FLIGHT SAFETY FOUNDATION

DECEMBER 2002

# FLIGHT SAFETY DIGEST

# International Efforts Raise Awareness to Prevent Approach-and-landing Accidents

Status Report on HUDs

FLIGHT SAFETY FOUNDATION

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# Flight Safety Digest

**Vol. 21 No. 12** **December 2002**

## In This Issue





*Flight Safety Foundation is an international membership organization dedicated to the continuous improvement of aviation safety. Nonprofit and independent, the Foundation was launched officially in 1947 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce positive influence on aviation safety. Today, the Foundation provides leadership to more than 910 member organizations in more than 142 countries.*

# International Efforts Raise Awareness to Prevent Approach-and-landing Accidents

***During 2002, organizations in several areas of the world adapted and disseminated information from Flight Safety Foundation's* ALAR Tool Kit *to meet the regional needs of thousands of pilots, air traffic controllers and other aviation professionals.***

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*FSF Editorial Staff*

With an unexpected increase in airline accidents involving controlled flight into terrain (CFIT) as the backdrop, aviation organizations in many countries in 2002 introduced internationally recommended methods for preventing approach-and-landing accidents (ALAs) or fine-tuned their established awareness campaigns. In March 2002, Flight Safety Foundation (FSF) cited data from The Boeing Co. showing that in the previous decade, 116 large jet transport aircraft were involved in hull-loss ALAs. Other preliminary data showed that four jet transports were involved in CFIT hull-loss accidents worldwide during the first eight months of 2002, compared with two accidents during 2001 and three accidents during 2000.

CFIT occurs when an airworthy aircraft under the control of the flight crew is flown unintentionally into terrain, obstacles or water, usually with no prior awareness by the crew. This type of accident can occur during most phases of flight, but CFIT is more common during the approach-and-landing phase, which begins when an airworthy aircraft under the control of the flight crew descends below 5,000 feet above ground level (AGL) with the intention to conduct an approach and ends when the landing is complete or the flight crew flies the aircraft above 5,000 feet AGL en route to another airport. A hull loss involves damage to a commercial airplane that is substantial and beyond economic repair; or an airplane that remains missing after search for wreckage has been terminated; or an airplane that is substantially damaged and inaccessible.

Stuart Matthews, FSF president and CEO, said that "the scourge of CFIT has reappeared with a vengeance." He said that the aviation industry must redouble its effort to increase awareness of this problem and to implement preventive measures.[1]

"After all the work that the Foundation and many others put into CFIT prevention in past years, I do not want to say that it is 'back to the drawing board,' but we must renew our efforts to ensure full awareness of the problem and of the many preventive measures that we have developed. Above all, we must continue to call for the installation in all aircraft of the equipment now available to help prevent CFIT, such as TAWS — the terrain awareness and warning system.[2]

"The FSF *Approach-and-landing Accident Reduction (ALAR) Tool Kit* — aimed at preventing ALAs and CFIT — is, perhaps, the most significant product that the Foundation has produced in its more than 50-year history. With the help of the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA) and other major aviation organizations, we will continue in 2003 to support the worldwide ALAR campaign."

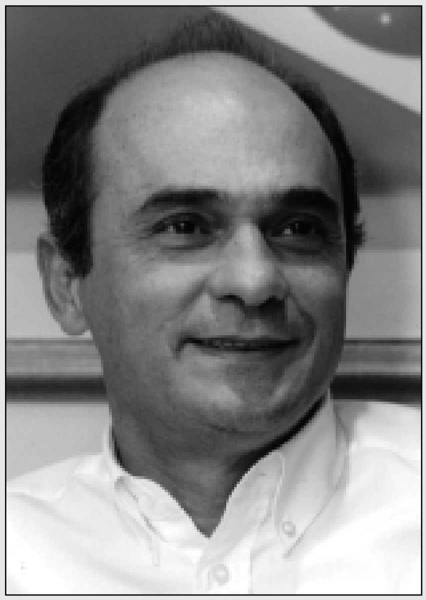
The *ALAR Tool Kit* provides on compact disc (CD) a unique set of pilot briefing notes, videos, presentations, risk-awareness checklists and other tools designed to help prevent ALAs and CFIT. The tool kit is the culmination of the Foundation-led efforts of more than 300 safety specialists worldwide to identify the causes of ALAs and CFIT, and to develop practical recommendations for prevention of these accidents. The tool kit is a compilation of work that was begun in 1996 by an

*Continued on page 3*

## TAM President Sees ALAR as Long-term Investment

The commitment of individual airlines to approach-and-landing accident reduction (ALAR) also can have — by extension — a significant influence on national efforts and regional efforts to prevent accidents, said Daniel Mandelli Martin, president of TAM Brazilian Airlines.[1] TAM has pushed for ALAR awareness beyond its own operations in the belief that aviation safety is a noncompetitive mutual interest among airlines in Brazil, he said.

"We cannot measure directly the return on investment in safety — that is clear," Martin said. "We can measure safety indirectly, however, if something in our operations goes in the wrong direction. For example, an accident would affect the image of the company — something that we can measure. More than this, safety is the most important thing that we all must practice in the airline business because we are transporting people. We must put in practice what we speak, and we must transmit to the customer the reality of what we do internally in safety."



*Daniel Mandelli Martin says that investments in internal/external aviation safety programs generate immeasurable long-term returns.* (FSF Photo)

An effective safety program within each airline begins with a direct reporting relationship between the chief executive of the company and the director of safety. At TAM, for example, this structure enables Capt. Marco A.M. Rocha Rocky, flight safety officer and an Airbus A330 captain, to communicate about emerging safety issues, company safety priorities and resources required to remain involved in safety initiatives at the company level, national level, regional level and international level.

"Capt. Rocky has a direct relationship with me — an open door to talk about new programs or any other aspect of safety," he said. "Together, we try first to put in the minds of our people that safety is the most important thing in airline transportation. One big challenge that we have is integrating new people at TAM, and we are working hard on this challenge. When someone comes to work for us and begins the four-day initial integration period, we try to transfer to them TAM's culture, including how we view safety and our safety methods. They begin hearing about safety from their first day. For example, the flight safety team in Capt. Rocky's department routinely dedicates time — during these company orientations on culture and procedures — to talk about safety policy and the safety procedures that are necessary as part of day-by-day operations. Safety also is part of the syllabus of every class in TAM, whether it covers customer service or crisis management."

At TAM, the flight safety officer also works from an annual fixed budget that is not linked to the performance of the company through financial measures such as increases or decreases in the number of passengers or whether the airline is operating profitably, he said.

"If it is necessary to increase the safety budget for any reason during a budget year, such as a special situation, we treat the request with consideration of the financial side, but safety is not linked to the performance of the company — it is a fixed budget," he said.

This safety philosophy also prompted TAM to invest in flight operational quality assurance (FOQA), among other safety programs. FOQA is a program for obtaining and analyzing data recorded in flight operations to improve flight crew performance, air carrier training programs, operating procedures, air traffic control procedures, airport maintenance and design, and aircraft operations and design.

"We are doing the best we can to accumulate data and analyze data from 100 percent of our flights in our FOQA program," he said. "This has been a good tool that mainly enables us to oversee the performance of procedures for safety reasons — to see how we are flying, how procedures are working and the way to optimize flight profiles — but we can use FOQA for economic reasons, too. This is something new for Brazil, and we want to use FOQA on an open basis, with cooperation and integration with the civil aviation authorities. We want the authorities to understand that this is a tool that must be used just to help us improve safety, to optimize procedures for safety reasons, with no use of data against the company, such as penalty decisions. Brazilian civil aviation authorities must understand that this is a contribution we are making to safety of flight."

Global civil aviation authorities and other government authorities also will play a major role in balancing airline safety requirements and airline security requirements.

"We cannot just transfer to the airlines 100 percent of the costs, the responsibility and the procedures of security," Martin said. "The government and the airlines must walk together in the same direction on safety and security. What is important is that if we have a new requirement for security for any reason, we must have the cooperation of authorities to help us on security procedures. The security issue is linked most closely to the airports and to the government jurisdictions that have police authority. If new security is required, we must invest in security, but we cannot penalize an airline's safety budget."

Membership in Flight Safety Foundation has helped TAM to identify some of the methods that the company has chosen to support ALAR at various levels in the industry, Martin said. For example, the company has paid for staff time, materials, travel and other costs to conduct ALAR workshops outside the company and outside Brazil on behalf of the Pan American Aviation Safety Team (PAAST).

"The Foundation has been a key in the exchange of safety information among airlines, enabling us to know what is happening in other airlines' operational environments," Martin said. "When something that affects safety happens in China, for example, we must know as soon as possible. In turn, we must transmit to China — and Europe and around the world — what is happening here. The Foundation helps us to join in this worldwide effort to implement safety initiatives and to improve safety."

In the context of ALAR, airlines worldwide will benefit from identifying and supporting, among their own safety professionals, individuals who demonstrate and sustain a personal passion for improving safety, he said.

"It is not easy to find someone with the required professional profile to focus on airline safety," he said. "The industry needs many people in aviation safety who decide to dedicate their lives to this purpose: to fly each day with more safety. This work takes a special kind of person who is willing to dedicate a lot of time to providing the airline with all available information about what is happening in the world, and how to avoid the many things that could compromise safety or could cause an unsafe flight. That is more than professional dedication, it is personal dedication; that is more than a matter of money, it is a matter of life."♦

— FSF Editorial Staff

## Note

1. Mandelli Martin, Daniel. Interview by Rosenkrans, Wayne. São Paulo, Brazil, Aug. 9, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

international group of aviation industry volunteers who comprised the FSF ALAR Task Force, which launched the second phase of work begun in 1992 by the FSF CFIT Task Force.[3] The Foundation received the 2002 *Flight International* Aerospace Industry Award for achievement in training and safety; the award cited FSF implementation of a grass-roots ALAR awareness campaign worldwide.

Voluntary efforts and mandatory requirements are being combined to prevent ALAs, including accidents involving CFIT, using data-driven recommendations of the *ALAR Tool Kit*, said Capt. Paul Woodburn, director of safety for IATA and chairman of the 24-member FSF CFIT/ALAR Action Group (CAAG), which presents workshops as part of its ongoing technical support of regionally led ALAR efforts.[4]

CAAG members — who are volunteers from throughout the aviation industry — in 2002 presented or participated in ALAR workshops in Perth and Melbourne, Australia; Rio de Janeiro, São Paulo, Curitiba and Porto Alegre, Brazil; Cairo, Egypt; Reykjavik, Iceland; and Beijing, People's Republic of China, as part of their ongoing technical support for regionally led ALAR efforts.

In January 2002, ICAO formally urged its 187 member states to incorporate the tool kit in their training programs. ICAO Secretary General R.C. Costa Pereira said, "The ALAR Tool Kit has been assessed as containing extremely valuable accident prevention material which will greatly assist accident prevention programs. … States may wish to give urgent consideration to the incorporation of this material in training programs to take maximum advantage of its recognized potential in accident prevention. … Further distribution will be effected on missions related to aircraft operations and air traffic management."[5]

To improve understanding and acceptance, ICAO has been translating elements of the tool kit from English to Arabic, Chinese, French, Russian and Spanish, and began distributing 10,000 copies of the tool kit through its regional safety offices to member states and to attendees at ICAO meetings and ICAO-sponsored workshops. The European Joint Aviation Authorities and the U.S. Federal Aviation Administration (FAA) also have accepted many of the ALAR recommendations, which are forming the basis of revised training requirements for pilots of large aircraft.

"We have seen a high level of interest in ALAR workshops; the number and variety of participants' questions have provided important feedback and showed that participants are very knowledgeable about these issues," Woodburn said. "The IATA 2001 Safety Report shows that there has been a 21 percent increase in ALAs involving Western-built large commercial jets between 2000 and 2001. There also is variation in regional safety performance, so we have to target safety efforts on a regional basis to address differences in performance.

"We need both regulatory encouragement and some requirements, but not to a level of detail that becomes onerous. The remainder of ALAR implementation rests on the shoulders of aircraft operators seeking superior safety performance.

"The objective of CAAG in 2002 was to help establish regional safety organizations that will gain motivation, build momentum, grow larger, have influence and take action to have better safety results — and to ensure that regional team leaders are actively supported by all of the regional industry interests. After establishing ALAR initiatives in 2002, some regional safety teams also have followed this model to address other safety issues that they have identified." Regional team leaders — often a role played by local organizations — are native speakers of the region's predominant languages, have many contacts and credibility in aviation, and are active in the region's aviation community (see "PAAST Leads Implementation in Mexico, Central America, Caribbean and South America," page 11).

As a small sample of ICAO's work — which included participation in CAAG ALAR workshops — the Foundation has received periodic reports during 2002 about activities of the ICAO South America office and Middle East office; Cooperative Development of Operational Safety and Continuing Airworthiness Program–South Asia (COSCAP–SA); and Cooperative Development of Operational Safety and Continuing Airworthiness Program–Southeast Asia (COSCAP–SEA).

The ALAR Tool Kit has been endorsed by some civil aviation authorities and has been incorporated into the training programs of many airlines. For example, in the United States, FAA and the National Transportation Safety Board have cited the *ALAR Tool Kit* as a source of best practices for the industry. FAA purchased 10,000 tool kits for its safety programs in 2002, and the Commercial Aviation Safety Team (CAST) has incorporated the recommendations into its ALAR initiatives within the broader context of a programmed reduction by 2007 of the risk of fatal accidents in U.S. commercial air transportation.

The following update on ALAR activities is based on reports by regional team leaders, FSF staff and other sources in Australia; China; Iceland; Mexico, Central America, the Caribbean and South America; South Africa; West Africa; South Asia; and Southeast Asia.

## Australians Develop Schedule of ALAR Workshops for 2003

Two one-day FSF workshops were conducted in Australia in September 2002 for flight safety professionals representing airlines, the Civil Aviation Safety Authority, military training organizations, on-demand operators, aviation schools and other organizations (see "Two ALAR Workshops in Australia Trigger Implementation Ideas"). Several of the 33 workshop participants agreed to conduct follow-up meetings to plan additional awareness activities, including addition of ALAR briefings to a schedule of aviation safety forums and workshops that might reach aviation professionals in nearly 30 cities and rural areas.

*Continued on page 6*

### Two ALAR Workshops in Australia Trigger Implementation Ideas

The Aviation Safety Foundation Australia (ASFA) hosted Flight Safety Foundation (FSF) Approach-and-landing Accident Reduction (ALAR) workshops in Perth, Western Australia, Sept. 5, 2002, and in Melbourne, Victoria, Sept. 7, 2002. Thirty-three aviation professionals participated in the workshops.

"ASFA asks people in our industry to go one step further in their operations than what is required to comply with regulations of the Civil Aviation Authority of Australia (CASA), so we complement what CASA is doing," said William Mattes, executive director of ASFA and member of the FSF Board of Governors.[1] "We want operators to raise the bar in safety, to think of safety at a higher level that gets to the cultural aspects, so that there is a will to improve within their organization. This means finding methods of addressing safety issues on an incentive basis, rather than the enforcement basis typically used by regulators."

ASFA was incorporated in 1997 as an independent, nonprofit and nonpolitical safety organization to promote aviation safety, establish standards of practice within the industry and coordinate and facilitate independent aviation-safety resources in Australia. The opportunity to engage more organizations in effective use of the FSF *ALAR Tool Kit* is consistent with this basic philosophy, Mattes said.

"The Foundation's support for regional ALAR campaigns is targeting the right people," Mattes said. "If we look at Australia and think in terms of its zero accident rate, we must remember that this represents only the safety performance of operators of large commercial jets. If you look at our safety record in general aviation — such as charters and training — we do not have a good safety record given our benign weather conditions and generally nonhazardous terrain.

"ALAR initiatives fit in very well with ASFA efforts to assist in increasing the level of awareness. They specifically are compatible with our continuing professional-development program for pilots and instructors. Our nation is no different than others in that most accidents occur during the approach-and-land phases. For us, the tool kit has great value in recommending standard operating procedures that can be taken down to the flight-instruction level to make Australia's skies safer."

A related ASFA objective is to accredit members, whose safety programs would be subjected to annual audits. As envisioned, accreditation would qualify members for minimum-risk (lowest-cost) premiums in obtaining aviation-insurance coverage, he said.

"ASFA has set up a technical committee that is working on the accreditation guidelines," Mattes said. "There is no precedent in the nation's aviation industry, but when the complete process has been determined, we hope to have accreditation operating within 12 months. While this is in the development stage, ALAR is a program ready for us to offer, so we are looking at how can complement implementation of the *ALAR Tool Kit* by our members — especially assisting organizations to develop their own ALAR-awareness programs. Having seen how Flight Safety Foundation conducted the ALAR workshop in Perth, I know that ALAR really does help to formalize an organization's method of addressing ALAs. We anticipate more ALAR workshops in Perth, Sydney, Brisbane and Adelaide."

ASFA also wants to make available its new headquarters, which includes a resource/training center, for Australian safety professionals and to cooperate with CASA on ALAR initiatives, he said.

*William Mattes promotes a safety culture in which aircraft operators have a will to surpass minimum regulatory requirements.* (FSF Photo)

Alastair Bridges, program delivery specialist for CASA, said that he expects several methods of cooperation on ALAR training to be considered in 2003. The Foundation's ALAR campaign is familiar to some CASA safety professionals, but how various divisions might become involved in ALAR efforts has not been determined.[2]

"Our people involved in safety education currently use Flight Safety Foundation's *ALAR Tool Kit* and Internet site quite a bit," Bridges said. "CASA conducts flight safety forums annually in eight cities and safety road shows in 20 rural locations. A new CD [compact disc] published by CASA on in-flight decision making contains material about approach-and-landing-accident prevention and prevention of controlled flight into terrain [CFIT]. The *ALAR Tool Kit* is an absolutely excellent product that encompasses just about anything that we might want to use. I have been talking to ASFA's leaders about selecting parts of the tool kit to add to our road show, perhaps inviting ASFA representatives to do presentations geared to flight instructors and charter operators, for example. That would go well with some of the things that we do."[3]

Some pilots who attended one of the workshops said that, despite some unique characteristics of operating in Australia, the tool kit has proven to be readily adaptable to their requirements.

Capt. Gavin Brooks, flight training manager for Southern Australian Airlines (QantasLink) and a British Aerospace BAe 146 pilot and simulator instructor, said, "In a lot of cases, the tool kit articulates well concepts which I had difficulty explaining to other pilots. Nevertheless, I believe that line pilots tend to accept new information more readily than instructors, who sometimes hold on to very strong opinions. One instructor may be able to facilitate, instruct and preach ALAR messages to a line crew — but if the next recurrent session is with an instructor who does not teach the same content, an inconsistent message will come across to the line crew."[4]

Brooks said that the extensive information and search capability built into the tool kit has proved valuable in line-check situations.

"Recently, when I was a line-check pilot, the crew asked about company policy on using a wet, grooved runway for takeoff as if the runway were dry. The organization that trained us did not provide clear cut basis for policies on use of grooved runways. I pulled out my laptop computer in the aircraft, fired up my *ALAR Tool Kit* CD and quickly found as a reference several studies on braking coefficients.

"This was the most convincing source of information we found to show how grooving a runway helps braking performance. We also have included material from the tool kit in our training, such as revising standard operating procedures to include callouts for 'radio altimeter alive' and for acknowledging that the runway is in sight directly in front of the pilot."

Flight Lt. Ray Wurly, a flying instructor for the Royal Australian Air Force (RAAF), said, "ALAs are just as much a threat to us as they are to any aviation organization. What we saw today was very interesting and applicable to our training institution because we train pilots who go on to the transport world. If ALAR training can be incorporated into their conversion training, they will get a backup set of lectures and presentations that will complement what they already have learned in the RAAF pilot's course. For me, a nonprofit, altruistic motivation behind the *ALAR Tool Kit* and the use of data gave this presentation a lot of credibility. More could be said about ALAs in the world of rotary-wing operations, however."[5]

After the September workshops, one group of pilots based in Perth met several more times with colleagues from several parts of Western Australia to plan a series of follow-up ALAR activities in 2003, Mattes said.♦

— FSF Editorial Staff

## Notes


1. Mattes, William. Interview by Rosenkrans, Wayne. Melbourne, Australia, Sept. 7, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

2. Bridges, Alastair. Interview by Rosenkrans, Wayne. Melbourne, Australia, Sept. 7, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

3. Controlled flight into terrain (CFIT) occurs when an airworthy aircraft under the control of the flight crew is flown unintentionally into terrain, obstacles or water, usually with no prior awareness by the crew. This type of accident can occur during most phases of flight, but CFIT is more common during the approach-and-landing phase, which begins when an airworthy aircraft under the control of the flight crew descends below 5,000 feet above ground level (AGL) with the intention to conduct an approach and ends when the landing is complete or the flight crew flies the aircraft above 5,000 feet AGL en route to another airport.

4. Brooks, Gavin. Interview by Rosenkrans, Wayne. Melbourne, Australia, Sept. 7, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

5. Wurly, Ray. Interview by Rosenkrans, Wayne. Perth, Australia, Sept. 5, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

## Chinese Authorities Emphasize English and Technology Upgrades

The Foundation conducted a two-day workshop in Beijing, People's Republic of China, on Sept. 10–11, 2002, at the invitation of the General Administration of Civil Aviation of China (CAAC). The workshop, organized by CAAC, was attended by 112 safety specialists, including airline pilots and managers, CAAC administrators, air traffic controllers and representatives of the CAAC Flying College, Airbus China Training and Flight Operation Support, and the Boeing China Support Organization. Capt. Rao Shao Wu, director general of the CAAC Flight Standards Department, said that China experienced accidents and incidents during 2002 that were relevant to ALAR efforts.[6]

"Airlines have to enhance their safety to prevent further accidents," Rao said. "CAAC conducted safety audits of 16 airlines in the two months preceding the workshop. In these audits, we had a lot of findings. We want airlines to concentrate more on the regulations, their safety systems and their operations manuals — especially to assure that they follow the regulations and their own manuals. It is each airline's responsibility to set up its own safety system and its own self-audit system."

Ma Tao, deputy director general of the CAAC Flight Standards Department, said that among barriers to overcome in China are reaching Chinese aviation professionals who require ALAR materials translated into the national language and introducing ALAR while major changes occur in airline regulation, airline organization and government oversight of civil aviation. For some Chinese pilots — especially captains and first officers ranging in age from 40 to 55 — learning English at the level of proficiency required to fully use the *ALAR Tool Kit* is very difficult, Ma said.[7]

"Today, aviation professionals have to know English aviation language to operate safely — not only for air-ground communications but also for utilization of equipment in the aircraft like TAWS, which generates warnings in English," he said. "All the instruments now have English indications, so pilots have to understand English to safely operate their aircraft. From the mid-1990s, CAAC has had English programs for pilots and regulations requiring all pilots to take English-proficiency tests.

"CAAC regulations say that if you were born after Jan. 1, 1960, you have to pass a test in English air-ground communications and a professional aviation-oriented English test. If you cannot pass these tests, you cannot apply to fly on international routes (including routes to Hong Kong and Macau), and you cannot transition to larger aircraft, like the Boeing 737 and the McDonnell Douglas MD-80. We require pilots born from 1955 to 1960 to pass a test in English air-ground radio communications."

CAAC has developed aviation English courses including textbooks, audio tapes and CDs to help pilots prepare for tests, and has sent pilots for language study in Australia and other English-speaking countries, he said.

Because of rapid economic development throughout the 1990s, China — ranked by ICAO as the world's sixth-largest aviation market — required a larger fleet of aircraft, more pilots and


*Ma Tao (left) and Capt. Rao Shao Wu said that the workshop presented the first opportunity for a wide-ranging familiarization with ALAR.* (FSF Photo) more ground support equipment to handle passengers flying among 10 major cities with the greatest economic development, Ma said. In response to these dynamic changes, most CAAC direct-controlled airlines are scheduled to be reorganized into three groups.

"When airlines reorganize, CAAC will be able to go to one bigger airline — with one operations certification and one operations manual to audit — to do certification and oversight, rather than going to many smaller airlines," Ma said. "When the grouping of airlines is finished, CAAC will function solely as the regulatory agency, regulating and auditing airlines but not managing or operating them. CAAC Minister Yang Yuan-yuan has said that this process will occur after the industry is stabilized, with no deadline, because we have to ensure safety. CAAC believes that these changes will have a positive influence on airline safety."

In this context, CAAC regulations require the use of the traffic-alert and collision avoidance system (TCAS) and TAWS for domestic transport aircraft operating into China's major airports and for all aircraft operating internationally. CAAC is taking action to require that operators install or upgrade equipment on relatively few older aircraft in domestic service that do not have ground-proximity warning systems (GPWS) or TAWS, Ma said (see "China's ALAR Discussions Address TAWS Problems"). With few exceptions, the fleets of major Chinese airlines are relatively new and have equipment compatible with ALAR guidelines, Ma said.

"CFIT prevention was introduced in China through seminars, mainly by Boeing and Airbus," he said. "Very few people in China had received the tool kit before the workshop, so we hoped to bring here all the people who have responsibilities for safety to learn the new developments in accident-reduction programs."

Several pilots at the workshop said that implementing ALAR in China will require a combination of centralized guidance and direction with broad understanding among airlines of the safety benefits.

Capt. Li Jun, director of Boeing 737 flight operations for Air China, said, "The *ALAR Tool Kit* is a very important effort in helping Air China and other airlines to improve their safety. I have been discussing with a colleague that we need to get not only the information in the tool kit, but also the rest of the presentation material from this workshop. We want to collect as much information as possible and try to distribute the elements to every pilot of the Air China fleet. I believe that it would be best that individual airlines be approached with this initiative, and also that we form a national task force to push the implementation."[8]

Capt. Meng Qing Gui, director of the Flight Standards and Training Center and vice chief pilot and instructor-inspector

*Continued on page 9*

## China's ALAR Discussions Address TAWS Problems

Airlines in the People's Republic of China and officials of the General Administration of Civil Aviation of China (CAAC) have worked during 2002 to equip Chinese aircraft fleets with current hardware and/or databases for terrain awareness and warning systems (TAWS) in a time frame consistent with requirements of the International Civil Aviation Organization (ICAO) and the U.S. Federal Aviation Administration, said Capt. David Carbaugh, chief pilot for flight operations safety at Boeing Commercial Airplanes and a member of the Flight Safety Foundation (FSF) Controlled-flight-into-terrain (CFIT)/Approach-and-landing Accident Reduction (ALAR) Action Group (CAAG).[1,2] Carbaugh was a member of the CAAG team that conducted an ALAR workshop Sept. 10–11, 2002, in Beijing, China. The workshop was organized by the Foundation and Boeing Commercial Airplanes and included safety specialists from Airbus, the International Air Transport Association and other organizations from several countries.

Ma Tao, deputy director general of the CAAC Flight Standards Department, said that the workshop provided the first opportunity to bring together Chinese safety specialists to discuss the current international consensus on ALAR, including prevention of CFIT. Among safety priorities in Chinese aviation relevant to ALAR are overcoming language barriers to ensure that all flight crews can take full advantage of current technologies, and completing plans to adopt new technologies and/or to improve their implementation in China.[3]

Ma said, "CAAC regulations currently require the use of traffic alert collision avoidance systems (TCAS) and terrain awareness and warning systems (TAWS) for domestic transport aircraft operating into China's major airports and for all aircraft operating internationally. We are taking action to require that a relatively few older aircraft in domestic service that do not have ground proximity warning systems (GPWS) or TAWS install or upgrade equipment among methods of preventing ALAs." With few exceptions, the fleets of major Chinese airlines are relatively new and have equipment compatible with ALAR guidelines, Ma said.

Fall 2002 was a particularly opportune time for the ALAR workshop because Chinese airlines and CAAC were very motivated by two Chinese airline accidents earlier in the year to provide the latest versions of TAWS on their aircraft, Carbaugh said.

"Our presenters were very heartened to hear that they are pushing this effort because there is a great safety benefit — and to see that they intend to add a mandatory TAWS requirement for the national fleet; that was great news," he said.

The issues involved in adopting current TAWS technology throughout China are not unlike the challenges elsewhere;

they provide examples for many countries' efforts to prevent ALAs and CFIT accidents, he said after a TAWS-related meeting with CAAC Minister Yang Yuanyuan and Ma held apart from the ALAR workshop.


(FSF Photo)

"All Boeing aircraft in China that do not have TAWS currently are equipped with the ground-proximity warning system (GPWS)," Carbaugh said. "To enable TAWS implementation in China to proceed correctly, airlines will need to use the latest version of TAWS hardware and the latest terrain databases, which have a geometric-altitude feature designed to enable the use of procedures involving QFE altimeter settings[5] — the most prevalent system in China — and prevent some nuisance warnings, radar-altimeter problems and other problems. Among 19 database upgrades since TAWS entered service, the last two upgrades have included improved data for China, including four new airports. The Chinese airlines are developing a new infrastructure for retrofitting TAWS hardware and are continually updating TAWS databases."

The Chinese government also will be working to enhance the value of TAWS equipment — as a tool for preventing ALAs and CFIT accidents domestically and internationally — by providing current and accurate aeronautical data to TAWS manufacturers, he said.

"Manufacturers need to have accurate runway-positioning information and terrain data from the Chinese authorities, said Carbaugh. "Typically, about 40 percent of a small number of nuisance warnings that occur in the countries with the most robust TAWS databases are caused by database errors; data show that Chinese pilots have experienced a very large number — perhaps 20 times greater — compared to the rest of the world. We have to solve this problem in order for Chinese pilots to have confidence in this equipment and safer operations."

Carbaugh said that conducting QFE-type flight operations, sometimes with TAWS equipment on an airplane that does not have a new QFE-compatible computer, is another significant part of the problem in China and elsewhere.

"Some operators have the same fleet, but two different airplanes can be equipped two different ways," Carbaugh said. "There has to be a clear process that airlines adopt as they upgrade/retrofit airplanes so that pilots know the status of equipment on the day they are flying a specific airplane. When they turn on TAWS when it is not set for QFE, and then try to conduct a QFE-type operation, the equipment is not going to work. If something changes in terms of terrain or runways before the database contains the change, crews also need to turn off the TAWS or GPWS when approaching the affected airport to prevent unwanted warnings. Otherwise, when flying into China's new airport at Guangzhou, for example, without that runway data in the TAWS database, the system provides warnings as if the aircraft were descending into the dirt. That is a typical database problem in China that we are working to solve."

CAAC and Boeing analyzed a sample of TAWS warnings in China from 11,524 sectors flown in China with Boeing airplanes, Airbus airplanes and Bombardier Regional Jets (RJs), he said. The data showed 489 total TAWS warnings on those flights, including 246 QFE-related problems (that is, crews operating using QFE without the latest database). The data showed that 209 of the warnings were caused by the database and that 23 terrain-closure warnings occurred.

"Terrain-closure warnings are caused by radio-altimeter spikes or situations in which the terrain database is not correct (and contains the wrong height of an obstacle)," he said. "Radio-altimeter spikes occur when an the aircraft crosses a steep ridge line and TAWS logic calculates that

*Capt. Gong Yifang (left), flight operations manager of China Eastern Wu Han Airlines; and Sun Qun Irene, a staff member of the Safety and Technology Center, General Administration of Civil Aviation of China (CAAC); and Capt. David Carbaugh, chief pilot for flight operations safety, Boeing Commercial Airplanes. They discussed a flight during which Gong received a terrain warning from an enhanced ground-proximity warning system (EGPWS) because data for the newly constructed destination airport had not been added to the airplane's EGPWS database.* (FSF Photo) the aircraft is experiencing an abnormally rapid rate of closure with the top of the ridge even though the aircraft actually will clear the terrain. Out of the 23 terrain-closure warnings, the vast majority can be solved by improvements in the terrain database. The exact number of legitimate terrain warnings was not reported, but they included five legitimate warnings of unstabilized approaches. Six equipment problems with early-generation TAWS on Chinese aircraft were resolved by updating to current versions of software."

CAAC officials told Carbaugh that they consider pilot training an important element in every TAWS upgrade, retrofit and database revision, he said. Honeywell believes that by implementing the recommended changes, 489 nuisance warnings and legitimate warnings to pilots would be reduced to about seven legitimate warnings, Carbaugh said.

"Boeing has recommended to CAAC that every transport-airplane-qualified pilot in China should complete CFIT/ALAR training using an initial course that could be implemented in a time frame of a few months," he said. "Whether the initial module involves computer-based training or some form of ground school, the same material then should be provided to Chinese pilots who are beginning their airline careers and to other pilots receiving refresher training. Boeing recommends that, as part of the simulator training that pilots complete for recurrent training, crews should be exposed to CFIT warnings and be required to perform the escape procedures correctly. No airline wants a situation in which any pilot hears the English-language TAWS warnings 'Pull up! Pull up!' or 'Glide slope! Glide slope!' and has to ask what these warnings mean — that situation has happened. Training will provide CAAC leaders and Chinese airline leaders confidence that crews will know immediately what the warnings mean and will perform the correct action. Some of the simulators in China also will need to be upgraded to include the TAWS display and to generate the warnings."

In the years since he was a Boeing instructor, training pilots throughout China in the 1980s, Carbaugh said that he has observed dramatic improvements ranging from new airport facilities in Beijing and other major cities to provide a safer infrastructure for flight operations, including ALAR.

"Chinese aviation officials and airlines are very aware of the tremendous opportunity they have to advance directly from today's ground-based navigation to satellite-based navigation with related cost savings and safety improvements," he said. "This includes making long-term decisions about airplanes that can use current TAWS and the future technology."♦

— FSF Editorial Staff

### Notes

1. Carbaugh, David. Interview by Rosenkrans, Wayne. Beijing, China, Sept. 11, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

2. Controlled flight into terrain (CFIT) CFIT occurs when an airworthy aircraft under the control of the flight crew is flown unintentionally into terrain, obstacles or water, usually with no prior awareness by the crew. This type of accident can occur during most phases of flight, but CFIT is more common during the approach-and-landing phase, which begins when an airworthy aircraft under the control of the flight crew descends below 5,000 feet above ground level (AGL) with the intention to conduct an approach and ends when the landing is complete or the flight crew flies the aircraft above 5,000 feet AGL en route to another airport. Approach-and-landing accident reduction (ALAR), including prevention of CFIT, is an international aviation safety initiative led by Flight Safety Foundation.

3. *Terrain awareness and warning system* (TAWS) is the term used by the European Joint Aviation Authorities and the U.S. Federal Aviation Administration to describe equipment meeting International Civil Aviation Organization standards and recommendations for ground-proximity warning system (GPWS) equipment that provides predictive terrain-hazard warning; *enhanced GPWS* and *ground collision avoidance system* are other terms used to describe TAWS equipment.

4. Ma, Tao. Interview by Rosenkrans, Wayne. Beijing, China, Sept. 10, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S,

5. QFE refers to height above field elevation, involving an altimeter setting that causes the altimeter to read zero feet on the ground. QNH refers to height above sea level (sea level atmospheric pressure), involving an altimeter setting that causes the altimeter to read field elevation on the ground. The Civil Aviation Administration of China is working on plans to convert from standardized use of QFE to QNH in the People's Republic of China; similarly, discussion of conversion of altitudes from meters to feet is being considered.

for Hainan Airlines, said that the workshop exposed him to detailed accident data.[9]

"Hainan Airlines has analyzed data about CFIT accidents, and I was partly aware of the CFIT/ALA problem in the rest of the world," Meng said. "The ALA data presented are very important; they provided the facts and lessons from these accidents and incidents. The *Flight Safety Digest* titled 'Killers in Aviation' should be published in as many languages as possible; sharing this information with the Chinese aviation industry was very helpful in improving safety and in working out correct operating procedures. We need to translate the *ALAR Tool Kit* recommendations into Chinese so that more people can compare these recommendations to their current standard operating procedures [SOPs] to see if there is a better way of using SOPs and manuals. We should enable every pilot and everyone else responsible for flight operations to study ALAR materials on our company network."

Boeing data from 1993 to 2002 for hull-loss accidents and fatal accidents in Western-built large commercial jets showed that China's accident rate was 1.1 accidents per million departures, compared to the worldwide rate of 1.3 accidents per million departures, based on accident data by airline domicile. Participants learned that the rates of CFIT accidents, landing accidents and loss-of-control accidents in China are similar to worldwide rates. In China, ALAs (including CFIT accidents) represented 63 percent of the hull-loss accidents and fatal accidents, and 50 percent of the fatalities.

With a grant from The Friendship Fund, the Foundation provided 2,500 *ALAR Tool Kits* for use in airline pilot training and safety programs of the People's Republic of China. The Friendship Fund, a philanthropic trust based in the United States, was established by Charles R. Crane, who was U.S. minister to China in 1920 and 1921. Crane's grandson, Richard T. Crane, in 1945 was a founder of the Foundation.

## Iceland's Airlines Band Together With Multiple ALAR Solutions

Airlines in Iceland are working together to improve methods of preventing ALAs in international operations and in their challenging domestic operations, said several participants during a workshop conducted by the Foundation on May 21, 2002, in Reykjavik. The workshop was attended by 59 safety specialists, including airline pilots, regulators and accident investigators.

Safety has far-reaching economic implications because the travel industry is Iceland's second-largest business, said Sturla Bodvarsson, Iceland's minister of transport and communications.

The Icelandic Aircraft Accident Investigation Board (AAIB) believes that the *ALAR Tool Kit* has applications in accident investigation as well as in pilot training, said Thormodur Thormodsson, chief inspector of accidents and one of four AAIB members who attended the workshop.[10]

"The workshop touched on the same patterns and statistical outcomes that we have seen in our work and in our investigations," Thormodsson said. "After an incident, we can read through a checklist from the tool kit, for example, and see how an operation could have been conducted safely or how a runway or airport should have been evaluated."

AAIB also considers the tool kit useful for developing ALAR-related safety recommendations as part of accident/incident investigations, he said.

Sigurdur Dagur Sigurdarson, flight safety officer of Islandsflug Icebird Airlines, said, "After this workshop, FSF–Iceland [an independent affiliate of the Foundation] is going to be at full speed in planning to implement the *ALAR Tool Kit*. Members of the Icelandic Airline Pilots Association who attended also are looking at the tool kit very positively. My airline has been using the tool kit in recurrent-training simulator sessions for prebriefing and debriefing."[11]

Capt. Kári Kárason, safety officer of Icelandair, said that Icelandair has adopted a stabilized-approach policy based on the *ALAR Tool Kit* and has distributed to its pilots the FSF CFIT Checklist.[12]

Some flight operations in Iceland involve challenges found in few areas of the world, said Thorgeir Palsson, director general, Icelandic Civil Aviation Administration (ICAA). Among these are natural geography with very little land suitable for airport construction, requiring construction of some airports adjacent to high terrain, in narrow fjords or in locations where other difficulties exist in providing safety areas around runways; about 75 percent mountainous terrain; lack of visual cues because of the sparse population; island weather, including strong winds, severe downdrafts and heavy precipitation; icing conditions; five months to seven months per year of contaminated runways or slippery runways; and winter darkness of up to 19 hours every day. Nevertheless, aviation activities have been increasing rapidly, he said.[13]

Most flying by Icelandic airlines involves about 50 large transport aircraft, a relatively large number for the country's small population, with many aircraft operating exclusively on international routes, said Palsson.

"We are always looking for new opportunities to improve safety; the FSF ALAR initiative is a good example, and we are looking forward to making good use of the tool kit in our expanded safety activities," he said.

FSF–Iceland, which sponsored the workshop, was established June 25, 2001. Members include Air Atlanta Icelandic, Air Iceland, Icelandair, Islandsflug Icebird Airlines and ICAA, said Einar Oskarsson, flight safety officer of Air Atlanta Icelandic. FSF–Iceland's main objective is to improve safety by developing the safety culture of airlines in Iceland, said Oskarsson.[14]

ICAO arranged to provide a copy of the *ALAR Tool Kit* to each participant in the Reykjavik workshop, said Michel Béland, technical officer, Operations/Airworthiness Section, ICAO, and a CAAG member.[15]

After the workshop, FSF–Iceland conducted several meetings to prepare an event in early 2003 to re-emphasize *ALAR Tool Kit* training, said Capt. Hállgrimur Jónsson, chief pilot of Icelandair. Since the release of the tool kit, individual Icelandic airlines have adopted the recommendations, scheduled them into training and shared their experiences.[16]

"The majority of our pilots will do a lot of home study, so we plan for all the airlines to buy the tool kit CD for every pilot through FSF–Iceland," he said. "It will not be enough just to hand each pilot the CD — that is like asking them to take medicine. In Iceland, first we give them a carrot — the kickoff event — saying, 'Here, take a bite.' Once they take a bite, they are OK — but it would be premature to expect pilots to study the tool kit without an introduction and follow-up awareness activities."

Heads of training for Icelandic airlines have decided that each of them would review part of the *ALAR Tool Kit* and share recommendations for a preliminary plan in December 2002 and an implementation plan in January 2003, Jónsson said.

"We assigned some primary tasks to each person, and we are working hand in hand," he said. "We have many different requirements, such as those for small airlines going into airports in narrow fjords. The experience presented in the ALAR workshop by Capt. Andrés Fabre [director, flight operations, Mas Air Cargo in Mexico, and a CAAG member, who presented "Establishing an Operational Safety Culture in a Small Airline and the Implementation of an ALAR Program Accordingly"] seems to be the best model for us. We are continuing to invite representatives from air traffic control and the Icelandic Flight Academy to be involved."

Jónsson said that the newest item on the FSF–Iceland agenda is advocating the development of constant-angle nonprecision approaches (CANPA) — working with Icelandic aviation authorities on preparation of approach charts and with Jeppesen, a publisher of navigation charts and data, on the approach charts and the implementation of SOPs and training.

"FSF–Iceland is advocating CANPA wherever it can apply geographically or it can apply to equipment on the airplane," he said. "At Icelandair, for example, we will focus on CANPA for all our Boeing 757s equipped with the Pegasus FMS [flight management system]. I expect that CANPA development in Iceland will happen over one year to two years."

Other priorities on FSF–Iceland's agenda that complement ALAR efforts include advocacy of flight operational quality assurance (FOQA) for all of the nation's airlines, Jónsson said. (FOQA is a program for obtaining and analyzing data recorded in flight operations to improve flight-crew performance, air carrier training programs, operating procedures, air traffic control procedures, airport maintenance and design, and aircraft operations and design.)

"We believe in FOQA — and we need FOQA programs urgently in Iceland," he said. "We already have identified within Icelandair and Air Atlanta incidents that routine analysis of flight data could have prevented. We are 10 years behind our European colleagues in FOQA, but we can influence Icelandic airlines and authorities through a learning process."

To advance work on an issue discussed at the workshop, Capt. Al Garin, a CAAG member and US Airways pilot, provided technical advice on coordinating an ALAR awareness program for Icelandic air traffic controllers.

## PAAST Leads Implementation In Mexico, Central America, Caribbean and South America

The Pan American Safety Team (PAAST), the first organization to implement a regional ALAR awareness campaign after release of the *ALAR Tool Kit*, worked through an executive team during 2002 to prioritize and select regional safety interventions; a steering team to define prevention activities and prepare safety products; and action teams to deliver products, implement training and measure/validate results.[17]

Action team leaders were selected, trained and deployed in several areas. Action team leaders from ICAO have focused on civil aviation authorities; other action team leaders have focused on airlines and air traffic services.

Key work activities in 2002 included translating parts of the tool kit into Spanish and Portuguese; preparing guidelines for stabilized approaches in English and Spanish; training workshop facilitators and course instructors in several countries; conducting ALAR presentations for airlines of the region through IATA and the Asociación Internacional de Transporte Aéreo Latinoamericano (Latin American International Air Transport Association, AITAL); meeting with civil aviation authorities; publicizing the ALAR awareness campaign extensively through magazines and other aeronautical publications; and conducting numerous seminars, briefings and workshops for pilots.

As of November 2002, PAAST had reached more than 14,500 pilots from more than 44 airlines in the region through its activities that included conducting more than 65 seminars and workshops in 10 countries. Among major meetings in the region were a May 2002 ICAO seminar in Lima, Peru, for airlines of ICAO states in the Caribbean and South America and a presentation to the ICAO Air Navigation Commission in May 2002.

PAAST completed the following objectives in 2002:

- Conducted missions with IATA and ICAO to improve airport infrastructure in the Bahamas, Dominican Republic and Haiti;
- Developed and distributed a CD containing methods for airline safety self-audit in cooperation with AITAL and the Foundation;
- Continued to coordinate a common safety agenda with the ICAO GREPECAS (Grupo Regional de Ejecución y

*Continued on page 14*

## Aeronautical Science Students Confront ALAR in Brazilian Universities

Some leaders of efforts to implement approach-and-landing accident reduction (ALAR) in Brazil believe that, despite wide discussion and implementation of the Flight Safety Foundation (FSF) *ALAR Tool Kit,* more work remains to be done in 2003, said Capt. Marco A.M. Rocha Rocky, co-chairman of the Pan American Aviation Safety Team (PAAST) and flight safety officer and Airbus A330 captain for TAM Brazilian Airlines.[1] PAAST was created in 1998 to encourage participation in aviation safety programs — such as prevention of approach-and-landing accidents (ALAs), including those involving controlled flight into terrain (CFIT) — by people from nations and territories of the Caribbean, Central America, Mexico and South America.[2]

During August 2002, PAAST conducted an ALAR briefing for 45 attendees at the Sindicato Nacional das Empresas Aeroviárias (SNEA, the national airline association of Brazil) in Rio de Janeiro and conducted four-hour ALAR workshops, attended by about 800 aeronautical science students, at the following Brazilian universities: Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS) in Porto Alegre, Rio Grande do Sul; Universidade Anhembi Morumbi in São Paulo; Universidade Estácio de Sá in Rio de Janeiro; and Universidade Tuiuti do Paraná in Curitiba, Paraná. The briefing and workshops were advertised widely as "ALAR Week in Brazil" and aeronautical sciences students from Universidade Veiga de Almeiga participated in the SNEA briefing while some SNEA members attended the university workshops. The SNEA briefing and university workshops were presented by Rocky and by Capt. John Long, a member of the Air Line Pilots Association, International, and a Boeing 757/767 captain for a major U.S. airline. During 2002, PAAST workshops in many parts of Brazil were conducted by Rocky and two members of the TAM Flight Safety Department: Capt. Eros Fonseca, an Airbus A320 captain, and Capt. Geraldo Costa de Meneses Harley, a Fokker F-100 captain.

"Based on discussions during monthly safety meetings of the SNEA Safety Commission, I know that many airlines in Brazil have had parts of the *ALAR Tool Kit* translated into Portuguese for use in training, but I am not convinced that ALAR recommendations have been integrated yet into more than 10 percent of airline pilot training syllabuses," Rocky said. "In spring 2002, I urged other SNEA aviation safety professionals to focus their message on using the tool kit, not to leave this CD [compact disc] unused on the shelf. From answers to my questions about what kind of obstacles and difficulties my colleagues have experienced in implementing ALAR, I have perceived that some believe that simply distributing to pilots a CD and a magazine was sufficient."

*Capt. Marco A.M. Rocha Rocky speaks to students who filled a large aircraft hangar on the campus of Universidade Tuiuti do Paraná in Curitiba, Paraná, Brazil, about how to prevent approach-and-landing accidents.* (FSF Photo)

Rocky said that his main message during the August ALAR briefing at SNEA was that airline management must ensure that their pilots receive effective ALAR training and must not rely solely on the initiative of pilots to learn what they need to know about ALAR.

"Active efforts by management will give pilots the weapons they need to fight against CFIT and ALAs," he said. "I told them, 'It is not only the pilot's task to look for this information; airline management and the civil aviation authorities must have this information at their disposal for pilots and air traffic controllers. By doing this, you also are protecting yourselves.'"

A second message to SNEA attendees was that Brazil will need to expand its corps of ALAR instructors, especially to meet training needs outside of the airlines. To do this, operators that have not enabled their pilots to travel and participate in industrywide ALAR initiatives should reconsider their policies, he said. Otherwise, people become enthusiastic about ALAR opportunities during workshops and discussions but later say that they do not have budgets or staff time to do more. This problem requires more attention from Brazilian airline CEOs, he said. (TAM has distributed 13,000 copies of an ALAR issue of *TAM Safety Digest,* 1,000 VHS-format videotapes and 100 CDs containing information in Portuguese adapted from the FSF *ALAR Tool Kit.*)

Ronaldo Jenkins, coordinator of SNEA and director of aeronautical courses at Instituto do Ar (Air Institute), Universidade Estácio de Sá, said, "This briefing was a reinforcement of information, not new information, for our airlines because they already are involved in ALAR. Our intention is to reach a critical mass, to multiply the effectiveness of information while using the FSF *ALAR Tool Kit.* Airlines such as Varig Brazilian Airlines, TAM and VASP Brazilian Airlines have produced their own training programs and incorporated ALAR into their normal training of pilots. We specifically invited to this briefing other airline pilots who will be involved with training of pilots within their companies because, typically, the company received the tool kit. The important thing is for pilots not only to see the tool kit, but to really know how to use and customize the knowledge inside it to conduct briefings and simulator training. Since 2001, members of the SNEA Safety Commission have been exchanging information about how companies are using the kit in their training, and SNEA has helped its associated companies to overcome difficulties in developing ALAR presentations. Normally, we emphasize the need for company personnel to make ALAR presentations because only they know their own operations."[3]

In addition to using SNEA as a forum for encouraging wider implementation of ALAR initiatives, PAAST has made presentations to civil aviation regulators to build greater understanding and generate support, he said.

For example, the Civil Aviation Department operates seven civil aviation regions, each conducting annually one or more regional safety seminars. In 2001, PAAST urged leaders of these seminars to include three-hour ALAR briefings during many of these seminars, and all regions provided some ALAR training. During 2002, some regions were more active than others in promoting ALAR, Rocky said. For example, one region conducted six voluntary ALAR workshops in a 12-month period attended by approximately 200 pilots per meeting.

"I presented some of the workshops in that region, primarily to general aviation pilots, and I was surprised to find many airline pilots in the audience," he said. "The airline pilots told me afterward that they had seen ALAR ads while they were on layovers in these cities and they decided to attend. One problem with disseminating ALAR information on CDs in Brazil is that only about 15 percent of airline pilots and 10 percent or less of commercial pilots and corporate pilots have personal computers."

Although the August 2002 ALAR workshops were held for the first time at these universities, some university students said that they had attended earlier workshops on ALAR conducted by the civil aviation regions.

"It seemed very logical to me to reach out to future airline pilots this way," Rocky said. "University students are starting their careers in these aeronautical sciences programs. The university program directors told me in March 2002 that they would be more than glad to host this workshop, to send two of their faculty members to the TAM Flight Safety Department for annual one-day training as ALAR instructors, to consider annual faculty-led ALAR workshops on their campuses and to incorporate ALAR into the aeronautical sciences syllabus of each university. After the August workshops, I received a lot of email messages from students thanking the PAAST presenters and requesting more copies of the *TAM Safety Digest* issue on ALAR."

To hold the attention of the student audiences, Rocky said that he made a special effort to punctuate basic ALAR facts, data and recommendations with humorous stories about pilot experiences during landing that illustrate serious concepts, differences in how pilots of large jets perceive risks during takeoff, approach and landing phases compared with pilots of small aircraft, and analogies to nature (noting, for example, that an albatross appears to conduct a graceful takeoff but a disastrous landing).

"I kept giving students examples to make correlations between ALAR facts and real-world operations," he said. "For example, I said that FSF data show that a cargo flight, a repositioning flight or a charter flight involves eight times greater risk of an ALA than a regular passenger flight. I told them, 'On a cargo flight, the boxes do not call the president of the airline to complain. On a charter flight, the pilot may have added risk when landing at an airport for the first time. On a repositioning flight, normally the pilots are alone and they may try to do extra training or press on below minimums.' I also asked students why, in their opinion, these operations involved greater risks."

Data about ALAs and CFIT in Brazil were used throughout the workshops, and students typically said that they were indignant to see Brazil — which has a rate of 0.4 fatal/hull-losses accidents per million departures — represented in charts by the higher accident rate for the Latin American region as a whole. Brazil had no accidents among its large commercial jets in the 1998–2000 period and two nonfatal accidents during 2001.

"Some students said, 'Look how they are considering our 0.4 rate with the rest of Latin America — it is not fair because we have a well-developed aviation industry, infrastructure, training practices, airline operations and aircraft manufacturing in Brazil,'" Rocky said. "I told them that it is up to all of us to challenge and overcome specific misconceptions about Brazil, but I reminded them that the same situation is true in many other countries that have an aviation safety record that is much better than the continent where they are located. This is because of the grouping of countries by the International Air Transport Association and the International Civil Aviation Organization — it is not up to Brazil to change the grouping — but fair people familiar with the accident data will point to Brazil as a positive example."

Students also had many questions about current aerospace technology and future technology to improve safety during approach and landing.

"I repeatedly pointed out to students that although scenes in the ALAR videos kept showing large jets, an ALA can happen to any aircraft at any time — including during their primary flight training," he said. "I told them, 'Having an ALA or CFIT is not a privilege of younger pilots. Do not forget these lessons until the last flight of your life — you could have an ALA on the very last flight before your retirement. From student comments, I am confident that we achieved our goals; I hope that this impression of the importance of preventing CFIT and ALAs really will be with them for the rest of their professional lives — only time will give us the answer."

Maria Regina de Moraes Xausa, director of the PUCRS Faculty of Aeronautical Sciences, said, "I have been extremely impressed with the depth of the FSF *ALAR Tool Kit,* the quantity of material now at our disposal, and the amount of time that was taken to produce this information and to put in place ALAR initiatives. The way that the Foundation has involved people from the region, who speak the language of the region, will help greatly to implement this program. Considering how many students attended and that almost 100 percent of them remained in the workshop for more than four hours, Capt. Rocky and Capt. Long got their attention and won their enthusiasm. Congratulations and thank you for bringing the workshop to our campus because this information will help to keep people alive."[4]

After ALAR Week in Brazil, Rocky sent two copies of the FSF *ALAR Tool Kit,* a Portuguese version of the video "An Approach-and-landing Accident: It Could Happen to You," and 25 copies of the *TAM Safety Digest* ALAR issue to all 87 aero clubs in Brazil as part of the PAAST outreach to general aviation pilots.

"Over time, every student beginning flight training in Brazil will know the basic concepts of ALAR such as a stabilized approach and accident-prevention methods," he said.♦

— FSF Editorial Staff

**Notes**

1. Rocha Rocky, Marco A.M. Interview by Rosenkrans, Wayne. São Paulo, Brazil, Aug. 10, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

2. Controlled flight into terrain (CFIT) occurs when an airworthy aircraft under the control of the flight crew is flown unintentionally into terrain, obstacles or water, usually with no prior awareness by the crew. This type of accident can occur during most phases of flight, but CFIT is more common during the approach-and-landing phase, which begins when an airworthy aircraft under the control of the flight crew descends below 5,000 feet above ground level (AGL) with the intention to conduct an approach and ends when the landing is complete or the flight crew flies the aircraft above 5,000 feet AGL en route to another airport. Approach-and-landing accident reduction (ALAR), including prevention of CFIT, is an international aviation safety initiative led by Flight Safety Foundation.

3. Jenkins, Ronaldo. Interview by Rosenkrans, Wayne. Rio de Janeiro, Brazil, Aug. 6, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

4. Xausa, Maria Regina de Moraes. Interview by Rosenkrans, Wayne. Porto Alegre, Rio Grande do Sul, Brazil, Aug. 9, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

Planificación para el Caribe y América del Sur [Caribbean and South American Regional Planning and Implementation Group]) Aviation Safety Board; and,

- Participated in briefings, regional seminars and conferences of the International Federation of Airline Pilots' Associations (IFALPA).

Several thousand airline pilots, air traffic controllers and others were trained in Mexico and Brazil under the auspices of PAAST (see "TAM President Sees ALAR as Long-term Investment," page 2; "Aeronautical Science Students Confront ALAR in Brazilian Universities," page 12; "Top-down Method Reaches Thousands of Pilots in Mexico," page 15; and "Brazilian Captain Shares CFIT/ALA Accident Experience in ALAR Courses," page 18).

## Airlines in Middle East Tailor ALAR Individually

The Foundation conducted an ALAR workshop March 26, 2002, in Cairo at the request of the Arab Air Carriers Organization (AACO). The workshop was hosted by the Middle East Office of ICAO and EgyptAir for 54 safety specialists from Bahrain, Egypt, Jordan, Kuwait, Lebanon, Oman, Saudi Arabia and Sudan.

AACO, founded in 1965 and based in Beirut, Lebanon, has 19 member airlines in Arab countries from Morocco in the west to Oman in the east, and from Iraq in the north to Sudan in the south. AACO has an aviation training center in Amman, Jordan, and publishes a safety bulletin.

AACO had recognized an increase in the annual number of ALAs and CFIT accidents in the Middle East, said Capt. Mohammed Aziz, Ph.D., chairman of the AACO Safety Subcommittee, chairman of the AACO Security Committee and adviser to the chairman of Middle East Airlines in Lebanon.[18]

"We saw part of Asia progress from nine CFIT/ALAs a year to three accidents a year and Latin America progress from seven accidents to three accidents," Aziz said. "If we go back to 1994, our region had about one of these accidents per year — now the number is about three. This was alarming and made AACO want to intervene."

Based on preliminary Boeing data by airline domicile, the Middle East had 3.4 hull-loss accidents per million departures from 1992 through 2001 involving Western-built large commercial jets. This rate compared with a worldwide average rate of 1.3 accidents per million departures. Landing accidents, CFIT accidents and accidents involving loss of control in flight (including hull losses with fatalities) were the top three types of fatal accidents in the Middle East, as they are worldwide.

*Continued on page 17*

## Top-down Method Reaches Thousands of Pilots in Mexico

Mexican pilots and civil aviation officials have collaborated closely to conduct a 4.5-hour course nationwide on approach-and-landing accident reduction (ALAR). More than 5,300 pilots in 16 cities — about 60 percent of all Mexican pilots — and 80 air traffic controllers attended the course between October 2001 and August 2002, said Capt. Carlos Limón, a Mexicana Airlines pilot representing the International Federation of Airline Pilots' Associations (IFALPA) on the Flight Safety Foundation CFIT/ALAR Action Group[1] and the Asociación Sindical de Pilotos Aviadores de México [Aviation Pilots Union Association (ASPA) of Mexico].[2] The Colegio de Pilotos Aviadores de México (Mexican College of Pilots, an independent professional standards organization similar to a bar association for lawyers) has been at the center of the effort, he said.

Several factors have been responsible for the results to date: early support for ALAR efforts at the highest administrative level of the General Directorate of Civil Aviation (DGAC); the reputation of Colegio de Pilotos throughout Mexico as an ethical organization; a structured top-down method for quality control over materials and instruction; and voluntary efforts by a small corps of pilots who became ALAR lead instructors (to train course instructors) or course instructors, Limón said.

A few Mexican airline pilots discovered the opportunity to conduct an ALAR awareness campaign through their involvement in the Pan American Aviation Safety Team (PAAST), which had monitored closely Flight Safety Foundation's completion of the FSF *ALAR Tool Kit* in spring 2001. Within weeks of the release of the final version of the tool kit, they decided first that Colegio de Pilotos would be asked to support their proposal for mandatory ALAR training, and then that Colegio de Pilotos, in its official advisory capacity, would recommend that DGAC implement this initiative with the Mexican airline industry.

In April 2002, the objective was reached, as DGAC introduced a requirement for all Mexican pilots to attend an approved course on the prevention of CFIT and on ALAR as part of their annual license revalidation. [See "Mexico Works to Integrate CFIT/ALAR Into Pilot Licensing in 2002" in *Flight Safety Digest,* August–September 2001, 2–3.]

To help win DGAC support, Colegio de Pilotos offered the services of a few airline-pilot volunteers as ALAR-awareness specialists, translators of materials into Spanish, lead instructors and managers of workshop logistics on a national scale. DGAC and Colegio de Pilotos agreed that only two pilots would function initially as lead instructors; one lead instructor handled most of the translations of selected material from the tool kit, including video subtitles in Spanish. Later, two more lead instructors were designated.

DGAC and Colegio de Pilotos decided that ALAR instructors had to be professional pilots (whereas many nonpilot aeronautical engineers had been used in the late 1990s to teach CFIT workshops in Mexico). The organizations also decided that any aviation company interested in conducting ALAR courses for pilot-license revalidation would have to submit its course details, curriculum and materials to DGAC for approval and official accreditation. A few schools received the accreditation but, except for Aeroméxico and Mexicana Airlines, operators chose to send pilots to courses conducted under the official sponsorship of DGAC and Colegio de Pilotos, he said.

"Aeroméxico and Mexicana Airlines sent their instructors to Colegio de Pilotos, so when these two airlines present an ALAR course, Colegio de Pilotos provides the certificate for each pilot who attends," he said. "By mid-August 2002, three Mexicana Airlines instructors had provided an ALAR course to about 850 of their pilots, and four Aeroméxico instructors had provided an ALAR course to about 630 of their pilots. All other Mexican airlines chose to have Colegio de Pilotos conduct ALAR workshops for them at their sites."

Lead instructors from Colegio de Pilotos conducted five seminars and trained 45 instructors. Instructors came from the ranks of professional pilots in airlines, the Mexican Navy, the Mexican Air Force and a federal law-enforcement agency. Typical training sites included the Alas de América (Wings of America, an aviation school), DGAC facilities, state government facilities and small aviation schools.

"Not many Mexican pilots wanted this training to be mandatory, but DGAC provided accident data about the reality of ALAR in Mexico and explained their reasons for making the workshops mandatory," he said. "We also told instructors, 'If you want to go deeper into ALAR, just open the tool kit and you will find anything you want for your course.'" Typically, these instructors came from ASPA, but they taught the course as representatives of Colegio de Pilotos.

DGAC authorized Colegio de Pilotos to charge instructors and attendees only for the cost of materials. Elements of the DGAC-approved ALAR course for instructors were the FSF *ALAR Tool Kit*, ALAR materials adapted in Spanish on a compact disc (CD), instructor guidelines, two VHS-format videotapes with Spanish subtitles, posters, attendance forms and official certificates of participation. Course attendees received the CD in Spanish, a binder of course materials and a certificate of participation. Attendees also had the opportunity to buy a copy of the FSF *ALAR Tool Kit* for US$13.

"We wanted all Mexican pilots to get a copy of the *ALAR Tool Kit,* and we encouraged all course attendees to read this very important material," Limón said. "We believe that $13 is a very affordable price in our country."

Nevertheless, Mexican ALAR instructors had to be resourceful and tolerant of less-than-ideal classroom conditions, whether audiences comprised 10 pilots or more than 500 pilots.

"For one course in the city of Monterrey, Nuevo Leon, more than 500 pilots showed up at a location that did not have enough room; some of them became angry at first because they had flown to Monterrey from other cities to attend," Limón said. "Our solution was for the instructor to conduct two seminars on the same day, instead of just the one that we had planned. I conducted one course for about 270 pilots inside a non-air-conditioned aircraft hangar in the city of Chihuahua, Coahuila, a desert area where the outside temperature was about 30 degrees Celsius (86 degrees Fahrenheit); we used a bed sheet for a projection screen and blocked the windows with newspaper pages. In the city of Acapulco, Guerrero, a local bar set up a screen in one room for our ALAR course, and we served everyone cold soft drinks and sandwiches."

One of the benefits of DGAC's early cooperation and support was its ability to advertise ALAR courses to all Mexican pilots through established calendars of events and distribution channels for posters and flyers, such as its network of local offices.

Out-of-pocket monetary costs for instructors involved in Mexico's ALAR campaign proved to be minimal because of arrangements made by Colegio de Pilotos and various forms of support that airline pilots received from employers. Paid days off were provided through ASPA under a union agreement. Meals during travel and accommodations to stay overnight in a city as required were paid by Colegio de Pilotos. Positive-space free-ticket airline flights were provided by airline companies under the same contractual travel arrangement used for union business.

"A few instructors did most of the work, with many others supporting them, but we knew from the beginning that not all instructors could be engaged in the same way," he said. "We did not always know when or where we would need an instructor or when we would require a substitute for a scheduled instructor, but we knew that other instructors would help us with one course or two courses whenever there was a need."

Another reason that having 45 instructors proved valuable was that the lead instructors from Colegio de Pilotos also were invited to conduct ALAR seminars and to share their materials and experience in other countries. By late 2002, lead instructors had visited Argentina, Bolivia, Colombia, Cuba, Dominican Republic, Ecuador, Portugal and Spain. The organization that invited a representative of Colegio de Pilotos typically paid for the presenter's accommodations and meals and, in some cases, airlines in the host country provided courtesy airline tickets; other costs were covered by Colegio de Pilotos.

"I could spend all year accepting invitations outside Mexico; instead, I told these audiences, 'Here is our material; please find local volunteers who want to do this job because we cannot do campaigns in all these countries,'" Limón said. "Nevertheless, at the last meeting of the IFALPA Accident Analysis Committee, we received a standing ovation for the work that has been done in our region, and other IFALPA representatives said that they were inspired to do more in their home regions."

Overall, there has been a far greater commitment to the ALAR awareness campaign by Mexican lead instructors and instructors than ever was envisioned, said Capt. Luis García, who is a Mexicana Airlines pilot, cochairman of PAAST, an ASPA representative and an IFALPA representative. García said that Brazil and Colombia are other examples of countries that have produced campaign leaders whom he calls "ALAR heroes" because of their personal sacrifices — especially time away from their families beyond airline duty schedules.

"Our countries have been passing through very difficult financial situations during the same time as this first ALAR-implementation effort," García said. "Nevertheless, we are still fighting to get out this ALAR message because airline safety also is such a very important part of the economic development of our countries. I tell others, 'If you are convinced that you can make a difference and you have commitment, creativity and passion to compensate for limited resources, you can raise your safety level.' We have done a lot, but we are committed to do more in 2003. PAAST members have learned that it does not matter that you are not a big guy among major airlines; you do not have to have great economic power to do significant work in safety.

"PAAST members also have learned that whenever we have presented our consolidated team and our strong safety agenda, other people who have more resources have been willing to trust us to use additional money in specific ways that will help the industry worldwide. As a result, we are getting help from international organizations such as aircraft manufacturers, airlines, the International Air Transport Association, the International Civil Aviation Organization and the Foundation — and we expect that we will receive more.

"I had an extraordinary experience when I did a presentation about PAAST activities at the 2002 Global Aviation Information Network (GAIN) conference. An airline pilot came up to me and said, 'I need to get more information because I am so impressed, and I want to do the same thing in my region.' Personally, what really impressed me was that he was from Japan, not an underdeveloped country. That tells me that we really are moving the world in the right direction."♦

— FSF Editorial Staff

## Notes

1. Controlled flight into terrain (CFIT) occurs when an airworthy aircraft under the control of the flight crew is flown unintentionally into terrain, obstacles or water, usually with no prior awareness by the crew. This type of accident can occur during most phases of flight, but CFIT is more common during the approach-and-landing phase, which begins when an airworthy aircraft under the control of the flight crew descends below 5,000 feet above ground level (AGL) with the intention to conduct

an approach and ends when the landing is complete or the flight crew flies the aircraft above 5,000 feet AGL en route to another airport. Approach-and-landing accident reduction (ALAR), including prevention of CFIT, is an international aviation safety initiative led by Flight Safety Foundation.

2. Limón, Carlos; García, Luis; Goñi, Angel. Interviews by Rosenkrans, Wayne. Dublin, Ireland, Nov. 5, 2002, and Beijing, China, Sept. 10–11, 2002. Flight Safety Foundation (FSF), Alexandria, Virginia, U.S. Information for this article also came from presentations and meetings during the FSF 55th annual International Air Safety Seminar in Dublin and a workshop on approach-and-landing accident reduction conducted in Beijing by the Foundation and Boeing Commercial Airplanes.

In a 10-year period, ALAs and CFIT accidents comprised 46 percent of the accidents and 24 percent of the fatalities in the Middle East. In a 10-year period, the Middle East had 3 percent of the worldwide ALA hull-loss accidents and 5 percent of the worldwide CFIT accidents but about 2 percent of the worldwide departures. Reviewing ALAs and CFIT accidents by operator region, the combined accident rate in the Middle East was the world's third highest.

In March 2002, AACO formally determined its methods of supporting ALAR campaigns among member airlines, Aziz said. AACO has played an advisory role, and its safety subcommittee has provided support.

"We presented the *ALAR Tool Kit* in AACO committees and recommended introducing the tool kit to all airlines that do not have it yet. We leave the decision to them to use the material the way they want," he said. "Approval of our implementation plan by the AACO Technical Committee was straightforward and very encouraging. We consider safety subcommittee members as the champions of ALAR at their airlines." Each airline provides feedback to the subcommittee about its decisions and methods.

The AACO Safety Subcommittee includes air safety investigators, quality auditors, physicians, pilots, engineers, flight training managers, human factors specialists, operations managers, engineering managers, traffic managers and commercial managers.

Airline campaigns typically include the following components:

- Providing the *ALAR Tool Kit* and related guidance to all training pilots and check pilots;
- Introducing ALAR briefings as part of the license-renewal ground course for pilots of each airline — among airlines that have not taken this step already — to reach all pilots by early 2003, and receiving pilot feedback about the value of having a personal copy of the tool kit;
- Increasing the use of ALAR scenarios in flight simulator training;
- Determining the feasibility of providing a copy of the *ALAR Tool Kit* to all pilots of AACO member airlines and encouraging pilots to review ALAR issues before attending briefings;
- Sharing ALAR-related changes in policies, practices and SOPs among member airlines; and,
- Gathering feedback from airlines after the first year to evaluate the effectiveness of these methods.

"There is one goal but many ways to get there," Aziz said. "For example, translation of ALAR materials is not a problem because all our work is conducted in English — no Arab airline uses a language other than English for technical purposes. Only for the official purposes of some civil aviation authorities might we need ALAR materials in Arabic."

AACO members' preference for *ALAR Tool Kit* materials in English has been "a definite advantage" in quickly adapting the materials to various uses, such as safety briefings and training, he said.

"Many AACO airlines are using the videos and pictures from the *ALAR Tool Kit* because they help pilots to visualize what we are communicating," Aziz said. "The ALAR Briefing Notes, checklists and other elements enable management of our airlines to audit where they stand now and where they can improve."

Some AACO member airlines have more than 100 aircraft and others have one or two; some member airlines have been established for more than 70 years and others were established recently. With few exceptions, the fleets of member airlines are relatively new and have equipment compatible with ALAR guidelines, he said.

"Differences among airlines affect levels of experience and how much money that AACO airlines can spend on safety issues, so established airlines help the newcomers and the small airlines to identify safety threats," he said. "Most newcomers and small airlines do not have opportunities to attend meetings abroad or to participate in international safety initiatives. During AACO meetings in 2002, however, they have learned about all these initiatives."

The importance of aviation safety in attaining national economic goals should not be underestimated, said Ahmed Zerhouni, regional director, ICAO Middle East Office, Cairo. Egypt, for example, is one of the countries where industry leaders understand what safety means for the economic health of aviation, which supports tourism in almost all the countries of the Middle East, Zerhouni said.[19]

"They cannot ignore issues that affect their safety credibility, which they must show to the world," he said.

During 2002, the ICAO Middle East Office was involved indirectly in implementing ALAR, he said. For example, the office encouraged many representatives of large airlines and small airlines to attend the Cairo workshop and to take advantage of the *ALAR Tool Kit*, Zerhouni said.

"CFIT/ALA information is one of the most important things that we have to disseminate — we may need a regional plan as we have for the air navigation system," he said. "Although the *ALAR Tool Kit* is ready to be used, some airlines have internal technical support to create, adapt or organize ALAR materials, but others require outside technical support."

Ideally, training schools in the Middle East would be among the first to incorporate the *ALAR Tool Kit* into their courses, scenarios and simulations, Zerhouni said.

## Coordination Work Continues In South Africa, West Africa

Except for the workshop in Cairo, the Foundation did not conduct ALAR workshops on the continent of Africa during 2002. ALAR workshops were presented in November 2001 in Nairobi, Kenya, and Johannesburg, South Africa.20 Preliminary plans are to conduct one or more workshops in Morocco, Nigeria and West Africa during 2003, said James Burin, FSF director of technical programs and vice chairman of CAAG.21

A number of African airlines worked separately on ALAR implementation during 2002, Burin said. For example, Capt. Tesfaye Zewdie, chief safety officer for Ethiopian Airlines, said that by May 2002, he had provided training to 120 of Ethiopian's 180 pilots, and that the remainder gradually were being trained in weekly classes. Zewdie also said that ALAR training activities would be expanded to include Ethiopian air traffic controllers at Addis Ababa during 2002.[22]

The Foundation did not receive reports on regional efforts from the Africa Aviation Safety Council (AFRASCO), the ALAR regional team leader that prepared six training captains, four aviation safety specialists and nine airlines to organize an ALAR awareness initiative during 2001. Nevertheless, Trevor Fox, IATA's director of regional operations and infrastructure for Africa, said in September 2002 that a new director in Nairobi is coordinating with AFRASCO to implement an ALAR awareness campaign in South Africa and nations of East Africa.[23]

*Continued on page 20*

### Brazilian Captain Shares CFIT/ALA Accident Experience in ALAR Courses

One of the Brazilian airline captains who conducts courses in approach-and-landing accident reduction (ALAR) on behalf of the Pan American Aviation Safety Team (PAAST) often refers to an accident that he experienced to underscore the need for all pilots to conduct stabilized approaches and to follow procedures for every landing. PAAST was created in 1998 to encourage participation in aviation safety programs by people from nations and territories of the Caribbean, Central America, Mexico and South America.

Capt. Geraldo Costa de Meneses Harley, now a Fokker F100 pilot in the Flight Safety Department of TAM Brazilian Airlines, said that while flying for a different company in May 1994 as a 21-year-old first officer on an Embraer Bandeirante E110, the aircraft struck terrain during the crew's approach at São Gabriel da Cachogira, Amazonas.[1] The two pilots and several of the 15 passengers were injured in the accident; the assessment of aircraft damage was not reported, he said. Harley said that he provided information to accident investigators from the Brazil Civil Aviation Department but was unable to obtain a copy of the accident report. The following account of the accident is based only on his recollection.

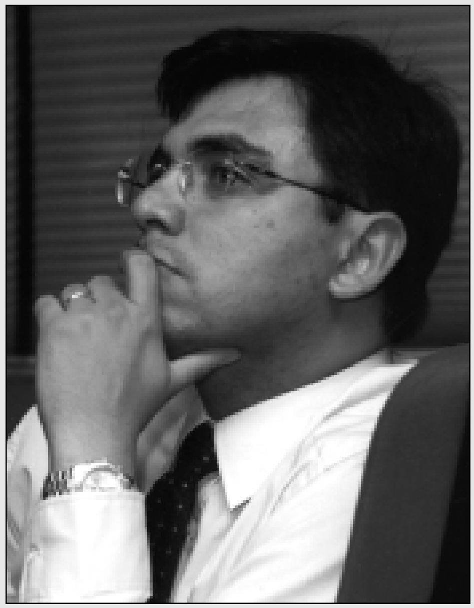
The scheduled air taxi flight had departed from Manaus, Brazil, under instrument flight rules; instrument meteorological conditions (IMC), including cumulonimbus clouds, prevailed in the vicinity of the airport at São Gabriel around 1300 local time, he said. The aircraft was carrying sufficient fuel to fly to a planned alternate airport. Small tree-covered hills were located north of the airport, the Negro River was located south and west of the airport, and a road connecting the airport and the city was west of the airport. The airport had a nondirectional beacon (NDB) adjacent to Runway 05/23 and a published NDB instrument approach procedure.

The captain conducted one NDB approach, which ended in a missed approach when Harley reported that he could not see the runway in IMC at the minimum descent altitude of 1,250 feet. The captain conducted the missed approach and then said that he would conduct a second NDB approach with a descent to an altitude of 1,150 feet and, if necessary, to 1,000 feet. The captain told Harley to watch continually for a familiar road between the city and the airport, Harley said.

In his briefing for the second approach, the captain also said that if Harley reported visual contact with Runway 05 following the procedure turn, he planned to cross over the runway, and make a tight left turn to a downwind leg from which he would intercept final approach for Runway 05. Harley said that he did not remember the altitude at which the captain leveled off the airplane during the second approach.

"He asked me, 'Do you see the airport?' and I told him, 'No, I see the road,'" Harley said. "He told me to keep my eyes on the road and that we would fly along the road to the airport. I said, 'OK, no problem.' When I had visual contact with the runway on my side, I selected flaps-eight and gear down," Harley said. "The captain told me not to lose sight of the runway [during the initial part of the maneuver until the captain had the runway in sight from his side of the cockpit]. When the captain leveled the wings after the tight turn, however, we saw that we were about 45 degrees off the runway centerline, that we could not do the final approach as planned and that there were trees higher than our altitude, so we began a go-around. The captain pushed the throttles to the firewall and established a nose-up attitude; I raised the landing gear. At first, I thought that we were OK. The airplane continued to fly level, however, and did not climb. The first thing that I saw next was the airspeed indicator fluctuating between 120 knots and zero knots — apparently as trees hit and blocked the pitot tube — and I heard scratching noises. We felt the impact of hitting the top of the trees, then we just fell. The airplane hit three times on the ground, near the runway, traveled about 120 meters [394 feet] into the jungle and stopped.

"I remember that the captain was not wearing his shoulder harness and that he hit his head on the glare shield and lost consciousness. I was conscious, but it took a few seconds for me to know what had happened and to believe that this had happened to me. I started to evacuate the passengers out the door and a window emergency exit, but initially we could not open them because trees against the airplane blocked the doors and the window emergency exit. I went back to the cockpit to get the crash ax. Passengers and I opened the door a little bit, and we were able to chop away the tree and open the door."



*Capt. Geraldo Costa de Meneses Harley survived a CFIT/ALA.* (FSF Photo)

Harley said that people at the air taxi operator's station believed that they had heard an airplane strike the ground, and they called the airport's air traffic control tower. Personnel in the tower tried to call by radio the crew of the accident airplane, but received no answer. The tower controller initially would not permit people to go onto the runway because of uncertainty about whether the aircraft crew was still conducting the approach and landing. When another aeronautical facility advised the control tower that an emergency-locater transmitter signal was being received from the airport, however, rescue crews began to search for the missing airplane. Rescuers arrived about 15 minutes or 20 minutes after impact and helped the occupants to exit the airplane, he said.

In retrospect, Harley said that the accident calls to mind many hazards and types of crew errors that have been identified in the Flight Safety Foundation *ALAR Tool Kit,* which has formed the basis of ALAR courses in Brazil and many other countries since 2001.

"This was a very familiar airport, and we often conducted instrument approaches to this runway," he said. "On the accident flight, we believed that we knew where we were, and we had the runway in sight at all times. On other flights, when the ceiling was below visual-flight-rules minimums, we would fly over the river because we knew that the river was a clear area where there would not be any kind of trees or other obstacles. We believed that if we flew at 200 feet below minimums in this part of the region, we would not reach any kind of mountains or similar obstacle.

"We would fly over the river and wait to have visual contact with the runway, then we would conduct something like a combination instrument approach and visual approach. We had done approaches like that a lot of times before — this was normal operation — but an accident never had happened. We did not know of anyone who had crashed while conducting an approach and landing like that. There also can be a tendency to tell yourself that accidents like this happen to the guys over there, but could not happen to us because we know the region so well. There also can be an element of knowing that you are doing something wrong, but you still do it."

Harley said that for a time after the accident, he felt anger about what had occurred. Today, he believes that the experience has provided valuable lessons not only for him but also for other pilots.

"I learned a lot from this accident, and I never will forget it," he said. "From the time I became a captain about six months after the accident, I really have taken care in using the minimums on the charts, and I have respected the procedures. Now as I pass on my experience to others in training, the main point I try to transmit is: An approach-and-landing accident could happen to you. You have to take care at all times. Each approach is a different approach, even if you fly to the same airport two times a day, three days or four days a week. I teach pilots to brief every approach, to brief every chart and to ask if there is something that they missed the last time. I tell them, 'Just do this the way that you have trained to do it.'"♦

## Note

1. De Meneses Harley, Geraldo C. Interview by Rosenkrans, Wayne. Rio de Janeiro, Brazil, Aug. 5, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S. Harley joined TAM Brazilian Airlines in 1996; he has been a Fokker F100 captain for about two years.

Dr. Harold Olusegun Demuren, managing director and CEO of AfriJet Airlines, president of FSF–West Africa (an independent affiliate of the Foundation) and a member of the FSF Board of Governors, conducted an ALAR presentation on behalf of the Foundation during the Aviation Finance for Africa Conference, July 29–30, 2002, in Abuja, Nigeria. Several ministers of aviation from African nations participated in the meeting, and almost all African countries were represented, which substantially increased interest in ALAR, Demuren and Fox said.

## ICAO Group Helps Coordinate ALAR Initiatives in South Asia

During an ALAR workshop sponsored by the Foundation and Boeing in September 2001 in Bangkok, Thailand — following the Association of Asia Pacific Airlines (AAPA)–Boeing Flight Safety Seminar — AAPA helped CAAG to identify the following regional team leaders: COSCAP–SA; COSCAP–SEA; Garuda Indonesia in Indonesia; Yangon Airways in Myanmar; and Thai Airways International in Thailand.

During 2002, COSCAP–SA conducted two-day ALAR workshops in Bangladesh, India, Nepal, Pakistan and Sri Lanka, said Capt. Len Cormier, chief technical adviser, COSCAP–SA.24

COSCAP/SA also made an ALAR presentation to the Directorate General of Civil Aviation of India (DGAC) in New Delhi and said that DGAC is considering a requirement for ALAR training prior to issuance/renewal of pilot licenses. The first South Asia Regional Aviation Team (SARAST) meeting was held in June 2002 and included ALAR among safety interventions on the discussion agenda.

Safety professionals from Indian airlines produced and distributed a comprehensive aviation safety tool on CD containing adaptations of information from the *ALAR Tool Kit* and extensive additional material about landing procedures, runway surfaces, tires, brakes and other subjects.

## ICAO Urges Authorities to Keep ALAR Focus in Southeast Asia

Capt. Larry Meacham, project coordinator/chief technical adviser, COSCAP–SEA, said that a Southeast Asia Regional Aviation Safety Team (SEARAST) was created during 2002 and held a meeting in Bangkok, which included a presentation about the *ALAR Tool Kit*. COSCAP–SEA conducted three-day ALAR workshops in Brunei, Hong Kong, Myanmar and Singapore, and distributed 76 tool kits provided by ICAO, Meacham said.[25]

Six of 12 member states of COSCAP–SEA provided to civil aviation authorities (CAAs) a model flight-operations notice about ALAR training. The notice was designed for CAAs to localize and send to all of their operators of large aircraft. The notice urged all operators in Southeast Asia to review and implement the ALAR Tool Kit to the extent possible by June 2003. COSCAP–SEA also prepared an ALAR report form for use by CAAs and encouraged CAAs to require operators to make a decision about their need to revise SOPs.

Burin said that among other activities reported in the region, Thai Airways incorporated ALAR into operational objectives, and assisted regional airlines in Thailand to obtain copies of the *ALAR Tool Kit*. Malaysia Air added ALAR requirements to base checks for the Airbus A330 fleet in the first half of the year and planned to expand to other fleets; the airline also organized an ALAR seminar. A Malaysian pilots association also began efforts to organize an ALAR action group and a national safety team, he said.[26]

Woodburn, Béland, Burin, Fabre and Garin were joined by the following volunteer members of CAAG, who, with the support of their organizations, were responsible for FSF ALAR workshops on the *ALAR Tool Kit* during 2002: Capt. David Carbaugh, chief pilot for flight operations safety, Boeing Commercial Airplanes; Al Castan, director, operations and infrastructure, IATA Latin America and Caribbean, and co-chairman of PAAST; Capt. Angel Goñi, a representative of the Aviation Pilots Union Association (ASPA) of Mexico and IFALPA, a project leader for PAAST and an Aeroméxico pilot; Capt. Dan Gurney, head of flight safety for BAE Systems; Capt. John Long, a member of the Air Line Pilots Association, International, and a Boeing 757/767 captain for a major U.S. airline; Dick McKinney, a captain retired from American Airlines; Kyle Olsen, manager, continued operational safety, Transport Airplane Directorate, FAA; Richard Slatter, consultant, operations/airworthiness, Air Navigation Bureau, ICAO; and Michel Trémaud, senior director of operational standards development and flight operations safety, flight operations support and line assistance, Airbus.♦

## Notes

1. Matthews, Stuart. Opening remarks at the Flight Safety Foundation (FSF) 55th International Air Safety Seminar (IASS). Dublin, Ireland, Nov. 5, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

2. Terrain awareness and warning system (TAWS) is the term used by the European Joint Aviation Authorities and the U.S. Federal Aviation Administration (FAA) to describe equipment meeting International Civil Aviation Organization (ICAO) standards and recommendations for ground-proximity warning system (GPWS) equipment that provides predictive terrain-hazard warnings; enhanced GPWS and ground collision avoidance system are other terms used to describe TAWS equipment.

3. FSF Editorial Staff. “International Organizations Rise to Challenge to Prevent Approach-and-landing Accidents.” *Flight Safety Digest* Volume 20 (August–September 2001).

4. Woodburn, Paul. Opening remarks at the FSF Approach-and-landing Accident Reduction (ALAR) Workshop, Cairo, Egypt, March 26, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

5. Costa Pereira, R.C. Letter to ICAO member states, Jan. 31, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

6. Rao, Shao Wu. Opening remarks at the FSF ALAR Workshop. Beijing, People’s Republic of China, Sept. 10, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

7. Ma, Tao. Interview by Rosenkrans, Wayne. Beijing, People’s Republic of China, Sept. 10, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

8. Li, Jun. Interview by Rosenkrans, Wayne. Beijing, People’s Republic of China, Sept. 11, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

9. Meng, Qing Gui. Interview by Rosenkrans, Wayne. Beijing, People’s Republic of China, Sept. 11, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

10. Thormodsson, Thormodur. Interview by Rosenkrans, Wayne. Reykjavik, Iceland, May 21, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

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12. Kárason, Kári. Interview by Rosenkrans, Wayne. Reykjavik, Iceland, May 21, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

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14. Oskarsson, Einar. Interview by Rosenkrans, Wayne. Reykjavik, Iceland, May 21, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

15. Béland, Michel. Personal communication with Rosenkrans, Wayne. Reykjavik, Iceland, May 21, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

16. Jónsson, Hállgrimur. Interview by Rosenkrans, Wayne. Dublin, Ireland, Nov. 6, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

17. García, Luis. “Pan American Aviation Safety Team (PAAST): Latin America and the Caribbean.” Presentation at the FSF 55th IASS. Dublin, Ireland, Nov. 5, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

18. Aziz, Mohammed. Interview by Rosenkrans, Wayne. Cairo, Egypt, March 26, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

19. Zerhouni, Ahmed. Interview by Rosenkrans, Wayne. Cairo, Egypt, March 26, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

20. FSF Editorial Staff. “ALAR Regional Implementation Campaign Reaches Key Objective of Introducing Safety Tools in Africa.” *Flight Safety Digest* Volume 21 (January 2002).

21. Burin, James M. Remarks during the meeting of the FSF Controlled-flight-into-terrain (CFIT)/ALAR Action Group (CAAG). Beijing, People’s Republic of China. Sept. 9, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

22. Zewdie, Tesfaye. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S., May 1, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

23. Burin, James. “CAAG Regional Team Leader Progress Summary.” Sept. 9, 2002. Alexandria, Virginia, U.S. Flight Safety Foundation, Alexandria, Virginia, U.S.

24. Cormier, Len. Briefing to South Asia Regional Safety Team. “COSCAP – South Asia ALAR Interventions.” June 26, 2002.

25. Meacham, Larry. E-mail communication with Burin, James. Alexandria, Virginia, U.S. Aug. 17, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

26. Burin. “CAAG Regional Team Leader Progress Summary.” May 22, 2002. Alexandria, Virginia, U.S. Flight Safety Foundation, Alexandria, Virginia, U.S.

# Head-up Displays in Civil Aviation: A Status Report

***Airlines and business aircraft operators worldwide increasingly are recognizing the safety benefits — chiefly, the improvement of flight crew situational awareness — the increased operational capabilities and the associated economic benefits of using HUDs. Enhanced vision systems and synthetic vision systems add to the utility of this tool.***

*FSF Editorial Staff*

Head-up displays (HUDs) first were used as gunsights, but about 30 years ago technological advances enabled them to be used to help military pilots find their targets at night or in low-visibility conditions. Civil aircraft operators have recognized the safety benefits, operational benefits and resulting economic benefits of using HUDs, but implementation has lagged far behind the military.

Currently, that is changing. More than 30 airlines worldwide have equipped at least portions of their fleets with HUDs. Some business-airplane manufacturers offer HUDs as standard equipment; Airbus soon will follow suit in its commercial airplanes. Boeing, which has a HUD as standard equipment in the Boeing Business Jet, is considering doing the same in its commercial airplanes. Manufacturers and operators are embracing or keeping a close eye on emerging technologies, including enhanced vision systems (EVS) and synthetic vision systems (SVS), which increase the utility of HUDs.

"The growing use of head-up displays is a positive trend for improving safety," said Stuart Matthews, president and CEO of Flight Safety Foundation (FSF). "Foundation studies have pointed to HUDs as a potent — and available — tool for safety enhancement."[1]

In 1990, the Foundation completed a contracted study to determine the potential of HUDs to improve civil jet transport safety. Analysis of more than 1,000 accidents that occurred between 1959 and 1989 indicated that a properly functioning HUD operated by a correctly trained flight crew "might have prevented or positively influenced the outcome of 31 percent of the accidents," said the Foundation in its final report.[2]

In 1998, the FSF Approach-and-landing Accident Reduction (ALAR) Task Force identified unstable approaches as a major factor in approach-and-landing accidents. Among the task force's recommendations was that aircraft operators install HUDs that display angle-of-attack information and airspeed-trend information to help flight crews monitor the aircraft's energy state and projected touchdown point during approach.[3]

The International Federation of Air Line Pilots' Associations (IFALPA) has recommended that all jet transport airplanes be equipped with HUDs.

"A HUD contributes to safer flying by increasing the pilot's situational awareness," the association said. "IFALPA believes that tomorrow's modern airliners should have a flight deck designed around the HUD certified as a PFD [primary flight display] for all phases of flight, with full aircraft software and hardware design.

"HUDs should be installed on both the captain's and the first officer's sides of the cockpit in order to provide both pilots with the best possible instrumentation. Dual HUD installation is also desired for monitoring purposes and redundancy."[4]

Capt. Paul McCarthy, vice president, technical, of IFALPA, said, "I have never heard a bad word about HUDs from pilots who use them. Everything you need is in your field of view when you look out the windshield.

"The transition from instrument flight to visual flight during an approach has been problematic for years. The HUD really answers that problem. If you put the 'bird' [flight-path symbol] on your intended touchdown point, you can be assured that is where the airplane is going to go. The landing accuracy facilitated by the HUD can help prevent undershoots, overshoots, landing off the side of the runway and hard landings.

*The combiner is relatively unobtrusive in the cockpit, visible here with a black frame on two sides between the pilot's eyes and the runway.* (Thales Avionics photo by Patrick Darphin)

"Another benefit from a HUD is the ability to do a low-visibility takeoff. Taking off from a coastal airport with a 15-knot, 90-degree crosswind and an RVR [runway visual range] of 600 feet[/175 meters] can be challenging — but not with a HUD."[5]

A typical HUD installation (see photo, page 24) comprises the following line-replaceable units (LRUs — units that can be replaced by line maintenance technicians):

- Computer, which receives data from aircraft sensors and generates display symbology;
- Overhead unit, which includes a cathode-ray tube that projects the image onto the combiner;
- Combiner, a holographic optical element (glass plate or plastic plate), mounted behind the windshield, that reflects the projected image toward the pilot's eyes, while allowing ambient light to pass through (see photo, this page);
- Control panel, which is used by the flight crew to select among various HUD modes and features, and to enter data that the computer does not receive from aircraft sensors; and,
- Annunciator panel, which provides HUD status information and warning information.

*Head-up display* is a common term. HUD manufacturers use other terms. BAE Systems and Honeywell are partners in *visual guidance systems* (VGS). Rockwell Collins Flight Dynamics markets *head-up guidance systems* (HGS). Thales Avionics markets *head-up flight-display systems* (HFDS).

BAE Systems, formed in 1999 by the merger of British Aerospace and GEC–Marconi Electronic Systems, entered the military HUD market in 1962.

"Our launch platform was the [Blackburn] Buccaneer," said Paul Childs, business development manager for BAE Systems.[6] "We entered the civil market around 1997 through a partnership with Honeywell. The equipment, which comprises elements from both Honeywell and BAE Systems, generally is referred to as the Honeywell VGS for the business/regional jet market and the BAE Systems VGS for the air transport sector.

"Total deliveries are now in excess of 13,000, with around 12,500 being for military applications and the rest for civil applications."

Childs said that the BAE Systems VGS is certified for the Boeing 737-800 and that "we also have provisions for certification on all Boeing NG [next-generation] types."

Jerry Moore, Honeywell's manager of marketing and program development for business, regional and general aviation displays, said that the company has delivered between 200 and 300 VGS systems (formerly called the HUD-2020) since it received its first HUD certification, for the Gulfstream Aerospace Gulfstream IV, in 1995.[7]

Gulfstream Aerospace offers the Honeywell VGS as standard equipment on the Gulfstream G400, GV and G550 (GV-SP [special performance]), and as optional equipment for the G300 (a lighter version of the G400) and G500 (a lighter version of the G550).[8]

Flight Dynamics, which was acquired by Rockwell Collins in 2000, entered the civil HUD market in 1986, when it installed HGS systems in aircraft operated by Alaska Airlines.

Thomas Kilbane, director of airline marketing for Rockwell Collins Flight Dynamics, said that HGS equipment currently is in use in about 1,200 civil airplanes. HGS systems are certified for Boeing 727s and 737s; Boeing Business Jet (BBJ); Bombardier Aerospace Challenger 604, CRJ-200, CRJ-700 and Dash 8; Dassault Falcon 2000 and 900EX; Embraer ERJ-145; Fairchild Dornier 328; and Saab 900.[9]

Thales Avionics (formerly Sextant Avionique) began developing HUDs for military aircraft in the 1950s and installed the first HUD in a civil jet transport — the Dassault–Breguet Mercure — in 1975. Thales (pronounced "tallis") HFDS systems are certified for Airbus A320s and A330s; Boeing 737s, 747s and MD-80s; and the Bombardier Global Express.[10]

The Thales HFDS will be standard equipment in the Bombardier Global Express in 2003 and standard equipment in the Global 5000, which Bombardier Aerospace expects to bring to the market in 2004.[11]

Currently, all HUD installations in civil aircraft are single installations — that is, the installations comprise one set of equipment with the combiner on the captain's side of the flight deck. Some military aircraft have twin installations, with combiners on both sides of the flight deck but with a single computer. Only two military jet transports — the Boeing C-17A and the Lockheed Martin C-130J — have dual installations, which comprise two complete and independent sets of equipment. The dual installation in the C-130J also serves as the PFD.

"It is true that in a typical airline operation in a HUD-equipped aircraft, every other landing is made by the copilot without a HUD, but the captain is able to watch the progress of the landing," said IFALPA's McCarthy. "And, if the landing is not progressing properly, the captain can intervene. A dual installation, however, especially one that's also certified as the PFD, would be optimal."

The first HUDs developed for civil aircraft typically displayed the same types of information that are provided on the PFD: airspeed, altitude, localizer, glideslope, etc. Among the newer features of HUDs are flight-path symbols, flight-path-trend vectors, airspeed-trend vectors, angle-of-attack information, runway depictions, landing-flare cues, runway-remaining information, tail-strike warning and unusual-attitude-recovery symbology.

With proper training, flight crews of HUD-equipped aircraft can obtain certification to conduct hand-flown instrument landing system (ILS) approaches to Category IIIa minimums (defined by the International Civil Aviation Organization [ICAO] as a decision height [DH] lower than 30 meters/1,200 feet, or no DH and RVR not less than 200 meters/700 feet) and to conduct takeoffs at specific airports with RVR as low as 75 meters/300 feet. (ICAO does not specify standards for takeoff minimums but says that "commonly acceptable" takeoff minimums for multi-engine turbine aircraft are RVR 175 meters/600 feet or RVR 500 meters/1,600 feet, depending on runway equipment.)[12]

Honeywell's Moore said that HUDs also are useful when conducting approaches in visual meteorological conditions (VMC).

"A head-up display is not dependent on published approach procedures; it is a safety factor also when flying into an airport or a runway that does not have an instrument approach," Moore said. "For example, if you're flying into a black hole[13] at night and you have some runway lights in the distance, you can place your flight-path symbol on the end of the runway and dial up the glideslope on your display and

*The computer (lower left), overhead unit and combiner of a typical HUD installation.*
(Thales Avionics photo by Patrick Darphin)

actually fly an artificial three-degree glideslope to an unimproved runway."

The U.S. Federal Aviation Administration (FAA) has begun to review requests by operators of autoland-equipped aircraft and HUD-equipped aircraft to conduct ILS Category I operations to lower-than-standard Category I minimums. The guidelines for such operations are in FAA Order 8400.13, "Procedures for the Approval of Category II Operations and Lower Than Standard Category I Operations on Type I Facilities."

Southwest Airlines, which has HUDs installed in 345 of its 372-airplane fleet, has received FAA approval to use HUDs to conduct the ILS Category I approach to Runway 4 at Houston (Texas, U.S.) Hobby Airport to a DH of 100 feet. The FAA (and ICAO) minimum standard for a Category I DH is 200 feet.

Rich Willis, the airline's HUD flight instruction specialist, said, "There are several other airlines in the U.S. that have requested such approvals at other airports. I have submitted about 20 requests for Southwest. There is an education problem right now in getting the airport authorities and the FAA to have the confidence and understanding that using a HUD to conduct a Category I approach to lower-than-standard minimums can be done and that it is safe to do. Eventually, I think, we will have a lot of airports where Category I approaches can be conducted to lower-than-Category I minimums with HUDs."[14]

In Europe, Scandinavian Airlines System (SAS) has obtained approval from Scandinavian civil aviation authorities to use HUDs to conduct Category I approaches to specific runways with a minimum RVR of 500 meters/1,600 feet; (the ICAO standard is 550 meters/1,800 feet).

"This equals a HUD credit of 50 meters RVR," said Capt. Orjan Goteman, human factors pilot for SAS. "No credit is given on decision height."[15]

Capt. Goteman said that the Joint Aviation Authorities is in the process of issuing an advance notice of proposed amendment of the Joint Aviation Requirements based on the Scandinavian authorities' approval for SAS to use HUDs to conduct Category I approaches with a minimum RVR of 500 meters.

"The proposal includes more HUD credit for approaches to runways with different approach-light systems than those in the current Scandinavian approval," Goteman said.

SAS currently is conducting trials at Lulea–Kallax (Sweden) Airport to conduct Category I approaches to a 100-foot DH and with visibility as low as RVR 350 meters/1,200 feet.

Currently, 42 of the 137 airplanes in the SAS fleet are equipped with HUDs. Goteman said that SAS began equipping its fleet with HUDs in 1999 because the airline frequently conducts nonprecision instrument approaches to airports with mountainous terrain and "sometimes very interesting weather."

"Other reasons were better takeoff capabilities, the possibility of obtaining approval for lower Category I minimums and to conduct Category II operations at Type I facilities," he said. "The HUD also serves as a platform for new technologies, such as EVS and SVS."

The ability to conduct instrument approaches and takeoffs with lower-than-standard minimums was a factor in the decisions by several other airlines to equip their aircraft with HUDs.

***The ability to conduct instrument approaches and takeoffs with lower-than-standard minimums was a factor in the decisions by several other airlines to equip their aircraft with HUDs.***

Joe Marott, director of the Southwest Airlines Flight Operations Training Center, said, "We have some airports in our system that have weather-related problems, typically fog, at certain times of the year that caused diversions to other airports, and we had to bus people back to the airports where we could not land."[16]

In the early 1990s, Southwest, which conducted only Category I operations, was considering the purchase of Morris Air, which had some Boeing 737-300s equipped with HUDs.

"It was a good time to re-explore our operations and decide whether we wanted to have something in our airplanes that would allow us to operate with lower than Category I minimums," Marott said. "Looking at the weather conditions in cities in both Southwest's system and in Morris Air's system, we realized that there would be a number of days that we might be constrained by weather if we remained a 'Cat I' airline.

"We studied whether it would be best to go with HUDs, as Morris Air had done, or with autoland systems. It became clear that the HUD solution was more cost-effective than the autoland solution and offered a lot more potential operational advantages. One of the advantages was that we would be able to do low-visibility takeoffs, which we could not do with an autoland system.

"Where the HUD had the cost advantage was in recurring maintenance. The autoland system historically had more maintenance cost involved with it than the HUD system. But the overriding issue was the additional operational advantages of HUDs that you do not have with autoland systems."

Marott said that another factor in the decision to equip with HUDs, rather than autoland systems, was the airline's philosophy that favors hand-flying.

"Southwest has always had the philosophy of keeping pilots in the loop, so that if something goes wrong, the pilot already is 'connected' with the airplane and can manually do whatever is necessary," he said. "By its very nature, the autoland system takes the pilot further out of the airplane loop, and the pilot becomes a monitor of what the airplane is doing. By using the HUD, the pilot is flying the airplane manually and is well inside the loop of what is going on."

Marott said that the airline's standard operating procedure when weather conditions are below Category I minimums is for the captain to hand-fly the approach using the HUD.

"The head-up display is probably the most significant safety advance in conducting instrument approaches since the ILS was devised," he said. "It has made it extremely safe to go into low-visibility operations — even more so, to our thinking, than autoland systems."

At Alaska Airlines, the philosophy is different. Although the airline initially equipped its aircraft with HUDs to conduct hand-flown Category III approaches, most of the airline's Boeing 737s now are equipped both with HUDs and with autoland systems, said Capt. Mike DiBello, fleet captain on the airline's B-737-400, -700 and -900; captains use the HUDs to monitor autoland approaches.[17]

Alaska Airlines was the first U.S. airline to equip its aircraft with HUDs. In 1986, the airline installed Flight Dynamics HGS1000 systems in 24 B-727-200s, which were not equipped with autoland systems.

About 70 percent of Alaska Airlines' fleet currently is equipped with HUDs. The airline's B-737-400s and -700s have HGS2000 series HUDs.

"What we have on those airplanes is pretty equivalent to what we had on the 727s," DiBello said. "The 737-900 is coming equipped with the HGS4000, which has some new features, such as tail-strike warning for both takeoff and landing, which is pretty critical, especially because the 900 has a longer body than previous 737s."

The system displays a pitch-limit indication on takeoff and a "TAIL STRIKE" warning, if necessary, on landing.

"The system also displays roll-out guidance for landing, which helps the pilot maintain the runway centerline in low-visibility conditions; a runway-remaining indication for takeoff and landing; a ground-deceleration display; an angle-of-attack display [see photo]; and an improved unusual-attitude display," DiBello said.

The ground-deceleration display indicates braking performance as "1," "2," "3" or "MAX," which correspond to autobrake settings.

*The dial symbol in the upper right corner of the display shows that angle-of-attack is 11.7 degrees.* (Rockwell Collins Flight Dynamics)

"In low-visibility conditions, you really don't have a lot of depth of view, so, whether you're using manual braking or autobrakes, it is difficult to really get a sense of how quickly you are bringing the airplane to a stop," DiBello said. "The deceleration level displayed by the HUD is a backup to reinforce your senses. For example, if you set the autobrakes to '3' and you are seeing a '1' on the HUD, this can alert you that maybe there is more contamination on the runway and you are not getting the deceleration level you want or expect."

The unusual-attitude display is presented when specific flight parameters are exceeded.

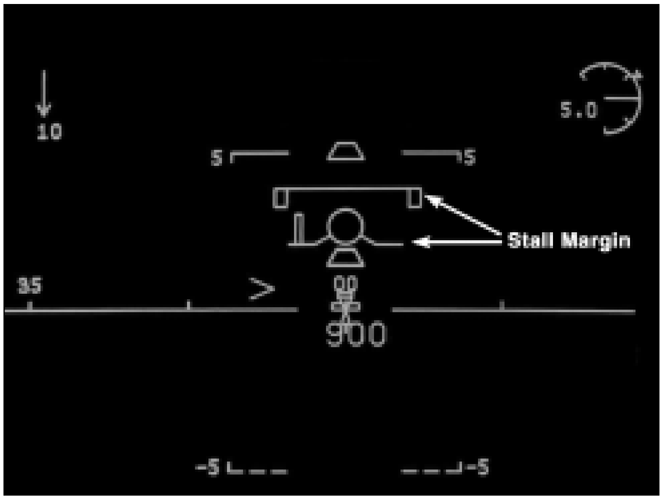
"If the aircraft's pitch attitude exceeds 35 degrees nose-up or 20 degrees nose-down, or if bank angle exceeds 55 degrees, the display is changed to resemble a conventional ADI [attitude director indicator] display with a 'sky-pointer' symbol to improve the pilot's situational awareness of where the horizon is."

Among other features of current-generation HUDs are traffic-alert and collision avoidance system (TCAS) alerts and resolution advisories, stall-margin indications (see photo, page 27) and wind shear warnings and escape guidance.

"If you have a TCAS alert, you want to be 'eyes out,'" said Kilbane of Rockwell Collins Flight Dynamics. "You do not want to be looking down at the TCAS display in the cockpit."

Alaska Airlines flight crews use HUDs to conduct takeoffs with RVR as low as 300 feet at the airline's main hub airport in Seattle, Washington, U.S. DiBello said that the airline expects to obtain FAA authorization to use HUDs to conduct low-visibility takeoffs at Portland, Oregon.

"To me, however, the greatest value from the HUD comes during the transition from IMC [instrument meteorological




*Symbols indicate proximity to aerodynamic stall or to stick-shaker (stall-warning) activation.* (Rockwell Collins Flight Dynamics)

conditions] to VMC, especially during a nonprecision approach," he said. "For example, if you break out on a nonprecision approach and see that the flight-path symbol is well short of the runway, you know that you are going to land short of the runway unless you make a correction. If the flight-path symbol is past the upwind part of the runway, you know that you are going to be high on the approach.

"Many CFIT [controlled flight into terrain[18]] accidents have occurred on nonprecision approaches. Currently, the industry is moving toward constant-angle nonprecision approach procedures, as opposed to the old 'dive-and-drive' procedure. The HUD is another way of monitoring that the angle you are flying to get to the runway is a good angle."

DiBello said that a HUD also would be valuable if smoke entered the flight deck.

"If smoke filled the cockpit, you would not be able to read your primary flight instrument very well; but, because you can adjust the illumination intensity of the HUD, you can see the HUD symbology in a smoke-filled cockpit. The glass [i.e., combiner] is about eight inches [20 centimeters] from your nose."

First Officer Tom Staigle, fleet technical pilot for Delta Air Lines, said that pilots can hand-fly an airplane with more precision by using a HUD.[19]

"Using a HUD is like wearing eyeglasses; you get about a 120-degree field of view without moving your eyes," Staigle said. "Because the combiner is so close to your head, you are looking at an instrument that appears to be eight feet [two meters] wide. You can see the most minute deviations from where you want to be — airspeed or altitude, glideslope, localizer. That is why you can fly such a precise hand-flown Category III approach."

IFALPA's McCarthy agrees that HUDs allow the pilot to "do a better job."

"This is good for the airline," he said. "The better job a pilot can do of making a smooth, controlled landing and deceleration, the happier the people in back [i.e., the passengers] are going to be."

Despite the benefits of HUDs, "it is a hard sell," McCarthy said.

Honeywell's Moore said that one reason civil aircraft operators have lagged behind the military in using HUDs is the price. "It is expensive," he said. A typical installation costs about US$500,000.

Rockwell Collins Flight Dynamics' Kilbane said, "Category III capability is a quantifiable benefit; you can quantify the value of having this capability in terms of schedule reliability. Some of the other features are just as valuable but are more safety-related, and it is harder to make a business case based on the safety features.

"An airline operation is different from a corporate operation in this regard. The corporate operators are less constrained by the requirements of a business case; if they can make a solid argument that the HUD improves the safety of their operation — and they can — then, usually they can justify the investment. The airlines are operating in a tighter financial environment, and there are a lot more things competing for the investment dollar right now. You have to have a very solid business case to get an airline to make a commitment to install head-up displays."

Moore said that publication of an "ARINC characteristic," which comprises standards for the design and manufacture of avionics equipment, likely will accelerate the installation of HUDs in civil aircraft.

"The fact that an ARINC characteristic is being written means that you are probably going to see HUDs on all new types of air transport airplanes from now on," Moore said. "I would venture to say that HUDs probably will be standard equipment on some of them."

Paul J. Prisaznuk, secretary of the Airlines Electronic Engineering Committee (AEEC) HUD Working Group, said that an ARINC characteristic is a set of electrical-engineering standards that define avionics equipment for air transport aircraft and "high-end" general aviation aircraft.[20]

Among the most important standards for HUDs are wiring standards, he said. The ARINC characteristic will define standards for wiring both within the HUD LRUs and for integration with airplane systems.

Prisaznuk said that the HUD standards, which will be published as ARINC Characteristic 764, will have "huge cost-savings implications." He said the standards will allow HUD manufacturers to design and build equipment to industry standards that meet the approval of the airline community. This will allow aircraft manufacturers to pre-wire their airplanes and HUD manufacturers to deliver equipment for a large number of airplanes.

Prisaznuk said that the HUD Working Group in mid-2003 likely will have a "mature draft" of ARINC Characteristic 764 to submit to the airlines for approval.

HUDs currently are available as optional equipment on several civil aircraft models but are standard equipment on only a few, including the Boeing Business Jet and several Gulfstream models.

Capt. Rudy Canto, director of flight operations, technical, for Airbus North America, said that Airbus in 2003 will begin installing HUDs as standard equipment on all of its aircraft.[21]

"We are coordinating the internal design now and how it is going to be integrated into our fly-by-wire cockpit philosophy," Canto said. "In other words, it is not going to be a bolt-on system; we are going to design it from the bottom up and be sure that it is fully integrated into our cockpit philosophy."

Canto said that Airbus will offer a dual HUD installation as an option.

Boeing offers the HGS4000 and the BAE Systems VGS as optional equipment in current B-737 models and is considering offering HUDs as optional equipment in other models in production.[22]

Tom Brabant, communications specialist for Boeing Commercial Airplanes, said that the company currently is evaluating the market to determine whether to make HUDs standard equipment on its commercial airplanes.[23]

***HUDs currently are available as optional equipment on several civil aircraft models but are standard equipment on only a few, including the Boeing Business Jet and several Gulfstream models.***

Capt. Mike Hewett, Boeing Business Jet chief pilot, said that the HGS4000 has been standard equipment in the BBJ since the aircraft was introduced in 1998.[24]

"We saw that corporate aircraft operators were selecting head-up displays as an option," Hewett said. "By equipping and pricing the aircraft with a HUD, data-link capability and some backup navigation capability as standard equipment, we wanted everybody to realize that we were serious about getting into the business jet world.

"And it is easier for us at The Boeing Co. to establish equipment as standard and have all the BBJs come through the line the same way. When you start adding options to an airplane, it increases your manufacturing costs because you have to have new sets of drawings and change things as the airplane comes through the assembly line."

Robert Baugniet, spokesman for Gulfstream Aerospace, said that the company currently offers an EVS as standard equipment on the G550 and as an option for other Gulfstream models.[25] The system projects infrared images from the Kollsman All Weather Window onto a Honeywell VGS.

"This system is the first EVS certified in civil aviation," said Itzhak Hevrony, Kollsman's vice president for commercial and air transport avionics. "The system increases the chances of the pilot seeing runway details by 50 percent."[26]

The Kollsman All Weather Window EVS comprises a forward-looking infrared sensor mounted in the airplane's weather-radar radome and an electronic processor. The sensor captures thermal images of approach lights and runway lights, which emit about three times more infrared energy than ambient light, as well as the thermal images of objects on the airport and of surrounding terrain. The images are processed and presented as conformal images on a HUD. (Conformal means that the infrared images are overlaid on the HUD symbology; the infrared image of the runway, for example, would appear within the HUD-generated outline of the runway.)

Hevrony said that FAA has certified the EVS-equipped Gulfstreams to be flown below the standard ILS Category I approach DH if the pilot observes infrared images of any of the visual cues required by U.S. Federal Aviation Regulations Part 91.175 (e.g., the runway threshold lights, runway end identifier lights, touchdown zone lights, runway lights, etc.) to 100 feet above the runway touchdown zone elevation, where the pilot must observe with unaided vision the visual cues required to continue the approach to landing.

Gulfstream's Baugniet said, "Statistics show that the three major causes of aircraft accidents and incidents are CFIT, runway incursions and approaches and landings in restricted visibility. A common thread is reduced visibility; these types of accidents occur primarily because the crew cannot see well enough to avoid flight into the ground or collision with an object in the takeoff path or landing path. Several studies have concluded that if all flights could be flown with good visibility, or if good visibility could be applied to all flights, then the primary causal factors of these accidents could be eliminated."

Bombardier Aerospace in 2005 will offer an EVS system manufactured by CMC Electronics (formerly Canadian Marconi Co.) and a Thales HFDS as standard equipment in the Global Express and Global 5000.[27]

Rick Beasley, director of enhanced vision systems for CMC Electronics, said that the company's SureSight infrared sensor will be mounted in the nose of the airplane, either in the radome or between the radome and the windshield.[28]

Beasley said that the infrared-based EVS system will give the pilot "a better set of eyes" by capturing images in most weather conditions.

"Infrared can 'see' through most weather conditions," he said. "It can see through some clouds — not all clouds — darkness, snow, scud, rain; but there are some fog conditions that infrared cannot penetrate."

Beasley said that two infrared technologies currently are being developed for EVS; one operates at a relatively long wavelength, the other at a relatively short wavelength.

"For head-up displays, the technology of choice among the aircraft manufacturers is an indium-antimonide sensor, which operates at a wavelength of one [micron (one-millionth of a meter)] to five microns. The other technology is the microbolometer [a device that senses infrared radiation based on the temperature changes induced by the radiation]. The microbolometer works at eight [microns] to 14 microns. The indium-antimonide sensor 'sees' through more weather than the microbolometer; that is why Bombardier and Gulfstream have selected it."

Beasley said that the company also is developing an EVS based on millimeter-wave radar, which operates at a wavelength of 94 gigahertz (94 billion hertz).

"Millimeter-wave radar penetrates most weather," he said. "Some will argue that it penetrates all weather. That is probably true, but we have not tested that yet."

Like weather-radar displays, millimeter-wave-radar displays currently require interpretation by the pilot.

"One of the challenges is to produce an image that a pilot can use when landing an airplane," Beasley said. "The pilot does not have time to interpret a display; the image has to be intuitive — it has to be obvious what you are looking at. I project that millimeter-wave radar is three years to five years away from being ready to be certified for EVS."

Cessna Aircraft Co. in 2003 will offer an EVS system developed by Max-Viz as an option for the Citation X and the Sovereign. The infrared images will be presented on head-down displays in the aircraft.[29]

Dick Hansen, director of operational requirements for Max-Viz, said that the company is seeking FAA certification for two systems: the EVS-1000 and EVS-2000 (the system chosen by Cessna).[30]

"The primary difference is that the EVS-1000 uses a long-wave, eight-micron to 14-micron, microbolometer," Hansen said. "The EVS-2000 comprises two sensors and covers two bandwidths: the long-wave, which is the best wavelength range to image all the background detail, such as terrain, airports and any hazards on airports; and the short-wave, which operates at 1.5 microns, which images peak emissions from the runway-lighting system. The images produced by the two sensors are combined to present a composite view to the pilot.

"The basic concept of EVS is to allow the pilot to 'see' when he cannot see due to darkness, fog, smoke or haze," he said. "There certainly are environmental limitations; EVS does not give you X-ray vision. Infrared penetrates darkness, smog, haze and dust extremely well, but once you start getting into visible moisture, like fog, infrared penetration is reduced. It diminishes rapidly when you get into heavy fog.

"Millimeter-wave radar can overcome most of the limitations of infrared, because it can 'see' through fog and precipitation extremely well. Millimeter-wave radar, when used for EVS, is an active radar system. It sends out a signal, captures returns and assembles an image."

One of the greatest challenges of adapting millimeter-wave radar for EVS is its bulk, Hansen said.

"To make these things operational, we are going to have to put them into existing radomes and not have them interfere with the weather-radar equipment," he said.

Another evolving technology that is being adapted to HUDs is synthetic vision, which involves the display of images assembled from an onboard database.

Dan Baize, SVS project manager for the U.S. National Aeronautics and Space Administration (NASA) said, "We have concepts in which the entire database could fit on a single CD [compact disc] — about 600 megabytes — all the way up to many, many gigabytes. It depends on the intended function of the database, whether the data will be used for advisory purposes or will be flight-critical and intended for sole means of navigation."[31]

NASA has conducted flight tests of an SVS in a Boeing 757 at Vail, Colorado, U.S. The test database included terrain and obstructions, landing and approach patterns, and runway surfaces at the Vail airport.

Baize said that NASA is blending images generated by an SVS with images derived from infrared sensors and millimeter-wave radar.

"The goal of the project, which will continue into 2005, is to mature the technology sufficiently — to reduce the technical risk — so that industry can go forward with this kind of system to help prevent CFIT accidents and runway incursions," he said.

Kilbane, of Rockwell Collins Flight Dynamics, said that the company is developing a surface-guidance system based on SVS technology.

"Synthetic vision is similar to TAWS [terrain awareness and warning system[32]], which has a big terrain database," Kilbane said. "Instead of using a forward-looking sensor, we are using a database aboard the airplane to draw an image of the terrain and present the image on the combiner.

"The beauty of SVS is that it is not subject to the limitations of a sensor. The disadvantage is that if an object is not in your database, it is not going to show up on the display. For example, an airplane on the runway will not be displayed.

"With SVS, we are taking advantage of the head-up display after the airplane has touched down to provide guidance to the pilot to get him from the active runway to the gate. We see a huge opportunity here, because that is often the most challenging phase of flight. Pilots have fully automatic systems to get the airplane on the ground in low visibility, then they are lost in a sea of blue lights on the tarmac, trying to figure out where they are, particularly at an unfamiliar airport."♦

## Notes

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13. The *black hole* effect typically occurs during a visual approach conducted on a moonless or overcast night, over water or over dark, featureless terrain where the only visual stimuli are lights on and/or near the airport. The absence of visual references in the pilot's near vision affect depth perception and cause the illusion that the airport is closer than it actually is and, thus, that the aircraft is too high. The pilot may respond to this illusion by conducting an approach below the correct flight path (i.e., a low approach).

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19. Staigle, Tom. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S., 5 November 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

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25. Baugniet.

26. Hevrony, Itzhak. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S., 30 October 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

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30. Hansen, Dick. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S., 14 November 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

31. Baize, Dan. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S., 18 November 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

32. *Terrain awareness and warning system* (TAWS) is the term used by the European Joint Aviation Authorities and the U.S. Federal Aviation Administration to describe equipment meeting ICAO standards and recommendations for ground-proximity warning system (GPWS) equipment that provides predictive terrain-hazard warnings; *enhanced GPWS* and *ground collision avoidance system* are other terms used to describe TAWS equipment.

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# Data Show Final Approach and Landing Remain Riskiest Phase of Flight

***Data compiled by The Boeing Co. show that the majority of hull-loss accidents and/or fatal accidents among Western-built large commercial jets from 1992 through 2001 occurred during final approach and landing. Accidents that occurred during climb (flaps up) included more fatalities than accidents that occurred during other phases of flight.***

*FSF Editorial Staff*

Data compiled by The Boeing Co. show that, of 233 hull-loss and/or fatal accidents that occurred from 1992 through 2001 among Western-built large commercial jet airplanes,[1] 54 percent of accidents occurred during final approach and landing, even though that phase of flight is estimated to account for 4 percent of flight time (Figure 1, page 33).[2] Twenty-two percent of the 6,714 fatalities occurred during final approach and landing.

Boeing's data include commercial jet airplanes with maximum gross weights of more than 60,000 pounds/27,000 kilograms. The data exclude airplanes manufactured in the Commonwealth of Independent States because of a lack of operational data. Commercial airplanes in military service also are excluded, as are aircraft destroyed during experimental test flights and as a result of military action, sabotage, hijacking and terrorism (including the Sept. 11, 2001, attacks involving four airplanes in the United States).

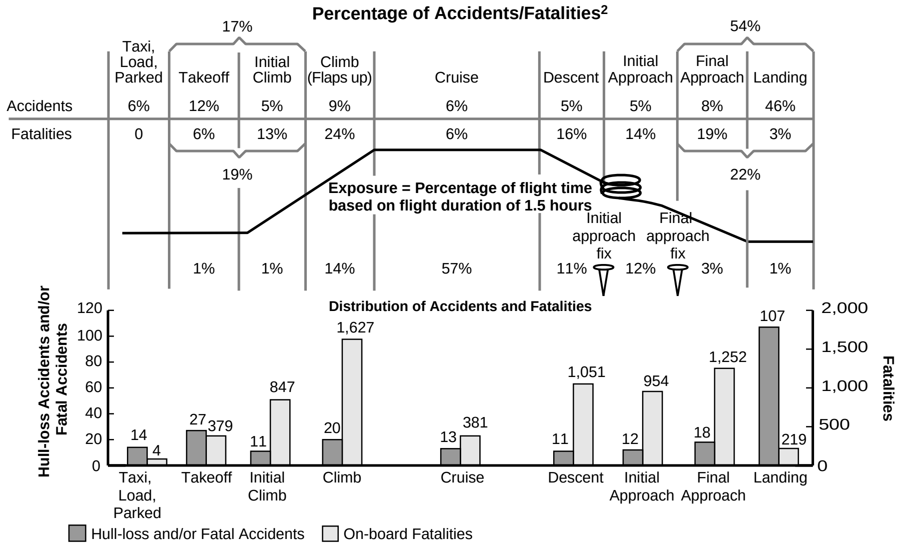
The data also show that 17 percent of accidents and 19 percent of fatalities occurred during takeoff and initial climb and that 9 percent of accidents and 24 percent of fatalities occurred during climb (flaps up).

Of 112 fatal accidents from 1992 through 2001, 28 percent resulted from loss of control in flight and 24 percent were controlled-flight-into-terrain (CFIT) accidents (Figure 2, page 33).[3] Of the 6,924 fatalities (including 6,714 on-board fatalities and 210 fatalities involving people not in the airplanes), 34 percent resulted from loss-of-control accidents and 31 percent resulted from CFIT accidents. The remaining 35 percent of the fatalities occurred in accidents in 13 other categories.

Of 210 hull-loss accidents that occurred from 1992 through 2001, investigative authorities identified the causes of 149 accidents (71 percent). Causes of the remaining 61 accidents (29 percent) were unknown, either because accident investigations were continuing or because investigators had not identified a cause (Figure 3, page 34). Of the 149 accidents, the primary cause of 66 percent involved

# Accidents and On-board Fatalities by Phase of Flight

## Hull-loss and/or Fatal Accidents — Western-built Large Commercial Jet Airplanes — 1992–2001[1]




[1]Data include airplanes heavier than 60,000 pounds/27,000 kilograms maximum gross weight, except those manufactured in the Commonwealth of Independent States, commercial airplanes in military service, and those involved in experimental test flights, military action, sabotage, hijacking and terrorism.

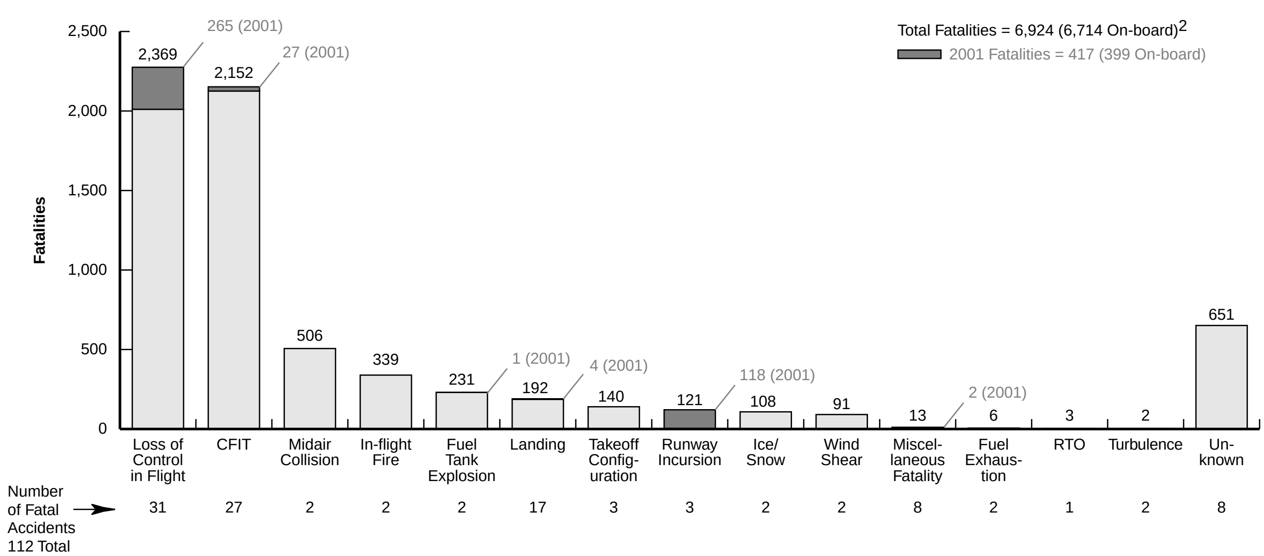
[2]Percentages do not total 100 because of rounding.

Source: The Boeing Co.

**Figure 1**

# Fatalities by Accident Category

## Fatal Accidents — Western-built Large Commercial Jet Airplanes — 1992–2001[1]




CFIT = Controlled flight into terrain RTO = Refused takeoff

[1]Data include airplanes heavier than 60,000 pounds/27,000 kilograms maximum gross weight, except those manufactured in the Commonwealth of Independent States, commercial airplanes in military service, and those involved in experimental test flights, military action, sabotage, hijacking and terrorism.

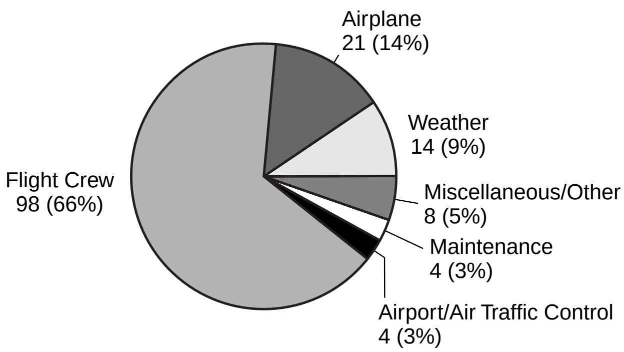
[2]Accidents involving multiple fatalities not aboard the airplane are included; accidents involving single fatalities not aboard the airplane are excluded.

Source: The Boeing Co.

**Figure 2**

## Accidents by Primary Cause[1]

**Hull-loss Accidents — Western-built Large Commercial Jet Airplanes — 1992–2001[2]**




**Total with known causes = 149**
**Unknown causes or awaiting reports = 61**
**Total = 210**

[1]Primary cause as determined by the investigative authority.

[2]Data include airplanes heavier than 60,000 pounds/27,000 kilograms maximum gross weight, except those manufactured in the Commonwealth of Independent States, commercial airplanes in military service, and those involved in experimental test flights, military action, sabotage, hijacking and terrorism.

Source: The Boeing Co.

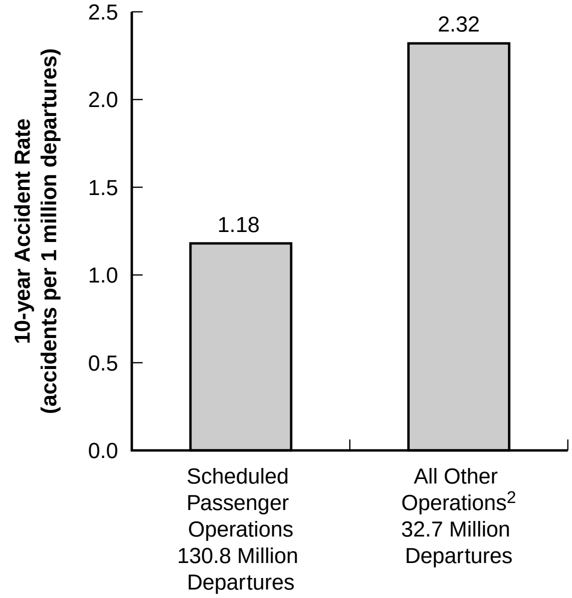
**Figure 3**

the flight crew. The airplane was cited as the primary cause in 14 percent of the accidents, weather was cited in 9 percent, miscellaneous/other was cited in 5 percent, and maintenance and airport/air traffic control each were cited in 3 percent.

The data show that the 10-year accident rate from 1992 through 2001 was 1.18 per 1 million departures for scheduled passenger flights (Figure 4). For all other operations (unscheduled passenger flights and charter flights, cargo flights, ferry flights, test flights, training flights and demonstration flights), the accident rate was 2.32 per 1 million departures.♦

## Accident Rates by Type of Operation

**Hull-loss and/or Fatal Accidents — Western-built Large Commercial Jet Airplanes — 1992–2001[1]**




[1]Data include airplanes heavier than 60,000 pounds/27,000 kilograms maximum gross weight, except those manufactured in the Commonwealth of Independent States, commercial airplanes in military service, and those involved in experimental test flights, military action, sabotage, hijacking and terrorism.

[2]Category includes unscheduled passenger flights and charter flights, cargo flights, ferry flights, test flights, training flights and demonstration flights.

Source: The Boeing Co.

**Figure 4**

## Notes

1. The Boeing Co. defines a hull loss as airplane damage that is substantial and beyond economic repair. Hull loss also includes events in which an airplane is missing, a search for the wreckage has been terminated without its being located, or an airplane is substantially damaged and inaccessible.

2. Calculations were based on an average flight duration of 1.5 hours.

3. Boeing defines a controlled-flight-into-terrain (CFIT) accident as "an event where a mechanically normally functioning airplane is inadvertently flown into the ground, water or an obstacle (not on airport property while attempting to land)."

   The Flight Safety Foundation definition differs slightly. The Foundation says that CFIT occurs when an airworthy aircraft under the control of the flight crew is flown unintentionally into terrain, obstacles or water, usually with no prior awareness by the crew. This type of accident can occur during most phases of flight, but CFIT is more common during the approach-and-landing phase, which begins when an airworthy aircraft under the control of the flight crew descends below 5,000 feet above ground level (AGL) with the intention to conduct an approach and ends when the landing is complete or the flight crew flies the aircraft above 5,000 feet AGL en route to another airport.

## Publications Received at FSF Jerry Lederer Aviation Safety Library

# Report Describes Development of System for Analyzing Human Error in Air Traffic Management

***The system, developed by Eurocontrol and the U.S. Federal Aviation Administration, is designed to identify the human factors that result in human error in airspace incidents.***

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*FSF Library Staff*

## Reports

***Development of an FAA-Eurocontrol Technique for the Analysis of Human Error in ATM***. Pounds, Julia; Isaac, Anne. U.S. Federal Aviation Administration (FAA) Office of Aerospace Medicine (OAM). DOT/FAA/AM-02/12. July 2002. 26 pp. Figures, tables, appendix, references. Available on the Internet at <www.cami.jccbi.gov> or through NTIS.*

Although human error is a dominant risk factor in safety-oriented industries, including air traffic control (ATC), little is known about the factors leading to human error in air traffic management (ATM) systems. (ATM includes both ATC and air traffic flow management, which monitors the flow of traffic in constrained areas in an effort to increase efficiency.) As the capacity and complexity of airspace increase and ATC develops more advanced interfaces and more computerized support technology, the need to identify human factors that lead to human error will increase.

FAA currently uses the Human Factors Analysis and Classification System (HFACS), which was developed by the U.S. Navy, to investigate civil aviation accidents and causal factors in ATC operational errors. Eurocontrol developed and uses the Human Error Reduction in ATM (HERA) system for retrospective analysis of airspace incidents and for prospective analysis during ATM system development.

This report describes the activities undertaken to explore the possibility of harmonization of HFACS techniques and HERA techniques. As the activities progressed, specialists in ATM determined that the techniques were compatible and began harmonizing their elements. The result was an integrated approach called Janus, which is undergoing experimental testing within the U.S. ATM system and by seven member states in the European Civil Aviation Conference.

## Books

***Mayday***. Winslow, John. Fyshwick, Australia: Aerospace Publications, 2002. 114 pp. Photographs, glossary.

The book describes 17 events in which statistical odds and unfortunate circumstances created challenging and life-threatening experiences for crewmembers who overcame unusual difficulties to return damaged aircraft to earth. The author discusses some of the many significant advances in aviation safety that have followed accidents and incidents, especially those in which aircraft were landed and investigation teams subsequently determined what had occurred.

***The Mammoth Book of Fighter Pilots***. Lewis, Jon E., Ed. New York, New York, U.S.: Carroll & Graf Publishers. 2002. 496 pp. Appendixes.

The editor describes his anthology as one that discusses "the perennial question of the earthbound: What is it like to be a fighter pilot?" The book tells the stories of 50 air battles — first-hand accounts of great military campaigns of aerial warfare from 1914 through 1991. Included in the accounts are descriptions of combat aircraft and various facets of fighter pilot life, such as bailing out in enemy territory and being shot down. The air battles are described in chronological order to give readers an appreciation of the changing experiences, tactics and machinery of aerial warfare.

## Other Reading

***IS-BAO: An International Standard for Business Aircraft Operations.*** International Business Aviation Council (IBAC). Montreal, Quebec, Canada: IBAC. 2002. 130 pp. Appendix, compact disc, loose-leaf manual, bound manual. Available from IBAC.**

IS-BAO was developed by the business aviation community to promote global harmonization of quality operating practices for business aircraft operations on the regional level, the national level and the international level. IS-BAO was based on generally accepted principles of other international standards and was designed to be compatible with operator certification. The IS-BAO manual says that the IS-BAO standard represents "'base-line' requirements which operators should apply in structuring and staffing their flight departments and planning and conducting their operations." The standard applies to operators of multi-engine, turbine-powered, pressurized aircraft but may be adapted to other types of aircraft.

The primary document in the IS-BAO package is a loose-leaf manual that discusses topics including safety management systems, organization and personnel requirements, training and proficiency, flight operations, operations in international airspace, aircraft equipment requirements and aircraft maintenance requirements. Other materials included are a bound generic company operations manual (GCOM) to guide flight department personnel in executing their duties and a compact disc (CD). The CD contains an electronic copy of the IS-BAO loose-leaf manual and four versions of the GCOM (two of which are described as "regular" versions and two Joint Aviation Requirements — Operations versions).

***Ground Vehicle Operations on Airports***. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5210-20. June 21, 2002. Illustrations, appendixes. 24 pp. Available from GPO.***

Airport accidents and incidents involving aircraft, ground vehicles and pedestrians result in property damage, injuries and fatalities. Causes of these events vary, but causes related to ground vehicle operations may be preventable with corrective action, such as improved visual aids for vehicle drivers or changes in vehicle operator training. This AC provides guidance to airport operators in developing training programs for safe airside pedestrian movements and ground vehicle movements. The AC discusses vehicle requirements and operator requirements; vehicle access and control; routine, non-routine and emergency operations; situational awareness; and enforcement. Sample guides and manuals suggest training topics, rules and regulations, signs and markings, and communication techniques.

***Voluntary Industry Distributor Accreditation Program.*** U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 00-56A. June 13, 2002. Appendixes. 14 pp. Available from GPO.***

Parts distributors are a major source of products for commercial aircraft operators and others in the aircraft industry. FAA does not directly regulate distributors but relies upon third-party accreditation programs (not programs conducted by distributors or purchasers) to provide quality system standards that are subsequently audited. This AC describes a system for accreditation of civil aircraft parts distributors and provides information for developing accreditation programs. Included in the AC are a list of minimum acceptable criteria for an accredited distributor's quality system; a list of quality system standards organizations and related responsibilities, procedures and qualifications; instruction on arranging audits; and information for distributors approved by civil aviation authorities having bilateral agreements with FAA.

[This AC cancels AC 00-56, *Voluntary Industry Distributor Accreditation Program*, dated Sept. 1, 1996.]♦

## Sources

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

** International Business Aviation Council (IBAC)
9999 University St., Suite 16.33
Montreal, Quebec, H3C 5J9, Canada
Internet: <www.ibac.org>

*** Superintendent of Documents
U.S. Government Printing Office (GPO)
Washington, DC 20402 U.S.

## Accident/Incident Briefs

# Boeing 747 Door Handle Unlocks During Transoceanic Flight

***After the handle moved toward an unlocked position early in the flight, maintenance personnel told the captain that cabin pressure would keep the door closed; just before landing, the handle moved farther in the unlocked direction, and a flight attendant tried to hold the handle in place for the remainder of the flight.***

*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.*

### Technical Logbook Showed Repeated Problems With Door Handle

*Boeing 747. No damage. No injuries.*

About 40 minutes after departure from Australia on a flight to Japan, the flight crew observed the warning light for the no. 5 (left-main) entry door. The flight engineer checked the door and observed that the door handle had moved from the fully locked "4 o'clock" position to an unlocked "3 o'clock" position.

The flight engineer and a cabin crewmember were unable to move the handle back to the fully locked position. A check of the airplane's technical logbook revealed that the problem had occurred previously. The captain radioed maintenance personnel, who said that the door would not open because the cabin was pressurized and that the flight could be continued to its destination.

The accident report said that cabin crewmembers monitored the door for the remainder of the flight. Just before landing, the door handle "jumped to the '2 o'clock' position, at which time a loud wind noise could be heard," the report said.

"Leaving his seat, the flight attendant grabbed the handle and forced it down," the report said. "Paper was observed being sucked under the door as the passenger seated directly in front of the door (adjacent to the window) turned and grabbed the door handle, giving assistance in pushing the handle down toward the locked position. The handle reached the horizontal 3 o'clock position with the flight attendant keeping weight on it until the aircraft had [been] landed and [had been] taxied to the terminal."

After the flight, maintenance personnel performed a minor adjustment of the door upper gate. The next two flights were uneventful, but on the third flight, the warning light again illuminated and the door handle again moved from the fully locked position to the unlocked 3 o'clock position.

"On arrival at the destination, an inspection by engineers found the force required to move the door handle from the locked [position] to unlocked position was lower than required, necessitating further adjustments to the door," the report said.

The airplane was flown on two additional flights — with no reported problems — before it was returned to the main base, where maintenance personnel removed and disassembled the door and inspected the door bearings. No defects were found. The door was reinstalled on the airplane, and a rigging check was performed before the airplane was returned to service.

After the incident, the operator reviewed door-rigging procedures and required that if door-rigging defects occur, "a full door-rigging procedure should be carried out in accordance with the maintenance manual and scheduled in a 'heavy maintenance' environment."

## Airplane Strikes Baggage Vehicle Parked Near Gate

*Airbus A320. Minor damage. No injuries.*

After landing at an airport in England on a rainy night, the flight crew taxied the airplane to the gate, which was located near the taxiway in a position that offered the flight crew little time to observe the gate area after turning onto the taxiway centerline. The captain believed that the gate was clear, and he observed that the gate guidance system appeared to be operating correctly. He complied with standard operating procedures to turn off the airplane's taxi lights before turning into the gate. He followed the centerline guidance system and stopped the airplane at the position indicated by the parallax aircraft parking aid. He then was told that the outer side of the no. 1 engine nacelle had struck a parked vehicle.

The accident report said that the vehicle — an unattended pair of baggage belt loaders that belonged to another airline — had been parked in the gate area by a ground crew working on another airplane that had been taxied out of the area. The baggage vehicle was outside the area marked for safe parking of vehicles.

"The flight dispatcher, who was responsible for ensuring that the stand [gate] was clear of obstructions, was busy checking details of the cargo load on the incoming aircraft, so he asked the ramp agent to turn on the stand guidance systems," the report said. "The ramp agent agreed to do this and, believing the stand to be clear, turned on the guidance systems."

The report also said that rain and darkness obscured the flight crew's view of the area and that, after the airplane was positioned on the gate centerline, the baggage vehicle would have been hidden from the first officer's view.

## Emergency Evacuation Ordered as Smoke Enters Taxiing Airplane

*McDonnell Douglas MD-82. Minor damage. One serious injury, six minor injuries.*

The flight crew had landed the airplane at an airport in the United States and had begun to taxi toward the parking area when they started the airplane's auxiliary power unit (APU). About 30 seconds later, smoke began to enter the cabin. The captain ordered an emergency evacuation using the airplane's four evacuation slides.

An inspection of the airplane revealed that a hydraulic line had broken and hydraulic fluid had accumulated near the APU inlet.

Air Taxi
Commuter

## Airplane Damaged by Lightning Strike

*De Havilland DHC-8 Dash 8 Series 300. Minor damage. No injuries.*

The airplane departed from an airport in Scotland just before sunset, with weather conditions that included visibility of 4,000 meters (2.5 statute miles) in light snow, a cloud base of 1,500 feet and a few cumulonimbus clouds.

The flight crew received radar vectors from air traffic control (ATC), then resumed their own navigation as the airplane was flown through 8,000 feet. Soon afterward, the airplane was struck by lightning. Both engine-driven direct-current generators failed. The flight crew told ATC that the airplane had been struck by lightning, conducted the appropriate checklist to reinstate both generators, declared an emergency and returned the airplane to the departure airport, where they conducted an instrument approach and landing.

An examination of the airplane revealed that lightning had damaged the radome and both windshields. Burn marks were found on the upper fuselage and the left-horizontal stabilizer.

## Pilot Retracts Landing Gear After Touchdown

*Beech Super King Air B200C. Substantial damage. No injuries.*

As the airplane touched down at an airport in Canada, the pilot not flying inadvertently raised the landing-gear selection lever instead of moving the propeller controls. The landing-gear warning horn sounded, and the airplane descended further.

The pilot flying conducted a go-around and flew the airplane to a safe altitude to determine whether the airplane had been damaged. The flight crew extended the landing gear and observed an unsafe indication for the left-main landing gear. They conducted the emergency procedure to lower the landing gear and observed that the left-main landing gear had extended; nevertheless, the unsafe indication remained.

The crew declared an emergency and landed the airplane. As the airplane touched down, the left-main landing gear collapsed. The airplane stopped on the runway, left of the centerline.

**Corporate Business**

## Airplane Strikes Terrain During Stall Maneuver

*Aero Commander 500-B. Destroyed. Three fatalities.*

Visual meteorological conditions prevailed for the flight conducted from an airport in the United States for the purpose of demonstrating the airplane to a prospective buyer.

One witness, who held a private pilot certificate, said that the airplane was being flown at about 1,000 feet. The witness said that he observed a power-off stall, followed by a recovery that he described as "good." During a second stall maneuver, however, the witness observed the airplane's pitch attitude increase. He said that the right wing dropped and the airplane pitched nose-down, rotated about 1 1/2 times and then disappeared from his sight behind trees.

Other witnesses said that they heard an increase in engine power before the airplane struck the ground.

## Airplane Strikes Terrain During Emergency Landing

*Piper Aerostar 601P. Substantial damage. No injuries.*

Visual meteorological conditions prevailed and an instrument flight rules flight plan had been filed for the night flight in the United States. The pilot said that he confirmed visually that the wing fuel tanks and the fuselage fuel tank were full before departure. The fuel tanks hold 165 gallons (625 liters) of usable fuel.

The pilot conducted the takeoff and flew the airplane for four hours. As he turned the airplane from the downwind leg to the base leg at 700 feet above ground level for a visual approach at the destination airport, both engines lost power. The pilot conducted an off-airport landing in a field, where the airplane struck a fence.

**Other General Aviation**

## Landing Gear Collapses During Test Flight

*Piper PA-34-220T Seneca. Substantial damage. No injuries.*

The airplane, which was registered as an experimental/test prototype, was being flown on a factory test flight at an airport in the United States. The strut on the airplane's nose landing gear had been modified as part of a research program for a new design of the landing-gear warning system.

The pilot landed the airplane, and during rollout, the nose landing gear collapsed. Then, both main landing gear collapsed, and the airplane skidded off the right edge of the runway.

## Airplane Lands in Lake After Bumpy Takeoff

*De Havilland DH-60G Gipsy Moth. Substantial damage. No injuries.*

The pilot had been attending a de Havilland Moth Club rally and planned a departure from the private grass landing strip in

England for a formation flight with the pilot of a Tiger Moth. The accident airplane was the second to depart. During the takeoff roll, the airplane passed over a mound of earth, bounced into the air with a nose-high attitude and touched down on the runway.

"As the runway appeared to be too uneven for the aircraft to accelerate, the pilot elected to steer to the right in the hope that the smoother ground would aid acceleration," the accident report said.

Because there was insufficient distance to reject the takeoff, the pilot maintained full power and planned to fly the airplane in ground effect across a lake to land on smoother ground at the other side.

"As the aircraft passed over the near edge of the lake, the pilot realized that the aircraft would not be able to climb enough to clear a four-feet-high bank on the far side," the report said.

The airplane stalled, the right lower wing touched the water and the airplane stopped in a nose-down attitude in the lake in about three feet (0.9 meter) of water.

The report said that the bounce was unexpected and outside the experience of the pilot, who had an airline transport pilot certificate and 10,660 flight hours, including 34 flight hours in Gipsy Moths, and that runway conditions had "caused some concern" among pilots during the two-day rally. The pilot also indicated that his judgment might have been affected because he was dehydrated, because he had hurried his departure preparations and because of his desire to continue the takeoff to conduct the formation flight. The pilot said that warm temperatures and the airplane's cruise-pitch propeller also might have reduced the airplane's performance.

## Short Circuit Detected After Pilot Observes Smoke in Cockpit

*Cessna 172N. Minor damage. No injuries.*

The airplane was being flown to an airport in Canada just before midnight when the pilot observed smoke in the cockpit. He told air traffic control about the smoke and requested that emergency equipment be available after he landed the airplane, but he did not declare an emergency.

The pilot shut down all electrical equipment on the airplane, and the smoke began to clear. He landed the airplane, taxied off the runway and shut down the engine. An inspection by maintenance personnel revealed a short-circuit of the landing-light switch.

# Rotorcraft

## Helicopter Strikes Power Line During Cattle-herding Flight

*Robinson R22 Alpha. Destroyed. One fatality, one serious injury.*

The helicopter was being flown in a cattle-mustering (herding) operation in Australia when cattle were observed outside a fenced area and the pilot descended the helicopter to herd the cattle toward the fence. The passenger then asked the pilot to fly the helicopter along the fence to check its security. The report said that the passenger then requested that the pilot fly the helicopter higher and that, as the pilot initiated a climb, the helicopter — being flown at 55 knots — struck a power line. The power line did not break, and the helicopter pitched nose-down and struck the ground in an inverted attitude.

The power line was struck at about mid-span, and an investigation revealed that there were no markers on the power line, which was below the altitude at which markers were required. The investigation also revealed that the power-line poles would have been obscured from the pilot's view by trees and terrain.

The accident report said, "It is possible that the pilot may have intended to initially conduct an inspection flight to locate the missing cattle; however, after locating the cattle, the nature of the flight changed to a mustering role, and safety precautions normally carried out prior to mustering operations were not taken. … Pilots operating at a low height should not rely on being able to see a power line in time to take avoiding action."

## Helicopter Strikes Terrain During Missed Approach

*Bell 430. Destroyed. Two fatalities.*

Night instrument meteorological conditions prevailed for the business flight in Mexico, and fog and low visibility were reported at the destination airport.

Witnesses said that, before the accident, they heard the sound of a helicopter overhead and believed that the pilots were conducting a missed approach. A preliminary report said that the helicopter was destroyed when it struck terrain after a loss of control during a missed approach. The helicopter's wreckage was found in a field.♦

# Call for Nominations

## Flight Safety Foundation Business Aviation Meritorious Service Award

This award has been presented by the Foundation since 1975 for outstanding service and contributions to corporate aviation safety. The award, which was established during an era in which the role of business and corporate aviation was expanding, recognizes individuals whose work enhances safety in this segment of the industry. Recipients have included industry leaders, government officials, members of the news media and researchers whose findings were especially relevant to corporate aviation. The award includes a handsome, wood-framed, hand-lettered citation.

**The nominating deadline is February 7, 2003.** The award will be presented in Hollywood, Florida, U.S. at the FSF Corporate Aviation Safety Seminar, April 22–24, 2003.

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**Submit your nomination(s) via our Internet site.**
**Go to http://www.flightsafety.org/merit_award.html**

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