FLIGHT SAFETY FOUNDATION
CABIN CREW SAFETY
Vol. 36 No. 1 *For Everyone Concerned With the Safety of Flight* January–February 2001

Strategies Target Turbulence-related Injuries To Flight Attendants and Passengers

Civil aviation authorities in various world regions have taken steps to reduce injury risk in light of recent accident experience. Additional methods to help pilots avoid turbulence are on the horizon, but using flight attendant restraints effectively — and encouraging passengers to keep seat belts fastened at all times while seated — remain the best protection.

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FSF Editorial Staff

Among nonfatal air carrier accidents, turbulence has been the leading cause of in-flight injuries to passengers and flight attendants in the United States. U.S. air carriers have defined turbulence in their cabin crew training as "the violent, irregular motion of air currents over a short distance" and have associated severe turbulence and extreme turbulence with aircraft position relative to the jet stream, mountain waves and thunderstorms.[1]

Efforts by the U.S. Federal Aviation Administration (FAA) to analyze and prevent turbulence-related injuries during the last 10 years included a 1994 report, a 1994 industry conference, a cabin safety initiative on passenger seat-belt use begun in 1996 and an industry training aid in 1997.[2]

In the late 1990s, turbulence-related injuries continued to occur during air carrier operations under U.S. Federal Aviation Regulations (FARs) Part 121. FAA said that generally, two-thirds of turbulence-related accidents occur at or above 30,000 feet; in 1997, about half of such accidents occurred above 30,000 feet.[3]

The latest U.S. work on the prevention of turbulence-related injuries has been conducted with oversight by the Commercial Aviation Safety Team (CAST), a joint FAA-industry effort that has focused national accident-prevention resources using data on the leading causes of fatalities in U.S. commercial aviation.[4]

Debi Bacon, air traffic control specialist in the FAA Aviation Weather Policy Division and CAST spokesperson, said that a group of FAA weather specialists and industry weather specialists in early 1999 recommended that FAA and industry groups jointly update methods of preventing turbulence-related injuries. While known to have caused three fatalities on U.S. air carriers in 1983–1999, turbulence also caused serious injuries during that period and increased public concern, Bacon said.[5]

CAST formed a 34-member Turbulence Joint Safety Analysis Team (Turbulence JSAT), which began its work in October 1999 and presented its analysis and results to CAST in January 2001. Bacon, a Turbulence JSAT team leader, said that potential benefits from applying CAST analytical processes also made turbulence an appropriate subject for CAST attention.

CAST then formed a Turbulence Joint Safety Implementation Team (Turbulence JSIT) to determine the most feasible methods among Turbulence JSAT-recommended interventions, she said. The Turbulence JSIT will conduct its work from February 2001 through June 2001.

Bacon said that the annual number of U.S. turbulence-related accidents and turbulence-related injuries peaked in the late 1990s at approximately double the average number that had occurred from 1980 through 1995. Data from the U.S. National Transportation Safety Board (NTSB) showed 15 turbulence-related accidents in 1997 (one passenger fatality, 13 serious injuries to flight attendants and 14 serious injuries to passengers), 12 turbulence-related accidents in 1998 (nine serious injuries to flight attendants and five serious injuries to passengers) and 15 turbulence-related accidents in 1999 (10 serious injuries to flight attendants and five serious injuries to passengers). These 42 accidents in three years involved a total of 333 aircraft crewmembers and 5,253 passengers.[6]

The following are some findings of FAA's 1994 report and changes that have occurred since the report:

- The report said that emerging technology — enhancing pilots' ability to predict and/or to avoid turbulence — may result in fewer turbulence-related accidents. Research, development and tests of such technologies have been conducted. In December 2000, U.S. government and industry representatives began planning for the certification of turbulence-detection systems for transport aircraft beginning in 2001;[7]

- The report said that no requirements existed for flight attendants to be seated with restraints fastened except during takeoff and landing. Since then, FAA guidance has been provided to air carriers on appropriate procedures to prevent turbulence-related injuries during flight operations (see "FAA Guidance Shapes Air Carrier Operating Procedures," page 5);[8]

- The report said that although passengers outnumbered flight attendants 20-to-1 on turbulence-accident flights, the number of flight attendants receiving serious injuries "is comparable to that of passenger serious injuries." NTSB data for 1998 and 1999 show that more flight attendants than passengers received turbulence-related serious injuries during air carrier operations;

- The report said that flight attendants are at the greatest risk of injury because they often continue working after the seat-belt sign is illuminated unless advised by the flight crew to discontinue cabin service; nevertheless, flight attendants sometimes are delayed in being seated because they are securing equipment and, depending on each airline's procedures, may be confirming that passengers have fastened seat belts. The report said, "Current regulatory guidance is silent on the issue of flight attendant requirements to be seated with seat belt fastened except for takeoff and landing." Relevant paragraphs of FARs Part 121.317 have not changed, but a 1995 policy says that FAA principal operations inspectors should ensure that each air carrier's flight attendant training and operational manuals include "guidance and specific signals to notify flight attendants when they are to cease in-flight services, secure [the] galley, be seated with their restraints fastened and/or resume duties."[9] Bacon said that the Turbulence JSAT report in January 2001 similarly found that a major factor in the higher risk for flight attendants continues to be that they are unrestrained while conducting most of their duties;[10] and,

- The report said that in some accidents, loose objects in the cabin, such as serving carts, caused serious injuries and that further study was necessary to determine the extent to which loose objects and interior cabin design contribute to serious injuries.[11]

Turbulence JSAT Proposes Data-driven Interventions

Bacon said, "JSAT's objective was to analyze why turbulence accidents happen and to develop possible intervention strategies to allow commercial airlines to either avoid turbulence or to mitigate the effects of turbulence."

Bacon said that Turbulence JSAT members used the following working scenarios to help conceptualize the prevention of turbulence-related injuries:

- Operations that are conducted without risk of turbulence-related injury because the flight crew avoids areas of turbulence;

- Operations that present a low risk of turbulence-related injury because flight crews fly aircraft into an area of

turbulence with advance planning and a secure cabin;[12] and,

- Operations that present the greatest risk of turbulence-related injury because turbulence is encountered without any warning or preparation by pilots, flight attendants or passengers.

"One significant trend is that flight attendants get hurt most often in turbulence encounters," said Bacon. "The basic issue we found is that if you are seated and belted, you do not get hurt but if you are up and around in the cabin, you may get hurt. For example, pilots — seated and belted with a five-point harness — do not get hurt. But the nature of flight attendants' work is that they are up and around."

Turbulence JSAT members reviewed data showing that a flight attendant's risk of serious injury is 26 times greater than a passenger's risk of serious injury, she said.

"In one accident studied, flight attendants were injured and were not able to call the flight deck to say what happened," she said. "The flight crew did not know that the flight attendants were injured."

The frequency of turbulence accidents during flight operations over the United States has been attributed to the convergence of jet streams over North America, mountain wave activity over the Rocky Mountains, a high incidence of convective activity over the continent, and the influence of the Caribbean Sea and the Gulf Stream in the U.S. southern region and mid-Atlantic region, she said. Aircraft operating in Western Europe, by comparison, have less frequent turbulence encounters and less risk of turbulence-related injury, she said. Turbulence encounters also occur frequently on the western rim of the Pacific Ocean.

Bacon said that Turbulence JSAT members reviewed the following statistics developed from an FAA analysis of NTSB data on 131 turbulence accidents among U.S. air carriers in 1983–1999:

- Flight attendants represented about 4 percent of aircraft occupants but experienced about 52 percent of serious injuries or fatal injuries; and,

- Passengers represented about 94 percent of aircraft occupants but experienced about 48 percent of serious injuries or fatal injuries.

Turbulence JSAT members also reviewed estimates — based on ratios of accidents to incidents at one large air carrier — showing that for every report of a serious turbulence-related injury to a flight attendant, 70 minor injuries to flight attendants occurred, said Bacon.

The cost to the industry of lost work days has been significant, she said. Based on an average loss of 11 work days per reported injury to a flight attendant, estimates showed (from data provided by the large air carrier) that the U.S. airline industry averaged an annual loss of 10,000 flight attendant work days in 1980–1994, and averaged an annual loss of 15,000 flight attendant work days in 1995–1999.

Turbulence JSIT members will consider 30 Turbulence JSAT-proposed interventions, which are based on analysis of 51 accident reports and incident reports (48 reports from the NTSB Aviation Accident/Incident Database, one report from the U.S. Department of Defense and two reports from a U.S. air carrier). The proposed interventions were not released to the public.[13]

"The CAST philosophy is that if we are going to make changes, we have to prove that what we say is happening is really happening," said Bacon.

Probable Causes of Accidents Show Nature of Problems

The following probable causes — selected from NTSB final reports on FARs Part 121 accidents that occurred in 1997–1999 — reveal issues involved in preventing turbulence-related injuries:

- "The pilot-in-command's inadequate evaluation of the weather conditions. Factors associated with the accident were the turbulence encountered and the seat-belt sign [not] illuminated.";[14]

- "The failure of the flight crew to alert the cabin crew to the possibility of turbulence, leading to a serious injury when severe turbulence was encountered.";[15]

- "Unforecast and sudden encounter with clear-air turbulence when passengers and flight attendants were not secured in their seats.";[16]

- "The flight attendants did not follow the [flight] crew's instructions to be seated because of expected turbulence. A factor associated with the accident was the turbulence encountered.";[17]

- "Failure of the aft flight attendant to secure her seat belt. Related factors were turbulence in clouds, and the flight attendant not receiving the crew briefing.";[18]

- "The flight attendant's seat belt was not secured. A factor was turbulence in the clouds.";[19]

- "The passenger's failure to secure her seat belt as directed by the flight crew (seat-belt sign illuminated) on initial takeoff climb resulting in her ejection from her seat during an encounter with turbulence.";[20] and,

- "Inadvertent encounter with turbulence, which resulted in spillage of hot coffee in a passenger's lap."[21]

Crews Report Experiences During Turbulence Encounters

Pilot descriptions and flight attendant descriptions of turbulence encounters in 1997–1999 from the U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) contained similar issues.[22] They said that turbulence encounters that caused serious injuries lasted from two seconds to five minutes (with multiple jolts), but several said that their severe-turbulence encounters lasted three seconds to five seconds. After the first indications of turbulence, severe turbulence sometimes occurred within a few seconds, giving insufficient warning for flight attendants to be seated and to fasten their restraints.

Several of the ASRS reports said that no passengers were injured because all passengers were wearing seat belts. Several reports said that unrestrained flight attendants were injured when they struck forcefully the aircraft ceiling one time to several times. Several unsecured carts were knocked over or were lifted off the floor and then struck occupants or fell across passenger-seat armrests. In one turbulence encounter, all four flight attendants who vacated their seats to attend to an injured child suffered serious injuries. Two flight attendants were injured while trying to prevent an unrestrained flight attendant from being lifted off the cabin floor. Some flight attendants said that they did not notice immediately their own serious injuries.

The following reports included recommendations from pilots and flight attendants for the prevention of turbulence-related injuries:

- "Lessons [from the accident]: I will insist [that] flight attendants remain seated in areas of radar returns or suspected turbulence, rather than just warning [them]." (NASA ASRS Report no. 409266, July 1998);

- "Contributing factors [are] industry-wide cabin attendant disregard for [the] seat-belt sign and service-priority orientation." (NASA ASRS Report no. 375766, July 1997);

- "Passengers are not aware [of] what indeed might occur with turbulence. But also [cabin] crew. Crew tend to still work too long. We must sit down. Forget the service, forget the time (we tend to think that we have to accomplish a service). Think of safety for yourself and everybody else. Better [to have] no service, but [to be] healthy and not injured." (NASA ASRS Report no. 385302, October 1997);

- "[The flight attendant's] first concern upon hearing the announcement was to check passenger seat-belt compliance, which she was on her way to do after securing her cart from the aisle where she was serving passengers. There was no time or warning [before she was injured]. [She] stressed the importance of a preflight briefing with flight crew concerning weather and the necessity to make adjustments to the planned meal services in the cabin with carts in the aisle, hot food and trays at the passenger seats. [She said that the] flight crew came aboard while passengers were boarding at departure and no safety briefing was conducted." (NASA ASRS Report no. 403318, May 1998); and,

- "My thoughts about safety for flight attendants would be to have more 'hand holds' located in [the] cabin. Perhaps the aisle seat back/sides could be fitted with 'hand holds' for us to use in turbulence — if not every aisle seat, every other aisle seat (top). This would assist us in self-protection and allow us to perhaps reach jump seats. Had it not been for the galley 'hand hold' I was able to grab, more severe injury would have happened to me. [The flight attendant] was near a jump seat but could not get to it without releasing her hold since there were no others." (NASA ASRS Report no. 426481, January 1999).

FAA Sees Focus Shift Since Early 1990s

Nancy Claussen, cabin safety inspector in the FAA Air Transportation Division, said, "The shift since the early 1990s has been [to] more communication and coordination, and more specific procedures to address different levels of turbulence. What we typically find now is that air carriers assign levels of severity to turbulence and give [pilots and flight attendants] very specific procedures to follow once the level of expected turbulence — light, moderate, severe or extreme — has been determined. For example, in light turbulence, the cabin crew would be permitted to continue with in-flight duties. For moderate and severe turbulence, flight attendants follow procedures to enhance the safety of the cabin as much as possible and mitigate some of the negative effects. Inherent in those procedures are crewmember coordination and communication."[23]

Claussen said that FAA has conducted the following activities to help prevent turbulence-related injuries:

- Issued updated guidance on appropriate air carrier policies and procedures in light of current knowledge about turbulence;

- Issued guidance to improve communication and coordination between flight attendants and pilots;

- Provided information to increase flight attendants' awareness during their training of the risk of turbulence-related injury and its prevention; and,

- Continued a 1996 public awareness campaign to encourage passengers to wear seat belts at all times while seated.

Inadequate guidance by an air carrier to its pilots and flight attendants can cause misunderstanding of responsibilities and inappropriate cabin crew responses to information about expected turbulence, she said.

Claussen said that current U.S. airline procedures typically incorporate clear division of responsibility, crew resource management, explicit actions for pilots and flight attendants and appropriate responses to turbulence encounters, and may include joint training of pilots and flight attendants.

"The preparation is better now because it is more defined," said Claussen. "Communication is the critical component; FAA recommends discussion of turbulence in the preflight briefing. Certainly if the aircraft encounters turbulence, there must be communication and coordination between the flight deck and cabin — and flight attendants must consider that their personal safety is of the utmost importance."

FAA Guidance Shapes Air Carrier Operating Procedures

Claussen said that two 1994 FAA air carrier operations bulletins contain the latest guidance for flight crews, cabin crews and air carriers to prepare for turbulence and to react to turbulence encounters.[24,25] In 1995, FAA issued its "Policy for Passenger and Flight Attendant Use of Seat Belts During Turbulence."[26]

The documents discuss the following:

- Hazards of passengers unfastening their seat belts while seated;
- Flight attendants' exposure to turbulence-related injuries;
- Close coordination between cabin crew and flight crew to facilitate the timely completion of cabin services;
- Periodic reminders to passengers that the seat-belt sign is illuminated;
- Forceful announcements if passengers stand while the seat-belt sign is illuminated — especially during operations in turbulent air;
- How to discourage passengers from regarding the illumination of the seat-belt sign as a signal to prepare for landing by going to the lavatory, standing or stowing baggage. Cabin crews should make an announcement before illumination of the seat-belt sign, telling passengers that the aircraft will be landing shortly, that a final opportunity exists to move about the cabin or go to the lavatory before illumination of the seat-belt sign, and that when the seat-belt sign is illuminated, all passengers must be in their seats with their seat belts fastened for safety;
- Air carriers should train flight attendants to use announcement techniques that forewarn passengers of pending situations that will require illumination of the seat-belt signs and passenger compliance, such as when approaching an area of turbulence. Such techniques discourage passengers from moving around the cabin after the seat-belt sign has been illuminated;
- Pilot training and procedures should stress the importance of a predeparture briefing of the senior flight attendant to include forecast turbulence-related weather conditions, scheduling of cabin services, cleanup, and the securing of passengers, galleys, cabin and carry-on baggage;
- Procedures for pilots should include effective use of the public address system to alert flight attendants and passengers about anticipated in-flight turbulence; and,
- Procedures should include guidance on pilot notification of flight attendants to discontinue in-flight service, secure the galley, be seated with their restraints fastened and to resume service.

FAA said, "Many airlines cooperated [in response to 1994 FAA guidance] by making innovative changes to announcements and placing articles in publications informing passengers of the dangers associated with sitting in a seat without [the] seat belt fastened.

"In spite of all these efforts, passengers and flight attendants continue to sustain injuries in flight during turbulence, evasive maneuvers or other in-flight disturbances. Many of these injuries are serious and have resulted in broken bones (especially ankle bones) and head injuries.

"[FARs Part 121.571(a)(2)] requires that a crewmember give an announcement after each takeoff, immediately before or immediately after turning the seat-belt sign off, that passengers should keep their seat belts fastened, while seated, even when the seat-belt sign is off. The requirement for this announcement should be emphasized. Operators should … make a public address announcement to remind passengers that federal regulations require them to fasten their seat belts when the seat-belt sign is turned on.

"The FAA is concerned about coordination and communication between the [flight] crewmembers and the flight attendants during all phases of flight. … These procedures should address:

- "Guidance to flight crewmembers on the importance of a predeparture briefing of the flight attendants to include forecast turbulence-related weather conditions, securing the galley and cabin, carry-on baggage, passengers, scheduling of cabin service and pickup [cleanup];

- "Use of the public address system or other signal to alert flight attendants and passengers of anticipated in-flight turbulence;

- "Guidance and specific signals to notify flight attendants when they are to cease in-flight services, secure the galley, be seated with their restraints fastened, and/or resume duties; and,

- "Guidance for flight attendants regarding flight attendant determination that turbulence is too severe for the continuing of service and taking their seats with their restraints fastened, and that they are to notify the flight crewmembers regarding this action."

Australia, Canada Reconsider Seat-belt Compliance Methods

Monitoring seat-belt compliance is an effective method of preventing turbulence-related injuries; nevertheless, flight attendants have inherent challenges and limitations, Claussen said.

"Airlines have policies and procedures to make the [cabin] crewmember as responsible as possible," she said. "The responsibility also rests with the passenger, however, not just the crewmember. Regulations are written so that the passenger is responsible for remaining in the seat with the seat belt fastened when the seat-belt sign is illuminated and for following crewmember instructions. FAA's compliance and enforcement [methods] relate to the passenger. The crewmember is not responsible for physically restraining passengers. By educating passengers, informing them and asking for their compliance, they have fulfilled all their responsibilities."

Safety authorities in some countries have recommended mandatory fastening of seat belts at all times when the passenger is seated and further research into methods of protecting aircraft occupants when they are not seated. For example, the Australian Bureau of Air Safety Investigation (BASI) — now the Australian Transport Safety Bureau — in 1998 said, "Procedures to be followed in the event of unexpected turbulence may lack guidance for the possible reduction of injury when passengers and crew are unable to reach seats with restraint systems. Currently, there are few effective methods of restraint provided in areas such as aircraft toilets or galleys for the protection of passengers and crew in the event of unexpected turbulence. … [BASI] is considering a recommendation to the Civil Aviation Safety Authority (CASA) to incorporate into regulations a requirement for passengers to fasten their seat belts at all times when seated. … Passengers often ignore recommendations from aircrew to keep seat belts fastened when the seat-belt signs are not illuminated. … Cabin crewmembers' duties require frequent movement in the cabin, often at some distance from available seat restraints.

"Passengers most frequently move from their seats to use toilet facilities or for exercise during long flight sectors. However, toilet facilities and galley areas often lack safety features such as hand holds which may assist in reduction of injury when passengers or crew are unrestrained during unexpected turbulence. … [BASI] recommends that [CASA,] in cooperation with airlines and manufacturers, investigate the feasibility of providing means to guard against injury when passengers and crew are not restrained in seats during unexpected turbulence."[27]

Claussen said that FAA has considered, and rejected as "unrealistic and unworkable," mandatory seat-belt use by passengers at all times as a method of preventing turbulence-related injuries.

"Currently, there is no initiative at FAA seeking regulations that would require passengers to keep seat belts fastened at all times," said Claussen. "We do not want to dilute the effect of the fasten-seat-belt sign by having it illuminated at all times. That is not in the interest of safety."

Transport Canada in 1999 took a similar position and addressed air carrier practices that, while intended to reduce turbulence-related injuries, are considered to be "unproductive and misleading."

Transport Canada said, "Some air operators are adopting a mandatory seat-belt-use policy … [requiring] passengers to remain seated with seat belts fastened even when the seat-belt sign is not illuminated. Passengers who use the lavatory facilities when the seat-belt sign is not illuminated are asked to fasten their seat belts upon returning to their seats. Transport Canada views this … as a positive method of promoting passenger safety. Another [method] taken by some operators in an attempt to keep passengers in their seats is through the use of the seat-belt sign at all times during the flight. Transport Canada views this [method] as having a negative effect on safety. This practice causes passengers to ignore the seat-belt sign when it is illuminated for a valid reason."

Transport Canada's recommendations on communication with passengers about seat belts included the following:

- "The message must be conveyed to passengers that the best protection against unanticipated turbulence-related injuries is through constant use of seat belts;

- "An announcement should be made from the flight deck when the seat-belt sign is first turned off during flight,

explaining the hazards associated with turbulence and the importance of keeping seat belts fastened at all times during flight;

- "Passengers also should be advised of what they must do if the seat-belt sign should be turned on. It educates the passengers that the illumination of the seat-belt sign is not 'accidental' and that the seat-belt sign is not merely a cabin ornament;

- "Air operators should discourage the unnecessary illumination of the seat-belt sign;

- "When the seat-belt sign is illuminated and flight attendants are still providing service, an explanation should be given periodically to passengers explaining why the passengers need to be seated with seat belts fastened even though the flight attendants are not;

- "Once the threat of turbulence has expired, the seat-belt sign should be turned off. An announcement should be made to passengers informing them that although the threat of turbulence has passed, they should keep their seat belts fastened to prevent injuries from unexpected turbulence;

- "Flight attendants who are not performing assigned duties should fasten their restraint systems at all times when the seat-belt sign is illuminated during flight; and,

- "Flight attendants and flight crew should be encouraged to lead by example and keep their restraint devices fastened at all times while seated or at rest during periods of flight when the seat-belt sign is not illuminated."[28]

Turbulence-simulation Video Dramatizes Cabin Hazards

In 1996, FAA launched a public awareness campaign called Turbulence Happens, and this campaign continues in 2001, Claussen said. The campaign comprises a Web site and print, radio and television public service announcements.

Under FAA's Safer Skies — A Focused Agenda, a strategy begun in 1998 to prioritize U.S. accident-prevention efforts, FAA continued support for this public awareness campaign, stressing the importance of continual seat-belt use.[29] Partners in Cabin Safety, an FAA-industry coalition, also initiated the development of a video simulation of turbulence effects as a training aid.[30]

Vahid Motevalli, Ph.D., P.E., developer of the video simulation at George Washington University Transportation Research Institute, said, "Similar to safety research on air bags in cars, attention shifts over time in aviation research on turbulence. As we improve safety in one area, more things show up. There is a need to look at any trends in turbulence-related injuries as air traffic increases."[31]

He said that researchers must investigate how much time flight attendants use securing the cabin after a warning of expected turbulence, including the influence of their past experience and attitudes on their behavior, and the relationship of turbulence encounters to weather-avoidance decisions made by pilots expected to meet on-time performance goals.

Airborne Turbulence Sensor Certification Process Proceeds

Claussen said, "Currently one of the most difficult aspects of injury prevention is knowing when or where a turbulence encounter will occur. Pilots have some information sources, such as pilot reports, for clear-air turbulence. Currently, FAA, NASA and aerospace companies are developing new airborne turbulence-detection systems.[32,33] Some people have asked, 'Is new technology worth the cost? Would 30 seconds or 60 seconds of turbulence warning make a difference? If we have such a very short time frame, is it worthwhile to develop that technology?' The answer is a resounding yes. Any tool that can be used for advance notice — regardless of the time frame — is technology that we want to pursue. We strongly support any additional tool that a pilot could use to predict a turbulence situation. The cabin safety tie-in is that NASA and FAA also are asking 'If we knew a minute ahead that the aircraft would penetrate turbulence, do we have procedures for the actions that should be taken by [cabin crew] to use that minute effectively?' Certainly there are steps that could be taken inside the cabin to use any advance information."

Issues under discussion for forward-looking airborne turbulence-detection systems include the types of displays and alerts to be used and crew responses that would be appropriate (or mandatory) when airborne sensors detect turbulence at different ranges. Other issues are pilots' expectations of turbulence-sensor performance relative to current wind shear sensors; time required to attain various levels of cabin security, and defining these levels relative to turbulence-sensor performance, when turbulence can be detected routinely from the flight deck; and mitigating false alerts perceived by pilots, flight attendants and passengers.

Flight Attendants Need Clear Guidance on Stopping Service

The Association of Flight Attendants (AFA), a U.S. labor union, said in 1998 that the following measures should be implemented to reduce turbulence-related injuries:[34]

- Flight attendants should be seated whenever sterile-cockpit procedures are in effect;[35] and,

- Flight attendants need authority, by regulation, to discontinue service, to secure the cabin and to take their seats with restraints fastened when necessary to lessen the risks of turbulence-related injury.

AFA has recommended regulations similar to those adopted in Canada in 1996, which instruct pilots to order the discontinuation of cabin service when greater than light turbulence is anticipated.

"The [Canadian] in-charge flight attendant can also direct other cabin crewmembers to discontinue service, secure the cabin and buckle up, even if the pilot thinks such a precaution is not necessary," AFA said. "Further, when an aircraft is experiencing turbulence, the in-charge flight attendant can direct the passengers to fasten their seat belts."

Air carriers must give flight attendants clear guidance about discontinuing and resuming service based on the level of turbulence experienced in the cabin, said Candace Kolander, AFA safety and health coordinator.[36]

"Often, flight attendants have a mentality to jump up quickly after departure to start service," said Kolander. "They believe they need to get up immediately to complete company-required service. Service is the priority on most occasions. We advocate that carriers instruct flight attendants to stay seated a little bit longer. Passengers have the responsibility for their own safety, so in preparing for turbulence, carriers should not expect flight attendants to verify that passengers are putting on seat belts. If the situation warrants, the flight attendant should sit down and make the fasten-seat-belt announcement."

Because of crew resource management training during the 1990s, flight crews typically have more awareness of cabin conditions, and communication with flight attendants has improved in some respects, she said.

"For example, the cabin crew should advise the flight crew if switching off the seat-belt sign has been overlooked," she said. "We still have a long way to go."

FAA-Industry Training Aid Stresses Cabin Readiness

Advance warning of turbulence — enabling airline pilots to know when they will be entering areas of turbulence and to anticipate the severity — is the key to reducing turbulence-related accidents significantly, said Ron Welding, director of operations standards for the Air Transport Association of America (ATA).[37]

Welding said that ATA's recent work on other interventions included the 1997 *Turbulence Education and Training Aid* (developed with FAA and McDonnell Douglas [now part of Boeing Commercial Airplanes Group]) and participation during 1999–2000 in the Turbulence JSAT. ATA distributed the training aid to all member airlines, and Boeing distributed the product to its customers worldwide.

The training aid and video contain the following recommendations:[38]

- The best defense is to keep the cabin as ready as possible for a turbulence encounter at any time. Cabin readiness includes checking periodically that passengers are wearing seat belts while seated; communicating the importance of the fasten-seat-belt sign (especially to children and others who may not understand announcements); checking that overhead bins are latched properly and that carts and loose items are stowed; and knowing at all times the nearest place to be seated (not necessarily a jump seat, possibly the floor);

- Crews can expect greater effects of turbulence, including injuries, in the aft cabin — where about 79 percent of such injuries have occurred — than on the flight deck, so pilots should be informed of significant turbulent conditions in the cabin. (Pilots' perceptions of turbulence effects may be influenced by the type of restraints they use, expected aircraft behavior and other factors. Aircraft-specific training includes information about variation in turbulence effects by occupant location.);

- Pilots and flight attendants should guard against complacency that can develop because turbulence is so common and many encounters seem insignificant;

- Flight attendants should have a clear understanding of company procedures and be able to recognize conditions that require the discontinuation of service, securing the cabin and securing themselves in the nearest jump seat or passenger seat without direction from the flight deck;

- Flight attendants should expect from pilots timely briefings about turbulence, including the estimated time until reaching the turbulence area, the estimated intensity and duration of the turbulence, necessary actions before and after entering turbulent conditions, and details of public address announcements;

- Flight attendants should focus their attention during light turbulence on the security of children and infants (including those in lavatories), on securing unattended carts and on stowing loose service items;

- Difficulty in walking is a signal that flight attendants promptly should take a seat and fasten the restraint; moving about the cabin during severe turbulence significantly increases the risk of serious injury;

- If turbulence is felt and the captain has not illuminated the fasten-seat-belt sign, the cabin crew should make a

cautionary announcement to passengers, then ask the captain to illuminate the seat-belt sign; and,

- When the captain tells flight attendants that cabin duties can be resumed safely after a turbulence encounter, flight attendants should increase cabin lighting to a bright setting, calm the passengers, and check for and report any injuries or aircraft damage.

Near-term methods of reducing turbulence-related injuries will extend the initiatives of the 1990s, and they can be summarized as continuing public education about proper use of seat belts; recognizing and raising awareness of the safety risks among flight attendants; assessing any cabin-design factors[39]; updating operational procedures and crew communication based on current safety knowledge; and determining how to implement technologies that can alert pilots to impending turbulence encounters.♦

Notes and References

1. U.S. Federal Aviation Administration (FAA); Air Transport Association of America; McDonnell Douglas. "Turbulence: A Little Bumpy Air." *Turbulence Education and Training Aid.* May 1997. The training aid and video said, "Turbulence is caused primarily by convective currents, wind flow obstruction and wind shear. … [Turbulence] areas include over hills and mountains, in and near clouds and in the vicinity of thunderstorms. Light [turbulence] or moderate turbulence often occurs in the lower 5,000 feet of the atmosphere when surface winds range up to around 30 knots and where the air is colder than the underlying surfaces. Severe turbulence is found on the cold side of the jet stream within 50–100 miles of its center. It also occurs in troughs aloft or in lows aloft where vertical wind shears exceed 10 knots per 1,000 feet and horizontal wind shears exceed 40 knots per 150 miles. … Extreme turbulence is defined as that where the aircraft is violently tossed around and is practically impossible to control. It may cause structural damage. … Extreme turbulence occurs in mountain-wave situations, in and below well-developed rotor clouds and in severe thunderstorms."

2. Coleman, Patricia. "Turbulence-related Injuries Pose Continued Risk to Passengers and Cabin Crew." *Cabin Crew Safety.* Volume 29 (May–June 1994). The 1994 FAA report — "Turbulence Injuries: U.S. Air Carrier Part 121 Scheduled and Part 135 Commuter Operations for the Period 1982–1991" — analyzed 55 turbulence-related injury accidents. Conclusions and recommendations of the Industry/Government Cabin Safety Roundtable on Reduction of Turbulence-related Injuries, June 22–23, 1994, are in the *Turbulence Education and Training Aid*. As part of *Safer Skies: A Focused Agenda* in 1998, FAA formed a coalition called Partners in Cabin Safety with pilot organizations, flight attendant organizations and airlines to conduct an educational campaign about passenger seat-belt use to prevent turbulence-related injuries.

3. FAA. "Facts About Turbulence." FAA *Turbulence Happens* Web site. January 8, 2001. www.faa.gov/apa/turb/Facts/fact.htm

4. Bacon, Debi. Telephone interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S. January 18, 2001. Alexandria, Virginia, U.S.

5. Bacon.

6. U.S. National Transportation Safety Board (NTSB). Aviation Accident/Incident Database. Accidents counted by FSF editorial staff involved clear air turbulence, convective turbulence or wake turbulence but did not include other accident circumstances such as mechanically induced changes in aircraft attitude or abrupt maneuvers by flight crews responding to ground-proximity warning systems (GPWS)/terrain awareness and warning systems (TAWS), traffic-alert and collision avoidance systems (TCAS) and/or visual detection of aircraft that presented a collision hazard.

7. Claussen, Nancy. Telephone interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S. January 16, 2001. Alexandria, Virginia, U.S.

8. Claussen.

9. FAA. "Policy for Passenger and Flight Attendant Use of Seatbelts During Turbulence." Flight Standards Information Bulletin (FSIB) for Air Transportation (FSAT) 95-25. September 28, 1995.

10. Bacon.

11. Bacon.

12. The Turbulence Joint Safety Implementation Team is expected to factor into its deliberations pending research on the minimum times that flight attendants need to secure the cabins of different types of aircraft after receiving a warning of turbulence, said Debi Bacon, a team leader of the Turbulence Joint Safety Analysis Team (Turbulence JSAT). During 2001, the U.S. National Aeronautics and Space Administration (NASA) and FAA will conduct a secure-cabin exercise to measure this time under experimental conditions. The measurements will be factored into development of airborne turbulence-avoidance sensor systems and will help air carriers to develop faster methods of securing cabins.

13. Turbulence JSAT members first reviewed 149 turbulence accidents and 40 turbulence incidents from various U.S. and non-U.S. government databases; they selected a subset of 51 accidents and incidents based on the adequacy of information and the suitability of cases for developing intervention strategies.

14. NSTB. Aviation Accident/Incident Database (AID). Report no. CHI99LA184, June 11, 1999.

15. NTSB AID. Report no. ATL97LA064, April 28, 1997.

16. NTSB AID. Report no. LAX98LA104, March 4, 1998.

17. NTSB AID. Report no. CHI99LA145, May 5, 1999.

18. NTSB AID. Report no. NYC97LA155, July 25, 1997.

19. NTSB AID. Report no. CHI97LA292, September 14, 1997.

20. NTSB AID. Report no. MIA98LA017, October 31, 1997.

21. NTSB AID. Report no. MIA98LA054, January 6, 1998.

22. The NASA Aviation Safety Reporting System (ASRS) is a confidential incident-reporting system. ASRS reports are voluntary and subject to several limitations. ASRS *Directline* (December 1998) said, "Reporters to ASRS may introduce biases that result from a greater tendency to report serious events than minor ones; from organizational and geographic influences; and from many other factors. All of these potential influences reduce the confidence that can be attached to statistical findings based on ASRS data. However, the proportions of consistently reported incidents to ASRS, such as altitude deviations, have been remarkably stable over many years. Therefore, users of ASRS may presume that incident reports drawn from a time interval of several or more years will reflect patterns that are broadly representative of the total universe of aviation safety incidents of that type."

23. Claussen.

24. FAA. "Flight and Cabin Crewmember Coordination and Communication." *Air Carrier Operations Bulletin* (*ACOB*) 1-1994-15. August 25, 1994.

25. FAA. "Passenger Seatbelt Discipline." *ACOB* 1-1994-27. August 25, 1994.

26. FAA. "Policy for Passenger and Flight Attendant Use of Seatbelts During Turbulence."

27. Australian Bureau of Air Safety Investigation (now Australian Transport Safety Bureau). "R980238 and R980239 – Injury as a Result of Unexpected Turbulence Encounters." *Regional Airlines Safety Bulletin.* March 1998.

28. Transport Canada. "Seat Belt Use and Seat Belt Discipline." Commercial and Business Aviation Advisory Circular no. 0149. January 15, 1999. "In-flight Use of Seat Belts/Safety Harness — Flight Attendants." Air Carrier Advisory Circular no. 0070R. December 12, 1996.

29. U.S. Federal Aviation Administration (FAA). "New Safety Program Unveiled: Safer Skies — A Focused Agenda." News release. April 14, 1998.

30. Motevalli, Vahid. Interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S. January 16, 2001. Alexandria, Virginia, U.S. Motevalli said that the video simulation uses a finite-element model of a representative aircraft structure, modeled Hybrid III "crash-test dummies" and flight data from an actual turbulence event to show realistically what can occur inside a commercial jet cabin. A 2.25-second period was selected to depict the critical moments of an in-flight turbulence encounter. The simulation shows the frontal cross section of a generic aircraft fuselage with one belted dummy occupant, one unbelted dummy occupant and an unrestrained serving cart in an aisle. The belted dummy occupant remains restrained safely in the seat, the unbelted dummy occupant is thrown violently against the cabin ceiling and the cart strikes the overhead bin and ceiling. Cabin material properties were programmed to simulate typical materials but not a specific aircraft or product, he said. The accident-modeling technology used for this simulation also could be applied to the trajectories and forces of other unsecured objects during various levels of turbulence, such as overhead bin structures, seats and child-restraint systems, he said.

31. Motevalli. Palmerton, David. Interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S. January 19, 2001. Alexandria, Virginia, U.S. FAA's Civil Aeromedical Institute has made the two-minute video available to airlines for recurrent training materials on turbulence for pilots, flight attendants, dispatchers and air traffic controllers. FAA also plans to develop during 2001 a short training video incorporating the simulation, other digital images and video that show graphically the effects of severe turbulence when occupants and objects are not restrained.

32. Bogue, Rod. "Turbulence Detection and Characterization Elements." Presentation to the NASA-FAA-Industry Workshop on Forward-looking (Airborne) Turbulence Sensor Certification. Boulder, Colorado, U.S. December 1, 2000. Sensor technology was tested in 1998–2000 to detect convective turbulence from the aircraft flight deck, including very low levels of moisture, using software

enhancements to microwave radar (airborne weather radar that can detect precipitation and wind shear) — and to detect clear-air turbulence with a type of laser technology called light detection and ranging (LiDAR), which measures changes in the velocities of microscopic particles (aerosols) in turbulent air. (The CLR Photonics Division of Coherent Technologies, developer of LiDAR, also has called the technology "Doppler laser radar" and "clear air turbulence infrared radar.")

33. Honeywell. "United Airlines, AlliedSignal Aerospace [now Honeywell Aerospace] and Coherent Technologies Inc. to Develop All-Weather Turbulence Sensor for Commercial Airlines." News release. April 28, 1999. U.S. National Center for Atmospheric Research (NCAR). "First Test Flights Are a Hit: Onboard Sensor Reveals Invisible Turbulence Ahead of Aircraft in Time to Issue Warnings." News release. April 6, 1998. Crotty, Ron. Interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S. January 17, 2001. Alexandria, Virginia, U.S. The initial deployment by air carriers of microwave-radar enhancements (Honeywell RDR-4B radar) is projected to occur by 2002 and the initial deployment of systems incorporating these and other technologies is projected to occur by 2004. Other companies involved the FAA/NASA certification discussions include The Boeing Co. and Rockwell-Collins. Honeywell, Coherent Technologies and United Airlines announced in 1999 a collaboration in developing airborne turbulence-sensing technologies. Estimates used by NASA and NCAR on the annual cost of U.S. turbulence-related injuries, aircraft damage and government investigations have been as high as $100 million.

34. Gonzales, Fidel. "Turbulence in Air Travel — Time for Change." Paper presented to the 15th annual International Aircraft Cabin Safety Symposium, Oklahoma City, Oklahoma, U.S. February 2, 1998.

35. The *sterile cockpit rule* refers to U.S. Federal Aviation Regulations Part 121.542, which states: "No flight crewmember may engage in, nor may any pilot-in-command permit, any activity during a critical phase of flight which could distract any flight crewmember from the performance of his or her duties or which could interfere in any way with the proper conduct of those duties. Activities such as eating meals, engaging in nonessential conversations within the cockpit and nonessential communications between the cabin and cockpit crews, and reading publications not related to the proper conduct of the flight are not required for the safe operation of the aircraft. For the purposes of this section, critical phases of flight include all ground operations involving taxi, takeoff and landing, and all other flight operations below 10,000 feet, except cruise flight."

36. Kolander, Candace. Telephone interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S. January 18, 2001. Alexandria, Virginia, U.S.

37. Welding, Ron. Telephone interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S. January 18, 2001. Alexandria, Virginia, U.S.

38. FAA; Air Transport Association of America; McDonnell Douglas. "Turbulence: A Little Bumpy Air."

39. Frantz, Robert. "Turbulence Injury Reduction — A Systems Approach." 1998. Frantz, a member of the Turbulence JSAT representing the Air Line Pilots Association, International, in this paper said, "We have raised the point that some cabin design improvements could help reduce [turbulence-related] injuries. These include: inset hand holds in strategic locations for flight attendants to help secure themselves; safety lids for coffee pots; secondary retaining devices for luggage in the overhead bins; seat-belt-monitoring system (the technology currently exists in hospitals and automobiles); light-signaling method to warn flight attendants of impending turbulence and its severity; and a method of securing the service carts to the floor."

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