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High Stakes in
Language Proficiency

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Message From the President

Looking Ahead: A New Format for FSF Publications

I am pleased to announce that Flight Safety Foundation (FSF) publications will be undergoing their most thorough upgrading in the Foundation's history. The format will change to offer greater convenience, usefulness and eye appeal. It's a transformation we are excited about, as we believe you will be.

Briefly, here is what you can look forward to.

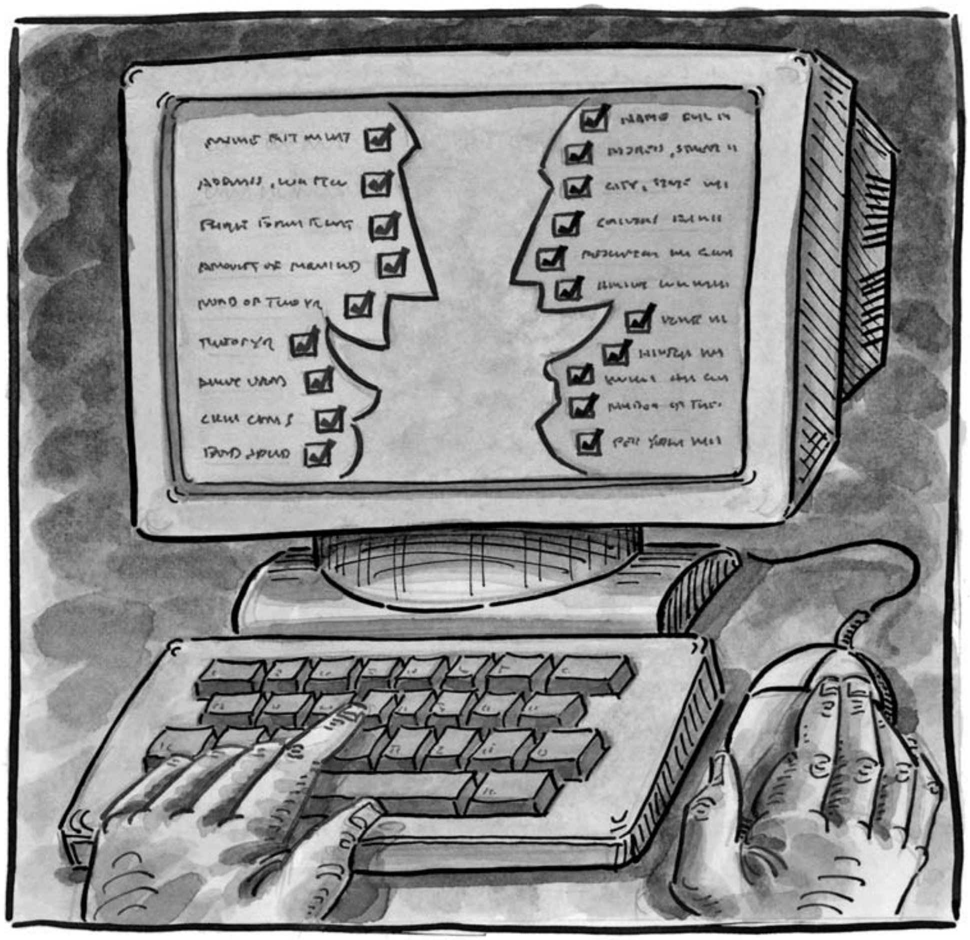
The seven current FSF publications (two monthly, five bimonthly) will be replaced by a single monthly publication called *Aviation Safety World*. We will continue to cover the same topics that we always have, as well as new ones, in a single package.

Aviation Safety World will provide a completely upgraded, four-color design. The new look will feature color photographs and charts; contemporary, more varied typography; and glossy, magazine-type paper.

We have committed ourselves to this change because the importance of the information and insight we bring you deserves a worthy format. Your Board of Governors and officers of Flight Safety Foundation recognize that this encompassing transformation cannot be brought about in gradual increments. The transition will require a major effort, which will entail placing our publications "on hold" following this issue as we concentrate on bringing you a new and better product. The launch of *Aviation Safety World* is scheduled for the July issue.

Although I must ask your indulgence for the pause, I am confident that you will find *Aviation Safety World* to be worth the wait.

Stuart Matthews
President and CEO
Flight Safety Foundation



High Stakes in Language Proficiency

In an effort to reduce accidents involving communication deficiencies, ICAO is requiring pilots, controllers and aeronautical station operators involved in international operations to be tested for their ability to speak and understand English. At stake are careers, industry investment in training and testing — and safety.

— FSF EDITORIAL STAFF

Concern about fatal accidents involving inadequate proficiency in the use and comprehension of English in pilot-controller communication has prompted the International Civil Aviation Organization (ICAO) to establish a baseline for language proficiency and requirements for testing. Current requirements are for initial testing to be completed by March 2008.

With the new standards has come the designation of English as the language of international pilot-controller communication.

"English has long played the role of a de facto common language for international aviation," ICAO said.[1] "The new provisions formalize that role."

English is the native language or a widely used national language in about 60 countries and is a second language in many more countries, ICAO said. People who speak English as a second language or as a "foreign language" outnumber those who speak English as a first language.

Nevertheless, the designation of English for international radiotelephony (the transmission of speech by radio) has not been without controversy.

"Because language is so closely tied to our sense of national and cultural identity, people are naturally

"Utilization of standard terminology, although established and encouraged, is not enforced."

sensitive to issues of language use and policy," said Elizabeth Mathews, a specialist in applied linguistics and leader of an international group — the Proficiency Requirements in Common English Study Group (PRICESG) — that developed English language proficiency standards for ICAO.[2] "In the case of international aviation, the need for a single, common language is universally acknowledged. The choice of English for international aviation communications is more a tool for enhancing safety than anything else."

There may be some changes to the new language proficiency requirements. ICAO currently is surveying its member states on the need to "adjust" some of the standards and to extend the deadline for testing.

"The deadline of 2008 was driven by legal requirements," said Paul Lamy, chief of ICAO's Flight Safety Section.[3] "Our language specialists believe that it does not provide enough time for operators in some parts of the world, so there may be some tweaking. We don't expect any major change."

The PRICESG will reconvene in April 2006 to study the survey results and determine whether to make further recommendations to ICAO.

Safety Implications

Flight Safety Foundation (FSF) is among the organizations that have called for the development of minimum performance standards for English language proficiency. The Foundation's recommendations were generated by findings from research in the 1990s on controlled flight into terrain (CFIT) and approach-and-landing accidents.

"There are documented occurrences of controllers and flight crews using nonstandard phraseology," the FSF Approach-and-landing Accident Reduction (ALAR) Task Force said in 1998.[4] "In several occurrences involving non-native English speakers, the language issues exacerbated the poor communication between the flight crews and ATC [air traffic control]. Several occurrences involved ambiguous communication of an on-board emergency by a flight crew, without an ATC request for clarification/verification of the ambiguous transmission.

"The safety implications that may result from pilot-controller misunderstandings are well documented. Some of these problems are related to the nature of English-language ATC applications, which involve radio exchanges of often highly formatted communications by individuals whose native language may not be English. Though ICAO recognizes other languages, English is most widely used by ATC communications and is a de facto standard. Other problems may result from lack of adequate air traffic controller English-language skills and nonstandard use of certain terminology. Because of the sensitive political [aspects] and cultural aspects of this situation, the international aviation community has not adopted international standards or recommendations for English-language skill levels. Utilization of standard terminology, although established and encouraged, is not enforced."

High Priority

In 1998, India formally called on the ICAO Assembly to take action to ensure that pilots and controllers "are proficient in conducting and comprehending radiotelephony communications in the English language."

In its proposed resolution, India specifically cited the 1995 CFIT accident in Cali, Colombia, and the 1996 midair collision near Delhi as having indicated "lack of proficiency and comprehension of the English language by flight crews and air traffic controllers" (see "Lost in Translation," page 3).

The ICAO Assembly adopted, and assigned high priority to, the resolution proposed by India. In 2000, the PRICESG was established to identify deficiencies in ICAO standards and recommended practices (SARPs) affecting voice communications in international flight operations, develop minimum English-language proficiency requirements and develop standardized testing requirements and procedures.[5]

Based on the study group's recommendations, ICAO in 2003 adopted several amendments to Annex 1 (personnel licensing), Annex 6 (international

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Lost in Translation

A ground collision, a fuel-exhaustion accident, a controlled flight into terrain (CFIT) accident and a midair collision were cited by the International Civil Aviation Organization (ICAO) as examples of fatal air carrier accidents involving inadequate English-language proficiency.[1]

"What these seemingly different types of accidents had in common was that, in each one, accident investigators found that insufficient English-language proficiency on the part of the flight crew or a controller had played a contributing role in the chain of events leading to the accident," ICAO said. "In addition to these high-profile accidents, multiple incidents and near misses as a result of language problems are reported annually, instigating a review of communication procedures and standards worldwide."

'We Are Now at Takeoff'

The ground collision cited by ICAO involved two Boeing 747s at Los Rodeos Airport in Tenerife, Canary Islands, Spain, on March 27, 1977.[2]

Visibility was reduced substantially by fog when a controller issued departure instructions to the flight crew of a KLM 747 that was lined up for takeoff on the runway. The first officer, whose native language was Dutch, read back the controller's instructions and said, "We are now at takeoff."

The controller, whose native language was Spanish, did not understand that the first officer's transmission was meant to convey that the KLM crew were conducting a takeoff. Instead, the controller believed that the KLM crew were maintaining the airplane's position on the runway and awaiting takeoff clearance.

The controller acknowledged the first officer's transmission by saying, "OK. Stand by for takeoff. I will call you."

At the same time, the flight crew of a Pan American 747 radioed, "We are still taxiing down the runway." The simultaneous transmissions by the controller and the Pan Am crew resulted in a whistling sound on the radio frequency that lasted three seconds.

The controller told the Pan Am crew to report clear of the runway, and the Pan Am crew acknowledged the instruction. Soon thereafter, the flight engineer aboard the KLM airplane asked his colleagues if the Pan Am airplane was clear of the runway.

The KLM captain replied, "Oh, yes."

The KLM airplane was being rotated for takeoff when it struck the Pan Am airplane. A total of 583 people were killed in the collision.

In its final report, the Spanish government said that the fundamental cause of the accident was that the KLM captain "took off without clearance; did not obey the 'stand by for takeoff' [instruction] from the tower; did not interrupt takeoff when Pan Am reported that they were still on the runway; [and,] in reply to the flight engineer's query as to whether the Pan Am [airplane] had already left the runway, replied emphatically in the affirmative."

'I Think We Need Priority'

The flight crew's failure to clearly convey a critical low-fuel situation to air traffic control (ATC) played a role in the Jan. 25, 1990, fuel-exhaustion accident involving an Avianca Airlines Boeing 707 at Cove Neck, New York, U.S.[3]

Because of adverse weather conditions in the northeastern United States, the crew had been instructed to hold three times, for a total of about one hour and 17 minutes, during their scheduled flight from Bogotá, Colombia, to John F. Kennedy International Airport (JFK), New York.

The airplane was in the third holding pattern about 39 nautical miles (72 kilometers) south of JFK when the controller extended the time at which the crew could expect further clearance. The first officer said, "Ah, well, I think we need priority."

The center controller said, "Roger. How long can you hold and what is your alternate [airport]?"

In separate radio transmissions, the first officer said, "We'll be able to hold about five minutes," and that their alternate airport "was Boston, but we can't do it now … we run out of fuel now."

The controller issued a vector to sequence the 707 with traffic on an extended left downwind leg for Runway 22L. As the airplane neared the airport, however, the controller told the crew to conduct a 360-degree turn for spacing.

The airplane encountered wind shear as the crew conducted the instrument landing system (ILS) approach to Runway 22L. The runway environment was not in sight when the airplane reached decision height, and the captain called for a missed approach.

After reporting the missed approach, the first officer told the approach controller, "We're running out of fuel, sir."

The controller said, "I'm going to bring you about fifteen miles [28 kilometers] northeast and turn you back on for the approach. Is that fine with you and your fuel?"

"I guess so. Thank you very much," the first officer said. A few minutes later, he requested, and received, a vector to the final approach course.

Although the captain had told the first officer several times to declare an emergency, the first officer had not declared an emergency. The first officer believed that his request for priority handling had been understood by ATC as a request for emergency handling.

All four engines flamed out, and the airplane struck terrain about 16 nautical miles (30 kilometers) from the airport. Of the 158 occupants, 73 were killed and 81 were seriously injured.

In its final report, the U.S. National Transportation Safety Board said that the probable causes of the accident were "the failure of the flight crew to adequately manage the airplane's fuel load and their failure to communicate an emergency fuel situation to [ATC] before fuel exhaustion occurred."

'Go Tulua?'

In the CFIT accident, a Spanish-speaking controller's inability to probe for information from an English-speaking flight crew about seemingly illogical clearance requests and position reports resulted in the controller not realizing that the flight crew were confused about their position and flying the airplane near mountainous terrain north of Cali, Colombia, on Dec. 20, 1995.[4]

The crew of the American Airlines Boeing 757 were transitioning from cruise flight to a nonprecision instrument approach to Runway 19 at the Cali airport. En route from Miami, Florida, U.S., the airplane was being flown in a nonradar ATC environment and in nighttime visual meteorological conditions (VMC).

The controller issued the following clearance: "Cleared to VOR DME [very-high-frequency omnidirectional radio/distance measuring equipment] approach runway one niner, Rozo number one arrival. Report Tulua VOR."

The Tulua VOR was about 34 nautical miles (63 kilometers) north of the airport. The Rozo nondirectional beacon (NDB) was 2.6 nautical miles (4.8 kilometers) north of the airport. The crew discussed which navigational aid they should fly to next. The captain (the pilot not flying) then asked the controller for clearance to navigate directly to the Rozo NDB "and then do the Rozo arrival."

The controller replied, "Affirmative. Take the Rozo one and runway one niner. The wind is calm." The controller then told the crew to report Tulua and the 21-nautical-mile (39-kilometer) DME fix south of Tulua.

As the captain acknowledged the instructions, the airplane passed over the Tulua VOR and then turned left to an easterly heading. The crew did not realize that the airplane had passed over the VOR because the waypoints entered in the flight management system (FMS) had been erased when they had attempted to enter the identifier for the Rozo NDB. In addition, instead of entering the identifier for the Rozo NDB, the crew had entered the identifier for the Romeo NDB, which was about 132 nautical miles (244 kilometers) east.

The airplane remained on the easterly heading, toward the Romeo NDB, about one minute. The captain then told the first officer to turn right and proceed to the Cali VOR, which was about 10 nautical miles (19 kilometers) south of the airport.

The captain told the controller that the airplane was 38 nautical miles (70 kilometers) from the Cali VOR and asked, "You want us to go Tulua and then do the Rozo … to runway one nine?"

The controller told investigators that the crew's query about flying directly to the Tulua VOR made no sense because their reported position 38 nautical miles from the Cali VOR indicated that the airplane was south of the Tulua VOR.

"He said that his fluency in non-aviation English was limited and he could not ask them to elaborate on the request," said the final report by the Aeronáutica Civil of the Republic of Colombia. "The controller further stated that, had the pilots been Spanish-speaking, he would have told them that their request made little sense and that it was illogical and incongruent. He said that because of limitations in his command of English, he was unable to convey these thoughts to the crew."

Instead, the controller restated the clearance and requested the 757's position relative to the Cali VOR as follows: "You can [unintelligible word] landed runway one niner. You can use runway one niner. What is your altitude and the DME from Cali?"

The captain said that the airplane was 37 nautical miles (69 kilometers) from the Cali VOR and at 10,000 feet.

The crew were discussing the programming of the FMS when the controller again asked for the airplane's altitude. The captain replied that the airplane was at 9,000 feet. The controller asked for a position report, but the captain did not respond.

Five seconds after the controller's request for a position report, the crew received a ground-proximity warning system (GPWS) terrain warning. They applied full power and raised the airplane's nose, but did not retract the spoilers. The airplane struck a mountain ridge at about 8,900 feet. Of the 163 occupants, 159 were killed and four were seriously injured.

Aeronáutica Civil said that the probable causes of the accident were:

- "The flight crew's failure to adequately plan and execute the approach to Runway 19 [at the Cali airport] and their inadequate use of automation;
- "Failure of the flight crew to discontinue the approach into Cali, despite numerous cues alerting them of the inadvisability of continuing the approach;
- "The lack of situational awareness of the flight crew regarding vertical navigation, proximity to terrain and the relative location of critical radio aids; [and,]
- "Failure of the flight crew to revert to basic radio navigation at the time when the FMS-assisted navigation became confusing and demanded an excessive workload in a critical phase of flight."

'Flight Level 140'

A flight crew's misunderstanding of an altitude clearance played a role in the midair collision of a Saudi Arabian Airlines Boeing 747 and a Kazakh Airways Ilyushin IL-76T that occurred near Delhi, India, on Nov. 12, 1996. Nighttime VMC prevailed, but both airplanes were being flown in clouds when the collision occurred. A report by Airclaims said that neither airplane was equipped with a collision-avoidance system.[5]

The 747 flight crew were conducting a standard instrument departure procedure after takeoff from Delhi. The crew told ATC that they were near their assigned altitude, Flight Level (FL) 140 (approximately 14,000 feet), and requested clearance to continue the climb. The controller told the crew to maintain FL 140.

The IL-76T crew were conducting a descent on a reciprocal heading to land at Delhi. The controller told the crew to maintain FL 150 and advised that an outbound airplane was at FL 140. The radio operator aboard the IL-76T asked the controller for the other airplane's position. The controller said, "Traffic is eight miles now, flight level one four zero."

The captain, first officer, flight engineer and navigator aboard the IL-76T reportedly misunderstood the controller's instructions to mean that they had been cleared to descend to FL 140. The radio operator observed that the airplane was descending below FL 150 and shouted to his colleagues, "Keep at one five zero. Don't descend." The pilots were initiating a climb when the collision occurred. The 37 occupants of the IL-76T and the 312 occupants of the 747 were killed.

"The failure of most of the IL-76 crew to correctly understand the situation was attributed to their lack of a working knowledge of English," the Airclaims report said. ■

— FSF Editorial Staff

Notes

1. International Civil Aviation Organization (ICAO). Document 9835. *Manual on the Implementation of ICAO Language Proficiency Requirements*. 2004.

2. Government of Spain. *Aircraft Collision: Boeing 747, PH-BUF, of KLM and Boeing 747, N737PA, of Pan Am at Los Rodeos (Tenerife) on March 27, 1977*. English version, July 12, 1978.

3. U.S. National Transportation Safety Board. *Aircraft Accident Report: Avianca, The Airline of Colombia; Boeing 707-321B, HK 2016; Fuel Exhaustion; Cove Neck, New York; January 25, 1990*. NTSB/AAR-91/04.

4. Aeronáutica Civil of the Republic of Colombia. *Controlled Flight Into Terrain; American Airlines Flight 965; Boeing 757-223, N651AA; Near Cali, Colombia; December 20, 1995*.

5. Airclaims. *World Aircraft Accident Summary*. Issue 139: A96:37.

operations), Annex 10 (aeronautical telecommunications) and Annex 11 (air traffic services).

In 2004, ICAO published Document 9835, *Manual on the Implementation of ICAO Language Proficiency Requirements*, to provide guidance for "training managers of civil aviation administrations, the airline industry and training organizations."

SARPs related to the use of language in radio communications are shown in Appendix A (page 11). ICAO's Lamy noted the importance of understanding that many of the standards currently are in force. For example, Annex 1 (paragraphs 1.2.9.1 and 1.2.9.2) requires pilots, controllers and aeronautical station operators to "demonstrate the ability to speak and understand the language used for radiotelephony communications."

Among the principal changes made in 2003 was the adoption of formal criteria for determining language proficiency. A new paragraph (1.2.9.4) requires pilots, controllers and aeronautical station operators by March 5, 2008, to demonstrate the ability to meet specific criteria contained in a language proficiency rating scale (Table A-1, page 13).

The language proficiency rating scale includes six levels: Pre-elementary (Level 1); Elementary (Level 2); Preoperational (Level 3); Operational (Level 4); Extended (Level 5); and Expert (Level 6). Each level includes criteria for pronunciation, structure, vocabulary, fluency, comprehension and interactions.

Minimum Proficiency

Pilots, controllers and aeronautical station operators who conduct international operations will be required to demonstrate at least Level 4 proficiency, which is characterized by the language proficiency rating scale as follows:

- Pronunciation — "Pronunciation, stress, rhythm and intonation are influenced by the first language or regional variation and frequently interfere with ease of understanding."
- Structure — "Basic grammatical structures and sentence patterns are used creatively and are usually well-controlled. Errors may occur, particularly in unusual or unexpected circumstances, but rarely interfere with meaning."
- Vocabulary — "Vocabulary range and accuracy are usually sufficient to communicate effectively on common, concrete and work-related topics. Can often paraphrase successfully when lacking vocabulary in unusual or unexpected circumstances."
- Fluency — "Produces stretches of language at an appropriate tempo. There may be occasional loss of fluency on transition from rehearsed or formulaic speech to spontaneous interaction, but this does not prevent effective communication. Can make limited use of discourse markers or connectors. Fillers are not distracting."
- Comprehension — "Comprehension is mostly accurate on common, concrete and work-related topics when the accent or variety used is sufficiently intelligible for an international community of users. When the speaker is confronted with a linguistic or situational complication or an unexpected turn of events, comprehension may be slower or require clarification strategies."
- Interactions — "Responses are usually immediate, appropriate and

ICAO is developing a tool on compact disc that will include speech samples.

informative. Initiates and maintains exchanges even when dealing with an unexpected turn of events. Deals adequately with apparent misunderstandings by checking, confirming or clarifying."

Speech Samples

Lamy pointed out that the language proficiency rating scale was developed by linguists on the PRICESG for use by linguists who will conduct the English language training and testing. He said that the criteria might be difficult to understand by people without a background in linguistics.

To help airline and air traffic service managers, pilots, controllers, aeronautical station operators and others understand the criteria, ICAO is developing a tool on compact disc (CD) that will include speech samples corresponding to Level 3, Level 4 and Level 5 proficiency. Lamy said that the CD should be available for purchase from ICAO at the end of March 2006.

"People will be able to hear the differences," he said. "Together with that, there will be explanations of why they should be rated at the respective levels, taking into account the criteria for fluency, structure, pronunciation and so on. The speech samples and explanations will show everybody what we mean when we say Level 4."

Overall Ability

The appendix to Annex 1 includes "holistic descriptors" that prescribe the requirements for overall ability to understand and speak the language. According to the holistic descriptors, pilots, controllers and aeronautical station operators must demonstrate the ability to:

- "Communicate effectively in voice-only (telephone/radiotelephone) and in face-to-face situations." (Document 9835 says that voice-only communication is more difficult than face-to-face communication because the speaker cannot use facial expressions, gestures or body language to help deliver the message.)

- "Communicate on common, concrete and work-related topics with accuracy and clarity."

- "Use appropriate communicative strategies to exchange messages and to recognize and resolve misunderstandings (e.g., to check, confirm or clarify information) in a general or work-related context." (One example of a communicative strategy is to rephrase or paraphrase a message when the speaker determines that the recipient did not understand the message. "Sometimes, the phraseology 'say again' should be understood as a request for clarification rather than repetition," Document 9835 says.)

- "Handle successfully and with relative ease the linguistic challenges presented by a complication or unexpected turn of events that occurs within the context of a routine work situation or communicative task with which they are otherwise familiar." (In other words, pilots, controllers and aeronautical station operators must have sufficient language proficiency to prevent a communication breakdown when something unexpected occurs.)

- "Use a dialect or accent which is intelligible to the aeronautical community." (Although instructors and evaluators must use their experience and judgment to determine what constitutes a strong regional dialect or accent that might be unintelligible, Document 9835 points out that people have the capability to modify their speech patterns and often do so to make themselves understood.)

Level 6 proficiency is the goal of the new SARPs. Paragraph 1.2.9.6 of Annex 1 requires that pilots, controllers and aeronautical station operators who demonstrate Level 4 proficiency or Level 5 proficiency be retested until they demonstrate Level 6 proficiency.

Retesting schedules will be established by the individual states. ICAO has recommended that those who demonstrate Level 4 proficiency be retested every three years and that those who demonstrate Level 5 proficiency be retested every six years. Retesting is not recommended after Level 6 proficiency is demonstrated.

Standard Phraseology

Before 2003, the use of "standard phraseology" was required by the SARPs. Annex 10 (paragraph 5.1.1.1) now requires the use of "ICAO phraseology or plain language when standardized phraseology cannot serve an intended transmission."

ICAO phraseology is published in Annex 10, Volume II, and in Chapter 12 of PANS–ATM (*Procedures for Air Navigation Services–Air Traffic Management*). ICAO phraseology differs in some instances from standard phraseologies published by member states that have filed differences with ICAO. For example, using ICAO phraseology, a controller would clear a flight crew to "line up and wait" on the runway for takeoff clearance; using U.S. Federal Aviation Administration (FAA) phraseology, the controller would clear the crew to taxi into "position and hold" on the runway.

Brian Day, an ICAO technical officer and member of the PRICESG, said that inconsistencies in the standard phraseologies used by individual states can cause confusion and undermine safety.[6]

"Civil aviation administrations in a number of states have complained about foreign flight crews using terminology that their controllers did not understand, a situation that has caused confusion and led to incidents," Day said.

Document 9835 says that universal use of ICAO standard phraseology might require "reorientation" by pilots and controllers who have become accustomed to other phraseologies.

"Those controllers and pilots so affected need simply consider the efforts required by non-native English-speaking counterparts to acquire English-language proficiency at the ICAO Operational Level 4 in order to understand the value of conforming to ICAO phraseologies exclusively," the document says.

Plain Language

Although standardized phraseology is adequate for routine radio communication and for some nonroutine situations and emergency situations, it cannot be applied in all situations.

"Language proficiency limited to memorized phraseologies is inadequate, and a need exists to use a breadth of language beyond the narrow subset of ICAO phraseologies," ICAO said.[7]

Mathews said that the need to understand and speak "plain English" can arise quickly in nonroutine or emergency situations.

"Such circumstances may require that a controller or pilot reach beyond the scope of standardized phraseologies," she said.[8] "In addition, a pilot or controller not infrequently encounters the need to clarify communications, to explore intent or to negotiate for meaning. All such linguistic demands might lie beyond the abilities of an individual whose language proficiency is limited to the specific realm of standardized phraseologies."

Examples of plain language are a pilot's report that "there is a deer on the runway," and a controller's instruction to "report passing the barn with the orange roof."

Which Language?

Annex 10 (paragraph 5.2.1.2.1) was amended to *require*, rather than recommend, that radio communication "be conducted in the language normally used by the station on the ground." Another change added the words *or in the English language*.

"Although the heaviest training and testing burden will fall in the area of English-as-a-second-language use, the language proficiency requirements apply to any language used in international aeronautical radiotelephony communications," says Document 9835.

> **"Language proficiency limited to memorized phraseologies is inadequate."**

As the result of an additional amendment, controllers and aeronautical station operators providing international services must communicate in English when requested to do so by a flight crew.

"As an example, Spanish is spoken as the national language in states from Mexico through Central America and throughout much of South America," Document 9835 says. "For international flights in such states, Spanish or English can be used, but English must be made available. International pilots flying in this airspace may use either English or Spanish."

Onus on Operators

Paragraphs added to Annex 6 and Annex 11 in 2003 require international commercial aircraft operators to ensure that their pilots meet the new language proficiency standards and that air traffic service providers ensure that their controllers meet the standards.

With these requirements comes the responsibility of aircraft operators and air traffic service providers to develop training and testing procedures. Elizabeth Mathews said she agrees that the 2008 testing deadline is aggressive and requires a serious and concerted effort, but she noted that the deadline was imposed upon ICAO by its own articles, which require that new licensing standards become applicable five years after they are adopted.

"Because of that, ICAO set standards for an industry that does not have an infrastructure to develop English-language proficiency," she said.[9] "Tests are being developed, but there is no accreditation vehicle in place to determine whether the tests will be suitable."

"ICAO set standards for an industry that does not have an infrastructure to develop English-language proficiency."

Existing English-language proficiency tests, such as TOEFL (Test of English as a Foreign Language), are not suitable because they are designed to gauge comprehension (i.e., listening, not speaking) and are not based on the criteria in the ICAO language proficiency rating scale.

Mathews said that about a dozen companies — including her own company, Aviation English Services (AES) — currently are developing training programs and testing programs to help the industry meet the ICAO requirements.

Berlitz, for example, is developing programs that will be available at its 450 language centers worldwide and on its Internet site for airlines that are members of the International Air Transport Association.

At press time, however, only one testing program actually existed — Eurocontrol's updated version of the Proficiency in English Language for Air Traffic Controllers (PELA) test, which originally was developed in 1994 to test student controllers.

Adrian Enright, project leader at the Eurocontrol Institute of Air Navigation Services and a member of the PRICESG, said that the PELA test complies with ICAO's Level 4 criteria.[10]

The PELA test, which is administered by English-language instructors and ATC instructors who have completed a three-day training course, has four parts:

- The first part evaluates the candidate's listening ability by requiring the candidate to write specific information derived from recorded pilot-controller communications;

- The second part evaluates the candidate's ability to respond orally to recorded messages and requests from pilots;

- The third part evaluates the candidate's ability to interact orally by using a trained controller to play the role of a pilot encountering an unusual situation and the role of an ATC supervisor; and,

- The fourth part, which is required by some Eurocontrol states, evaluates the candidate's ability to read typical ATC documents written in English.

Proficiency Takes Time

While Document 9835 says that 100 hours to 200 hours of instruction will be required to effect any *measurable* improvement in language proficiency, Mathews estimates that, depending on a non-native speaker's starting level of English proficiency, 200 hours to 800 hours of instruction typically will be required to meet the Level 4 requirements.

Mathews said that the new English-language proficiency requirements are going to "make or break the careers" of pilots and controllers involved in international operations.

Beyond career consequences, "the economic repercussions on airlines or air traffic service providers could be severe if pilots and controllers are denied a license to operate internationally because of noncompliance with the ICAO language proficiency requirements," says Document 9835.

Mathews said that the industry cannot afford training and testing that do not work.

"Training and testing that are too difficult will threaten the airlines' economic health and the pilots' careers; if they're too easy, airline safety standards will be threatened," she said. "The good news is that almost everyone, regardless of age, has the capability to learn a new language."

Mathews said that an effective training program will include computer-based training as a supplement to classroom training to accommodate the schedules of pilots and controllers. Although subject-matter specialists would be a useful adjunct, the training must be conducted primarily by qualified English teachers.

"Most people believe that teaching English is easy — that anyone who can speak English can teach English," she said. "That is a misperception. Language teaching is a *profession*."

ICAO says that an optimum instructor will have graduate-level qualifications in language teaching, practical experience in teaching aviation English as a second language and experience as a pilot or controller. Minimum qualifications are a certificate in teaching English as a second language, experience in language teaching and the "ability to work well with a subject-matter expert."

ICAO recommends that qualified English instructors with no aviation experience be paired with aviation subject-matter specialists.

"What has *not* been found effective is relying on technical experts alone to provide the optimal environment for language learning to occur," Document 9835 says. "While individuals with flight experience or an air traffic control background make valuable (and necessary) subject-matter experts to facilitate language teaching, the task of *teaching* language classes or developing appropriate language learning materials should be delegated to language teaching experts and material developers."

The industry cannot afford training and testing that do not work.

ICAO said that instructors do not have to be native English speakers.

"Non-native instructors can, for example, bring their first-hand experience of learning a second language to bear on their teaching," says Document 9835.

A common core test with job-specific components for pilots, controllers and aeronautical station operators is likely, Mathews said, but the testing will have to be done orally by an interviewer (face-to-face or via telephone) or by oral questions presented by a computer program.

"It is not a pen-and-paper test," she said. "Testing must involve one human listening to another human, whether live or recorded."

ICAO recommends that tests conform to standards developed by the International Language Testing Association (ILTA), a noncommercial, nonprofit organization.

"Test users and developers can refer to the ILTA code of ethics as guidance to ensure that their test development and testing practices maintain high standards," says Document 9835, which includes the ILTA code of ethics.

'Natives' Not Exempt

Although *all* pilots, controllers and aeronautical station operators who conduct international operations must meet the language proficiency requirements, ICAO said that testing of an individual for whom English is his or her native language likely could consist of a brief interview by a representative of the state's licensing authority, to determine that the individual does not have a speech impediment or "inappropriately strong" regional accent that affects communication.

ICAO recommends that those with Level 6 proficiency make an effort to improve the clarity and understandability of their radio transmissions by using standard phraseology, moderating their rate of speech and avoiding the use of "unintelligible language," such as idioms and colloquialisms.

An idiom is an expression or figure of speech that cannot be defined by the words it contains. For example, a pilot might say, "We'll toss the anchor," to acknowledge a controller's instruction to reduce airspeed, or "We're on the go" to report a missed approach (ICAO standard phraseology for reporting a missed approach is "going around"). Colloquialisms are informal expressions such as "gonna" for "going to" and "ain't" for "isn't."

No Cure-all

Although increasing use of digital data transmission (data link) systems shows promise for significantly reducing deficient communication, the need for oral communication likely will never be eliminated.

"While data link systems will, no doubt, improve aviation communications on some levels, possibly improving efficiency and safety, it is not at all clear that such systems will obviate the requirement for good oral communication skills," Mathews said.[11] "There will continue to be a need for oral communication in nonroutine or emergency situations and as a backup for system failure."

As long as the need for oral communication exists, communication error will continue to present a risk to aviation safety.

"Communication errors will probably never be completely eliminated; however, compliance with the ICAO language proficiency requirements will enable speakers to more readily recognize errors and work toward the successful and safe resolution of misunderstandings," says Document 9835. ■

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Appendix A

International Standards and Recommended Practices Relating to Language Use in Radio Communications

Annex 1 to the Convention on International Civil Aviation: Personnel Licensing; Chapter 1, Definitions and General Rules Concerning Licences

1.2.9.1 [Airplane] and helicopter pilots and those flight navigators who are required to use the radiotelephone aboard an aircraft shall demonstrate the ability to speak and understand the language used for radiotelephony communications.

Note — Pursuant to Article 42 of the Convention on International Civil Aviation, paragraph 1.2.9.1 does not apply to personnel whose [licenses] are originally issued prior to 5 March 2004 but, in any case, does apply to personnel whose [licenses] remain valid after 5 March 2008.

1.2.9.2 Air traffic controllers and aeronautical station operators shall demonstrate the ability to speak and understand the language used for radiotelephony communications.

1.2.9.3 Recommendation — Flight engineers, and glider and free balloon pilots should have the ability to speak and understand the language used for radiotelephony communications.

1.2.9.4 As of 5 March 2008, [airplane] and helicopter pilots, air traffic controllers and aeronautical station operators shall demonstrate the ability to speak and understand the language used for radiotelephony communications to the level specified in the language proficiency requirements in [Appendix 1].

1.2.9.5 Recommendation — [Airplane] and helicopter pilots, flight navigators required to use the radiotelephone aboard an aircraft, air traffic controllers and aeronautical station operators should demonstrate the ability to speak and understand the language used for radiotelephony communications to the level specified in the language proficiency requirements in the [Appendix 1].

1.2.9.6 As of 5 March 2008, the language proficiency of [airplane] and helicopter pilots, air traffic controllers and aeronautical station operators who demonstrate proficiency below the Expert Level (Level 6) shall be formally evaluated at intervals in accordance with an individual's demonstrated proficiency level.

1.2.9.7 Recommendation — The language proficiency of [airplane] and helicopter pilots, flight navigators required to use the radiotelephone aboard an aircraft, air traffic controllers and aeronautical station operators who demonstrate proficiency below the Expert Level (Level 6) should be formally evaluated at intervals in accordance with an individual's demonstrated proficiency level, as follows:

a) Those demonstrating language proficiency at the Operational Level (Level 4) should be evaluated at least once every three years; and,

b) Those demonstrating language proficiency at the Extended Level (Level 5) should be evaluated at least once every six years.

Note 1 — Formal evaluation is not required for applicants who demonstrate expert language proficiency, [that is,] native and very proficient non-native speakers with a dialect or accent intelligible to the international aeronautical community.

Note 2 — The provisions of 1.2.9 refer to Annex 10, Volume II, Chapter 5, whereby the language used for radiotelephony communications may be the language normally used by the station on the ground or English. In practice, therefore, there will be situations whereby flight crew members will only need to speak the language normally used by the station on the ground.

Appendix 1 [to Annex 1]: Requirements for Proficiency in Languages Used for Radiotelephony Communications

To meet the language proficiency requirements contained in Chapter 1, Section 1.2.9, an applicant for a [license] or a [license] holder shall demonstrate, in a manner acceptable to the licensing authority, compliance with the [following] holistic descriptors … and with the ICAO [International Civil Aviation Organization] Operational Level (Level 4) of the ICAO Language Proficiency Rating Scale [page 13].

Proficient speakers shall:

a) Communicate effectively in voice-only (telephone/radiotelephone) [situations] and in face-to-face situations;

b) Communicate on common, concrete and work-related topics with accuracy and clarity;

c) Use appropriate communicative strategies to exchange messages and to recognize and resolve misunderstandings (e.g., to check, confirm or clarify information) in a general or work-related context;

d) Handle successfully and with relative ease the linguistic challenges presented by a complication or unexpected turn of events that occurs within the context of a routine work situation or communicative task with which they are otherwise familiar; and,

e) Use a dialect or accent which is intelligible to the aeronautical community.

Annex 6 to the Convention on International Civil Aviation: Operation of Aircraft; Part I: International Commercial Air Transport — Aeroplanes

3.1.6 Operators shall ensure that flight crew members demonstrate the ability to speak and understand the language used for aeronautical radiotelephony communications as specified in Annex 1.

Annex 6 to the Convention on International Civil Aviation: Operation of Aircraft; Part III: International Operations — Helicopters

1.1.3 Operators shall ensure that flight crew members demonstrate the ability to speak and understand the language used for radiotelephony communications as specified in Annex 1.

Annex 10 to the Convention on International Civil Aviation: Aeronautical Telecommunications; Volume II: Communication Procedures Including Those With PANS [Procedures for Air Navigation Services] Status; Chapter 5, Aeronautical Mobile Service — Voice Communications

5.1.1 In all communications, the highest standard of discipline shall be observed at all times.

5.1.1.1 ICAO standardized phraseology shall be used in all situations for which it has been specified. Only when standardized phraseology cannot serve an intended transmission, plain language shall be used.

5.2.1.2.1 The air-ground radiotelephony communications shall be conducted in the language normally used by the station on the ground or in the English language.

Note 1 — The language normally used by the station on the ground may not necessarily be the language of the State in which it is located. A common language may be agreed upon regionally as a requirement for stations on the ground in that region.

Note 2 — The level of language proficiency required for aeronautical radiotelephony communications is specified in the Appendix to Annex 1.

5.2.1.2.2 The English language shall be available, on request from any aircraft station, at all stations on the ground serving designated airports and routes used by international air services.

Annex 11 to the Convention on International Civil Aviation: Air Traffic Services

2.28.1 An air traffic service provider shall ensure that air traffic controllers speak and understand the language(s) used for radiotelephony communications as specified in Annex 1.

2.28.2 Except when communications between air traffic control units are conducted in a mutually agreed language, the English language shall be used for such communications. ■

Table A-1
International Civil Aviation Organization Language Proficiency Rating Scale

	Pronunciation[1]	Structure[2]	Vocabulary	Fluency	Comprehension	Interactions
Level 6 Expert	Pronunciation, stress, rhythm and intonation, though possibly influenced by the first language or regional variation, almost never interfere with ease of understanding.	Both basic and complex grammatical structures and sentence patterns are consistently well-controlled.	Vocabulary range and accuracy are sufficient to communicate effectively on a wide variety of familiar and unfamiliar topics. Vocabulary is idiomatic, nuanced and sensitive to register.	Able to speak at length with a natural, effortless flow. Varies speech flow for stylistic effect — for example, to emphasize a point. Uses appropriate discourse markers and connectors spontaneously.	Comprehension is consistently accurate in nearly all contexts and includes comprehension of linguistic and cultural subtleties.	Interacts with ease in nearly all situations. Is sensitive to verbal and nonverbal cues and responds to them appropriately.
Level 5 Extended	Pronunciation, stress, rhythm and intonation, though influenced by the first language or regional variation, rarely interfere with ease of understanding.	Basic grammatical structures and sentence patterns are consistently well-controlled. Complex structures are attempted but with errors which sometimes interfere with meaning.	Vocabulary range and accuracy are sufficient to communicate effectively on common, concrete and work-related topics. Paraphrases consistently and successfully. Vocabulary is sometimes idiomatic.	Able to speak at length with relative ease on familiar topics but may not vary speech flow as a stylistic device. Can make use of appropriate discourse markers or connectors.	Comprehension is accurate on common, concrete and work-related topics and mostly accurate when the speaker is confronted with a linguistic or situational complication or an unexpected turn of events. Is able to comprehend a range of speech varieties (dialect and/or accent) or registers.	Responses are immediate, appropriate and informative. Manages the speaker-listener relationship effectively.
Level 4 Operational	Pronunciation, stress, rhythm and intonation are influenced by the first language or regional variation and frequently interfere with ease of understanding.	Basic grammatical structures and sentence patterns are used creatively and are usually well-controlled. Errors may occur, particularly in unusual or unexpected circumstances, but rarely interfere with meaning.	Vocabulary range and accuracy are usually sufficient to communicate effectively on common, concrete and work-related topics. Can often paraphrase successfully when lacking vocabulary in unusual or unexpected circumstances.	Produces stretches of language at an appropriate tempo. There may be occasional loss of fluency on transition from rehearsed or formulaic speech to spontaneous interaction, but this does not prevent effective communication. Can make limited use of discourse markers or connectors. Fillers are not distracting.	Comprehension is mostly accurate on common, concrete and work-related topics when the accent or variety used is sufficiently intelligible for an international community of users. When the speaker is confronted with a linguistic or situational complication or an unexpected turn of events, comprehension may be slower or require clarification strategies.	Responses are usually immediate, appropriate and informative. Initiates and maintains exchanges even when dealing with an unexpected turn of events. Deals adequately with apparent misunderstandings by checking, confirming or clarifying.
Level 3 Preoperational	Pronunciation, stress, rhythm and intonation are influenced by the first language or regional variation and frequently interfere with ease of understanding.	Basic grammatical structures and sentence patterns associated with predictable situations are not always well-controlled. Errors frequently interfere with meaning.	Vocabulary range and accuracy are often sufficient to communicate on common, concrete or work-related topics, but range is limited and the word choice often is inappropriate. Is often unable to paraphrase successfully when lacking vocabulary.	Produces stretches of language, but phrasing and pausing are often inappropriate. Hesitations or slowness in language processing may prevent effective communication. Fillers are sometimes distracting.	Comprehension is often accurate on common, concrete and work-related topics when the accent or variety used is sufficiently intelligible for an international community of users. May fail to understand a linguistic or situational complication or an unexpected turn of events.	Responses are sometimes immediate, appropriate and informative. Can initiate and maintain exchanges with reasonable ease on familiar topics and in predictable situations. Generally inadequate when dealing with an unexpected turn of events.
Level 2 Elementary	Pronunciation, stress, rhythm and intonation are heavily influenced by the first language or regional variation and usually interfere with ease of understanding.	Shows only limited control of a few simple memorized grammatical structures and sentence patterns.	Limited vocabulary range consisting only of isolated words and memorized phrases.	Can produce very short, isolated, memorized utterances with frequent pausing and a distracting use of fillers to search for expressions and to articulate less-familiar words.	Comprehension is limited to isolated, memorized phrases when they are carefully and slowly articulated.	Response time is slow and often inappropriate. Interaction is limited to simple routine exchanges.
Level 1 Pre-elementary	Performs at a level below the Elementary level.	Performs at a level below the Elementary level.	Performs at a level below the Elementary level.	Performs at a level below the Elementary level.	Performs at a level below the Elementary level.	Performs at a level below the Elementary level.

1. Assumes a dialect and/or accent intelligible to the aeronautical community.

2. Relevant grammatical structures and sentence patterns are determined by language functions appropriate to the task.

Global Passenger-mortality Risk Decreased Substantially in Accidents From 2000 to 2005

The risk of dying in an accident aboard a randomly chosen flight was lower than ever in the period 2000–2005, in every industry segment examined. When passenger fatalities during the terrorist attacks of Sept. 11, 2001, were included, however, passenger-mortality risk did not decrease on U.S. scheduled domestic passenger jet flights compared with the period 1990–1999.

— ARNOLD BARNETT, PH.D.

[FSF editorial note: In the April 2000 *Flight Safety Digest*, Arnold Barnett and Alexander Wang provided an analysis of passenger-mortality risk — that is, the statistical probability of a passenger dying on a randomly chosen flight — in worldwide scheduled jet operations during 1987–1996.[1] Barnett subsequently prepared statistics for the decade of the 1990s.[2] In the following article, he analyzes this risk again based on data from Jan. 1, 2000, to Dec. 31, 2005.]

More than 100 million scheduled flights were conducted by the world's passenger airlines during 2000–2005.[3] They provide enough data to search for statistically significant trends relative to earlier periods. Such trends are helpful in assessing current industrywide performance, which is an important aspect of risk management.

The data show that the passenger-mortality risk associated with aviation accidents has decreased in all segments of the air transport industry that were studied (Advanced World domestic jet flights; Advanced World international jet flights; jet flights between Advanced World countries and Developing World countries; jet flights within the Developing World; and Advanced World non-jet domestic flights).[4] Statistical analysis indicates that the improvement is unlikely to be the result of chance. In operations ranging from scheduled domestic flights within the Advanced World — traditionally the world's safest — to flights within the Developing World, major gains in accident-risk reduction have been achieved.

Possible reasons for the decrease in passenger-mortality risk were not studied for this article. The numbers reflect credit on individuals and organizations dedicated to risk reduction.

There is, however, a counterpoint to the pattern of improvement. Although safety and security are not directly comparable issues, both affect overall passenger-mortality risk. In the time period studied, the terrorist attacks of Sept. 11, 2001, killed more people (including victims on the ground) than all previous aviation terrorist attacks combined. As a result, when these passenger fatalities were added to those caused by accidents, the result was equivalent to nullifying the decrease in accident-related passenger-mortality risk during 2000–2005 on scheduled U.S. domestic jet flights.

Q-statistic

The analytical method used in the 2000 *Flight Safety Digest* article[1] and several other papers was the Q-statistic, which represents the *mortality risk for a passenger on a randomly chosen flight*. The Q-statistic answers the question: "Given that a passenger chooses a flight at random within a data set of interest (e.g., U.K. domestic passenger jet flights during 1990–1999), what is the probability of the passenger not surviving the flight?"

A *flight* is defined as a nonstop trip from one city to another (also called a departure); "not surviving" in these studies means dying because of an aviation accident or crime/terrorism. (Causes not related to the flight, such as a passenger dying in an in-flight medical event, are excluded.)

The Q-statistic has conceptual advantages compared with other methods of measuring passenger-mortality risk.[5,6] Rather than calculating the chances of a passenger being in an airplane involved in a fatal accident, the Q-statistic weights each accident by the *proportion* of passengers killed, which brings three benefits:

- It distinguishes a fatal accident with a high survival rate from another with few survivors or no survivors;
- It ignores irrelevant fluctuations in the fraction of seats that are occupied on an airplane involved in a fatal accident (i.e., when a passenger jet hits a mountain, killing everyone aboard, the safety implications are the same whether the airplane is full or one-third full); and,
- It ignores the sector length and duration of a flight, because the majority of fatal accidents occur during takeoff/climb and approach/landing.[7]

Moreover, the Q-statistic is easy to calculate and understand. The Q-statistic uses the formula:

$$Q = V/N$$

where Q = Q-statistic

V = total number of full-loss equivalents that arose during the N flights

N = number of relevant flights

The *full-loss equivalent* is the proportion of passengers who do not survive the flight. (For example, if the flight is completed safely, the full-loss equivalent is zero; if 30 percent of passengers are killed in an accident, the full-loss equivalent is 0.3; if all the passengers are killed in an accident, the full-loss equivalent is 1.0.)[8] Adding these proportions for all N flights gives the value V.

The Q-statistic is the basis of the analyses in this article.

Zero Accident Risk

In previous analyses, scheduled Advanced World domestic jet flights have been the safest in the world. During 1990–1999, their Q-statistic was 1 in 13 million. At that rate, a passenger who took one randomly selected flight every day would on average go 36,000 years before dying in an accident.[9]

All the relevant passenger fatalities during the 1990s in Advanced World scheduled domestic jet operations were caused by accidents rather than criminal/terrorist acts. Considering accidents only, the passenger-mortality data for 2000–2005 improved, as shown in Table 1 (page 16).

During 2000–2005, there were approximately 75 million scheduled domestic jet flights in Advanced World countries (the majority conducted in the United States). No passenger fatality was caused by an accident on *any* of these flights.[10]

In absolute terms, the passenger-mortality risk could not have been better. But could this improvement compared with the 1990s represent mere chance? Even in a statistical process that is stable over time, it is surprisingly common for several events to occur in quick succession, interspersed with long periods without any events.

Table 1

Passenger-mortality Risk From Accidents, Advanced World Scheduled Domestic Jet Operations, 2000–2005

	Q-statistic
United States	0
Other Advanced World Countries	0

Note: *Passenger-mortality risk* (the Q-statistic) is defined as the statistical probability of a passenger dying on a randomly chosen flight. A *flight* is defined as a nonstop trip from one city to another (also called a "departure").

The Advanced World comprises countries that are generally considered economically advanced, technically advanced and democratic: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, the United Kingdom and the United States.

Source: Arnold Barnett, Ph.D.

Some calculations are illuminating on this point. Based on fatal-accident data from the 1990s and flight-activity levels during 2000–2005, 6.0 full-loss equivalents would have been expected between Jan. 1, 2000, and Dec. 31, 2005, in Advanced World domestic jet services. This value, extrapolated from the period 1990–1999, would arise from about 10 fatal accidents in which the average proportion of passengers killed would be about 55 percent. In actuality, there were zero fatal accidents, however, not 10. Such a discrepancy has an exceedingly low probability of being the result of chance.

Specifically, approximately half of the Advanced World domestic jet flights that were conducted during 1990–2005 were conducted during 2000–2005. (Daily flight frequencies were higher in the last six years of the period 1990–2005 than in the earlier years.) Thus, if all flights during 1990–2005 had the same probability of involvement in a fatal accident, approximately half the 10 accidents during 1990–2005 should have occurred in 2000–2005. None did, however, and that is about as likely to occur by coincidence as getting the same result 10 times in a row in a coin toss. The probability is about one in 500, which means very high statistical significance under any commonly used threshold of significance.

Table 2

Passenger-mortality Risk From Accidents During Various Scheduled Passenger Jet Operations, 1990–1999 and 2000–2005

	Q-statistic	
Type of Service	**1990–1999**	**2000–2005**
Advanced World Domestic	1 in 13 million	0
Advanced World International	1 in 6 million	1 in 8 million
Between Advanced World and Developing World	1 in 1 million	1 in 1.5 million
Within Developing World	1 in 500,000	1 in 2 million

Note: These data exclude fatalities caused by terrorist/criminal acts.

Passenger-mortality risk (the Q-statistic) is defined as the statistical probability of a passenger dying on a randomly chosen flight. A *flight* is defined as a nonstop trip from one city to another (also called a "departure").

The Advanced World comprises countries that are generally considered economically advanced, technically advanced and democratic: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, the United Kingdom and the United States. The Developing World comprises all other countries.

Source: Arnold Barnett, Ph.D.

A World of Improvement

Table 2 helps to explain that Table 1 did not represent an isolated situation.

Table 2 shows that, in both periods considered, scheduled passenger-jet operations in the Advanced World entailed considerably lower passenger-mortality risk than in the Developing World. As earlier studies found, this pattern has prevailed throughout the jet era, beginning about 1960.[10]

Perhaps more striking, however, is that in all four types of scheduled passenger jet operations, passenger-mortality risk per flight was lower during 2000–2005 than during 1990–1999. Beyond the already noted 100 percent reduction in passenger-mortality risk in Advanced World domestic operations, shown in Table 2, there was a noteworthy 75 percent reduction for flights within the Developing World. The second reduction is statistically significant: Given the number of fatal accidents involved, it would be farfetched to attribute a 75 percent decrease in passenger-mortality risk to chance.

In two types of operations — Advanced World International and Between Advanced World and Developing World — the decreases in passenger-mortality risk between the 1990s and the years 2000–2005 were smaller than for the other two types of operations. Moreover, those decreases were based on very few fatal accidents, both in the 1990–1999 period and the 2000–2005 period, so that the decrease in the Q-statistic might be construed as random fluctuation. However, in the context of a worldwide decrease in passenger-mortality risk — in which the overall trend for all operations combined was statistically significant — it might be more plausible to accept the modest improvements in the intermediate categories as signs of progress than to dismiss them as "statistical noise" (i.e., without practical meaning).

As noted, the analyses did not attempt to determine precisely why passenger-mortality risk decreased across the board during 2000–2005. The point is that a major decrease did take place, and it was not a coincidence or short-term streak of good luck.

Other Continuing Improvement

Interest in the safety of non-jet operations (involving reciprocating-engine aircraft and turboprop aircraft) may be increasing again because, faced with surging fuel prices, some airlines are redeploying turboprop aircraft on routes where they had been replaced by regional jets. In an earlier article by Barnett and Wang,[1] the Q-statistic for U.S. domestic propeller/turboprop operations was estimated as 1 in 2 million for 1987–1996. Table 3 shows continuing safety gains in more recent periods.

Table 3
Passenger-mortality Risk for Scheduled Non-jet Operations, Advanced World, 1990–1999 and 2000–2005

Period	Q-statistic
1990–1999	1 in 2.5 million
2000–2005	1 in 5 million

Note: These numbers exclude terrorist/criminal acts, but there were no such acts on these services during 1990–2005.

Passenger-mortality risk (the Q-statistic) is defined as the statistical probability of a passenger dying on a randomly chosen flight. A *flight* is defined as a nonstop trip from one city to another (also called a "departure").

The Advanced World comprises countries that are generally considered economically advanced, technically advanced and democratic: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, the United Kingdom and the United States.

Source: Arnold Barnett, Ph.D.

Competitive Routes

The earlier article also noted that, while Advanced World airlines had far lower overall Q-statistics than Developing World airlines, that difference did not arise for routes on which airlines from the two categories competed, namely, between an Advanced World city and a Developing World city (e.g., Paris, France, to Karachi, Pakistan). The Q-statistic was about 1 in 600,000 on such routes for both categories of airlines. This pattern raised the possibility that at least some of the aggregate differences in passenger-mortality rates between Advanced World airlines and Developing World airlines might be attributable to differences in flying conditions rather than among the airlines.

Table 4 (page 18) shows the same pattern for the latest study period.

These data are consistent with a broader pattern that was identified in the earlier study: *When two airlines flying passenger jets fly the same route, very rarely is there any statistically valid reason related to safety to prefer one to the other*. For example, the data from 2000–2005 do not suggest that low-cost domestic jet carriers in the Advanced World were more hazardous than traditional carriers: On both groups of airlines, the Q-statistic was zero over many millions of flights.

Increased Threat of Terrorism

An unprecedented number of fatalities in airline operations were caused deliberately in the latest study period. Historically, accidents have accounted for the great majority of aviation fatalities: In the 1990s, there was not a single fatality caused by crime or terrorism on any airline flight in the Advanced World. On Sept. 11, 2001, however, all the passengers on four U.S. domestic flights were killed by terrorists.[12] Table 5 (page 18) suggests the resulting "role reversal" that occurred for passenger-mortality risk factors.

That is, although the Q-statistic for accidents was reduced to zero, the Q-statistic for passenger fatalities counting those from crime/terrorism went from zero to one in 11 million. (Indeed, if data include fatalities on the ground in the calculations, eight times as many people were killed on Sept. 11 as in all U.S. domestic jet accidents of the 1990s *in total*.)

Terrorist acts and criminal acts also have affected passenger-mortality risk for scheduled passenger jet operations in

Table 4

Passenger-mortality Risk for Nonstop Scheduled Jet Routes Between Advanced World Countries and Developing World Countries, 2000–2005

Category	Q-statistic
Advanced World Airlines	1 in 1.5 million
Developing World Airlines	1 in 1.5 million

Note: *Passenger-mortality risk* (the Q-statistic) is defined as the statistical probability of a passenger dying on a randomly chosen flight. A *flight* is defined as a nonstop trip from one city to another (also called a "departure").

The Advanced World comprises countries that are generally considered economically advanced, technically advanced and democratic: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, the United Kingdom and the United States. The Developing World comprises all other countries.

Source: Arnold Barnett, Ph.D.

Table 5

Passenger-mortality Risk, by Cause, U.S. Scheduled Domestic Passenger Jet Operations, 1990–1999 and 2000–2005

	Q-statistic		
Period	**Accidents**	**Terrorism/Crime**	**Combined Causes**
1990–1999	1 in 11 million	0	1 in 11 million
2000–2005	0	1 in 11 million	1 in 11 million

Note: *Passenger-mortality risk* (the Q-statistic) is defined as the statistical probability of a passenger dying on a randomly chosen flight. A *flight* is defined as a nonstop trip from one city to another (also called a "departure").

Source: Arnold Barnett, Ph.D.

Table 6

Passenger-mortality Risk, by Cause, Developing World Scheduled Jet Operations, 2000–2005

Q-statistic		
Accidents	**Terrorism/Crime**	**Combined Causes**
1 in 2 million	1 in 10 million	1 in 1.5 million

Note: *Passenger-mortality risk* (the Q-statistic) is defined as the statistical probability of a passenger dying on a randomly chosen flight. A *flight* is defined as a nonstop trip from one city to another (also called a "departure").

The Developing World comprises all countries other than Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, the United Kingdom and the United States.

Source: Arnold Barnett, Ph.D.

the Developing World. Table 6 shows the effects of the deliberate destruction of two jets in Russia and one in China on Q-statistics of the Developing World.[13]

Nearly 20 percent of total mortality risk in Table 6 is related to crime or terrorism. Therefore, the factor-of-four (75 percent) improvement shown in Table 2, associated with fewer accidents, was reduced to a factor-of-three (67 percent) overall improvement.

Threat of Hostile Acts

In a worldwide trend, passenger-mortality risk from airline accidents improved in 2000–2005. While encouraging, that circumstance does not mean that there is any room for complacency in airline safety.

The industry also has experienced periodically significant effects on passenger-mortality risk from terrorist/criminal acts. It is too soon to know whether Sept. 11 was a terrible aberration. A precedent might be of some relevance: The 1990s, when there were no passenger fatalities attributed to terrorism/crime, were preceded by a series of terrorist/criminal acts in the late 1980s which, among many other consequences, destroyed Pan American Flight 103, UTA Flight 772 and Pacific Southwest Airlines Flight 1771,[14] none of which had survivors. This troubling trend was largely halted in 1990, at least for a decade. Current security measures might likewise avoid disasters in the years ahead. It would be unfortunate, however, if these measures were reduced because their very success was construed as evidence that the risk has been eliminated. ■

Notes

1. Barnett, A.; Wang, A. "Passenger Mortality Risk Estimates Provide Perspectives About Airline Safety." *Flight Safety Digest* Volume 19 (April 2000).
2. Barnett, A. Blackett Memorial Lecture. "Air Safety: End of the Golden Age?" *Journal of the Operational Research Society* Volume 52 (August 2001).
3. To approximate numbers of flights conducted, the author used a sampling technique based on worldwide schedules in the *Official Airline Guide* (OAG). (That technique is discussed in Barnett and Wang, *op.cit.*, p. 12.) The numbers are subject to some sampling error and other imperfections, but

the imprecision in estimates about flights conducted is not enough to cast doubt on the conclusions.

4. For the purposes of this article, the Advanced World comprises countries that are generally considered economically advanced, technically advanced and democratic: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, the United Kingdom and the United States. All other countries, insofar as data could be obtained (see note 3 and note 8), are defined as the Developing World.

5. For other methods that have been used to estimate passenger-mortality risk, see Barnett and Wang, *op. cit*., pp. 1–2.

6. Barnett, A.; Higgins, M.K. "Airline Safety: The Last Decade." *Management Science* Volume 35 (January 1989).

7. Boeing Commercial Airplanes. *Statistical Summary of Commercial Jet Airplane Accidents, 1959–2004*. May 2005.

8. To determine numbers of full-loss equivalents on scheduled flights, the author used records of fatal accidents as compiled by AirSafe.com, the Air Safety Network, the U.S. National Transportation Safety Board and *Flight International*.

9. The author did not include crewmember fatalities in the calculation of Q-statistics. Crewmember risk arguably is different than passenger risk. For example, cabin crewmembers are more likely on average to be injured by turbulence because they often are standing when most passengers are seated with seat belts fastened. Flight crewmembers and cabin crewmembers generally remain aboard the aircraft until emergency passenger evacuations are completed, which might increase mortality risk to the crewmembers.

10. Although no passengers were seriously injured when a U.S. domestic jet departed a runway in Chicago, Illinois, U.S., in 2005, one person on the ground was killed.

11. Barnett, A.; Abraham, M.; Schimmel, V. "Airline Safety: The Last Decade." *Management Science* Volume 35 (January 1989).

12. On Sept. 11, 2001, four U.S. airliners were hijacked by terrorists. Two of the aircraft (American Airlines Flight 11 and United Airlines Flight 175) were flown into the World Trade Center, New York, New York, U.S. Another aircraft (American Airlines Flight 77) was flown into the Pentagon near Washington, D.C., U.S. United Airlines Flight 93 struck a field in Pennsylvania, U.S., after passengers attempted to regain control from the hijackers. On-board fatalities (including those of the hijackers) included 81 passengers, nine flight attendants and two pilots on American Flight 11; 56 passengers, seven flight attendants and two pilots on United Flight 175; 58 passengers, four flight attendants and two pilots on American Flight 77; and 37 passengers, five flight attendants and two pilots on United Flight 93.

13. On Aug. 24, 2004, two Russian airliners were destroyed within minutes of one another. A Tupolev Tu-234A struck terrain while en route between Moscow, Russia, and Volgograd, with 35 passengers and nine crewmembers killed. A Tu-154B struck terrain en route from Moscow to Sochi, with 38 passenger fatalities and eight crewmember fatalities. Traces of explosive were found in the wreckage of both airplanes.

    A McDonnell Douglas MD-82 was destroyed when it struck the sea near Dalian, China, on May 7, 2002. Fatalities included 103 passengers and nine crewmembers. According to media reports, the last radio contact with the flight crew occurred when one of the pilots reported a fire in the cabin. No indication of burned wiring or other obvious source of ignition in the aircraft's systems has been found. Sabotage by a passenger is suspected.

14. Pan American Flight 103 broke up in flight over Lockerbie, Scotland, on Dec. 12, 1988. An explosive charge, probably Semtex, had been hidden inside a radio/cassette player that had been interlined and eventually loaded onto the aircraft in London, England. Fatalities included 243 passengers, as well as 16 crewmembers and 11 people on the ground.

    On Sept. 19, 1989, Union des Transports Aériens (UTA) Flight 772, a McDonnell Douglas DC-10-30, was destroyed when it broke up above a remote region of the Sahara Desert in Niger. The investigation found indications that an explosion had occurred in the forward cargo hold. In 2003, Libya admitted responsibility and agreed to pay compensation to the estates of the 156 passengers and 14 crewmembers who were killed.

    Pacific Southwest Airlines (PSA) Flight 1771 was en route from Los Angeles, California, U.S., to San Francisco, California, when the flight crew reported that they had heard gunshots in the cabin and selected the emergency code on the British Aerospace (BAe) 146-200's transponder. Witnesses reported seeing the aircraft in a steep dive that continued until ground impact, killing the 38 passengers and five crewmembers. The investigation determined that an ex-employee of the airline who had been terminated for petty theft had used his employee credentials, which he had not surrendered, to board the flight as a passenger with a pistol in his possession. He had then shot the two pilots.

About the Author

Arnold Barnett, Ph.D., is George Eastman Professor of Management Science at the Massachusetts Institute of Technology (MIT) Sloan School of Management, Operations Research Center. His specialty is applied mathematical modeling on issues of policy importance, with aviation safety one of his primary areas of emphasis. He has extensive consulting experience in aviation, having worked for five airports, 14 airlines, the U.S. Federal Aviation Administration (FAA) and the U.S. Transportation Security Administration (TSA). He is co-director of the FAA National Center for Excellence in Aviation Operations Research and the Sloan Foundation Center to Study the Global Aviation Industry. In 2002, he received a president's citation from Flight Safety Foundation. Dr. Barnett holds a doctorate in applied mathematics.

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Increased Automation Will Bring New Human Factors Challenges to ATM

Air traffic management (ATM) human factors specialists are working to anticipate, and thus avoid, problems associated with greater automation.

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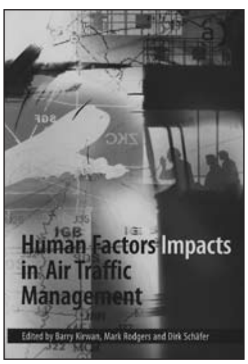


Books

Human Factors Impacts in Air Traffic Management. Kirwan, Barry; Rodgers, Mark; and Schäfer, Dirk (editors). Aldershot, England: Ashgate, 2005. 584 pp. Figures, tables, index, references, glossary.

Route complexity, traffic density and the demand for capacity are continuously increasing in air traffic management (ATM). "This has led many to consider that the time has come for significant changes to ATM, and for many this means increased controller support in the form of automated tools," the editors say.

Other changes that may affect the working lives of air traffic controllers include the possible partial or complete abandonment of fixed route networks in favor of permitting pilots to navigate for their greatest efficiency, using cockpit traffic displays.

"Such changes are full of human factors implications," the editors say. "The general insertion of more automation raises questions not only of workload, but also of situation awareness and trust in the automation, as well as skill retention and the ability to recover should things go wrong, such as the automation failing or giving erroneous information."

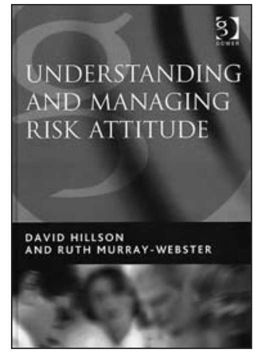
The editors say that automation changed the types of errors committed in other areas of aviation, such as the errors resulting from introduction of glass cockpits, and automation can be expected to bring new types of errors to ATM.

"The aim should therefore be to anticipate and prevent such errors contributing to accidents as has happened in other introductions of automation," the editors say. "With a wave of automation and other changes on the horizon and even closer, there is a need to get things right at the design and development stage, or at least prior to operations — learning after the event via accidents will constitute unnecessary loss of life and will seriously damage confidence in ATM and air travel generally."

The editors say that their aim was "to produce a book which would bring together real cases where human factors had real impact" (i.e., rather than a compilation of purely theoretical or academic studies). About 20 specialists provided chapters that emphasize the operational effects of automation.

The result is a set of chapters focusing on four main areas:

- Human factors in operations (e.g., changes to position handover protocols);
- Human factors and human resources (e.g., improvements in training-success rates);
- Human factors methodologies (e.g., measuring air traffic controller performance); and,
- Human factors integration programs (e.g., integrating human factors into company policy and working practice).



Understanding and Managing Risk Attitude. Hillson, David; Murray-Webster, Ruth. Aldershot, England: Gower, 2005. 206 pp. Tables, figures, bibliography, index.

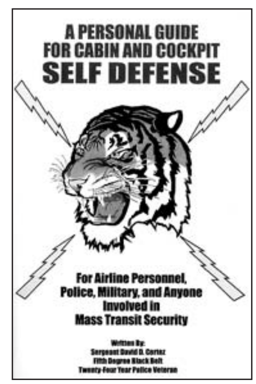
"The human aspects of risk management are acknowledged as being critical to success, but very little has been written about what this really means in practice, or about how to manage proactively the influence of human behavior on the risk process," the authors say. "A people-centered approach for risk management would address this issue and allow risk attitudes to be both understood and managed. This would provide practical guidelines allowing individuals, senior managers and risk professionals to diagnose real situations and develop strategies for good practice, as well as minimizing the impact of situations where risk attitudes may be counterproductive."

The book explores the human factors aspects of risk management, especially the role played by "emotional literacy." The authors define that term as "the ability to recognize emotions, understand emotions, appropriately express emotions and deal with emotions." One of the book's premises is that emotions can help, or hinder, people in managing risk.

Emotional literacy can influence the following aspects of risk management, the authors say: identification of uncertainties; accurate assessment of probability; accurate assessment of objectives; and risk response decisions.

Groups, as well as individuals, can have a signature "risk attitude." The authors say that groups can express such corporate characteristics as "groupthink" (members prefer unanimity and suppress dissent); "the Moses factor" (an influential person's risk attitude is adopted against the personal preferences of group members); "cultural conformity" (decision making that matches the perceived organizational norms); "risky shift" (the tendency of a group to be more risk seeking than its individual members because of a lack of individual accountability); and "cautious shift" (the opposite of risky shift, when the group attitude is weighted toward risk aversion because of an overemphasis on personal accountability or because no one in the group is prepared to assume responsibility for risk taking).

The authors say that effectively addressing the human element of risk management, although it adds complexity to the job, offers important benefits. These include the "ability to focus on objectives instead of being distracted or diverted by unmanaged personal issues"; "improved motivation, both for individuals and for groups"; and "more effective teamwork, understanding and building on the strengths of each member."



A Personal Guide for Cabin and Cockpit Self Defense. Cortez, David D. Bloomington, Indiana, U.S.: AuthorHouse, 2005. 141 pp. Figures.

"Flight attendants and pilots do not have the luxury of calling the police while in the air," says the author, a police officer, former U.S. Marine and defense tactics instructor with advanced martial arts skills. "At 30,000 feet, they are the police."

Despite the increased level of security screening that passengers undergo in today's aviation system, it is impossible to eliminate all potential weapons, the author says. Used innovatively, even such innocuous items as hand luggage, clothing belts, cellular phones, laptop computers and shoelaces can become improvised weapons.

Nor, the author says, is all passenger behavior necessarily what it seems. A passenger who appears to be having a heart attack probably is undergoing a genuine medical emergency, but could also be simulating the condition to create a diversion that will distract flight attendants from the actions of other terrorists in the cabin, or testing to see if the pilots will be disciplined enough to remain in the cockpit.

The book describes and illustrates with photographs martial arts techniques that the author says were "chosen because of their effectiveness, simplicity, reliability and adaptability to close-quarters situations."

Moreover, mental preparedness is as important as physical fitness in thwarting terrorist tactics, the author says. A flight attendant or pilot must expect or visualize an attempted terrorist takeover until it cannot come as a complete surprise, and must visualize the response so that it will be virtually automatic. Although the author advocates using no more force than necessary, he is emphatic that "if you have to fight, especially a terrorist, hit him or her as hard as you can, as fast as you can, as often as you can, and as mean as you can."

Reports

Terminal Radar Approach Control: Measures of Voice Communications Performance. Prinzo, O. Veronika; McClellan, Mark. U.S. Federal Aviation Administration (FAA) Office of Aerospace Medicine. DOT/FAA/AM-05/19. Final report. October 2005. 22 pp. Available via the Internet at <www.faa.gov/library/reports> or through the National Technical Information Service.*

As the U.S. National Airspace System evolves from its current ground infrastructure and voice communications system to one that encompasses both ground systems and airborne systems, digital data transmission may become the principal communications medium. Emerging systems will need to be evaluated by comparison with existing systems according to performance measures such as setup delay, voice streaming, pause duration and message propagation.

This report describes "a first step" in providing objective and quantifiable performance measures of the current communications systems that can be used as a baseline in evaluating the next generation of communications systems.

The authors analyzed nearly 8,000 voice transmissions from the five terminal radar approach control (TRACON) facilities with the highest number of operations in the 48 contiguous United States. They found that communications occurred at a rapid rate and with little silence between transmissions.

"On average, there were about 13 air-ground transmissions generated for every minute sampled," the report says. "Typically, once the push-to-talk switch was depressed, communications began 81 milliseconds later. It took about 2.5 seconds to generate a message, and another 127 milliseconds lapsed before the push-to-talk switch was released."

The study also found that blocked, stepped-on and clipped transmissions were rare, disrupting efficient information transfer in 1.16 percent of the sampled transmissions. Because disruptions often required additional message exchanges to resolve information-transfer problems, an average of 14.54 messages were transmitted between pilots and controllers when disruptions were present, and an average of 9.90 messages were transmitted when there was no disruption.

Flight Safety Special Issue: Bird Strike Prevention. Flight Safety Foundation (FSF)–Taiwan. July 2005. 147 pp. Figures, tables, photographs. Available from FSF–Taiwan.**

The Bird Strike Committee–Taiwan (BSC–TW) was established by Flight Safety Foundation (FSF) sister organization FSF–Taiwan in 2001 to consolidate related civil aviation resources and military aviation resources to help resolve the bird strike problem. During the following four years, BSC-TW published articles on the topic that have been assembled in this report, along with articles published by other international organizations.

"BSC-TW [was] based on the concept of '[be concerned with] flight safety first and be responsible for the preservation of birds' to provide appropriate measures for dispersing birds away from the operating spaces of airports, thus enabling the birds and aircraft to share the sky in a safe manner while minimizing bird strike incidents," says the publication's introduction.

One unusual bird strike prevention measure described in an article was the dismantling of illegal pigeon houses. The Taiwan Civil Aeronautics Administration in 1998 banned all pigeon raising in areas adjacent to runways. All pigeon raisers in the prohibited areas were compensated for promising in writing not to fly their pigeons.

"However, every now and then, flying pigeons have been spotted around and over airports," the article says. "Investigation showed that some pigeon raisers who had signed the agreement continued to fly their birds."

BSC-TW contracted with part-time workers to study pigeon activity in prohibited areas and to try to ascertain whether people who had signed the agreement were still raising birds in those areas.

"Three pigeon raisers … were found flying their birds in banned areas during sunset," the article says. "The information was passed to the [Taipei] Sung Shan Airport authorities. The pigeon houses of the three raisers were dismantled according to law by the [Taipei city government]."

Articles are grouped under the following headings: "The Concept of Bird Strike Prevention," "The Equipment and Techniques of Bird Strike Prevention," "Bird Strike Meeting and Interchange Information," "International Activities of Bird Strike Prevention," "The Activities of Bird Strike Prevention in Taiwan," and "Bird Strike Analysis."

Level Bust Study Using Safety Principles. Eurocontrol Experimental Centre. Report no. 402. January 2006. Gizdavu, Adrian; Bieder, Corinne; Paries, Jean. 81 pp. Figures, tables. Available in English and French via the Internet at <www.eurocontrol.int>.

In 2003, Eurocontrol began exploring the potential benefits of studying level busts (deviations from assigned altitudes) using a method called SMART (Safety Management Assistance and Recording Tool).

"SMART is intended to facilitate the extraction of 'safety lessons' from reported events and to support safety-related decision making," the report says. "The key idea underlying SMART is to make the safety model that presided over design choices explicit (design being used in a broad sense, i.e., design of equipment, organization, training, procedures), and to put it into the test of reality."

The safety model consists of beliefs — conscious or unconscious — that the designers of the system had about factors that would protect against level busts, recover from level busts or mitigate their consequences. These factors are called safety principles (SPs).

The study described in the report analyzed 35 actual level bust incidents in terms of the SPs, to determine how effective or ineffective each SP was in that incident.

Among the report's conclusions are the following:

- "The current situation seems to be a rather weak prevention layer, this weakness being hidden by the role of low airspace occupation density (alias for 'providence'), and a rather efficient recovery layer"; and,
- "In complex and dense airspace like large TMAs [terminal maneuvering areas], the design or relative trajectories is such that there is no room for deviations. The system is not error tolerant, [and] a level/altitude deviation may lead to a dangerous situation. Departure routes intersecting arrival routes one flight level below a holding stack gives no margin for error if the climbing aircraft is busting its cleared flight level. The recovery of such a situation is poor as well, [and] usually [it] is TCAS [traffic-alert and collision avoidance system] and providence that save the day."

Risk Factors Associated with Weather-Related General Aviation Accidents. U.S. National Transportation Safety Board (NTSB). NTSB/SS-05/01. September 2005. 78 pp. Figures, tables, appendixes, photos, glossary. Available via the Internet at <www.ntsb.gov> or from the National Technical Information Service.*

This report describes an NTSB study that was designed to produce better understanding of the risk factors associated with instrument meteorological conditions (IMC) or low visibility. Researchers collected data from 72 general aviation accidents that occurred between August 2003 and April 2004. The researchers also interviewed pilots of 135 flights that were operated in the vicinity at the time of those accidents.

In addition, U.S. Federal Aviation Administration (FAA) records provided information about pilots of accident flights and non-accident flights, including test results.

Statistical analyses were then used to identify variables associated with a greater risk of weather-related general aviation accidents.

The study's conclusions included the following:

- "Pilots who start flying earlier in life are at lower risk of being involved in a weather-related general aviation accident than those who start flying when they are older, and age at [the time of receiving a] first certificate is a better predictor of future accident involvement than age at the time of [the accident] flight";
- "Periodic training and evaluation may be necessary to ensure that pilots maintain weather-related knowledge and skills"; and,
- "Knowledge and practical-test failures are both associated with a higher risk of a pilot being involved in a weather-related general aviation accident."

Instructional and Management Guides

Safety Management Systems: The Senior Airline Manager's Implementation Guide. First edition. Montreal, Quebec, Canada: International Air Transport Association (IATA), October 2005. Figures, photographs, bibliography, annexes. Available from IATA.***

A safety management system (SMS) is defined by IATA as "the systematic management of the risks associated with flight operations, related ground operations and aircraft engineering or maintenance activities to achieve high levels of safety performance."

This guide is designed to provide a practical methodology for airlines that have not yet implemented an SMS. The guide begins with an introduction to SMS, followed by sections titled "Operational Safety Program," "Emergency Response Program," the "IATA Safety Management Support System" and "Implementation."

Electronic Media

Cabin Operations Safety Toolkit: Turbulence Management & Inadvertent Slide Deployment Prevention; Cabin Safety Management Systems. Second edition. Montreal, Quebec, Canada: International Air Transport Association (IATA), January 2006. Available from IATA.***

A product of the work performed by the IATA Cabin Operations Safety Task Force, established in 2004, this compact disc tool kit is designed to help safety officers, training instructors and airline managers to develop strategies for reducing turbulence-related injuries and inadvertent slide deployments. This edition also includes presentations about safety management systems.

The tool kit includes guidance material to improve procedures, tools for incident/accident analysis, training material that can be used as is or integrated into existing courses, and management briefings that include action plans and cost analysis templates. Presentations for training include instructor's notes for the classroom or workshops.

Content is provided in the form of portable document format (PDF) files, Microsoft PowerPoint presentations and Internet links.

Regulatory Materials

Synthetic Vision and Pathway Depictions on the Primary Flight Display. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 23-26. Dec. 22, 2005. 18 pp. Appendix. Available from FAA via the Internet at <www.airweb.faa.gov>.

This AC presents an acceptable means, but not the only means, of showing compliance with U.S. Federal Aviation Regulations (FARs) Part 23, *Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes*, for two new concepts in small airplanes: (1) synthetic vision and (2) pathway depictions displaying the navigation course on the primary flight display. This AC addresses the two concepts in a head-down display format only. ■

Sources

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

** Flight Safety Foundation–Taiwan
5–1, 8F, No. 51, Keelung Road, Sec. 2
Taipei 110 Taiwan R.O.C.

*** International Air Transport Association (IATA)
800 Place Victoria
P.O. Box 113
Montreal H4Z 1M1 Quebec, Canada
Internet: <www.iata.org>

Cleaning Solvent Blamed for B-777 Landing Gear Fire

Investigators found that the subsequent evacuation exceeded certification time limits and that passengers were not led to a secure area.

— FSF EDITORIAL STAFF

The following information provides an awareness of problems through which such occurrences may be prevented in the future. Accident/incident briefs are based on preliminary information from government agencies, aviation organizations, press information and other sources. This information may not be entirely accurate.

AIR CARRIER

Fire Leads to Recommendations for Expeditious Evacuations

Boeing 777. Minor damage. 31 minor injuries.

After a flight from Pakistan, the flight crew conducted a normal autopilot-coupled approach to an automatic landing at an airport in England. After a "smooth and normal" touchdown, the crew taxied the airplane off the runway and stopped on the taxiway to establish communication with the ground controller.

After receiving clearance and beginning to taxi toward the stand (gate), a crewmember of an airplane on an adjacent runway said, on the ground controller's radio frequency, that he saw flames on the accident airplane's left main landing gear.

The crew stopped the airplane on the taxiway, and aircraft rescue and fire fighting (ARFF) personnel were called to extinguish the fire. The ARFF watch commander observed what appeared to be an increasing amount of smoke and recommended an evacuation of the airplane on the right side.

Passengers and crewmembers evacuated, using four evacuation slides on the right side of the airplane. Thirty-one passengers and five ARFF personnel received minor injuries during the evacuation. Evacuation of the 332 passengers was completed four minutes 10 seconds after the first evacuation slide was deployed; after an additional two minutes 30 seconds, the last crewmember evacuated. After evacuating the airplane, passengers clustered near the evacuation slides. When buses arrived and passengers walked toward them, the passengers passed downwind of what authorities believed was still a fire.

The investigation found that the fire "most likely resulted from the maintenance practice used when cleaning the wheel heat shields," the final accident report said. "It was likely that these had been immersed in a flammable solvent, which allowed the ceramic fiber insulation material contained within to become contaminated. The fire occurred on the second landing after the wheel had been fitted to the aircraft, when the brake-pack temperature was likely to have been higher than on the previous landing."

The investigation also found that, although the watch commander believed that the amount of smoke increased as firefighters poured water on the fire, he actually was observing steam as it "lifted" carbon deposits from the landing gear. Firefighter training material did not include this information, the report said. The fire itself burned out quickly and was contained within the chin ring of the no. 10 wheel.

In addition, the investigation found that the evacuation took considerably more time than the evacuation time required for aircraft certification — the requirement is for a full load of passengers to be evacuated in 90 seconds using half of an aircraft's available exits.

As a result of the investigation, the U.K. Air Accidents Investigation Branch issued four recommendations:

- That the U.K. Civil Aviation Authority (CAA) review its guidance on leading passengers who have been evacuated from an aircraft "to secure areas away from the scene of the incident, and [to] ensure that the relevant aerodrome/emergency orders suitably address this topic";

- That the airline review its cabin crew training "with the intention of ensuring that, in the event of an evacuation command being given by the aircraft commander, the evacuation is carried out as expeditiously as possible, irrespective of the lack of any threat to the aircraft perceived by the cabin crew";

- That CAA require, at some airports, that "a radio frequency to facilitate direct communications between an aircraft and the [ARFF service], in the event of an accident or incident to an aircraft on the airfield, is made available and appropriately promulgated"; and,

- That CAA require "that any radio communication frequency used to facilitate direct communications between an aircraft and the [ARFF service], in the event of an accident or incident on the airfield, should be recorded, in order that it may be reproduced to assist in accident and incident investigation."

The report said that 19 instances of wheel brake fires on B-777 airplanes were reported between June 1999 and January 2006, when the accident report was issued. Of these, eight fires were attributed to excessive grease, five fires were attributed to the solvent used in cleaning wheel components, and one fire was attributed to a hydraulic leak; the causes of five of the fires are unknown.

'Robust Monitoring' Recommended for Loading Procedures

Airbus A340. No damage. No injuries.

During a flight from England to Japan, the flight crew was told that the airplane's center of gravity (CG) was slightly forward of the allowable limit. The problem was corrected by moving three passengers toward the rear of the airplane, and a new load sheet was created to show the change. The flight was continued to the destination, where the crew conducted a normal landing.

The operator's Safety Services Department arranged before the landing to have all cargo weighed after arrival. The incident report said that, when the cargo was weighed, significant differences were found, compared with weights noted on the cargo weight statement.

"The errors were subsequently traced to inaccuracies generated by the cargo scales at [the departure airport]; the source of these errors has now been eliminated," the report said.

In addition, an investigation found that a worker at the central load-planning facility (operated by an outsourced contractor in another country) had incorrectly entered cargo details into the computer planning system that generated the load sheet.

The report said that a review by the U.K. Air Accidents Investigation Branch found that the operator had experienced "an abnormally high frequency of loading errors" and that the operator's internal investigation resulted in internal safety recommendations for all aspects of loading procedures and a complete review of the loading system. In addition, the U.K. Civil Aviation Authority was monitoring the loading procedures, the report said.

"While human mistakes will occur, there should be a robust monitoring system for all critical aspects of flight," the report said. "Incorrect weight and CG can have very serious consequences and should be given a high degree of importance in terms of staffing, training, monitoring and auditing."

Crew Reports Multiple Bird Strikes While Trying to Avoid Flock

Airbus A320. Minor damage. No injuries.

After a flight from the Netherlands, the crew was conducting an approach to an airport in Ireland. During the approach, the captain observed a large flock of birds rising from the runway. He ordered a go-around when the radar altimeter indicated 100 feet.

During the go-around, as the crew flew the airplane through about 150 birds that were at the top of the flock, they heard the sound of several impacts.

After the airplane was landed, the remains of several sea gulls were found on and near the runway. An inspection of the airplane found that several birds were ingested into the no. 2 engine, a hole was punctured in a trailing-edge flap, and blood stained the nose landing gear bay.

The incident report said that the bird strike occurred while bird-scaring activities were in progress in another area of the airport.

"In spite of bird-scaring activities … and preventive techniques being regularly employed, absolute bird-strike prevention is impossible to achieve due to the unpredictable nature of birds," the report said.

Faulty Transistor Blamed for Smoke on Flight Deck

Embraer EMB 145EP. Minor damage. No injuries.

During a flight from England to Italy, as the airplane was being flown through Flight Level (FL) 100 (approximately 10,000 feet) over France, the flight crew was unable to keep the autopilot engaged.

Later, while in cruise at FL 270, the crew detected an unusual odor, and soon afterward, smoke was seen beneath the captain's seat. At the same time, the captain's primary flight display, multifunction display, radio management unit and the engine indicating and crew-alerting system failed. The pilots performed emergency actions for smoke on the flight deck, donned oxygen masks and smoke goggles, declared an emergency and asked for clearance to land at a large airport in France.

After landing, the crew received taxi instructions to a remote stand (gate) in an area of the airport with which they were not familiar; as a result, passengers did not disembark for about five minutes after touchdown. (Controllers in the airport air traffic control tower had said that the airplane could be stopped at any time, if disembarkation was required before reaching the gate.)

Maintenance personnel identified the source of the smoke as the no. 1 IC-600 avionics integrated computer, which collates data for flight deck displays. A subsequent examination of the equipment by the manufacturer found that a transistor had failed, which resulted in overheating of nearby components.

The investigation found that a revision of the *Quick Reference Handbook* (QRH) had omitted procedures for recovery of information in the event of the computer's failure. As a result of the investigation, the U.K. Air Accidents Investigation Branch recommended that Embraer "publish a readily identifiable procedure in the [QRH] … which restores information to flight instruments affected by the failure of either IC-600 avionics integrated computer." Embraer said that the company was conducting the revision.

Bolt Installation Cited in Landing Gear's Failure to Extend

Piper PA-34-200T Seneca II. Minor damage. No injuries.

Near the end of a domestic freight flight in New Zealand, after the pilot selected landing gear "DOWN," the "LANDING GEAR UNSAFE" warning light failed to extinguish. The pilot observed that the nose landing gear had not extended.

He discontinued the approach and used emergency landing gear extension procedures, but the nose landing gear still did not extend. Other procedures, including yawing and rocking the airplane and a touch-and-go landing, also failed to extend the nose landing gear.

He landed the airplane, with all landing gear retracted, on a grass runway.

An investigation found that the nose landing gear had not extended because the centering spring attachment had "jammed against the nose [landing] gear door aft tube assembly," the final accident report said.

The report said that a bolt had been installed incorrectly during maintenance nine weeks before the incident. Contributing factors were the "overloading of the nose baggage compartment and a possible lack of rigidity in the nose cone."

Double Engine Failure Leads to Landing in Mud Flats

Piper PA-31-350 Chieftain. Substantial damage. No injuries.

The airplane was being flown on a round-trip visual flight rules charter flight in Australia between airports that were about 40 nautical miles (74 kilometers) apart. As the airplane neared the destination on the second leg of the flight, the pilot received clearance from air traffic control to conduct a visual approach.

As the pilot turned the airplane onto left base at 1,000 feet, he declared an emergency, indicating that both engines had failed. He landed the airplane on tidal mud flats west of the airport.

The pilot said later that both engines failed about the same time, without surging, running rough or any other anomalies. He said that the mixture controls were at the full-rich setting and that fuel boost pumps and magnetos had been selected; neither engine responded when he advanced the throttles, he said.

After the incident, about 236 liters (62 U.S. gallons) of fuel were recovered from the fuel tanks. The fuel tanks had a capacity of 728 liters (192 U.S. gallons), including about 38 liters (10 U.S. gallons) of unusable fuel. An inspection of the fuel system confirmed that the fuel-selector controls were operating correctly, the fuel and fuel filters were uncontaminated and the tank-venting system was functioning normally. No problems were identified in the engines or engine systems that might have contributed to the engine failures.

The fuel tanks were estimated to have held about 300 liters (79 U.S. gallons) of fuel before the flight, an amount sufficient to complete the flight.

The final accident report said that the pilot, who also flew the company's Embraer EMB 110P1 Bandeirante airplanes, typically selected the Bandeirante's engine fuel condition levers to "LO IDLE" during pre-landing checks.

"The configuration of those engine controls was similar to that of the Chieftain's fuel-mixture controls," the report said. "Moving the Chieftain's mixture controls to a position consistent with 'LO IDLE' for a Bandeirante would stop the flow of fuel to both engines and result in a sudden and complete loss of engine power. …

"The aircraft was [at] about 1,000 feet when the pilot noticed the loss of engine power, and this was shortly after he had completed his pre-landing checklist. … The investigation was unable to further identify factors that may have contributed to the simultaneous failure of the engines."

Photos Enable In-flight Analysis Of Landing Gear Problem

Gulfstream Aerospace Gulfstream V. No damage. No injuries.

Soon after takeoff from an airport in the United States, as the flight crew attempted to retract the landing gear, the door on the right main landing gear failed to retract. The crew conducted checklist actions, which included cycling the landing gear, and the right main landing gear became jammed in a partially extended position.

During a low pass above the runway at the departure airport, maintenance personnel on the ground photographed the airplane's undercarriage. Gulfstream Aerospace engineers reviewed the photographs and told the crew what actions to take to fully extend the landing gear. The crew landed the airplane about six hours after takeoff. The investigation was continuing.

Tire Fails on Touchdown

Raytheon Beech 390 Premier I. Substantial damage. No injuries.

Instrument meteorological conditions prevailed for the landing at an airport in the United States. When the airplane touched down, the left main landing gear tire failed, and the airplane veered left.

The pilot said that he flew the airplane off the runway, banked right and experienced an "ugly flare" before the airplane touched down hard on the right landing gear.

OTHER GENERAL AVIATION

Fire Fighting Airplane Strikes Ground During Familiarization Flight

Air Tractor AT-602. Destroyed. One fatality.

The single-seat airplane was being flown above a runway in Australia as part of the pilot's initial familiarization with the aircraft, which was used in water-dropping operations.

A preliminary report said that witnesses saw water begin to fall from the underside of the airplane and that, near the end of the water-drop run, there was a "large whoosh of water … with large clouds of water falling away from the aircraft." After the water drop had been completed, the airplane's nose pitched up and the airplane gained altitude before the nose pitched down and the airplane descended to the ground. Witnesses who observed the airplane from the side said that the nose was pointing toward the ground and they could see the underside of the right wing.

The report said that the pilot — who previously had flown a different aircraft type used by the operator for water-dropping operations — had completed a training session earlier in the day that had included ground taxiing, takeoffs and landings, and general airplane handling, including simulated spray runs and low passes along the runway. The operator's chief pilot, who was overseeing the training, suggested that, during his familiarization flights, the pilot operate the cockpit drop handle, which opened the water-drop door to allow release of the water.

The chief pilot said that the airplane probably was carrying several hundred liters of water — about the same amount that had been loaded for the morning training session.

Maintenance Personnel Extinguish Landing Gear Fire

Cirrus Design SR22. Substantial damage. No injuries.

The pilot was conducting an extended taxi for departure from an airport in the United States when a controller in the airport air traffic control tower told him that the airplane's right main landing gear was on fire.

The pilot and two passengers exited the airplane. The on-board fire extinguisher was discharged but did not extinguish the flames. Two maintenance technicians from a nearby hangar then discharged large-capacity fire extinguishers into the fire and extinguished the flames.

A preliminary accident report said that a review of the accident database showed several similar events had occurred on Cirrus SR20 and SR22 airplanes.

Landing Gear Breaks After Touchdown on Grass Airstrip

Extra EA 300. Minor damage. No injuries.

The airplane was the fourth in a formation flight, and the pilot had been briefed for a landing on a grass airstrip in England after the three airplanes in front of him had been landed.

The pilot said that the airplane touched down on the tail wheel before the main wheels and that the touchdown was firm.

The leg of the right main landing gear broke and dug into the grass, causing the airplane to yaw right and slide to a stop.

A weather aftercast said that the surface wind at the time of the accident would have been from about 290 degrees at seven knots to 11 knots. The pilot said that the surface wind was from 340 degrees at six knots.

Maintenance personnel said that the airplane's maintenance schedule required routine visual inspection of the landing gear but no routine load testing.

The accident report said that, without load testing, "there was the possibility of a pre-existing weakness in the main landing gear."

ROTORCRAFT

Helicopter Strikes Branch During Anti-poaching Flight

Bell 206L-3 LongRanger. Minor damage. No injuries.

The helicopter was being flown in an anti-poaching operation in a national park in Tanzania when poachers were observed. The pilot conducted a landing in a forest clearing so that two law enforcement personnel could disembark. He then conducted a takeoff for a flight to the base, where additional law enforcement personnel were to board the helicopter.

The pilot said later that, in his haste to return the helicopter to the base, he did not see a tree branch above the main rotor. After initiating a climb, he heard "a rattling sound" and felt the helicopter wobble. He maneuvered the helicopter for a landing in the same clearing.

Wheel Breaks Through Helipad Deck

Agusta A109C. Substantial damage. Two minor injuries.

After landing the helicopter at a helipad in Australia and allowing a passenger to disembark while the engines continued operating, the pilot applied collective pitch control in preparation for liftoff. He felt the helicopter "lurch" and roll right, the final accident report said.

The pilot applied full left cyclic pitch control and maintained the collective pitch control position, but the helicopter struck the ground between the helipad and a riverbank. The initial examination of the accident site found that the helicopter's right main wheel had broken through the helipad deck.

The report said that factors in the accident were that "management and maintenance of the helipad did not encompass all the aspects necessary to ensure that the actual load-bearing capability of the helipad … was known," that "the actual load-bearing capability of the helipad was less than that required for safe use by the Agusta A109C helicopter" and that "the pilot did not check before the flight whether the helipad was capable of safely accepting the loads imposed by the Agusta A109C helicopter."

Kneeboard Position Cited in Landing Accident

Robinson R22 Beta. Substantial damage. One minor injury.

The student pilot was preparing to land the helicopter at the end of a round-trip flight in Northern Ireland when, as he attempted to move the cyclic control left, the control handle caught under the kneeboard and its attachment strap on his left knee. The restriction on the control prevented the pilot from correcting a right drift, and in attempting to free the control, the pilot lifted his left foot off the left tail-rotor control pedal. The helicopter yawed right, the right skid struck the ground, and the helicopter rolled onto its right side.

The final accident report said that before the flight, the pilot had ensured that there was adequate clearance between the cyclic control and the kneeboard and that during the landing on the first leg of his flight, he experienced no control restriction. The problem became apparent only at the end of the second leg of the flight, when — with the prevailing wind from the left — the pilot turned the helicopter right to hover taxi. ■

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