the flight was diverted to ANC, where it landed without incident. The lower left recirculation fan was placarded inoperative in accordance with the minimum equipment list and the flight continued to its destination. Maintenance replaced the left recirculation fan. The system was normal during ground checks.</td></tr>
<tr><td>Feb. 26</td><td>Climb</td><td>—</td><td>Engine (turbine/turboprop)</td><td>Smoke</td><td>Embraer 145XR</td><td>Atlantic Southeast Airlines</td></tr>
<tr><td colspan="7">The flight crew reported smoke in the cockpit immediately after takeoff and performed an air turnback. Maintenance inspected the aircraft and determined it had been deiced prior to takeoff. Deicing fluid was found in both engine inlets. Maintenance removed fluid and ran engines and packs with no smoke noted.</td></tr>
<tr><td>Feb. 26</td><td>Climb</td><td>—</td><td>Air distribution system</td><td>Smoke</td><td>Boeing 757</td><td>United Airlines</td></tr>
<tr><td colspan="7">Smoke was seen in the cockpit and cabin at climb power with the left pack running. Turning off the pack, in accordance with a service tip from the maintenance manual, stopped the smoke.</td></tr>
<tr><td>March 2</td><td>Descent</td><td>—</td><td>Cabin cooling system</td><td>Smoke</td><td>Embraer 190</td><td>JetBlue Airways</td></tr>
<tr><td colspan="7">The flight crew declared an emergency due to smoke in the cabin. The smoke dissipated when the cabin in-flight entertainment (IFE) system was turned off as the flight crew conducted QRH cabin smoke procedures. Debris was found on the heat exchanger, and the right ACM and dual heat exchanger were removed and replaced. Operations and leak checks were normal.</td></tr>
<tr><td>March 3</td><td>Climb</td><td>—</td><td>Engine (turbine/turboprop)</td><td>Smoke</td><td>Bombardier CL600</td><td>Air Wisconsin Airlines</td></tr>
<tr><td colspan="7">The cabin and cockpit filled with smoke and fumes after bleeds were transferred from the auxiliary power units (APUs) to the engines. The smoke and fumes abated when the bleeds were returned to the APUs. The flight crew contacted maintenance and confirmed this was the first flight after compressor cleaning. They suspected that residual chemicals from the compressor wash caused the smoke and fumes. The crew did not declare an emergency but returned to Philadelphia, Pennsylvania, U.S., for an uneventful landing. No smoke or odor were noted during a 20-minute engine run.</td></tr>
<tr><td>March 17</td><td>Climb</td><td>St. Louis, Missouri, U.S. (STL)</td><td>Heating system</td><td>Smoke</td><td>McDonnell Douglas MD-80</td><td>American Airlines</td></tr>
<tr><td colspan="7">The flight crew reported smoke and fumes in the forward cabin. They declared an emergency and returned to STL, landing without incident. An aircraft inspection found that the forward cargo compartment heater had failed. The repair was deferred in accordance with the minimum equipment list, and the flight continued to its destination. The forward cargo heater was subsequently replaced and the system was normal during a ground check.</td></tr>
</table>

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