



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

February 24, 2020

Group Chairman's Factual Report

OPERATIONAL FACTORS

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Table Of Contents

A.	ACCIDENT	4
B.	OPERATIONAL FACTORS GROUP	4
C.	SUMMARY	4
D.	DETAILS OF THE INVESTIGATION	4
E.	FACTUAL INFORMATION	5
1.0	History of Flight.....	5
2.0	Flight Crew Information	7
2.1	Captain	7
2.1.1	Captain's Training and Proficiency Checks Completed	7
2.1.2	Captain's Flight Times	8
2.2	First Officer.....	8
2.2.1	First Officer's Training and Proficiency Checks	9
2.2.2	First Officer's Flight Times.....	9
3.0	Airplane Information	10
3.1.1	Maintenance Logbook Entry	11
3.2	Weight and Balance	11
4.0	Meteorological Information.....	12
4.1	Dispatch Release	12
4.2	Archived PIREPs	12
5.0	Company Overview	14
6.0	Relevant Systems.....	15
6.1	Airplane Operations Manual Vol. 2.....	15
6.1.1	Traffic Collision Avoidance System (TCAS)	15
6.1.2	Weather Radar.....	15
6.1.2.1	Turbulence Detection	16
6.1.2.2	Weather Radar Indications on the Primary Flight Display (PFD)	16
6.1.2.3	Weather Radar Indications on the Multifunction Display (MFD)	18
7.0	Compass Airlines Guidance.....	21
7.1	Flight Operations Manual	21
7.1.1	Turbulence – Industry Definitions	21
7.1.2	Severe Weather Policy	22
7.1.3	Turbulence Avoidance	22
7.1.3.1	Unexpected Turbulence Guidelines	22

7.1.4	Avoidance of Known Severe Weather	24
7.1.5	Approved Sources of Weather	25
7.1.6	SIGMETs: General.....	26
7.1.7	Reporting Unforecast Weather Irregularities	26
7.1.8	Reduced Vertical Separation Minimum (RVSM).....	27
7.1.8.1	Pilot/Controller Actions – RVSM	28
7.1.9	Required Maintenance Reports	28
7.2	Aircraft Operating Manual Vol. 1.....	29
7.2.1	Traffic Alert and Collision Avoidance (TCAS).....	29
7.2.2	TCAS Operation in RVSM Airspace	29
7.2.3	TCAS Recovery	30
7.2.3.1	TCAS Indication	33
7.2.3.2	TCAS Map Overlay Indication	34
7.2.4	Altitude/ Course Deviations Due to Weather.....	35
7.3	System Operations Control Procedures Manual	35
7.3.1	Dispatchers Requirement to Flight Follow	35
7.3.2	Enhanced Weather Information System (EWINS)	36
8.0	FAA Guidance	36
F.	LIST OF ATTACHMENTS	39

A. ACCIDENT

Operator: Compass Airlines
Location: Near Reno Nevada
Date: February 13, 2019
Time: 1455 Pacific Standard Time (PST)¹
Airplane: Embraer E170-200LR, Registration N613CZ, Serial No. 17000203
Flight No.: 5763

B. OPERATIONAL FACTORS GROUP

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

Patrick Hempen
AVP-100
Federal Aviation Administration
800 Independence Ave
Washington, DC 20594

Jonathan Gourdoux
Director of Safety
Compass Airlines
Minneapolis, MN

Alexander Lindsey²
Vice-Chairman Central Air Safety
Airline Pilots Association – Compass
Minneapolis, MN

C. SUMMARY

On February 13, 2019 about 1232 PST, Compass Airlines flight 5763 (CPZ5763), an Embraer 175 (E175), registration N613CZ, from John Wayne-Orange County Airport (SNA), Santa Ana, California to Seattle-Tacoma International Airport (SEA), Seattle, Washington encountered turbulence while in cruise flight at flight level 340 (FL340) and subsequently diverted into Reno-Tahoe International Airport (RNO), Reno, Nevada. One flight attendant sustained serious injuries and 3 passengers received minor injuries. None of the other passengers or crewmembers were injured and the airplane received minor damage. CPZ5763 was operating under the provisions of 14 *Code of Federal Regulations (CFR)* Part 121 as a passenger flight and instrument meteorological conditions in flight prevailed at the time.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board (NTSB) investigator on the Operational Factors Group was assigned to the accident on February 23, 2019 and did not travel to the accident location. The group chairman was briefed by the Investigator in Charge (IIC) on the events surrounding the incident. An Operational Factors Group was formed with party members from the

¹ All times in the report will be Pacific Standard Time except as otherwise noted. At the time of the incident Greenwich Mean Time, also known as Zulu time, was 8 hours ahead of PST and the date and time of the event was February 16, 2017 0400Z

² Alexander Lindsey had left Compass ALPA at the time of the group factual completion. The group factual was reviewed by ALPA Engineer Chris Heck.

Federal Aviation Administration (FAA), Compass Airlines (Operator), and the Airline Pilots Association (ALPA).

The Operational Factors Group chairman requested from the operator manuals and other various items for the investigation, as well as notifying the operator that the Operational Factors Group would be interviewing the flight crew.

The Operational Factors Group interviewed both pilots on March 5, 2019. See attachment 1- "Flight Crew Interview Summaries and Statements" for additional information on the pilot's interviews.

The Operational Factors Group interviewed an additional Compass Airlines crew on March 7, 2019 due to that flight's close proximity to the accident flight at the time of the turbulence encounter. See attachment 2, "Overhead Flight Crew - Interview Summaries" for additional information.

The Operational Factors Group interviewed Compass Airlines' personnel on March 20 through March 26, 2019. The interviewees included, in part, the accident flight dispatcher, a dispatch duty manager, and other personnel. See attachment 4, "Compass Airline Personnel Interview Summaries," for additional information.

E. FACTUAL INFORMATION

1.0 History of Flight³

Compass Airlines flight 5763 had departed John Wayne-Orange County Airport (SNA) at 1130 Pacific standard time (PST), which was the original scheduled departure time. The flight's planned arrival time was 1411 PST.

The accident flight's departure phase was uneventful. The captain reported that during climbout they had some rain showers in their vicinity and both pilots reported that the air was turbulent for the first approximately 40 minutes of flight. In cruise they kept the seatbelt sign illuminated and had the flight attendants remain in their seats due to the turbulence. They classified the turbulence as moderate, decreasing to light and subsequently smooth. Prior to the accident flight they had flown from SEA to SNA and they reported during that flight, they had assessed the weather and ride conditions for their return flight (accident flight).

Prior to departure from SNA, the captain reviewed the weather packet provided by operations in their dispatch release for their return flight and determined the ride would be similar to the flight they had just completed from SEA. The dispatch release provided them with SIGMETs⁴ for turbulence as well as a PIREP⁵ indicating severe turbulence. However, the PIREP was below their planned cruise altitude. The crew determined the flight attendants would remain

³ Sources: Attachment 1 - "Flight Crew Interview Summaries" and Attachment 2 - "Flight 6058 Flight Crew Interview Summaries."

⁴ Significant Meteorological Information

⁵ Pilot Report

seated and the captain, after the flight climbed through 10,000 feet, would make an announcement to the passengers of the potential turbulence and the seatbelt sign was to remain illuminated.

The captain stated that approximately 40 minutes into the flight they had encountered smooth air and air traffic control (ATC) had reported “occasional light chop” in the area. Considering the information, the captain determined the flight attendants could conduct their cabin service but left the seatbelt sign illuminated.

During the flight crew interviews, the accident crew reported they were “between cloud layers” but considered it to be instrument meteorological conditions (IMC). Additionally, another aircraft was flying southbound and one-thousand feet above the accident flight, reported they were on top of the cloud layer but that it was “hazy.”

The accident crew further stated that ATC “pointed out” the opposite direction traffic one-thousand feet above their route of flight. However, due to the cloud layer they were unable to visually acquire the approaching aircraft. Subsequently, the accident flight encountered an area of “severe turbulence,” which resulted in the aircraft ascending in altitude, and the airplane providing an audible alert to descend from the TCAS⁶. The captain further reported after encountering the turbulence, “anything not secured on the flightdeck had become airborne.” The first officer, who was the pilot flying (PF), reported that he disengaged the autopilot and applied forward control column pressure, in order to place the FPV⁷ symbol into the TCAS RA⁸ box. However, the first officer reported that he was applying forward pressure but could not get the FPV symbol into the range needed. The captain, who was the pilot monitoring (PM) for the flight, assisted on the controls in order to descend the aircraft as the RA guidance was depicting. During this time, the other aircraft that was one-thousand feet above the accident aircraft, received a “traffic, traffic” audible alert. The symbol showing the accident flight turned from white to yellow⁹. (For further TCAS system information reference Section 7.2.3.2 in this report.)

The accident crew additionally provided after they had descended, they received an audible “clear of conflict” alert from the TCAS system and the “severe turbulence” they had encountered subsided. The FO stated they climbed back up to their assign altitude of FL340, engaged the autopilot, and estimated that the encounter with the turbulence was about 8 seconds in duration. The captain then reported the TCAS RA and turbulence to ATC

Following the turbulence encounter, while the PM was communicating with ATC the PF contacted the flight attendants to assess the cabin but was told initially there were items in the aisle and coffee dripping from the ceiling. Subsequently, the PM contacted the cabin and was informed that one of the flight attendants, located in the aft section of the cabin, may have broken her arm. Also, one passenger who had been using the lavatory at the time of the encounter had a laceration on her head and was bleeding.

⁶ Traffic Collision Avoidance System

⁷ Flight Path Vector

⁸ Resolution Advisory

⁹ Section 7.2.3.2 uses the term ‘amber’ instead of ‘yellow’ as the captain reported.

The crew divided up their duties and the PF assumed control of the radios, while the captain contacted their dispatcher via a radio frequency. The determination was to divert to RNO, and the flight would be met by ARFF¹⁰ to assess any exterior damage as well as to assist with the injured.

After landing, the crew taxied the airplane to the gate, where EMTs¹¹ boarded the flight to assess the injured. After the EMTs assessed the injured they deplaned the passengers and the injured flight attendant and injured passenger were transported to a local hospital.

2.0 Flight Crew Information

Documentation provided by Compass Airlines showed the accident flight occurred on the last day of a 2-day crew rotation. The first day of the rotation began with a report time of 0709 and included 1 flight from SEA to Portland International Airport (PDX), Portland, Oregon with a 19:33-hour layover in Portland. The second day (day of the accident flight) began with a report time of 0515 and the crew operated a flight from PDX to SEA, then SEA to SNA, and then the accident flight to SEA.

Pilot certification information was obtained from the pilots, operator, and the FAA.

The accident flightcrew consisted of 2 pilots and 3 cabin crew¹² members. The first officer was the pilot flying (PF) and the captain was the pilot monitoring (PM) on the accident flight.

2.1 Captain

The captain was 32 years old and held an Airline Transport Pilot (ATP) certificate with a rating for airplane multiengine land and type ratings on the BE-1900¹³, ERJ-170¹⁴, and ERJ-190, which included limitations of “ATP CIRC. APCH. – VMC ONLY and ERJ-170 ERJ-190 CIRC. APRCH. VMC ONLY.” He also held a commercial pilot certificate for airplane single-engine land. He held an FAA first-class medical certificate dated January 24, 2019, with no limitations or waivers. At the time of the accident he was based at SEA.

According to the captain’s interview summary, he had been hired at Compass Airlines in April of 2015.

2.1.1 Captain’s Training and Proficiency Checks Completed

A synopsis of the captain's recent training at Compass Airlines was as follows¹⁵:

Date of Hire at Compass	May 11, 2015
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¹⁰ Airport Rescue and Fire Fighting

¹¹ Emergency Medical Technician

¹² The EMB175 required 2 cabin crewmembers; however, on the accident flight one of the cabin crewmembers was conducting an annual line check for the cabin crewmembers assigned to the flight.

¹³ Beechcraft Corporation 1900, 1900C, 1900D. Source FAA Order 8900.1, Figure 5-88.

¹⁴ Embraer S.A. ERJ 170-100 STD, ERJ 170-100 LR, ERJ 170-100 SU, ERJ 170-100 SE, ERJ 170-200 STD, ERJ 170-200 LR, ERJ 170-200 SU, ERJ 190-100 STD, ERJ 190-100 LR, ERJ 190-100 IGW, ERJ 190-100 ECJ, ERJ 190-200 STD, ERJ 190-200 STD, ERJ 190-200 LR, ERJ 190-200 IGW. Source: FAA order 8900.1 Figure 5-88.

¹⁵ Source: Attachment 5 – “Flight Crew Training Records [Excerpt]”.

Recurrent Ground School ¹⁶	December 21, 2018
Upgrade OE ¹⁷	January 17, 2017
Upgrade to captain ¹⁸	November 30, 2016
Most Recent Line Check	April 3, 2018
Most Recent Crew Resource Management	December 21, 2018
Most Recent Maneuver Validation (MV)	December 22, 2018
Most Recent Line Oriented Evaluation (LOE)	January 27, 2019
Most Recent FAA Observation	March 12, 2018
Most Recent High Altitude Operations Training ¹⁹	May 15, 2015
Aircraft Systems – Continuing Qualification	September 26, 2018

2.1.2 Captain’s Flight Times

The Captain’s flight times were based on the pilot’s interview summary and Compass Airlines provided documentation:

Total pilot flight time ²⁰	4,284 hours
Total EMB175 flight time ²¹	2,745 hours
Total EMB175 PIC flight time ²²	1,588 hours
Total flight time preceding 24 hours ²³	5:27 hours
Total flight time preceding 7 days	9:06 hours
Total flight time preceding 30 days	39:00 hours
Total flight time last 90 days ²⁴	116:00 hours

2.2 First Officer

The FO was 30 years old; held an ATP certificate with type ratings on the ERJ-170, ERJ-190, and SAAB 340²⁵ as second in command (SIC); with limitations of “SF-340 SIC

¹⁶ Recurrent ground instruction included Knowledge Validation, Advanced CRM, Aircraft Systems, Emergency Drills, Emergency Situation Training, and Weight & Balance and Performance.

¹⁷ Operating Experience

¹⁸ Upgrade training began with initial ground school on November 30, 2016 and concluded December 4, 2015 with Procedures Validation training.

¹⁹ This was part of the pilot’s initial training

²⁰ Total flight was an estimation provided by the captain; the airline had his total time as 4,270 hours.

²¹ Flight time was an estimate provided by the captain; the airline had his total flight experience in the EMB175 as 2,727 hours.

²² PIC flight experience in the EMB175 was an estimation by the captain; the airline had his total PIC experience in the EMB175 as 1,570 and total PIC experience in all aircraft was 1,962 hours.

²³ Flight time **does not** include the accident flight. Attachment 6 – “Accident Flight Crew Schedules.”

²⁴ Source: Compass Airlines completed NTSB Accident/Investigation 6120.1 form

²⁵ SAAB-Fairchild International, S-58188 Linköping, Sweden SAAB-Fairchild 340. Source FAA Order 8900.1, Figure 5-88.

PRIVILEGES ONLY.” He held a commercial pilot certificate for airplane single-engine land. He also held an FAA first-class medical certificate dated November 16, 2018, with no limitations or waivers. At the time of the accident he was based at SEA.

According to the first officer’s interview he had been hired at Compass Airlines in January 2018 and had been flying the EMB175 aircraft the entire time.

2.2.1 First Officer’s Training and Proficiency Checks

A synopsis of the FO’s recent training at Compass Airlines is as follows²⁶:

Date of Hire with Compass	January 25, 2018
Initial Ground School ²⁷	February 1, 2018
Initial OE	May 14, 2018
Most Recent Line Check ²⁸	May 14, 2018
Line Oriented Evaluation	April 25, 2018
Initial AQP Maneuver Validation	April 8, 2018
Initial AQP Procedures Validation	March 15, 2018
Initial Aircraft System Training	February 1, 2018
Initial AQP Systems Validation	March 2, 2018
Emergency Situation Training	February 15, 2018
AQP High Altitude Operations Training	January 14, 2019

2.2.2 First Officer’s Flight Times

The First Officer’s flight times were based on Compass Airlines provided documentation and pilot interview summaries:

Total pilot flight time ²⁹	2,233:00 hours
Total EMB175 flight time	674:00 hours
Total flight time preceding 24 hours ³⁰	5:27 hours
Total flight time preceding 7 days	18:08 hours
Total flight time preceding 30 days	40:00 hours
Total flight time last 90 days ³¹	195:00 hours

²⁶ Source: Attachment 5 – “Flight Crew Training Records [Excerpts].”

²⁷ Initial Ground School began on February 1, 2018 and concluded on February 15, 2018. Topics covered included in part crew resource management, emergency drills, high altitude operations, and aircraft systems.

²⁸ The first officer’s line check was his initial line check in accordance with *CFR* 121.440. Source: Attachment 5 – “Flight Crew Training Records.”

²⁹ Total flight was an estimation provided by the first officer. Source: Attachment 1 – Flight Crew Interview Summaries. Additionally, the company provided documentation reported 566 hours of flight experience as PIC in all aircraft but 0 hours of PIC experience in the EMB175.

³⁰ Flight Time **does not** include the accident flight. Source: Attachment 6 – “Accident Flight Crew Schedules.”

³¹ Source: Compass Airlines completed NTSB Accident/Investigation 6120.1 form

3.0 Airplane Information



Photo 1: Accident Airplane, N613CZ (Courtesy of JetPhotos.net)

The accident airplane (Registration N613CZ, Serial No. 17000203) was an Embraer-Empresa Brasileira De ERJ 170-200LR. The airplane was built in 2008, registered to Delta Air Lines, Inc, operated by Compass Airlines LLC as a Delta Connection flight, and held a transport category airworthiness certificate dated January 23, 2008. The airplane was powered by 2 General Electric CF34-8E5 engines, each were rated at 14,510 pounds of thrust. The airplane was configured with 2 pilot seats, 1 cockpit observer seat, 4 flight attendant seats, and 76 passenger seats.

According to the accident flight's dispatch release there were no maintenance deferral items at the time of departure.

3.1.1 Maintenance Logbook Entry

After landing at RNO the captain made the following three entries in the aircraft maintenance logbook³²:

Encountered severe turbulence in cruise (for about 5 secs) along with the possibility of overspeed for less than 10 sec. occurred once.

R2 Door Trim Damaged and trim by R2 exit sign cracked and light hanging down.

Aft first aid kit opened in flight.

3.2 Weight and Balance

The following weight and balance information was taken from the flight manifest. Limitations were taken from the Compass Airlines Aircraft Operating Manual, Chapter 2 “Limitations”, dated June 15, 2015 and are indicated in **bold** type. All weights below are in pounds (lbs.).

Basic Operating Weight	50,703
70 Passengers ³³	12,678 ³⁴
Total Baggage/Cargo ³⁵	1,350
Total Payload	14,028
Zero Fuel Weight	64,731
Maximum Zero Fuel Weight	70,547
Required Fuel	16,000
Taxi Fuel	500
Ramp Weight	80,731
Maximum Ramp Weight	89,352
Takeoff Weight	80,231
Maximum Takeoff Weight³⁶	89,000
Planned Fuel Burn	8,760
Planned Landing Weight ³⁷	71,471
Maximum Landing Weight	75,177

³² Source: Attachment 12 – “Aircraft Maintenance Logbook Entry.”

³³ Total Passengers included 61 Adults and 9 Children.

³⁴ Compass used average passenger weights to compute weight and balance. The Compass Airlines Weight and Balance Control Manual, Chapter 1 “W&B Programs & Procedures, Standard Average Weight Program”, pg. 3-1-2 defined an average adult weight (13 years and older) as 195 lbs. and an Average Child Weight (2 years to 12 years of age) was 87 lbs.

³⁵ Baggage/Cargo Weight included 45 bags and no cargo in the cargo hold. The Compass Airlines Weight and Balance Control Manual, Chapter 1 “W&B Programs & Procedures, Standard Average Weight Program”, pg. 3-1-3 defined a checked bag weight as 30 pounds and a heavy bag weight 60 pounds.

³⁶ The maximum takeoff weight allowed due to performance requirements for departure from SNA was 83,937. Source: Attachment 7 – “Accident Flight Dispatch Release.”

³⁷ Planned landing weight was a dispatch estimated weight based on an estimated takeoff weight. The landing weight would have likely been 71,091 lbs. based on actual payload of the aircraft.

4.0 Meteorological Information

4.1 Dispatch Release

The accident flight's dispatch release was 63 pages in length and was titled "OFP 1." It consisted of the flight plan summary section on pages 1 thru 11, which contained crew names, remark section, planned weights, fuel requirements for the flight, and the flight plan. Page 12 thru 40 included, departure, enroute and arrival weather, which included AIRMETS³⁸, SIGMETS, Convective SIGMETS, NOTAMs³⁹, and PIREPs. Page 41 thru 57 included weather graphics and satellite images. Additionally, page 58 thru 63 included takeoff and landing performance data.

During the course of the investigation, it was noted that pages 41 to 57 were not included with the paperwork that the accident pilots received prior to departure. Compass Airlines was able to determine that the reason it was not included was due to a printer capability issue.

According to the accident flight crew, SNA operations utilized a dot-matrix or teletype printer which was unable to print off the weather graphics. The dot-matrix or teletype printers would provide the crew with the textual depiction only. Additionally, the accident flight's dispatcher was aware that a dispatch release printed, at the station, would not include the graphical weather charts. A System Operational Control Center duty manager, that was interviewed, was unaware of the printer limitation at the outstations. In order for some of the stations to print off the graphical charts for the crew, the gate agent would be required to locate a laser printer⁴⁰.

4.2 Archived PIREPs⁴¹

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 11 PIREPs within approximately 100 miles of RNO. The 11 PIREPs were filed as follows:

MOD UA /OV MOD055060/TM 2110/FL320/TP E75L/TB MOD CHOP/RM ZOA CWSU

TPH UA /OV MVA260015/TM 2131/FL310/TP CL60/TB MOD/RM ZOA CWSU

TPH UA /OV MVA/TM 2132/FL370/TP B737/TB CONS LGT-OCNL MOD/RM ZOA CWSU

SCK UA /OV LIN060060/TM 2201/FL350/TP UNKN/TB LGT CHOP 310-390/RM RPTD BY MULTIPLE AIRCRAFT...ZOA CWSU

SMF UUA /OV HNW070030/TM 2300/FL220/TP PRM1/TB SEV/RM 220-120 DURD

³⁸ Airmen's Meteorological Information

³⁹ Notice to Airmen

⁴⁰ Source: Attachment 4 – Compass Airline Personnel Interview Summaries ppg. 4 and 25

⁴¹ Source: Iowa State University, Iowa Environmental Mesonet

<https://mesonet.agron.iastate.edu/request/gis/pireps.php>

AUN UUA /OV HNW090030/TM 2303/FL220/TP PRM1/TB SEV CAT 220-100/RM ZOA CWSU

RNO UA /OV FMG360015/TM 2305/FL300/TP B752/TB MOD/RM ZOA CWSU

RNO UA /OV FMG160050/TM 2306/FL220/TP CRJ7/TB LGT-MOD 220-160/RM DURD NORTH BOUND...ZOA CWSU

AUN UUA /OV HNW/TM 2314/FL120/TP PRM1/WX RA/TB MOD-SEV 220-120/RM ZOA CWSU

MOD UA /OV MOD070060/TM 2319/FL260/TP B712/TB MOD CAT/RM ZOA CWSU

TPH UA /OV MVA/TM 2355/FL370/TP B737/TB LGT-OCNL MOD CHOP/RM ZOA CWSU

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

Modesto City/County Airport (MOD), Modesto, California; Location – over a point 60 miles east northeast of MOD VOR⁴²; Time 2110 UTC (1310 PST); Altitude - FL320; Aircraft - Embraer 175L; Turbulence – Moderate Chop; Remarks Oakland Center Weather Service Unit.

Tonopah Municipal Airport (TPH), Tonopah, Nevada; Pilot Report (UA); Location – over a point 15 miles to the west of the Mina VORTAC (MVA), Mina, Nevada; Time 2131 UTC (1331 PST); Altitude – FL310; Aircraft – CL-60⁴³; Turbulence – Moderate; Remarks – Oakland Center Weather Service Unit.

Tonopah Municipal Airport (TPH), Tonopah, Nevada; Pilot Report (UA); Location – over the Mina VORTAC (MVA), Mina, Nevada; Altitude – FL370; Turbulence – continuous light to occasional moderate; Remarks – Oakland Center Weather Service Unit.

Stockton Metropolitan Airport (SCK), Stockton, California; Pilot Report (UA); Location – over a point 60 miles east northeast of the Linden VOR/DME, Linden, California; Time – 2201 UTC (1401 PST); Altitude – FL350; Aircraft – Unknown; Turbulence – light chop between FL310 and FL390; Remarks – Reported by multiple aircraft Oakland Center Weather Service Unit.

Sacramento International Airport (SMF); Sacramento, California; Urgent Pilot Report (UUA); Location – over a point 30 miles east of the Hangtown VOR/DME (HNW), Placerville, California; Time – 2300 UTC (1500 PST); Altitude – FL220; Aircraft – PRM1⁴⁴; Turbulence – Severe; Remarks – between FL220 and 12,000 ft during descent.

⁴² Very-high Omni-directional Range with Distance Measuring Equipment

⁴³ Bombardier Challenger 600 series business jets.

⁴⁴ Beechcraft Premier I was a light jet aircraft made by the Beechcraft division.

Auburn Municipal Airport (AUN), Auburn, California; Urgent Pilot Report (UUA); Over a point 30 miles to the east of the Hangtown VOR/DME (HNW), Placerville, California; Time - 2303 UTC (1503 PST); Altitude – FL220; Turbulence – Severe Clear Air Turbulence from FL220 to 10,000 ft; Remarks – Oakland Center Weather Service Unit.

Reno International Airport (RNO), Reno, Nevada; Pilot Report (UA); Location – Over a point 15 miles to the north of the Mustang VORTAC⁴⁵ (FMG); Reno, Nevada; Time – 2305 UTC (1505 PST); Altitude – FL300; Aircraft – Boeing 757-200; Turbulence – Moderate; Remarks – Oakland Center Weather Service Unit.

Reno International Airport (RNO), Reno, Nevada; Pilot Report (UA); Location 50 miles to the south of the Mustang VORTAC (FMG); Reno, Nevada; Time – 2306 UTC (1506 PST); Altitude – FL220; Aircraft – CRJ7; Turbulence – Light to Moderate from FL220 to 16,000 ft during descent northbound Oakland Center Weather Service Unit.

Auburn Municipal Airport (AUN), Auburn, California; Urgent Pilot Report (UUA); Location – Over the Hangtown VOR/DME (HNW), Placerville, California; Time – 2314 UTC (1514 PST); Altitude – 12,000 ft; Aircraft – PRM1; Weather – Rain; Turbulence – Moderate to Severe between FL220 and 12,000 ft; Remarks – Oakland Center Weather Service Unit.

Modesto City/County Airport (MOD), Modesto, California; Pilot Report (UA); Location – Over a point 60 miles east of the Modesto VOR/DME (MOD), Modesto, California; Time – 2319 UTC (1519 PST); Altitude – FL260; Aircraft – Boeing 717-200; Turbulence – Moderate Clear Air Turbulence; Remarks – Oakland Center Weather Service Unit.

Tonopah Airport (TPH), Tonopah, Nevada; Pilot Report (UA); Location – Over the Mina VORTAC (MVA), Mina, Nevada; Time – 2355 UTC (1555 PST); Altitude – FL370; Aircraft – B737; Turbulence – Light to Occasional Moderate Chop; Remarks – Oakland Center Weather Service Unit.

5.0 Company Overview

Compass Airlines began operation in March 2006 and received their FAA certification in April 2007. They began ERJ service in August of 2007 and in 2010, Compass Airlines was acquired by Trans States Holdings⁴⁶.

Compass Airlines provided scheduled air transportation within the United States, Canada, and Mexico. All of their flights were operated under code-share agreements with Delta Air Lines and American Airlines.

As of March 1, 2019, Compass Airlines, had 56 ERJ-170LR aircraft in scheduled service and of those 36 aircraft were operated under the Delta Air Lines agreement and 20 aircraft were operated under the American Airlines agreement.

⁴⁵ Very-high frequency Omni-directional Range with Tactical Air Navigation system

⁴⁶ Trans States Holdings, Inc was a privately-owned holding company for three regional airlines: Compass Airlines, GoJet Airlines, and Trans States Airlines.

According to Compass Airlines Operation Specification A001-1, Compass Airlines was authorized to conduct operations in accordance with FAA-approved Operation Specification, certificate number C77A868L. Compass Airlines was authorized to conducted Domestic, Flag, Supplemental Operations, and 14 *CFR Part 91* flights.

As of February 14, 2018, Compass Airlines employed 723 pilots, 538 flight attendants, and 22 dispatchers.⁴⁷

Compass Airlines was based in Minneapolis, Minnesota. Compass began in 2006 as part of the Northwest Airlines⁴⁸ restructuring plan.

Compass Airlines' pilots were based at one of 3 pilot bases, Los Angeles International Airport (LAX), Los Angeles, California, Phoenix Sky Harbor International Airport (PHX), Phoenix, Arizona, or SEA.

6.0 Relevant Systems

6.1 Airplane Operations Manual Vol. 2

Compass Airlines, Airplane Operations Manual – Volume 2, Revision 18, dated July 2, 2014 provided the following information on the following systems:

6.1.1 Traffic Collision Avoidance System (TCAS)

Compass Airlines, Airplane Operations Manual – Volume 2, Section “Systems Description Warning System – Traffic Collision Avoidance System” provided the following information about the TCAS system:

The TCAS detects the nearby airplanes and display symbols to represent them. The relative or absolute altitude and the vertical motion of the other airplanes are information displayed with each symbol.

The TCAS monitors a potential collision hazard and alerts the flight crew. It interrogates the mode A, mode C and mode S operating transponders in other airplanes and calculates the flight path of the possible intruder airplane.

If the intruder airplane is also equipped with operating TCAS, the systems will communicate with each other to coordinate and generate guidance for the optimal avoidance maneuver.

NOTE: *Intruder airplanes that do not have operating transponders are invisible to the TCAS.*

6.1.2 Weather Radar

Compass Airlines equipped their airplanes with either the Honeywell Primus WU-660 or WU-880 weather radar systems. The accident aircraft had the WU-660 installed. The system was

⁴⁷ These numbers did **not** include supervisors or duty managers for each work group.

⁴⁸ Northwest Airlines was a major airline in the United States and was merged with Delta Air Lines on October 29, 2008.

designed primarily for detection and analysis of the weather during flight and for ground mapping. The multifunction display (MFD) handles the display of radar data and in addition provided virtual controllers for weather radar control. Weather data was displayed on both MFDs, as well as on the Primary Flight Displays (PFD).

The weather radar system consisted of an integrated receiver transmitter antenna and two virtual weather radar controllers. Display of the weather data was available on the MFDs and PFDs.

6.1.2.1 Turbulence Detection

Compass Airlines, Airplane Operations Manual – Volume 2, Section “Systems Description – Flight Instruments/Comm/Nav/FMS” provided the following information about the turbulence detection available through the weather radar system:

The radar processes return signals in order to determine if a turbulence signature is present. Areas of moderate, severe, or extreme turbulence are displayed in soft white. TURB may only be engaged in the WX mode and at selected ranges of 50 NM or less.

NOTE: – It may occur that the Turbulence function annunciation in MFD and PFD to remain displayed for ranges above 50 NM even though the function is deactivated.

– Range selections of 200 NM or greater always clear Turbulence function annunciation.

6.1.2.2 Weather Radar Indications on the Primary Flight Display (PFD)

Compass Airlines, Airplane Operations Manual – Volume 2, Section “Systems Descriptions – Flight Instruments/Comm/Nav/FMS” provided the following pictorial and textual information about the weather radar indications on the PFD:

GREEN (WX/TX): Weather transmitting, but not selected for display on the PFD or MFD, when the airplane is in air.

GREEN (GMAP): GMAP mode.

GREEN (FSBY): forced standby.

GREEN (TEST): test mode and no faults.

AMBER (WX/TX): Weather transmitting, but not selected for display on the PFD or MFD, when the airplane is on ground.

AMBER (WX CTRL): invalid WX control bus.

AMBER (FAIL): failure is detected.

AMBER (OVRNG): MAP range greater than 300 NM.

WHITE (WX OFF): WX is OFF.

WHITE (WAIT): power up.

WHITE (STBY): normal standby.

WHITE (S): slave mode is active.

– *Third line:*

– *Stabilization annunciation: radar stabilization is inhibited.*

– *Target and gain mode annunciation.*

GREEN (TGT): TGT selected.

FLASHING AMBER (TGT): TGT selected and alert condition.

AMBER (VAR): variable gain selected.

4 - *WEATHER RADAR VIDEO ANNUNCIATION*

– *Indicates weather radar video failure.*

6.1.2.3 Weather Radar Indications on the Multifunction Display (MFD)

Compass Airlines, Airplane Operations Manual – Volume 2, Section “Systems Description – Flight instruments/Comm/Nav/FSM” provided the following pictorial and textual information about the weather radar indications on the MFD:



Figure 2: Weather Radar indications on the MFD (Source: Aircraft Operating Manual, Vol. 2)

1 - WEATHER RADAR RETURNS

- Displays target in colors.
- WX mode: the color indicates rain intensity. In increasing order of intensity: green, yellow, red and magenta.
- RCT mode: attenuation is too high, hiding possible severe weather areas (cyan).
- GMAP mode: color indicates surface information: black, cyan, yellow and magenta.
- TURB mode: areas of potentially hazardous turbulence (white).

2 - TARGET ALERT CHECKBOX

- Enables and disables the radar target feature. Can only be selected in the WX mode and at selected ranges of 200 NM or less.

3 - RAIN ECHO ATTENUATION COMPENSATION TECHNIQUE CHECKBOX

- Enables REACT function in all modes, except GMAP.

4 - ALTITUDE COMPENSATED TILT CHECKBOX

- Enables automatic adjustment of the antenna tilt in relation to the altitude and selected range.
- 5 - **TURBULENCE DETECTION CHECKBOX**
 - Enables the turbulence function only in the WX mode and at selected ranges of 50 NM or less.
- 6 - **GAIN INDICATION DISPLAY**
 - Indicates receiver sensitivity level from 0 to 100.
- 7 - **RECEIVER GAIN CHECKBOX**
 - Enables manual variation of the receiver sensitivity.
- 8 - **ANTENNA STABILIZATION CHECKBOX**
 - Enables/disables automatic antenna stabilization.
 - An amber STAB label is displayed within the weather box when automatic antenna stabilization is disabled.
- 9 - **SECTOR SCAN CHECKBOX**
 - Enables the sector scan function for both pilots' displays.
- 10 - **OFF MODE**
 - Turns off the weather mode, provided OFF is selected in both weather radar virtual controllers.
 - In flight only, a single virtual controller selected to OFF operates in SLAVE mode.
- 11 - **STANDBY MODE**
 - Selects the radar system into a standby mode, provided STBY is selected in both weather radar virtual controllers.
 - A green FSBY label is displayed within the weather box when forced standby is active, on the ground.
- 12 - **GROUND MAPPING MODE**
 - Enables ground mapping mode.
- 13 - **RADAR MODE**
 - In flight, activates the radar mode.
- 14 - **FORCED STANDBY OVERRIDE**
 - Enables WX on the ground, when selected on both pilots' virtual control panel.

NOTE: Selection of Antenna Stabilization checkbox (STAB OFF) 4 times in less than 3 seconds enables the forced Standby Override function (FSBY OVRD).

15 - WEATHER RADAR ANNUNCIATIONS

- First line:
 - CCD inner knob icon: tilt angle is modifiable.
 - Tilt angle readout: displays the tilt angle.
 - ACT annunciation: ACT is active.
 - Fault code data (entire line): fault has been detected.
- Second line:
 - Weather radar mode annunciation:
 - GREEN (WX): normal WX.
 - GREEN (WX/R): normal WX with RCT.
 - GREEN (WX/T): normal WX with TURB.

GREEN (WX/R/T): normal WX with RCT and TURB.
 GREEN (GMAP): GMAP mode.
 GREEN (FSBY): forced standby.
 GREEN (TEST): test mode and no faults.
 AMBER (WX CTRL): invalid WX control bus.
 AMBER (FAIL): failure is detected.
 AMBER (OVRNG): MAP range greater than 300 NM.
 WHITE (WX OFF): WX is OFF.
 WHITE (WAIT): power up.
 WHITE (STAB): STAB OFF function selected.
 WHITE (STBY): normal standby.
 WHITE (S): slave mode is active.

– Third line:

- Stabilization annunciation: radar stabilization is inhibited.
- Target and gain mode annunciation.
 - GREEN (TGT): TGT selected.
 - FLASHING AMBER (TGT): TGT selected and alert condition.
 - AMBER (VAR): variable gain selected.

7.0 Compass Airlines Guidance

7.1 Flight Operations Manual

Compass Airlines, Flight Operations Manual, Revision 30, provided the following guidance and policies:

7.1.1 Turbulence – Industry Definitions

The Compass Airlines, Flight Operations Manual, Section 8-19.3, provided the following table defining industry definitions of turbulence intensity and duration:

Intensity	
Light	Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw) OR causes slight rapid and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude (also called “Light Chop”)
Moderate	Turbulence 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 OR is similar to Light Chop but of greater intensity, causing rapid bumps or jolts without appreciable changes in aircraft altitude or attitude (also called “Moderate Chop”)
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.

Extreme	Turbulence in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage.
Duration	
Occasional	Occurring less than 1/3 of the time.
Intermittent	Occurring 1/3 to 2/3 of the time.
Continuous	Occurring greater than 2/3 of the time.

Table 1: Turbulence Definitions. (Source: Compass Airlines FOM Table 8-18-1)

7.1.2 Severe Weather Policy

The Compass Airlines, Flight Operations Manual, Section 8-9.2, provided the following policy of operating around severe weather. The policy was:

- A. *It is Compass policy not to operate flights in the proximity of severe or dangerous weather phenomena.*
- B. *Pilots and dispatchers will keep fully informed on the location and intensity of such phenomena, including ice, hail, thunderstorms, turbulence, volcanic ash, smoke and other similar occurrences, and take appropriate action.*
- C. *Flight deck crewmembers shall check the aircraft radar (as specified in AOM I) to ensure proper operation prior to flight in conditions requiring its use.*

7.1.3 Turbulence Avoidance

The Compass Airlines, Flight Operations Manual, Section 8-9.4, provided, in part, descriptions of the different levels of turbulence and crew actions, those were:

- A. *Compass policy is to avoid flight in moderate turbulence during cruise phase of flight and avoid occasional severe turbulence and greater in all phases of flight.*
- B. *There are four (4) levels of turbulence:*
 - 1. *Light: Small, erratic changes in altitude and/or attitude. Passengers and crew can feel a small strain against the seat belt.*
 - 2. *Moderate: Changes in altitude and/or attitude occur, but the aircraft stays in positive control at all times. It usually causes variation in the indicated airspeed. Passengers and crew feel a strain against seat belts.*
 - 3. *Severe: Large, abrupt changes in altitude and/or attitude. It usually causes large variation in the indicated airspeed. Aircraft can be momentarily out of control. Passengers and crew are violently force [sic] against seat belts.*
 - 4. *Extreme: The aircraft is violently tossed about and it is practically impossible to control it. This can cause structural damage.*

7.1.3.1 Unexpected Turbulence Guidelines

Turbulence			
Type	Conditions	Flight Crew Response	FA Response
Light	- Coffee shakes but does not splash out of cup. - Carts still maneuverable	- Ensure seat belt sign is "ON." - Via the interphone, advise FA-A of type of turbulence and expected duration of turbulence. - Make PA emphasizing the need for passengers to be seated. (examples below)	- Service may need to be modified or discontinued depending on intensity and duration of turbulence. - Monitor compliance with seat belt sign by visually checking passengers are seated with belts fastened. - FAs may need to secure themselves in jumpseat.
Light or Occasional Moderate	- Coffee occasionally splashes out of cup. - Carts are occasionally difficult to maneuver.	- Ensure seat belt sign is "ON." - Via the interphone, advise FA-A of type of turbulence and expected duration of turbulence. - Make PA emphasizing the need for passengers and FAs to be seated and service to be discontinued. (examples below) - Communicate with FA-A as required.	- Stop all service. - Stow all carts and galley equipment, time and conditions permitting. - FAs secure themselves in jumpseat as soon as possible using seat belt and shoulder harness (take nearest passenger seat if necessary). - FA-A: - Calls other FA to ensure FA-B and the passengers are seated. - Communicates with flight deck on cabin conditions as required.
Moderate	- Coffee consistently splashes out of cup. - Carts are difficult to maneuver.		

Turbulence			
Type	Conditions	Flight Crew Response	FA Response
Moderate or Occasional Severe	- Items occasionally fall over or lift off surfaces. - Standing is sometimes difficult or impossible without holding on to a part of the aircraft.	- Ensure seat belt sign "ON." - When Operationally Safe to Do So: - Make PA per the examples below. - After conditions subside, make PA to inform FAs and passengers. - Communicate with FA-A as required.	- Stop all service and leave carts with brakes engaged until turbulence is reduced. - FAs secure themselves in nearest available seats. If in jumpseat, use seat belt and shoulder harness. - When safe to do so: - Stow all carts and galley equipment. - FA-A calls other FA to ensure FA-B and the passengers are seated. - Check for injuries or damage. - FA-A will notify flight deck when all secure. - FA-A communicates with flight deck on cabin conditions as required.
Severe or Extreme	- Items fall over or lift from surfaces with consistency. - Standing is impossible without holding on to a part of the aircraft.		

Figure 3: Unexpected Turbulence Guidelines (Compass Airlines Flight Operations Manual)

Additionally the guidance provided example PAs for the flight crew to use, some of the examples provided were:

- 1) *Predicted Turbulence: “Ladies and Gentleman [sic], this is your Captain/FO speaking. It looks like we may be experiencing some light/moderate/severe turbulence up ahead [if possible insert timeframe in minutes] so I’m going to turn on the fasten seatbelt sign. [if necessary for light, and always for moderate/severe:] I’m going to ask that our flight attendants discontinue service and take a seat until it is safe to get up. Thank you.”*
- 2) *Experience Turbulence: [seatbelt sign off] “Ladies and Gentleman [sic], this is your Captain/FO speaking. We are experiencing Light/Moderate/Severe turbulence so I’m going to turn on the fasten seatbelt sign. Please return to your seats and ensure your seatbelt is fastened. [if necessary for light, and always for moderate/severe:] I’m also going to ask the flight attendants to discontinue service and take as [sic] seat until it is safe to be up. Thank you.”*

7.1.4 Avoidance of Known Severe Weather

The Compass Airlines, Flight Operations Manual, Section 8-9.5, provided guidance on pilot and dispatcher responsibilities to avoid known severe weather, the guidance was:

Pilot Responsibilities

1. *Recent research has proven that all thunderstorms are potentially dangerous and should be avoided. Compass flights will pass at least 20 miles (preferably upwind) from known thunderstorms and reported or sighted volcanic ash or dense smoke from volcanic action or forest fires. In the case of thunderstorms, the pilot-in-command may be able to determine from radar indications and/or his observations that passage at a closer distance is safe.*
2. *No Compass flight will take off or land if a thunderstorm is occurring within the airport boundary (within 5 SM of the airport center).*
3. *Forward reports to ATC and System Control of any severe weather encountered, giving nature, location, route, altitude and intensity.*
4. *Initiate requests to avoid severe weather activity as soon as possible, being specific concerning route and altitude desired. Pilots are reminded to review the Compass policy and procedures in this manual and AOM I pertaining to thunderstorm avoidance and use of SIGMETs.*
5. *Adjust speed as necessary to maintain adequate control of aircraft in turbulent air and advise ATC as soon as possible. Comply with the AOM procedures for flight in turbulence.*
6. *Do not rely completely on air traffic controllers to provide information or to initiate radar vectors to aircraft for avoidance of severe weather, particularly when arriving and departing terminals or in holding patterns.*
7. *Proper and timely use of weather radar controls in accordance with the AOM (tilt, range, contour, gain) and interpretation of returns will facilitate identification and avoidance of severe weather.*

Dispatcher Responsibilities

- 1. Suggest use of alternate routes whenever possible to avoid known areas of severe weather along normal or requested routes.*
- 2. Expedite action on requests for route/altitude deviation to avoid known areas of severe weather. Such requests are time critical.*
- 3. Relay PIREPs of severe weather to other flights as appropriate and, if necessary, initiate requests for additional reports to aid in anticipating requests for detours. Plan ahead when known areas of severe weather conditions exist and provide pilots with maximum information, rendering assistance in avoiding such areas when requested.*

7.1.5 Approved Sources of Weather

The Compass Airlines, Flight Operations Manual, Section 8-13.2, provided the following information from Compass Airlines' OpsSpecs A010:

- A. Compass OPSS A010 provides all approved sources of weather; all sources providing Compass weather must be approved by the U.S. National Weather Service (NWS). [121.101(b)(1)]*
- B. The Weather Company (TWC) meets these requirements and is the primary source of weather forecasts, reports, altimeter settings and NOTAMs. Delta Meteorology is an approved source of weather, but will only be used to supplement NWS/TWC weather information in the event neither source is available.*
- C. Each of the sources listed in OPSS A010 also provides adverse weather phenomena. Adverse weather phenomena are meteorological conditions that, if encountered in flight or during ground operations could directly diminish the safety of an operation. Compass weather reporting and forecasting systems as listed here and in OPSS A010 provide adequate information on the following conditions: [121.101(d)]*
 - 1. Strong surface winds (exceeding 30 knots);*
 - 2. Widespread low ceilings and/or visibilities that affect selection of destination and alternate airports;*
 - 3. Active thunderstorms;*
 - 4. Moderate or severe in-flight icing;*
 - 5. Icing that affects ground operations;*
 - 6. Severe or extreme turbulence;*
 - 7. Low altitude windshear (below 2000' AGL)*
 - 8. Occurrence of unforecast weather conditions below takeoff or landing weather minimums;*
 - 9. Volcanic ash;*
 - 10. Sandstorms and dust storms; and/or*
 - 11. Meteorological conditions that contaminate a runway surface and adversely affect aircraft performance or prohibit use of a runway.*
- D. Flight crews can obtain approved weather information through the aircraft ACARS (NWS), the crewmember work stations in domicile (NWS/TWC), hard copy through the dispatch release or an operations printer or FAX (NWS/TWC), or by telephone communication with Compass Dispatch (NWS/TWC). In addition to NWS and/or TWC, Delta Meteorology may*

be used by Dispatch to supplement weather information in the event the primary approved sources are not available.

- 1. The use of ACARS to retrieve weather information shall only be used for operational purposes.*
- E. If the above sources of weather are unavailable to the flight crew, approved alternate sources for crews to obtain weather are:*
 - 1. FAA FSS*
 - 2. FAA or privately-operated air traffic control tower or other ATC facility*
 - 3. Approved NWS-trained weather observation personnel, ASOS, or AWOS*
 - 4. Any combination of information from the NWS or TWC, as supplemented by Delta Meteorology in accordance with this section, may be used to determine if the weather conditions will be adequate for the planned flight*
 - 5. Limited Aviation Weather Reporting Stations (LAWRS)*
- F. Any other sources of weather that the company provides (i.e. weather applications on company iPad/EFBs) are approved for use as a secondary weather source only, and act only as a supplement to the sources described above.*

7.1.6 SIGMETs: General

The Compass Airlines, Flight Operations Manual, Section 8-15.1, provided the following information about SIGMETs and CONVECTIVE SIGMETs:

- A. SIGMETs and CONVECTIVE SIGMETs are advisory in nature and are to be taken into consideration when flying into an area, but they are not restrictive.*
- B. For example, a SIGMET for severe turbulence in a specified area would not prevent flying into that area unless there was a legitimate PIREP validating the presence of severe turbulence, then flight into that area would cease. To determine whether a PIREP is legitimate, factors such as aircraft size, distance from destination or route of flight, and time of PIREP must be considered.*

Note: *All available weather data must be considered by dispatchers and pilots prior to and when operating in areas where a SIGMET is active.*

7.1.7 Reporting Unforecast Weather Irregularities

The Compass Airlines, Flight Operations Manual, Section 8-19, provided the following information about unforecasted meteorological conditions that required a flight crew to report the encounter to dispatch:

General

- A. Whenever meteorological conditions are encountered which are substantially different from that forecast or which may have a potentially adverse impact on the safe operation of other flights, the PIC will ensure Dispatch is provided a PIREP as soon as practical. [121.561(a)]*
- B. Whenever irregularities in ground or navigation facilities are encountered that may have a potentially adverse impact on the safe operation of other flights, the PIC will ensure Dispatch is provided a PIREP as soon as possible. [121.561(a)]*

- C. Dispatch will be responsible for disseminating PIREPs and other pertinent reports to the FSS nearest to the location of the report. [121.561(b)]

Conditions Requiring Weather Reports

A. These conditions include but are not limited to:

1. Moderate or worse icing
2. Moderate or worse turbulence
3. Flight level (or surface) winds not consistent with the flight plan or forecast
4. Windshear encountered during any phase of flight
5. Volcanic ash or dense smoke observed or reported in your flight path

B. Pilots shall provide in-flight weather information for Dispatch as conditions permit.

C. Selected flights may be requested to provide [sic] en route weather to Dispatch, including:

1. Sky cover (clear, scattered, broken, overcast)
2. Obstructions to visibility (rain, snow, etc.)
3. Icing
4. Turbulence
5. Windshear
6. En route winds
7. OAT⁴⁹
8. A general overview of other data that may be pertinent
9. Notify Dispatch as soon as practical of any significant changes to the route of flight as assigned by ATC or any en route delays (e.g., holding) caused by adverse/hazardous weather.

7.1.8 Reduced Vertical Separation Minimum (RVSM)⁵⁰

The Compass Airlines, Flight Operations Manual, Section 9-9.7, provided the following information about operating in RVSM and encountering severe turbulence or mountain wave activity:

Severe Turbulence

Report severe turbulence encounters to ATC. Until the flight crew reports clear of severe turbulence, the controller will apply merging target vectors to one or both passing aircraft to prevent their targets from merging.

Mountain Wave Activity (MWA)

⁴⁹ Outside Air Temperature.

⁵⁰ RVSM was implemented to reduce the vertical separation above flight level (FL) 290 from 2000-ft minimum to 1000-ft minimum. It allows aircraft to safely fly more optimum profiles, gain fuel savings and increase airspace capacity. The process of safely changing the separation standard required a study to assess the actual performance of airspace users under the old vertical separation standard of 2000-ft and potential performance under the new standard 1000-ft. In 1988, the ICAO Review of General Concept of Separation Panel (RGCSP) completed this study and concluded that safe implementation of the 1000-ft separation standard was technically feasible. RVSM was subsequently implemented and today RVSM represents a global standard for 1000-ft vertical separation. Source: https://www.faa.gov/air_traffic/separation_standards/rvsm/

1. Significant MWA occurs both below and above the floor of RVSM airspace and can produce altitude excursions, airspeed fluctuations and light turbulence. With sufficient amplitude, however, wave action can induce altitude and airspeed fluctuations accompanied by severe turbulence. MWA is difficult to forecast and can be highly localized and short lived.
2. In-flight MWA Indicators include:
 - a) Altitude excursions and/or airspeed fluctuations with or without associated turbulence;
 - b) Pitch and trim changes required to maintain altitude with accompanying airspeed fluctuations; and
 - 1) Light to severe turbulence depending on the magnitude of the MWA.

7.1.8.1 Pilot/Controller Actions – RVSM

The Compass Airlines, Flight Operations Manual, Section 9-9.10, provided, in part, the following table of pilot and controller actions for “RVSM Irregular Operations”:

Pilot Actions	Controller Actions
GENERAL GUIDANCE	
Notify ATC and request assistance. Maintain cleared flight level, to the extent possible, while evaluating the situation. Watch for conflicting traffic both visually and by reference to TCAS, if equipped. Alert nearby aircraft by illuminating exterior lights (IAW with aircraft limitations).	
SEVERE TURBULENCE AND/OR MOUNTAIN WAVE ACTIVITY (MWA)	
Advise ATC if experiencing MWA/Severe Turbulence induced altitude fluctuations greater than +/-200 ft. Request vector clear of traffic at adjacent FLs. If so desired, pilot may request a FL change or re-route. Report location and magnitude of MWA to ATC.	Advise pilot of conflicting traffic at adjacent FL. If pilot requests, vector aircraft to avoid merging target with traffic at adjacent RVSM flight levels, traffic permitting. Issue FL change or re-route, traffic permitting. Issue PIREP to other aircraft.

Table 2: Pilot/Controller Actions in RVSM (Source: Compass Airlines FOM Figure 9.8.2)

7.1.9 Required Maintenance Reports

The Compass Airlines, Flight Operations Manual, Section 14-1.4, provided the following list of mechanical discrepancy that were required to be entered in the “Aircraft Maintenance Logbook (AML) and also required notification to maintenance control:

1. RSV thrust is activated and/or the thrust levers are advanced to the "MAX" position
2. An in-air engine restart is conducted
3. Overweight/hard landing
4. Aircraft limitation exceedance
 - a. Overspeed
 - b. Flap/slat extend speed exceedance
 - c. Landing gear extended airspeed exceedance
 - d. Engine limit exceedance
5. Landing with temperature less than -40°C
6. Cabin depressurization
7. Aircraft on ground which departs approved and/or paved airport surface
8. High speed aborted takeoff (Greater than 80 knots)
9. Landing gear extension malfunction
10. Lightning strike
11. Hail encounter
12. Bird Strike
13. Tow bar shear pin failure
14. Severe turbulence encounter

7.2 Aircraft Operating Manual Vol. 1

The Compass Airline, "ERJ 170 Aircraft Operating Manual – Volume 1," Revision 24, provided the following guidance:

7.2.1 Traffic Alert and Collision Avoidance (TCAS)

The Compass Airline's, Aircraft Operating Manual, Chapter 2 "Limitations – Navigation & Comm Equip" provided the following limitations for the TCAS system:

The following limitations are applicable to the Traffic Alert and Collision Avoidance System (TCAS):

- *Deviation from the ATC assigned altitude is authorized only to extent necessary to comply with a TCAS Resolution Advisory (RA).*
- *Maneuvers must not be based solely on information presented in the traffic display.*

7.2.2 TCAS Operation in RVSM Airspace

The Compass Airline's, Operating Manual, Chapter 3 "Operating Procedures – Enroute," provided the following guidelines when operating in RVSM Airspace:

Under certain conditions in RVSM airspace, there is the potential for some versions of TCAS II to issue TAs and RAs during normal operations when airplane are maintaining required separation. Very few RAs are expected to occur in RVSM airspace during normal operations but a TA may occur when an airplane passes in close proximity to another at an adjacent flight level.

Moderate and severe turbulence can induce airplane motion which TCAS can interpret as a climb or descent. These vertical speed changes can result in TCAS projecting the vertical

separation to be less than 800 feet at the closest point of approach, which can result in an RA being issued if the airplane is in close proximity to another airplane at an adjacent altitude.

The following are recommended operating practices that will minimize disruptions caused by the issuance of unnecessary TAs and RAs during RVSM operations:

- *TCAS should be operated in the TA/RA mode during all operations in RVSM airspace and transition areas.*
- *Climb and descent rates in RVSM airspace and transition areas should be limited to 1000 fpm when operating within five NM and ± 2000 feet of other airplane to minimize the generation to TAs and RAs.*
- *Finally, if an RA is encountered, it must be followed. Following the flight, submit a Crew Report detailing the incident as required by the FOM.*

7.2.3 TCAS Recovery

The Compass Airlines, Operating Manual, Chapter 3 “Traffic Resolution and Advisory,” provided, in part, the following guidelines for the TCAS Recovery procedure:

This section describes the airplane-specific procedures associated with the TCAS RA maneuver. An RA is a prediction that an intruder will enter your collision airspace within approximately 20 seconds. TCAS bases its guidance on the assumption that the crew will promptly and smoothly follow the vertical command. Comply with the following procedure in conjunction with the AOM I, 2-11.2, Traffic Alert and Collision Avoidance (TCAS).

Compliance with TCAS resolution advisory is required unless the crew considers it unsafe to do so. Maneuvers that are in the opposite direction of the RA are extremely hazardous, especially RAs involving altitude crossing and thus are prohibited unless it is visually determined to be the only means to assure safe separation. TCAS does not diminish or otherwise alter the crew's authority or responsibility to ensure safe separation.

TA Procedure

Traffic advisories (TA) does not provide resolution advisories but announces “TRAFFIC-TRAFFIC” when other airplane is approximately 35 to 45 seconds from the TCAS collision area and is represented as an amber solid circle.

Do not carry out evasive maneuvers based solely on traffic advisories/displays (TA) without visually sighting the traffic.

Upon receiving a TCAS TRAFFIC ADVISORY or a possible conflict is advised by ATC:

PF -

1. *Place hands on control column and thrust levers to be prepared to react to TCAS resolution.*

2. Scan for visual contact with the intruder.
3. Adjust vertical speed as necessary.

PM -

1. Turn all external lights ON.
2. Turn FSTN BELTS sign ON.
3. Query ATC about proximity of the traffic.
4. Scan for visual contact with the intruder.

Pilots should not maneuver horizontally based solely on TA information. TCAS TA display information is inadequate for collision avoidance maneuvers. A pilot maneuver based ONLY on this information might result in a loss of separation with the intruder (e.g., a turn toward the intruder).

Pilots should maneuver horizontally only on receiving guidance from ATC or on acquiring visual contact with the intruder. If an intruder cannot be acquired visually but is perceived as a threat and additional information is not available from ATC, vertical maneuvers which permit the aircraft to remain within 200 feet of the assigned altitude are permissible. Changes in climb or descent rates when approaching an intruder aircraft are not viewed as evasive.

RA Procedure

A Resolution Advisory (RA) is annunciated when other airplane is approximately 20 to 30 seconds from the TCAS collision area. It is represented as a red solid square.

The RA aural messages associated to displayed advisories may be the following:

- *“INCREASE CLIMB; INCREASE CLIMB”*: Increase immediately the rate of climb.
- *“INCREASE DESCENT; INCREASE DESCENT”*: Increase immediately the rate of descent.
- *“CLIMB, CLIMB NOW!; CLIMB, CLIMB NOW!”*: The airplane is descending and a reversal of vertical speed is necessary to provide adequate separation.
- *“DESCEND, DESCEND NOW! DESCEND, DESCEND NOW!”*: The airplane is climbing and a reversal of vertical speed is necessary to provide adequate separation.
- *“CLIMB; CLIMB; CLIMB”*: Begin to climb immediately at the indicated rate of climb.
- *“DESCEND; DESCEND; DESCEND”*: Begin to descend immediately at the indicated rate of descent.

When receiving a TCAS RA command which requires maneuvering:

- *Both pilots will visually clear the airspace in the maneuver area.*
- *If maneuvering is commanded by the RA, the PF will disconnect the autopilot (TCS or AP/TRIM DISC) and smoothly adjust pitch and thrust to satisfy the RA commands.*

Note

Under certain conditions, such as pitch greater than 10 degrees, the fly-to zone may not be completely visible. In this case, accurate pilot guidance is provided by the VSI.

- If the autothrust system is left engaged, confirm that it is in the proper mode. If needed, promptly and smoothly adjust the airplane's pitch to fly into the green rectangle (if displayed), and fly out of the red trapezoidal shaped avoidance zone(s). This should require no more than 0.75g to 1.25g maneuver (+/-0.25g). An immediate smooth response to an RA is required to obtain maximum separations. TCAS II algorithms are based on the pilot initiating the initial maneuver within 5 seconds of the RA and within 2 1/2 seconds for additional corrective RAs (increases or reversals). Any delay in responding to RAs will reduce the separations provided. From level flight, proper response to a TCAS RA typically results in an overall altitude deviation of 300 to 500 ft. to resolve a traffic conflict.*
 - o Exaggerated responses to TCAS RAs are not desirable or appropriate because of the other potential traffic conflicts and ATC consequences.*
 - o If a climb RA occurs in the landing configuration, smoothly adjust pitch to satisfy the RA commands while performing a normal go-around procedure.*
 - o The consequences of not following an RA may result in additional RAs in which aural alert and visual annunciations may not agree with each other.*
- The PM will confirm the PF's action and continue to visually clear the airspace in the maneuver area.*

Note

Disregard the flight director commands during the RA maneuver since the flight director is not tied into TCAS (the flight director does not command the RA maneuver).

- Notify ATC of the RA maneuver as soon as possible.*
- Continue to follow the planned lateral flight path unless visual contact with the conflicting traffic requires other action.*
- When TCAS advises "CLEAR OF CONFLICT," promptly and smoothly maneuver the airplane back to the ATC cleared altitude.*
- If necessary, coordinate with ATC for further clearance.*
 - o When the RA is cleared, the flight crew should advise ATC that they are returning to their previously assigned clearance or should acknowledge any amended clearance issued.*
- Re-establish the autopilot and autothrust modes, as desired.*

Properly executed, the RA maneuver is mild and does not require large or abrupt control movements. RA maneuvers require only small pitch attitude changes which should be accomplished smoothly and without delay. Remember that the passengers and flight attendants may not be seated during this maneuver.

During the RA, pilots must maintain situational awareness since TCAS may issue RAs in conflict with terrain considerations (e.g., TCAS may command a descent in an area of rising terrain). Windshear, GPWS, and stall warnings take precedence over TCAS advisories.

The responsibility for avoiding mid-air collisions still remains with the flight crew and ATC. TCAS is simply another “tool” to help reduce the collision potential.

7.2.3.1 TCAS Indication

Compass Airlines, Airplane Operations Manual, Volume 2, Chapter 14 “Systems Description Warning System” pg. 15, provided the following picture and textual guidance on the TCAS indications on the primary flight display (PFD):

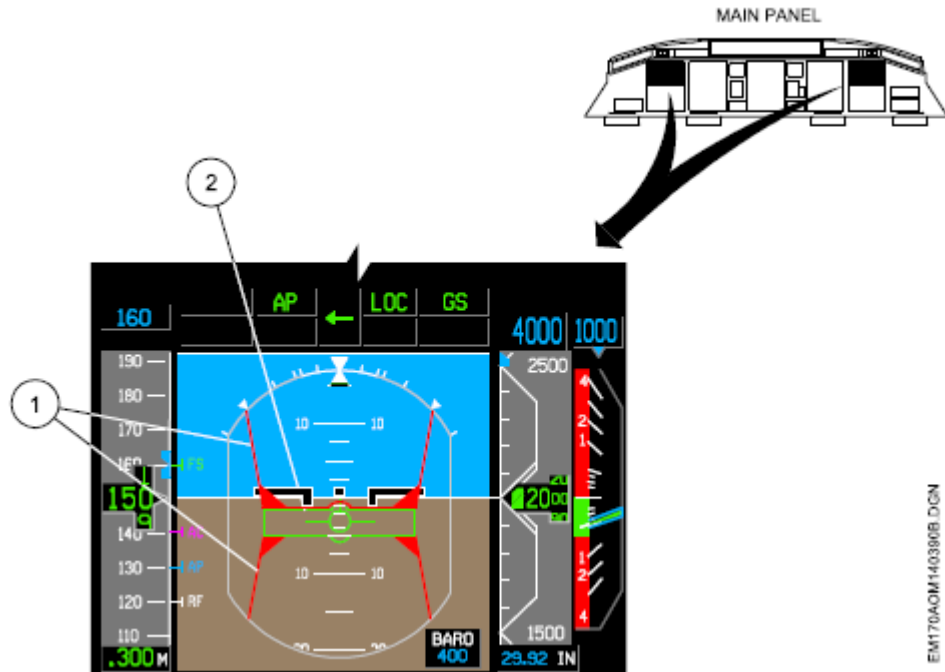


Figure 4: TCAS Indications on the PFD (Source: Compass Airlines AOM Vol. 2 Section 14-15-05 pg. 10)

The commands provide pitch guidance information to the flight crew to recommend or prohibit a maneuver and prevent hazardous encounters with other [sic] airplane.

The vertical speed scale is used to display TCAS resolution advisories.

The red range is the avoidance zone and the green range is the fly-to-zone.

1 - AVOIDANCE ZONE

- Symbol: Trapezoid.
- Color: Red.

2 - FLY-TO ZONE

- Symbol: Rectangle.
- Color: Green.

7.2.3.2 TCAS Map Overlay Indication

Compass Airlines, Airplane Operations Manual, Volume 2, Chapter 14 “Systems Description Warning System” pg. 11, provided the following picture and textual guidance on the TCAP Map indications on the PFD:



Figure 5: TCAS Map Indications with Symbols (Source: Aircraft Operations Manual Vol. 2)

1 - TCAS SELECTION IN MAP MENU

– Activates the TCAS information to be displayed on the map overlay format window.

2 - RESOLUTION ADVISORY (RA) INDICATION

– Symbol: Solid square.

– Color: Red.

3 - TRAFFIC ADVISORY (TA) INDICATION

– Symbol: Solid circle.

– Color: Amber.

4 - PROXIMATE TRAFFIC INDICATION

– Symbol: Solid diamond.

– Color: Cyan.

5 - OTHER TRAFFIC INDICATION

– Symbol: Hollow diamond.

– Color: Cyan.

6 - TCAS MODE

– Annunciates the TCAS operating mode.

– Labels and Colors:

TCAS FAIL: amber.

TCAS TEST: green.
TCAS OFF: amber.
TA ONLY: green.
TCAS TA/RA: green.

NOTE: The TA ONLY flashes amber when it is the active mode and a RA condition is detected.

7.2.4 Altitude/ Course Deviations Due to Weather

The Compass Airlines, Operating Manual, Chapter 3 “Operating Procedures – En Route” provided, in part, the following guidelines about altitude deviations due to weather, while operating in RVSM airspace:

For both Mountain Wave Activity (MWA) and severe turbulence encountered in RVSM airspace, an additional concern is the sensitivity of TCAS when other airplane fly directly above or below your position. Severe turbulence and MWA can cause large abrupt changes in altitude and/or attitude.

7.3 System Operations Control Procedures Manual

Compass Airlines, System Operations Control (SOC) Procedures Manual, Revision 18 provided the following guidance:

7.3.1 Dispatchers Requirement to Flight Follow

A. The Dispatcher must monitor the following contents of the Dispatch Release until the flight has landed safely:

- 1. Fuel status, flight time remaining, destination and alternate weather trends, en route winds and weather (including pilot reports), status of airport and navigation facilities must be considered.*
- 2. While en route, the flight crew will notify Dispatch any time a flight is going to arrive later than 15 minutes past the ETA due to delays occurring after departure.*
- 3. Ensure OUT, OFF, ON and IN times in all appropriate codeshare partner computer systems are monitored and accurate.*

B. The Dispatcher will monitor the status of the flights that he has been assigned in order to look for weather changes or safety concerns, such as:

- 1. Weather en route, destination and any alternates listed on the Dispatch Release.*
- 2. Before and during flight, the aircraft dispatcher shall provide the PIC any additional available information of meteorological conditions (including adverse/hazardous weather phenomena, such as clear air turbulence, thunderstorms, and low altitude windshear), airport conditions and irregularities of navigation facilities and services that may affect the safety of flight (for communication procedures reference FOM 7-2 Communications: System Control. [121.601(a), 121.601(b), 121.601(c)])*

Note: *It is the responsibility of the dispatcher to update FLIFO of any delays or pertinent information that is required by other operational personnel to properly plan and manage the operation.*

7.3.2 Enhanced Weather Information System (EWINS)

- A. *The Weather Company aviation forecasters and Delta Airlines Meteorologists continuously monitor weather data and forecasts to keep The Weather Company Terminal Area Forecast and Delta Airlines Meteorology Terminal Area Forecast (TAF) updated for changing conditions.*
- B. *Compass Airlines Uses the following forecast products from The Weather Company and Delta Airlines Meteorology:*
 - 1. *TAF - A terminal forecast issued by The Weather Company and Delta Meteorology which replaces the NWS TAF.*
 - 2. *TAP's - Turbulence Auto PIREP System feed through The Weather Company for real time turbulence reports from reporting capable aircraft.*
 - 3. *Pilot Brief Optima – Pilot Brief Optima from The Weather Company is a computer desktop tool for which Flight Dispatchers can gain access to meteorological information. Pilot Brief Optima is also available to flight crew members via their iPad Device. Flight Crew members will only be able to reference the TAP's tool in Pilot Brief Optima via The Weather Company for improved turbulence situational awareness.*

8.0 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.”*⁵¹

8.1 FAA Turbulence Fact Sheet

The FAA provided the following guidance titled “Fact Sheet – Turbulence” on August 1, 2019 on their website:⁵²

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?

⁵¹ Source: https://www.faa.gov/travelers/fly_safe/turbulence/

⁵² 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.

8.2 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 – Flight Crew Interview Summaries and Written Statements

Attachment 2 – Flight 6058 Flight Crew Interview Summaries

Attachment 3 - Flight Attendant Written Statements

Attachment 4 – Compass Airline Dispatch Personnel Interview Summaries

Attachment 5 – Accident Flight Crew Training Records [Excerpts]

Attachment 6 – Accident Flight Crew Schedule [Excerpt]

Attachment 7 – Accident Flight Dispatch Release

Attachment 8 – Weight and Balance

Attachment 9 – Compass Airlines Aircraft Operating Manuals Volumes 1 & 2 [Excerpt]

Attachment 10 – Compass Airlines Flight Operations Manual [Excerpt]

Attachment 11 – Compass Airlines System Operations Control Procedures Manual [Excerpt]

Attachment 12 – Aircraft Maintenance Logbook Entry

Attachment 13 – Operational Factors Group Party Form

Attachment 14 – Archived PIREPs

Submitted by:

Shawn Etcher
Air Safety Investigator

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