NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

January 9, 2020

Specialist's Report

OPERATIONAL FACTORS

DCA20CA071

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A. ACCIDENT

Operator:	PSA Airlines (JIA)
Location:	Knoxville, Tennessee (TYS)
Date:	February 7, 2020
Time:	0105 Eastern Standard Time[1]
Airplane:	Bombardier CRJ-900, N610NN

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 February 7, 2020, about 0105 eastern standard time, PSA Airlines flight 5634, a Canadair CRJ-900, N610NN encountered turbulence while descending to land at McGhee Tyson Airport (KTYS), Knoxville, Tennessee. One flight attendant and 21 passengers sustained minor injuries. One flight attendant sustained serious injuries, and the airplane sustained minor damage. The regularly scheduled domestic passenger flight was operating under the provisions of 14 *Code of Federal Regulations* Part 121 from Charlotte Douglas International Airport (KCLT), North Carolina, to TYS.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board (NTSB) Operational Factors investigator was assigned to the accident on February 10, 2020 and did not travel to the accident location. The Operational Factors investigator requested manuals and other various items for the investigation, from the operator. Pilot certification information was obtained from the pilots, operator, and the Federal Aviation Administration (FAA).

E. FACTUAL INFORMATION

1.0 History of Flight[2]

According to flight crew statements, the flight was scheduled to depart at 1956 on February 6, 2020. However, the accident aircraft was delayed arriving at CLT and did not arrive until 2300. The flight crew boarded the aircraft after the inbound crew disembarked and began performing the acceptance checklist. One of the captains notified the gate agent that the flight attendants scheduled for the flight were in another city and crew scheduling was looking for 2 other flight attendants to crew the flight.

[1] All times are Eastern Standard Time (EST) based on a 24-hour clock, unless otherwise noted. At the time of the event EST was UTC -5 hours.
[2] Source: Attachment 1 - "Crew Interview Summaries"

At 2339, an amended release was sent to the flight, amending the crew names.

Prior to departure the captain upgrade candidate, who was the pilot flying and seated in the left seat, referenced the weather app on the company provided EFB[3], which indicated "*a little light green and a very small yellow streak over the mountains*."

On February 7, 2020, at 0013, an ACARS[4] message was sent to the company dispatch showing that the brakes had been released.

At 0035, an ACARS message was sent to company dispatch showing that the flight was airborne. According to the flightcrew, the flight climbed to FL220 in visual meteorological conditions and it was "smooth at cruise."

Both flight crewmembers reported the weather radar was on. The radar display was visible on each of their MFD[5] screens and that it was not depicting any precipitation. Air traffic control (ATC) advised the flight they (ATC) were showing areas of "light to extreme precipitation" in their vicinity.

The crew was given a descent, at pilot's discretion to 13,000 feet; however, the crew delayed their descent as they observed a cloud deck around their same altitude. When the crew began the descent, they were descending at 1,000 to 1,300 feet per minute and slowing the aircraft to 290 knots. The pilot flying (PF) adjusted the radar tilt downward until ground clutter appeared on the outside edge of the radar display and then readjusted the radar tilt upward until the clutter began to disappear. The PF further reported that the moonlight illuminating off the cloud deck showed it was "pretty thick." He reduced the thrust more in order to slow the airplane to 280 knots and informed the pilot monitoring (PM) that they may encounter "a little bump or two."

The PF described, when the aircraft encountered the cloud layer as a "severe jolt," disengaging the autopilot, and pitching the airplane's nose down. The PM described the encounter as "hitting a brick wall." They described the encounter as lasting "a few seconds" and they subsequently exited out of the cloud into visual meteorological conditions (VMC). However, they continued to encounter moderate turbulence.

The pilot flying engaged the autopilot. Both flightcrew members further reported that they did not encounter any rain. However, they did receive an "ICE" message and turned on the engine cowl and wing anti-ice system. The PM contacted the flight attendants via the aircraft's interphone system but received no response from the flight attendants. The PM notified ATC that they had encountered "extreme-severe turbulence" from FL190[6] to approximately 16,000 feet.

[3] Electronic Flight Bag
[4] Aircraft Communication Addressing and Reporting System
[5] Multifunction Display
[6] A level of constant atmospheric pressure related to a reference datum of 29.92 inches of mercury. Ease is stated in three digits that represent hundreds of feet. FL190 represent a barometric altimeter indication of 19,000 feet. Source: FAA Instrument Procedures Handbook (FAA-H-8083-16)

The PM attempted to contact the flight attendants again via the interphone system, which was subsequently answered by a deadheading flight attendant, who informed the crew the forward flight attendant had fallen and was injured. Sometime later, the deadheading flight attendant contacted the flight crew and informed them that the aft flight attendant was also injured as well as some passengers.

At 0105, the flight crew sent an ACARS message to company dispatch stating, "*need medical FA hurt in severe turbulence."* Company dispatch responded to the message about 6 minutes later.

The flight landed in TYS at 0113 and the main cabin door opened at 0121. EMT personnel boarded the airplane to provide medical care to those who were injured.

2.0 Flight Crew Information

The accident flightcrew consisted of 2 pilots and 3 cabin crew members[7]. The accident flight was an OE[8] flight for the captain upgrade candidate. The captain upgrade candidate, seated in the left seat, was the PF and the line check airman, seated in the right seat, was the PM.

2.1 Line Check Airman

The line check airman (LCA) was 53 years old and held an Airline Transport Pilot (ATP) certificate with a rating for airplane multiengine land and type ratings on the, CL-65[9], and EMB-145[10]; limitations included "ATP CIRC APCH. – VMC ONLY; CL-65 EMB-145 CIRC APRC – VMC ONLY." He held an FAA first-class medical certificate dated December 9, 2019, with no limitations.

2.1.1 Line Check Airman's Training and Proficiency Checks Completed

A synopsis of the captain's recent training at PSA Airlines was as follows:

Date of Hire at PSA Airlines	February 16, 2015
Upgrade to captain[11]	June 12, 2017
Initial LCA FAA Observation	August 29, 2018
Most Recent Right Seat Qualification	August 16, 2019
Most Recent Recurrent Ground Training	May 13, 2019
Most Recent Simulator Evaluation[12]	November 3, 2019

[7] One flight attendant was deadheading, or repositioning, to TYS and was not a working crewmember at the time of the turbulence encounter. Source: Attachment 2 – Flight Crew Schedules.
[8] Operating Experience
[9] Bombardier Inc. CL-600-2B19, BL-600-2C10, CL-600-2D24, CL-600-2D15. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.
[10] Embraer S.A. EMB-135ER, EMB-135LR, EMB-135KE, EMB-135KL, EMB-135BJ, EMB-145, EMB-145ER, EMB-145MR, EMB-145LR, EMB-145XR, EMB-145MP, EMB-145EP Source FAA Order 8900.1 Figure 5-88, dated July 15, 2019.
[11] Upgrade training concluded with an Upgrade Line Check and Upgrade Operating Experience, which was conducted in an CRJ7 aircraft.
[12] Maneuvers Validation event. Source: Attachment 3 – Flight Crew Training Records (Excerpts).

Most Recent Systems Validation Oral Event	November 4, 2019
Most Recent LOE[13]	November 4, 2019
Most Recent Line Check	February 3, 2020
Most Recent Upset Recovery Training	August 16, 2019
Most recent Weather Radar Basics course[14]	April 28, 2019

2.1.2 Line Check Airman's Flight Times

The Captain's estimated flight times were based on PSA Airlines provided documentation:

Total pilot flight time	8,700
Total CRJ-900 flight time	2,800
Total CRJ-900 PIC flight time	1,350
Total flight time preceding 24 hours[15]	1:06
Total flight time preceding 7 days	10:31
Total flight time preceding 30 days	71:00
Total flight time preceding 90 days	212:00
Total flight time preceding 12 months	768:00

2.2 Captain

The captain upgrade candidate was 30 years old and held an Airline Transport Pilot (ATP) certificate with a rating for airplane multiengine land and type ratings on the, CL-65, CE-500[16], CD-750[17]; limitations included "ATP CIRC APCH. – VMC ONLY CL-65 CIRC APRC – VMC ONLY." He held an FAA first-class medical certificate dated April 12, 2019, with no limitations.

2.2.1 Captain's Training and Proficiency Checks Completed

A synopsis of the captain's recent training at PSA Airlines was as follows:

Date of Hire at PSA Airlines	October 9, 2017
Upgrade to captain[18]	November 18, 2019
Most Recent Ground Training	November 19, 2019
Most Recent Simulator Evaluation[19]	November 30, 2019

[13] Line Operations Evaluation event
[14] This training was part of the Q2 2019 Distant Learning which was Hazardous weather and Radar Use training and did include a section on Turbulence. The course did not provide a grade but only stated "completed". Source: Operational Factors Attachment 3 – Flight Crew Training Records.
[15] Flight time does **not** include the accident flight and only includes a flight on May 24, 2019 that the captain operated from Atlanta Georgia to MDW.
[16] Textron Aviation Inc. 500, 501, 550, S550, 551. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.
[17] Textron Aviation Inc. 750. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.
[18] Upgrade training was being conducted on the captain at the time of the turbulence encounter; however, upgrade training began with ground school beginning on November 18, 2019.
[19] Maneuvers Validation event. Source: Attachment 3 – Flight Crew Training Records (Excerpts)

Most Recent Systems Validation Oral Event	November 20, 2019
Most Recent LOE[20]	January 18, 2020
Most recent Weather Radar Basics course[21]	May 28, 2019

2.2.2 Captain's Flight Times

The Captain's estimated flight times were based on PSA Airlines provided documentation:

Total pilot flight time	3,106:00
Total PIC flight time	1602:00
Total SIC flight time[22]	1310:00
Total CRJ flight time[23]	1,300
Total CRJ-900 PIC flight time	9:00
Total flight time preceding 24 hours[24]	1:06
Total flight time preceding 7 days	10:31
Total flight time preceding 30 days	10:31
Total flight time preceding 90 days	10:31
Total flight time preceding 12 months	563:00

3.0 Airplane Information

Photo 1: Accident Airplane, N610NN (Courtesy of planespotter.net)

[20] Training Records indicate that the upgrading captain attempted the LOE on December 6, 2019, however, was graded as unsatisfactory. The unsatisfactory item was "*due to imaginary emergency situation and unnecessary diversion to not the most suitable airport.*" Source: Attachment 3 - Training Records

[21] This training was part of the Q2 2019 Distant Learning which was Hazardous weather and Radar Use training and did include a section on Turbulence. The course did not provide a grade but only stated "completed". Source: Operational Factors Attachment 3 – Flight Crew Training Records.

[22] Second-in-Command time total included **only** his time at PSA as a SIC.

[23] According to the operator the companies CrewTrac system only indicates CRJ time and does not differentiate between CRJ200, CRJ700, or CRJ900 flight time.

[24] Flight time does include the accident flight.

The accident airplane (Registration N610NN, Serial No. 15476) was a Bombardier CRJ-900. The airplane was manufactured in 2019, registered to American Airlines Inc., operated by PSA Airlines, and held a transport category airworthiness certificate dated November 21, 2019. The airplane was powered by 2 General Electric CF34-8C5 engines, each were rated at 13,360 pounds of thrust. The airplane was configured with 2 pilot seats, 1 cockpit observer seat, 2 flight attendant seats, and 76 passenger seats[25].

According to the PSA Airlines, Pilot Operating Handbook, Section 3 "Limitations" the following limitations applied to the accident aircraft:

Turbulence Penetration Speed	*280 KIAS/.75M, whichever is lower*
Maneuvering Limit Load Factors	
Flaps Retracted	*-1.0 to +2.5 G*

According to the accident flight's dispatch release[26] there were two maintenance deferrals:

MEL 27-51-2-2A	Flap Subsystem
MEL 25-21-01	Passenger Seats

Neither of the deferrals affected the performance of the weather radar or any other function associated with this accident.

3.1 Weight and Balance

The following weight and balance information was taken from the dispatch flight release and weight data record. Limitations[27] are indicated in **bold** type. All weights below are in pounds (lbs.).

Basic Operating Weight		49,346
Passengers	13,650	
Baggage/Cargo[28]	1,440	
Total Payload		15,090
Zero Fuel Weight		64,436
Maximum Zero Fuel Weight		**70,750**
Planned Block Fuel[29]		9,564
Taxi Fuel		421
Ramp Weight		74,000
Maximum Ramp Weight		**84,500**
Takeoff Weight		73,579
Maximum Takeoff Weight		**85,000**
Planned Enroute Fuel Burn		2,224

[25] The passenger seating configuration consisted of 12 business class and 62 economy class seats.
[26] See Attachment 4 – Accident Flight's Dispatch Release for a list of the 2 deferred items.
[27] Source: PSA Pilot Operating Handbook Chapter 3 "Limitations" Section 3.14 "Structural Weights."
[28] The cargo/baggage consisted of 25 standard checked bags at 30 lbs. each, 1 heavy checked bag at 60 lbs. each, and 21 gate claim/planeside checked baggage at 30 lbs. each. Source: PSA Pilot Operating Handbook, Section 10.1.4 Average Baggage Weight.
[29] Minimum fuel for takeoff was listed as 7,243 lbs. Source: Attachment 4 – Accident Flight's Dispatch Release.

Planned Landing Weight[30]	71,365
Maximum Landing Weight	**75,100**

3.2 Post-Accident Aircraft Maintenance Logbook Entry

The following aircraft maintenance logbook entries[31] were made following the aircraft's encounter with severe turbulence:

Encountered severe turbulence in descent while passing through FL190.

Aft Emergency Portable O_2 bottle used during flight.

Overhead bin 18/19 DF Door Aft Hinge, Arm is Broke.

4.0 Operator Information[32]

PSA Airlines was owned by American Airlines and operated an all-jet fleet consisting of Bombardier regional jet aircraft. They operated about 800 daily flights and were headquartered in Dayton, Ohio. They had 7 flight crew bases of which TYS and CLT were two of those bases. They operated 137 aircraft which consisted of 35 CRJ200, 48 CRJ700 and 54 CRJ900 aircraft.

5.0 Accident Dispatch Release and Weather Packet

5.1 Dispatch Release

PSA Airlines' dispatch release for the accident flight was listed as "Release 27171702 generated at 0438 07FEB20 UTC." The release was 19 pages in total length. It contained information for the accident flight such as, fuel required, route of flight, departure, destination, and alternate airports, MELs, departure and planned arrival weights, weather which consisted of departure, enroute, destination, and alternate weather. In addition, it contained the following information:

////EXTRA FUEL FOR TANKERING////

The flight plan fuel section of the release showed that the dispatcher had added an additional 1,082 lbs. of "*contingy*[33]" fuel, and 1,900 lbs. of "*tanker*" fuel.

5.1.1 Route of Flight

According to the PSA Airlines' Dispatch Release for the accident flight showed the route of flight was:

KCLT BOBZY4 BOBZY DCT BRAYN DCT REWET DCT VXV DCT KTYS

According to the dispatch release, for the accident flight, the estimated time enroute was 31 minutes at a filed altitude of FL220.

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[30] Planned landing weight was a dispatch estimated weight based on an estimated takeoff weight. According to Operator provided information on the NTSB 6120.15 form the weight at the time of the event was 70,600 lbs.
[31] Source: Attachment 14 – Aircraft Maintenance Logbook Entries.
[32] Source: https://www.psaairlines.com/about
[33] Due to character limitation contingency was shortened to "contingy".

5.1.2 Turbulence Related ACARS Messages

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

February 7, 2020 at 0105 EST (0605Z)

QU DAYACOH
.DDLXCXA 070605
AGM
FI OH5634/AN N610NN
DT DDL TYS 070605 M77A
- NEED MEDICAL FA HURT
IN SEVERE TURBULENCE

5.1.3 Weather Briefing

The following destination weather information was included on the flight release for the accident flight, prior to departure from CLT.

Current reported weather at the time the release was printed:

070353Z 28010KT 10SM -RA SCT012 OVC029 07/04 A2937 RMK AO2 RAB06 SLP942 P0003 T00720044

Forecasted weather at the time the release was printed:

TYS 070258Z 0703/0724 31006KT 6SM BR OVC020
TEMPO 0703/0707 3SM -SHRA BR
FM070700 27013KT 4SM BR OVC015
TEMPO 0707/0711 2SM -SHRA BR OVC008
FM071100 25018KT P6SM -SHRA OVC011
TEMPO 0711/0714 4SM -SHRASN OVC008
FM071400 25021KT P6SM OVC022 PROB30 0714/0719 4SM -SHRASN OVC015
FM072000 26020KT P6SM OVC035

5.2 WSI Pilotbrief Optima

PSA provided the flightcrew with the WSI Pilotbrief Optima application on their electronic flight bags (EFBs). It combined high performance maps, high definition weather information, enhanced overlays, real time weather updates, and weather graphics on their EFBs. The application was trained during basic indoctrination training when a pilot was first hired into the company. In addition to a general overview of all applications, by an instructor during recurrent training. Pilots were also provided the following iPad training guide:

WSI PILOTBRIEF OPTIMA

- *Sign In*

    - *Username: aa then 6 digit AA number (ex: aa123456}*
    - *PW:*
- *Layer Settings {Paper Stack on Map Tool bar)*
    - *Basemap: Select Terrain, Black or White (recommend black or white for download speeds)*
    - *Radar, Satellite, FPGs, Sigmets, Radar Summary*
- *Route Briefing*
    - *Flight ID (begins with JIA ex: JIAS156}*
    - *Route Selection (may also manually type in route)*
- *Active Data Connection Required*
    - *Tap arrow to hide or open briefing*
    - *Selection of Weather and Notams*
    - *Departure, Enroute, or Destination Notams*
- *Offline Mode*
    - *Information downloaded will be available*

5.3 PIREPs[34]

5.3.1 Dispatch Release PIREPs

The following PIREPs were on page 16 of 19 on the dispatch release:

PILOT REPORTS
UA /OV CLT230020/TM 0123/FL105/TP A321/TB MOD/RM MOD TURB
105-075 DURD

UA /OV VXV230003/TM 0430/FL029/TP CRJ9/SK SCT012 OVC029/WX 10SM
-RA/TA 07/WV 28006/TB NA/IC NA/RM BASES 029 SMOOTH RIDE ON FINAL

UUA /OV GQO285020/TM 0053/FL170/TP C56X/TB SEV CAT/RM DURD
150-110 ZTLFD

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

Charlotte VOR/DME[35] (CLT), Charlotte, North Carolina standard pilot report (UA); Location – Over a point southwest of the CLT VOR, Charlotte, North Carolina 20 miles; Time – 0123Z; Altitude – 10,500 feet; Aircraft –A321; Turbulence –moderate; Remarks – Moderate turbulence 10,500 feet to 7,500 feet during descent.

McGhee Tyson Airport (TYS); Knoxville, Tennessee routine pilot report (UA); Location – Over the Volunteer VORTAC[36], Knoxville, Tennessee; Time – 0536Z; Altitude – 1,200 feet; Aircraft – B712[37]; Sky conditions – scattered clouds at 1,200 feet, overcast at 3,800 feet; Weather

[34] Pilot Reports
[35] Very-high Omnidirectional Radial with Distant Measuring Equipment.
[36] Very-high Omnidirectional Radial with Tactical Air Navigation
[37] Boeing 717-200

– 10 statute miles of visibility; Temperature - 7° C; Wind – from 290° at 8 knots; Turbulence – Not available; Icing – Not available; Remarks – Bases of the clouds at 1,200 feet.

Choo Choo VORTAC (GQO), Chattanooga, Tennessee urgent pilot report (UUA); Location – Over a point west of the Choo Choo VOR 20 miles; Time – 0053Z; Altitude – 17,000 feet; Aircraft – C56X[38]; Turbulence – Severe Clear Air Turbulence; Remarks – During descent from 15,000 feet to 11,000 feet, filed by Atlanta ARTCC.

5.3.2 Archived PIREPs

A review of archived PIREPs, throughout the national airspace, showed that of the 168 PIREPs provided in the approximate 2 hours prior and 1 hour after the accident flight's encounter with turbulence, there were 17 PIREPs within approximately 100 miles of the accident location. The 17 PIREPs were filed as follows:

SPA UA /OV SPA030020/TM 0406/FL330/TP E75L/TB MOD/RM ZTLFD

AVL UA /OV SUG360005/TM 0422/FL240/TP E215/TB MOD 240-160/RM ZTLFD

TRI UA /OV TRI250015/TM 0425/FL080/TP E135/WX RA/TB LGT/OCNL MOD/RM DURD

AHN UA /OV AHN170015/TM 0427/FL280/TP B739/TB MOD CAT/RM ZTLFD

TYS UA /OV VXV230003/TM 0430/FL029/TP CRJ9/SK SCT012 OVC029/WX 10SM -RA/TA 07/WV 28006/TB NA/IC NA/RM BASES 029 SMOOTH RIDE ON FINAL

AVL UA /OV SUG290010/TM 0434/FL080/TP CRJ2/TB MOD/RM ZTLFD

GRD UUA /OV GRD345020/TM 0435/FL120/TP G401/TB SEV CAT 110-130/RM NO DAMAGES OR INJURIES REPORTED ZTLFD

HKY UA /OV BZM360015/TM 0519/FL340/TP CRJ7/TB MOD CHOP/RM ZTLFD

CLT UA /OV CLT340060/TM 0520/FL170/TP C680/TB LGT-MOD 170-120/RM ZTLFD

HKY UA /OV BZM300010/TM 0523/FL320/TP CRJ7/TB MOD CHOP 320-300/RM ZTLFD

TYS UA /OV TYS/TM 0536/FL012/TP B712/SK SCT012 OVC038/WX 10SM/TA 07/WV 29008/TB NA/IC NA/RM BASES 012

LOZ UA /OV LOZ150020/TM 0540/FLDURD/TP CRJ7/TB MOD 220-160

AVL UA /OV SUG360010/TM 0546/FL160/TP CRJ9/TB LGT-MOD CHOP /RM HARD TO HOLD ALTITUDE ZTLFD

[38] Cessna Citation Excel

HKY UUA /OV BZM320015/TM 0558/FL170/TP CRJ9/TB OCNL SEV CAT 170-160/RM NO DAMAGES OR INJURIES RTEPORTED ZTLFD

TYS UA /OV VXV130005/TM 0600/FL190/TP CRJ9/TB MOD CAT 190-160/RM DURC ZTLFD

TYS UUA /OV VXV150055/TM 0600/FL190/TP CRJ7/TB SEV CAT 190-160/RM DURD FLIGHT ATTENDANT INJURED NECK AND ANKLE ZTLFD

TYS UUA /OV VXV120050/TM 0608/FL160/TP CRJ9/SK SCT012 OVC028/WX 10SM -RA/TA 06/WV 27009/TB /TB SEV 190-160/IC NA

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

Spartanburg VORTAC, Spartanburg, South Carolina routine pilot report (UA); Location – over a point northeast of the SPA VOR 20 miles; Time 0406Z; Altitude – FL330; Aircraft- E75L[39]; Turbulence – Moderate; Remarks – filed by Atlanta Air Route Traffic Control Center (ARTCC).

Ashville Regional Airport (AVL), Ashville, North Carolina routine pilot report (UA); Location – Over a point north of the Sugarloaf Mountain VORTAC, Asheville, North Carolina; Time – 0422Z; Altitude – FL240; Aircraft – E215[40]; Turbulence – Moderate between FL240 to 16,000 feet; Remarks – filed by Atlanta ARTCC.

Tri-Cities Airport (TRI), Blountville, Tennessee routine pilot report (UA); Location – Over a point west-southwest of the TRI airport 15 miles; Time – 0425Z; Altitude – 8,000 feet, Aircraft – E135[41]; Weather – Rain; Turbulence – Light occasional moderate; Remarks – During descent.

Athens VOR/DME, Athens, Georgia routine pilot report (UA); Location – Over a point south of the Athens VOR 15 miles; Time – 0427Z; Altitude – FL280; Aircraft – B739[42]; Turbulence – Moderate Clear Air Turbulence; Remarks – filed by Atlanta ARTCC.

McGhee Tyson Airport (TYS); Knoxville, Tennessee routine pilot report (UA); Location – over a point west-southwest of the Volunteer VORTAC, Knoxville, Tennessee 3 miles; Time – 0430Z; Altitude – 2,900 feet; Aircraft – CRJ9; Sky conditions – scattered clouds at 1,200 feet, overcast at 2,900 feet; Weather – 10 statute miles of visibility, light rain; Temperature - 7° C; Wind – from 280° at 6 knots; Turbulence – Not available; Icing – Not available; Remarks – Bases of the clouds at 2,900 feet, smooth ride on final.

Ashville Regional Airport (AVL), Ashville, North Carolina routine pilot report (UA); Location - Over a point west of the Sugarloaf Mountain VORTAC, Asheville, North Carolina 10

[39] Embraer 175
[40] Boeing F-15E Strike Eagle
[41] Embraer ERJ-135
[42] Boeing 737-900

miles; Time 0434Z; Altitude – 8,000 feet; Aircraft – CRJ2[43]; Turbulence – Moderate; Remarks – Filed by Atlanta ARTCC.

Greenwood VORTAC (GRD), Greenwood, South Carolina urgent pilot report (UUA); Location – Over a point northwest of the GRD VOR 20 miles; Time – 0435Z; Altitude – 12,000 feet; Aircraft – G401; Turbulence – Severe Clear Air Turbulence from 11,000 feet to 13,000 feet; Remarks – No damages or injuries reported, filed by Atlanta ARTCC.

Hickory Regional Airport (HKY), Hickory, North Carolina routine pilot report (UA); Location – Over a point north of the Barretts Mountain VOR/DME, Hickory, North Carolina 15 miles; Time 0519Z; Altitude – FL340; Aircraft – CRJ7; Turbulence – Moderate Chop; Remarks – Filed by Atlanta ARTCC.

Charlotte VOR/DME (CLT), Charlotte, North Carolina standard pilot report (UA); Location – Over a point north-northwest of the CLT VOR, Charlotte, North Carolina 60 miles; Time – 0520Z; Altitude – 17,000 feet; Aircraft – C680[44]; Turbulence – Light to moderate between 17,000 feet and 12,000 feet; Remarks – Filed by Atlanta ARTCC.

Hickory Regional Airport (HKY), Hickory, North Carolina routine pilot report (UA); Location – Over a point northwest of the Barretts Mountain VOR/DME, Hickory, North Carolina 10 miles; Time 0523Z; Altitude – FL320; Aircraft – CRJ7; Turbulence – Moderate Chop from FL320 to FL300; Remarks – Filed by Atlanta ARTCC.

McGhee Tyson Airport (TYS); Knoxville, Tennessee routine pilot report (UA); Location – Over the Volunteer VORTAC, Knoxville, Tennessee; Time – 0536Z; Altitude – 1,200 feet; Aircraft – B712; Sky conditions – scattered clouds at 1,200 feet, overcast at 3,800 feet; Weather – 10 statute miles of visibility; Temperature - 7° C; Wind – from 290° at 8 knots; Turbulence – Not available; Icing – Not available; Remarks – Bases of the clouds at 1,200 feet.

London VOR/DME (LOZ); London, Kentucky routine pilot report (UA); Location – Over a point south-southeast of the LOZ VOR, London, Kentucky 20 miles; Time – 0540Z; Altitude – During descent; Aircraft – CRJ7; Turbulence – Moderate from FL220 to 16,000 feet.

Ashville Regional Airport (AVL), Ashville, North Carolina routine pilot report (UA); Location - Over a point north of the Sugarloaf Mountain VORTAC, Asheville, North Carolina 10 miles; Time 0546Z; Altitude – 16,000 feet; Aircraft –CRJ9; Turbulence – Light to moderate chop; Remarks – Hard to hold altitude, filed by Atlanta ARTCC.

Hickory Regional Airport (HKY), Hickory, North Carolina routine urgent pilot report (UUA); Location – Over a point northwest of the Barretts Mountain VOR/DME, Hickory, North Carolina 15 miles; Time 0558Z; Altitude –17,000 feet; Aircraft – CRJ9; Turbulence – Occasional Severe Clear Air Turbulence from 17,000 feet to 16,000 feet; Remarks – No damages or injuries report, filed by Atlanta ARTCC.

[43] Bombardier CRJ100/200
[44] Cessna Citation Sovereign

McGhee Tyson Airport (TYS); Knoxville, Tennessee routine pilot report (UA); Location – Over a point southeast of the Volunteer VORTAC, Knoxville, Tennessee 5 miles; Time – 0600Z; Altitude – FL190; Aircraft –CRJ9; Turbulence – Moderate Clear Air Turbulence from FL190 to 16,000 feet; Remarks – During climb, filed by Atlanta ARTCC.

McGhee Tyson Airport (TYS); Knoxville, Tennessee routine urgent pilot report (UUA); Location – Over a point southeast of the Volunteer VORTAC, Knoxville, Tennessee 55 miles; Time – 0600Z; Altitude – FL190; Aircraft – CRJ9; Turbulence – Severe Clear Air Turbulence from FL190 to 16,000 feet; Remarks – During descent flight attendant injured neck and ankle, filed by Atlanta ARTCC.

McGhee Tyson Airport (TYS); Knoxville, Tennessee routine urgent pilot report (UUA); Location – Over a point southeast of the Volunteer VORTAC, Knoxville, Tennessee 50 miles; Time – 0608Z; Altitude –16,000 feet; Aircraft – CRJ9; Sky conditions – Scattered clouds at 1,200 feet overcast clouds at 2,800 feet, 10 statute miles visibility, light rain, outside temperature 6° C, wind from 270° at 9 knots; Turbulence – Severe from FL190 to 16,000 feet; Icing – not available.

6.0 PSA Airlines Guidance

6.1 PSA Airlines – Flight Operations Manual

The PSA Airlines – Flight Operations Manual, Revision 38, dated October 24, 2019, provided the following guidance for flight crews as it pertained to turbulence:

6.1.1 Normal Operations

The PSA Airlines – Flight Operations Manual, Section 4 "General – Crew Resource Management," provided, in part, the following guidance:

> *Each crewmember must strive to maintain good communication throughout flight operations. During the flight, the flight crew communicates with the flight attendant(s) by utilizing a variety of cabin announcements and bell chimes, along with two-way communication through the interphone. Each crewmember should be familiar with the "normal" flight routine of other crewmembers so that he/she is able to detect when something is wrong or out of the ordinary. The flight crew has a heavy task load such as during critical phases of flight (critical phases of flight are defined as taxi, takeoff, landing, all operation below 10,000 ft. except cruise and severe turbulence). Communication during these times should be limited to issues related to the safe operation of the flight, including:*
>
> • *Responding to any call from the flight crew*
> • *A serious disturbance created by a passenger*
> • *An emergency situation of which the flight crew must be made aware*
> • *A problem with the aircraft doors, structure, or systems*
>
> *It is the responsibility of all flight attendants to keep the flight crew informed as to the condition of the cabin and passengers. If discrepancies are present, the flight crew should be notified. Accurately express all concerns clearly and concisely.*

CRJ-701 and CRJ-900 *– The FWD FA is responsible for direct communication with the flight crew and for maintaining communication with the AFT FA.*

6.1.2 Passenger Announcements

The PSA Airlines – Flight Operations Manual, Section 4 "General – Communications" provided, in part, the following guidance pertaining to passenger announcements:

Miscommunication can arise when one pilot is off ATC frequency. To increase the likelihood that both pilots monitor ATC clearance, it may be necessary to tailor timing and/or length of the announcements relative to anticipated ATC clearances.

Taxi Delay.

When a taxi delay is encountered, the flight crew will provide customers with updated delay status approximately every 15 minutes (parking brake set). This announcement allows the Flight Attendant(s) to move about the cabin providing customer-related services.

• Note •

Subsequent movement of the aircraft must be coordinated with the Flight Attendant(s) to ensure passenger service items are collected prior to continuing taxi.

In-Flight Turbulence.

When moderate or greater turbulence is anticipated, alert the Flight Attendant(s) and passengers and illuminate the fasten seatbelt sign.

In-flight Fasten Seatbelt Sign.

On.

When the fasten seatbelt sign is illuminated in flight, a flight deck crewmember will make an announcement instructing passengers to return to their seats and remain seated with their seat belts fastened. The Flight Attendant(s) may call the flight deck via the interphone for additional information.

Off.

When the seatbelt sign is turned off, a flight deck crewmember will make an announcement advising passengers to keep their seatbelts fastened at all times when seated.

6.1.3 Preventing Injuries Caused by Turbulence

The PSA Airlines – Flight Operations Manual, Section 4, "General – Preventing Injuries Caused by Turbulence," provided the following guidance:

The Captain must emphasize the importance of the Flight Attendants' personal safety. Flight Attendant injuries occur at a disproportionately high rate compared to other crewmembers

and other cabin occupants because Flight Attendants spend more time in the passenger cabin unseated and, therefore, unbelted. Flight Attendants 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 is imperative that the Captain instruct the Flight Attendant(s) to be seated in such conditions.

An effective preflight briefing should include:

• Potential of turbulence encounters during each flight leg
• Emphasis on the importance of keeping the flight deck informed of the conditions in the cabin
• Commitment to using standard air carrier procedures and phraseology during a turbulence encounter
• The importance of maintaining communication during the flight, including communication with the aircraft Dispatcher, as appropriate
• The results of communication errors; such as the use of vague, inaccurate descriptions and nonstandard phraseology regarding turbulence

In Flight:

• Flight crew must promptly and clearly communicate turbulence advisories including specific directions to Flight Attendants and to passengers. Those advisories can include directions to be seated with seatbelts fastened, and to secure cabin service equipment, as conditions may require
• Flight Attendants must effectively communicate directions to passengers to be seated with seatbelts fastened
• Flight Attendants can verify that any CRS is secured properly in a forward facing seat and that the child appears to be properly secured in the CRS
• Before descent, or early in the descent, depending on conditions, flight crews may give passengers notice via an announcement that the Fasten Seatbelt sign will be illuminated in 10-15 minutes, and that any personal needs requiring movement in the cabin should be met before that time. This practice emphasizes the requirement to comply with the Fasten Seatbelt sign
• The Captain should promote reasonable communication between Flight Attendants and the flight crew regarding the use of the Fasten Seatbelt sign
• The environment in the cabin may be very different from the environment in the flight deck during turbulence. Flight Attendants should feel free to request that the flight crew illuminate the Fasten Seatbelt sign whenever they judge it is appropriate to do so
• When the Fasten Seatbelt sign remains illuminated for prolonged periods of time for reasons other than protection from a turbulence encounter, its effectiveness can diminish for passengers and Flight Attendants. Flight Crewmembers should turn off the seatbelt sign as soon as conditions cease to exist. If forecast conditions exist that warrant leaving the seatbelt sign illuminated, an announcement should be made describing the conditions and the need to remain seated.

Dispatchers and flight crews should be encouraged to maintain 2-way communication before, during, and after a flight. In the preflight planning phase, the Dispatcher may use the "Remarks" section of the dispatch (flight) release to advise flight crews of known or forecast turbulence. A "call Dispatch" notation on the dispatch release may be included to indicate that the Dispatcher believes a telephone conversation with the pilot is necessary. Communication may resume at any time during or after flight using an Aircraft Communication Addressing and Recording System (ACARS), company radio, or telephone and is encouraged to improve the flow of real-time information regarding turbulence. During a flight, the pilot(s) and Dispatcher must communicate any changes in the forecast or actual turbulence conditions via voice or digital communication methods in order to pass real-time turbulence information along to other flights.

6.2 PSA Airlines – Dispatch Standard Process Manual

The PSA Airlines – Dispatch Standard Process Manual provided, to dispatch personnel, the following guidance as it pertained to turbulence and/or thunderstorm activity.

6.2.1 Turbulence

The PSA Airlines – Dispatch Standard Process Manual, Section 6 "Weather – Hazardous Weather" provided the following table for turbulence definitions and crew actions during turbulence encounter:

Turbulence Encounters			
Intensity	**Airplane Reaction**	**Cabin Reaction**	**Crew Action**
Light Chop	No appreciable changes in altitude/ attitude. Slight, rapid and somewhat rhythmic bumpiness occurs.	Occupants may feel a slight strain against seat belts. Unsecured objects remain stable. Coffee is shaking slightly, but not splashing out of cup. No difficulty in walking.	**Flight Deck Crewmember:** • Illuminate the seat belt sign (at Captain's discretion). • Make PA instructing passengers to be seated. *"Ladies & Gentlemen, as turbulence is not always anticipated, please keep your seatbelts fastened while seated."* **Flight Attendant(s):** • Verify passenger (including infants/children) seat belts are securely fastened. • Secure unattended carts and stow loose cabin & galley items. • Continue cabin service with caution.
Light	Momentary, slight, erratic changes in altitude and/or attitude.	Walking and cart maneuvering may be difficult. Coffee is shaking, but not splashing out of cup.	
Moderate Chop	Rapid bumps or jolts without appreciable changes in altitude or attitude.	Occupants feel definite strain against seat belt. Unsecured objects move about. Coffee is splashing out of cup. Very difficult to walk and maneuver carts.	**Flight Deck Crewmember:** • Illuminate the seat belt sign. • Make PA instructing passengers to be seated. • Report turbulence encounter to the controlling Dispatcher. **Flight Attendant(s):** • Discontinue cabin service. • Communicate with Captain. • Attempt to stow cart or set cart brakes but leave cart in present location. • Cover coffee pots or place on floor. • Sit down in nearest passenger seat or jumpseat. If seat is unavailable, sit on floor and hold on.
Moderate	Changes in altitude/ attitude and airspeed fluctuations occur, but the airplane remains in positive control.		
Severe	Large, abrupt changes in altitude/ attitude occur. Usually large airspeed fluctuations occur. Airplane may be momentarily out of control.	Occupants forced violently against seat belts. Unsecured objects tossed about or lifted from floor. Walking or standing without holding on to something for support is impossible.	**Flight Deck Crewmember:** • Ensure seat belt sign is on. • Make a PA instructing passengers and Flight Attendant(s) to be seated. • Report turbulence encounter to the controlling Dispatcher. • Maintenance write-up and airplane inspection required. **Flight Attendant(s):** • Discontinue cabin service. • Command passengers to sit down and fasten seat belts, if flight deck is unable to make PA. • Sit down and hold on. If seat is unavailable, sit down on the floor. • Communicate with Captain (if practical). • Inspect cabin and report damage/injuries to the Captain.
Extreme	Airplane tossed violently about. Practically impossible to control. May cause structural damage.		
Frequency Definition	**Occasional:** Occurring less than 1/3 of the time.	**Intermittent:** Occurring 1/3 - 2/3 of the time.	**Continuous:** Occurring more than 2/3 of the time.

Figure 1: Turbulence Encounter and Crew Actions
(Source: PSA Airlines Dispatch Standard Process Manual pg. 6-40)

Clear Air Turbulence (CAT).

Initiate flight level or course change when encountering jetstream turbulence with direct headwinds or tailwinds. Jetstream turbulence encountered in a crosswind is normally in a narrow band across the wind. When crossing the jetstream, climb with rising temperature and descend with a dropping temperature if necessary.

Mountain Wave Turbulence.

If the ratio of the wind speed 6,000 feet above the ridge to the winds at ridge top level is 1.6 or less, the probability of moderate or greater turbulence increases. This turbulence can exist at all altitudes. If the ratio of the wind speed 6,000 feet above the ridge to the wind at ridge-top level is greater than 2, turbulence is likely to be confined to lower altitudes.

Example.
If the wind speed at 18,000 feet is 50 knots and the wind speed at 12,000 feet is 35 knots, the ratio is 1.4. Moderate or greater turbulence may exist up to high altitudes.

Turbulence and Thunderstorms.

Expect moderate or greater turbulence within thunderstorms, or in the vicinity of thunderstorm tops, wakes, downbursts, and gust fronts.

Severe or Extreme Turbulence Encounter.

Do not plan flight into severe/extreme turbulence. If encountered, make a maintenance logbook write up to ensure a special aircraft structural inspection is accomplished.

Flight Attendant and Cabin Notification of Turbulence.

When moderate or greater turbulence is anticipated, illuminate the fasten seatbelt sign and make a PA announcement instructing passengers to be seated.

Notify the Flight Attendant(s) via the interphone to be seated. Inform the Flight Attendant(s) via the interphone when it's safe to resume duties.

6.2.2 Pre-Planning Considerations

The PSA Airlines – Dispatch Standard Process Manual, Section 4 "Dispatch Routine – Pre-planning Conditions" provided, in part, the following guidance:

Before beginning the dispatch release process, each dispatcher should perform a self briefing and become familiar with such things as:

Routing
• Extended overwater operations prohibited. No PSA flight may operate at a distance beyond 50NM to the nearest shoreline….

Weather

• Do the METARs match conditions called for in the TAFs?
• Does radar indicate approaching storms to where an alternate may be desirable even though forecasts do not indicate one is needed?
• Are there areas of severe turbulence that may affect safety of flight or passenger comfort?

Maintenance

• Are any aircraft out of service that may jeopardize a flight departing on time if a substitution is not made?
• Do any aircraft have MELs that may restrict the flight's ability to carry the projected number of passengers?

• Do any aircraft have MELs that may restrict the flight's ability to fly safely to its scheduled destination

6.2.3 Hazardous Weather

The PSA Airlines – Dispatch Standard Process Manual, Section 6 "Weather – Hazardous Weather" provided the following guidance about hazardous weather:

Purpose. *This section contains policies and procedures for aircraft operating in the vicinity of hazardous weather which include thunderstorms, microbursts, severe windshear and turbulence, volcanic ash, and severe icing.*

Dispatch Policy.

Flights will not dispatch or operate through areas of reported or forecast hazardous weather unless these hazards can be avoided by:

- *changing routing or altitude,*
- *delaying takeoff or landing,*
- *holding, or*
- *landing at an alternate.*

WARNING

Remain safely clear of hazardous weather regardless of ATC requirements.

PIREPS.

ATC PIREPS.

Notify ATC via PIREP of any severe weather condition which might adversely affect safety of flight as soon as situation permits. Include type, location, altitude and intensity of weather hazard. Use the term "PIREP" on ATC frequency controlling the aircraft in the sector directly affected by the PIREP. Request routing deviation or altitude change as soon as practical for adequate coordination and traffic separation.

• Note •

ATC controllers assist pilots to avoid weather as long as assistance does not detract from their primary responsibility of traffic separation. ATC radar equipment has limited ability to track aircraft and simultaneously display areas of potential or actual severe weather.

Company PIREPS.

Flight crews will:

• Advise the controlling Dispatcher of unreported or unforecasted weather conditions which might materially affect safe or effective operations.
• Include type, location, altitude, and intensity of weather hazard, and time of encounter.
• Respond as soon as practical to any requests for weather updates.

6.2.3.1 Thunderstorms

The PSA Airlines – Dispatch Standard Process Manual, Section 6 "Weather – Hazardous Weather" provided the following guidance about thunderstorms:

Thunderstorms present significant hazards; avoid thunderstorm activity.

Radar Use.

Use large scales on weather radar to keep "big picture." Use smaller scales as necessary to assist in avoidance.

Radar and Turbulence in Thunderstorms.

Consider the turbulence level of the entire cell to be that of the most intense portion of the radar return (e.g., when an echo contains green, yellow, and red intensity levels, the turbulence level of the entire cell is red).

Enroute Lateral Separation.

Lateral separation is preferred for avoiding thunderstorm activity. Contact ATC as early as possible for deviations. Use distances in the following table for <u>minimum</u> lateral separation:

Minimum Lateral Thunderstorm Avoidance Criteria

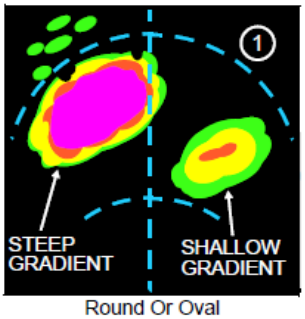
Echo Type	Description	Avoidance Minima
Convective Shower	• Lightning possible • Round/oval shape • Symmetrical gradient • Radar tops ≤ 30,000 ft • Isolated cell • NWS VIP ≤ 4 • Echo containing magenta turbulence echo or yellow and/or red	— Avoid visible clouds — Avoid displayed precipitation echo (including green echo)

Intense	Contains red echo and any of the following: • Irregular shape (notches, hooks, pendant shape, etc.) • Asymmetrical gradient • Radar tops >30,000 ft • Southern-most cell in a line • NWS VIP level 5/6 • Prominent shadow • Magenta precipitation echo	SAT>0°C (32°F) — Avoid flight into and below visible clouds. — Avoid all displayed. precipitation by 10 nm in upwind quadrants/20 nm in downwind quadrants SAT £ 0°C (32°F) — Avoid flight into and below all visible clouds by 5 nm. — Avoid displayed precipitation from echo (including green echo) by 20 nm.

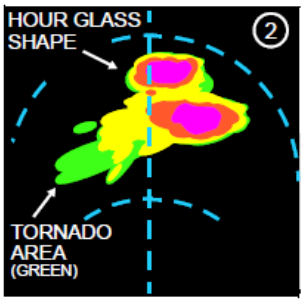
VIP - An acronym for Video Integrator and Processor. This processor was used on the WSR-57 and WSR-74C radars to indicate rainfall rates. It is still used occasionally on WSR-88D radar products. This processor contours radar reflectivity (in dBZ) into six VIP levels.

VIP Levels - Categorized intervals of reflectivity which are computer processed by a Digital Video Integrator Processor (D/VIP). These intervals were very important before the installation of the 88-D Radar network. Some of the 88-D Radar products still have these intervals on them. The following table illustrates the various rainfall rates associated with VIPs:

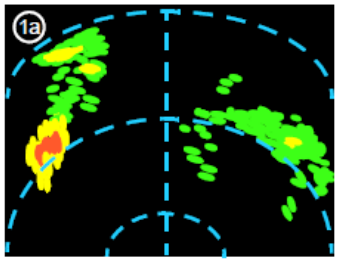
VIP Level	Precipitation Description	Rainfall Rate (inches/hour)	
		Stratiform	Convective
VIP 6 (>57 dBZ)	Very heavy rain and hail; large hail possible		7.10" or more
VIP 5 (50-57 dBZ)	Very heavy rain; hail possible		4.50" - 7.10"
VIP 4 (44-50 dBZ)	Heavy rain		2.20" - 4.50"
VIP 3 (38-44 dBZ)	Moderate to heavy rain	0.50" - 1.00"	1.10" - 2.20"
VIP 2 (30-38 dBZ)	Light to moderate rain	0.10" - 0.50"	0.20" - 1.10"
VIP 1 (18-30 dBZ)	Light precipitation	0 - 0.10"	0.05" - 0.20"



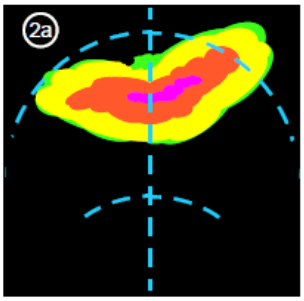
Round Or Oval



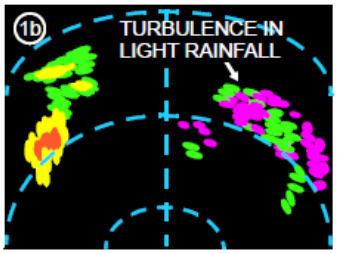
Asymmetrical Gradient



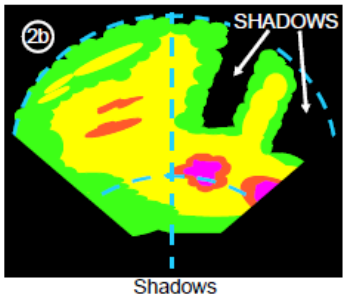
In this WX mode avoid the cell to the left.



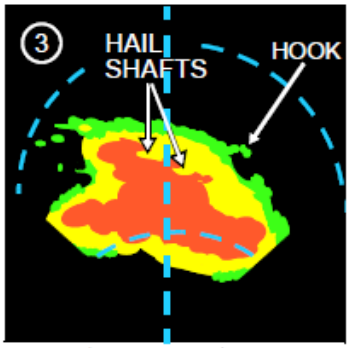
Crescent Shape
(Intense, shadow- producing storm)



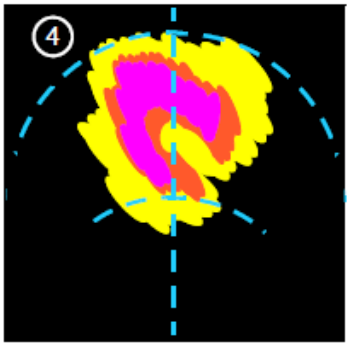
In the WX+ Doppler mode the turbulence occurring in the light rain to the right can be seen. Avoid this area. (If the Doppler echoes were not present, the green stratus area on the right could be penetrated.)



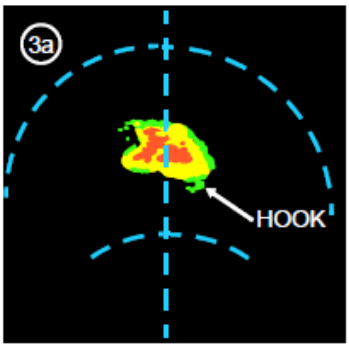
Shadows



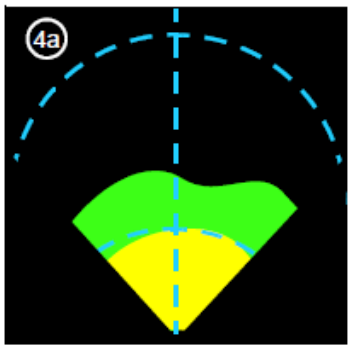
Pendant shape with scallops (hail shafts) along far edge of red on 3-color radar.



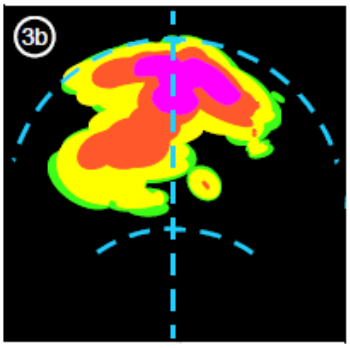
Classic U - Shaped Notch



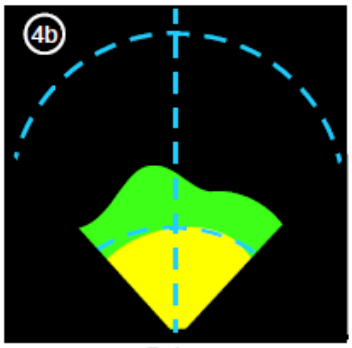
Same pendant cell with gain reduced. Red still remains, it's a level 5 or 6 storm. (Note hook)



Dip



Note finger on far side (hail); and classic hook on left.



Bulge

Factors Increasing Thunderstorm Hazards.

The following factors increase hazards associated with thunderstorms. Consider these factors when choosing a course of action; multiple factors may increase hazards exponentially.

- *significantly unstable atmosphere,*
- *dewpoint >10°C,*
- *temp/dewpoint spread >16°C,*
- *storm movement >10 kts,*
- *southern-most cell in a line.*

Overflight Avoidance.

Avoid hazardous weather laterally if possible. In IMC, clear cell tops by at least 20 percent of radar cell height; in VMC, visually clear cell tops by at least 5,000 ft.

Anvil Circumnavigation.

The downwind side of a thunderstorm may contain hail and severe turbulence above or below the anvil. A good rule of thumb is to avoid the downwind (anvil) side of the main body of the cells by at least one mile for every knot of wind at that altitude (e.g., If the winds aloft at the altitude of the anvil are 270° at 60 kts, avoid the downwind side of the main body by 60 nm).

Caution

Be alert for hail. Severe hail has been encountered as much as 20 mi downwind of large thunderstorms.

Thunderstorm Penetration.

If all attempts to avoid hazardous weather fail and thunderstorm penetration is unavoidable:

- *Tighten safety belt and fasten shoulder harness; advise the Flight Attendant(s) as soon as possible.*
- *Use all available resources including ATC, weather radar, and visual observations to select a straight course that passes through the least intense area of the storm.*

WARNING

Do not penetrate radar shadows. Fly away from crescent shapes or dips in display; fly towards bulges.

Radar beam attenuation can cause areas of heavy precipitation to appear as clear areas or radar shadows.

- *Avoid altitudes near the freezing level. Greatest probability of severe turbulence and lightning strikes exists near the freezing level.*
- *Once inside a cell, continue on a straight course. Expect very large fluctuations in pitot static instruments; use gyrostabilized instruments for flight indications.*
- *Refer to Chapter 8: Adverse Weather in the applicable Pilot Operating Handbook for specific instructions.*

6.2.4 Enroute Weather

The PSA Airlines – Dispatch Standard Process Manual, Section 6 "Weather – Weather Minima" provided the following guidance about enroute weather:

> ***Dispatch Policy***
>
> *Flights will not dispatch or operate through areas of reported or forecast hazardous weather unless these hazards can be avoided by:*
>
> - *changing routing or altitude,*
> - *delaying takeoff or landing,*
> - *holding, or*
> - *landing at an alternate.*
>
> ***WARNING***
>
> *Remain safely clear of hazardous weather regardless of ATC requirements.*
>
> ***WARNING***
>
> *No PSA flight will be dispatched into known or forecast severe icing/turbulence.*

6.3 PSA Flight Attendant Guidance

The following guidance was provided to PSA Flight Attendants via their Flight Attendant Manual, Revision 26, dated September 23, 2019.

6.3.1 Communication

Chapter 1 "General Policies and Procedures – Crew Resource Management (CRM)" provided the following guidance when it came to communication:

> *The safe completion of the flight requires clear and effective communication between all personnel involved, including the captain, first officer, flight attendant(s), the Operations Control Center (OCC), Air Traffic Control (ATC) and Ground Operations. Policies and procedures are established to provide a standard for flight operations. When following the standard, our ability to detect an abnormality that could potentially cause a problem is increased. Guidelines are provided for emergencies to help each crewmember respond effectively.*
>
> *Just as we follow a standard for operations, we must follow a standard for good communication. If effective communication skills are established during normal operation, each crewmember will be better equipped to handle an emergency situation. Before a critical situation is encountered, the team must be built by discussing your mission, what could go wrong and a plan to handle*

possible unusual or emergency situations. Each crewmember must strive to maintain a balance between their social and their operational focus.

Each crewmember must strive to maintain good communication throughout flight operations. During the flight, the flight crew communicates with the flight attendant(s) by utilizing a variety of cabin announcements and bell chimes, along with two-way communication through the interphone. Each crewmember should be familiar with the "normal" flight routine of other
crewmembers so that he/she is able to detect when something is wrong or out of the ordinary.

Be aware of when the flight crew has a heavy task load such as during critical phases of flight (critical phases of flight are defined as taxi, takeoff, landing, all operation below 10,000 ft. except cruise and severe turbulence). Communication during these times should be limited to issues related to the safe operation of the flight, including:

- *Responding to any call from the flight crew.*
- *A serious disturbance created by a passenger.*
- *An emergency situation of which the flight crew must be made aware.*
- *A problem with the aircraft doors, structure, or systems.*

It is the responsibility of all flight attendants to keep the flight crew informed as to the condition of the cabin and passengers. If discrepancies are present, the flight crew should be notified. Accurately express all concerns clearly and concisely.

***Dual Class** – The FWD FA is responsible for direct communication with the flight crew and for maintaining communication with the AFT FA.*

6.3.2 Crew Briefing

Chapter 3, "Flight Attendant Duties – Reporting for Duty" provided the following information in regard to crew briefing:

Effective, two-way communication between Flight Deck and Cabin Crewmembers is mandatory to ensure safe and efficient flight operation. Effective communication is established through the Crew Briefing.

A successful Crew Briefing is one in which all crewmembers actively participate. The captain should set the tone by establishing open communication and safety guidelines for the trip. He/she should encourage questions and participation from the other crewmembers.

The Crew Briefing must be accomplished prior to each flight. If the entire crew is continuing from an earlier flight, the CA may brief the crew on the changes and then state "no other changes". The Crew Briefing should include:

***N**ames (and Positions)*

***E**mergency Procedures*
***W**eather (General)*
***D**oor Entry Procedure (Interphone Inop during Flight)*
***A**ircraft Specific Information (MELs)*
***T**urbulence Considerations*
***E**stimated Flight Time*
***S**pecial Considerations (Ground and/or Aircraft Security Issues, Prisoners, Law Enforcement Officers)*

6.3.3 Communication Prohibition During Sterile Flight Deck

Chapter 3, "Flight Attendant Duties – Communication Systems and Procedures" provided the following information in regard to prohibition to communication during sterile flight deck:

14 CFR 121.587 states that crewmembers are responsible for ensuring the Flight Deck Door is locked during flight. Doing so is a security measure that serves to enhance the concentration of flight crewmembers.

Loss of a flight crewmember's concentration during many phases of flight may result in the creation of extremely hazardous conditions. This is especially true while departure procedures are being conducted as well as any time frequent communication occurs between the pilots and ground personnel; such as during bad weather conditions or an emergency situation.

14 CFR 121.542 defines Sterile Flight Deck as the Critical Phases of flight during which flight crewmembers are specifically prohibited from engaging in any activity that:

- *Is not related to the proper conduct of the flight*
- *Is not required for safe operation of the flight*
- *Could distract them from or interfere with the performance or proper conduct of their duties*

The Critical Phases of Flight during which Sterile Flight Deck is in effect are:

- *Taxi*
- *Take-Off*
- *Landing*
- *All Flight Operations below 10,000 feet except cruise flight*
- *Severe Turbulence*

FA-Initiated Communication During Sterile Flight Deck.

The flight attendants may initiate communication with the Flight Deck Crew during Sterile Flight Deck for safety-related or emergency situations only. Examples of such conditions include, but are not limited to:

- *Problems discernible from the cabin relating to aircraft doors, structures or systems*

- *Fire or smoke in cabin*
- *Serious passenger-created disturbance*
- *Unexpected illumination of emergency track lighting*

If a flight attendant or the cabin is not prepared for imminent Take-Off or Landing, the Flight Deck MUST be notified immediately. These actions are imperative to safe flight operations and are not a violation of Sterile Flight Deck regulations.

6.3.4 Turbulence Procedures

Chapter 3, "Flight Attendant Duties – Turbulence Procedures" provided the following information in regard to turbulence:

Turbulence, whether anticipated or unexpected, is a primary cause of FA and passenger injury onboard the aircraft. FA(s) can guard against injuries by:

- *Securing articles that are not being used*
- *Requiring passengers to keep their seat belts fastened at all times while seated*

Whenever turbulence is anticipated, the Flight Crew will turn on the Fasten Seat Belt sign and make an announcement advising passengers to remain seated with their seat belts fastened. The FA(s) should deliver the announcement if the Flight Crew does not. Always tend to your safety by taking the nearest seat and fastening your seat belt. Time permitting; the Flight Crew will notify the FA(s) via Interphone to be seated, when moderate to severe turbulence is anticipated. FA(s) may also initiate contact with the Flight Crew to discuss turbulence experienced in the cabin. Follow procedures based on the Turbulence Level Action Chart.

Turbulence Level Action Chart	
LIGHT: *Bumpiness and momentary changes in altitude/attitude*	
Characteristics: • *Occupants may feel a slight strain against seat belts* • *Liquids shaking but not splashing out of cup*	
FA Procedures	***Pilot Procedures***

— *Deliver Fasten Seat Belt Sign On announcement, if necessary* — *Continue service with caution* — *Discontinue service of hot liquids and remove hot liquids from top of carts* — *If Fasten Seat Belt sign is turned on, verify that passenger seat belts are fastened and infants/children are secured in child restraint systems, if applicable* — *If Fasten Seat Belt sign turned on, verify lavatories unoccupied*	• *Fasten Seat Belt Sign turned on at flightdeck's discretion* • *If Fasten Seat Belt sign is turned on, flightdeck may deliver announcement instructing passengers to return to seats* • *Notify FA(s) that **Light Turbulence** procedures are in effect and expected turbulence duration, if known*

Turbulence Level Action Chart	
***MODERATE:** Rapid bumps or jolts; changes in altitude/attitude*	
Characteristics: • *Occupants feel definite strains against seat belts* • *Liquids splashing out of cups* • *Difficulty walking*	
FA Procedures	***Pilot Procedures***
— *Deliver Fasten Seat Belt Sign On announcement, if necessary* — *Discontinue service and stow carts* — *Secure galley equipment and carts* — *Sit down and secure seat belt* — *Remain seated until notified by the flightdeck or the Fasten Seat Belt Sign is turned off* — *Once flightdeck advises it is safe to resume duties, check for passengers/crew in lavatories/ cabin needing attention or assistance. Inform flightdeck of injuries or interior cabin damage*	• *Fasten Seat Belt Sign turned on* • *Deliver announcement instructing passengers and FA(s) to be seated* • *Notify FA(s) that **Moderate Turbulence procedures** are in effect and expected duration, if known* • *When Moderate Turbulence is no longer in effect, notify FA(s) when service may resume and turn off Fasten Seat Belt Sign*

Turbulence Level Action Chart

SEVERE: *Large, abrupt changes in altitude/attitude*	
Characteristics: • *Occupants forced violently against seat belt* • *Items falling over or lifting off surface* • *Walking is impossible*	
FA Procedures	***Pilot Procedures***
— *Deliver Fasten Seat Belt Sign On announcement, if possible* — *Discontinue service immediately* — *Set brakes on all carts in present location; remove hot liquids from top of cart and place on floor* — *Sit down immediately and secure nearest seat belt* — *Remain seated until notified by the flightdeck or the Fasten Seat Belt Sign is turned off* — *Once flightdeck advises it is safe to resume duties, check for passengers/crew in lavatories/ cabin needing attention or assistance. Inform flightdeck of injuries or interior cabin damage*	• *Fasten Seat Belt Sign turned on* • *Deliver announcement instructing passengers and FAs to be seated* • *Notify FA(s) that **Severe Turbulence** procedures are in effect and expected duration, if known* • *When Severe Turbulence is no longer in effect, notify FA(s) when service may resume and Fasten Seat Belt Sign turns off*

6.3.5 Child Restraint Systems

Chapter 4, "Customer Care Procedures – Passenger Handling", provided the following information in regard to child restraint system available for aircraft:

> *For taxi, takeoff, landing, during turbulence or when the Fasten Seatbelt Sign is on, only CRSs and Aviation Child Safety Devices (ACSDs) certified for use in aircraft are permitted. FAA approved devices must have a label stating approval for use on aircraft.*
>
> *Labels.*
>
> *• The child restraint label must include the text: "This child restraint system conforms to all applicable Federal Motor Vehicle Safety Standards" "this child restraint is certified for use in motor vehicles and aircraft." The label is printed in red.*
> *• When an approved child restraint system for use on the aircraft with a worn off/unreadable label is presented, the parent must furnish a letter or document from the*

manufacturer that specifically ties the child restraint system (through detailed description or specific make and model number) to approval for use on aircraft.
• The labeling for an ACSD must include the text: "FAA approved in accordance with 14 CFR 21.305(d). Approved for Aircraft Use Only.
• If manufactured outside the U.S., a car seat may be accepted provided it bears the label showing approval from a foreign government or U.N. approval, as designated by a circle surrounding the letter "E" followed by the number of the approving country similar to the following image:

Non-Approved Devices.

The following may not be used during taxi, takeoff, and landing and when the Fasten Seatbelt Sign is on:

• Any device without an approval label
• Booster seats with no approval label or shoulder harness
• Belt extensions that attach to the parent or the parent's seatbelt
•Vest and/or harness type devices (with the exception of ACSD bearing FAA aircraft approval label)
• Any device that positions a child on the lap or chest of an adult

Devices PROHIBITED from use at all times:

• Backless booster seats and belts

Permitted Locations - Preferred location is a window seat.

• On all aircraft, CRS or ACSD may be placed in a window seat while the accompanying adult occupies the aisle seat
— Other locations may be acceptable provided the CRS (not the child's feet) does not block the egress of any passenger to the aisle
• Responsible person must be seated in the same row
• CRSs may face FWD or AFT in accordance with instructions on the label

Prohibited Locations.

• CRSs and ACSDs are prohibited in emergency exit rows
• CRSs and ACSDs are prohibited FWD and AFT of an emergency exit row

6.3.6 Public Address Announcements

"Chapter 11, Announcements – Non Routine Announcements" provided the following guidance for making announcements when the flight is experiencing turbulence:

This announcement is to be made when experiencing turbulence.
***Dual Class** – Either FA can deliver this announcement.*

✈ We are experiencing turbulence. Please return to your seat or take any open seat near you and fasten your seatbelt immediately.

7.0 Relevant System

7.1 PSA Airlines – Pilot Operating Handbook

The PSA Airlines – CRJ Pilot Operating Handbook, dated September 10, 2018 provided the following guidance as it pertained to the Rockwell Collins WXR-840 weather radar.

7.1.1 Weather Radar

The PSA Airlines – Pilot Operating Handbook, Section 8, "Adverse Weather – Weather Radar," provided the following information in regard to the aircraft weather radar:

The primary function of the WXR-840 weather radar system is to aid pilots in the detection and avoidance of areas of precipitation in and around thunderstorms.

The WXR-840 cannot detect clear air turbulence, windshear, clouds or lightning. However, rain, wet hail, moderate to heavy wet snow — and in some cases, possible icing conditions — can be detected by the system.

The WXT-840 can also be used to map-read the terrain.

The basic characteristics of the X-band radar system are:
- *Low-power transmitter (25 watts)*
- *Flat-plate antenna (14 inches)*
- *Digital processing*
- *Relatively narrow beam width, and*
- *Color screen imagery*

This new-technology solid-state radar requires different operating techniques when compared to older parabolic-antenna radar.

Power Output.

The WXR-840 weather radar system uses digital-signal processing which has allowed transmitter power requirements to be reduced to 25 watts.

The use of digital-signal processing and low power optimizes the performance of the radar system.

Display Calibration.

The colors on this radar represent variations in rainfall rate and create a display which is easier to interpret than the older monochrome sets. Detectable weather appears as one of the following colors — least reflective to most reflective: Black, Green, Yellow, Red, and Magenta.

Another significant difference is the way the picture is painted on the screen. In previous analog weather radar, new returns were added by each sweep of the antenna while old returns gradually bled away.

The new radar display is generated in the same way as a TV screen; each new sweep is a totally new picture — the old picture is completely erased. Thus, color changes can occur quickly if a return is close to the threshold between rainfall-rate categories.

Digital weather radar incorporates hypersensitive receivers and sensitivity time control (STC) circuitry to present a true calibrated image within a range of approximately 60 miles. Therefore, a yellow storm return at 60 miles will still be yellow at 10 miles.

WARNING

Sunglasses with polarized lenses that are designed to filter specific colors/frequencies of light may adversely affect a pilot's ability to see some colors shown on radar and EFIS displays. Some elements on the display could be completely invisible while wearing these types of sunglasses.

Also, the color of some elements may be changed. For example, some blue light filtering lenses can change magenta to red. For a radar target, this represents a reduction in the actual level of intensity of the target.

Storm Category	VIP* Level	Precipitation Rate		Color
		in/hr	mm/hr	
-		Less than 0.03	Less than 0.8	BLACK
Weak[1]	1	0.03 to 0.07	0.8 to 1.8	GREEN
Moderate[2]	2	0.07 to 0.2	1.8 to 5.1	YELLOW
Strong[3]	3	0.2 to .52	5.1 to 13.2	RED
Very Strong[4]	4			
Intense[5]	5	0.52 and greater	13.2 and greater	MAGENTA
Extreme[6]	6			

* Video Integrated Processor
[1] Weak Storm - Light to moderate turbulence, possible lightning
[2] Moderate Storm - Light to moderate turbulence, possible lightning
[3] Strong Storm - Severe turbulence, possible lightning
[4] Very Strong Storm - Severe turbulence, likely lightning
[5] Intense Storm - Severe turbulence, lightning, wing gusts, hail
[6] Extreme Storm - Severe turbulence, large hail, lightning, extensive wind gusts.

Figure 2: Weather Radar Color Intensity Level
(Source: PSA Pilot Operating Handbook pg. 8-15)

Flat-Plate Antenna.

Some energy from the older parabolic antenna was lost in the side lobes. This resulted in more ground clutter at low altitudes and more close-range weather returns around the periphery of the main beam. The flat-plate antenna transmits a narrow-focus, long-range beam which greatly reduces the side lobes and focuses much more energy into the main lobe.

With the loss of the side lobes, TILT control becomes more critical. As you approach storms and reduce the range, the tilt must be adjusted downward to avoid overscanning significant returns.

When using a flat-plate antenna for the first time, some pilots have expressed doubts about the lack of weather targets displayed, pointing out that they could see clouds that were not shown on the radar. Since radar display of clouds is dependent upon moisture content, clouds with low moisture may not have enough reflectivity to be displayed. This misunderstanding has been aggravated by use of the flat-plate antenna.

The flat-plate antenna exhibits characteristics different from the parabolic antenna. A great reduction in side-lobe energy results in the tilt setting being very sensitive, and its adjustment is critical to effective weather detection. It is recommended that the PM coordinate tilt and range selections with the PF to detect and avoid weather.

TILT Control.

The TILT control allows the radar beam to be moved up +15°or down -15° to aid the pilot in interpreting storm activity. Proper use of the TILT control allows the pilot to achieve the best picture of storm-cell size, height, and relative direction of movement. Procedures for adjusting the TILT control vary depending on user requirements. Proper use requires experience and practice.

Operating Tips.

Maximum rainfall rates in a thunderstorm usually occur about mid level in the storm. This is normally the area that will paint the strongest returns. If the airplane is below that altitude, some antenna uptilt will be needed. Conversely, if the airplane is above that altitude, some degree of down-tilt will be needed.

The amount of tilt needed varies with the estimated distance of the storm, the closer the storm, the more tilt required. In either instance, it is good practice to periodically move the TILT control throughout its range to reduce the possibility of missing close-in targets.

When operating over land, the best general guideline is to select a range that is within the line-of-sight distance to the horizon and adjust the antenna tilt until a small amount of ground clutter appears at about the outer third of the display.

An aircraft at 10,000 ft. AGL, with the 300 nm range selected, will not be able to paint ground clutter much beyond 123 nm. A better range selection at this altitude may be the 100 nm setting.
Once weather activity is identified, it is important to keep the radar beam pointed to the liquid portion of the cell. As discussed earlier, ice crystals reflect less energy than liquid precipitation. Tilting the beam above the freezing level may result in an underestimation of the cell's intensity. Move the TILT control up and down to determine the most reflective portion of the cell.

Autotilt (AUTO) Switch.

Autotilt is designed to reduce pilot workload by automatically adjusting the antenna tilt angle to maintain to ratio tilt/angle following altitude or range changes.

Autotilt is selected with the PUSH AUTO switch (push ON/push OFF). On the weather radar mode line, active autotilt is indicated by a suffix "A" at the angle readout.

When autotilt is selected ON, manual tilt commands from the TILT control remain operational.

GAIN Control.

The GAIN control is a seven-position switch that allows manual GAIN control of the radar system when operating in the MAP and WX modes. When placed in the NORM position, the gain is preset to a value that allows the radar receiver to calibrate its operation to the actual reflectivity level.

To aid pilots in making correct weather judgements, the GAIN control may be adjusted to higher or lower gain settings. The high settings (+1, +2, +3) may be chosen to identify the highest levels of precipitation, while the lower settings (-1, -2, -3) may be temporarily chosen to allow a more in-depth study of the most intense weather targets.

Each of the minus settings (-1, -2, -3) reduces the sensitivity of the radar system below that of the NORM setting by approximately one color level.

Each of the plus settings (+1, +2, +3) increases the sensitivity of the radar system through a combination of lengthening the transmitted pulse-width and increasing the receiver gain. The effective gain increase with each setting can be as much as one color level when the target is in close (out to approximately 65 nm) and less than one color level at longer ranges.

The greatest utility offered by the plus gain setting is the ability to display light precipitation that otherwise would be just under the green level threshold on the NORM setting. In many cases, these light levels still cause turbulence and can be avoided by use of the plus gain feature.

Proper use of the GAIN control allows a pilot, with weather radar operating experience, to estimate rainfall rates greater than a VIP level 3 (red) or 5 (magenta) return. Targets that show in a reduced gain condition indicate that severe turbulence, hail, and heavy rainfall is likely.

Caution

Although proper use of the GAIN control can provide added knowledge of the targets being displayed, the pilot should always return the GAIN control to the NORM position when finished analyzing the display. Failure to do so may result in missing significant targets at any range when operating in one of the minus settings (-1, -2, -3).

Ground Clutter Suppression.

Ground clutter suppression (GCS) is operable only in the WX mode. When selected, GCS reduces the intensity of ground returns and makes the precipitation returns easier to interpret. When selected, "GCS" is annunciated in cyan in the upper left corner of the MFD.

GCS should only be used to identify ground clutter. Continuous operations with the GCS feature turned on is not recommended because some precipitation returns may also be reduced in intensity or eliminated from the display.

If the antenna is excessively tilted down and GCS is turned on, a phenomenon knows [sic] as a "GCS wedge" may occur. This wedge is represented as a black area (an area showing no return) located approximately +/- 10 degrees from the aircraft's nose, and of the same depth of the ground return that was being painted prior to turning on GCS. To eliminate the wedge, turn GCS off or raise the tilt angle until the wedge disappears.

RANGE Control.

The RANGE control is a rotary knob that is used to select the maximum display range. For all of the selectable ranges, one cyan or white (white for MAP mode only) half-range arc is shown in the center of the MFD.

Extending outward from the aircraft symbol is a blanked ranged area. The size of this blanked range area equals one eighth of the selected range. The pilot should remember that the area between the airplane symbol and the perimeter of the blanked range does not show any targets. The selectable ranges, range-arc annunciations and blanked range are shown on the MFD.

• Note •

The pilot must always keep in mind the blanked area of the radar display during and after airplane maneuvers in the presence of potential weather. If one of the longer ranges is selected during and after airplane maneuvers, it is possible for weather targets to slip

within the blanked range area and therefore not shown on the display. The shortest practical range should be momentarily selected both during and following airplane maneuvers to ensure close-in weather shows on the display.

Transfer Mode.

In dual-radar control installations, the radar works in the split-scan mode. In the split-scan mode, the radar display on one side can be completely different from the one on the other side except for the scan width (SEC). Selecting the XFR switch will cause the system to operate as if it was a single-radar installation.
In single-radar installations, the XFR push button determines which display control panel (DCP) has control of the radar range. If both sides have selected the radar format on the multifunction display and the ranges are the same, the display mileage on the side controlling the radar range will be white; it will be yellow on the side not in control. A push on the XFR switch will cause
the other DCP to assume control of the radar range.

When the radar range is different than the one on the MFD, the annunciation "RADAR NOT AT THIS RANGE" will be displayed.

Operation.

Ground Operation.

The description of operation that follows has been derived from the vendor's Pilot's Guide. For a complete description of operation, refer to the Collins WXR-840 Weather Radar System, Pilot's Guide-Operation.

Switch the system to STBY mode when on the ground, unless you are using WX mode to check the terminal area prior to departure.

WARNING

The safe distance for human exposure to radar radiation of the WXR-840 weather radar system is 2 feet. Users should take necessary and reasonable precautions to ensure that personnel and equipment sensitive to microwave radiation are kept safely beyond this distance.

Takeoff and Climb.

Prior to takeoff, a short range selection such as 20 nm scale should be used. Tilt the antenna up to approximately +5 degrees to scan for weather along the departure path. Select autotilt to compensate for the initial altitude and range changes during climbout. As the airplane climbs, the tilt should be gradually decreased to aim at the regions of maximum precipitation while avoiding ground clutter, and the range should be increased. To reduce pilot workload, the use of autotilt during ascents and descents is encouraged.

Cruise.

For cruise, the tilt should be adjusted so that the ground returns are barely visible at the outer edge of the screen. Ground returns are displayed in arcs, paralleled to range marks. They merge together as the tilt is brought down and cause shadowing behind prominent features. They are generally smaller, sharper, and more angular than weather returns. To avoid overscanning, the tilt will have to be adjusted more frequently as storms are approached or range is changed.

Having once adjusted the tilt setting, pilots should not be content with just an occasional glance at the screen. Failure to periodically down-tilt leads to disappearing targets.

Middle Altitudes.

Antenna tilt for airplane flying at 20,000 ft. should be set near 0 degrees or slightly down.

Higher Altitudes.

This radar detects only liquid moisture in the form of raindrops, wet hail or wet snowflakes. Unless the beam is aimed at or below the freezing level of weather cells, there may not be sufficient moisture to paint a return on the display.

TILT Control at High Altitudes (Above FL350).

The tilt used for the middle altitudes is not effective for flight above 35,000 feet. Typically, at high altitudes, a longer range is selected and the tilt is adjusted slightly down. When selecting the operating range, keep in mind the line-of-sight distance to the horizon. When operating at the higher altitudes, it is particularly easy to scan over the top of significant storm cells.

Do not attempt to overfly targets. It is possible that dry hail (which generally cannot be detected) and severe turbulence may be present far above (radar) top of any areas of detected precipitation. The pilot should always remember that the weather radar system is an avoidance tool. It is strongly recommended that pilots never attempt to overfly, underfly, or penetrate storm cells or squall lines. For the safest operation, it is suggested that the pilot plan ahead to establish a flight path that avoids all returns by the distance established in the FOM.

Descent.

Antenna tilt has to be raised approximately one degree per 10,000 ft. of descent down to 15,000 ft., then one degree per 5,000 ft. below 15,000 ft. Range should be adjusted as necessary to scan the arrival route adequately. In heavy weather, the longest appropriate range should be used to plan a safe avoidance route; the selection of shorter ranges will show greater details as you enter the affected area. Remember that more tilt adjustment

will be required each time the range is switched. Only very small corrections will be required when using autotilt.

Summary.

Experience enables the pilot to properly analyze various types of storm displays. The key to avoiding detected weather is to first determine the heading change needed to bypass a storm safely. Once established on the appropriate heading, recheck the weather radar display to determine if further heading changes are required. The pilot should remember that the weather radar system was designed as a weather avoidance tool.

The pilot has the sole responsibility to decide how close to approach the various types of storms shown on the displays. Most convective weather systems in North America travel from south/southwest to north/northeast. The areas ahead of these storms (north/northeast) can then be expected to contain gust fronts, turbulence, heavy rain, and possibly hail. It is suggested that these areas be avoided by no less than the minimum distance established in the FOM.

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."*[45]

8.1 FAA Turbulence Fact Sheet

The FAA provided the following guidance titled "Fact Sheet – Turbulence" dated August 1, 2019 on their website:[46]

What is turbulence?

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

What should passengers do to avoid injuries?

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

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

[45] Source: https://www.faa.gov/travelers/fly_safe/turbulence/
[46] Source: https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=20074

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?

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

The NTSB requires airlines to report serious injuries and fatalities. A serious injury is "any injury that (1) requires the individual to be hospitalized for more than 48 hours, commencing within seven days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second-or third-degree burns, or any burns affecting more than five percent of the body surface." The FAA tracks these reports, but not general incidents of turbulence.

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: Crew Statements
Attachment 2: Flight Crew Schedules
Attachment 3: Flight Crew Training Records
Attachment 4: Dispatch Release
Attachment 5: Accident Flight Cargo Load Slip
Attachment 6: Accident Flight ACARS Messages [Excerpts]
Attachment 7: PSA Flight Operations Manual [Excerpts]
Attachment 8: PSA Airlines CRJ Pilot Operating Handbook [Excerpts]
Attachment 9: PSA Airlines Dispatch Standard Process Manual [Excerpts]
Attachment 10: PSA Airlines Flight Attendant Manual [Excerpts]
Attachment 11: Hazardous Weather and Radar Use Training
Attachment 12: Captain Upgrade Weather Radar Training
Attachment 13: Archived PIREPs
Attachment 14: Aircraft Maintenance Log Entries

Submitted by:

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