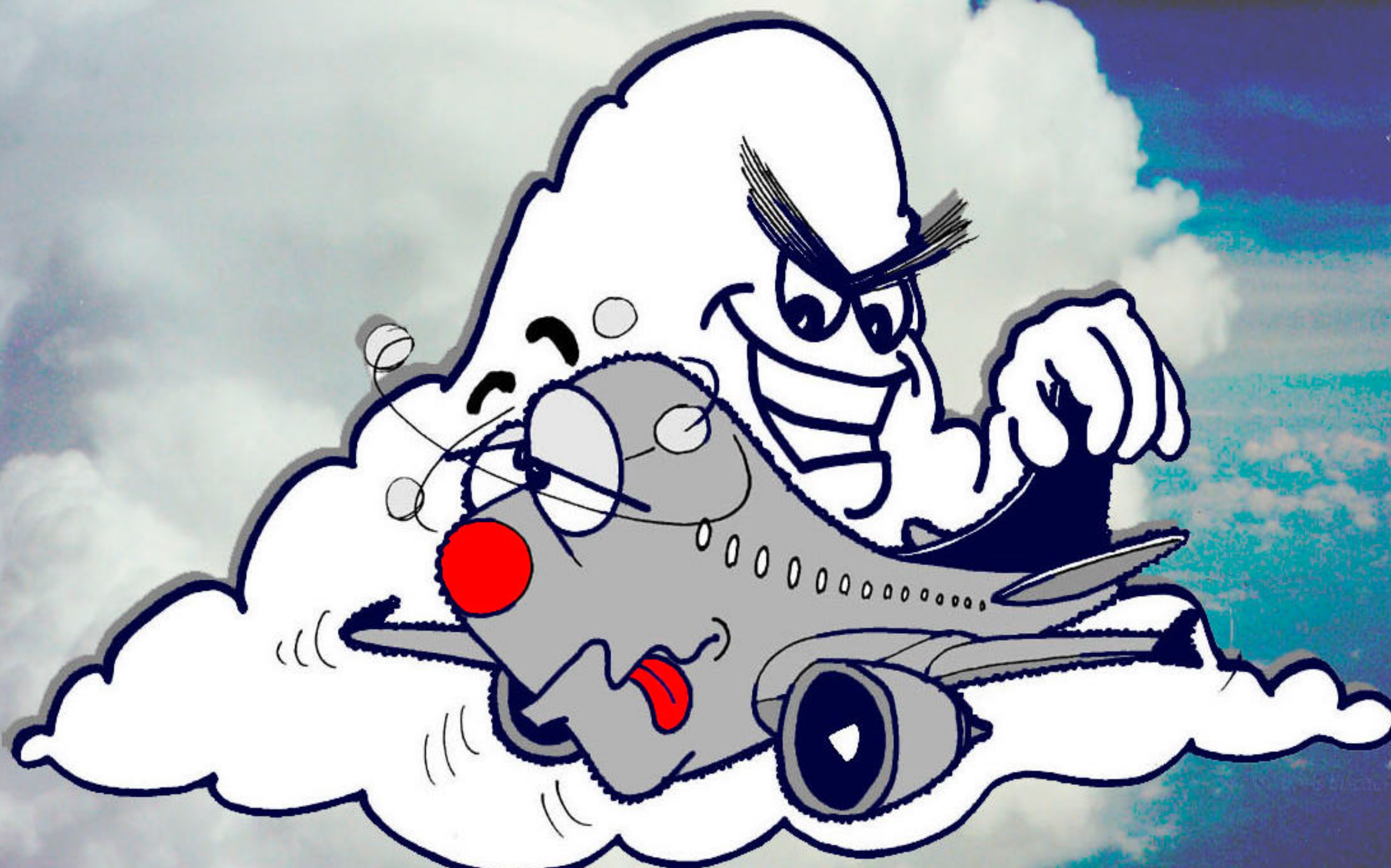
Turbulence Avoidance Special Issue

US AIRWAYS

Safety On Line

A Flight Safety Publication For All US Airways and US Airways Express Flight Personnel June 2005

Turbulence Avoidance



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Cover
Illustration by Chris Snyder

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Safety On Line is published by US Airways' Corporate Safety Department. The contents of this publication are created solely for the professional use of US Airways' crewmembers and Dispatchers, and other selected industry organizations and are not intended for the general public. Articles obtained for the publication are derived from a variety of sources for the purpose of increasing and enhancing safety knowledge at USAirways. Opinions expressed by individuals do not necessarily reflect those of the Company, and are not meant to supersede operational policies and procedures or Federal Aviation Regulations. Contributions, commentary and feedback are welcome, though the Editor reserves the right to summarize or edit portions of any submission due to space limitations.

Flight Safety Perspective

It is altogether fitting that my first column as Vice President of Safety and Regulatory Compliance is to cornerstone the edition devoted to turbulence. Much like a cure for the common cold, we have made some progress in detecting turbulence, but it has mostly been through knowledge and education, since detection technology has not evolved. There are some technology efforts in test now that show some promise in detecting clear air turbulence ahead and some ground prediction systems that reveal areas of possible turbulence, but a truly accurate system has still eluded industry.

Our efforts in education have been effective and crew diligence in ensuring seat belt adherence has decreased the number of passenger injuries due to turbulence significantly. I am still concerned about timely notification to allow flight attendants time to check passenger compliance and yet have enough time to strap in before encountering turbulence.

Pilots use PIREPS, experience and intuition to make these calls, and it surely is not an exact science. But, we have improved and that is great.

This issue has some terrific articles that review distinct areas of the turbulence avoidance effort. If you participate in the flight whether airborne or on the ground, there is something in this edition for you. Reviewing results and procedures is always a good idea, and both the passengers and our employees will be the beneficiaries for your effort.

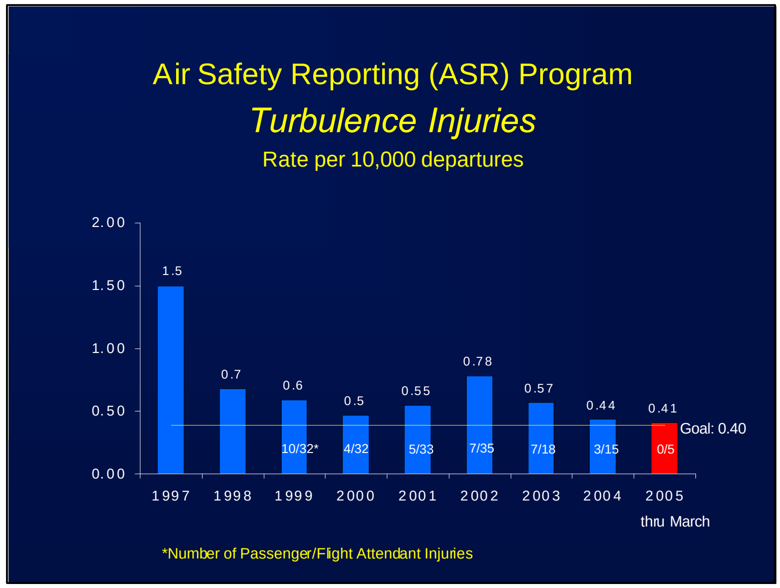
Jim

Jim Schear
Vice President, Safety and Regulatory Compliance

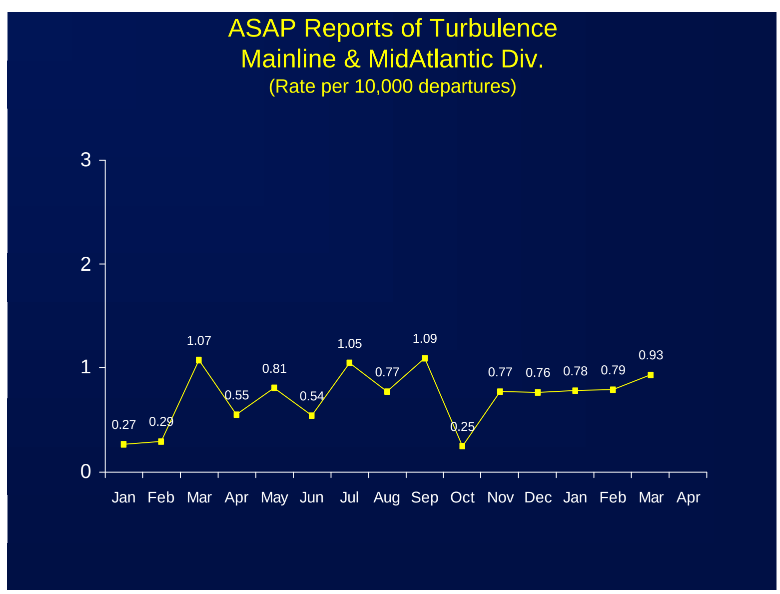
Turbulence Reporting

By Anthony Palombo
Manager, Cabin Safety

For decades, safety advocates have recognized turbulence as the leading cause of non-fatal injuries to flight attendants and passengers. According to FAA statistics, passengers made up almost 94 percent of the aircraft occupants, but they accounted for only 48 percent of the fatal and serious injuries. By contrast, only 4 percent of the aircraft occupants were flight attendants, but they accounted for 52 percent of serious or fatal injuries.



Passenger turbulence-related injuries have decreased dramatically, from 48 per year to just over 5 per year, since US Airways instituted the mandatory seatbelt policy. Most passenger injuries occur because they elected to ignore the seatbelt sign, or were in the lavatory at the time turbulence hit. Flight attendant injuries have averaged almost 40 per year for the past eight years.



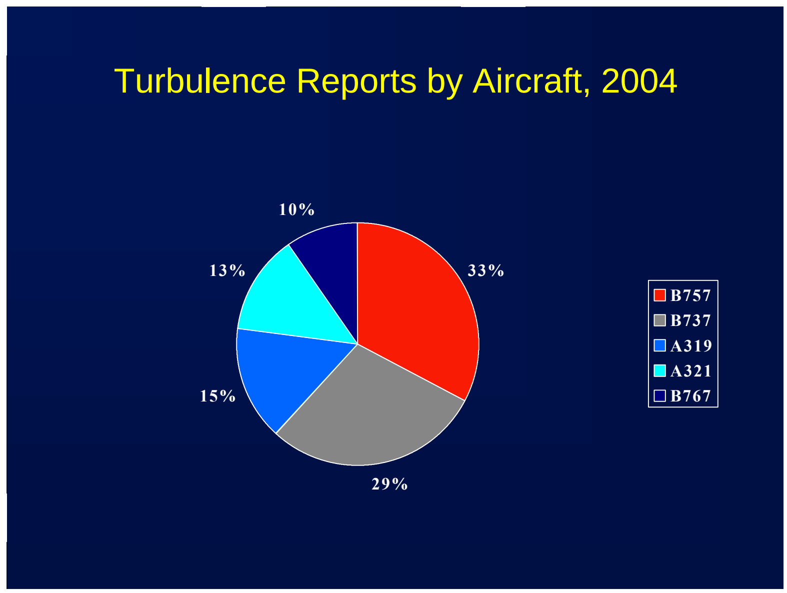
Additional review and analysis by the FAA of turbulence data collected through 2003 revealed that the number of turbulence reports has increased steadily for a decade. The data strongly suggest that the most effective measure during a turbulence encounter is to have passengers and flight attendants seated with seatbelts fastened. From 1980-2003, just 4 people received serious injuries who were seated with seatbelts fastened

Remember that you are not invincible. Industry data reveals that most injuries occur because flight attendants are usually not seated with the seatbelt fastened while working, and often continue working after the fasten seatbelt sign is illuminated unless explicitly advised by the flight crew to discontinue cabin service. Even after an announcement from the flight deck that turbulence is anticipated, flight attendants are sometimes delayed in being seated because they are securing equipment and confirming that passengers have fastened their seatbelts.

The risk per flight attendant of serious injury caused by turbulence is nearly 24 times higher than the risk per passenger. A review of available injury histories indicates that flight attendants sustain a high number of injuries to the back, foot, ankle and toe, with a smaller number of injuries to the head, leg and knee.

The key to preventing injury is advance notification and avoidance, whenever possible. Discuss anticipated turbulence in the pre-flight briefing, or whenever turbulence is reported. The environment in the cabin may be very different from the environment in the flight deck during turbulence. Keep in mind; the ride in the aft galley of a 757 is much different than in row 1.

Follow these simple rules when standing during turbulence:



- Stagger your feet and keep the knees slightly bent to avoid unnecessary impact to your knees and back.
- Hold on to something stationary to keep your balance.
- If possible, stow loose objects securely to avoid injuries from thrown objects. Listen to pilot announcements. If you are instructed to sit during turbulence, do so, and fasten your seatbelt.
- Anytime you believe your safety is at risk from turbulence, sit down immediately and buckle up.

Also, use the Fasten Seatbelt sign wisely. When the Fasten SeatBelt sign remains illuminated for prolonged periods of time during smooth air, its effectiveness can diminish for passengers and flight attendants.

The FAA and NASA have teamed together with airlines on a collaborative effort to develop accurate, reliable aircraft turbulence detection systems. Until that technology is perfected, we must rely on the tools currently available to us in planning for areas of turbulence. To avoid potential hazards, effective communication with company personnel and fellow crewmembers is essential. Fly safe!

Tools of the Trade

By Donald Billings
Instructor, Dispatch Training & Quality Assurance

The statistics are troubling. Since 1983, air carriers in the United States have experienced 131 turbulence-related accidents, with a total of 3 passenger fatalities. In addition to the 3 fatalities, 83 passengers and 93 flight attendants suffered serious injuries, while 423 passengers and 121 flight attendants suffered minor injuries.

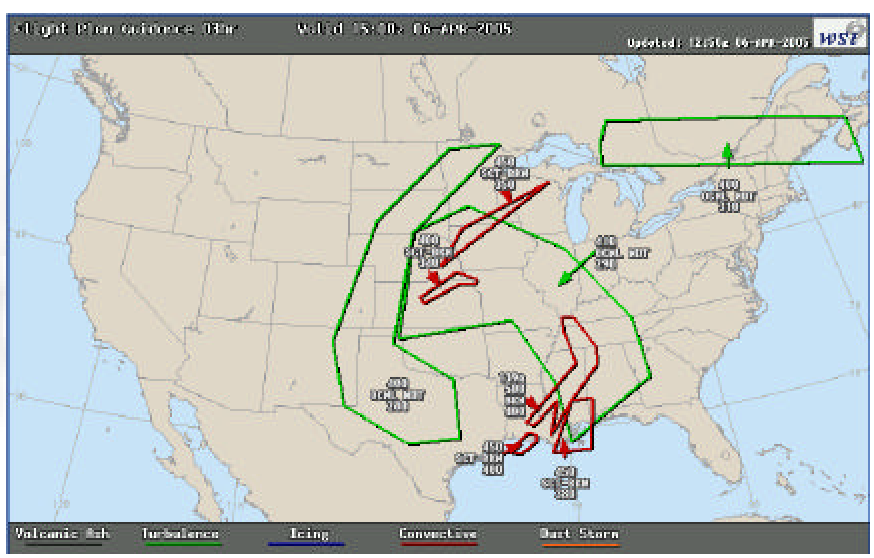
The ability to detect and warn our flight crews of turbulence provides a constant challenge to our dispatchers in the Operations Control Center. Tremendous strides in technology over the past decade have made this important task easier to accomplish. Just recently we have been provided with new tools that will bring additional depth to the graphics that are used in the pre-flight planning phase. Our primary weather graphics vendor, WSI Incorporated, has provided us with a very thorough suite of tools through the PilotBrief Vector system, which is available to all employees through a link off the home page of theHub.

WSI serves customers in broadcast, aviation, energy and utilities, government, and consumer markets. Within the aviation industry, WSI is the leader in developing advanced systems and in turning massive amounts of meteorological information into meaningful data, products and services. Our dispatchers rely heavily on the information contained within the PilotBrief Vector system, which is delivered by dual independent satellite feeds into the Operations Control Center.

In February 2005, WSI was given the responsibility of developing the turbulence indicator values and weather discussions that appear on the flight plan/weather package for each flight. The meteorologists at WSI utilize a system called WxPro, which ingests and "layers" data at different altitudes from multiple numerical models including the Weather Research and Forecast (WRF) model, which is a next-generation mesoscale numerical weather prediction system. Additionally WSI utilizes the Graphical Turbulence Guidance (GTG) model as they layer multiple products together within the WxPro platform. The GTG uses a total of 22 different algorithms to predict clear air turbulence severity. This information, along with water vapor and infrared satellite channels, is used to develop a number of products that are sent to us through the PilotBrief Vector System.

Flight Plan Guidance Chart

The electronic Flight Plan Guidance Chart is a relatively new product for us that became available in February of 2005. Through the methods described above, WSI portrays the anticipated location of five different types of hazards that could impact our flight operations. These hazards include volcanic ash, dust storms, convective activity, icing and turbulence. The various hazards are manually drawn as colored polygon overlays on the WxPro System and given vertical and lateral limits. Where turbulence is anticipated, the area is given a numeric value, which relates to the expected turbulence intensity. This value is then exported to Sabre FOS and appears automatically as a turbulence indicator

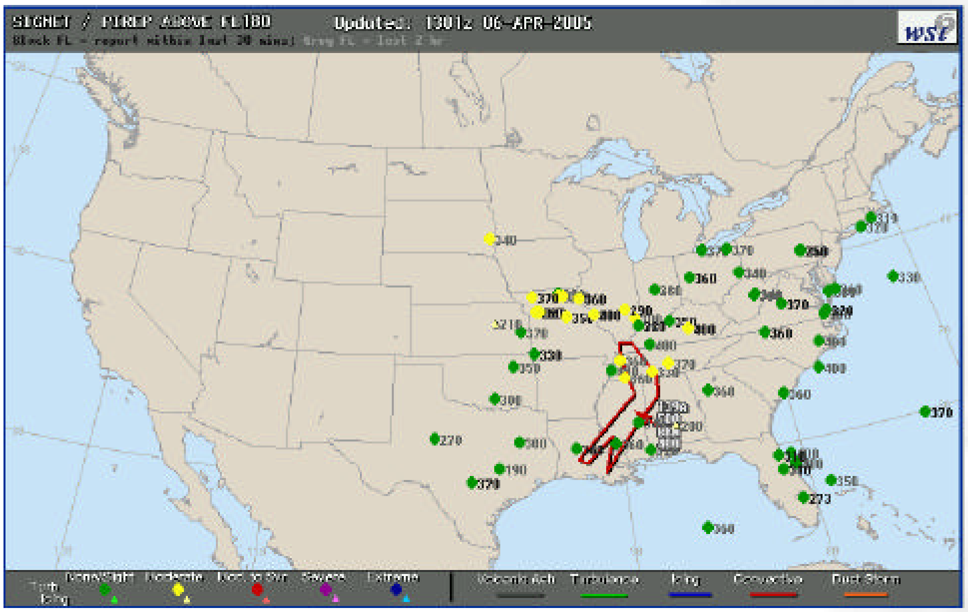


WSI Flight Plan Guidance Chart

value on any flight plan that is routed through the area contained within the polygon. With the recent change to WSI, we should find our turbulence indicator values to be more reliable than we have found them to be in the past.

WSI Sigmets and PIREPs

When certain thresholds are met, WSI will issue a Sigmet. This is not to be confused with a National Weather Service (NWS) Sigmet, as a WSI Sigmet is generally more conservative in nature and is specifically tailored for transport category aircraft. With respect to turbulence, the NWS will issue a Sigmet only when severe turbulence is anticipated. WSI will generate a Sigmet for turbulence anytime moderate or greater turbulence is anticipated. The WSI Sigmet will also be automatically exported to Sabre FOS, and when it enters this environment, its name changes. Within the confines of Sabre we call it a Sigmec, so that we can differentiate between what is sent by WSI and what is sent to us by the National Weather Service. Sigmecs automatically append to the weather package for each flight to warn our flight crews of those areas where turbulence might be expected.



WSI Sigmet/PIREPs Chart

In addition to receiving the Flight Plan Guidance charts, we recently began receiving graphically portrayed pilot reports. This is a tool that has been particularly helpful, as in the past the dispatcher had to create a visual image in his or her mind of where reports of turbulence were based solely on the availability of textual reports. The charts that include these PIREPs provide us with a visual image of where turbulence has been reported within the last two hours, and in many cases within the last 30 minutes. This is tremendously useful when providing our flight crews with a pre-flight briefing.

PIREP information is ingested from a mixture of publicly available reports and American Airlines position reports. We are working with WSI now to export position reports from US Airways to supplement this data. The reports are filtered to only include transport category aircraft above FL180. Additionally, the chart automatically refreshes every 20 minutes. The intensity of the reported turbulence is shown in the form of a colored circle along with the appropriate altitude. The altitudes shown in bold are reports that have occurred within the last 30 minutes. Those altitudes shown in gray are reports that have occurred within the last 2 hours. Animating the chart provides one with the ability to see how different areas have grown or dissipated over a given period of time. The WSI Sigmet and PIREP charts are available for each of the geographic regions in which we operate.

Emerging Technologies

A number of emerging technologies, products and delivery systems are being developed by various entities within the aviation industry to detect turbulence. The following descriptions will provide you with some insight into this area of development.

- **Turbulence Prediction and Warning Systems** (TPAWS). Currently NASA and FAA are leading a multi-disciplined government/industry team directed at developing the scientific basis, algorithms and performance requirements for the detection of convective and non-convective related turbulence. The emerging TPAWS technologies include:

    1. Enhanced Turbulence Prediction Airborne Radar Systems. The goal is to improve convectively induced turbulence detection in the 25-40 mile range and deliver meaningful alerts/information of the turbulence safety hazard, specifically for the aircraft and its flight conditions, to the crew. This first of such systems was developed and tested by NASA, and is presently undergoing operational testing and evaluation.

    2. Turbulence Automated PIREP (TAPS) Reporting. The goal is to provide to an aircraft during any phase of flight an automated, event-driven report of a turbulence hazard. The hazard reporting metric is related to aircraft loads/accelerations incurred at the time of the encounter and is then transmitted from an aircraft to a ground station. It provides a clear, concise advisory that eliminates the subjectivity, latency and aircraft-type specificity associated with existing verbal pilot reports. This initiative was also developed and validated by NASA, and is presently installed and fully functioning on 71 aircraft comprising the B737-800 fleet of a carrier in the United States for evaluation through the end of this year.

- **EDR** (Eddy Dissipation Rate). As part of the FAA Turbulence Product Development Team (PDT), the National Center for Atmospheric Research (NCAR) has developed the technology to use existing aircraft performance systems to derive an automated turbulence measurement (EDR). In collaboration with the FAA and NCAR, one airline has installed EDR software on over 200 aircraft. These aircraft have been providing automatic downlink of peak and average turbulence readings at one-minute intervals. This information is currently being used for research and as input into automated turbulence forecasts, such as the Graphical Turbulence Guidance model described previously.

- **OCND** (Ocean Convective Nowcast Demonstration). Convection over oceanic areas has been and continues to be a major source of air carrier turbulence encounters and related injuries. This issue is being addressed by the FAA Oceanic Weather Product Development Team (OWPDT). As OWPDT members, NCAR and the Naval Research Lab (NRL) have developed an experimental graphic oceanic convective product. Using real time oceanic satellite data and associated analysis algorithms, convective cloud top graphics are generated at 30-minute intervals. Currently, experimental OCND products are available for the Pacific and Caribbean, with plans to expand coverage to include the North Atlantic in the near future. These graphics are available on the National Center for Atmospheric Research web site: (http://www.rap.ucar.edu/projects/owpdt).

- **CIWS** (Center Integrated Weather System). CIWS is an FAA-sponsored program to develop an improved aviation convective weather graphic. CIWS was developed by MIT/Lincoln Lab and uses radar inputs from NWS NEXRAD, TDWR and ASR radars to generate automated, high update information on storm locations and echo tops, along with 2-hour high resolution animated growth and decay forecasts of storms. Coverage is limited to the Great Lakes and northeast corridor at this time. We hope to have access to CIWS through theHub in the near future for the use of flight crews and dispatchers in their pre-flight planning.

The detection of turbulence continues to evolve and improve as technology moves forward. The Operations Control Center is committed to utilizing the latest technology in this area as we strive to plan a safe, efficient and reliable flight for our crewmembers and passengers. You are encouraged to take advantage of the resources available to you – the WSI Pilotbrief System and a call to your dispatcher will ensure that proper communication and planning is in place as you begin your flight. The statistics are troubling indeed – we must do our part to ensure that we do not add to them.

What Does "1" Represent?

By Rich DeMary
Inflight Training Specialist

In this table, "1" represents a flight attendant. A better way to read the table would be: "1" flight attendant, out of 144 total occupants onboard, sustained a serious injury as a result of a turbulence encounter." This information was taken from NTSB data on accidents reported in 2004, where an occupant received serious injuries as a result of a turbulence encounter on a commercial aircraft. Of all serious injuries reported to the NTSB, only flight attendants received serious injuries as a result of turbulence. Additional information can be found by conducting a search at the following web address:

A/C Type	Serious Injuries	Total Occupants
B 767	1	144
B 737	1	46
A 319	1	110
MD 80	1	29
B 737	1	135
MD 80	1	87
B 737	1	121
B 737	1	108
B 757	1	175

http://www.ntsb.gov/ntsb/query.asp#query_start

Protecting Our Passengers
In general, flight attendants are the last line of defense in protecting our passengers from turbulence related injuries. We make announcements, check and re-check for seatbelt compliance, and we assure passengers that seatbelt compliance is necessary for their safety. But what we often fail to do is assume a proactive role in protecting ourselves. Because flight attendants move about the cabin, they are vulnerable to turbulence and often sustain the only injuries when turbulence is encountered.

Are You Protecting Yourself?

Much of what we do to protect our passengers also serves to protect us, the flight attendants. Just as regulations require passengers to have their seatbelts securely fastened when seated, we must also have our seatbelts and shoulder harnesses fastened when in the jumpseat. Often, the challenge is getting to your jumpseat before the turbulence encounter. When given forewarning of potential turbulence, our "window of opportunity" to protect ourselves is often diminished by checking passengers' seatbelts and securing the cabin. A high number of flight attendant injuries occur as flight attendants are about to take their jumpseat. We can increase this available time by not only checking for compliance when the seatbelt sign is illuminated, but also checking for seatbelt compliance as we conduct service and interact with passengers. Additionally, keeping galleys secure at all times and maintaining an immediate plan of action if turbulence is encountered may give you the needed time to protect yourself. Your plan of action should include, immediately and without hesitation, taking the nearest available passenger seat when faced with moderate or severe turbulence. If no passenger seat is available and the situation warrants, sit on the floor and hold on.

Turbulence: What's Happening?
Basically, we experience turbulence as alternating positive and negative G forces. We have all experienced the "heaviness" of positive G forces and the "floating sensation" of temporary negative G forces. Astronauts, for example, train for the weightlessness of space in specially fitted aircraft. The aircraft is stripped of its interior furnishings and thick layers of padding are

applied to the floor, ceiling and sidewalls. The aircraft ascends at a very high rate of climb to a predetermined altitude. At the top of this "parabola," the nose of the aircraft is pitched down and maintained in a constant descent, providing a prolonged period of weightlessness. I think all of us have experienced a "parabola" at one time or another. The climb and then the rapid descent of a roller coaster come to mind. Also, driving down a highway and cresting a small hill in the road can also give us a momentary sense of weightlessness. It is this period of weightlessness that presents the greatest hazard to flight attendants. Testimonials from flight attendants who have experienced severe turbulence include such descriptions as "the cart lifted off the floor," "items were flying everywhere," or "I was lifted off my feet." Any period of weightlessness on earth is temporary and adds credence to the old adage, "What goes up must come down." Flight attendants are very prone to serious injury during turbulence and must make every effort to protect themselves during this time. A few years ago in Recurrent Training, flight attendants were presented a video on maintaining a defensive stance during turbulence. Simply stated, any stance where you are better able to maintain your balance while standing will also help you return to your feet if you're lifted off the floor during turbulence.

Policies and Procedures

For the last several years in Recurrent Training, flight attendants and pilots have reviewed our policies and procedures as they relate to turbulence and the illumination of the seatbelt sign. During this Recurrent Training year, many of you also participated in a survey where your knowledge of policies and procedures were measured. Your overall knowledge of policies and procedures related to turbulence and the illumination of the seatbelt sign is substantial. Your training also identified misconceptions regarding the advantages of keeping the seatbelt sign on, even when no threat of turbulence exists. Proper use of the policy regarding the illumination of the seatbelt sign will help to limit complacency in flight and serves as a greater and more meaningful barrier to the threat of turbulence.

What Else Can We Do? Use CRM

One of the basic tenets of effective CRM is creating and maintaining open lines of communication among crewmembers. Injury prevention not only involves the proper application of policy and procedure, but it also depends on actively applying Crew Resource Management. Pilots must provide as much information to flight attendants as possible. Additionally, CRM only works if flight attendants remain an active participant.

If you have questions or concerns that could impact your safety or the safety of a passenger, do not hesitate to contact the flightdeck. Safety is enhanced when you speak up and ask questions.

Always keep in mind your vulnerability to injury and that without proper planning and preparation, the "1" most likely to suffer a serious injury as a result of turbulence is **you**.

Flight Attendants Receive Injuries from Turbulence Event

Many carriers report turbulence injuries to flight attendants or passengers. The following report from another carrier has many parallels with the turbulence injuries our crews have experienced in the past. The weather conditions this flight encountered occur every day during the spring and summer months.

SUMMARY

A Boeing 757, operating as a regularly scheduled passenger flight from encountered severe turbulence while in cruise flight at F290. Two flight attendants were injured. One flight attendant suffered fractures of the left tibia and fibula. The other flight attendant received minor bruising to the knees. The flight attendant with the fractures was treated and stabilized by a physician on board. There were no other reported injuries. The aircraft continued to destination where an uneventful landing was made. There was no reported damage to the aircraft.

FACTs

Weather

Flight-level winds in the region were 250 degrees at 60-65 knots.

Vertical wind shears and stability indices alone at flight level were NOT considered to be within the threshold of moderate or greater turbulence. The horizontal temperature gradients at flight level were large, but this is rarely indicative of CAT by itself. This analysis was facilitated by National Center for Atmospheric Research RUC model interpolations.

Thunderstorms consisted of scattered cells within a line extending NE-SW from extreme western South Carolina across northern Georgia to east-central Alabama moving east-northeast about 20-25 knots. The pilot stated he 'had just cleared convection' when the incident occurred. Radar confirms that at the time of the incident the aircraft had just exited a small cluster of cumulo-nimbi (CBs) with echo tops near or just above FL300. The aircraft was at FL295 at the time of the incident. Lightning data shows that there were cloud-to-ground strikes directly below the aircraft at the time of the incident. Also important, there was another cluster of CBs, 20NM in breadth, 35-55NM west-southwest of the aircraft with maximum echo tops to FL350.

PIREPS: There were no turbulence reports in the area at the time of the incident.

SIGMETS: A convective was in effect until 1655 EDT for the time and location of the incident.

The high-level significant weather chart valid at 1400 EDT showed the aircraft to be just within an area of predicted moderate turbulence from FL250-380.

The turbulence was most likely induced by convection, either just below the aircraft and/or from the convection upstream (35-55NM west-southwest) of the aircraft. Winds aloft, both direction and speed, would have been favorable to propagate wave activity from the convective cells located just to the southwest of the aircraft, as mentioned above. This is most likely yet another incident where the on-board radar equipment may have given the pilot a false sense of security. Building convective cells below the level of flight and/or convection upstream (in this case abeam/due left) can both be "out-of-sight" and yet be equally as capable of inducing turbulence if conditions are favorable.

Flight Crew Perspective

The flight crew reported that they were well rested from the previous layover. Upon arriving at the airport, the flight crew learned that departure was delayed approximately two hours due to an ATC flow control that was in effect due to strong winds at ORD. The Captain contacted Dispatch and requested that additional fuel be added to the aircraft in anticipation of extended holding at ORD. While in Operations, the Captain reviewed the on-line weather data and observed that there were a number of showers along their route extending up to Atlanta, GA (ATL). The weather systems were on the east and west sides of his route.

Between the time the Captain left Operations and arrived at the gate, the gate agent was announcing that the flow control hold had been reduced and the aircraft would be leaving soon. The Captain returned to Operations and got a new flow time, which was 55 minutes from the original scheduled departure. The Captain briefed the purser on the weather and to expect some moderate turbulence enroute and a bumpy landing at ORD. The aircraft departed early and made an uneventful takeoff and climb to altitude. Their planned cruising altitude was FL350. However, ATC reported that FL350 was a rough ride and suggested FL310. Once stable at FL310, the Captain turned off the seat belt sign. The ride was smooth at this point in the flight. As the flight continued, the flight crew observed some thunder showers ahead and on the west side of their route. They also spotted some stratus clouds at their altitude. They began to experience intermittent light chop, which increased to continuous chop. The seat belt sign was put back on. This lasted for approximately 30 minutes, and the crew reported being IMC while in the stratus.

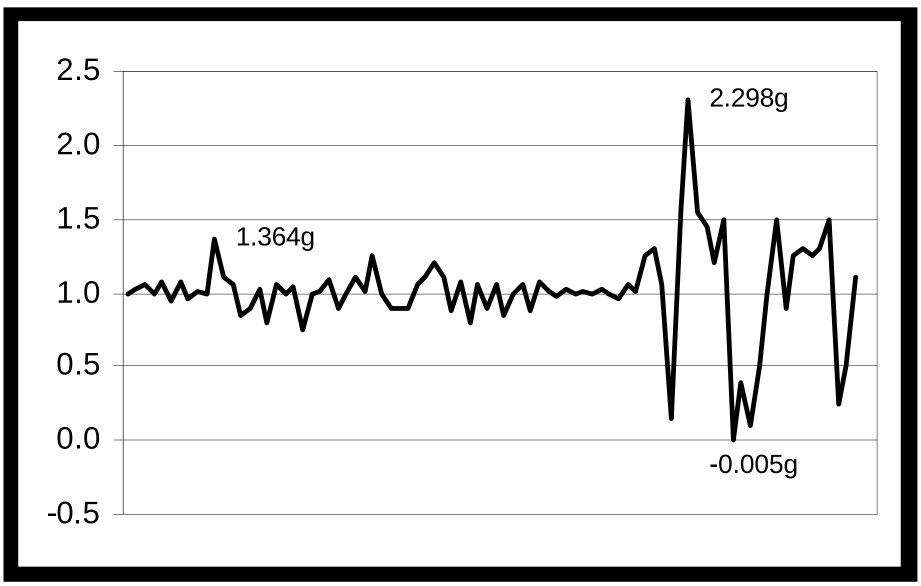
The Captain contacted ATC and received clearance to deviate for the showers. They made numerous 10 to15 degree turns to avoid the showers. ATC contacted the flight and requested that they descend to FL290 due to other deviating aircraft in the area. While they were leaving FL310, they could see a clear path through the showers to the north. They entered another stratus layer when they arrived at FL290. While at this altitude they continued to deviate to avoid the showers. As they came out of the stratus, they could see what appeared to be the end of the weather system to the north. The First Officer had his radar range set at the 20-mile scale, while the Captain alternated switching his from 20 to 40, and occasionally the 80-mile range along with adjusting the tilt. While they were still VMC, they could see the end of the line of showers and wanted to go through the hole that they could see ahead. About 15NM ahead, they saw an oval-shaped green cell on the east side. As they neared the last few miles of cells, the First Officer observed an area of stratus that had a domed area. He deviated to the left to avoid a potential area of build-up. The Captain loosened his seat belt to look out the First Officer's window to see what his concern was. The aircraft was still in light chop at this time. The Captain agreed with the left turn to avoid the domed area, but wanted to go back to the right as soon as possible to head for the clear area. As the Captain sat down, ATC called requesting that they climb to FL310. The First Officer requested max continuous thrust. As the Captain set up for the climb, he saw two green cells on the right at 15NM, which started to show Doppler returns. They wanted to make a right turn to head for the hole, but during the climb they entered the same stratus layer as before and lost their visual to the hole. The Captain adjusted his radar to look up and straight ahead and saw two scalloped cells embedded in the stratus straight ahead. They were unsure as to the cell height. They then encountered 4-5 seconds of turbulence characterized by the flight crew as moderate with a strong updraft for a few seconds, which caused the wings to rock in a 5-degree bank to the left and right. The Captain noted that, while he held on to the armrests, he did not strain against his seat belt during the encounter. The aircraft remained in control during the turbulence, and the ignition was moved to continuous.

Once they exited the top of a cumulus cloud, they were once again in the stratus layer. The purser contacted the flight deck asking if the turbulence would continue. The Captain reported that they were now clear of the weather. He asked if everyone was OK, to which the purser replied "yes." The Captain kept his interphone volume up and heard the aft flight attendant saying that there was an injured flight attendant. They reported a possible broken leg. Medical assistance was requested from the cabin, and the medical kit was retrieved from the flight deck. The Captain directed the First Officer to continue flying while he handled the emergency. Dispatch was contacted and paramedics were requested to meet the aircraft at ORD.

Cabin Crew Perspective

The purser reported being in moderate chop throughout the flight. The seat belt sign was illuminated. The turbulence the purser experienced immediately preceding the encounter felt sharper than what she had experienced throughout the flying day. The change in the feel of the turbulence caused the purser to make a public address announcement requesting the flight attendants to be seated immediately.

Flight attendant #2 and flight attendant #3 were in the aft coach section of the airplane (10 rows from the rear) picking up a trash cart when the purser made the announcement to be seated. They continued to push the cart toward the rear of the airplane. When they got to the last row of seats the turbulence occurred. Flight attendant #3, who was on the forward end of the cart, knelt down while keeping his left hand on the cart. He grabbed the armrest with his right hand. Flight attendant #4, seated at 3L, attempted to maintain physical contact with flight attendant #2. Flight attendant #2 lost her balance, fell backwards, and flew into the air. Her body was perpendicular to the floor. As her body lifted off the floor, her leg kicked up, striking the aft counter in the rear galley



Flight attendant #4 was unable to maintain contact with injured flight attendant #2, when the second wave of turbulence was encountered. Flight attendant #2 landed on the floor against the aft rear lavatory door, holding her left leg. The leg was bent 20 degrees toward the other leg. She was shouting that she had broken her left leg, which appeared to be broken between the ankle and the knee. Before flight attendant #3 could stand up after the first occurrence, he flew into the air again. He landed on his knees. The airplane continued to bounce.

Flight attendant #3 stowed the cart in the aft galley. He went to check on flight attendant #2. Flight attendant #3 contacted the purser and requested medical assistance. Two medical doctors responded to the purser's page for assistance. The purser obtained the first aid kit from the cabin. A doctor onboard used the metal splint from the first aid kit. He placed flight attendant #2 in the last row, right aisle seat, securing her left leg to the armrest of the aisle ahead of her.

ANALYSIS

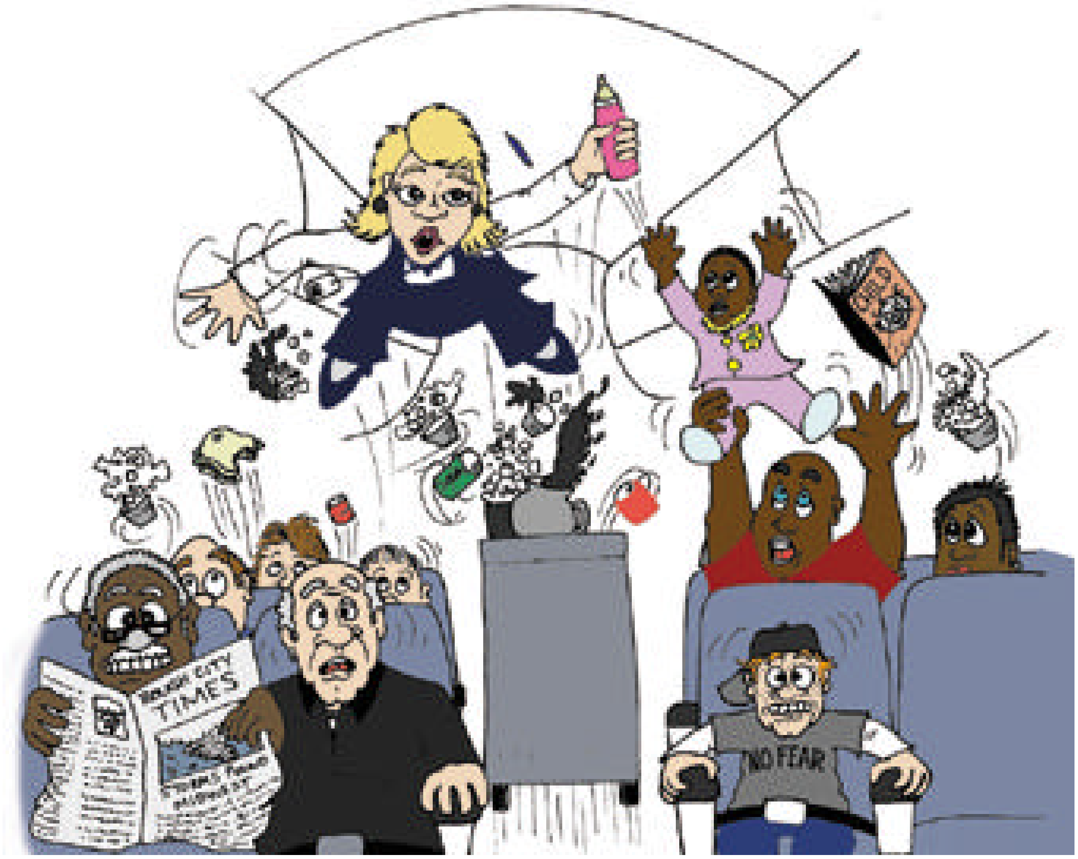
Flight Data Recorder

The flight data recorder was removed for analysis to determine the extent of the turbulence encounter. The data shows the precursor that the purser reported she felt and was the reason to make the announcement for the flight attendants to take their seats immediately.

The aircraft was flying level at FL290 when it encountered the first "bump" at a GMT of 20:07:42. The vertical acceleration was minor, increasing from 0.978 to 1.364g. The aircraft began to climb 5 seconds after this as this minor turbulence tapered off. The aircraft continued a gradual climb, and at GMT 20:08:15 it had reached 29,623 feet when it experienced a slight dip of about 50 feet in altitude with the vertical acceleration dropping from approximately 1.0g to 0.876g. At this time, the aircraft recorded winds from 264 degrees at a speed of 62 knots. One second later the aircraft experienced a sudden spike in vertical acceleration up to 2.298g. It dropped to 1.208g across the next second, followed by a short spike up to 1 .607g before dropping to -0.005g.

The aircraft experienced a similar cycle of peaks and valleys continually diminishing in intensity and finally tapering off at 20:08:25. The total event lasted 10 seconds. There was no significant disturbance observed in airspeed, altitude or heading. In addition, there was complimentary activity in lateral acceleration. However, this was not at any significant magnitude.

Significant Turbulence Incidents



Graphic By Chris Snyder

Expect the Unexpected, and Communicate With Fellow Crewmembers When Turbulence is Expected or Reported

BWI - JAX 737-200

Dispatch Report: A Pirep was issued by AA Weather – location showed the code CSN. Some confusion with AA as to whether location was Cassanova or Carson City, NV.

F/A Summary: While preparing for beverage service in the aft galley, we unexpectedly hit moderate turbulence. Both F/As were bounced around, and lost their balance. One F/A fell on her left ankle and her foot twisted in – she heard the leg snap. The second F/A hurt her back. Both stayed on the floor and held on to whatever they could to secure themselves until the turbulence stopped.

Captain's Report: Climbing through FL 190 we experienced moderate turbulence unexpectedly. I had the F/O tell the F/As to be seated. The B F/A informed me that the B F/A might have broken her ankle. After discussing the situation with Dispatch, considering our current position, and the employee's condition we elected to continue to JAX and have EMS meet the flight. I was later informed that B F/A had hurt her back. The ride immediately before and after the event was smooth.

Event Summary: One F/A with Broken ankle. One with sore back and multiple bruises.

LGA – DCA A320
FAIR: Flight was holding at 11,000 feet for DCA due to thunderstorms over the field. Captain said the ride was smooth, then they quickly hit turbulence that he classified as light to moderate. He received word that two F/As needed medical attention. F/As were standing near the beverage cart when they hit turbulence. The cart smashed one F/As right arm.
Event Summary: One F/A with a broken elbow. One F/A with broken rib, bruised tailbone, and bruised thigh.

SFO – PIT B767
ASAP Summary: Flight was level at FL250, when the aircraft encountered moderate to severe turbulence that was unexpected and lasted 2-3 minutes at 20-30 second intervals. The seat belt sign was on. B F/A was in the rear galley preparing for arrival and was thrown 2-4 feet in the air. He landed on his ankle and could hear a "snap." The other crew and pax were OK. Upon landing in PIT, A/C met by paramedics.

Event Summary: F/A had small fractures in his ankle, fractured fibula, and ligament damage.

SFO – PHL 757
Fair: The Captain reported that when going around a T-storm at FL 250 over HAR, he hit a down draft and several pax came out of their seats and hit the overhead bins. The Captain had previously turned on the seat belt sign and warned pax of possible turbulence in this area descending into PHL.
Update: F/A sustained back, head, neck injuries, facial cuts, as well as coffee burns on right side. Pax taken to the hospital with 2-inch cut on head.

ATL – PHL 737
The Capt reported that on climbout between FL 220 and 240 in clear air, they hit turbulence – light to moderate. They were following another aircraft at the time, which was not reporting any weather or turbulence. This is when he was notified that a F/A had broken her ankle – compound break. They used both O2 bottles and med kits. There was a lot of bleeding. Flight returned to ATL with no problems. F/A was in the rear galley at the time.

**"Turbulence Injuries are Serious Business.
Our Focus is on Keeping You Safe."**

TURBULENCE

By Captain Dan Sicchio

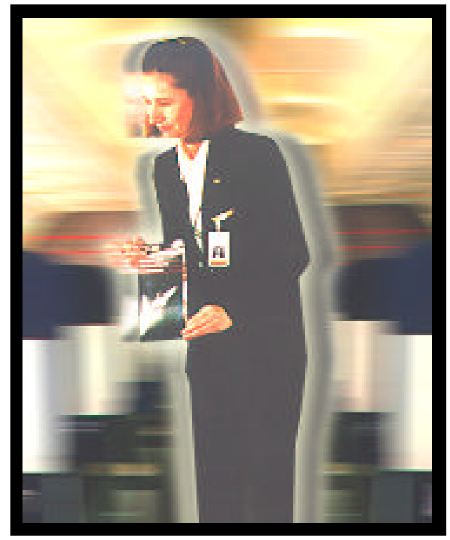
With the change of seasons come changes of focus. From icing to thunderstorms is a dramatic change that we all expect. In the interim we actually experience a more subtle change with en-route turbulence becoming more of a challenge. Thunderstorm season means almost constant encounters with en-route turbulence. In spite of almost daily encounters, the less frequent encounters during late spring actually result in more frequent injuries to flight attendants and passengers. This may be hard to believe, but the statistics bear this out. The reasons are poor forecasting of turbulence, as well as the difficulty involved in recognition. During thunderstorm season it becomes evident where the rough air is, although there are still areas where we may be surprised. While en-route in VMC conditions with a smooth ride, all zeros on the release and no Sigmets of any kind, it would be difficult to anticipate the kind of turbulence that can injure somebody and turn the inside of a cabin into a disaster area, but this continues to happen.

While there are no magical solutions to the above, awareness on the part of the entire crew is critical. Most cases that result in injury occur when there is an extreme change in conditions in a short timeframe. In this case the cockpit crew needs to be decisive. The seatbelt sign needs to be put on immediately, and an announcement made as close to simultaneously as possible. In reality it may still be too late in some cases, but an announcement with great urgency may give the flight attendants the clues they need to brace, rather than to begin preparation. The significance of this should not be lost. There is a big difference between a flight attendant putting away beverage carts, making an announcement, and checking seatbelts; and the other scenario, getting passenger assistance, holding down the cart, and crouching in a brace position. The speed and the effectiveness of our communication is the only thing that will give the flight attendants a clue as to which course of action is appropriate. Obviously there is a huge difference, and the result of a mistake could range from extreme embarrassment to disaster. The intent of this short piece is not to tell you, our experienced flight crews, how to fly your airplane, or how to coordinate with your crew, but rather to point out the unique time of year we are approaching, and the reality, which most of us are unaware of, that it is a time where the hazards of turbulence are the greatest, even though the season should be among our most benign.

Although the focus has been on your reaction to the unknown turbulence, the main emphasis should be on improving the forecasting and eliminating the unknown areas. On this subject there is some good news. The turbulence forecast which was unreliable in the past, has been updated by our weather providers. The new forecasting tools should prove to be more reliable. The numerical scale on the dispatch release should now mean something. We should also see numbers other than twos and zeros. The actual scale is from zero through eight (even numbers only). Hopefully this improved information will prevent unexpected encounters. Another improvement is the availability of other weather products. All of the weather information that Dispatch has available should be available on *theHub*. In many of our cities (34) this will be available at the gate computers. Simply ask the agent for access, select weather and flight planning, and the several useful weather products will be presented. One of the more useful might be the PIREP summary. This chart indicates the location and severity of PIREPS for turbulence and icing and their severity on a map of the US. For convective activity the radar summary charts are also available. One quick look can give you a very good idea of what you face on a given leg. All other products are available by selecting the pilot briefing section, if more information is necessary.

Should you have an encounter with turbulence of any kind, whether unexpected or not, the ASAP form continues to be the best weapon for preventing future encounters. Also keep in mind that in the unlikely event that an error on your part contributed, it will also give you a great deal of protection. Injuries to our crews and passengers are something that we all dread, and are almost always a total surprise. In many cases, the flight crew is totally unaware of the extent of damage in the cabin, opening up another area where crew coordination is critical. The question becomes, how best to communicate the amount of damage or disarray in the cabin. Again this is not an attempt to tell the most experienced crews in the industry how to perform, but is a reminder to consider the possibilities.
In past cases we have learned a good deal, however, it is apparent there is still far to go. Our hope is that the new forecasting tool will eliminate the problem, but we must also be realistic, realizing that no system is perfect. Therefore, the mitigation procedures that you use will probably have to be employed at some point by some of our crews.

Just When You Least Expect It…



By Nancy Gilmer
AFA / MEC Safety Chairperson

Clear Air Turbulence (CAT) can catch you off guard! That's why we are vigilant in keeping our galleys locked up. What we tend to forget is our own safety because we become comfortable in the aircraft as our work place environment and CAT is relatively rare…so we fail to protect ourselves after we have finished serving and we sit down, either in our jumpseat or in a passenger seat, by forgetting to fasten OUR seatbelts – even when the seatbelt sign is off.

We sometimes have a tendency to not take *anticipated turbulence* as seriously as we should. Why? Because we feel we should keep serving…after all, *we just have two* more *rows to go* or we are working A or CSD and feel the passengers are somehow entitled to service, no matter what! Let's be smart about avoiding injuries. Just talk to a flight attendant who has been injured or seriously scared to death by severe turbulence.

What can we do to increase our chances of not getting injured?

- In your crew briefing, if your Captain doesn't mention it, ask about possible weather problems.
- Remind the flight deck crew that the A is supposed to call them if the seatbelt sign has been illuminated, and they don't make an announcement with details about what is expected and how long the turbulence will last.
- You could discuss the fact that many pilots have good intentions by leaving the seatbelt sign on the entire flight when it is smooth, thinking it will protect the company from liability, but that is incorrect. Leaving the sign on under these circumstances leads to passenger and flight attendant complacency.
- What feels like light turbulence in the flight deck could, in fact, be moderate turbulence in the aft of some aircraft. Don't hesitate to call your flight deck crew to describe the turbulence and ask that they turn on the seat belt sign.

Observation ride statistics reveal that we are not as vigilant as we should be in requesting that passengers fasten their seatbelts at all times they are seated, either by announcement, or individual request. I hear a lot of flight attendants say, *Well, I'm the only one who does a walk through of the cabin when the seatbelt sign is illuminated, and I get tired of doing it all the time.* We suggest that you discuss this in your preflight briefing and have all flight attendants agree to share the responsibility, or designate certain flight attendant positions, per cabin, per leg, or per day of the trip to ensure passenger compliance. And remember, we are not the *police!* We request compliance! If the passenger does not comply after two polite requests, tactfully inform them that they are in violation of a FAR that requires their compliance with our instructions, and there are consequences you think they would want to avoid. Follow procedures for passenger non-compliance (FAEM 5.19.3, Level 1 Threat). Make sure you fill out a Disruptive Passenger Incident Report (DPIR), fax it to Corporate Safety and inform your AFA Local Safety, Health, & Security Committee for follow-up. Remember, ALL flight attendants must file a DPIR, even if they are not involved, in order for the FAA to investigate the incident. Your Captain should file an ASAP report.

Turbulence Detection Research

By Rod Bogue,
Staff Scientist, NASA Dryden Flight Research Center

Atmospheric turbulence poses a hazard to all flight vehicles, and turbulence is found in varying degrees at all altitudes where flight vehicles operate. Turbulence, in the presence of convective storms, has long been a recognized hazard since the early days of flight. With the advent of high altitude jet operation in the 1950's, so-called Clear-Air Turbulence (CAT) was recognized as a problem, particularly troublesome because it frequently provides no visual cues to warn pilots of the hazard. Dangerous turbulence conditions, those capable of causing in-flight injuries, are caused from natural atmospheric processes resulting largely from convective storms, jet stream activity, and mountain wave activity. It has been estimated that turbulence-related costs to the airline community amount to over $100M per year (Reference: Cabin Crew Safety, Jan-Feb, 2001 - Flight Safety Foundation). Because of the pervasive influence of turbulence on airline operations (i.e., cost of injuries to flight attendants and passengers, added maintenance and inspections, enroute deviations, passenger fear of flying, insurance costs), many in the airline community believe that the cost is far higher than $100M each year. Subsequent estimates that are believed to be more comprehensive than earlier studies have pegged turbulence costs at $800M per year (Study conducted by Volpe Research Center under the auspices of the Commercial Aircraft Safety Team). Research into turbulence hazards is underway in both government and academic communities.

Turbulence forecasting accuracy is being improved through the use of so-called "in-situ" turbulence measurements from commercial aircraft in flight.

Approach

The current, two-pronged approach for improving turbulence safety for both flight attendants and passengers uses both strategic and tactical elements. Turbulent regions of the atmosphere are avoided were possible through improved strategic turbulence forecasting. Turbulence forecasting accuracy is being improved through the use of so-called "in-situ" turbulence measurements from commercial aircraft in flight. These measurements are used to provide inputs to atmospheric turbulence models to improve accuracy and improve validity of turbulence forecasts.

A second element of avoiding turbulence injuries is based on tactical detection of impending turbulence encounters in time to warn cabin occupants and give time to avoid the turbulence or for achieving secure seating to protect occupants from injuries caused by aircraft motion. The near-term technology development focus is to address business jet and commercial transport needs. The available resources and time available to accomplish results preclude the development of low-cost solutions for general aviation aircraft. Government, in collaboration with industry partners, is focusing on maturing technologies to provide an in-flight turbulence encounter warning. A key factor in the tactical element is to define the time required for cabin occupants to achieve secured seating so that the warning time requirement can be provided for the tactical warning technology

Various government agencies are providing technical assistance for certification of commercial aircraft turbulence warning systems. Solutions for the turbulence hazard to vehicles in flight are multi-faceted, encompassing atmospheric science, aircraft design, aircraft dynamics, detection technology, cabin design, training, and operating procedures to highlight a few aspects of the problem. Other turbulence injury-reduction activities, such as improved forecasting, cabin procedures, and crew training, are being addressed by safety assessment and implementation groups as a part of the Commercial Aviation Safety Team (CAST), which represents a broad coalition of academia, industry, and government from the aviation community.

Tactical Pre-encounter warning time requirement

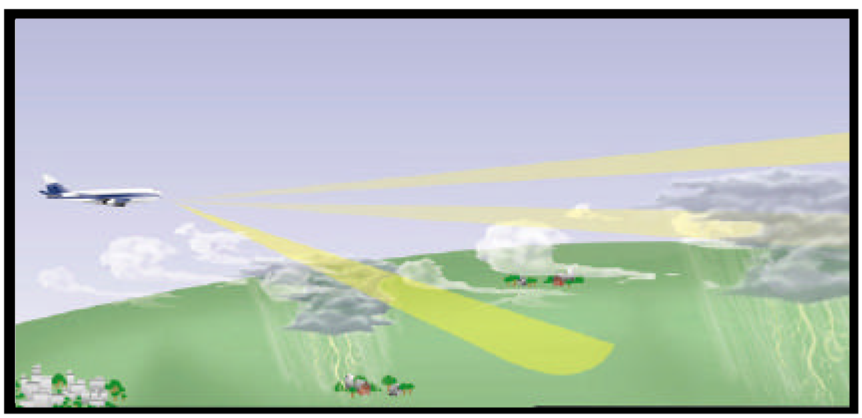
In October of 2002, the FAA and NASA collaborated to conduct a pre-encounter turbulence secure seating experiment on a ground-based wide-body aircraft simulator using active passenger subjects with different cabin scenarios that involved three aircraft line cabin attendant crews from three US airlines. The experiment results demonstrated that 95% of the passengers were able to be securely seated within 95 seconds of receiving an announcement from the captain of impending turbulence. The consistent results suggest that under full load conditions, the effects of different scenarios, and different flight crews have minimal effects on passenger seating time. The consistency of the seating times for passengers is an encouraging result since this "factor" in the overall seating process is probably one of the least controllable. It is unreasonable to presume that passenger behavior is subject to substantial modification by training or by any other influence and therefore the consistency in the results of an "uncontrollable" factor is good news combined with the relatively short seating time of 95 seconds.

Flight attendant seating times are far less consistent with the major factor being the variability between crews. The variability between crews is thought to be the result of different training and different procedures between the parent airlines. Flight attendant seating times range from 75 seconds to 240 seconds. Although the variability in the flight attendant seating times is quite high, this "factor" in the cabin seating process is one if the more controllable. Flight attendants undergo extensive initial and recurring training in the course of preparing to function as a professional member of the cabin crew. With adaptation of industry-wide best practices for crew seating and development of improved training procedures, it is not unreasonable to expect that most crews would approximate or even exceed the 75-second seating time demonstrated by one of the trial crews.

The 95-second seating time of the passengers is a realistic estimate of passenger seating time from this cabin seating test sequence and is believed to be representative of seating times which would be experienced in the commercial aircraft flight environment. The flight attendant seating times are believed to be a controllable factor and will result in secure seating time less than those of the passengers.

Current Technology Turbulence Warning Capability and Development Activity

Detection: Turbulence contains velocity gradients, and the primary detection device must be able to identify these gradients. Remote measurement of air motion is very difficult because air is transparent and offers no characteristic that is easy to track. The most common method of measuring motion is to use naturally occurring atmospheric constituents to trace the air motion. Atmospheric moisture reflects microwave radar energy, and natural aerosols reflect infrared laser energy. The Doppler shift of these reflected signals provides flow velocity gradient information when the moisture concentration is sufficiently high and/or the natural aerosols are present in sufficient density. Of all the detection approaches, radar-based detection technology is the most mature. However, the measurement range, and thus the pre-encounter warning time, is at the lower limit of that desired to provide adequate warning time for securing the aircraft (95 seconds as described above). Manufacturers of commercial weather radars have incorporated enhanced turbulence-warning capability for low moisture environments. Prototype radar sets are currently undergoing in-service testing to assess the safety benefit.



Auto-PIREP: An automated Pilot Report (PIREP) system is also undergoing in-service testing on a fleet of over 100 commercial aircraft. As the name suggests, the Auto-PIREP system operates as the classical manual PIREP wherein a pilot experiences a turbulence encounter and provides a report for use by other aircraft in the vicinity to avoid encountering the turbulent region. The major difference between the auto-PIREP and the manual PIREP is the use of the aircraft inertial system to measure the severity of the turbulence encounter and the automatic transmission of the PIREP message. The automated approach provides a more objective report compared the manual method, and allows scaling of reports to assess expected turbulence severity for the aircraft receiving the report. Reports may be generated by a variety of aircraft types flying at different altitudes with different speeds and load factors, so scaling is an important factor in providing an objective estimate of turbulence encounter severity. Dispatchers are working with pilots to develop a process that uses auto-PIREPS to improve safety and flight operation efficiency.

Aircraft Control Systems: With the availability of gust detector inputs, aircraft control systems may be designed to actively mitigate gust effects. This would be accomplished by moving the aircraft control surfaces (i.e., elevators and ailerons) to counteract the aircraft motion from turbulence encounters. Results from work in simulators and from very limited flight-testing suggest that the cabin effects from turbulence encounters can be reduced substantially by this method. A major objective would be to eliminate the "negative "g" effects which cause objects in the cabin to become weightless and unsecured cabin occupants to be lifted from their seats. With better understanding in this area, improvement of ride quality may also be a possibility. It is known that many potential airline passengers have been terrified, as the result of turbulence encounters, to the point that some refuse to fly or substantially reduce their travel by air. Improved ride quality would reduce this problem, and over time may encourage more airline travel.

Editors Note: *Rod Bogue is the deputy project manager for NASA's Aviation Safety Turbulence Element Program. In October, 2002, US Airways participated in NASA's Cabin Turbulence Warning Experiment, which was conducted in the 747 Aircraft Environment Research Facility at the Civil Aerospace Medical Institute (CAMI), in Oklahoma City. The project was designed to study the effects of several variables on time requirements needed for passengers and flight attendants to return to their assigned seats. The data collected from these time trials will be used in the design of early detection systems. Technology exists today that, under the right atmospheric conditions, can predict impending turbulence within a minute's notice.*

Turbulence Incidents
From Your ASAP Reports

A319 TPA - PIT
Moderate turbulence experienced / ATC vectoring issue

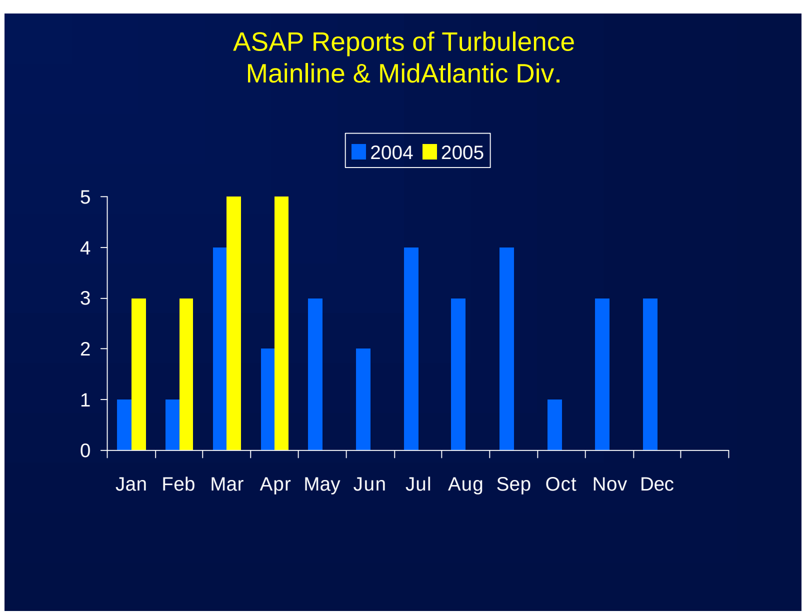
Flight delayed out of TPA due to weather North of the airport. Checked with Dispatcher via ACARS and utilized weather radar while awaiting take-off. Advised Flight Attendant's to remain seated until notified and passengers to check seatbelts fastened due to weather in the area. Departure Control vectored flight into weather area. We requested numerous deviations and encountered moderate turbulence. Continued requesting deviations until clear of turbulence area.

A320 PIT - SJU
Severe turbulence / Auto pilot disengaged / Over-speed exceedence

At cruise at FL 350, flight was IMC with radar on. Thunderstorms were in the area. Without warning, we got into severe turbulence. Autopilot disengaged. Experienced over speed exceedence for approximately 10 seconds. Altitude was plus 300 feet for about 10 seconds. Conditions smoothed out and the auto pilot was turned back on. Told controllers and checked to see if anyone was injured in the cabin. Everyone was ok. Rest of the flight was uneventful.

A321 PHL - DEN
Turbulence experience / Flight Attendant injury

An extra crewmember working the flight informed the Captain that on descent, she hurt her hand due to turbulence encountered at 48 NM east of PSB. Turbulence was between FL240 and FL270, moderate to severe. Captain spoke with the Flight Attendant on the ground and she said she was going to go have her hand X-rayed.

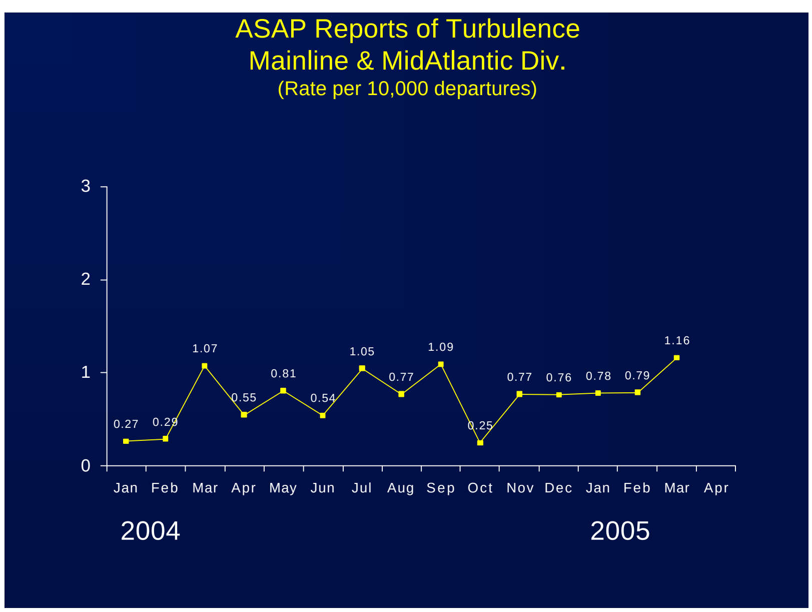


A321 SAN - PHL
Turbulence event / Flight Attendant injury

Flight was approaching BNA from the west at FL350. Crew anticipated moderate turbulence based on an OCC ACARS message. The seatbelt sign was turned on and two announcements were made. One by a Flight Attendant and the second by the First Officer. About 95 miles west of BNA, the flight encountered severe turbulence with a 20-knot increase in airspeed, which put the flight at 10 knots above VMC/MMO. Altitude hold could not maintain the altitude. The aircraft ballooned 400 feet up in a few seconds. ATC was notified of the situation. The aircraft abruptly lost 20 knots as we were descending back to FL350. The entire event lasted less than a minute. Once level in smooth air, again the crew called back to the Flight Attendants to see if anyone was hurt. All passengers were ok, but the “B” Flight Attendant had been lifted from her jump seat and slammed down. She was experiencing back pain that she described as a 7 on a scale of 1 through 10. Crew contacted MedLink and advised to continue to destination. Paramedics met the flight at the gate. The Flight Attendant opted for private transportation to a medical facility of her choice.

A321 SFO - CLT
Turbulence / Exceedance

Just west of PUB, flight encountered mountain wave action with light to moderate turbulence. With the turbulence, we had slowed to maneuver for the turbulence. The mountain wave at this point was plus or minus 200 to 300 and plus or minus 10 knots. Shortly thereafter, hit a pocket of mountain wave that was at least moderate, plus or minus 500 to 700 feet and plus or minus 20 to 30 knots. At this point we had to apply TOGA power as speed was dropping below VLS and slowing. At the other end, we were at idle power (auto-throttle disconnect). Even with throttles at idle, we still exceeded red line by 10 knots momentarily 5 to 7 seconds. We immediately requested a lower altitude and descended to FL330. There was still very light mountain wave at FL330. All systems were returned to normal. There was temperature fluctuation from -43 C to -37C. Logbook entry made and advised CLT Maintenance.



A321 LAX - CLT
Exceedance / Turbulence

Flight was in and out of IMC. Both pilots had radar on. Ride was relatively smooth. First Officer saw buildup and told ATC that they were turning to avoid it. During the turn, the flight encountered moderate turbulence and briefly got an overspeed warning. Radar painted a cell. Flight Attendants said everyone was fine in the back (the seatbelt sign was on).

A330 PHL - LGW
Turbulence event / TCAS RA

Flight was cruising at FL350 and cleared to cross 49N 50W at FL 360. Crew encountered strong moderate turbulence at FL350 and FL360. In the area of 50W, we received a TA followed by an RA (while in the midst of strong moderate turbulence) caused by an aircraft at FL370. The First Officer followed the RA commands in very turbulent conditions. Once clear of conflict, the autopilot was re-engaged. The turbulence played a major role in causing the TCAS RA to occur with a 1,000-foot separation between aircraft. This was in Gander Center airspace.

B-737-300 DCA - BOS
Heavy to moderate turbulence / Altitude loss

Level at FL 290, experienced heavy to moderate wake turbulence. No aircraft displayed on TCAS. Altitude loss was about 400 feet. Passengers' drinks spilled from the cabin floor to the ceiling.

B-737-300 CLT - ILM
Severe weather / Turbulence / Auto pilot disconnect / Altitude deviation

While deviating around an area of thunderstorms, encountered severe turbulence that caused autopilot to disconnect. Airspeed increased to VMO. Entered area of a severe updraft and even with forward yoke, aircraft climbed to approximately 18,000 feet. Exited the turbulence, notified ATC and descended back to 17,000 feet. No radar indications of this cell. Duration of the whole event lasted approximately 1.5 minutes.

B-757 MCO - PHL
Severe turbulence experienced / Passenger injuries

During descent passing FL260, aircraft encountered clear air moderate turbulence. A sharp jolt caused atleast six passengers to bump their heads. Paramedics met the aircraft at the gate after expeditious recovery. No aircraft damage noted, only Utility required. ATC had reported moderate turbulence airspeed during the time of event was around 290 knots. MedLink was called, but since aircraft was in recovery, no action was suggested. Paramedics met the aircraft upon gate arrival.

B-757 CLT - BWI
Severe turbulence experience / Flight Attendant injury

Encountered a brief period of severe Clear Air Turbulence (5 seconds). Prior to flight, we were advised by Dispatch of reports of severe turbulence between 230 and 290 on our route of flight. We climbed initially to FL230, got some moderate bumps and went down to FL210. It was reasonably smooth at FL210 until this 5 second encounter. We descended immediately to 17,000 and had a smooth ride. Three of our Flight Attendant's were in the back galley when we got the bumps and all three were airborne. One Flight Attendant reported a sore neck and bruised knee. The "A" Flight Attendant was standing in the forward galley and also reported getting airborne, but stayed on her feet. Very quick onset, very short duration, but scared them pretty good. Everybody said that they were ok.

EMB-170 PHL - IAH
Turbulence event / Flight Attendant thrown to the floor

While descending into IAH to make crossing altitude restriction at DAISETTA intersection, encountered brief moderate turbulence in a cumulus cloud. Turbulence threw Flight Attendant to the floor of the aft galley. Flight Attendant sustained scrapes and bruises but did not require medical treatment.

EMB-170 PHL - PIT
Severe Wake Turbulence felt from another aircraft

At cruise at 17,000 feet, encountered severe wake turbulence. ATC, when queried, stated we were in trail "13 miles, 3,000 feet below a C-5 aircraft". Received radar vectors to the north of course, and approximately 30 seconds later encountered wake turbulence again. When crew queried ATC for the second time, ATC gave our flight another heading to the north of course and an altitude change. Flight Attendant's advised no passengers or crewmembers were injured during the event.

Injuries and Damage Caused by Turbulence

On August 6, 2003 at Houston, Texas, an emergency was declared by a Lufthansa Airlines Flight, an Airbus A340-300. The aircraft had experienced severe turbulence at flight level 310, near Little Rock, Arkansas. The pilot was reporting six to eight serious injuries and requesting eight ambulances. There were 258 souls on board. A follow-up call reported a possibility of structural problems. The aircraft was approximately 10 minutes out, landing on Runway 27 at George Bush International Airport.

The aircraft landed and proceeded without delay to the Terminal. Upon arriving at the gate, Fire and Rescue crews entered the aircraft and found most of the injuries were in the aft cabin. After the second bulkhead, the interior of the aircraft was found in disarray. Ceiling panels were missing, and anything that hadn't been secured was thrown about, including personal items, drinks, and meals. Numerous passengers complained of minor injuries, such as lacerations, contusions, and pain.

Damage to aft galley ceiling

Displaced ceiling panels (3)

Damage above seat 42G

Fractured handrail above seat 42D

Procedures Review

FASTEN YOUR SEAT BELT

From our FOM, guidance on Hazardous Weather:

Cabin Notification of Turbulence. See Paragraph 4.6.11, "Announcements".
Announcements
In-Flight Turbulence. When moderate or greater turbulence is anticipated, alert the flight attendants and passengers and illuminate the fasten seatbelt sign. See also Paragraph 4.6.10, "Use of Cabin Signs".

Use of Cabin Signs
In-flight Fasten Seatbelt Sign.
On. When the fasten seatbelt sign is illuminated in flight, a Flightdeck crewmember will make an announcement instructing passengers to return to their seats and remain seated with their seat belts fastened. A flight attendant may call the flightdeck via the interphone for additional information.
Off. When the seatbelt sign is turned off, a flightdeck crewmember will make an announcement advising passengers to keep their seatbelts fastened at all times when seated.

10.6.7 Turbulence. See the following table for turbulence definitions, and crew actions during turbulence encounters. See also Paragraph 4.6.11, "Announcements".

Clear Air Turbulence (CAT). Initiate flight level or course change when encountering jetstream turbulence with direct headwinds or tailwinds. Jet stream turbulence encountered in a crosswind is normally in a narrow band across the wind. When crossing the jetstream, climb with rising temperature and descend with a dropping temperature if necessary.

Mountain Wave Turbulence. If the ratio of the wind speed 6,000 feet above the ridge to the winds at ridge top level is 1.6 or less, the probability of moderate or greater turbulence increases. This turbulence can exist at all altitudes. If the ratio of the wind speed 6,000 feet above the ridge to the wind at ridge-top level is greater than 2, turbulence is likely to be confined to lower altitudes.

> ***Example.*** If the wind speed at 18,000 feet is 50 knots and the wind speed at 12,000 feet is 35 knots, the ratio is 1.4. Moderate or greater turbulence may exist up to high altitudes.

Turbulence and Thunderstorms. Expect moderate or greater turbulence within thunderstorms, or in the vicinity of thunderstorm tops, wakes, downbursts, and gust fronts.

Severe or Extreme Turbulence Encounter. Do not plan flight into severe/extreme turbulence. If encountered, make a maintenance logbook write up to ensure a special aircraft structural inspection is accomplished. Refer to Chapter 3A, "Adverse Weather," of the applicable pilot handbook for specific procedures.

Chart from the US Airways Flight Attendant Emergency Manual

Intensity	Airplane Reaction	Cabin Reaction	Crew Action
Light Chop	No appreciable changes in altitude/attitude. Slight, rapid and somewhat rhythmic bumpiness occurs.	Occupants may feel a slight strain against seat belts. Unsecured objects remain stable. Coffee is shaking slightly, but not splashing out of cup. No difficulty in walking.	***Flightdeck Crewmember:*** • Illuminate the seat belt sign (at captain's discretion). • Make PA instructing passengers to be seated. *"Ladies & Gentlemen, as turbulence is not always anticipated, please keep your seat belts fastened while seated."* ***Flight Attendants:*** • Verify passenger (including infants/children) seat belts are securely fastened. • Secure unattended carts and stow loose cabin & galley items. • Continue cabin service with caution.
Light	Momentary, slight, erratic changes in altitude and/or attitude.	Walking and cart maneuvering may be difficult. Coffee is shaking, but not splashing out of the cup.	
Moderate Chop	Rapid bumps or jolts without appreciable changes in altitude or attitude.	Occupants feel definite strain against seat belt. Unsecured objects move about. Coffee is splashing out of cup. Very difficult to walk and maneuver carts.	***Flightdeck Crewmember:*** • Illuminate the seat belt sign. • Make PA instructing passengers to be seated. • Report turbulence encounter to the controlling dispatcher. ***Flight Attendants:*** • Discontinue cabin service. • Communicate with captain ('A' F/A). • Set cart brakes, but leave cart in present location. • Cover coffee pots/wine bottles or place on floor. • Sit down in nearest passenger seat or jumpseat. If seat is unavailable, sit on floor and hold on.
Moderate	Changes in altitude/attitude and airspeed fluctuations occur, but the airplane remains in positive control.		
Severe	Large, abrupt changes in altitude/ attitude occur. Usually large airspeed fluctuations occur. Airplane may be momentarily out of control.	Occupants forced violently against seat belts. Unsecured objects tossed about or lifted from floor. Walking or standing without holding on to something for support is impossible.	***Flightdeck Crewmember:*** • Ensure seat belt sign is on. • Make a PA instructing passengers and F/As to be seated. • Report turbulence encounter to the controlling dispatcher. • Maintenance write-up and airplane inspection required. ***Flight Attendants:*** • Discontinue cabin service. • Command passengers to sit down and fasten seat belts, if flightdeck is unable to make PA. • Sit down and hold on. If seat is unavailable, sit down on the floor. • Communicate with captain (if practical). • Inspect cabin and report damages/injuries to the captain.
Extreme	Airplane tossed violently about. Practically impossible to control. May cause structural damage.		
Frequency Definition	Occasional: Occurring less than 1/3 of the time.	Intermittent: Occurring 1/3—2/3 of the time.	Continuous: Occurring more than 2/3 of the time.

Mandatory Reporting Events

ASAP Reporting

1) When a system **DEFECT** occurs, which adversely affects the handling characteristics of the aircraft or renders it unfit to fly.
2) When an inflight **ENGINE SHUTDOWN** occurs.
3) When there is a warning of **FIRE** or **SMOKE**.
4) When an **EMERGENCY** is declared.
5) When **SAFETY EQUIPMENT** or **PROCEDURES** are defective or inadequate.
6) When deficiencies occur in **OPERATING PROCEDURES** or **MANUALS.**
7) When there is incorrect **LOADING** of **FUEL, CARGO,** or **DANGEROUS GOODS,** or when there is a significant error in the **WEIGHT & BALANCE.**
8) When operating standards are degraded due to deficient **GROUND SUPPORT** or ground facilities.
9) When an incident occurs resulting in **GROUND, AIRCRAFT,** or **PROPERTY DAMAGE.**
10) When a **REJECTED TAKEOFF** is executed after 60 kts.
11) When an **EXCURSION** occurs; if any part of the aircraft leaves the paved surface during taxi, takeoff, or landing.
12) Whenever significant aircraft **HANDLING** difficulties are experienced.
13) When a **NAVIGATION ERROR** occurs, involving a significant deviation from the intended track.
14) When an **ALTITUDE** error of more than 300 ft. occurs.
15) When there is an **EXCEEDENCE** of the limiting parameters for the aircraft **CONFIGURATION.**
16) When **COMMUNICATIONS** fail or are impaired.
17) Whenever a **GO-AROUND** (below 1,000 ft), or a **WINDSHEAR GO-AROUND** from any altitude is flown.
18) Whenever a **STALL WARNING** occurs.
19) When flight **DIVERSION** or **RETURN TO FIELD** occurs, or when landing on **WRONG RUNWAY**.
20) When a **HARD** or **OVERWEIGHT LANDING** is made.
21) When a serious loss of **BRAKING** occurs.
22) When the aircraft is **EVACUATED.**
23) When the aircraft lands with reserve **FUEL** or less remaining.
24) When a **NEARMISS, ATC INCIDENT** or **WAKE TURBULENCE** event occurs.
25) When a **TCAS RA** or **GPWS** warning occurs (or a TA in **RVSM** airspace).
26) When significant **TURBULENCE, WINDSHEAR** or other severe **WEATHER** is encountered (including **LIGHTNING** strikes).
27) When serious **ILLNESS, INCAPACITATION, INJURY,** or **DEATH** occurs to crew or passengers, if the **EMERGENCY MEDICAL KIT (EMK)** or **AUTOMATIC EXTERNAL DEFIBRILLATOR (AED)** is used, or if contact is made with **INFECTIOUS DISEASES.**
28) When the removal of **VIOLENT, ARMED,** or **INTOXICATED** passengers is required.
29) When the use of **DRUGS** or **ALCOHOL** by on duty crewmembers has been detected.
30) When **LAVATORY SMOKE DETECTORS** are activated or vandalized.
31) When an act of aggression (e.g. **BOMB THREAT** or **HIJACKING**) occurs, or when **SECURITY** procedures are breached.
32) When a **BIRD STRIKE** or **FOREIGN OBJECT DAMAGE** occurs.
33) **ANY EVENT WHERE SAFETY STANDARDS MAY HAVE BEEN COMPROMISED.**
34) **ANY EVENT WHICH MAY PROVIDE USEFUL INFORMATION FOR THE ENHANCEMENT OF FLIGHT SAFETY.**

Cabin Safety Reporting

1) When an act of aggression (e.g. **BOMB THREAT** or **HIJACKING**) occurs.
2) When **SECURITY** procedures are breached.
3) When the cabin is **PREPARED** for an **EMERGENCY LANDING.**
4) When a **COMMUNICATION SYSTEM** (e.g. PA, Video Equipment, or Call Bells) fails or becomes impaired.
5) When there is a **DECOMPRESSION** of the aircraft.
6) When a **DISRUPTIVE PASSENGER** is confronted.
7) When **DEATH** occurs to crew or passengers.
8) When **EMERGENCY EQUIPMENT** is **NON OPERATIONAL** or **NOT PRESENT**, (also notify Captain).
9) When an **EMERGENCY LANDING** is performed.
10) When the aircraft is **EVACUATED**.
11) When **FIRE/SMOKE/FUMES** are present in the passenger compartment.
12) When a **HAZARDOUS MATERIAL** is present in the passenger compartment.
13) When an **INTOXICATED PASSENGER** is confronted.
14) When the jumpseat is **BROKEN** or **INOPERABLE.**
15) When an **OVERFLOW** of the **LAVATORY WATER** occurs.
16) When there is a **POTENTIAL HAZARD** which may cause injury to a customer of Flight Attendant. For example: torn carpet or broken cart.
17) When there is a **PROBLEM ENFORCING FARs.**
18) When there is a **SAFETY RELATED INTERRUPTION DURING STERILE COCKPIT**.
19) When significant **TURBULENCE** is encountered.
20) When a **SLIDE** is inadvertently **DEPLOYED**.
21) When a **LAVATORY SMOKE DETECTOR** is activated or vandalized.
22) When there is a passenger **SMOKING** incident.
23) **ANY EVENT WHERE SAFETY STANDARDS MAY HAVE BEEN COMPROMISED.**
24) **ANY EVENT WHICH MAY PROVIDE USEFUL INFORMATION FOR THE ENHANCEMENT OF CABIN SAFETY.**
25) **AUTOMATED EXTERNAL DEFIBRILLATOR (AED) USAGE**

All Crews Must File a Safety Report Within 24 Hours

A Disruptive Passenger Incident Report (DPIR) Must be Completed for All Incidents Listed in Red

Guidelines for Pilots Involved in an Incident/Accident

1. **Notify the Company.** (Collect calls are accepted)
   Contact the dispatcher listed on your Flight Release. If unable, in an emergency, contact Operations Control Center – (412) 747-5898/5899. Contact Flight Safety – (412) 747-5980 or (800) 299-3550.

2. **Notify ALPA.** (Collect calls are accepted)
   Capt Dan Sicchio – Accident Invest – (315) 676-7964 or (412) 759-4428.
   Capt Matt Merillat – Violations – (703) 281-9546.
   ALPA Worldwide Hotline – (202) 797-4180.

3. **Understand that all records and any other items of evidence relevant to the incident/accident must be preserved.** Ensure someone is preserving evidence and recording the names, addresses and telephone numbers of all available witnesses.

4. **In case of a serious incident or accident keep your crew together.** Obtain rest facilities away from the scene, if possible. Let the Company and your ALPA representative know your location at all times.

5. **If any crewmember requires hospitalization, be alert to the fact that he/she might be in shock and not know it.** Someone other than you should determine that you are physically and mentally competent to answer questions and make accurate statements.

6. **Recognize that your responsibility is to cooperate with any safety or legal investigation.** The Company and ALPA employ experts to compile complete and accurate statements. Do not make any statements except as part of that process.

7. **Prepare all written statements with the assistance of a Company attorney and, if you desire, an ALPA attorney.** Your statements can affect not only yourself, but the Company as well. Fill out an ASAP within 24 hours, and consider filing a NASA report within 10 days. Make copies for yourself.

8. **You must show the FAA your certificate if asked, but do not relinquish your certificate to any investigator.**

9. **If you are confronted by the local law enforcement agencies be aware that you have the same rights as any citizen.** Provide general information, such as name and address, but if additional interrogation is attempted, politely explain you wish to exercise your right to be represented by an attorney before answering.

10. **Drug and alcohol testing is required to be done by the Company (not the NTSB), pursuant to FAA policy, if either pilot contributed to the incident/accident, or cannot be completely discounted as a contributing factor.** Failure to keep the Company advised of your whereabouts may be deemed as a refusal to submit to testing. Ensure you received your copy of the appropriate testing paperwork. Alcohol testing, if required, must be administered within 8 hours. Some state laws authorize crewmembers to be alcohol tested by local law enforcement. Clearly identify under whose authority the request is being made. Refusal to submit to a test which indicates the weight of the alcohol in the breath, is a violation of the FARs. Drug testing, if required, must be done as soon as possible, but not later than 32 hours after the incident/accident.

11. **Consider contacting a Critical Incident Response Program (CIRP) Representative.**
    First Officer Lucy Young - (617) 501-3155.
    First Officer Gary Van Hartogh - (724) 622-9127.