



## **NATIONAL TRANSPORTATION SAFETY BOARD**

Office of Aviation Safety  
Washington, D.C. 20594

January 9, 2020

### **Specialist's Report**

# **OPERATIONAL FACTORS**

DCA19CA208

## Table Of Contents

|         |                                                           |    |
|---------|-----------------------------------------------------------|----|
| A.      | ACCIDENT .....                                            | 4  |
| B.      | AIR SAFETY INVESTIGATOR .....                             | 4  |
| C.      | SUMMARY .....                                             | 4  |
| D.      | DETAILS OF THE INVESTIGATION .....                        | 4  |
| E.      | FACTUAL INFORMATION .....                                 | 4  |
| 1.0     | History of Flight.....                                    | 4  |
| 2.0     | Flight Crew Information .....                             | 5  |
| 2.1     | Captain .....                                             | 6  |
| 2.1.1   | Captain's Training and Proficiency Checks Completed ..... | 6  |
| 2.1.2   | Captain's Flight Times .....                              | 6  |
| 2.2     | First Officer.....                                        | 7  |
| 2.2.1   | First Officer's Training and Proficiency Checks .....     | 7  |
| 2.2.2   | First Officer's Flight Times.....                         | 7  |
| 3.0     | Airplane Information .....                                | 8  |
| 3.1     | Weight and Balance .....                                  | 8  |
| 4.0     | Accident Flight Release and Weather Packet .....          | 9  |
| 4.1     | Flight Release.....                                       | 9  |
| 4.1.1   | Route of Flight .....                                     | 9  |
| 4.1.2   | Turbulence Related ACARS Messages.....                    | 10 |
| 4.1.3   | Weather Briefing .....                                    | 11 |
| 4.1.4   | Delta Air Lines Turbulence Plots (TPs).....               | 12 |
| 4.2     | PIREPs .....                                              | 15 |
| 4.2.1   | Delta PIREPs.....                                         | 15 |
| 4.2.2   | Archived PIREPs.....                                      | 15 |
| 5.0     | Delta Air Lines Guidance .....                            | 17 |
| 5.1     | Delta Air Lines - Flight Operations Manual .....          | 17 |
| 5.1.1   | Cabin Notification – Turbulence .....                     | 17 |
| 5.1.1.1 | Customers.....                                            | 17 |
| 5.1.1.2 | Flight Attendants .....                                   | 17 |
| 5.1.2   | Turbulence Action Charts .....                            | 18 |
| 5.1.3   | Turbulence Plot (TP).....                                 | 20 |
| 5.1.4   | Required PAs.....                                         | 21 |
| 5.2     | Airway Manual .....                                       | 21 |

|         |                                                                |    |
|---------|----------------------------------------------------------------|----|
| 5.2.1   | Airway Manual – Expanded TP Guidance.....                      | 21 |
| 5.2.2   | Airway Manual – Turbulence Reporting Criteria .....            | 23 |
| 5.2.3   | Airway Manual – Clear Air Turbulence .....                     | 23 |
| 5.3     | Delta Air Lines Flight Operations Manual Volume 1 MD88-90..... | 25 |
| 5.3.1   | Turbulence.....                                                | 25 |
| 5.3.1.1 | Severe Turbulence.....                                         | 25 |
| 5.3.2   | Approach Checklist.....                                        | 26 |
| 5.3.3   | Turbulence Avoidance .....                                     | 27 |
| 5.4     | Delta Air Lines Flight Operations Manual Volume 2 MD88-90..... | 27 |
| 5.4.1   | Weather Radar System.....                                      | 27 |
| 5.4.2   | ND Weather Radar Messages .....                                | 28 |
| 5.5     | Delta Air Lines – Flight Crew Training Manual .....            | 29 |
| 5.5.1   | Turbulent Air Penetration.....                                 | 29 |
| 5.5.2   | Weather Radar.....                                             | 29 |
| 5.6     | Delta Air Lines – On-Board Manual .....                        | 31 |
| 5.6.1   | Turbulence Guidelines .....                                    | 31 |
| 5.6.2   | Turbulence Action Charts .....                                 | 32 |
| 6.0     | Boeing Aero Magazine .....                                     | 34 |
| 7.0     | FAA Guidance .....                                             | 37 |
| 7.1     | FAA Turbulence Fact Sheet.....                                 | 37 |
| 7.2     | Advisory Circular 120-88A .....                                | 38 |
| F.      | LIST OF ATTACHMENTS .....                                      | 39 |

## **A. ACCIDENT**

Operator: Delta Air Lines  
Location: Chicago, Illinois<sup>1</sup>  
Date: August 26, 2019  
Time: 2037 Central Daylight Time (CDT)<sup>2</sup>  
0137 Universal Time Coordinate (Z)  
Airplane: Boeing MD-88 (N911DL)  
Flight No.: 805

## **B. AIR SAFETY INVESTIGATOR**

Shawn Etcher - Investigator  
Operational Factors Division (AS-30)  
National Transportation Safety Board  
490 L'Enfant Plaza East, SW  
Washington, DC 20594-2000

## **C. SUMMARY**

On August 26, 2019, about 2037 CDT, Delta Air Lines flight 805, a Boeing MD-88, N911DL, encountered turbulence approximately 14,000 ft. A flight attendant in the aft section of the aircraft was unable to get to their assigned jumpseat before the turbulence occurred. As a result of the turbulence, the flight attendant sustained a fractured ankle. The flight was being operated under 14 *Code of Federal Regulations* Part 121 as a regularly scheduled passenger flight from Atlanta Hartsfield-Jackson International Airport (ATL), Atlanta, Georgia to Chicago O'Hare International Airport (ORD), Chicago, Illinois.

## **D. DETAILS OF THE INVESTIGATION**

The National Transportation Safety Board (NTSB) Operational Factors investigator was assigned to the accident on September 8, 2019 and did not travel to the accident location. The Operational Factors investigator requested manuals and other various items for the investigation, from the operator. Pilot certification information was obtained from the pilots, operator, and the Federal Aviation Administration (FAA).

## **E. FACTUAL INFORMATION**

### **1.0 History of Flight<sup>3</sup>**

Delta Air Lines flight 805 had departed ATL at 1937 Eastern Daylight Time (1837 CDT).

---

<sup>1</sup> According to the crew statements the turbulence encounter occurred near the HULLS intersection, located on the WATSN Arrival, during their arrival into Chicago.

<sup>2</sup> All times in the report will be Central Daylight Time except as otherwise noted. At the time of the accident Greenwich Mean Time, also known as Zulu (Z) time, was 5 hours ahead of CDT.

<sup>3</sup> Sources: Attachment 1 - "Crew Interview Summaries"

According to flight crew statements, during initial descent on the WATSN THREE ARRIVAL<sup>4</sup>, the crew heard reports from previous aircraft of some turbulence on the arrival. The captain contacted the cabin crew and informed them of the upcoming moderate turbulence and instructed them to be seated. The flight crew requested and received clearance to deviate to the right of the HULLS<sup>5</sup> intersection, which was around the reported area of turbulence. However, they were unable to avoid the weather and encountered “about 10 to 15 seconds of moderate turbulence.”

According to cabin crew statements, they had finished service and had stowed everything they needed to in the galley. The captain notified one of the flight attendants that turbulence “was coming in three to five minutes.” The injured flight attendant was almost in the aft section of the aircraft when they encountered a “very rough spot of turbulence.” Another flight attendant reported she was midcabin when the flight encountered turbulence causing her to fall to the floor. They estimated the turbulence encounter lasted between 5 and 30 seconds. After the turbulence had subsided all the flight attendants made their way to their respective jumpseats until landing and the injured flight attendant was able to immobilize his ankle.

The flight crew further provided, that after the flight exited the area of turbulence, they filed a PIREP<sup>6</sup> with approach control. The pilots further stated they overheard on the interphone system, the injured flight attendant notify the lead flight attendant that he had fallen and was in a lot of pain. The captain transferred the control of the radios to the first officer in order to communicate with the cabin crew. Once he was aware the injured flight attendant was able to get buckled into an aft jumpseat he notified company dispatch via ACARS<sup>7</sup> and requested they notify station personnel to have EMS<sup>8</sup> meet the flight at the gate upon arrival.

After landing, at 0137Z (2037 CDT), and parking at the gate, at 0146Z (2046 CDT), paramedics boarded the aircraft to assess the flight attendant.

After conferring with EMS the injured flight attendant was cleared to fly back to ATL as a passenger but not as a working crew member. EMS subsequently stabilized the ankle with a brace for the return flight.

## **2.0 Flight Crew Information**

The accident flightcrew consisted of 2 pilots and 3 cabin crew members. The captain was the pilot monitoring (PM) on the accident flight and the first officer (FO) was the pilot flying (PF).

---

<sup>4</sup> The WATSN THREE ARRIVAL was an area navigation (RNAV) standard terminal arrival route into ORD.

<sup>5</sup> The HULLS intersection was a waypoint located on the WATSN THREE ARRIVAL and was located approximately 60 miles to the southeast of ORD. According to FAA JO7350.9 the intersection is in the vicinity of Hulls, Indiana.

<sup>6</sup> Pilot Report

<sup>7</sup> Aircraft Communications, Addressing and Reporting System which is a digital data link system for the transmission of messages between aircraft and ground stations. Source: [https://www.skybrary.aero/index.php/Aircraft\\_Communications,\\_Addressing\\_and\\_Reporting\\_System](https://www.skybrary.aero/index.php/Aircraft_Communications,_Addressing_and_Reporting_System)

<sup>8</sup> Emergency Medical Services

## 2.1 Captain

The captain was 37 years old and held an Airline Transport Pilot (ATP) certificate with a rating for airplane multiengine land and type ratings on the, CL-65<sup>9</sup>, B757<sup>10</sup>, B767, DC-9<sup>11</sup>; limitations included “ATP CIRC APCH. – VMC ONLY; B-757 B-767 CL-65 DC-9 CIRC APRC – VMC ONLY.” He held an FAA first-class medical certificate dated April 8, 2019, with a limitation of “Must wear corrective lenses.”

### 2.1.1 Captain’s Training and Proficiency Checks Completed

A synopsis of the captain's recent training at Delta Air Lines was as follows:

|                                                             |                   |
|-------------------------------------------------------------|-------------------|
| Date of Hire at Delta Air Lines                             | February 2, 2015  |
| Most Recent Continuous Qualification Training <sup>12</sup> | August 21, 2019   |
| Upgrade to captain <sup>13</sup>                            | February 1, 2018  |
| Most Recent Simulator Evaluation <sup>14</sup>              | August 8, 2019    |
| Most Recent Systems Validation Oral Event                   | August 8, 2019    |
| Most Recent LOE <sup>15</sup>                               | October 26, 2018  |
| Most Recent Line Check                                      | February 21, 2018 |
| Most Recent Upset Recovery Training                         | October 26, 2018  |
| Most recent Weather Radar Basics course <sup>16</sup>       | May 1, 2018       |

### 2.1.2 Captain’s Flight Times

The Captain’s estimated flight times were based on Delta Air Lines’ provided documentation, and only included the flight time the pilot had accrued while being employed at Delta Air Lines:

|                             |          |
|-----------------------------|----------|
| Total pilot flight time     | 2,748:32 |
| Total MD-88 flight time     | 1,949:02 |
| Total MD-88 PIC flight time | 850:53   |

---

<sup>9</sup> Bombardier Inc. CL-600-2B19, BL-600-2C10, CL-600-2D24, CL-600-2D15. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.

<sup>10</sup> The Boeing Company 757-200 Series, 757-200PG Series, 757-200 CB Series, 757-300 Series, 767-200 Series, 767-300 Series, 767-300F Series, 767-400ER Series, 767-2C Series. Source FAA Order 8900.1, Figure 5-88, dated July 15, 2019.

<sup>11</sup> The Boeing Company DC-9-11, DC-12, DC-9-13, DC-9-14, DC-9-15, DC-9-15F, DC-9-21, DC-9-31, DC-9-32, DC-9-32F, DC-9-33F, DC-9-34, DC-9-34F, DC-9-41, DC-9-51, DC-9-81, DC-9-82, DC-9-83, DC-9-87, MD-88, MD-90-30, 717-200. Source FAA Order 8900.1, Figure 5-88, dated July 15, 2019.

<sup>12</sup> Q319 – Source: Operational Factors Attachment 2 - Flight Crew Training Records (Excerpts)

<sup>13</sup> Upgrade training concluded with a Line Operations Evaluation (LOE) event.

<sup>14</sup> Maneuvers Validation event. Source: Operational Factors – Attachment 2 – Flight Crew Training Records (Excerpts)

<sup>15</sup> Line Operations Evaluation event

<sup>16</sup> This training was part of the Q218 Distant Learning which was within the Summer Operations and Weather Radar Basics lessons portion of the training. It also included Turbulence related information.

|                                                    |        |
|----------------------------------------------------|--------|
| Total flight time preceding 24 hours <sup>17</sup> | 4:37   |
| Total flight time preceding 7 days                 | 9:45   |
| Total flight time preceding 30 days                | 62:00  |
| Total flight time preceding 90 days                | 160:17 |
| Total flight time preceding 12 months              | 631:58 |

## 2.2 First Officer

The First Officer (FO) was 41 years old; held an ATP certificate with type ratings on the CL-65 and DC-9, limitations included “ATP CIRC. APCH. - VMC ONLY; CL-65 DC-9 CIRC. APRCH. – VMC ONLY.” He held an FAA first-class medical certificate dated April 9, 2019, with no limitations.

### 2.2.1 First Officer’s Training and Proficiency Checks

A synopsis of the FO’s recent training at Delta Air Lines is as follows<sup>18</sup>:

|                                                             |                  |
|-------------------------------------------------------------|------------------|
| Date of Hire at Delta Air Lines                             | March 19, 2018   |
| Date of Initial New Hire Training at Delta <sup>19</sup>    | April 1, 2018    |
| Initial Aircraft Systems Training                           | April 14, 2018   |
| Most Recent LOE <sup>20</sup>                               | January 26, 2019 |
| Most Recent MV <sup>21</sup>                                | May 16, 2018     |
| Most Recent Upset Recovery Training                         | January 26, 2019 |
| Most Recent Continuous Qualification Training <sup>22</sup> | August 4, 2019   |

### 2.2.2 First Officer’s Flight Times

The First Officer’s estimated flight times were based on Delta Air Lines provided documentation and only included the flight time the he had accrued while being employed at Delta Air Lines:

|                                                    |              |
|----------------------------------------------------|--------------|
| Total pilot flight time                            | 819:19 hours |
| Total MD-88 flight time                            | 819.19 hours |
| Total flight time preceding 24 hours <sup>23</sup> | 4:37 hours   |
| Total flight time preceding 7 days                 | 15:13 hours  |
| Total flight time preceding 30 days                | 54:38 hours  |

<sup>17</sup> Flight time does **not** include the accident flight and only includes a flight on May 24, 2019 that the captain operated from Atlanta Georgia to MDW.

<sup>18</sup> Source: Attachment 2 – Flight Crew Training Records [Excerpt].

<sup>19</sup> The first officer’s initial airplane assignment at Delta Air Lines was the MD88.

<sup>20</sup> Line Operations Evaluation – Also the First Officer’s most recent simulator evaluation.

<sup>21</sup> Maneuvers Validation was associated with the initial maneuvers validation event.

<sup>22</sup> Q319 – Source: Operational Factors – Attachment 2 – Flight Crew Training Records [Excerpts]

<sup>23</sup> Flight time did **not** include the accident flight.

|                                       |               |
|---------------------------------------|---------------|
| Total flight time preceding 90 days   | 187.:49 hours |
| Total flight time preceding 12 months | 657:21 hours  |

### 3.0 Airplane Information



**Photo 1: Accident Airplane, N911DL (Courtesy of JetPhotos.net)**

The accident airplane (Registration N911DL, Serial No. 49542, Ship No. 0911) was a Boeing MD-88<sup>24</sup>. The airplane was manufactured in 1987, registered to and operated by Delta Air Lines, and held a transport category airworthiness certificate dated September 25, 2000. The airplane was powered by 2 Pratt and Whitney JT8D-219 engines, each were rated at 21,000 pounds of thrust. The airplane was configured with 2 pilot seats, 1 cockpit observer seat, 5 flight attendant seats, and 149 passenger seats.

According to the accident flight's dispatch release<sup>25</sup> there were two maintenance deferrals; both of which dealt with in-cabin items. Neither of the deferrals affected the performance of the weather radar or any other function associated with this accident.

### 3.1 Weight and Balance

The following weight and balance information was taken from the dispatch flight release and weight data record. Limitations are indicated in **bold** type. All weights below are in pounds (lbs.).

|                             |        |
|-----------------------------|--------|
| Basic Operating Weight      | 85,010 |
| Total Payload               | 30,155 |
| Passengers <sup>26</sup>    | 27,714 |
| Baggage/Cargo <sup>27</sup> | 2,441  |

<sup>24</sup> Originally had a model designation of "Douglas DC-9"; however, Boeing acquired McDonnell Douglas (the original aircraft manufacturer) in 1996 and merged McDonnell Douglas with Boeing in August 1997.

<sup>25</sup> See Attachment 3 – Accident Flight's Flight Release for a list of the 2 deferred items.

<sup>26</sup> Total passenger was 147 which included 7 kids. Source Attachment 5 - Accident Flight's ACARS Communication.

<sup>27</sup> The cargo/baggage was stored in 3 of the 6 bins as follows: 510 lbs. in bin 2, 761 lbs. in bin 5 and 1,170 lbs. in bin 6.

|                                      |                       |
|--------------------------------------|-----------------------|
| Zero Fuel Weight                     | 115,165 <sup>28</sup> |
| <b>Maximum Zero Fuel Weight</b>      | <b>122,000</b>        |
| Planned Block Fuel <sup>29</sup>     | 29,900                |
| Actual Fuel Weight <sup>30</sup>     | 30,150                |
| Taxi Fuel                            | 672                   |
| Ramp Weight                          | 145,315               |
| <b>Maximum Taxi Weight</b>           | <b>150,500</b>        |
| Takeoff Weight                       | 144,643               |
| <b>Maximum Takeoff Weight</b>        | <b>149,500</b>        |
| Planned Enroute Fuel Burn            | 11,137                |
| Planned Landing Weight <sup>31</sup> | 132,785               |
| <b>Maximum Landing Weight</b>        | <b>139,500</b>        |
| Takeoff Center of Gravity            | 10.3                  |

#### 4.0 Accident Flight Release and Weather Packet

##### 4.1 Flight Release

Delta Air Lines Flight Release for the accident flight was listed as “RLS 1”. The release contained information for the accident flight such as, fuel required, route of flight, departure, destination, and alternate airports, MELs, departure and planned arrival weights, weather which consisted of departure, enroute, destination, and alternate weather, and a “Dispatcher Remarks” section, which contained the following information:

*01- None*

The flight plan fuel section of the release showed that the dispatcher had added an additional 7,373 lbs. of fuel, which equated to 70 additional minutes of fuel at 15,000 ft in the clean configuration.

##### 4.1.1 Route of Flight

According to a Delta Air Lines Flight Release for the accident flight showed the route of flight was:

*KATL VARNM2 GLAZR Q118 MZZ VEECK4 KORD*

According to a Delta Air Lines representative the filed route of flight was a National Route Program (NRP) route, which was a user preferred route allowing the airline to take the most economical route.

---

<sup>28</sup> Delta Air Lines added 1,000 lbs. to the weight as a “subtraction tolerance” but could be reduced if needed by the flight crew. The 1,000 lb. tolerance was not associated with any ballast or cargo on board; however, for this calculation only weights associated with an item was used. Therefore the totals in this document will be 1,000 lbs. **less than** what the flight crew would have used.

<sup>29</sup> Minimum fuel for takeoff was listed as 27,122 lbs. Source: Attachment 3 – Accident Flight’s Dispatch Release.

<sup>30</sup> Source: Attachment 4 – “Accident Flight’s Weight Data Record” which recorded 9,100 lbs. left tank, 11,800 lbs. center tank, 9,250 lbs. right tank.

<sup>31</sup> Planned landing weight was a dispatch estimated weight based on an estimated takeoff weight.

#### 4.1.2 Turbulence Related ACARS Messages

According to Delta Air Lines ACARS Turbulence Plot (TP) messages received by the accident flight, the following were messages related to turbulence reports or forecasts along the route of flight and the time it was transmitted to the flightdeck:

***August 26, 2019 0020Z [1920 CDT]***

- 41 TP CN36 262338Z  
1.IL IN  
2.\* ADVISORY \*  
VOR:STL BDF PMM ENL  
HAZ:TURBC-OTHER  
SOURCE:PIREPS  
AREA:39N090W 41N090W  
42N086W 39N089W  
TIME:POSN AT 26/2338Z  
ALTS:FL280-410 LGT/MOD  
INFO:SPOTTY RPTS  
3.VALID 262338Z/270200Z  
4.CANCEL NONE  
ALONG ROUTE  
ENTER 27/0102Z VEECK292010  
EXIT 27/0109Z CLUSO  
;  
08270020/08270020 P99999 999

***August 26, 2019 0020Z [1920 CDT]***

- 41 TP CN38 262348Z  
1.IN OH KY TN AR MS  
2.\* ADVISORY \*  
VOR:ROD IIU SQS  
HAZ:TURBC-TROF LINE  
SOURCE:PIREPS  
LINE:40N084W 38N086W  
34N091W  
WIDTH:150NM  
TIME:POSN AT 26/2346Z  
ALTS:FL310-390 LGT/MOD  
MVG FROM:27025 NORTH  
27008 SOUTH  
INFO:A RPT OF MOD/SVR  
FL350 IN CLOUDS  
WEST OF HTS AT  
2232Z  
3.VALID 262348Z/270300Z

4.CANCEL CN31  
ALONG ROUTE  
ENTER 27/0025Z JEDER181005  
EXIT 27/0052Z MZZ154004  
;  
08270020/08270020 P99999 999

The following ACARS message was transmitted by the flight crew, reporting they encountered moderate turbulence and a flight attendant had been injured:

***August 27, 2019 (0124Z) [August 26, 2019 (2024 CDT)]***

A  
FA MAY BE INJURED IN CA  
BIN FROM TURB AT HULLS.  
HES ASKING FOR MED ASI  
ST PLZ CALL OPS TO ARRA  
NGE TOO CLOSE ON FINALZ  
NOW  
;  
08270124/08270124 P99999 999

#### **4.1.3 Weather Briefing**

The following weather information was included on the flight release for the accident flight, prior to departure from ATL:

DESTINATION WEATHER  
ORD 261900 METAR 261851Z  
HD 0805 26AUG2102 MBM ATL  
17016G24KT 10SM -RA BKN013 OVC018  
23/21 A2972 RMK AO2 RAB03E17B46 SLP061 P0000  
T02330206  
ORD 262000 METAR 261951Z 15008KT 8SM -RA BKN013 BKN022 OVC080  
23/21 A2969 RMK AO2 RAE01B41 SLP049 P0001 T02330211  
ORD 262100 METAR 262051Z 21008KT 9SM -RA FEW007 SCT018 BKN033  
BKN250 23/22 A2967 RMK  
HD 0805 26AUG2102 MBM ATL  
AO2 SLP042 P0053 60054  
T02330217 58025

DESTINATION FORECAST  
TERMINAL FORECAST  
ORD NWS 261954 AMD KORD 261951Z 2620/2724 17012G18KT P6SM  
-SHRA BKN012  
OVC025 TEMPO 2620/2622 2SM SHRA SCT012 BKN025 OVC040

*FM262200 21012G18KT*

#### **4.1.4 Delta Air Lines Turbulence Plots (TPs)**

The following “TPS – “Enroute and United States Regional Outlooks” were included on the flight release:

*SE01 262100-270300  
TP SE01 260439Z  
1.GA FL  
2.\* ALERT \*  
VOR:AMG ZFP DHP MCN  
HAZ:TSTMS  
SOURCE:FORECAST  
AREA:32N083W 27N079W  
26N081W 32N084W  
CVRG:SCT  
TOPS:FL450  
TREND:NC  
MVG FROM:CELLS  
3.VALID 262100Z/270300Z  
4.CANCEL SE78*

*CN31 26210  
HD 0805 26AUG2107 MBM ATL  
4-270000  
TP CN31 262104Z  
1.IN IL KY TN AR MS  
2.\* ADVISORY \*  
VOR:BVT PXV SQS  
HAZ:TURBC-TROF LINE  
SOURCE:PIREPS  
LINE:40N087W 37N088W  
34N091W  
WIDTH:150NM  
TIME:POSN AT 26/2103Z  
ALTS:FL310-390 LGT/MOD  
MVG FROM:27025  
3.VALID 262104Z/270000Z  
4.CANCEL CN15*

*SE10 261951-262351  
TP SE10 261951Z  
1.AL FL EGM  
2.\* ALERT \*  
VOR:LGC MGM SJI CIGAR  
HAZ:TSTMS*

SOURCE: RADAR  
AREA:32N085W 32N087W  
29N088W 29N086W  
CVRG:4/10 LVL 3 MAX 5  
TOPS:30N086W FL470  
TREND:NC  
MVG FROM:CELLS 22020  
3.VALID 261951Z/262351Z  
4.CANCEL SE07

TP CN36 262338Z  
1.IL IN  
2.\* ADVISORY \*  
VOR:STL BDF PMM ENL  
HAZ:TURBC-OTHER  
SOURCE:PIREPS  
AREA:39N090W 41N090W  
42N086W 39N089W  
TIME:POSN AT 26/2338Z  
ALTS:FL280-410 LGT/MOD  
INFO:SPOTTY RPTS  
3.VALID 262338Z/270200Z  
4.CANCEL NONE  
ALONG ROUTE  
ENTER 27/0102Z VEECK292010  
EXIT 27/0109Z CLUSO

In addition it included the following alerts and TPS-Station information:

ALERTS NOT AVAILABLE FOR FIX VARNM  
ALERTS NOT AVAILABLE FOR FIX PINKK  
ATL NO REPORT  
ORD NO REPORT  
DSM NO REPORT  
FNT NO REPORT

The following TPs were available after the airplane departed and were sent to the flight from Delta Air Lines dispatch:

TP CN38 262348Z  
1.IN OH KY TN AR MS  
2.\* ADVISORY \*  
VOR:ROD IIU SQS  
HAZ:TURBC-TROF LINE  
SOURCE:PIREPS  
LINE:40N084W 38N086W

34N091W  
WIDTH:150NM  
TIME:POSN AT 26/2346Z  
ALTS:FL310-390 LGT/MOD  
MVG FROM:27025 NORTH  
27008 SOUTH  
INFO:A RPT OF MOD/SVR  
FL350 IN CLOUDS  
WEST OF HTS AT  
2232Z  
3.VALID 262348Z/270300Z  
4.CANCEL CN31  
ALONG ROUTE  
ENTER 27/0025Z JEDER181005  
EXIT 27/0052Z MZZ154004

CN41 270053-270400  
TP CN41 270053Z  
1.IL IN OH  
2.\* ADVISORY \*  
VOR:BDF CRL ROD PXV  
HAZ:TURBC-OTHER  
SOURCE:PIREPS  
AREA:41N089W 42N084W  
41N084W 39N088W  
TIME:POSN AT 27/0053Z  
ALTS:FL320-410 LGT/MOD  
INFO:SPOTTY RPTS  
3.VALID 270053Z/270400Z  
4.CANCEL CN36

CN21 270300-270900  
TP CN21 261807Z  
1.IL MO  
2.\* ALERT \*  
VOR:DBQ BVT ENL IOW  
HAZ:TSTMS  
SOURCE:FORECAST  
AREA:42N091W 40N088W  
39N089W 41N092W  
CVRG:SCT  
TOPS:FL450  
TREND:NC  
MVG FROM:CELLS  
3.VALID 270300Z/270900Z  
4.CANCEL CN75

## 4.2 PIREPs<sup>32</sup>

### 4.2.1 Delta PIREPs

The following Delta specific PIREPs were provided to the accident flight on the flight release:

*DAL2809/26 SHIP 0978 POS GLAZR OVR 1818 NXT ETA ENS ALT 320 FOB  
0208 SAT 32 WND 234036 MCH TRB SMOOTH SKY ICE RMK*

*DAL1612/26 SHIP 9502 POSN36255W084468, GLAZR, 193420, 291, JEDER, 19  
4055, HELUB, M26, 22840, 158, 773 TS193420, 260819AFD8*

*DAL1958/26 SHIP 9508 POSN37197W084452, JEDER, 204054, 320, HELUB, 20  
4345, VOSTK, M35, 22141, 146, 772 TS204054, 260819226D*

*DAL1958/26 SHIP 9508 POSN39213W085078, HEVAN, 205757, 285, MZZ, 2107  
01, NYLEN, M27, 21343, 132, 671 TS205757, 260819D7EF*

*DAL1612/26 SHIP 9502 POSN40297W085408, MZZ, 200510, 259, NYLEN, 2008  
08, VEECK, M22, 20423, 132, 743 TS200510, 2608195A14*

*DAL1612/26 SHIP 9502 POSN41304W087215, HANNI, 201923, 110, CLUSO, 20  
2105, KAYTO, P7, 21232, 122, TS201923, 26081905AC  
REPORT INCOMPLETE*

No Delta PIREP reports involving turbulence, provided to the accident flight crew on the flight release, were in the vicinity of the accident flight's turbulence encounter.

### 4.2.2 Archived PIREPs<sup>33</sup>

A review of archived PIREPs, throughout the national airspace, showed that of the 203 PIREPs provided in the approximate 2 hours prior and 1 hour after the accident flight's encounter with turbulence, there were 6 PIREPs within approximately 70 miles of the accident location of those, 1 was reported as over or in the vicinity of the HULLS intersection. The 6 PIREPs were filed as follows:

*201908262314.00 A319 IGQ UA /OV CGT090025/TM 2314/FL180/TP A319/SK  
TOP 180 41.51 -87.08644846*

*201908270007.00 A320 SBN UA /OV 15 S SBN/TM 0007/FL090/TP A320/SK  
OVC/RM BASES 017 TOPS 035 NUMEROUS LAYERS ABOVE 035 41.48995834 -  
86.31639*

*201908270014.00 SR22 LAF UA /OV BVT360020/TM 0014/FL080/TP SR22/TB  
CONS LGT OCNL MOD 40.84968221 -87.07*

---

<sup>32</sup> Pilot Reports

<sup>33</sup> Source: Iowa State University, Iowa Environmental Mesonet  
<https://mesonet.agron.iastate.edu/request/gis/pireps.php>

201908270033.00 CRJ2 SBN UA /OV GIJ270025/TM 0033/FL150/TP CRJ2/TB  
MOD 41.77 -86.8055064

201908270042.00 B737 SBN UA /OV GIJ270020/TM 0042/FL200/TP B737/TA  
M08/IC MOD RIME 41.77 -86.70840512

201908270102.00 B787 LAF UA /OV BVT/TM 0102/FL410/TP B787/TB CONS  
MOD CHOP 40.56 -87.07

The PIREP reports in plain language taken from standard code and abbreviations, with altitudes in feet above mean sea level (MSL):

2019 August 26 at 2314Z (1814 CDT); Aircraft – A319; Lansing VOR<sup>34</sup> (IGQ) Lansing, Illinois routine pilot report (UA); Location – over a point 25 miles east of Chicago Heights VOR; Time – 2314Z; Altitude FL180; Aircraft – A319; Sky – Tops at FL180. 41.51°N/087.08644846°W.

2019 August 27 at 0007Z (August 26 at 1907 CDT); Aircraft – A320; South Bend VOR (SBN) South Bend, Indiana routine pilot report (UA); Location – over a point 15 miles south of SBN; Time –0007Z; Altitude – 9,000 ft; Aircraft – A320; Sky – Overcast; Remarks – cloud bases 1,700 ft, cloud tops 3,500 ft, numerous layers above 3,500 ft. 41.48995834°N/086.31639°W.

2019 August 27 at 0014Z (August 26 at 1914 CDT); Aircraft – SR22; Purdue University Airport (LAF), Lafayette, Indiana routine pilot report (UA); Location – over a point 20 miles north of Boiler VORTAC<sup>35</sup>, Lafayette, Indiana; Time –0014Z; Altitude – 8,000 ft; Aircraft –SR22; Turbulence – Continuous light occasional moderate. 40.84968221°N/087.07°W.

2019 August 27 at 0033Z (August 26 at 1933 CDT); Aircraft – CRJ2; South Bend VOR (SBN) South Bend, Indiana routine pilot report (UA); Location – over a point 25 miles west of Gipper VORTAC (GIJ), Niles, Michigan; Time –0033Z; Altitude – 15,000 ft; Aircraft –CRJ2; Turbulence - Moderate. 41.77°N/086.8055064°W.

2019 August 27 at 0042Z (August 26 at 1942 CDT); Aircraft – B-737; South Bend VOR (SBN) South Bend, Indiana routine pilot report (UA); Location – over a point 20 miles to the west of Gipper VORTAC (GIJ), Niles, Michigan; Time –0042Z; Altitude – FL200; Aircraft – B-737; Temperature minus 8°C; Icing – Moderate Rime Ice. 41.77°N/086.70840512°W.

2019 August 27 at 0102 (August 26 at 2002 CDT); Aircraft – B787; Purdue University Airport (LAF), Lafayette, Indiana routine pilot report (UA); Location – over the Boiler (BVT) VORTAC; Time –0102Z; Altitude – FL410; Aircraft – B-787; turbulence – Constant Moderate Chop. 40.56°N/087.07°W

---

<sup>34</sup> Very-high Omni-directional Range

<sup>35</sup> Very-high Omni-directional Range with Tactical Air Navigation system

## **5.0 Delta Air Lines Guidance**

### **5.1 Delta Air Lines - Flight Operations Manual**

#### **5.1.1 Cabin Notification – Turbulence**

##### **5.1.1.1 Customers**

The Delta Air Lines, Flight Operations Manual, Section 5 “Briefings & Cabin Crew Communications”, dated April 1, 2018, contained the following guidance for crews to brief the passengers:

*When anticipating turbulence:*

- *Illuminate the seat belt sign*
- *Make a PA (see turbulence action chart)*
- *When making a PA, use “rough air.” When speaking to flight attendants via interphone, use proper terminology (e.g., “light turbulence”).*
- *If applicable, the Language of Destination (LOD) flight attendant will make the seat belt PAs in the appropriate languages immediately following the flight deck PA*
- *Notify customers of any attempts to get out of turbulence, such as altitude changes.*

##### **5.1.1.2 Flight Attendants**

The Delta Air Lines, Flight Operations Manual, Section 5 “Briefings & Cabin Crew Communications”, dated April 1, 2018, contained the following guidance for crews to brief the flight attendants:

*Cabin conditions (turbulence level) can be markedly different from what the flight deck is experiencing. Communicate with the flight leader to help assess actual cabin conditions. If flight attendants feel it is unsafe to continue service, support their decision to be seated and make the customer service PA.*

##### ***Light Turbulence***

*For light turbulence, communicate to the flight leader/purser via interphone first and follow up with a PA as necessary (see sample PA in turbulence action chart). Communicate the following via the interphone:*

- *Estimated time remaining until turbulence is encountered and*
- *Estimated duration, if known*
- *Use proper phraseology when communicating via the interphone (e.g., “light turbulence” not “rough air”)*

##### ***Moderate Turbulence***

*For moderate turbulence, communicate to the cabin crew via PA first (see sample PA in turbulence action chart), and then follow up via interphone with the flight*

leader/purser. Use proper phraseology (e.g., “moderate turbulence” not “rough air”) on the interphone.

**Note:** On the A330 during Class 1 Crew Rest, direct the flight leader/purser to make the moderate turbulence PA. This is to prevent crew rest disruption due to the inability to de-select the crew rest facility from the flight deck PA system.

### **Severe or Greater Turbulence**

Severe or greater turbulence should be avoided if at all possible. If severe turbulence cannot be avoided, communicate to the cabin crew via PA first (see sample PA in turbulence action chart), and then follow up via interphone with the flight leader/purser. Use proper phraseology (e.g., “severe turbulence” not “rough air”) on the interphone.

### **Descent**

If moderate or greater turbulence is expected on descent to destination, notify flight attendants of the type of turbulence to expect and ask them to do their final cabin check as early as possible (e.g., We expect moderate turbulence on the descent, please do your final cabin check and be seated as early as possible.) Include the request for flight attendants being seated earlier in the descent in the top of descent PA. Refer to Customer PAs, Descent.

## **5.1.2 Turbulence Action Charts**

The Delta Air Lines, Flight Operations Manual, Section 5 “Briefings & Cabin Crew Communications”, dated April 1, 2018, was similar guidance that was provided to cabin attendants (see Section 5.5 for cabin crew guidance) contained the following guidance for the flight crew describing aircraft indications, cabin conditions and crew actions:

| <b>Light Turbulence</b>  |                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Aircraft Reaction        | Slight, erratic changes in altitude and/or attitude.                                                                                                                                                                                                                                                                                                                 |
| Cabin Conditions         | <ul style="list-style-type: none"> <li>• Liquids are shaking but not splashing out of cups.</li> <li>• Carts can be maneuvered with little difficulty.</li> <li>• Passengers may feel light strain against seat belts.</li> </ul>                                                                                                                                    |
| Pilot Actions            | <ul style="list-style-type: none"> <li>• Ensure seat belt sign ON.</li> <li>• Via interphone advise flight leader/purser of LIGHT turbulence.</li> <li>• Ensure PA is made reinforcing need for passengers to be seated.</li> <li>• Sample PA - <i>Ladies and gentlemen, due to the rough air please return to your seats and fasten your seat belts.</i></li> </ul> |
| Flight Attendant Actions | <ul style="list-style-type: none"> <li>• Continue service with caution.</li> <li>• Use caution serving hot food/beverages.</li> <li>• Visually check passenger seat belts.</li> </ul>                                                                                                                                                                                |

| Moderate Turbulence      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Aircraft Reaction        | Changes in altitude and/or attitude occur but with more intensity than light turbulence. Aircraft remains in control at all times.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Cabin Conditions         | <ul style="list-style-type: none"> <li>Liquids are splashing out of cups.</li> <li>Difficult to walk or stand without balancing or holding onto something.</li> <li>Carts are difficult to maneuver.</li> <li>Passengers feel definite strain against seat belt.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Pilot Actions            | <ul style="list-style-type: none"> <li>Ensure seat belt sign is ON.</li> <li>Immediately make PA directing FAs and passengers to be seated and service to be discontinued.</li> </ul> <p><b>Note:</b> On the A330 during Class 1 Crew Rest, direct the flight leader/purser to make the moderate turbulence PA. This is to prevent crew rest disruption due to the inability to de-select the crew rest facility from the flight deck PA system.</p> <ul style="list-style-type: none"> <li>Sample PA - <i>Ladies and gentlemen, due to the rough air (that we expect in the next XX minutes), we need you to be seated and check the security of your seat belts. We are also requiring all flight attendants to discontinue their service and be seated until it is safe to continue. This is for their safety as well as yours.</i></li> <li>Via interphone advise flight leader/purser of MODERATE turbulence and expected duration.</li> <li>Advise FAs when it is safe to resume their duties.</li> </ul> |
| Flight Attendant Actions | <p><b>WARNING: Do not wait for guidance from flight deck crew if experiencing moderate turbulence.</b></p> <ul style="list-style-type: none"> <li>Discontinue service and stow all carts.</li> <li>Stow galley equipment, time and conditions permitting.</li> <li>FAs secure themselves in jumpseats as soon as possible using seat belt and shoulder harness and contact the flight deck to relay status of carts and flight attendants.</li> <li>Visually check passenger seat belts en route to jumpseat.</li> <li>Flight leader/purser continues communication with flight deck on conditions in the cabin.</li> <li>Flight leader/purser calls all FA stations to ensure all passengers/crew are seated.</li> </ul>                                                                                                                                                                                                                                                                                       |

| Severe Turbulence        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Aircraft Reaction        | Large, abrupt changes in altitude and/or attitude. Usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Cabin Conditions         | <ul style="list-style-type: none"> <li>• Items are falling over. Unsecured items are tossed about.</li> <li>• Walking is impossible.</li> <li>• Passengers are forced violently against seat belts.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Pilot Actions            | <ul style="list-style-type: none"> <li>• Ensure seat belt sign is ON.</li> <li>• Immediately make PA directing FAs and passengers to be seated and service to be discontinued.</li> <li>• Sample PA - <i>Ladies and gentlemen, due to the rough air we need you to be seated and check the security of your seat belts. We are also requiring all flight attendants to immediately discontinue their service and be seated until it is safe to continue. This is for their safety as well as yours.</i></li> <li>• Via interphone advise flight leader/purser of SEVERE turbulence and expected duration.</li> <li>• Advise FAs when it is safe to resume duties.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Flight Attendant Actions | <p><b>WARNING: Do not wait for guidance from flight deck crew if experiencing severe turbulence.</b></p> <ul style="list-style-type: none"> <li>• Discontinue service immediately and leave carts with brakes engaged until turbulence is reduced.</li> <li>• If possible, place hot liquids on floor.</li> <li>• FAs secure themselves in nearest available seats. <ul style="list-style-type: none"> <li>• If in jumpseat, use seat belt and shoulder harness.</li> <li>• If a seat is not readily available, you may need to sit on the floor and grab on to the leg of a passenger seat or sit on a passenger's lap and ask for passenger assistance.</li> </ul> </li> </ul> <p>When safe to do so:</p> <ul style="list-style-type: none"> <li>• Flight leader/purser calls all FA stations to ensure all passengers/crew are seated and contacts the flight deck to relay status of carts and flight attendants.</li> <li>• Flight leader/purser continues communication with flight deck on conditions in the cabin.</li> <li>• Check for damage and injuries; notify flight deck crew of crew/passenger injuries and cabin conditions.</li> <li>• Stow all carts and galley equipment.</li> </ul> |

**Figure 1: Delta Air Lines Turbulence Action Charts**

### 5.1.3 Turbulence Plot (TP)

The Delta Air Lines Flight Operations Manual, Chapter 14, “Dispatch & Weather Planning,” dated October 1, 2018, provided the following guidance regarding Turbulence Plot (TP):

*Avoidance measures for both planned and enroute turbulence are based primarily on Turbulence Plot (TP) messages and upper air depiction charts issued by Delta Meteorology.*

*These products are based on forecasts and actual pilot reports from comparable aircraft types.*

*TPs are issued specifically for Delta operations. The nature of the turbulence, the availability of new data, and the degree of change expected over a given period of time dictate how often they are issued.*

*TP messages prevail over other sources, such as SIGMETs, Flight Weather Viewer (FWV), actual turbulence data, and other forecast products. TPs may also include volcanic ash information.*

*Refer to Airway Manual, Weather, Weather Depiction Charts for expanded TP guidance.*

#### **5.1.4 Required PAs**

The Delta Air Lines Flight Operations Manual, Chapter 11, “Customers,” Section 2 “Customer PAs” dated March 1, 2017, required the following:

*PAs made on every flight:*

- *Before Takeoff (required, AOM Vol. 1, Normal Procedures)*
- *Initial seat belt sign off (required, AOM Vol. 1, Normal Procedures)*
- *Descent: seat belt sign on, flight attendant prepare for arrival (required, AOM, Vol. 1, Normal Procedures).*
- *Turbulence, when encountered or anticipated*
- *After a Go-Around or Rejected Landing.*

## **5.2 Airway Manual**

### **5.2.1 Airway Manual – Expanded TP Guidance**

The Delta Air Lines “Airway Manual”; Chapter 6 “Weather,” section “Hazardous Weather” Avoidance, stated in part:

*Delta Meteorology produces a combination of textual and graphical weather products.*

*The Turbulence Plot System, or TP System, is the primary method for weather hazard avoidance. The system includes four components:*

- *Communication capabilities (both manual and automated/text and graphics)*
- *Avoidance policies & procedures (implemented jointly by pilots & dispatchers)*
- *TPs generated by Delta Meteorology*
- *System familiarization by pilots as well as meteorology producers and other users.*

*TP messages are issued for weather conditions and reports that are potentially hazardous to aviation. These hazards include:*

- *Clear air turbulence*
- *Mountain wave activity*
- *Thunderstorm activity*
- *Tropical systems*

- Windshear
- Volcanic ash
- Icing
- Significant ozone
- Space weather
- Any other weather conditions which warrant alerting flight crews TP messages and graphical weather depictions are used by dispatchers to develop a flight plan and by flight crews for preflight weather hazard awareness. Additionally, they support a pilot's enroute weather hazard monitoring...

### **TP Messages**

*Delta Meteorology issues TP messages for all possible weather related hazards. There are three types of TP messages.*

- **ADVISORY:** Indicates that a hazard exists (or has the potential to develop) that is below a specified criteria for that hazard. Avoidance is not required either during pre-flight by Flight Control or enroute by crews.
- **ALERT:** Indicates that a hazard exists (or has the potential to develop) that has reached a specified criteria and avoidance or action is recommended.
- **AVOID:** Indicates that a hazard exists (or has the potential to develop) that has reached or exceeded a specified criteria and avoidance or action is required.

*Audible ACARS "chimes" are only enabled for "Avoid TPs;" and are inhibited for all others.*

### **Auto-TP Uplinks**

*TP messages are automatically uplinked via ACARS during certain phases of flight. Only TPs that directly intersect the aircraft's flight path are uplinked.*

#### **Pre-Flight**

*Auto-TP uplinks are inhibited on the ground and become active at Off + 15.*

*All applicable TPs will be delivered to the crew and are included in the Flight Plan Weather Briefing. Any new TPs are issued as part of the Updated Weather Briefing.*

#### **Enroute**

*Only TPs that directly intersect the aircraft's flight path are uplinked. TPs are sent 60 minutes prior to entry into the TP area. If a TP is issued after the Updated Weather Briefing and the aircraft is within 60 minutes of entry, the uplink will occur at Top of Climb (TOC). All TP uplinks are based upon the flight plan route ( $\pm 0$  NM) and do not incorporate route changes, direct routing, or deviations unless the dispatcher updates the route in the flight planning system. Off course deviations require reference to the FWV to determine if any TPs are present along the intended route. If unable to reference the FWV, pilots should contact their dispatcher.*

*Auto-TP uplinks are inhibited 20 minutes prior to the estimated On time.*

## 5.2.2 Airway Manual – Turbulence Reporting Criteria

The Delta Air Lines “Airway Manual”; Chapter 6 “Weather - Hazardous Weather” provided the following chart for turbulence reporting criteria:

| INTENSITY       | AIRCRAFT REACTION                                                                                                                                                                                                                                                                                                                                       | REACTION INSIDE AIRCRAFT                                                                                                                                                                                    |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Light</b>    | <b>LIGHT TURBULENCE:</b><br>Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude.<br><br><b>LIGHT CHOP:</b><br>Turbulence that causes slight, rapid and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude.                                                                              | Occupants may feel a slight strain against seat belts or shoulder straps. Unsecured objects may be displaced slightly. Food service may be conducted and little or no difficulty is encountered in walking. |
| <b>Moderate</b> | <b>MODERATE TURBULENCE:</b><br>Turbulence that causes changes in altitude and/or attitude, but with the aircraft remaining in positive control at all times. Usually causes variations in indicated airspeed.<br><br><b>MODERATE CHOP:</b><br>Turbulence that causes rapid bumps or jolts without appreciable changes in aircraft altitude or attitude. | Occupants feel definite strains against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.                                                             |
| <b>Severe</b>   | <b>SEVERE TURBULENCE:</b><br>Turbulence that causes 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 seat belts or shoulder straps. Unsecured objects are tossed about. Food service and walking are impossible.                                                          |
| <b>Extreme</b>  | <b>EXTREME TURBULENCE:</b><br>Turbulence in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage.                                                                                                                                                                                      | Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food service and walking are impossible.                                                          |
|                 | <b>FREQUENCY:</b><br>1. Occasional<br>2. Intermittent<br>3. Continuous                                                                                                                                                                                                                                                                                  | <b>DEFINITION:</b><br>Less than 1/3 of the time<br>Occurring 1/3 to 2/3 of the time<br>Occurring more than 2/3 of the time                                                                                  |

**Figure 2: Turbulence Reporting Criteria (Source Delta Air Lines Airway Manual)**

**Note:** An encounter with severe or extreme turbulence requires a logbook write up and special aircraft structural inspection. Refer to FOM, Accidents, Incidents, & Irregularities, Operational Irregularities.

## 5.2.3 Airway Manual – Clear Air Turbulence

The Delta Air Lines “Airway Manual”; Chapter 6 “Weather - Hazardous Weather” provided the following guidance for the various types of Clear Air Turbulence:

*Clear air turbulence (CAT) is defined as turbulence that is not associated with convective clouds, and can exist during both the climb/descent phase and the enroute phase of flight. Clouds may be observed in the vicinity of CAT.*

## **Tropopause**

*The tropopause marks the boundary between the troposphere and stratosphere. Over the tropics the tropopause is usually found at 50,000' to 60,000' and slope to 25,000' to 30,000' near the poles. Awareness regarding the height of the tropopause is important during any clear air turbulence encounter, no matter what the cause. When turbulence associated with tropopause does occur, it can be the result of a variety of factors, including:*

- *Rapid jet stream movement*
- *Sharp ridge lines*
- *Atmospheric patterns, including strong vertical and/or directional shears, which produce waves along the tropopause boundary (sometimes manifested as transverse bands in high clouds on a satellite photo).*

*In most cases, the most significant turbulence will be encountered in a layer 2000' thick, extending 1000' either side of the tropopause boundary on the warm side of the jet core.*

## **Upper Front**

*The tropopause usually does not extend in an unbroken line from the tropics to the poles. Often a break or sharp dip will be found in the mid-latitudes. This break, called the upper front, is caused by an extension of a surface front into the upper troposphere. At this break, a jet stream will be found. The upper front is a boundary, sloping under the jet core, separating air masses of different characteristics. Strong vertical and horizontal windshear is present across an upper front. Moderate or greater turbulence can be expected across an upper front when the horizontal and/or vertical windshear exceeds certain values. Light/moderate turbulence can also occur across an upper front at altitudes surrounding the moderate or greater turbulence, and when horizontal and vertical windshear are above certain values.*

## **Front/Tropopause**

*Turbulence can occur at two different altitudes, one due to an upper front and the other due to the tropopause. The upper front turbulence is found below the jet stream at lower altitudes. The turbulence at higher altitudes is above the jet stream and associated with the tropopause.*

## **Trough**

*Not all troughs are turbulent. There are several factors which determine whether a trough will be turbulent. Any combination of the following factors can increase the risk and/or intensity of turbulence:*

- *Magnitude of the wind direction change across the trough*
- *Magnitude of the vertical directional windshear across the trough*
- *Strength of wind speeds near the trough*

- Magnitude of temperature field out of phase with wind flow
- Speed of lateral movement of trough

*The most intense turbulence will usually be encountered in a layer 1000' above to 4000' below the tropopause. However, the vertical extent of trough line turbulence can vary greatly. Generally, turbulence associated with a trough line is 200 NM wide, 100 NM either side of the line depicted in the TP message. In troughs where the wind pattern and the temperature pattern are out of phase, an area of moderate or greater turbulence may extend from the trough to 200 NM or more upstream. In these cases the extent of the turbulence area will be clearly stated in the TP message.*

### **Other Turbulence**

*When turbulent conditions cannot be attributed to one of the three above CAT causes (tropopause, upper front, trough line), a general turbulence area TP may be issued. Other causes of CAT include anti-cyclonic curvature in a ridge, strong divergence, and thermal instability. In addition, this type of TP is used to indicate turbulence associated with wave action in areas where predetermined wave areas have not been identified (i.e. Greenland). More details regarding this are contained within the Mountain Wave section.*

## **5.3 Delta Air Lines Flight Operations Manual Volume 1 MD88-90**

### **5.3.1 Turbulence**

The Delta Air Lines, Flight Operations Manual Volume 1 MD88/90, Section 5.16 “Adverse Weather” provided the following guidance:

*During flight in light to moderate turbulence, the autopilot and/or autothrottle may remain engaged unless airspeed, altitude or attitude deviations require use of manual control. Avoid making large pitch, roll, thrust or trim changes.*

*The turbulent air penetration speed provides ample protection from stall and high speed buffet, while also providing protection from exceeding the structural limit. Refer to Section 2.1 Operating Limitations for the turbulent air penetration speed. At 10,000 feet and below, minimum recommended speed is 250 KIAS or minimum maneuvering speed (whichever is greater). Do not fly less than minimum maneuvering speed for existing configuration.*

*Passenger Signs..... ON*

*Advise passengers to fasten seat belts prior to entering areas of reported or anticipated turbulence. Instruct flight attendants to check that all passengers' seat belts are fastened.*

#### **5.3.1.1 Severe Turbulence**

The Delta Air Lines, Flight Operations Manual Volume 1 MD88/90, Section 5.16.8.1 “Severe Turbulence” provided the following guidance:

Severe turbulence should be avoided if at all possible. If severe turbulence cannot be avoided, an increased buffet margin is recommended. This can be obtained by descending approximately 4,000 feet below optimum altitude. The autothrottle should be off in severe turbulence.

88

ENG IGN selector..... ON

90

Ignition Switch..... ON

- Note 1:** Refer to QRH, section 3, Severe Rain/Ice/Turbulence.
- Note 2:** If an approach must be made into an area of severe turbulence, delay flap extension as long as possible. The airplane can withstand higher gust loads in the clean configuration. Diversion to another airfield is the best policy if severe turbulence persists in the area.

### 5.3.2 Approach Checklist

The Delta Air Lines, Flight Operations Manual Volume 1 MD88/90, Section 3.4 “Normal Procedures – Amplified Procedures”, provided the following amplified guidance for the approach checklist:

| Pilot Flying               | Pilot Monitoring                   |
|----------------------------|------------------------------------|
| Call "APPROACH CHECKLIST." | Accomplish the Approach checklist. |

#### Approach Checklist

- Flight & nav instruments.....verified C&F
  - Ensure correct arrival and approach procedures are entered.
  - Ensure the proper frequency and course/radial are set as appropriate.
- Spoilers.....RET & disarmed PM
- Cabin notification.....complete C
  - Ensure that the cabin chime signal has been sounded twice.
  - If turbulence is anticipated on the arrival, consider an early cabin chime signal so that flight attendants can be seated.
- Altimeters....., xckd C&F
  - Ensure the captain, first officer, and standby altimeters are correctly set.
  - Verbalize the altimeter setting.

### 5.3.3 Turbulence Avoidance

The Delta Air Lines, Flight Operations Manual Volume 1 MD88/90, Section 5.15.5.10 “Turbulence Avoidance,” provided the following guidance:

*When using radar to avoid turbulence enroute:*

*Deviate upwind of storms when possible.*

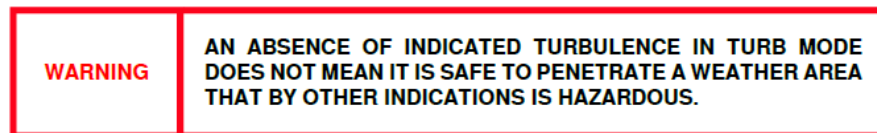
*Expect turbulence to be present in any convective activity regardless of intensity level displayed on radar.*

*When convective storms reach Level 3 (red):*

*Expect moderate to severe turbulence in all areas of the storm, including the Level 1 and 2 areas.*

**Note:** *TURB mode can be used to detect areas of horizontal rain movement within 40 nm.*

*Set tilt to ensure beam is sweeping at flight altitude.*



### 5.4 Delta Air Lines Flight Operations Manual Volume 2 MD88-90

The Delta Air Lines Flight Operations Manual Vol. 2 MD88-90, dated August 26, 2019 provided the following information about the weather radar:

#### 5.4.1 Weather Radar System

*The weather radar system displays weather and mapping targets on the ND and pedestal radar indicator. The system consists of a receiver/transmitter, antenna and radar control panel.*

*Weather and mapping targets are displayed in magenta, red, amber, and green colors. Magenta areas indicate possible turbulence. Red areas represent areas of high density precipitation or ground targets with high level reflectivity. Amber areas represent areas of lower density precipitation or ground targets with moderate level reflectivity. Green areas represent areas of light density precipitation or ground targets with low level reflectivity. Displays of the selected mode, range, and antenna tilt angle are also presented.*

*The radar antenna is normally stabilized in pitch and roll by IRS. The antenna tilt is controllable from 15 degrees up to 15 degrees down.*

## 5.4.2 ND Weather Radar Messages

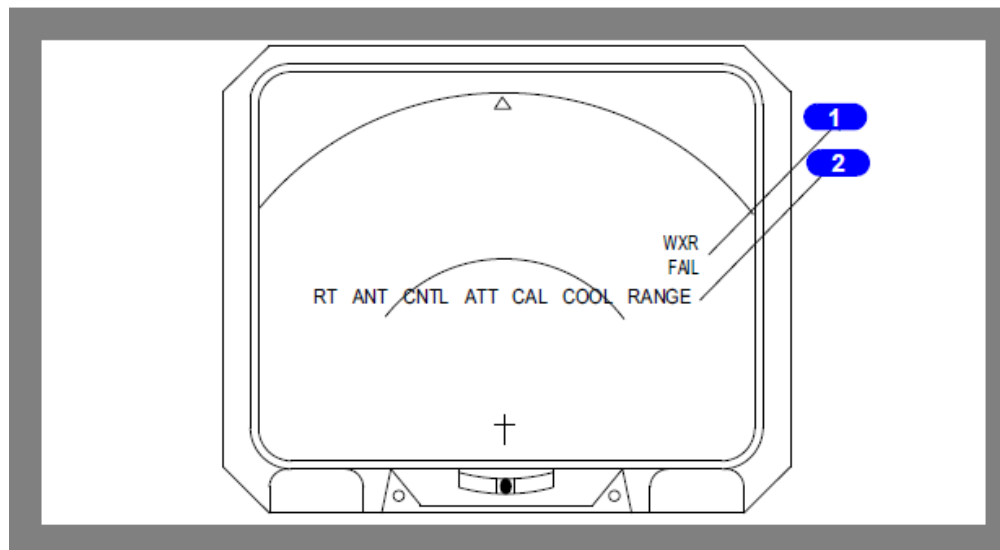


Figure 3: ND Display (Source: Delta Air Lines FOM Vol 2 MD88-90 pg. 515)

### (1) WXR Status Messages

*WXR OFF - Weather radar is off.*

*NO WX - Weather radar imagery has been removed due to overheat condition.*

*WXR FAIL - Receiver/transmitter fault, antenna fault, or control fault which results in removal of weather radar imagery.*

*WXR RANGE - Computed range is not equal to selected range which results in removal of weather radar imagery.*

*The following messages indicate operating modes of R/T unit:*

*WX - Weather radar displayed without turbulence.*

*MAP - Ground mapping displayed.*

*TURB - Turbulence displayed only.*

*REAC - Indicates R/T units inability to look behind intervening rainfall.*

*STBY - Weather radar in standby mode.*

*The following messages have the prefix XXXX. This represents any one of the operating modes that may appear directly above the message:*

*XXXX VAR - Weather radar input sensitivity is not calibrated to any precipitation rate.*

*XXXX CAL - Loss of calibration.*

*XXXX ATT - Attitude input fault.*

*XXXX STAB - Stabilization is off.*

### (2) LRU Fault Messages

*If a failure exists in test mode, TEST will be replaced by FAIL and one or more fault messages.*

*RT - Receiver/Transmitter fault.*

*ANT - Antenna fault.*

*CNTL - Control fault.*

*ATT - Attitude fault.*

*CAL - Calibration fault.*

*RANGE - Range fault (MSP fault).*

*COOL - R/T unit cooling fault.*

## **5.5 Delta Air Lines – Flight Crew Training Manual**

The following sections were extracted from the Delta Air Lines Flight Crew Training Manual MD88-90.

### **5.5.1 Turbulent Air Penetration**

*Severe turbulence should be avoided if at all possible. However, if severe turbulence is encountered, use the Severe Turbulence procedure listed in the Vol. 1, SP.16, Turbulence. Turbulent air penetration speeds provide high/low speed margins in severe turbulent air.*

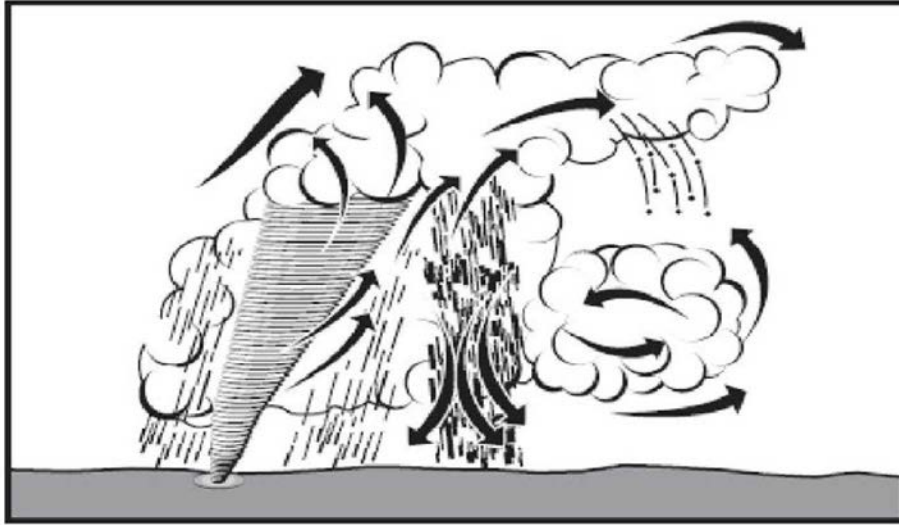
*During manual flight, maintain wings level and smoothly control attitude. Use the attitude indicator as the primary instrument. In extreme updrafts or downdrafts, large altitude changes may occur. Do not use sudden or large control inputs. After establishing the trim setting for penetration speed, do not change pitch trim. Allow altitude and airspeed to vary and maintain attitude. However, do not allow the airspeed to decrease and remain below the turbulent air penetration speed because stall/buffet margin is reduced. Maneuver at bank angles below those normally used. Set thrust for penetration speed and avoid large thrust changes. Flap extension in an area of known turbulence should be delayed as long as possible because the aircraft can withstand higher gust loads with the flaps up.*

*Normally, no changes to cruise altitude or airspeed are required when encountering moderate turbulence. If operating at cruise thrust limits, it may be difficult to maintain cruise speed. If this occurs, select a higher thrust limit (if available) or descend to a lower altitude.*

### **5.5.2 Weather Radar**

*Research has shown that when any part of a storm reaches Level 3 strength, moderate to severe turbulence occurs with equal probability throughout all areas of the storm, including the Level 1 and 2 areas. For turbulence avoidance, all areas of a storm should be avoided when any part reaches Level 3.*

*The color green is often associated with safe to go or normal operation. Green does not imply go or safe in conjunction with weather radar or turbulence avoidance. In weather depiction, green simply denotes the area of Level 1 precipitation. When associated with convective weather, green areas of rain may contain violent vertical activity. The graphic below illustrates how tornadoes are most often located at the outer edge of thunderstorms in the Level 1 areas of precipitation.*



### ***Turbulent Activity***

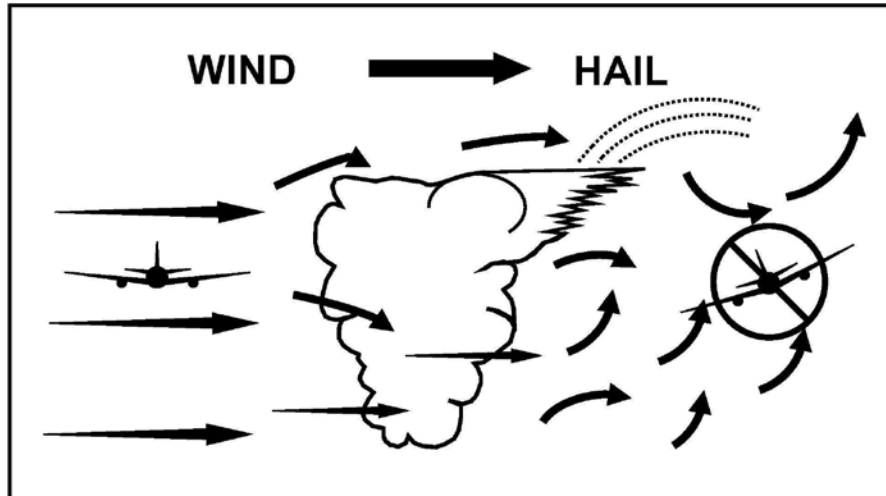
*Turbulent activity occurs away from the heavy rain core. Enroute deviations should be made upwind of the storm whenever possible, especially if winds aloft are strong. Deviating downwind greatly increases the chance of encountering hail and turbulence. Turbulence can be expected to exist downwind of the storm 1 NM for every knot of windspeed at flight altitude. The storm acts as an obstruction to the wind, creating turbulent eddies downwind of the storm.*

*To detect turbulence select the TURB mode to identify areas of horizontal movement of precipitation, which can be a good indication of turbulence.*

- *Turbulence will be displayed in magenta, overlaying the weather display.*
- *TURB mode will not detect clear air turbulence.*
- *Turbulence detection is limited to 40 NM.*

*Turbulence detection can be useful in identifying areas of turbulence, particularly in light rain areas. Some storm targets may display little or no turbulence, but that does not mean it is safe to penetrate. An absence of indicated turbulence does not justify penetrating a weather area that by other indications is hazardous.*

*The graphic below illustrates how enroute deviations should be made upwind of the storm and the turbulence that can be encountered downwind of the storm.*



## 5.6 Delta Air Lines – On-Board Manual

The Delta Air Lines On-Board Manual, Section 5.11 “Standards and Regulations” provided the following turbulence guidance to Delta Air Lines’ Cabin Crew.

### 5.6.1 Turbulence Guidelines

| Turbulence Guidelines                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Crew member guidelines:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <ul style="list-style-type: none"> <li>• Discuss turbulence procedures and use designated turbulence level when communicating turbulence information during all preflight briefings and in flight.</li> </ul>                                                                                                                                                                                                                                                                                                                                                    |
| <ul style="list-style-type: none"> <li>• Flight deck crew should ensure FAs are allotted adequate time to stow service and galley equipment before entering areas of anticipated turbulence.</li> </ul>                                                                                                                                                                                                                                                                                                                                                          |
| <ul style="list-style-type: none"> <li>• For light turbulence, flight deck crew will communicate to Purser/FL via interphone first and follow up with PA to cabin in accordance with Turbulence Action Chart. Flight deck crew will communicate the following via interphone:               <ul style="list-style-type: none"> <li>- Estimated time remaining until turbulence is encountered</li> <li>- Estimated duration, if known</li> <li>- Use proper phraseology (e.g., “light turbulence” not “rough air”)</li> </ul> </li> </ul>                        |
| <p><i>NOTE:</i> On the A330, flight deck crew does not have “PA All” functionality that prevents PAs from going into crew rest facility. For this reason, flight deck crew will not make any PAs from between the initial greeting, no later than top of climb, and the “prepare the Cabin” PA, 5 minutes prior to top of descent, except as required for emergencies. During preflight briefing, the Captain will coordinate with the Purser to make the “seat belt sign on PA” associated with light turbulence so as not to disturb crew members on rest.</p> |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Crew member guidelines: (Continued)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <ul style="list-style-type: none"> <li>For moderate turbulence, flight deck crew will communicate to cabin crew via PA first (see Turbulence Action Chart) and then follow up via interphone with the Purser/FL.</li> </ul> <p><b>Exception:</b> On the A330 during crew rest, flight deck crew will direct Purser/FL to make the moderate turbulence PA. This is to prevent crew rest disruption due to inability to de-select the crew rest facility from flight deck PA system.</p>                                                                                                                                                                                                                                                             |
| <ul style="list-style-type: none"> <li>For severe turbulence, flight deck crew will communicate to cabin crew via PA first (see Turbulence Action Chart) and then follow up via interphone with the Purser/FL.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <ul style="list-style-type: none"> <li>If conditions become turbulent (moderate or greater) in cabin, FAs should not wait for an announcement to take appropriate action to protect themselves. Follow procedures in Turbulence Action Charts, Flight Attendant Actions section.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <ul style="list-style-type: none"> <li>When the flight deck announces to be seated for turbulence, all FAs must immediately adhere to the warning and protect themselves.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <ul style="list-style-type: none"> <li>If passengers disregard the seat belt sign, Purser/FL should advise flight deck.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <ul style="list-style-type: none"> <li>If seat belt sign has been on for long periods of time without turbulence, Purser/FL should advise flight deck.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <ul style="list-style-type: none"> <li>Notify flight deck crew of the turbulence-related injury as soon as safely possible and ask that they send an ACARS Turbulence Report with location/flight level where the injury approximately occurred. Also ask them to include the code "PINJ" in the MISC TEXT section of the turbulence report. Refer to <a href="#">Turbulence Injury Reporting</a> in section 8.1, <b>Reporting Procedures</b> for additional information.</li> </ul>                                                                                                                                                                                                                                                               |
| <ul style="list-style-type: none"> <li><b>767 Safety Seats:</b> The last two seats in the main cabin on aircraft right are "soft blocked" for FA use in event of unanticipated turbulence while working in aft galley area. These seats will remain open if the flight is not completely full and will be the last seats ACS will assign in the main cabin. FAs should refrain from moving customers and/or jumpseat riders into these seats, if they are unoccupied.</li> </ul>                                                                                                                                                                                                                                                                   |
| <b>Crew member guidelines: (Continued)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <ul style="list-style-type: none"> <li>If moderate to severe turbulence is expected on descent to destination, flight deck crew will notify Purser/FL via interphone of type of turbulence to expect and the need for flight attendants to conduct final cabin checks and be seated for landing as early as possible. The pilots will include the request for flight attendants to be seated earlier in the top of descent PA. If notified of moderate or greater turbulence during descent, flight attendants will complete all Pre-Arrival procedures (<b>Initial Descent/Top of Descent and Before Landing/10,000 Feet Double Chime</b>) at the same time and as soon as possible following top of descent PA from flight deck crew.</li> </ul> |

Figure 4: Turbulence Guidelines (Source: Delta Air Lines On-Board Manual)

## 5.6.2 Turbulence Action Charts

*These charts are common to the OBM and FOM. The pilot actions are taken directly from the FOM and are written for pilots. They are included here for flight attendant awareness.*

| Light Turbulence                |                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Aircraft Reaction</b>        | Slight, erratic changes in altitude and/or attitude.                                                                                                                                                                                                                                                                                                                                        |
| <b>Cabin Conditions</b>         | <ul style="list-style-type: none"> <li>Liquids are shaking but not splashing out of cups.</li> <li>Carts can be maneuvered with little difficulty.</li> <li>Passengers may feel light strain against seat belts.</li> </ul>                                                                                                                                                                 |
| <b>Pilot Actions</b>            | <ul style="list-style-type: none"> <li>Ensure seat belt sign ON.</li> <li>Via interphone advise Purser/FL of LIGHT turbulence.</li> <li>Ensure PA reinforcing need for passengers to be seated is made. <ul style="list-style-type: none"> <li>Sample PA: <i>Ladies and gentlemen, due to the rough air, please return to your seats and fasten your seat belts.</i></li> </ul> </li> </ul> |
| <b>Flight Attendant Actions</b> | <ul style="list-style-type: none"> <li>Continue service with caution.</li> <li>Use caution serving hot food/beverages.</li> <li>Visually check passengers seat belts.</li> </ul>                                                                                                                                                                                                            |

| Moderate Turbulence             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Aircraft Reaction</b>        | Changes in altitude and/or attitude occur but with more intensity than light turbulence. Aircraft remains in control at all times.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Cabin Conditions</b>         | <ul style="list-style-type: none"> <li>Liquids are splashing out of cups.</li> <li>Difficult to walk or stand without balancing or holding onto something.</li> <li>Carts are difficult to maneuver.</li> <li>Passengers feel definite strain against seat belt.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Pilot Actions</b>            | <ul style="list-style-type: none"> <li>Ensure seat belt sign in ON.</li> <li>Make PA directing FAs and passengers to be seated and service to be discontinued. <ul style="list-style-type: none"> <li>Sample PA: <i>Ladies and gentlemen, due to the rough air (that we expect in the next ___ minutes) we need you to be seated and check the security your seat belts. We are also requiring all flight attendants to discontinue their service and be seated until it is safe to continue. This is for their safety as well as yours.</i></li> </ul> </li> <li>Via interphone advise Purser/FL of MODERATE turbulence and expected duration.</li> </ul> <p><b>Exception:</b> On the A330 during crew rest, flight deck crew will direct Purser/FL to make the moderate turbulence PA. This is to prevent crew rest disruption due to inability to de-select the crew rest facility from flight deck PA system.</p> <ul style="list-style-type: none"> <li>Advise FAs when it is safe to resume their duties.</li> </ul> |
| <b>Flight Attendant Actions</b> | <p> Do not wait for guidance from flight deck crew if experiencing moderate turbulence.</p> <ul style="list-style-type: none"> <li>Discontinue service and stow all carts.</li> <li>Stow galley equipment, time and conditions permitting.</li> <li>FAs secure themselves in jumpseats as soon as possible using seat belt and shoulder harness visually checking passenger seat belts en route to jumpseat.</li> <li>Purser/FL calls all FA stations to ensure all passengers/ crew are seated and contacts flight deck to confirm FAs are seated and carts are stowed.</li> <li>FAs resume duties once advised by flight deck crew it is safe to do so.</li> <li>Purser/FL continues communication with flight deck on conditions in the cabin.</li> </ul>                                                                                                                                                                            |

| Severe Turbulence               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Aircraft Reaction</b>        | Large, abrupt changes in altitude and/or attitude. Usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Cabin Conditions</b>         | <ul style="list-style-type: none"> <li>• Items are falling over. Unsecured items are tossed about.</li> <li>• Walking is impossible.</li> <li>• Passengers are forced violently against seat belts.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Pilot Actions</b>            | <ul style="list-style-type: none"> <li>• Ensure seat belt sign is ON.</li> <li>• Immediately make PA directing FAs and passengers to be seated and service to be discontinued. <ul style="list-style-type: none"> <li>- Sample PA: <i>Ladies and gentlemen, due to the rough air, we need you to be seated and check the security of your seat belts. We are also requiring all flight attendants to <b>immediately</b> discontinue their service and be seated until it is safe to continue. This is for their safety as well as yours.</i></li> </ul> </li> <li>• Via interphone advise Purser/FL of SEVERE turbulence and expected duration.</li> <li>• Advise FAs when it is safe to resume duties.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Flight Attendant Actions</b> | <p> Do not wait for guidance from flight deck crew if experiencing severe turbulence.</p> <ul style="list-style-type: none"> <li>• Discontinue service immediately and leave carts with brakes engaged until turbulence is reduced.</li> <li>• If possible, place hot liquids on floor.</li> <li>• FAs secure themselves in nearest available seats. <ul style="list-style-type: none"> <li>- If in jumpseat, use seat belt and shoulder harness.</li> <li>- If a seat is not readily available, you may need to sit on the floor and grab on to the leg of a passenger set or sit on a passenger's lap and ask for passenger assistance.</li> </ul> </li> </ul> <p><b>When safe to do so:</b></p> <ul style="list-style-type: none"> <li>• Purser/FL calls all FA stations to ensure all passengers/crew are seated and contacts flight deck to relay status of FAs and carts.</li> <li>• Stow all carts and galley equipment.</li> <li>• FAs resume duties once advised by flight deck crew it is safe to do so.</li> <li>• Purser/FL continues communication with flight deck on conditions in the cabin.</li> <li>• Check for damage and injuries; notify flight deck crew of crew/passenger injuries and cabin conditions.</li> </ul> |

Figure 5: Turbulence Action Chart (Source: Delta Air Lines On-Board Manual)

## 6.0 Boeing Aero Magazine

Boeing AERO Magazine<sup>36</sup> produced the following “Turbulence Education and Training Aid”<sup>37</sup> article in Issue 04 dated October of 1998:

### *Turbulence Education and Training Aid*

*Clear-air and mountain-wave turbulence is the leading cause of injury to cabin crews and passengers in non-fatality commercial airplane incidents. The resulting rough ride also*

<sup>36</sup>Boeing AERO magazine was published quarterly by Boeing Commercial Airplanes between 1998 and 2015.  
Source: [https://www.skybrary.aero/index.php/AERO\\_-\\_Boeing](https://www.skybrary.aero/index.php/AERO_-_Boeing)

<sup>37</sup> Source: Boeing AERO Magazine Issue 04  
[http://www.boeing.com/commercial/aeromagazine/aero\\_04/tr/tr01/index.html](http://www.boeing.com/commercial/aeromagazine/aero_04/tr/tr01/index.html)

*creates a negative public perception of the safety of flight. An industry team consisting of participants from U.S. operators, Douglas Products Division, and the U.S. Federal Aviation Administration (FAA) has developed a turbulence education and training aid to help reduce the number of turbulence-related incidents.*

*The turbulence created by clear-air and mountain-wave conditions presents a considerable threat of cabin crew and passenger injury and airplane damage to commercial airplane flights, and no onboard detection and warning device is currently available to alert flight crews to all impending encounters. Even though many turbulence-related incidents are minor and go unreported, data from the U.S. National Transportation Safety Board reveal that major U.S. operators have experienced more than 250 of these incidents in the past 15 years. The encounters resulted in the deaths of three passengers and serious injuries to 70 others.*

*The effort to reduce or even eliminate the threat of turbulence includes the following measures:*

- 1. FAA and operator response.*
- 2. Implementation of turbulence education and training aid.*
- 3. More efficient use of existing technologies.*
- 4. Development of new technologies.*

### **FAA and Operator Response**

*The FAA has responded to the threat of turbulence by launching a campaign to educate the traveling public. The FAA also emphasizes the importance of wearing seat belts throughout every flight, and particularly in response to flight-crew warnings. In addition, several major U. S. operators have recently implemented a policy that requires passengers to keep seat belts fastened for the duration of their flight.*

### **Implementation of Turbulence Education and Training Aid**

*The turbulence education and training aid is an educational resource designed to increase the awareness of flight crews, flight attendants, managers, dispatchers, meteorologists, and air traffic controllers to the potential for turbulence-related injuries and damage. It is also a baseline example of turbulence training that operators may use to develop their own programs. The training aid highlights the importance of operators establishing policies for avoiding turbulence and suggests that operators support in-flight avoidance actions that have the potential to delay subsequent arrival schedules. Establishing and following standard operating procedures for weather deviation and turbulence avoidance provides flight crews with the knowledge, confidence, and authority they need to act properly if they encounter turbulence.*

*The training aid consists of documentation and a video and is divided into four sections:*

- *A management overview that describes the effects of turbulence and the benefits of using the turbulence education and training aid.*
- *An operator's guide that contains educational materials for use by flight crews, dispatchers, meteorologists, and air traffic controllers.*
- *An example training program that contains ground training, test exams, and the script for the video included in the package. The program may be used either in its existing form or customized.*
- *Background data that include a list of reference materials, a video, and a visual aid containing most of the training subject matter. The video can be used to enhance understanding of the documentation.*

*An effective turbulence education program retains the key training elements of recognition and action included in the video and operator's guide. A ground-school presentation of the materials, video, and quiz can be most effective when operators customize the aid to match their existing facilities.*

### **More Efficient Use of Existing Technologies**

*In addition to turbulence education and training, other means of reducing the threat in the short term include greater use of Doppler radar, turbulence plotting, flight-crew reports of turbulence, and automatic uplinks through the Aircraft Communication Addressing and Reporting System.*

*Government regulatory agencies throughout the world can also assist in the immediate effort by encouraging more real-time communication of weather information to flight crews and by encouraging air traffic controllers to provide additional clearances for turbulence avoidance. These agencies can also call for increased cooperation and knowledge sharing among all affected parties.*

### **Development of New Technologies**

*In addition to assisting with short-term solutions, government regulatory agencies can help create long-term solutions. Examples of this activity include supporting the aviation industry in the development of new systems that detect clear-air and mountain-wave turbulence and that deliver an early warning to the flight crew. Further development of existing technologies can lead to increased communication between airplanes and the ground to provide the flight crew with continuous, real-time weather information.*

### **Summary**

*The threat presented by turbulence is significant, both for passengers and for commercial airplanes themselves. Operators can now use a turbulence education and training aid, developed by several members of the aviation industry, to mitigate the effects of turbulence. This education and training of personnel can be supplemented by other short-term solutions. However, the threat posed by clear-air and mountain-wave turbulence can be eliminated only by the development of systems that detect it and provide early warning to flight crews.*

## 7.0 FAA Guidance

The FAA defines turbulence as: “air movement that normally cannot be seen and often occurs unexpectedly. It can be created by many different conditions, including atmospheric pressure, jet streams, air around mountains, cold or warm weather fronts or thunderstorms. Turbulence can even occur when the sky appears to be clear.”<sup>38</sup>

### 7.1 FAA Turbulence Fact Sheet

The FAA provided the following guidance titled “Fact Sheet – Turbulence” on August 1, 2019 on their website:<sup>39</sup>

#### ***What is turbulence?***

*Clear air turbulence is air movement created by atmospheric pressure, jet streams, air around mountains, cold or warm weather fronts or thunderstorms. It can be unexpected and can happen when the sky appears to be clear.*

#### ***What should passengers do to avoid injuries?***

*Flying is the safest way to travel. Passengers can easily prevent injuries from unexpected turbulence by keeping their seat belt buckled at all times. The FAA’s tips for staying safe:*

- *Listen to the flight attendants. Pay attention to the safety briefing at the beginning of your flight and read the safety briefing card.*
- *Buckle up. Keep you and your family safe by wearing a seat belt at all times.*
- *Use an approved child safety seat or device if your child is under two.*
- *Prevent inflight injuries by adhering to your airline’s carry-on restrictions.*

#### ***What do airlines do to avoid turbulence and prevent injuries?***

*Working together through the Commercial Aviation Safety Team (CAST), the FAA developed guidance material to help air carriers and other operators prevent turbulence injuries. CAST develops an integrated, data-driven strategy to reduce the commercial aviation fatality risk in the United States and promotes government and industry safety initiatives throughout the world. Some of the material responds to investigative work from the National Transportation Safety Board. The focus of the material (see additional reading) is to help air carriers avoid the conditions that cause turbulence and minimize the risks when airplanes do encounter it. This impacts the operations and training of flight crews, flight attendants, dispatchers and managers.*

*The FAA recommends that air carriers:*

- *improve dispatch procedures by keeping communication channels open full-time;*
- *include turbulence in weather briefings;*
- *promote real-time information sharing between pilot and dispatcher;*

---

<sup>38</sup> Source: [https://www.faa.gov/travelers/fly\\_safe/turbulence/](https://www.faa.gov/travelers/fly_safe/turbulence/)

<sup>39</sup> Source: [https://www.faa.gov/news/fact\\_sheets/news\\_story.cfm?newsId=20074](https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=20074)

- reinforce the air carrier's turbulence avoidance policy through dispatcher training;
- consider rerouting using automation, atmospheric modeling, and data displays; and
- use all applicable weather data as well as reporting and forecasting graphics.

The FAA also encourages air carriers to use operating procedures and training to prevent turbulence injuries, emphasize the importance of flight attendant's personal safety, promote communication and coordination, and gather data and review the air carrier's history of turbulence encounters and injuries.

#### ***How many people have been injured during turbulence?***

| <b><i>Year</i></b> | <b><i>Passenger</i></b> | <b><i>Crew</i></b> | <b><i>Total</i></b> |
|--------------------|-------------------------|--------------------|---------------------|
| 2009               | 74                      | 27                 | 101                 |
| 2010               | 35                      | 23                 | 58                  |
| 2011               | 4                       | 25                 | 29                  |
| 2012               | 4                       | 19                 | 23                  |
| 2013               | 2                       | 4                  | 6                   |
| 2014               | 19                      | 9                  | 28                  |
| 2015               | 11                      | 16                 | 27                  |
| 2016               | 29                      | 13                 | 42                  |
| 2017               | 9                       | 8                  | 17                  |

The NTSB requires airlines to report serious injuries and fatalities. A serious injury is “any injury that (1) requires the individual to be hospitalized for more than 48 hours, commencing within seven 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 five percent of the body surface.” The FAA tracks these reports, but not general incidents of turbulence.

## **7.2 Advisory Circular 120-88A**

FAA Advisory Circular 120-88A “Preventing Injuries Caused by Turbulence” dated November 19, 2007 provided, in part, the following guidance:

***Emphasize the Importance of F/A's Personal Safety.*** F/A injuries occur at a disproportionately high rate compared to other crewmembers and other cabin occupants because F/As spend more time in the passenger cabin unseated and, therefore, unbelted. Effective training emphasizes to F/As that:

*(1) You are not invincible. The overlying objective throughout all crewmember training is to ensure that crewmembers 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 crewmember might be self preservation. Training courseware can make crewmembers aware of their vulnerability in moderate and extreme turbulence. Effective training can incorporate video/digital media, real world scenarios and interviews with crewmembers 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 crewmembers 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 (PA) system 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. Crewmembers 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, crewmembers might be less conservative regarding their personal safety than on a longer flight with no time constraints. crewmembers 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.*

It also provided the following guidance for imminent Turbulence or Turbulence Occurring:

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

*(1) Captain turns on seatbelt sign and makes a PA announcement, “F/As 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.”*

*(2) Cabin crew take first available seat and secure themselves.*

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

*(4) When conditions improve, captain makes PA announcement advising the cabin crew that they may resume their duties and whether or not the passengers may move about the cabin.*

## **F. LIST OF ATTACHMENTS**

Attachment 1: Crew Statements

Attachment 2: Flight Crew Training Records

Attachment 3: Accident Flight's Dispatch Release  
Attachment 4: Accident Flight's Weight Data Record  
Attachment 5: Accident Flight's Turbulence ACARS Message  
Attachment 6: Archived PIREPs  
Attachment 7: Delta Air Lines Airway Manual [Excerpts]  
Attachment 8: Delta Air Lines Flight Operations Manual [Excerpts]  
Attachment 9: Delta Air Lines Operations Manuals Md88/90 Vol.1 and 2 [Excerpts]  
Attachment 10: Delta Air Lines On-Board Manual [Excerpt]  
Attachment 11: Delta Air Lines Flight Crew Training Manual [Excerpt]

Submitted by:

---

Shawn Etcher  
Air Safety Investigator

**THIS PAGE INTENTIONALLY BLANK**