Advisory Circular

Subject: PREVENTING INJURIES CAUSED BY TURBULENCE

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Initiated by: AFS-200

AC No: 120-88A

1. Purpose. This AC provides information and practices that can be used to prevent injuries caused by turbulence.

a. Overall, U.S. air carriers have a superb safety record - one that has improved over time and now ranks among the best in the world. Air carrier incidents are infrequent; accidents are rare; and the risk of injury or death associated with this mode of transportation is very low. In an effort to reduce the chances that someone might get injured in an aircraft encountering turbulence, the Federal Aviation Administration (FAA) and the FAA's Government and industry partners in the Commercial Aviation Safety Team (CAST) developed the advisory material in this AC. Some of this material responds to investigative work and safety recommendations from the National Transportation Safety Board (NTSB).

b. Each of those organizations has called for industry and government to come together to develop guidance to help aircraft operators avoid conditions that cause turbulence and to help aircraft operators minimize risks when aircraft encounter turbulence. Those organizations have further called for the FAA (1) to consolidate strategies and procedures known to be effective in preventing injuries caused by turbulence and (2) to issue guidance for implementation in the operations and training of air carrier flightcrews, flight attendants, aircraft dispatchers, and managers. This AC is the product of the work done by the CAST partners and by certain others working apart from CAST.

2. Content of this AC. This AC highlights the data-driven methods of the FAA and its government and industry partners in identifying practices known to be effective against injuries caused by turbulence. Practices identified in the AC are suggested for crewmembers, aircraft dispatchers, managers, trainers, and others associated with flight operations under Title 14 of the Code of Federal Regulations (14 CFR) part 121. Those practices are suggested components of standard operating procedures that can be followed in daily flight operations and continually reinforced in training.

3. Related FAA guidance. This AC provides suggested measures for preventing injuries caused by turbulence and expands upon existing guidance including:

- Airplane Upset Recovery Training Aid, available at the following FAA public web site: (http://www.faa.gov/other_visit/aviation_industry/airline_operators/training/index.cfm)

- AC 00-30B, Atmospheric Turbulence Avoidance (http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf)

- FAA Turbulence Information Website (http://www.faa.gov/other_visit/aviation_industry/airline_operators/training/turbulence)

4. Related Regulations. 14 CFR part 121, sections 121.311, 121.317, 121.417, 121.421, 121.427, part 125, sections 125.211, 125.217, 125.287, 125.289, part 135, sections 135.117, 135.128, 135.331, 135.349, 135.351; Title 49 of the Code of Federal Regulations (49 CFR) part 830, section 830.2. These regulations are available on line at: http://www.gpoaccess.gov/cfr/index.html

5. Who should read this AC. Managers, trainers, flightcrew (pilots and flight engineers), flight attendants, aircraft dispatchers, and others involved in flight operations under 14 CFR part 121 should be familiar with the contents of this AC. This AC may also be valuable to persons associated with operations under part 125, part 135, subpart K of part 91 (fractional ownership programs), and part 91.

6. What the available data tells us about injuries caused by turbulence.

a. Definitions.

(1) Accident. The NTSB defines an "accident" in 49 CFR section 830.2 as "an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage."

(2) Fatal injury. The NTSB defines a fatal injury as "any injury that results in death within 30 days of the accident."

(3) Serious injury. The NTSB defines serious injury as "Any injury that (1) requires the individual to be hospitalized for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burns affecting more than 5% of the body surface.

(4) Minor injury. Any injury that is neither fatal nor serious.

b. Data Analysis by the FAA: Sit down and buckle up. The data strongly suggest that an effective measure during a turbulence encounter is to have passengers and flight attendants seated with seatbelts fastened. From 1980-2003, only four people received serious injuries during turbulence who were seated with seatbelts fastened (excludes cases of other people falling onto and injuring properly secured occupants). Graphical depictions of these data are contained in Appendix 5.

7. How an air carrier can design effective training to prevent or mitigate injuries to flight attendants caused by turbulence.

a. Take advantage of the training environment. The training environment presents an excellent opportunity to train crewmembers in an air carrier's standard operating procedures including standard phraseology, and to introduce concepts that might promote crewmembers' adherence to those procedures during a turbulence encounter. The training environment for flight attendants and flightcrew affords a unique opportunity for lectures, scenarios and exercises designed to explore subjects such as evaluating risk, good and bad decisionmaking and the importance of crew coordination before, during and after a turbulence encounter.

b. Emphasize the importance of flight attendants' personal safety. Flight attendant injuries occur at a disproportionately high rate compared to other crewmembers and other cabin occupants because flight attendants spend more time in the passenger cabin unseated and, therefore, unbelted. Effective training emphasizes to flight attendants that:

(1) You are not invincible. The overlying objective throughout all flight attendant training is to ensure that flight attendants are confident, competent, and in control while conducting their activities in the cabin. However, during a turbulence encounter, the most appropriate first response by a flight attendant might be self preservation. Training courseware can make flight attendants aware of their vulnerability in moderate and extreme turbulence. Effective training can incorporate video/digital media, real world scenarios and interviews with flight attendants who have experienced moderate and severe turbulence as a way to demonstrate that "turbulence can be stronger than you are."

(2) You have tools available to increase your safety and the safety of your passengers. Effective training shows flight attendants how to increase personal safety and passenger safety by identifying tools available to them in a turbulence encounter. Training can include the effective use of the passenger address system (PA) and other methods of communicating with passengers; the location of handholds throughout the airplane (or equipment that could be used as a handhold); and how to secure a service cart or an entire galley in minimum time.

(3) You need to recognize and avoid a denial reflex. Flight attendants can be made aware of ways in which human psychology might play into a turbulence encounter, and might actually increase their risk of injury. For example, on a short flight, with little time to complete a cabin service, flight attendants might be less conservative regarding their personal safety than on a longer flight with no time constraints. Flight attendants can also increase risk and compromise their personal safety by trying to adhere to routine procedures normally accomplished on every flight, such as completing seatbelt compliance checks, rather than by responding to the nonroutine situation that a turbulence encounter presents.

c. Promote communication and coordination. Crew resource management (CRM) training for crewmembers and dispatch resource management (DRM) training for aircraft dispatchers can emphasize that the individual is part of a team.

(1) Address turbulence response in CRM training. Communication and coordination among crewmembers is a critical component of an effective response to turbulence or a threat of turbulence. Air carriers can develop and implement CRM training in Initial and Recurrent crewmember training that encourages a coordinated crew response before, during and after a turbulence encounter.

(2) Subtopics supporting CRM and DRM training to counter turbulence. Effective and ineffective team performance can be made clearer by addressing topics such as:

- The importance of using standard phraseology so that meaning and intent are never in doubt
- The importance of using standard operating procedures (SOPs) so that all crewmembers know what to expect
- The importance of an effective preflight briefing that can include:

  - Potential of turbulence encounters during each leg
  - Emphasis on the importance of keeping the flight deck informed of the conditions in the cabin
  - Commitment to using standard air carrier procedures and phraseology during a turbulence encounter
- The importance of maintaining communication during the flight, including communication with the aircraft dispatcher, as appropriate
- The results of communication errors such as the use of vague, inaccurate descriptions and nonstandard phraseology regarding turbulence

NOTE: It is highly desirable to conduct joint CRM training including flightcrew, flight attendants, and aircraft dispatchers. However, if joint training is not practical, each of these training populations can be made aware of the others' functions regarding turbulence through other training methods.

8. Operating procedures an air carrier can implement to prevent injuries caused by turbulence.

a. Crewmembers. Appendix 1, CAST's Turbulence Template, contains suggested procedures for crewmembers developed by a broad collaboration of Government and industry representatives under CAST.

b. Passengers. Procedures promoting voluntary seatbelt use and compliance with the Fasten Seatbelt sign, can include the following:

- **Flightcrew promptly and clearly communicate turbulence advisories** including specific directions to flight attendants and to passengers. Those advisories can include directions to be seated with seatbelts fastened, and to secure cabin service equipment, as conditions may require
- **Flight attendants effectively communicate directions to passengers** to be seated with seatbelts fastened
- Air carriers develop and implement practices to **encourage the use of an approved child restraint system (CRS)** to secure an infant or a small child that is appropriate for that child's size and weight
  - Parents and guardians can be encouraged to ensure that children under the age of two, traveling with approved CRS, **occupy the CRS any time the Fasten Seatbelt sign is illuminated**
  - Flight attendants can verify that the **CRS is secured properly in a forward facing seat** and that the child appears to be **properly secured in the CRS**
- Air carriers develop and implement practices to **improve passenger compliance with seating and seatbelt instructions** from crewmembers such as:
  - **Video presentations** incorporated as part of a flight attendant's safety demonstration can illustrate the benefits of using effective turbulence practices
  - **Articles in airline publications, pamphlets in seat back pockets or information on safety information cards** can encourage passengers to engage in effective practices such as keeping seatbelts fastened at all times
  - Before descent, or early in the descent, depending on conditions, flightcrews may give **passengers notice by way of an announcement that the Fasten Seatbelt sign will be illuminated** in 10-15 minutes, and that any personal needs requiring movement in the cabin should be met before that time. This practice emphasizes the requirement to comply with the Fasten Seatbelt sign
- Air carriers can implement spoken and written advice to passengers that **FAA regulations require them as individuals to comply with crewmember instructions** regarding the Fasten Seatbelt sign
- Air carriers can promote **reasonable communication between flight attendants and the flightcrew** regarding the use of the Fasten Seatbelt Sign
  - The environment in the cabin may be very different from the environment in the flight deck during turbulence. Flight attendants should feel free to request that the flightcrew illuminate the Fasten Seatbelt sign whenever it is appropriate to do so in their judgment

– Conversely, when the Fasten Seatbelt sign remains illuminated for prolonged periods of time for reasons other than protection from a turbulence encounter, its effectiveness can diminish for passengers and flight attendants. Flight attendants should feel free to question the flightcrew regarding the necessity of having the Fasten Seatbelt sign illuminated

9. What else an air carrier can do to prevent injuries caused by turbulence.

a. Review its own history of turbulence encounters and injuries. Volunteers representing various stakeholder groups within an air carrier may work together as a highly competent team. The team can review the air carrier's own turbulence encounters and resulting injuries. That review might shed light on root causes of the encounters and the injuries, and, in turn, might show the way to effectively prevent them.

b. Gather current information on turbulence encounters and injuries. Current information is generated in a variety of ways such as turbulence reports from crewmembers, injury reports from flight attendants, postencounter interviews and other processes that provide information for review and analysis.

c. Information useful for analysis can include:

(1) Length of flight.

(2) Route of flight.

(3) Time of year.

(4) Phase of flight.

(5) Aircraft type.

(6) Type of injuries received by passengers.

(7) Type of injuries received by crewmembers.

(8) Adequacy of crewmember communications.

(9) Adequacy of air carrier procedures.

10. Cabin modifications, such as hand holds, restraints, or other devices, an air carrier can consider to reduce injuries caused by turbulence. When an aircraft encounters unanticipated turbulence there may not be time for preparation by crewmembers or passengers. In this situation, measures most likely to prevent or mitigate injuries caused by turbulence involve aircraft design. Effective aircraft design features promote the following:

- Interior restraints and overhead bin doors can prevent equipment failures during turbulence

- Cabin structures with hard or angular surfaces, corners, or protrusions can be minimized
- Emergency handholds can be readily identifiable and usable in the cabin, galley and lavatories (such as handles, bars, or interior wall cut outs) by flight attendants and passengers who are not seated with seatbelts fastened
- Handrails and/or handgrips can be installed under the overhead compartments in the cabin
- Horizontal and vertical “grab bars” can be installed on the counters and stowage compartments in galleys
- In configurations where seats are distributed with a large pitch and the seat backs can be reclined to an almost flat position, air carriers can install supplemental handholds beside the seats or install partitions around the seats to provide a handhold if the seat is fully reclined
- Handholds can be installed outside the lavatories on the bulkhead walls for use by passengers who may be standing outside the lavatory at the onset of a turbulence encounter

11. Improvements in dispatch procedures an air carrier can implement to prevent injuries caused by turbulence.

a. Keep communication channels open full-time. Dispatchers can communicate with flightcrews, and flightcrews can communicate with dispatchers, before, during, and after a flight, and can be encouraged to do so whenever necessary. In the preflight planning phase, the dispatcher may use the “Remarks” section of the dispatch (flight) release to advise flightcrews of known or forecast turbulence. A “call dispatch” notation on the dispatch release may be included to indicate that the dispatcher believes a telephone conversation with the pilot is necessary. Communication may resume at any time during or after flight using an Aircraft Communication Addressing and Recording System (ACARS), company radio, or telephone – and should be encouraged by an air carrier’s management to improve the flow of real-time information regarding turbulence.

b. Weather Briefings. Preflight weather briefings, verbal or written, must include forecasts of turbulence and pilot reports of turbulence caused by thunderstorm activity, mountain wave activity, clear air turbulence, low altitude frontal windshear and low altitude convective windshear.

c. Real-time Information Sharing. During a flight, the pilot and dispatcher must communicate any changes in the forecast or actual turbulence conditions via voice or digital communication methods in order to pass real-time turbulence information along to other flights.

12. Elements an air carrier can integrate into aircraft dispatcher training to prevent injuries caused by turbulence.

a. New products and services. Dispatcher training can include new weather products and services available from private vendors as well as those provided by the National Weather Service.

b. Continual reinforcement of the air carrier's turbulence avoidance policy can be evident in theory, in on-the-job training, and in practice.

- Assure pilot weather briefing includes known areas of turbulence
- Discuss flight routing, including en route altitudes, with flightcrew prior to departure
- Plan flights so they will not proceed through areas in which thunderstorms of more than moderate intensity are known to exist
- Add remarks to dispatch/flight release or weather briefing to emphasize areas where turbulence may be expected
- Plan flights to avoid areas of severe turbulence
- Plan flights to avoid areas with severe thunderstorms
- Add remarks to dispatch/flight release to emphasize areas of turbulence that can be avoided

13. Three fundamentals of effective practices against turbulence.

a. Turbulence Avoidance as corporate culture. The first and most fundamental step in developing effective practices is that an air carrier can adopt a corporate culture of avoidance of turbulence as the first line of defense. Implementing a turbulence avoidance culture can include standard operating procedures (SOPs) for dispatch and flight operations providing for rerouting around forecast and observed turbulence, and for observing standard clearances between thunderstorms and aircraft.

b. Rerouting. In the past the practice of rerouting has met with limited air carrier acceptance, primarily because of the inaccuracy of first generation turbulence forecast products, the subjectivity inherent in Pilot Weather Reports (PIREP) (if available), and the operational costs of rerouting. However, recent advances in automation, atmospheric modeling, and data display have improved forecast accuracy, data delivery, and PIREP subjectivity, improving the odds that a well-chosen rerouting would in fact avoid turbulence.

c. Standard clearances between thunderstorms and aircraft. See Appendix 2.

14. Other effective practices that can be used by managers, trainers, meteorologists, and aircraft dispatchers. Effective practices can include:

- Use all applicable weather data and products including alphanumeric weather information such as Aviation Routine Weather Reports (METARS), area forecasts and terminal area forecasts (TAFs), wind and temperature forecasts, National Weather Service (NWS) in-flight advisories such as Significant Meteorological Advisories (SIGMETS), Convective SIGMETS and Airman's Meteorological Information (AIRMETS), upper air charts, graphical radar summaries or composites, and satellite imagery
- Use sophisticated product generation to merge diverse sources into graphical product to track turbulence
- Compile turbulence information, including PIREPs, making relevant information easily usable to dispatchers, flightcrews, and air traffic controllers

15. New systems of turbulence reporting and forecasting developed since AC 00-30B was issued in 1997. There have been significant improvements in turbulence reporting and forecasting. Since 1997, major advances in data processing and delivery have allowed graphical depictions of weather to be delivered in near real-time, even to the flight decks of suitably equipped aircraft. Advanced reporting, forecasting, and delivery of graphics have been promoted by government/industry partnerships and by the leadership of various organizations including the FAA's program office for Aviation Weather Research. Some of the most promising advances are shown in Appendix 3 (Detection) and Appendix 4 (Delivery).

16. Additional steps air carriers can take to avoid turbulence and thereby prevent cabin injuries.

a. Real-time information, airplane-to-ground. Continued improvement in turbulence-related weather products requires better handling of real-time information on the state of the atmosphere at any given time. The most promising way to capture and convey this information is through a comprehensive program of reports from aircraft in flight. That program would be founded on automated turbulence reporting supplemented by human reports (PIREPs). Air carriers can promote real-time information handling by the following steps:

(1) Commit to the installation of the Turbulence Auto-PIREP System (TAPS). TAPS is being developed under the NASA Turbulence Prediction & Warning System (TPAWS) program. This system generates real-time, automatic reports of hazardous turbulence events, and displays the information for improved operations around turbulence. The reports quantify the severity of the loads experienced in the aircraft's cabin in accordance with the standard levels of light, moderate, severe, and extreme as described in the FAA's Aeronautical Information Manual (AIM). These downlinked reports are displayed on dispatchers' flight-following display network, and can be scaled and used to predict and inform other aircraft of potential turbulence encounter severity. Reports are only generated whenever significant turbulence events are encountered. Future efforts will develop the capability to broadcast the reports from aircraft-to-aircraft and display the reports in the flight deck.

(2) Operators of regional, commuter and smaller cargo-only aircraft may commit to installation of Tropospheric Aircraft Meteorological Data Reporting (TAMDAR) weather reporting systems on company aircraft. The TAMDAR system has been developed under NASA contract. TAMDAR is designed as a small, lightweight weather data sensor package and downlink system, primarily for use by smaller aircraft that operate below FL200. The TAMDAR data set includes automated turbulence reporting in terms of eddy dissipation rate (EDR; see Appendix 3), in addition to other atmospheric weather markers (winds, temperatures, relative humidity, etc.).

(3) Improve the coverage and objectivity of atmospheric turbulence reports by installation of automated aircraft turbulence downlink systems on all ACARS equipped aircraft. (The current International Civil Aviation Organization (ICAO) standard metric for automated turbulence reporting is EDR).

(4) Encourage additional reporting of PIREPs by flightcrews through air carrier PIREP awareness campaigns and by training flightcrews to follow established PIREP procedures.

(5) Establish communications links and encourage flightcrews to deliver air carrier "in-house" PIREPs to the National Weather Service (NWS) and to the FAA using Flight Watch.

b. Efficient delivery of current information, ground-to-airplane. In conjunction with improved turbulence reporting airplane-to-ground, air carriers may join with other industry groups and with government organizations to develop faster processing and delivery of current turbulence information ground-to-airplane. Work can be done in at least the following areas:

(1) Conducting an assessment of communications/processing/distribution systems for gridded, alphanumeric, and graphical image turbulence information exchange in the National Airspace System (NAS) in order to determine necessary improvements;

(2) Developing a plan to integrate required improvements in conjunction with normal upgrade/replacement cycles for ground-to-ground and ground-to-air systems, and/or a cost-effective mix of Internet, Intranet and other evolving communications systems;

(3) Developing a tailored "forced" uplink of critical alpha/numeric reports and forecasts to existing displays on the flight deck, and follow up with a comparable graphic product to take advantage of evolving flight deck display technology.

17. Actions air carriers can take to support emerging technologies. Air carriers support development and implementation of emerging technologies when they:

- Retrofit current predictive wind shear equipped aircraft with enhanced turbulence detection radar
- Assist in certification of enhanced radar
- Conduct inservice flight trials to determine the effectiveness of new onboard radar

systems in detecting turbulence, and the feasibility of using them

- Consider graphical onboard turbulence display systems
- Work with FAA, NASA, and other Government organizations, and with equipment manufacturers to develop industry standard weather formats for flight deck display systems (carry-on and new production panel mounted)

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APPENDIX 1. COMMERCIAL AVIATION SAFETY TEAM (CAST) TURBULENCE TEMPLATE

The CAST Turbulence Template comprises two parts:

STANDARD TERMINOLOGY FOR TURBULENCE, endorsed by the Commercial Aviation Safety Team, from the Aeronautical Information Manual (AIM)

PROCEDURES KNOWN TO BE EFFECTIVE AGAINST TURBULENCE, procedures identified by the Commercial Aviation Safety Team and suggested as standard operating procedures for voluntary implementation by U.S. air carriers

STANDARD TERMINOLOGY FOR TURBULENCE

The following terminology is endorsed by the Commercial Aviation Safety Team, from the Aeronautical Information Manual
(http://www.faa.gov/atpubs/)

DURATION OF TURBULENCE

Occasional. Less than 1/3 of the time.

Intermittent. 1/3 to 2/3 of the time.

Continuous. More than 2/3 of the time.

NOTE: Duration may be based on time between two locations or over a single location. All locations should be readily identifiable.

TURBULENCE INTENSITY

Light Chop. Slight, rapid, and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude.

Light Turbulence. Slight, erratic changes in altitude and/or attitude. Occupants may feel a slight strain against seatbelts. Unsecured objects may be displaced slightly. Food service may be conducted and little to no difficulty is encountered in walking.

Moderate Chop. Rapid bumps or jolts without appreciable changes in aircraft altitude or attitude.

Moderate Turbulence. Changes in altitude and/or attitude occur but the aircraft remains in positive control at all times. It usually causes variations in indicated airspeed.

APPENDIX 1. COMMERCIAL AVIATION SAFETY TEAM (CAST) TURBULENCE TEMPLATE (Continued)

Occupants feel definite strain against seatbelts. Unsecured objects are dislodged. Food service and walking are difficult.

Severe. Large, abrupt changes in altitude and/or attitude. Usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control. Occupants are forced violently against seatbelts. Unsecured objects are tossed about. Food service and walking are impossible.

Extreme. Aircraft is violently tossed about and is practically impossible to control. May cause structural damage.

TURBULENCE TYPES

Thunderstorm Turbulence. Turbulence associated within and in the vicinity of thunderstorms or cumulonimbus clouds. A cumulonimbus cloud with hanging protuberances is usually indicative of severe turbulence.

Clear Air Turbulence. High level turbulence (above 15000’) not normally associated with cumuliform cloudiness. Typically windshear turbulence even when in cirrus clouds.

Mountain Wave Turbulence. Turbulence as a result of air being blown over a mountain range or a sharp bluff causing a series of updrafts and downdrafts.

PROCEDURES KNOWN TO BE EFFECTIVE AGAINST TURBULENCE

The following procedures have been identified by the CAST and are suggested as standard operating procedures for voluntary implementation by U.S. air carriers

MAXIMIZE THE INFORMATION ABOUT YOUR FLIGHT CONDITIONS

Inform ATC of turbulence at check in with new controller.

Inform ATC when unforecasted turbulence is encountered en route.

Inform company via ACARS or dispatch frequency so that following flights will be aware of the flight conditions or be planned on another route.

Inform/query other aircraft operating in the area on a common frequency.

Query ATC about “the rides” when you check in with a new controller/sector.

APPENDIX 1. COMMERCIAL AVIATION SAFETY TEAM (CAST) TURBULENCE TEMPLATE (Continued)

WHEN INFORMED OF TURBULENT FLIGHT CONDITIONS:

Prior to departure, seek alternate routing to avoid the affected areas or delay departure until conditions improve.

Change en route altitudes or routes to avoid the turbulence.

Slow to the manufacturer's recommended turbulence penetration speed.

Prior to descent, seek alternate routing to avoid the affected areas or, if severity dictates, hold or divert to alternate.

AVOID any convective activity (CBs) en route by at least 20 nautical miles.

GENERAL TURBULENCE PROCEDURES

If flight into forecast turbulence is unavoidable, timely notification to the cabin crew is crucial to their safety.

If turbulence is expected before the flight departs, the preflight briefing to the lead flight attendant must include turbulence considerations. The briefing can be the same as an in-flight briefing for expected turbulence including:

- Actions the captain wants the cabin crew to undertake any time turbulence is expected
- Intensity of turbulence expected
- Methodology for communicating to the cabin the onset or worsening of turbulence, e.g., cabin interphone or PA
- Phraseology for the cabin crew to communicate the severity of turbulence
- Expected duration of the turbulence and how an "all-clear" will be communicated

Utilize a positive signal of when cabin crew may commence their duties after takeoff and when they should be seated and secured prior to landing.

Passengers will be informed of routine turbulence via the PA system. Do not rely on the seatbelt sign alone.

Cabin crew will be informed of routine turbulence via the interphone.

If at any time the cabin crew experiences uncomfortable turbulence without notice from the flight crew, they must immediately take their seats and inform the flight crew.

All service items must be properly stowed and secured when not in use.

APPENDIX 1. COMMERCIAL AVIATION SAFETY TEAM (CAST) TURBULENCE TEMPLATE (Continued)

TURBULENCE ONSET CATEGORIES

Expected Turbulence. Advance notice exists for the Captain to brief the cabin crew either prior to the flight or in-flight via the interphone.

Little Warning. Sufficient warning exists to seat the passengers and for the cabin crew to perform their duties.

Imminent Turbulence or Turbulence Occurring. Sudden, unexpected or imminent turbulence requiring immediate action to protect cabin crew and passengers.

INJURY AVOIDANCE ACTIONS

Expected Turbulence

Captain can thoroughly brief the cabin crew on the expected turbulence level and its duration.

Clearly articulate expectations from the cabin crew and request confirmation of completed actions.

Instruct the cabin crew to immediately and plainly report any deviations from the expected turbulence level.

Develop a method to inform the cabin crew of the completion of the turbulence event.

Little Warning

Captain turns on seatbelt sign and makes a public address announcement, ”Flight Attendants stow your service items and take your seats. Passengers please remain seated until this area of turbulence has passed and I have cleared you to move about the cabin.”

Cabin crew stows all applicable service items, performs cabin compliance check, and secures themselves in their jump seats.

Lead flight attendant informs captain of the completion of these items.

When conditions improve, captain uses the public address system to advise the cabin crew that they may resume their duties and whether or not the passengers may move about the cabin.

APPENDIX 1. COMMERCIAL AVIATION SAFETY TEAM (CAST) TURBULENCE TEMPLATE (Continued)

Imminent Turbulence or Turbulence Occurring

Captain turns on seatbelt sign and makes a public address announcement, "flight attendants and passengers be seated immediately. Passengers please remain seated until this area of turbulence has passed and I have cleared you to move about the cabin."

Cabin crew take first available seat and secure themselves.

No compliance checks are performed and items are secured only if they present no delay in securing a person in a seat.

When conditions improve, captain makes public address announcement advising the cabin crew that they may resume their duties and whether or not the passengers may move about the cabin.

APPENDIX 2. USAF PRACTICES TO AVOID THUNDERSTORMS AND ATTENDANT TURBULENCE

The practices shown below are excerpted from United States Air Force Flight Publications for pilots of the Air Mobility Command (AMC).

Many of the airplanes operated by AMC compare closely to the transport category airplanes operated by U.S. air carriers under 14 CFR part 121 in respect to size, weight, and other characteristics. Practices effective in AMC operations are often effective in commercial (air carrier) operations, and vice versa.

The following practices have been developed by the Air Force for AMC pilots as measures to prevent thunderstorm penetrations and to mitigate effects of proximate thunderstorms, especially loss of control and turbulence that might cause injury.

These practices are reprinted here for reference by managers and trainers of pilots operating transport category airplanes in commercial aviation, especially those carrying passengers and flight attendants under 14 CFR part 121. These practices are comprised of clear and objective criteria to facilitate recognition of cues associated with severe convective activity and guidance to improve flight crew decision-making.

During flight, use any means available to avoid thunderstorms by at least:

20 nautical miles at or above flight level (FL) 230
10 nautical miles below FL 230

In order to minimize exposure to thunderstorm hazards **when approaching or departing an airport** in an area where thunderstorms are occurring or are forecast;

Attempt to maintain visual meteorological conditions (VMC).
Maintain at least 5 nautical miles separation from heavy rain showers.
Avoid areas of high lightning potential, i.e., clouds within ± 5,000 feet of the freezing level.

NOTE: Approaches or departures may be accomplished when thunderstorms are within 10 nautical miles. The thunderstorms must not be producing hazardous conditions (such as hail, lightning, strong winds, gust fronts, heavy rain wind shear, or microburst) at the airport, and must not be forecast or observed to be moving in the direction of the route of flight (to include the planned missed approach corridor, if applicable).

APPENDIX 3. DETECTION: NEW AND EMERGING TECHNOLOGIES, PRODUCTS AND SERVICES TO DETECT TURBULENCE

(1) 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 (http://tpaws.larc.nasa.gov). TPAWS efforts are focused on two areas:

- Enhancements to existing aircraft radar systems – this includes new signal processing algorithms and alerting capabilities for predictive wind shear radars. The goal is to improve convective turbulence detection in the 25-40 mile range and deliver meaningful alerts to the crew

- New onboard turbulence detection/mitigation technologies – this includes research into look-ahead detection systems such as Light Detection and Ranging (LIDAR), and automated flight control systems to mitigate turbulence initiated cabin accelerations

NOTE: NASA and FAA are jointly conducting workshops for developing performance and certification criteria for development of turbulence sensors.

(2) MDCRS (Meteorological Data Collection and Reporting System) – The goal of the MDCRS program is to significantly increase the availability of automated aircraft weather reports. MDCRS is the result of collaboration between the FAA, NWS, and six participating U.S. air carriers. Currently, MDCRS provides over 100,000 daily-automated aircraft wind and temperature reports to the FAA and NWS.

(3) 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 100 aircraft. Since 2001, these 100 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 (see GTG below). Future plans include installation of EDR software on as many as 1200 commercial aircraft, converting the metric into aircraft specific ride reports, and distribution of this information nationally.

APPENDIX 3. DETECTION: NEW AND EMERGING TECHNOLOGIES, PRODUCTS AND SERVICES TO DETECT TURBULENCE (Continued)

(4) GTG (Graphic Turbulence Guidance) – MDCRS and EDR aircraft reports are being used to update forecast models (RUC and GFS), as well as being used to develop automated turbulence forecast products, such as the newly developed Graphic Turbulence Guidance (GTG). The GTG has been under development for several years by NCAR. The GTG provides a graphic depiction of clear air turbulence potential for altitudes above FL200, over the contiguous U.S. at 3-hour intervals out to 12 hours. This product is available on the FAA funded Aviation Digital Data Service (ADDS) web site hosted by the NWS Aviation Weather Center (http://adds.aviationweather.noaa.gov/).

(5) 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, the Oceanic Convective Nowcast Demonstration (OCND). Using real time oceanic satellite data and associated analysis algorithms, convective cloud top graphics are generated at 30-minute intervals. During initial development the OCND graphic was available to dispatchers and oceanic controllers via Internet, and also uplinked to aircraft in flight over the central and south Pacific. 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 an NCAR web site: (http://www.rap.ucar.edu/projects/owpdt).

(6) CIWS (Center Integrated Weather System) - CIWS is an FAA sponsored program to develop an improved aviation convective weather graphic. CIWS uses radar inputs from NWS Next Generation Weather Radar (NEXRAD), FAA Terminal Doppler Weather Radar (TDWR), and FAA Airport Surveillance Radar (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 (Chicago to the East Coast). Airline systems operations centers had access to the products via servers on the Internet and CDM-Net as well as via dedicated displays.

(7) ADDS (Aviation Digital Data Service) – ADDS is an operational FAA/NWS web site dedicated to providing graphic aviation products in real time. Developed by NOAA's Forecast Systems Lab (FSL) under FAA sponsorship, the site includes leading edge products such as GTG and the NCWF, as well as traditional aviation products such as SIGMETS and convective SIGMETS in graphic format. Many of the available products provide critical information on turbulence (pilot reports, forecasts, convective products, SIGMETS, etc.) in graphic form. (http://adds.aviationweather.noaa.gov/).

APPENDIX 3. DETECTION: NEW AND EMERGING TECHNOLOGIES,

PRODUCTS AND SERVICES TO DETECT TURBULENCE (Continued)

(8) NCWF (National Convective Weather Forecast) - The NCWF, designed and implemented by NCAR, provides current convective hazards and 1-hour extrapolation forecasts of thunderstorm hazard locations. The hazard field and forecasts update every 5 minutes. The NCWF development is sponsored by the FAA AWR program as part of the Convective Weather PDT. The Convective Weather PDT consists of MIT Lincoln Laboratories, National Severe Storms Laboratory (NSSL), National Weather Service's Aviation Weather Center (AWC), and NCAR. This graphic can be accessed via the ADDS web site under “Convection” (http://adds.aviationweather.noaa.gov/convection/java).

APPENDIX 4. DELIVERY: NEW AND EMERGING TECHNOLOGIES, PRODUCTS AND SERVICES TO DELIVER TURBULENCE INFORMATION

(1) Flight Deck Uplink. Flight deck uplink of graphic weather products uses Uplink product standards and the associated flight deck display systems. Carry-on display systems such as the Electronic Flight Bag (EFB) are being developed as a first generation flight deck weather display system. Second generation systems (new aircraft production) will feature flight deck panel mounted displays, designed to be compatible with the uplink graphics developed for the carry-on systems such as the EFB. Flight deck weather uplink is supported by several NASA/FAA/industry system/program initiatives, and associated standard setting activities.

- **AWIN:** Aviation Weather Information is a broad based Government/industry initiative to provide advanced weather products into the flight deck http://awin.larc.nasa.gov/overview.htm

- **WINNCOMM:** Weather Information Network COMMunication – NASA program that is investigating communication alternatives of weather products to the flight deck. This program will support flight deck initiatives such as AWIN http://wxap.grc.nasa.gov/wincomm/

- **EWXR:** Enhanced Weather Radar is a program to develop advanced processes for utilization of on-board weather radar information. Features under development include storm motion tracking, weather hazard analysis, storm top determination, and combination of airborne and ground based weather products to create a composite strategic and tactical weather display

(2) Flight Deck Uplink Standard Setting Activities

- **RTCA Special Committee SC-195:** This committee is developing the standards for data link of graphical weather to the flight deck

(3) Aircraft Sensor Systems. Aircraft weather radar enhancements and new aircraft turbulence sensors are being developed under several government/industry programs:

- **EDR:** Eddy Dissipation Rate is a derived atmospheric parameter for defining atmospheric turbulence developed by NCAR as part of the FAA Turbulence PDT. EDR software utilizes inputs from standard aircraft performance systems to generate an aircraft independent turbulence metric. ICAO has adopted EDR as the international standard for automated turbulence reporting. Currently, one airline has 100 aircraft downlinking average and peak EDR values at one-minute intervals

APPENDIX 5. GRAPHICAL DEPICTION OF SOME OF THE DATA USED IN THIS ADVISORY CIRCULAR

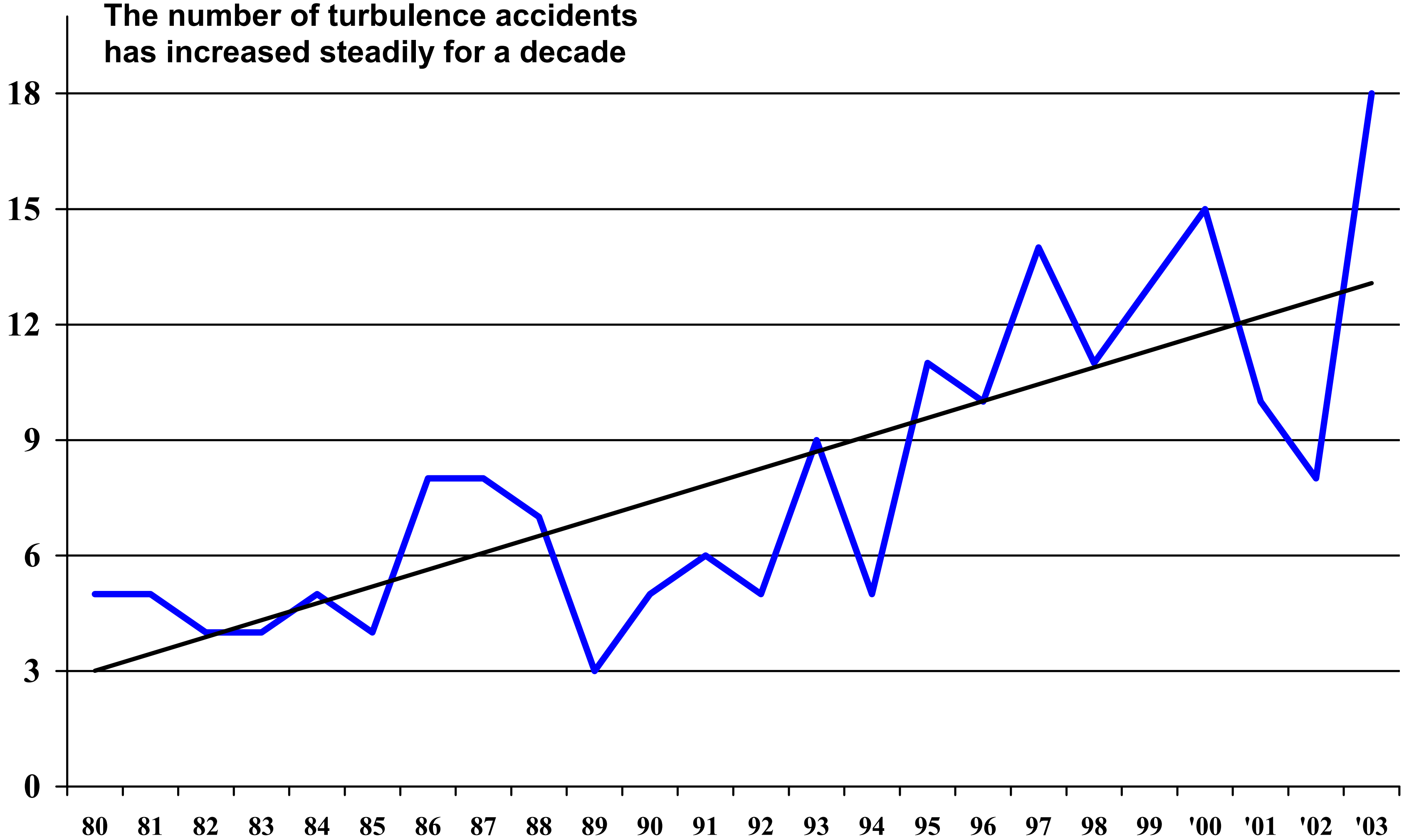
The following pages contain data compiled from NTSB accident reports relating to turbulence over the period 1980-2003.

Plots show year-to-year numbers and trend lines for:

- Turbulence Accidents, 1980 – 2003, U.S. Air Carriers
- Turbulence Accidents Per Million Departures, U.S. Air Carriers, 1982 - 2003

APPENDIX 5. GRAPHICAL DEPICTION OF SOME OF THE DATA USED IN THIS ADVISORY CIRCULAR (Continued)

Turbulence Accidents, 1980-2003
U.S. Air Carriers



APPENDIX 5. GRAPHICAL DEPICTION OF SOME OF THE DATA USED IN THIS ADVISORY CIRCULAR (Continued)

Turbulence Accidents Per Million Departures U.S. Air carriers, 1982-2003

The increase in accidents and injuries cannot be explained only by volume. The controlling factor might be load factors.