



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

December 4, 2019

Specialist's Report

OPERATIONAL FACTORS

DCA19CA206

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A. ACCIDENT

Operator: Frontier Airlines
Location: Approximately 20 miles Northeast of Denver, Colorado
Date: August 27, 2019
Time: Approximately 0650 Mountain Daylight Time (MDT)¹
Airplane: Airbus A320-251, Registration number N328FR
Flight No.: Frontier Flight 461

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 27, 2019, approximately 0650 mountain daylight time (MDT), an Airbus A320-251, N328FR, operated by Frontier Airlines as flight 461 encountered turbulence while on descent to the Denver International Airport (DEN), Colorado. As a result of the turbulence, one flight attendant sustained a broken left ankle. There were no other injuries to the crew or passengers, and no damage to the airplane.

The flight was a regularly scheduled flight from the Minneapolis/St. Paul International Airport (MSP), Minnesota. Visual flight conditions prevailed for the flight which was operated under the provisions of Title 14 *Code of Federal Regulation* Part 121.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board (NTSB) Operational Factors did not travel on this investigation and gathered the operation manuals, pilot certification information from the Operator and the Federal Aviation Administration (FAA).

E. FACTUAL INFORMATION

1.0 History of Flight²

Frontier Airlines flight 461 had departed MSP at 0600 Central Daylight Time (0500 MDT). The flight's planned arrival time was 0718 MDT.

¹ All times in the report will be Mountain Daylight Time except as otherwise noted. At the time of the accident Greenwich Mean Time, also known as Zulu (Z) time, was 6 hours ahead of MDT.

² Sources: Attachment 1 - "Crew Interview Summaries"

According to the captain, during descent into DEN approximately 15,000 ft, the crew visually acquired a “singular cumulous” cloud. Although assigned by air traffic control “best forward [speed]” the PF reduced the airplane speed to 250 knots and the PM notified the flight attendants to take their seat. Subsequently, the flight encountered moderate turbulence, which the captain estimated lasted “about 10 seconds.” The PM then contacted the flight attendants to confirm everyone was seated and ok. A few minutes later, a flight attendant reported to the flight crew that one flight attendant had injured her ankle while getting to her seat. The flight crew notified dispatch and had the EMTs³ meet the aircraft to attend to the flight attendant’s ankle.

According to flight attendant statements, while the injured flight attendant was providing the arrival announcement to the passengers via the public address system, the captain had called back and told another flight attendant to “be cautious”. Another flight attendant was mid cabin completing the compliance check when the turbulence occurred. They were able to secure themselves in an empty seat until the turbulence subsided and continued with their duties. The injured flight attendant was in the aft cabin conducting the arrival announcements to the passengers and reported that “the turbulence caused me to lose my footing while stepping towards my jumpseat

After encountering the turbulence the flight crew received a call from the “A” flight attendant stating that the “D” flight attendant was able to be seated in an empty passenger seat after falling to the floor of the aircraft and she had a possible ankle injury. The injured flight attendant would therefore be unable to perform her flight attendant duties for the remainder of the flight.

The flight crew notified their dispatcher and requested that EMTs meet the aircraft to attend to the flight attendant’s ankle.

After landing and parking at the gate the EMTs attended to the flight attendant and subsequently transported the “D” flight attendant, to the hospital due to the ankle injury.

2.0 Flight Crew Information

The accident flightcrew consisted of 2 pilots and 4 cabin crew members. The first officer was the pilot flying (PF) on the accident flight and the captain was the pilot monitoring (PM).

2.1 Captain

The captain was 57 years old and held an Airline Transport Pilot (ATP) certificate with a rating for airplane multiengine land and type ratings on the A320⁴ and BE-1900⁵, limitations included second in command required for the BE-1900. He held a commercial pilot certificate for airplane single-engine land. He held an FAA first-class medical certificate dated April 5, 2019, with a limitation of “Must have available glasses for near vision.” At the time of the accident he was based at DEN.

³ Emergency Medical Technicians

⁴ Airbus SAS A-318 Series, A-319 Series, A-320 Series, A-321 Series, includes all models on Type Certificate Data Sheet A28NM. Source FAA Order 8900.1, Figure 5-88, dated July 15, 2019,

⁵ Beechcraft Corporation 1900, 1900C, 1900D. Source FAA Order 8900.1, Figure 5-88, dated July 15, 2019.

According to information provided by Frontier Airlines, the captain had approximately 9,639 total hours of flight experience and his most recent flight review was conducted on August 13, 2019.

2.2 First Officer

The First Officer (FO) was 48 years old; held an ATP certificate with type ratings on the A320 and BE-1900, limitations included A-320 circling approach – VMC⁶ only and second in command required for the BE-1900. He held a commercial pilot certificate for airplane single-engine land. He also held an FAA first-class medical certificate dated January 14, 2019, with no limitations. At the time of the accident he was based at DEN.

According to information provided by Frontier Airlines, the first officer had accumulated about 6,835 hours of total flight experience and his most recent flight review was conducted on August 8, 2018.

3.0 Airplane Information



Photo 1: Accident Airplane, N328FR (Courtesy of JetPhotos.net)

The accident airplane (Registration N328FR, Serial No. 8118) was an Airbus 320-251N. The airplane was manufactured in 2018, registered to Wells Fargo Trust Company and operated by Frontier Airlines, and held a transport category airworthiness certificate dated March 14, 2018. The airplane was powered by 2 CFMI LEAP-1A26 engines. The airplane was configured with 2 pilot seats, 1 cockpit observer seat, 6 flight attendant seats, and 186 passenger seats.

According to the accident flight's dispatch release there was only one maintenance deferral item at the time of departure which was:

25-99-20AK – Tray table at seat 12A

⁶ Visual Meteorological Conditions

4.0 Accident Flight Dispatch Release and Weather Packet

4.1 Dispatch Release

Frontier Airlines Domestic Dispatch Release⁷ for the accident, was 21 pages in total length and contained information for the accident flight such as, fuel required, route of flight, departure and destination airports, MEL/CDLs⁸, planned departure and arrival weights, enroute winds and temperature summary, as well as a “weather brief” which began on page 4 and included a “remarks” section, which stated “NONE.”

4.2 Weather Packet

The Frontier Airlines Briefing packet for the accident flight was generated on August 27, 2019 at 0948Z (0348 MDT). The weather packet was 17 pages in length and contained the departure, enroute, and destination weather and NOTAMs⁹, and any SIGMETs¹⁰ or AIRMETs¹¹ that were available.

A review of the Weather Packet showed that there were 4 Convective SIGMETs, which encompassed an area from Missouri, Arkansas, and Texas towards the east and known of the SIGMETs were valid along the proposed flight path for the accident flight.

The Weather Packet also showed 13 AIRMETs of which 8 were for turbulence. There was one AIRMET for turbulence that was near Denver which was the following:

*AIRMET TURB...MT WY
FROM 60SSW YXH TO 50NNW ISN TO 70SW RAP TO 40NNW BFF TO 30SSE CZI TO
50SSE LWT TO 60SSW YXH
MOD TURB BTN FL180 AND FL330. CONDS CONTG BYD 15Z THRU 21Z.*

*.
OTLK VALID 1500-2100Z AREA 1...TURB MT WY
BOUNDED BY 70NW ISN-60WSW RAP-60E CZI-MLS-70NW ISN
MOD TURB BLW 100. CONDS DVLPG AFT 15Z. CONDS CONTG THRU 21Z.*

*.
AREA 2...TURB CO NM
BOUNDED BY 30ESE TBE-INK-40E DMN-40NE ABQ-30ESE TBE MOD TURB BLW
090. CONDS CONTG THRU 21Z.*

The Weather Packet did not include any PIREP¹² information; however, a review of archived PIREPs showed only one PIREP valid for the area around the accident location about the time of the accident¹³. That PIREP was within 100 miles of the turbulence encounter and was:

⁷ Source: Attachment 2 - Flight Dispatch Release and Weather Briefing

⁸ Minimum Equipment List/Configuration Deviation List

⁹ Notices to Airman

¹⁰ Significant Meteorological Information

¹¹ Airmen's Meteorological Information

¹² Pilot Reports

¹³ According to Google Earth the PIREP was approximately 50 miles to the east of the turbulence encounter.

AKO UA /OV FTG-AKO /TM 1437 /FL070/ TP C185 /SK OVC075 /TB NEG /RM SMTH

The reports in plain language taken from standard code and abbreviations, with cloud heights in feet above mean sea level:

Colorado Plains Regional Airport, Colorado, (AKO) routine pilot report (UA); Over – between Front Range Airport (FTG) and AKO; Time – 0837 MDT (1437Z); Altitude – 7,000 ft; Type aircraft – Cessna 185; Sky – Overcast skies at 7,500 ft; Turbulence – Negative; Remarks – Smooth.

5.0 Frontier Airlines Guidance

5.1 Severe Turbulence and/or Mountain Wave

The Frontier Airlines, Flight Operations Manual, “Routine Operations”, Revision 4-18, dated May 9, 2018, contained the following guidance regarding “Severe Turbulence and/or Mountain Wave Activity Induced Altitude Deviations of Approximately 200 feet”

When an aircraft experiences weather induced altitude deviations of approximately 200 feet, the pilot will contact ATC and state “Unable RVSM due to (state reason)” (e.g., turbulence, mountain wave). Until the pilot reports clear of the weather phenomenon, the controller will (traffic permitting) apply merging target vectors to one or both passing aircraft to prevent their targets from merging.

Pilots should also report the location and magnitude of turbulence or MWA to ATC. If desired, a FL change or reroute may be requested as noted below.

Mountain Wave Activity - MWA encounters do not necessarily result in altitude deviations on the order of 200 feet. When pilots encounter MWA of less significant magnitude, they should contact ATC and report the magnitude and location of the wave activity.

5.2 Turbulence

The Frontier Airlines, Flight Operations Manual, “Routine Operations”, Revision 4-18, dated May 9, 2018, contained the following guidance regarding “Turbulence”

When anticipating or encountering turbulence:

- Reference Table 25.50.1 for crewmember actions based on type and timing of turbulence encounters.*
- If severe turbulence, reduce to the appropriate severe turbulent air penetration speed.*
- Report turbulence encounters to ATC and to Dispatch using the criteria described in Table 25.50.1. Pilots should report location(s), time (UTC), intensity, whether in or near clouds, altitude, type of aircraft and duration of turbulence to ATC and to Dispatch. Duration may be based on time between two locations or over a single location. All locations should be readily identifiable.*

5.2.1 Turbulence Reporting Criteria and Recommended Crewmember Actions

The Frontier Airlines, Flight Operations Manual, “Routine Operations”, Revision 4-18, dated May 9, 2018, provided the following table regarding “Turbulence Reporting Criteria and Recommended Crewmember Actions”:

Turbulence Reporting Criteria and Recommended Crewmember Actions				
Intensity	Aircraft Reaction	Reaction Inside Aircraft	Flight Deck	Cabin
Light	Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw). Report as Light Turbulence , or Turbulence that cause slight, rapid and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude. Report as Light Chop .	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.	If expecting turbulence: Advise FAs of turbulence and expected time of entry (via interphone). At least five minutes prior, or if unexpected turbulence is encountered: At captain's discretion: • Turn the seat belt sign "ON." • Make PA advising passengers to be seated and fasten all seat belts.	Continue inflight service with caution; avoid serving hot liquids. If the seat belt sign comes on: • Make PA reinforcing need for passengers to be seated with seat belts fastened. • Monitor seatbelt compliance by visually checking that passengers are seated with seat belts securely fastened.
Moderate	Turbulence that is similar to Light Turbulence but of greater intensity. Changes in altitude and/or attitude occur but the aircraft remains in positive control at all times. It usually causes variations in indicated airspeed. Report as Moderate Turbulence , or Turbulence that is similar to Light Chop but of greater intensity. It causes rapid bumps or jolts without appreciable changes in aircraft altitude or attitude. Report as Moderate Chop .	Occupants feel definite strains against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.	If expecting turbulence: Advise FAs of turbulence and expected time of entry (via interphone). At least five minutes prior: • Ensure seat belt sign is "ON." • Make PA advising FAs and passengers to be seated and fasten all seat belts. If unexpected turbulence is encountered: • Ensure seat belt sign is "ON." • Workload permitting, make PA advising FAs and passengers to be seated immediately , fasten all seat belts, and discontinue cabin service (or as appropriate for the situation). During/After turbulent conditions: • Continue communication with FAs as required. • Ensure reports to ATC and Dispatch are made when time/workload permits. • Inform FAs when turbulence conditions have suspended.	If expecting turbulence: Have all carts and galley equipment stowed at least five minutes prior to expected entry into turbulence. If advance notice is given, once the seat belt sign comes on: • Make PA reinforcing need for passengers to be seated with seat belts fastened. • Time permitting, monitor seatbelt compliance by visually checking that passengers are seated with seat belts securely fastened. • Be seated with seat belt and shoulder harness secured. If unexpected turbulence is encountered: • Immediately stop all inflight service. • Be seated with seat belts and shoulder harness secured, or take nearest seat in the cabin or sit on floor, if necessary. • Make PA reinforcing need for passengers to be seated with seat belts fastened. During turbulent conditions: • FA "A" continues communications with flight deck on conditions in cabin as needed. • Remain seated until notified by the flight deck it is safe to resume duties. Upon notification it is safe, check passengers and cabin.
Severe	Turbulence that causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control. Report as Severe Turbulence .	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food service and walking are impossible.		
Extreme	Turbulence in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage. Report as Extreme Turbulence .			

Figure 1: Turbulence Reporting Criteria and Recommended Crew Actions (Source: Frontier FOM Vol 1)

5.2.2 Turbulence Duration

The Frontier Airlines, Flight Operations Manual, Volume I, “Enroute Procedures”, Revision 4-18, dated May 9, 2018, contained the following definitions regarding Turbulence Reporting terms:

Occasional – Less than 1/3 of the time.

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

Continuous – More than 2/3 of the time.

CAT (Clear Air Turbulence) – High level turbulence (normally above 15,000 feet ASL) not associated with cumuliform cloudiness, including thunderstorms, should be reported as CAT preceded by the appropriate intensity, or light or moderate chop.

5.3 Severe Turbulence

The Frontier Airlines, Flight Operations Manual – Volume II A320 Series, “Adverse Weather”, Revision 73, dated December 14, 2018, provided the following guidance for “Severe Turbulence”:

GENERAL

If turbulence is unavoidable, aim to keep the speed in the region of the target speed given in this section, so as to provide the best protection against the effect of gust on the structural limits, while maintaining an adequate margin above VLS. Consider requesting a lower flight level to increase margin to buffet onset. Sufficient buffet margin exists at optimum altitude.

Severe turbulence is defined as turbulence that causes large, abrupt changes in altitude or attitude. It usually causes large variations in airspeed. Occupants are forced violently against their seat belts and loose objects will move around the aircraft. If severe turbulence occurs during a flight, the flight crew must make a logbook entry in order to initiate maintenance action.

NOTE: Recommendations for severe turbulence are also applicable to extreme turbulence.

AUTOPILOT/AUTOTHRUST

Keep the autopilot ON. When thrust changes become excessive: Disconnect Autothrust. For approach: Use A/THR for managed speed.

THRUST AND AIRSPEED

Set the thrust to give the recommended speed (see appropriate table below). This thrust setting attempts to obtain, in stabilized conditions, the speed for turbulence penetration given in the graph below. Only change thrust in case of an extreme variation in airspeed, and do not chase your Mach or airspeed. A transient increase is preferable to a loss of speed that decreases buffet margins and is difficult to recover.

5.4 Speed Limitations

The Frontier Airlines, Flight Operations Manual – Volume II A320 Series, “General Limitations”, Revision 75, dated August 8, 2019, provided the following chart of airspeed limitations for turbulent air:

RECOMMENDED TURBULENT AIR PENETRATION SPEED

Operating Altitude	A319/A320	A321
FL190 and below	250 kt	270 kt
FL200 to FL310	275 kt	300 kt
Above FL310	0.76 Mach	0.76 Mach

Figure 2: Recommended Turbulent Air Penetration Speed (Source: Frontier Airlines FOM Vol. II)

5.4.1 Thrust Setting for Recommended Speed in Severe Turbulence

The Frontier Airlines, Flight Operations Manual – Volume II A320 Series, “Adverse Weather”, Revision 73, dated December 14, 2018, provided the following chart for thrust setting for recommended turbulence speed:

A320 NEO THRUST SETTING FOR RECOMMENDED SPEED IN SEVERE TURBULENCE

SEVERE TURBULENCE									
N1 SETTING FOR RECOMMENDED TURBULENCE SPEED (%)									
FL	Speed or Mach	WEIGHT (1000 lb)							
		100	110	120	130	140	150	160	175
		N1%							
390	0.76	77.5	78.5	79.8	81.1	-	-	-	-
370	0.76	76.5	77.4	78.3	79.4	80.6	-	-	-
350	0.76	76.0	76.7	77.6	78.4	79.3	80.4	81.6	-
330	0.76	75.8	76.5	77.2	78.0	78.8	79.6	80.5	82.1
310	280	75.7	76.2	76.9	77.5	78.3	79.0	79.7	81.0
290	280	74.0	74.6	75.2	75.8	76.5	77.2	78.0	79.3
270	280	72.5	73.0	73.5	74.2	74.8	75.5	76.2	77.5
250	280	70.8	71.3	71.8	72.5	73.1	73.8	74.5	75.7
200	280	67.0	67.5	68.0	68.6	69.2	69.8	70.5	71.6
150	260	60.0	60.6	61.3	62.0	62.7	63.5	64.3	65.6
100	260	56.1	56.6	57.2	57.8	58.5	59.3	60.1	61.4
50	260	52.6	53.0	53.6	54.1	54.7	55.4	56.1	57.3

Figure 3: N1 Thrust Setting for Recommended Turbulent Penetration Speed
(Source: Frontier Airlines FOM Vol II)

5.5 Weather Radar

The Frontier Airlines, Flight Operations Manual – Volume II A320 Series, “Adverse Weather”, Revision 73, dated December 14, 2018 provided the following guidance on the use of the weather radar:

OPERATIONAL USE

TILT AND RANGE

CAUTION

Before selecting WX, WX/T or MAP mode on the control unit, make certain that:

- No one is within a distance less than 17 feet from the antenna in movement, within an arc of plus or minus 135° of either side of the aircraft centerline.
- The aircraft is not directed towards any large metallic obstacle, such as a hangar, which is within 17 feet in a arc of plus or minus 90° on either side of the aircraft centerline.

DETECTION AND INTERPRETATION

General

1. The flight crew should monitor the weather at long range, as well as that at shorter ranges, in order to be able to plan efficient course changes and to avoid weather-defined blind alleys and box canyons.
2. Ground returns usually appear smaller, sharper, more packed, better defined, and more angular than weather targets, whereas the latter usually appear larger, have less definite shapes, and tend to remain relatively unchanged.
3. The line-of-sight distance to the horizon is:

$$D(\text{NM}) = 1.23 \sqrt{(\text{aircraft altitude (feet)})}$$

Red and magenta areas: thunderstorms, tornadoes, hail The steeper the gradient of rainfall rate, the stronger the turbulence (magenta color) and the possibility of hail.

- To use the radar effectively for avoiding thunderstorms, the flight crew should select the following ranges on the NDs (if possible):
 - 160 NM on the Pilot Non-Flying (PM) ND
 - 80 NM on the Pilot Flying (PF) ND
- To avoid a large storm, the flight crew must make decisions while still 40 NM from it. Therefore the flight crew should:
 - Avoid magenta (WX+T mode) and red areas and fringes by at least 20 NM above FL230 and by 5 to 10 NM below FL230.
 - Avoid single magenta areas of turbulence (not associated with heavy precipitation) by at least 5 NM.
- Flight crew should readjust the tilt frequently in order to monitor storm development and to get the best cell echo.
- Failure to tilt the antenna down periodically may cause a target to disappear.
- The following formula calculates the vertical distance between the top of the cell and the aircraft flight level:

$$\Delta h (\text{feet}) \approx d (\text{NM}) \times \text{Tilt (degrees)} \times 100.$$

Example: Cell at 40 NM disappearing at less than 3 degrees downtilt

$$\Delta h \approx 40 \times 3 \times 100 = 12\,000 \text{ feet.}$$

- The pilot should not attempt to penetrate a cell or clear its top by less than 5000 vertical feet, because otherwise the aircraft may encounter severe turbulence.
- If the top of cell is at or above 25000 feet, overflying should be avoided due to the possibility of encountering turbulence stronger than expected.
- In the same way, the pilot should avoid flying under a thunderstorm because of possible windshear, microbursts, severe turbulence, or hail.

Turbulence mode

- The turbulence detection mode is most effective when the ND is set on 40 NM and the antenna is tilted to avoid ground return.
- When examining areas of heavy rainfall in WX+T mode, the flight crew should adjust antenna tilt frequently, because turbulence areas vary with the altitude.
- Closely spaced (or thin lines between) color gradations are usually associated with severe turbulence.

5.6 Dispatch Operations Manual

The Frontier Airlines, Dispatch Operations Manual, provided guidance and policies to their dispatchers. The information that pertained to turbulence is covered under the following sections.

5.6.1 Standard Aviation Weather Information System

The Frontier Airlines Dispatch Operations Manual, Appendix E provided the following guidance as to the available weather information available to the dispatcher within the contiguous United States:

The Standard Aviation Weather Information System at Frontier Airlines involves the collection and dissemination of aviation weather information obtained from approved sources for all operations types. Frontier Airlines will only use weather sources approved in A010 of the Operations Specifications, which ensures enough weather reporting and forecasting services along each and every route Frontier Airlines is to fly.

The approved sources include:

- *Primary aeronautical weather data for operations within the contiguous 48 United States and the District of Columbia is obtained from Weather Services International (WSI), which sources their data from the U.S. National Weather Service (NWS). NOTAM data is also sourced from WSI.*

NOTE: Any other weather data source may be used, as long as it was prepared by the U.S. National Weather Services or is a source approved by the U.S. National Weather Service. These include Flight Service Stations (FSS), ASOS stations, AWOS stations, and NWS offices.

- *The U.S. Department of Defense*

5.6.2 Frontier Airlines Aviation Weather Information System

The Frontier Airlines Aviation Weather Information System is an integral part of Frontier Airline's SOC, Dispatch, Flight Following, and Operational Control systems that allows personnel to obtain, through electronic or satellite communication, aviation weather information from authorized and approved weather sources and to disseminate that information to flight crews, dispatchers, and persons authorized to exercise operational control. This system also allows Dispatchers and flight crews to obtain and disseminate weather information rapidly, accurately, and in a format that is operationally suitable.

This system has both integrated and stand-alone components:

- *Authorized NWS weather data and NOTAMs is sourced from WSI and is provided to the SABRE Dispatch Monitor flight planning software for integrated use in flight planning and operational control decisions.*
- *Authorized NWS weather data, PIREPs, and other graphical weather data is sourced from WSI and is provided to the SABRE Flight Explorer aircraft situation display for integrated use in flight planning and operational control decisions. This software*

package allows real-time weather information to be overlaid graphically and textually along with airborne aircraft's position and flight track for real-time situational awareness and enhanced decision-making.

- A stand-alone briefing system is available at WSI's Pilot Brief website accessible through the Internet at each Aircraft Dispatcher's workstation. A satellite and backup feed provides continuous weather information, in both textual and graphical format.*
- The Flight crews may request METARs, TAFs, and Digital ATIS (D-ATIS) information at any time through the ACARS system on-board the aircraft.*
- A stand-alone briefing system is also available through the Aviation Digital Data Service (NOAA), or ADDS. This website is available through the internet at each Aircraft Dispatcher's workstation*

SYSTEM CAPABILITIES

The Frontier Airlines Aviation Weather Information System has adequate equipment and procedures for obtaining and distributing operational weather information to flight crews, dispatchers, and persons authorized to exercise operational control. The Aircraft Dispatcher is responsible for providing all pertinent weather and NOTAM information sourced from this system to flight crews through the Dispatch Release, ACARS, ARINC, or the telephone. This system provides adequate meteorological information to meet the pertinent regulatory requirements for all phases of flight, including preflight planning, departure, enroute, and arrival...

ALL PHASES OF FLIGHT

For all phases of flight (preflight planning, departure, en route, and arrival), the system provides flight crews, dispatchers, and persons authorized to exercise operational control with at least the following weather information. The source of that information is also noted below:

Weather Information	Source
Weather reports and forecasts for departure, destination, and alternate airports	SABRE Dispatch Monitor, WSI PilotBrief, ACARS, ADDS
Weather reports and forecasts for airports along the route of flight	SABRE Dispatch Monitor, WSI PilotBrief, ACARS, ADDS
Forecast winds and temperatures aloft for all route segments at planned cruising altitudes	SABRE Dispatch Monitor, WSI PilotBrief, ADDS
Surface observations for departure, destination, alternate, and diversionary airports	SABRE Dispatch Monitor, WSI PilotBrief, ACARS, ADDS
NOTAMs for departure, destination, alternate, and diversionary airports, and navigational facilities	SABRE Dispatch Monitor, WSI PilotBrief
Information to determine the Density Altitude (DA) at airports where takeoff and landing will occur	SABRE Dispatch Monitor, WSI PilotBrief, ACARS, (METARS and TAFs), ADDS
Hazards and adverse weather phenomena en route such as thunderstorms, turbulence, wind shear, icing, and volcanic ash	SABRE Dispatch Monitor, WSI PilotBrief, SABRE Flight Explorer ADDS
Severe weather cloud types such as cumulonimbus (CB) and standing lenticular (SL)	SABRE Dispatch Monitor, WSI PilotBrief, ADDS
Tropical cyclone data (tropical storm, typhoon, hurricane, and cyclone)	WSI PilotBrief,
Continual updates to weather and hazard advisories such as SIGMETs, convective SIGMETs, AIRMETS, VAAs, and PIREPS.	WSI PilotBrief, SABRE Flight Explorer, ADDS

5.6.3 Weather Packet

The Dispatch Release must contain, or have attached to it, weather reports, available weather forecasts, or a combination thereof, for the destination airport, intermediate stops, and alternate airports, that are the latest available at the time the release is signed by the pilot in command and dispatcher. It may include any additional available weather reports or forecasts that the pilot in command or the aircraft dispatcher considers necessary or desirable.

In compliance with the above regulation, initial dissemination of weather information obtained from the aviation weather information system is provided to the flightcrew by via a weather package as part of the printed Dispatch Release for all operations types. It contains the following, which are the latest reports or forecasts at the time of the printing of the Dispatch Release:

- METARs for the departure airport, destination airport, alternates, and airports along the intended route of flight.*
- TAFs for the departure airport, destination airport, alternates, and airports along the intended route of flight.*

- *AIRMETs, SIGMETs, and CONVECTIVE SIGMETs along the intended route of flight.*
- *PIREPs along the intended route of flight.*
- *D and FDC NOTAMs for the departure airport, destination airport, alternates, and airports along the intended route of flight.*
- *Dispatch NOTAMs for the departure airport, destination airport, alternates, and airports along the intended route of flight.*

5.6.4 Adverse Weather Phenomena Reports and Forecasts

Reports of adverse weather phenomena are based on real-time information provided by radar and satellite imagery. Pilots can also report adverse weather phenomena, when encountered or observed, via (PIREPs). Reports of adverse weather phenomena are issued by the NWS, in the United States, and by meteorological offices operated by foreign States outside of the United States. Reports of volcanic ash are issued by the Volcanic Ash Advisory Center (VAAC), which has locations worldwide.

The following weather information is used by Frontier Airlines to provide adverse weather information data, and the source of that data is also noted below:

Weather Information	Source
AIRMETs	WSI PilotBrief, SABRE Dispatch Monitor, SABRE Flight Explorer, ADDS
SIGMETs	WSI PilotBrief, SABRE Dispatch Monitor, SABRE Flight Explorer, ADDS
CONVECTIVE SIGMETs	WSI PilotBrief, SABRE Dispatch Monitor, SABRE Flight Explorer, ADDS
Volcanic Ash Advisories (VAA)	WSI PilotBrief Information regarding the VAAC can also be found via the National Oceanic and Atmospheric Administration's (NOAA) VAAC. The Web site for the two U.S. VAACs in Washington, DC, and Anchorage, AK, are http://www.ssd.noaa.gov/VAAC and http://vaac.arh.noaa.gov
Aviation Tropical Cyclone Advisories (TCAs). (Includes tropical storms, typhoons, hurricanes, and cyclones)	WSI PilotBrief – Information regarding worldwide TCAs can be found at http://www.nhc.noaa.gov/aboutsmc.shtml – Eastern Pacific and Atlantic tropical cyclone information is available at http://www.nhc.noaa.gov. – Central Pacific tropical cyclone information is available at http://www.prh.noaa.gov/hnl/cphc. – Western Pacific tropical cyclone information is available at http://www.cpc.ncep.noaa.gov/products/fews/CYCLONES/wpacific.shtml
Radar Imagery	WSI PilotBrief, SABRE Flight Explorer, ADDS
Satellite Imagery	WSI PilotBrief, SABRE Flight Explorer, ADDS
Collaborative Convective Forecast Product (CCFP)	WSI PilotBrief, SABRE Flight Explorer, ADDS
PIREPs	WSI PilotBrief, SABRE Dispatch Monitor, ADDS
METARs/SPECIs	WSI PilotBrief, SABRE Dispatch Monitor, ADDS
TAFs	WSI PilotBrief, SABRE Dispatch Monitor, ADDS
Area Forecast	WSI PilotBrief, SABRE Dispatch Monitor, ADDS

5.6.5 Communication from Dispatch

Each Aircraft Dispatcher will quickly disseminate any adverse weather phenomena information that may affect safety of flight to their flights in question. Pre-departure, this

may be done via a Dispatch Release remark, telephone contact with the flightcrew, or via ACARS. In-flight, this information will be communicated promptly via ACARS or ARINC.

CONTINUOUS MONITORING

All adverse weather phenomena systems described in Appendix E will be continuously monitored by the Aircraft Dispatcher throughout their entire shift.

PILOT WEATHER REPORTS (PIREPS)

Each Aircraft Dispatcher will quickly disseminate any PIREPs that may affect safety of flight to their flights in question. Pre-departure, this may be done via a Dispatch Release remark, telephone contact with the flight crew, or via ACARS. In-flight, this information will be communicated promptly via ACARS or ARINC.

NOTE: PIREPs should only be disseminated when reported by aircraft of a similar type and size.

LOCATION OF PHENOMENA

The graphical weather maps in WSI PilotBrief provide the location of adverse weather phenomena with reference to navigational fixes, and the weather overlays in SABRE Flight Explorer provide the location of adverse weather phenomena with reference to aircraft relative position.

6.0 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.”¹⁴

6.1 FAA Turbulence Fact Sheet

The FAA provided the following guidance titled “Fact Sheet – Turbulence” as of August 1, 2019 on their website:¹⁵

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?

¹⁴ Source: https://www.faa.gov/travelers/fly_safe/turbulence/

¹⁵ Source: https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=20074

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;*
- *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?

<i>Year</i>	<i>Passenger</i>	<i>Crew</i>	<i>Total</i>
2009	74	27	101
2010	35	23	58
2011	4	25	29
2012	4	19	23
2013	2	4	6

<i>Year</i>	<i>Passenger</i>	<i>Crew</i>	<i>Total</i>
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.

6.2 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.

6.3 FAA Advisory Circular AC 00-30C Clear Air Turbulence Avoidance

FAA AC 00-30C “Clear Air Turbulence Avoidance,” dated March 22, 2016, section 5.1 defines Clear Air Turbulence (CAT) as “*sudden severe turbulence occurring in cloudless regions that causes violent buffeting of aircraft...includes turbulence in cirrus clouds, within and in the vicinity of standing lenticular clouds and, in some cases, in clear air in the vicinity of thunderstorms.*” The AC further went on to state “*CAT is a recognized problem that affects all aircraft operations. CAT is especially troublesome because it is often encountered unexpectedly and frequently without visual clues to warn pilots of the hazard.*” The AC, in section 7 “Modern Turbulence Reports and Forecasts” goes on to state “*Automated turbulence reporting systems are common on many commercial aircraft using the Aircraft Meteorological Data Relay (AMDAR) system. Airline pilot reports are now being relayed to others by the airline’s aircraft dispatchers and by meteorologists working at the Federal Aviation Administration’s (FAA) air route traffic control centers (ARTCC).*”

AMDAR reports turbulence in terms of Eddy Dissipation Rate (EDR) which was the International Civil Aviation Organization (ICAO) standard dimension for automated turbulence reporting. EDR was a state-of-the-atmosphere measure rather than a state-of-the-aircraft measure and thus makes it independent of aircraft type.

In-flight weather advisories such as SIGMET and AIRMET are used to disseminate important information on atmospheric turbulence, both convective and CAT. In-flight weather advisories in the contiguous United States are issued by the Aviation Weather Center (AWC) as well as 20 Center Weather Service Units (CWSUs).

F. LIST OF ATTACHMENTS

Attachment 1: Flight Crew Statements

Attachment 2: Dispatch Release

Attachment 3: Flight Operations Manuals [Excerpts]

Attachment 4: Dispatch Operations Manual [Excerpts]

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