National Transportation Safety Board

# Turbulence Accidents and NTSB Research Update

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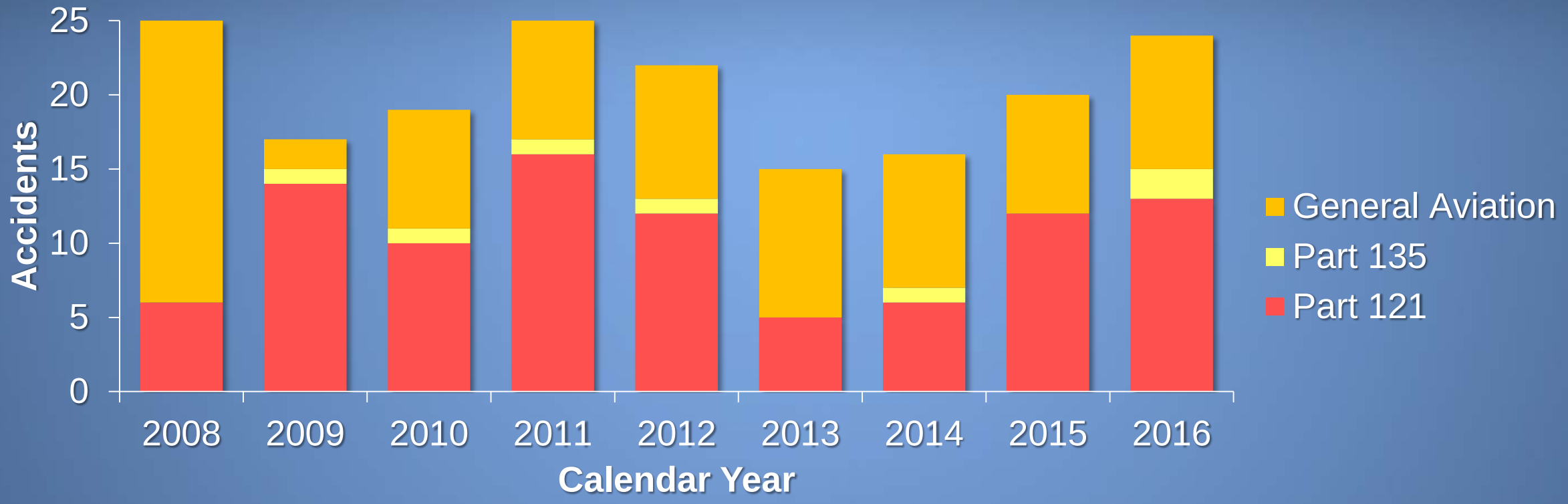
Turbulence Impact Mitigation Workshop 3

McLean, Virginia – September 6, 2018

# US Civil Aviation Turbulence Accidents




- Accident definition: ≥ substantial damage or ≥ serious injury



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# Defining Events Ranked by FAR Part

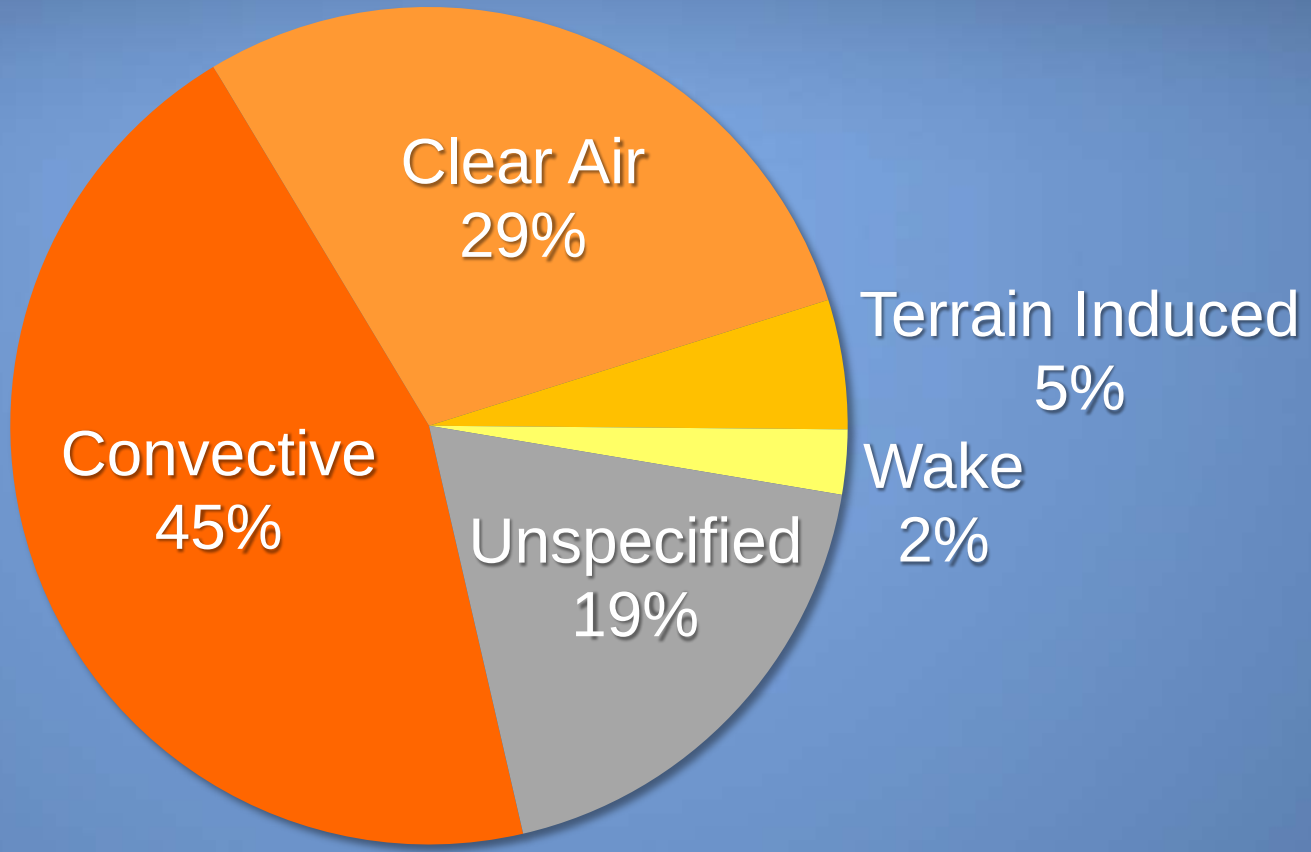
| General Aviation | | |
|---|---|---|
| 1 | Loss of Control-Inflight | 18% |
| 2 | Powerplant Malfunc | 18% |
| 3 | Loss of Control-Ground | 14% |
| 4 | Abnormal Rwy Contact | 13% |
| 5 | Fuel | 5% |
| ⋮ | ⋮ | ⋮ |
| ⋮ | ⋮ | ⋮ |
| **21** | **Turbulence** | **<1%** |

| Part 135 | | |
|---|---|---|
| 1 | Powerplant Malfunc | 15% |
| 2 | Loss of Control-Inflight | 14% |
| 3 | Abnormal Rwy Contact | 12% |
| 4 | Loss of Control-Ground | 9% |
| 5 | Non-Powerplant Malfunc | 8% |
| ⋮ | ⋮ | ⋮ |
| **14** | **Turbulence** | **1%** |

| Part 121 | | |
|---|---|---|
| **1** | **Turbulence** | **34%** |
| 2 | Ground Collision | 14% |
| 3 | Abnormal Rwy Contact | 10% |
| 4 | Cabin Safety Event | 9% |
| 5 | Ground Handling | 9% |

- 2008-2016 US civil aviation accidents
- Defining events from 32-category CAST/ICAO taxonomy

# Turbulence Types in Part 121 Accidents: 2008-2016



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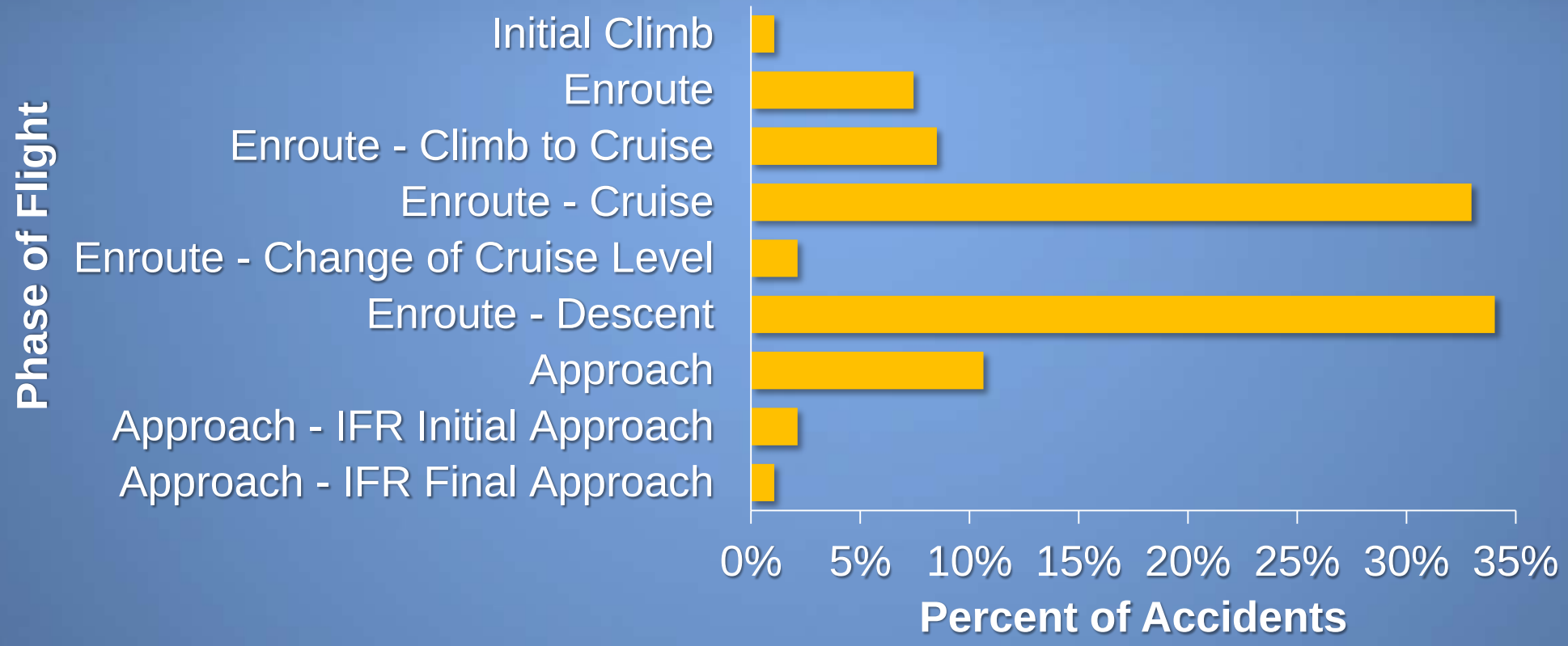
# Phase of Flight for Part 121 Turbulence Accidents: 2008-2016



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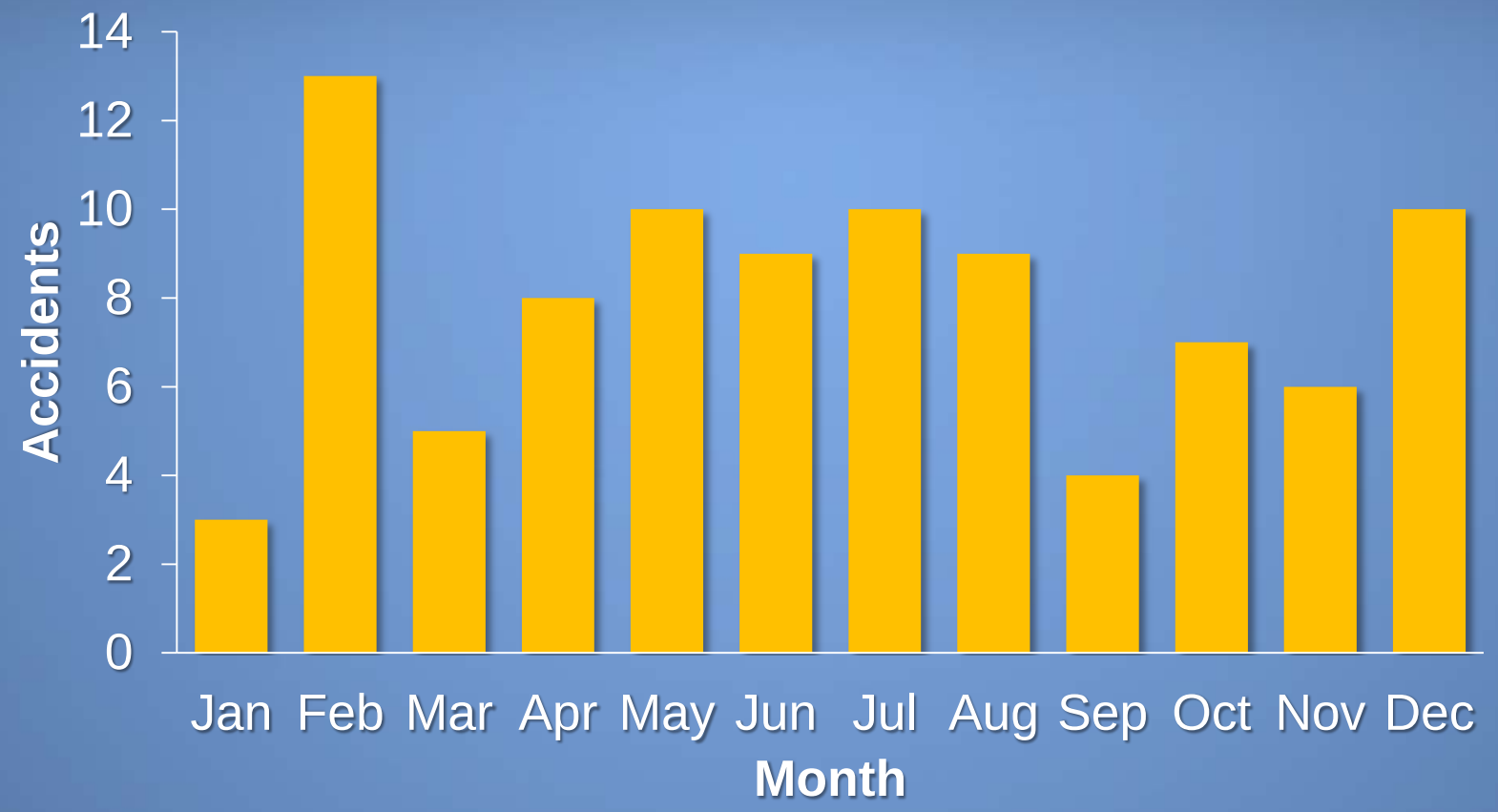
# Seasonality of Part 121 Turbulence Accidents: 2008-2016



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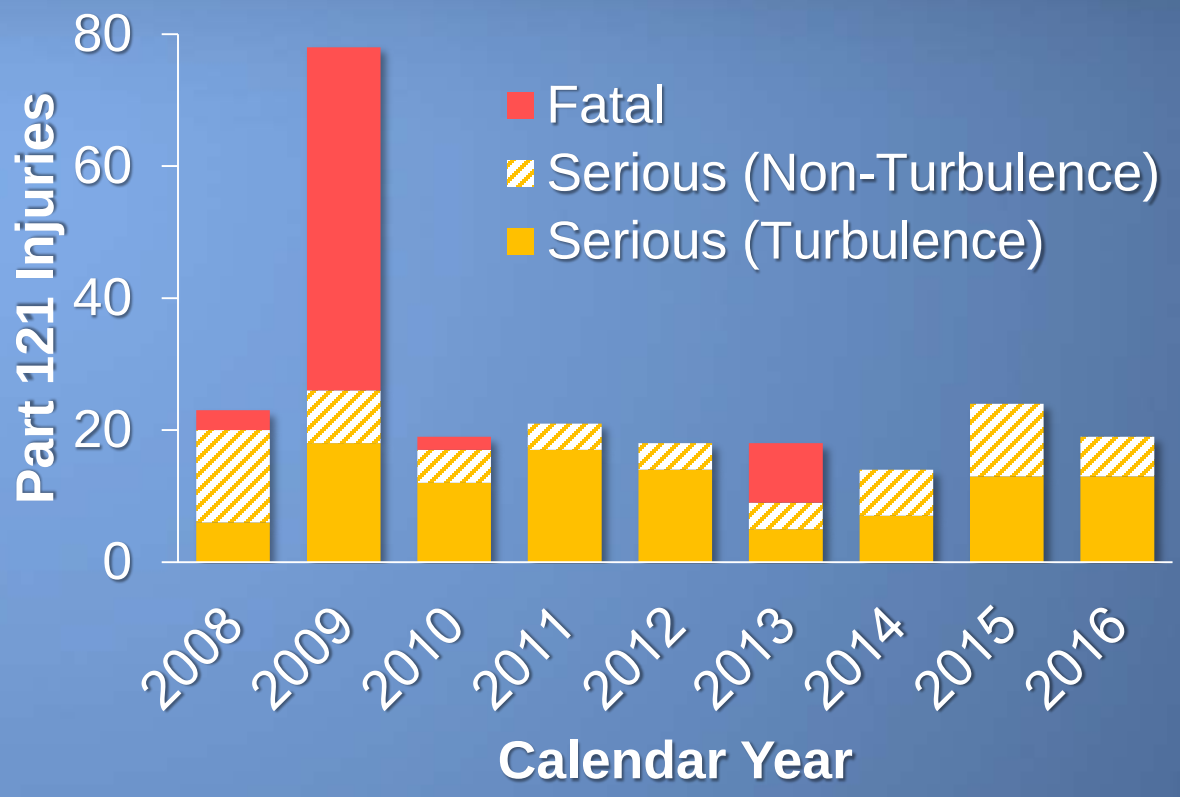
# Part 121 Turbulence Injuries and Aircraft Damage: 2008-2016

- 6% of accidents resulted in aircraft damage
- All damage classified as minor
  - Ceiling panels
  - Passenger service units
- Every accident resulted in at least one serious injury

# Part 121 Turbulence Injuries: 2008-2016

- Average of 12 serious injuries per year
  - 78% cabin crew
  - 22% passengers
- Accounted for 45% of all Part 121 serious injuries and fatalities
- Most recent Part 121 turbulence fatality in 1997



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| Part 121 Turbulence Accidents | | | | | Part 121 All Accidents | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CalendarYear | AccidentsTotal | AccidentsFatal | InjuriesFatal | InjuriesSerious | AccidentsTotal | AccidentsFatal | InjuriesFatal | InjuriesSerious | FlightHours (millions) |
| 1983 | 5 | 0 | 0 | 4 | 23 | 4 | 15 | 13 | 7.299 |
| 1984 | 6 | 0 | 0 | 5 | 16 | 1 | 4 | 11 | 8.165 |
| 1985 | 3 | 0 | 0 | 4 | 21 | 7 | 526 | 30 | 8.710 |
| 1986 | 8 | 0 | 0 | 12 | 24 | 3 | 8 | 22 | 9.976 |
| 1987 | 7 | 0 | 0 | 8 | 33 | 5 | 232 | 46 | 10.645 |
| 1988 | 6 | 0 | 0 | 6 | 29 | 3 | 285 | 57 | 11.141 |
| 1989 | 4 | 0 | 0 | 9 | 28 | 11 | 278 | 68 | 11.275 |
| 1990 | 5 | 1 | 1 | 7 | 24 | 6 | 39 | 29 | 12.150 |
| 1991 | 6 | 0 | 0 | 7 | 26 | 4 | 62 | 26 | 11.781 |
| 1992 | 4 | 0 | 0 | 3 | 18 | 4 | 33 | 22 | 12.360 |
| 1993 | 9 | 0 | 0 | 11 | 23 | 1 | 1 | 19 | 12.706 |
| 1994 | 5 | 0 | 0 | 5 | 23 | 4 | 239 | 31 | 13.124 |
| 1995 | 10 | 0 | 0 | 13 | 36 | 3 | 168 | 25 | 13.505 |
| 1996 | 10 | 0 | 0 | 15 | 37 | 5 | 380 | 77 | 13.746 |
| 1997 | 14 | 1 | 1 | 31 | 49 | 4 | 8 | 43 | 15.838 |
| 1998 | 10 | 0 | 0 | 12 | 50 | 1 | 1 | 30 | 16.817 |
| 1999 | 12 | 0 | 0 | 12 | 51 | 2 | 12 | 67 | 17.555 |
| 2000 | 14 | 0 | 0 | 17 | 56 | 3 | 92 | 31 | 18.299 |
| 2001 | 11 | 0 | 0 | 11 | 46 | 6 | 531 | 19 | 17.814 |
| 2002 | 8 | 0 | 0 | 10 | 41 | 0 | 0 | 24 | 17.290 |
| 2003 | 17 | 0 | 0 | 20 | 54 | 2 | 22 | 31 | 17.468 |
| 2004 | 11 | 0 | 0 | 11 | 30 | 2 | 14 | 20 | 18.883 |
| 2005 | 6 | 0 | 0 | 6 | 40 | 3 | 22 | 14 | 19.390 |
| 2006 | 6 | 0 | 0 | 6 | 33 | 2 | 50 | 9 | 19.263 |
| 2007 | 10 | 0 | 0 | 11 | 28 | 1 | 1 | 16 | 19.637 |
| 2008 | 6 | 0 | 0 | 6 | 27 | 2 | 3 | 20 | 19.127 |
| 2009 | 14 | 0 | 0 | 18 | 30 | 2 | 52 | 26 | 17.627 |
| 2010 | 10 | 0 | 0 | 12 | 30 | 1 | 2 | 17 | 17.751 |
| 2011 | 16 | 0 | 0 | 17 | 33 | 0 | 0 | 21 | 17.963 |
| 2012 | 12 | 0 | 0 | 14 | 26 | 0 | 0 | 18 | 17.722 |
| 2013 | 5 | 0 | 0 | 5 | 23 | 2 | 9 | 9 | 17.718 |
| 2014 | 6 | 0 | 0 | 7 | 32 | 0 | 0 | 14 | 17.752 |
| 2015 | 12 | 0 | 0 | 13 | 29 | 0 | 0 | 24 | 17.929 |
| 2016 | 13 | 0 | 0 | 13 | 31 | 0 | 0 | 19 | 18.274 |

- Notes
  - Data current as of Sep. 5, 2018
  - Coding scheme changed in 2008
  - Data for 2008 and later includes accidents with turbulence-related cause/factor and/or defining event
  - Pre-2008 data includes accidents with turbulence-related cause/factor

# NTSB Turbulence-Related Activities

- Accident investigations
- Workshops
- 2016 Forum and 2017 Special Investigation Report on PIREPs
- Safety Recommendations to improve weather forecasting and dissemination of weather reports
- Safety Study in progress: *Preventing Turbulence-Related Injuries in Part 121 Air Carrier Operations*

# NTSB Safety Studies

- NTSB mandate includes conducting *"special studies and investigations about transportation safety"*
- Studies are (in some ways) similar to major investigation
  - Report with safety recommendations
  - Public board meeting to present, discuss, and adopt report and recommendations
- Address transportation safety issues from a broad, nationwide perspective

# Turbulence Study: Objectives

- Summarize types and causes of turbulence
- Detail safety impacts on Part 121 operations
  - Accident characteristics and trends
  - Injury types and mechanisms
- Examine methods to reduce likelihood and consequences of turbulence encounters

# Turbulence Study: Areas of Inquiry

- Turbulence prediction and detection technologies
- Resources for planning and conducting flights
- Air carrier and ATC training, policies, procedures
- Outcomes of past industry efforts
- Aircraft technologies

# Turbulence Study: Methodology

- Literature review
- Analysis of NTSB accident data
- Analysis of external data on Part 121 turbulence encounters
- Stakeholder interviews
- Case studies of turbulence accidents

# Turbulence Study: Status

- Research proposal adopted by Board on September 5, 2018
- Contact: nathan.doble@ntsb.gov


# National Transportation Safety Board