

Preventing Turbulence-Related Injuries in Air Carrier Operations

Daniel R. Bower, Ph.D. – Investigator in Charge
Air Carrier and Space Investigations

Presentation to Safety Forum 2024 – Aviation Weather Resilience



About the NTSB



Making Transportation Safer

AVIATION • RAILROAD • TRANSIT • HIGHWAY • MARINE • PIPELINE • COMMERCIAL SPACE

NTSB At A Glance

- Independent federal agency
- Investigate civil aviation accidents and surface transportation events
- Determine probable cause and issue safety recommendations
- No regulatory authority
- Five Board Members nominated by the President and confirmed by the Senate to serve 5-year terms
- A staff of more than 400 investigators, analysts, researchers, and others support the mission



NTSB At A Glance

- Since 1967, the NTSB has investigated more than **150,000 aviation accidents** and thousands of surface transportation events
- **More than 15,000 safety recommendations** resulting from NTSB investigations issued to almost 2,500 recipients in all transportation modes



President Johnson signs the Department of Transportation Act of 1966 that created the NTSB.

Who We Are And What We Do

The NTSB is an independent federal agency charged by Congress with investigating every civil **aviation** accident in the U.S. and significant events in the other modes of transportation—**railroad, transit, highway, marine, pipeline**, and **commercial space**. We determine the probable causes of the accidents and events we investigate and issue safety recommendations aimed at preventing future occurrences.

In addition, we conduct **transportation safety research studies** and offer information and other **assistance to family members and survivors** for each accident or event we investigate.

We also serve as the **appellate authority** for enforcement actions involving aviation and mariner certificates issued by the Federal Aviation Administration (FAA) and U.S. Coast Guard, and we adjudicate appeals of civil penalty actions taken by the FAA.

Our Mission: *Making Transportation Safer*

We carry out our mission by:

- **Maintaining** our congressionally mandated independence
- **Conducting** objective, thorough investigations and safety studies
- **Deciding** fairly and objectively appeals of enforcement actions by the FAA and U.S. Coast Guard and certificate denials by the FAA
- **Advocating** for implementation of safety recommendations
- **Assisting** survivors and families of those involved in transportation accidents

Our Core Values

- **Integrity** — We hold ourselves and each other to the highest ethical standards.
- **Transparency** — We encourage openness, collaboration, and feedback to ensure clarity and trust.
- **Independence** — We are impartial and objective.
- **Excellence** — We are thorough, rigorous, and accurate.
- **Diversity and Inclusion** — We are committed to being fair, honest, respectful, and inclusive in our work and in our treatment of others. We continuously seek diverse perspectives in all that we do.

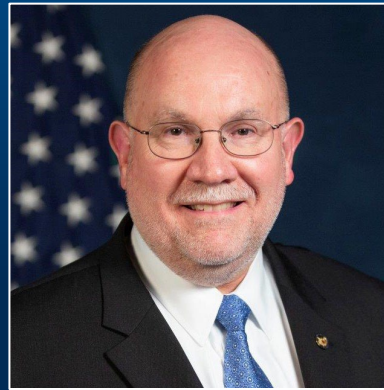
The NTSB Board



Jennifer Homendy
Chair



Michael E. Graham
Member



Thomas B. Chapman
Member



Alvin Brown
Member



J. Todd Inman
Member

NTSB On Scene

When you see our investigators working at the scene of an accident or crash, it is to **document the scene** and to **secure perishable evidence**.

We look at the roles of:

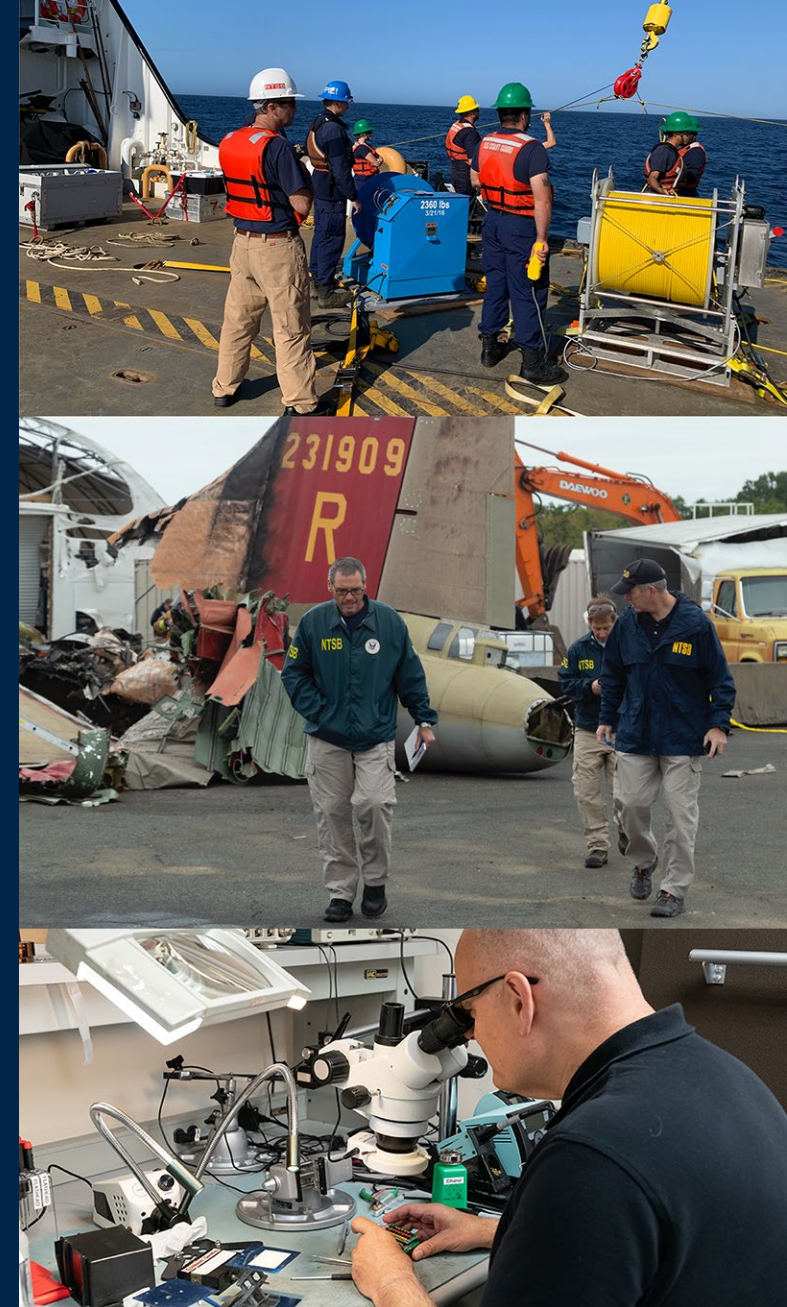
- **Humans** — Experience, physiological state, performance
- **Machines** — Mechanical failures, technology, management of the company
- **Environment** — Infrastructure, weather



Focus On Safety

We focus solely on safety. We make recommendations that could improve safety across all modes of transportation.

- We do not determine blame or liability
- We do not investigate intentional criminal acts



Investigation Process

On Scene



“Go Team”

Groups & parties
Family assistance
Media briefings
News releases

Fact Gathering



Preliminary report
Investigative updates

Public Hearing



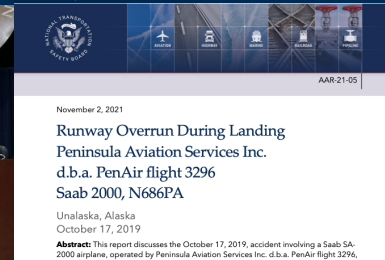
Depositions
Witnesses
Docket opening
Recorder transcript

Board Meeting



Findings
Conclusions
Probable cause
Safety recommendations

Final Report



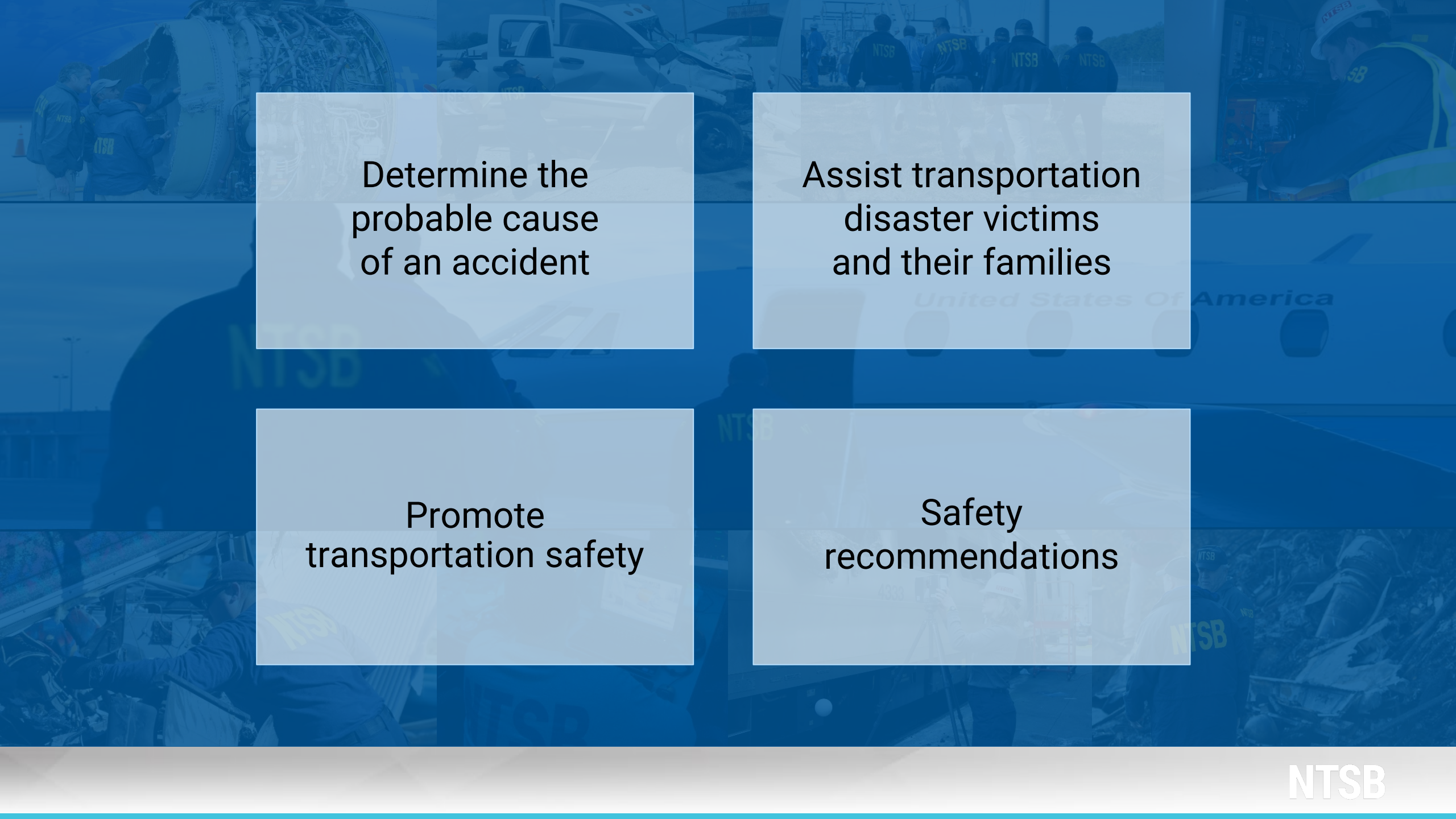
Published
2–4 weeks after
Board meeting

Beyond the Investigation ▶



Track progress
of safety
recommendations
Safety advocacy

Investigation timeline: 12–24 months

The background is a collage of four images related to NTSB investigations, all with a blue tint. Top-left: Two NTSB investigators in blue uniforms with 'NTSB' on the back are examining a damaged aircraft fuselage. Top-right: A group of NTSB investigators in blue uniforms are standing near a white emergency vehicle. Bottom-left: An NTSB investigator in a blue uniform is working on a damaged aircraft. Bottom-right: An NTSB investigator in a blue uniform is using a camera on a tripod to document a crash site.

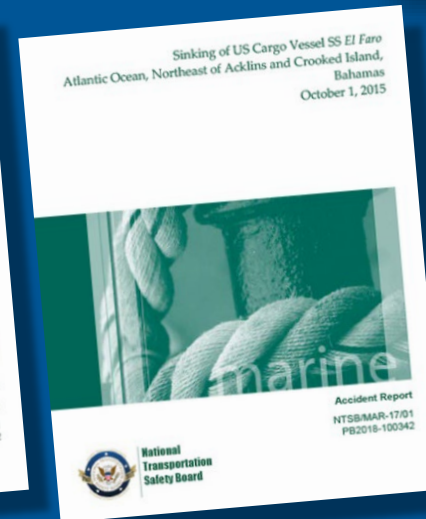
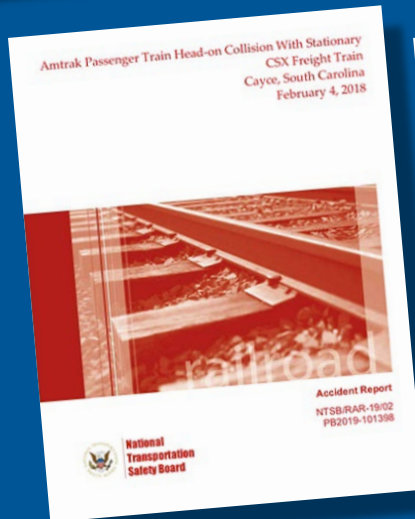
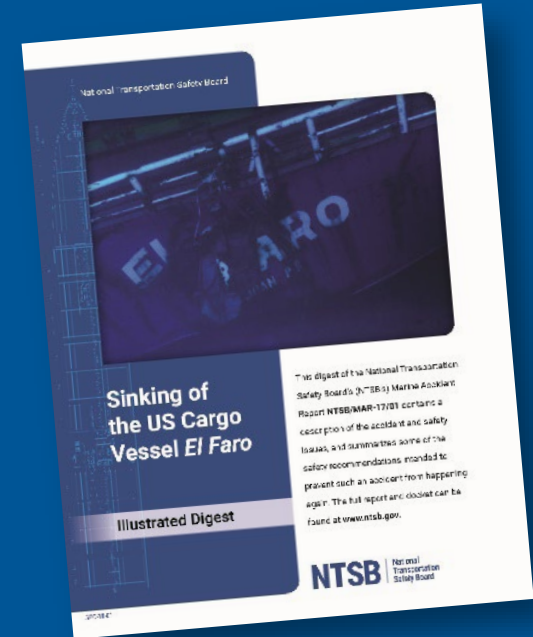
Determine the
probable cause
of an accident

Assist transportation
disaster victims
and their families

Promote
transportation safety

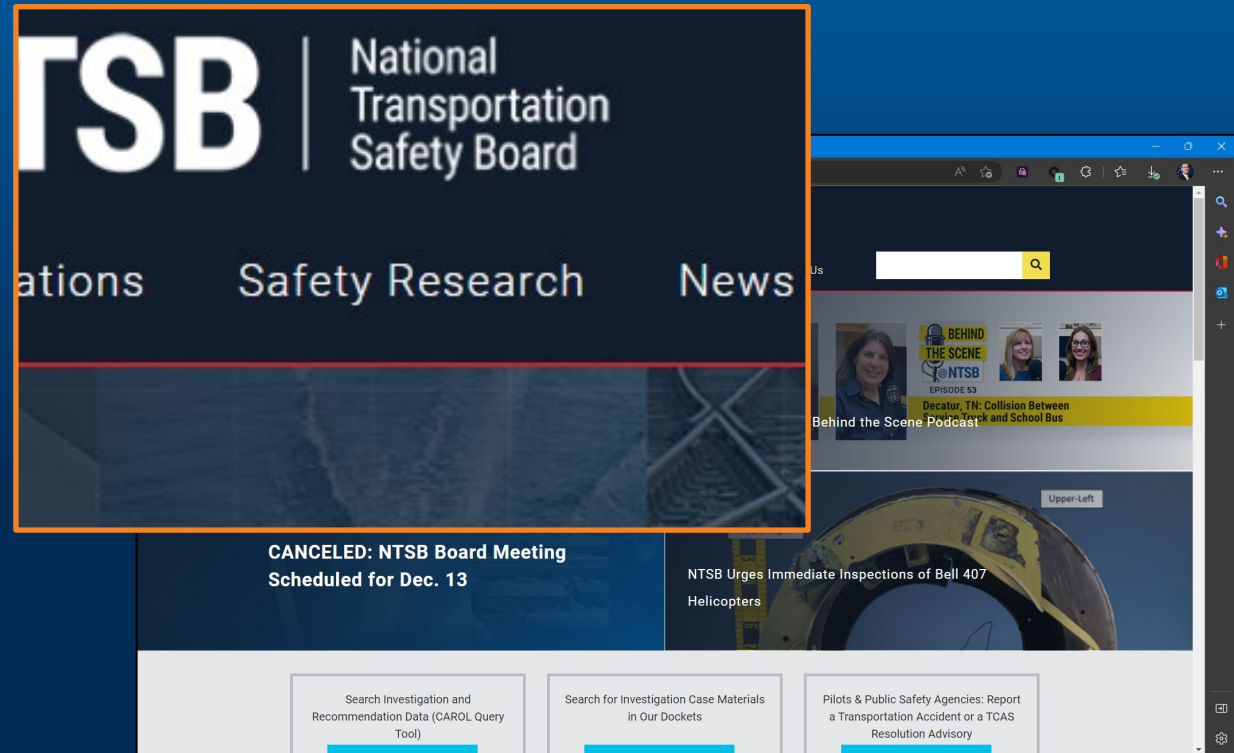
Safety
recommendations

Safety recommendations



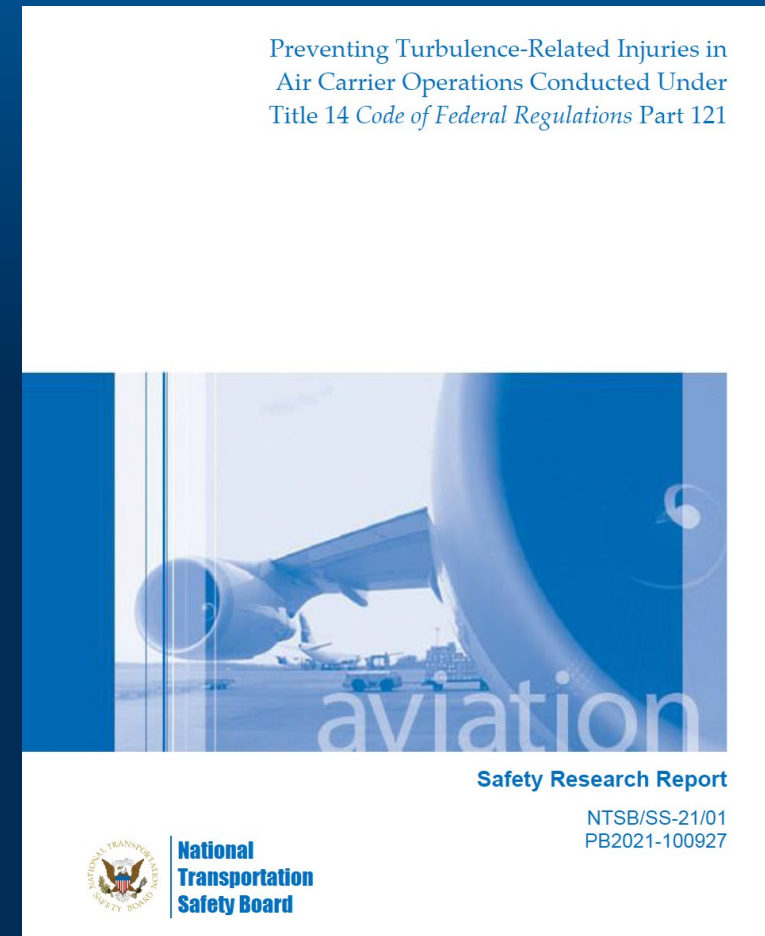
NTSB Safety Research

- NTSB is mandated to carry out special studies about transportation safety
- Larger research projects resemble major accident investigations in their outputs
 - Public meeting
 - Published report
 - Safety recommendations



Turbulence Safety Research Report

- Published September 2021
- Issued 21 new safety recommendations
 - 18 to Federal Aviation Administration (FAA)
 - 2 to National Weather Service (NWS)
 - 1 to Airlines for America (A4A), National Air Carrier Association (NACA), and Regional Airline Association (RAA)
- Reiterated 4 recommendations to FAA



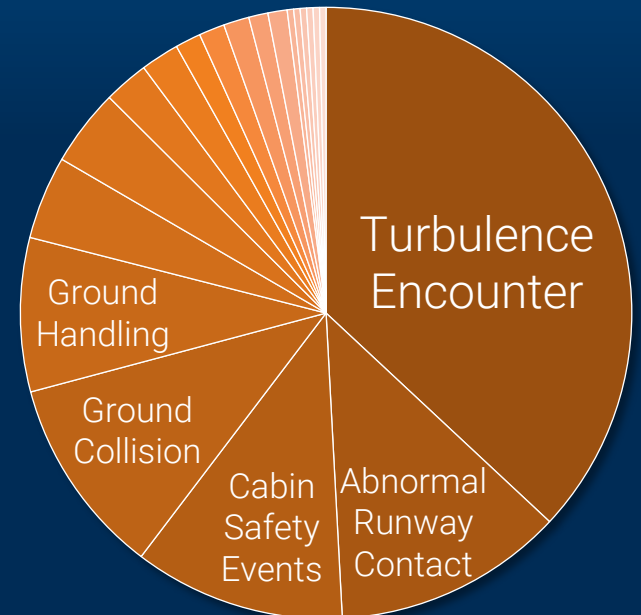
Why the NTSB Did This Research

- Turbulence-related accidents are the most common type of accident in 14 *CFR* Part 121 operations
 - Accident = serious injury or substantial aircraft damage
 - Part 121 = air carrier operations with ≥ 10 passenger seats or $> 7,500$ lbs cargo
- From 2009 through 2018:
 - Turbulence accounted for 111 of 295 Part 121 accidents (38%)
 - All resulted in at least one serious injury

The New York Times

36 People Hurt, 11 Seriously, as Turbulence Rocks a Flight to Hawaii

A 14-month old and a teenager were among those injured in the flight from Phoenix to Honolulu, the authorities said.



Part 121 Accident Types, 2009-2018

Research Methodology

- Literature review
- Data analysis
 - NTSB aviation accident database
 - Investigation docket materials, such as crewmember statements
- Case studies
 - 10 accidents between February 2019 and February 2020
- Stakeholder interviews
 - FAA
 - Air traffic control (ATC)
 - Air carriers
 - Meteorologists and commercial weather information providers
 - Pilot and flight attendant unions
 - Aircraft and airborne radar manufacturers

Safety Issue Areas

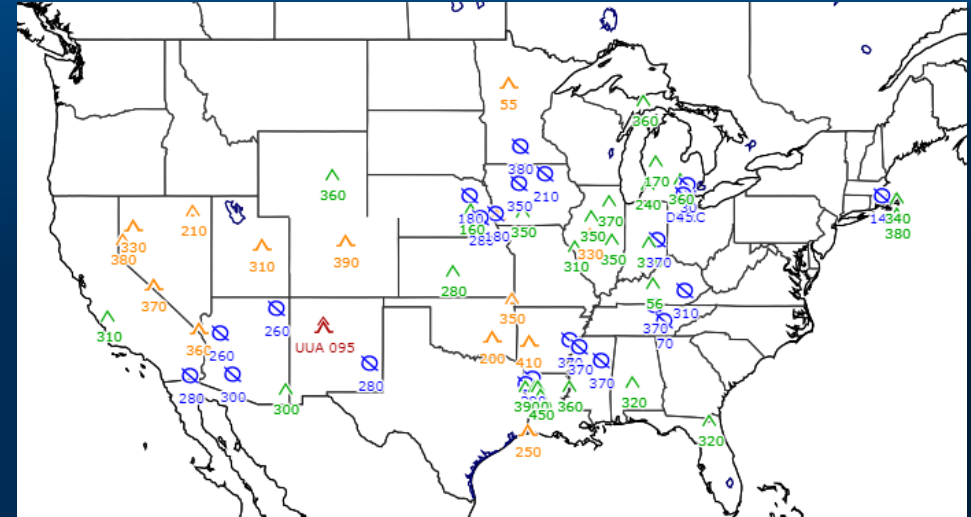
- Insufficient submission and dissemination of turbulence observations
- Lack of shared awareness of turbulence risks
- Need for mitigation of common turbulence-related injury circumstances
- Need for updated turbulence guidance from FAA to air carriers

Findings and Recommendations

- ATC procedures for processing pilot weather reports (PIREPs) are time-consuming and nonstandardized
 - FAA: work with stakeholders to standardize distribution of PIREPs across and within ATC facilities
 - FAA (reiteration): provide controllers with automated PIREP data-collection tools
 - FAA (reiteration): automatically populate PIREPs with data captured from controller displays
 - FAA (reiteration): provide a means of electronically accepting PIREPs
 - FAA (reiteration): encourage industry safety efforts to incentivize PIREP sharing

Findings and Recommendations

- Air carriers do not share all turbulence observations throughout the National Airspace System (NAS)
- FAA: as a condition of enhanced weather information system (EWINS) approval, require Part 121 air carriers to disseminate all turbulence observations to the NAS



Source: National Weather Service

Findings and Recommendations

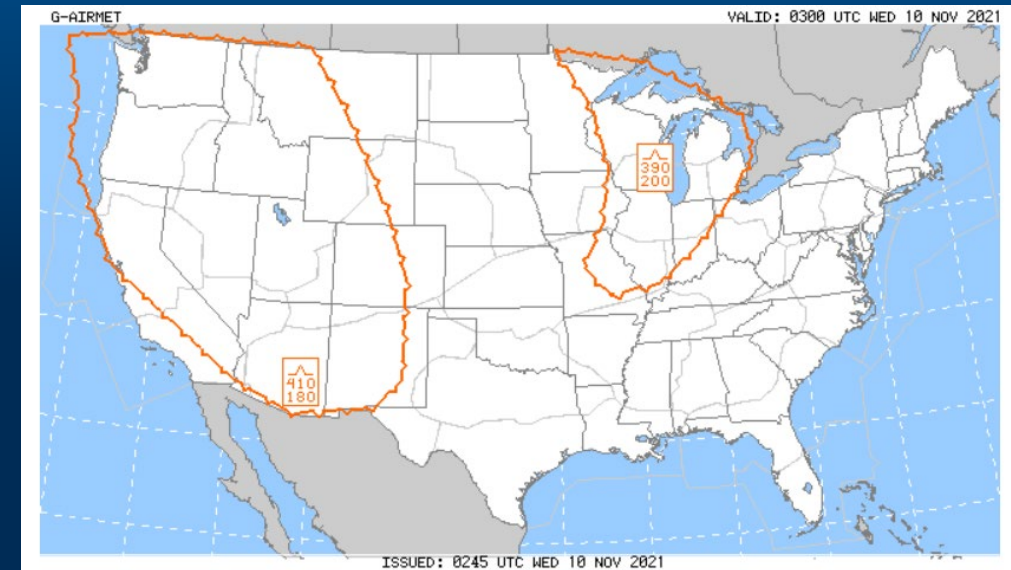
- Stakeholders lack access to important flight safety data because objective, in situ turbulence observations are not shared publicly to the greatest extent possible
 - FAA: incorporate automatic dependent surveillance-broadcast weather (ADS-B Wx) in the next version of the ADS-B technical standard order (TSO)
 - FAA: require that aircraft flown in Part 121 operations be retrofitted with ADS-B Wx
 - FAA: require ADS-B Wx equipped aircraft to broadcast ADS-B Wx information when operating in ADS-B airspace

Findings and Recommendations

- Methods are needed to translate between eddy dissipation rate (EDR) values calculated by different algorithms
- FAA: determine how to harmonize current and future EDR algorithm performance in operational environments

Findings and Recommendations

- Due to their large size, AIRMETs are of limited value to Part 121 pilots and ATC
- FAA & NWS: modify AIRMET issuing practices to include graphical AIRMETs with higher granularity



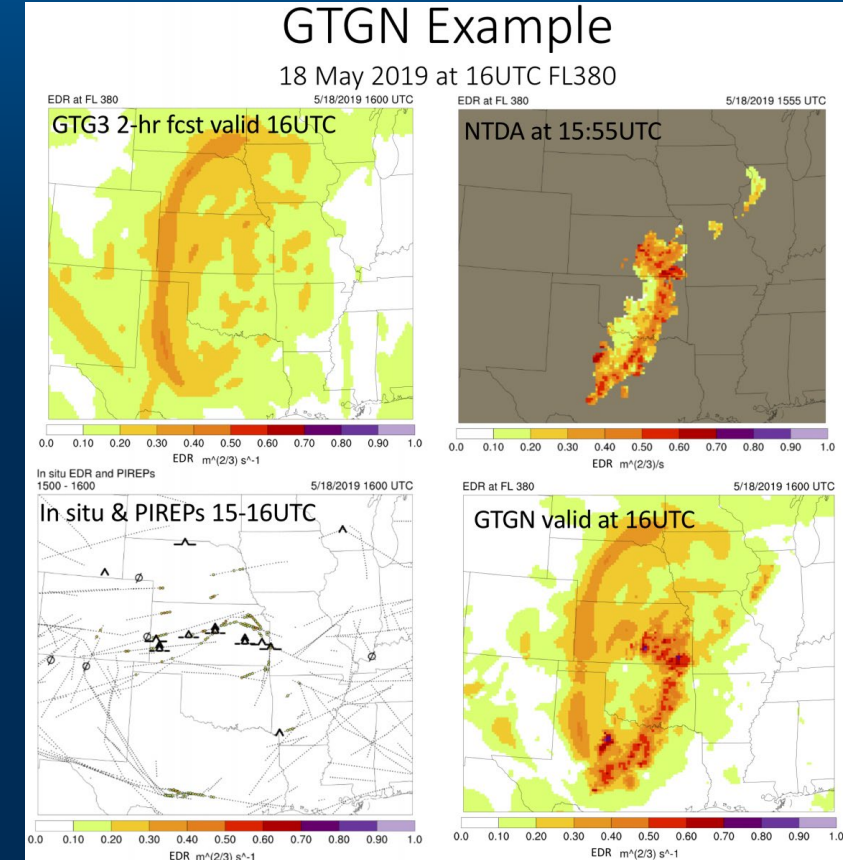
Source: National Weather Service

Findings and Recommendations

- Providing AIRMETs, SIGMETs, and center weather advisories (CWAs) on ATC displays would increase controller awareness of their locations
 - FAA: distribute graphical AIRMETs, SIGMETs, and CWAs as selectable layers on controller radar displays
- Lightning and hail information provide useful indicators for areas of convective turbulence
 - FAA: incorporate total lightning and hail information as selectable layers on controller radar displays
 - FAA: provide training to controllers on the use of lightning and hail information

Findings and Recommendations

- A turbulence nowcast would help pilots, dispatchers, and controllers respond tactically to turbulence
- FAA & NWS: operationalize a turbulence nowcast, such as the Graphical Turbulence Guidance Nowcast (GTGN)
- FAA: develop ATC guidelines for using a turbulence nowcast



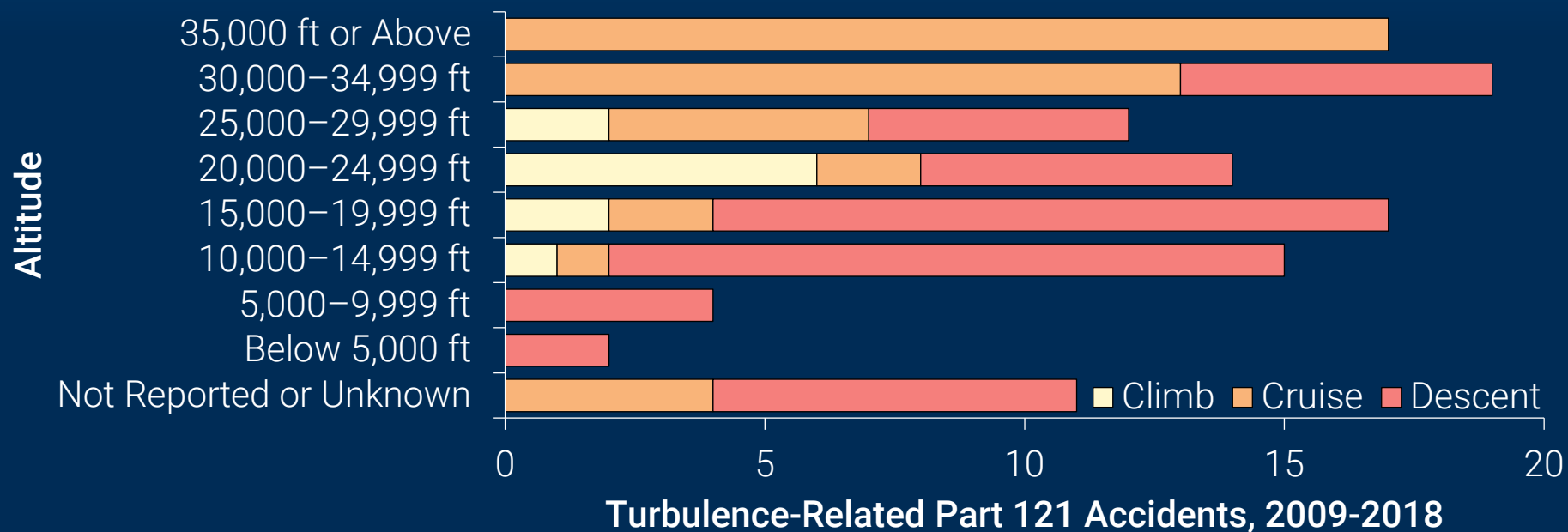
Source: National Center for Atmospheric Research

Turbulence Injury Circumstances

- Many accidents occur during the descent phase of flight
- Injuries are not uniformly sustained throughout the aircraft cabin
- Nearly all injuries are sustained by occupants who are not wearing their seat belts

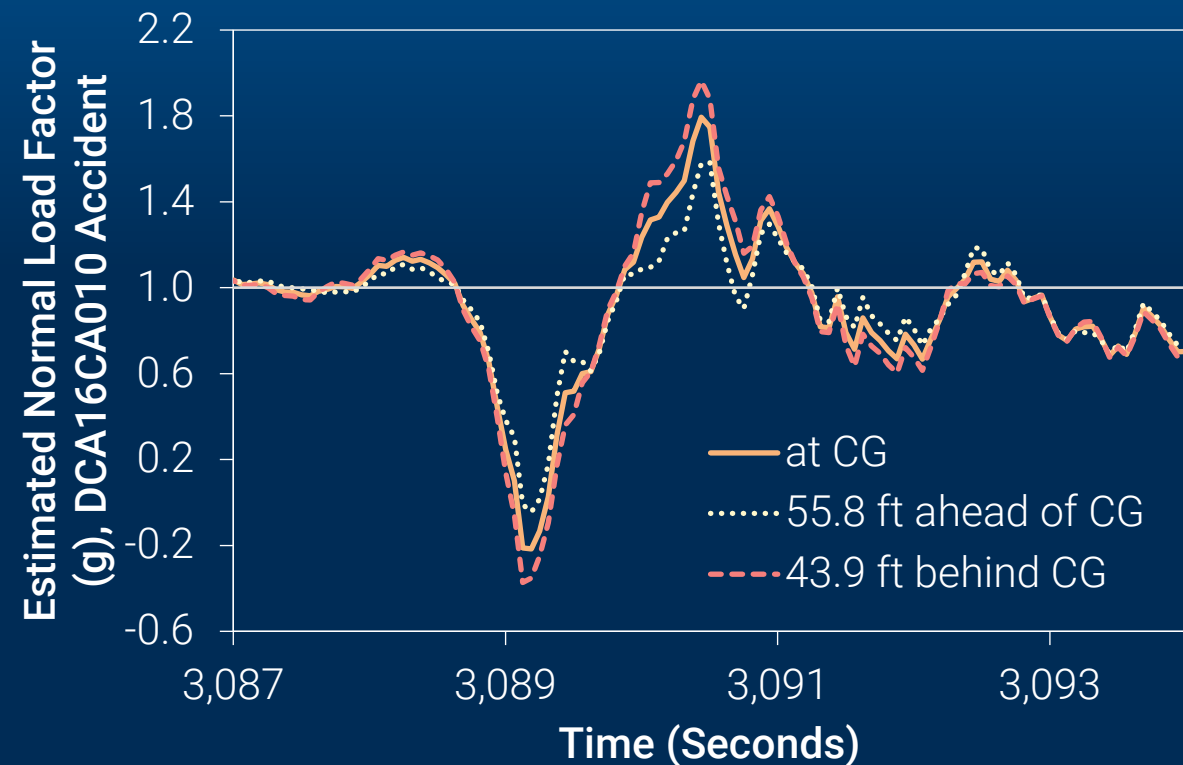
Findings and Recommendations

- Having flight attendants seated earlier in the descent would reduce accidents and injuries
- FAA: revise Advisory Circular 120-88A to include the phases of flight and altitudes at which flight attendants should be secured in their seats, including descent



Findings and Recommendations

- Assessing how aircraft accelerations from turbulence vary along the length of the aircraft would improve understanding of injury risk
- FAA: conduct a study of how aircraft accelerations vary along the length of the aircraft during turbulence encounters, including differences among aircraft types operated by Part 121 air carriers




Findings and Recommendations

- Wearing a seat belt reduces the risk of serious injury for all aircraft occupants during turbulence-related Part 121 accidents
- Researching factors that affect caregivers' decisions about using a child restraint system (CRS) would improve efforts to increase voluntary CRS use
 - FAA: conduct a study to determine the factors that affect CRS usage
 - FAA: use the study findings to direct FAA efforts to increase CRS usage
 - A4A, NACA, RAA: develop and implement a program to increase CRS usage, which should include data collection to determine the program's effectiveness

Findings and Recommendations

- Advisory Circular 120-88A (Preventing Injuries Caused by Turbulence) does not contain information about current available technologies and best practices for avoiding turbulence encounters and injuries
- FAA: Revise AC 120-88A



U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: Preventing Injuries Caused by Turbulence

Date: 1/19/06

AC No: 120-88A

Initiated by: AFS-200

Change:

1. PURPOSE. This advisory circular (AC) provides information and practices that can be used to prevent injuries caused by turbulence. This AC highlights the data-driven methods of the Federal Aviation Administration (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 (SOP) that can be followed in daily flight operations and continually reinforced in training.

2. RELATED REGULATIONS. These regulations are available online at: <http://www.gpoaccess.gov/cfr/index.html>.

- a. 14 CFR part 121, §§ 121.311, 121.317, 121.417, 121.421, 121.427; part 125, §§ 125.211, 125.217, 125.287, 125.289, part 135, §§ 135.117, 135.128, 135.331, 135.349, and 135.351.
- b. Title 49 of the Code of Federal Regulations (49 CFR) part 830, § 830.2.

3. DEFINITIONS. The following terms as they relate to this document are defined by the National Transportation Safety Board (NTSB).

- a. **Accident.** An “accident” as in 49 CFR § 830.2 is “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.”
- b. **Fatal Injury.** “A fatal injury is any injury that results in death within 30 days of the accident.”
- c. **Serious Injury.** A serious injury is “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 percent of the body surface.”

Current Status of New Safety Recommendations

- Open—Acceptable Response (12)
- Open—Unacceptable Response (9)
 - Recommendations to FAA to operationalize a turbulence nowcast
 - Recommendations to FAA to add lightning and hail information onto controller displays
 - Recommendation to FAA to incentivize sharing of PIREPs

Reiterated Safety Recommendations – to FAA

- Open—Acceptable Response (3)
 - Automated PIREP data collection tools
 - Automation that captures data elements from displays to automated PIREPS
 - Electronic PIREPs and availability to all users of NAS
- Closed – Unacceptable Response (1)
 - Encourage and incentivize sharing of PIREP information

NTSB Blog Post - November 2023

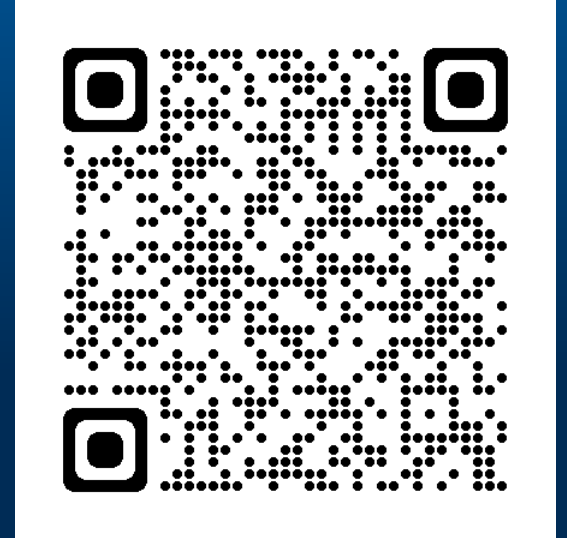
Flight Attendants Continue to be Seriously Injured in Turbulence

- Since Safety Study was published, NTSB has investigated 30 air carrier accidents involving turbulence. (Between August 2021 and September 2023)
- More than half involve flight attendants seriously injured when airplane experienced turbulence at or below 20,000 feet.
- In every case, seat belt sign illuminated, and passengers belted
- Flight attendants were not belted

Continued need for guidance during descent or areas of turbulence to have flight attendants seated and belted earlier

For More Information

- Report
 - [www.nts.gov » Safety Research » Safety Research Reports](https://www.nts.gov/safety/safety-research/safety-research-reports)
 - <https://www.nts.gov/safety/safety-studies/Documents/SS2101.pdf>
 - [Flight Attendants Continue to Be Seriously Injured in Turbulence | NTSB Safety Compass Blog \(wordpress.com\)](#)





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