NTSB | National Transportation Safety Board

Dust Devil Aviation Accidents and other Mountain West Hazards

Paul Suffern – NTSB Senior Meteorologist

NTSB

170 accidents since 1982…
10 accidents in last 4 years
6 accidents in 2023

NTSB

CEN23LA228

GRUMMAN ACFT ENG CORSCHWEIZER G-164, N8405K

Saffell, Arkansas

May 2023

Part 137 Ag flight

Loss of control in flight

Pilot ~16,000 hrs

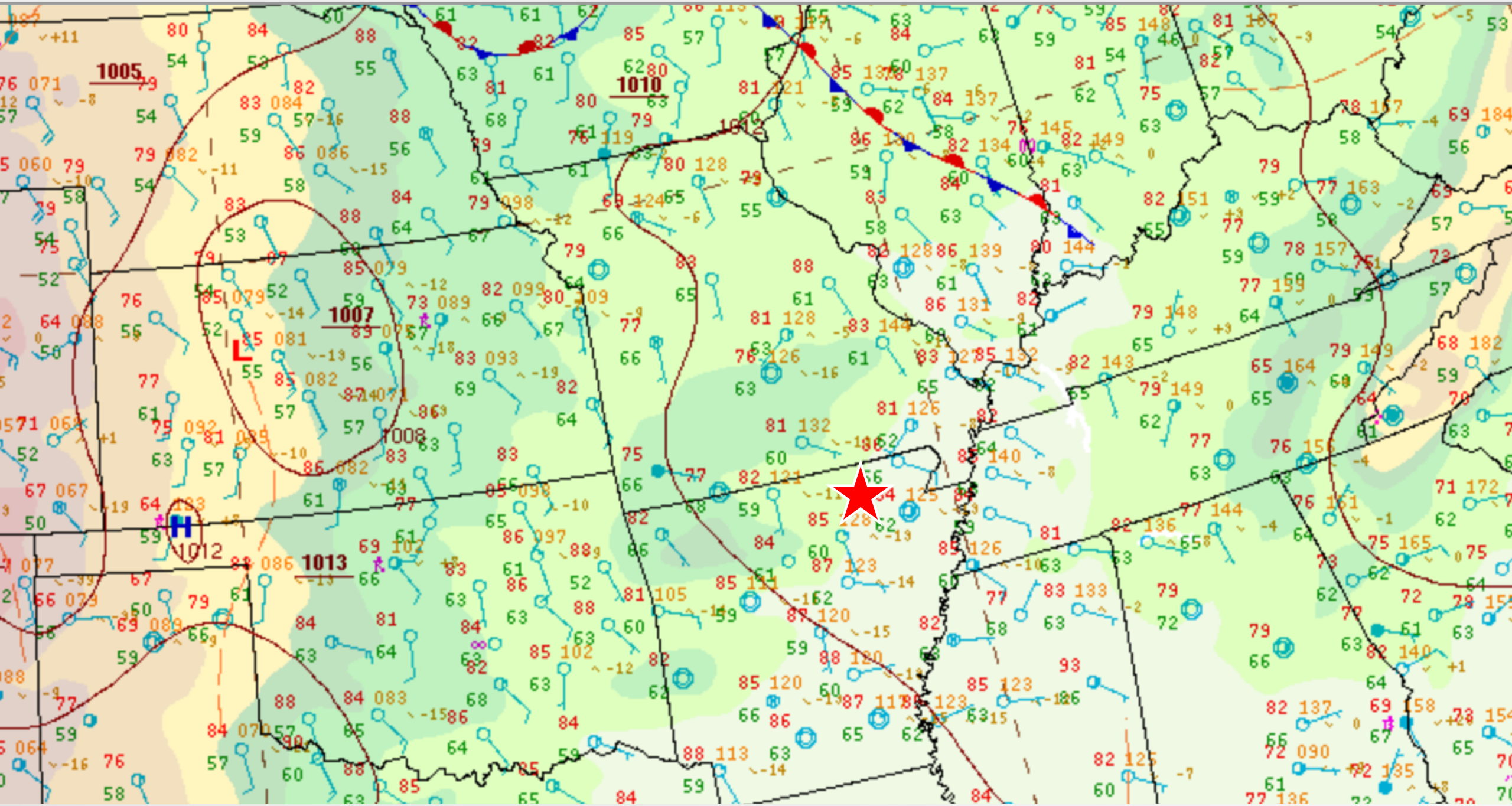
No record of weather briefing

No injuries

Substantial damage

METAR KARG 312156Z AUTO 14006KT 10SM FEW002 SCT110 31/16 A2993 RMK AO2 SLP135 T03060161=

NTSB

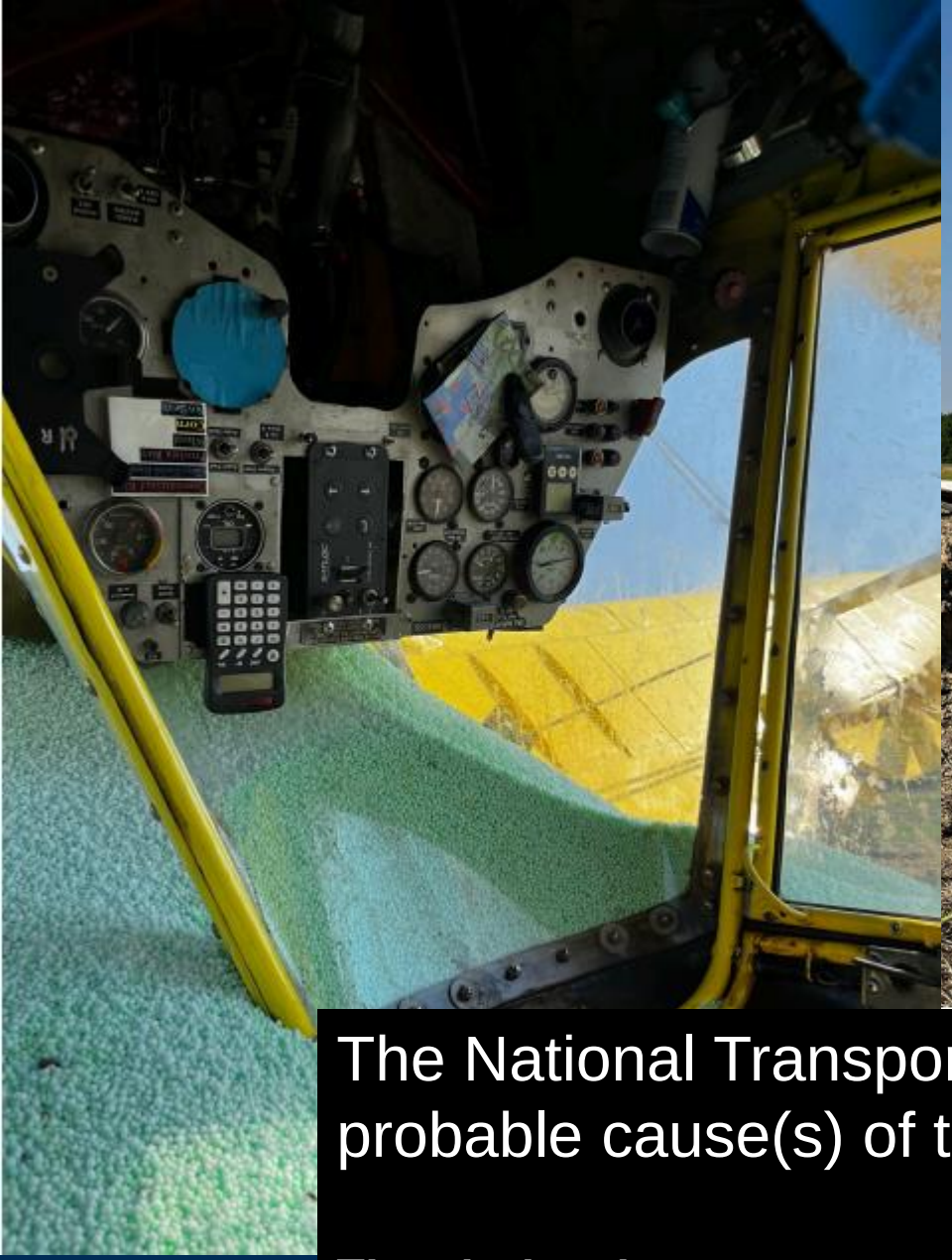

1005
1010
1007
1008
1012
1013
L
H

Pilot reported that he had encountered several dust devils earlier in the day

Shortly after takeoff for aerial application flight unknowingly flew through dust devil

Estimated 8-to-10-feet diameter with no visible debris

Airplane impacted dirt ditch, nosed over, and came to rest inverted



The National Transportation Safety Board determines the probable cause(s) of this accident as follows:

The airplane's encounter with a dust devil after takeoff, which resulted in a loss of lift, and a subsequent loss of control. Contributing to the accident was the presence of a dust devil in the airplane's flight path.

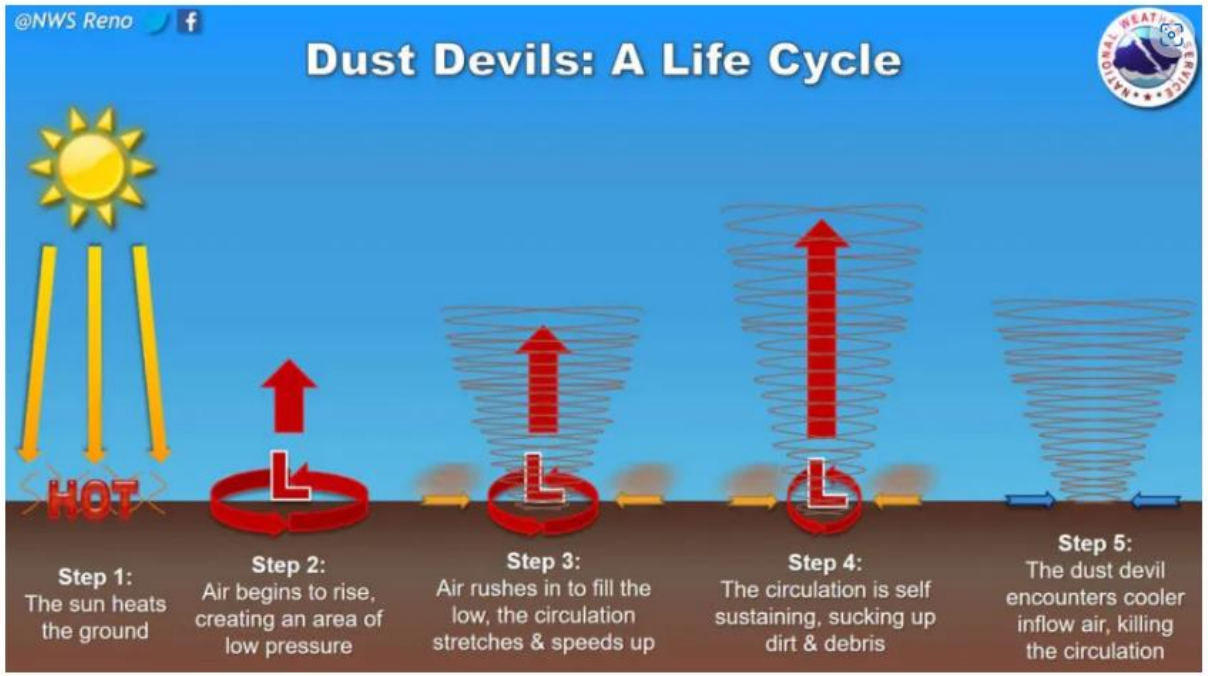
NTSB

Dust devils are significant hazard to aviation with 6 accidents in the past year

Often form under clear skies and warm conditions near different surface types

Can be as strong as tornadoes or waterspouts

Risk of sudden ded roll or yaw



Formation of a dust devil. Reno NWS.

NTSB

Always be vigilant for the potential presence
regions known for them, such as the US Sou

If operating in areas known for frequent dust
altitude, when possible

Never assume visibility equals safety: Just b
picking up debris doesn't mean it's not there

Diversify flightpaths: If operating in an area v
formation of dust devils, consider all availab
risk and be prepared to take evasive action

Dust Devils: Silent Sky Snares (ntsb.gov)
NTSB Safety Alert - Dust Devils: Silent Sk

SAFETY ALERT | NTSB National Transportation Safety Board | SA088 | December 2023

AVIATION | HIGHWAY | MARINE | RAILROAD | PIPELINE

Dust Devils: Silent Sky Snares

Understanding their threat to aviation safety

The problem

Dust devils, while often considered a harmless phenomenon, present significant hazards to aviation and have been present in more than 170 accidents the National Transportation Safety Board has investigated since 1982.

- Their spiraling updrafts, as shown in figure 1, can disrupt the flight of small aircraft. For pilots unfamiliar with or inattentive to the presence of dust devils, especially when operating at low altitudes, the consequences can be catastrophic.
- Dust devils, also referred to as whirlwinds, can occur under clear skies and warm conditions, especially in areas with flat terrain, and can be as strong as tornadoes and waterspouts. They typically form in areas of strong surface heating, such as between different surface types like asphalt or dirt.
- Given their often invisible nature (unless they pick up dust and debris), dust devils pose a risk of sudden and unexpected turbulence for pilots and aircraft, which may lead to rapid loss of lift, uncommanded roll or yaw, or other disturbances.

Figure 1. Dust devil (Source: NOAA).

How to detect dust devils with no or minimal visible debris

- **Shadow on the ground**: Dust devils can cast a shadow on the ground if the sun's angle is right. Even if the dust devil doesn't have visible debris, the vortex itself can cause enough air density and temperature differences to create a visible shadow.
- **Tracks**: In some environments, dust devils leave tracks or marks on the ground even if they don't lift visible debris. Observing these signs can provide an indirect method to estimate a dust devil's presence, size, and direction.

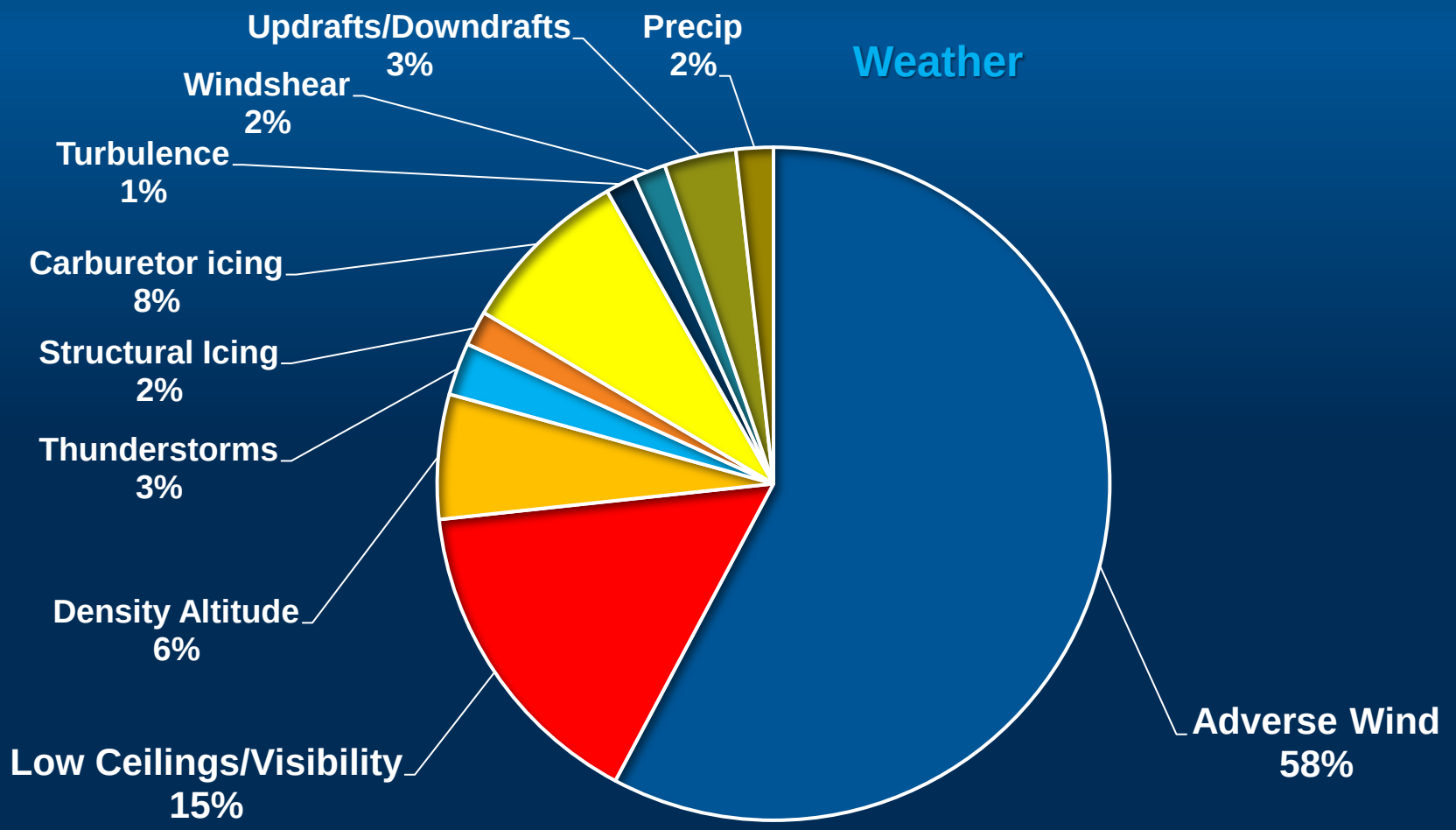
Part 91 Weather-Related Accidents 2008-2022

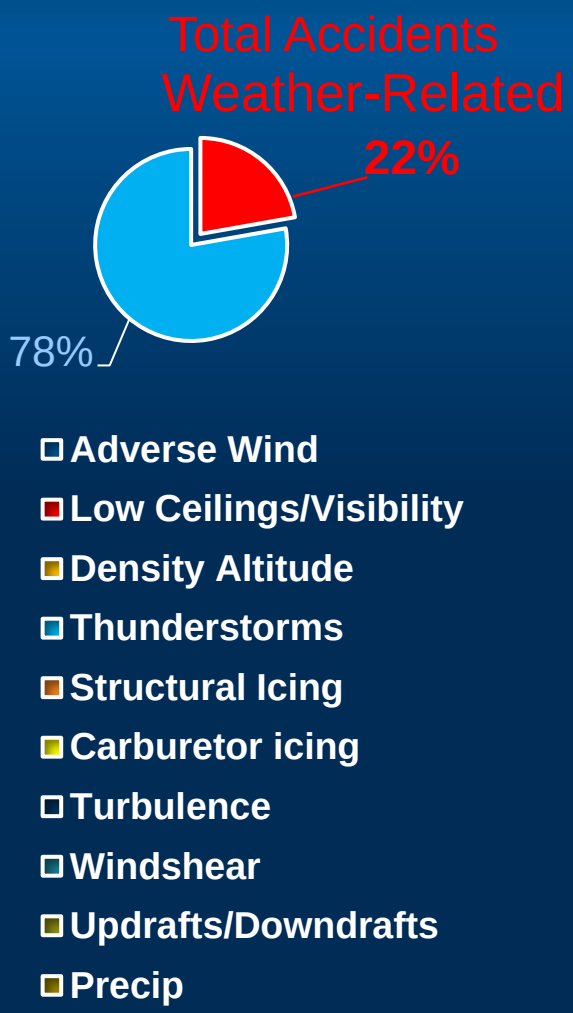
	Weather-Related	Non-Weather Related	Total	Weather-Related Percentage
Accidents	**4,341**	**15,197**	**19,538**	**22%**
Fatal Accidents	**990**	**2,586**	**3,576**	**28%**

D.Eick / J.Thomas NTSB 2024

- "Weather-Related" events are those for which a weather-related finding was listed for the accident/incident under 14 CFR Part 91. Weather-related findings include temperature, humidity, atmospheric pressure, high density altitude, conditions conductive to structural ice, turbulence, convective weather, wind (sudden wind shift, tailwind, windshear, variable wind, updrafts/downdrafts, crosswind, gusts, dust devils), ceiling and visibility, precipitation, or solar/lunar conditions.

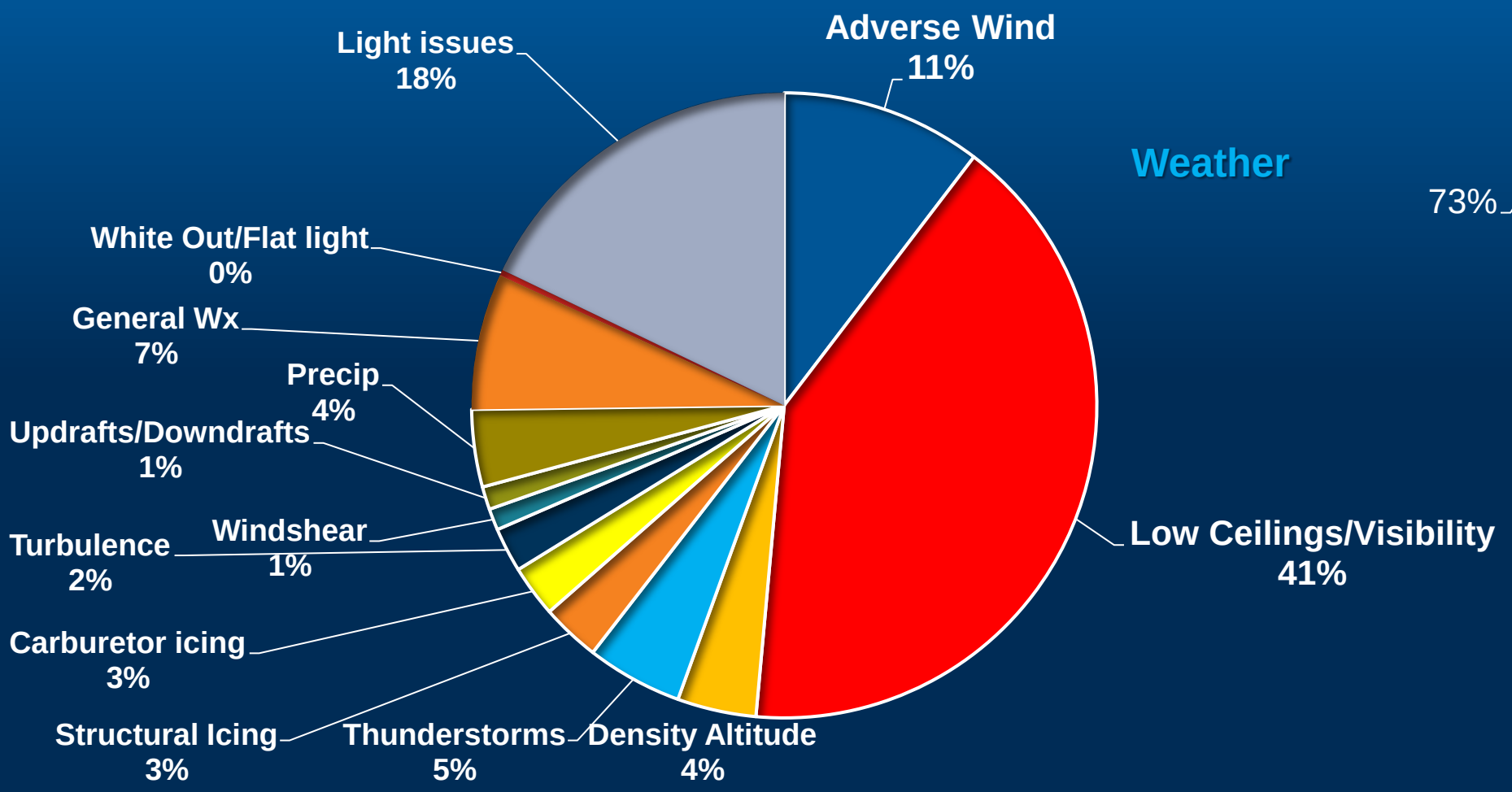
GA – Weather-Related Accidents, 2008-2022



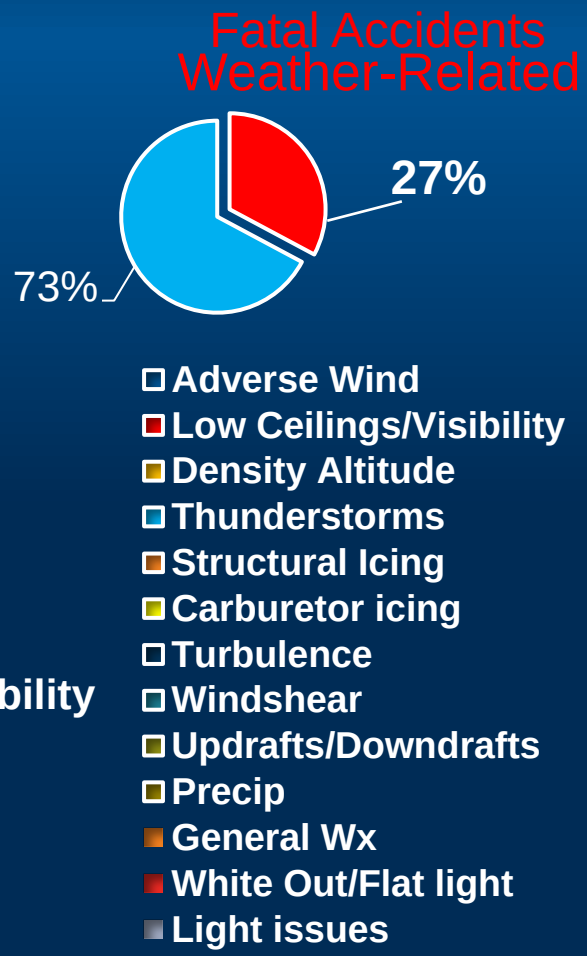


NTSB

GA– Fatal Weather-Related Accidents, 2008-2022



Weather



NTSB

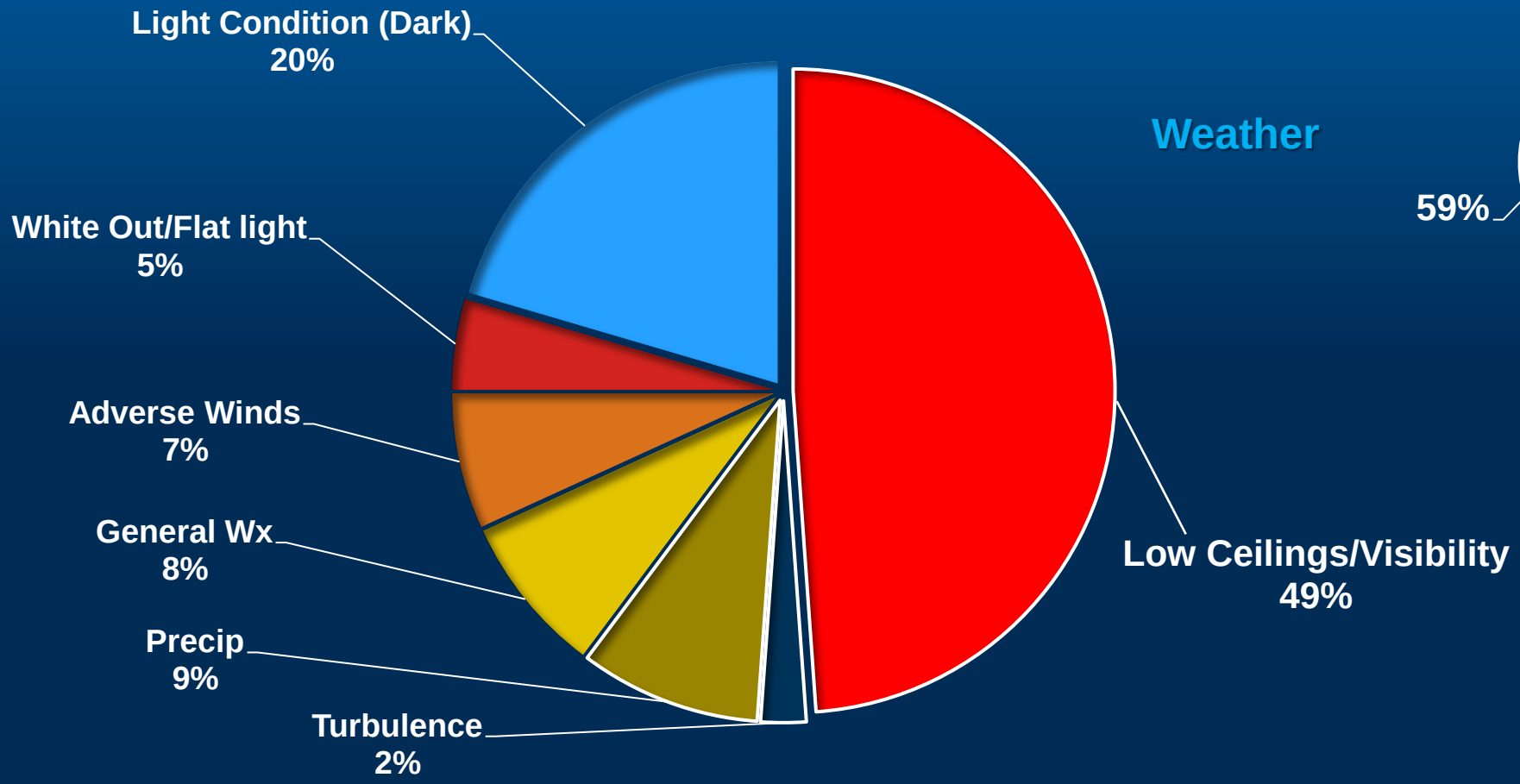
Part 135 Weather-Related Accidents 2008-2022

	Weather-Related	Non-Weather Related	Total	Weather-Related Percentage
Accidents	**197**	**492**	**689**	**29%**
Fatal Accidents	**56**	**82**	**138**	**41%**

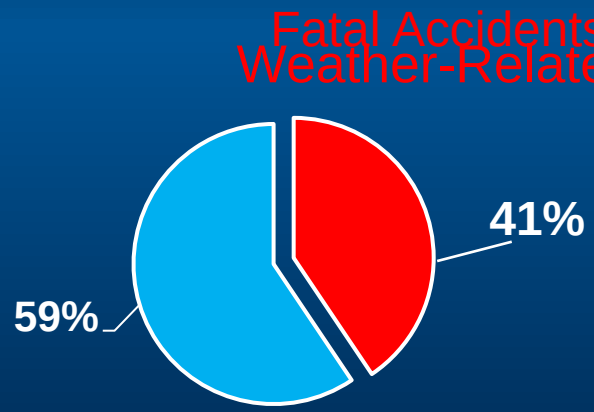
D.Eick / J.Thomas NTSB 2024

- "Weather-Related" events are those for which a weather-related finding was listed for the accident/incident under 14 CFR Part 135. Weather-related findings include temperature, humidity, atmospheric pressure, high density altitude, conditions conductive to structural ice, turbulence, convective weather, wind (sudden wind shift, tailwind, windshear, variable wind, updrafts/downdrafts, crosswind, gusts, dust devils), ceiling and visibility, precipitation, or solar/lunar conditions.

Part 135 – Fatal Weather-Related Accidents, 2008-2022



Weather

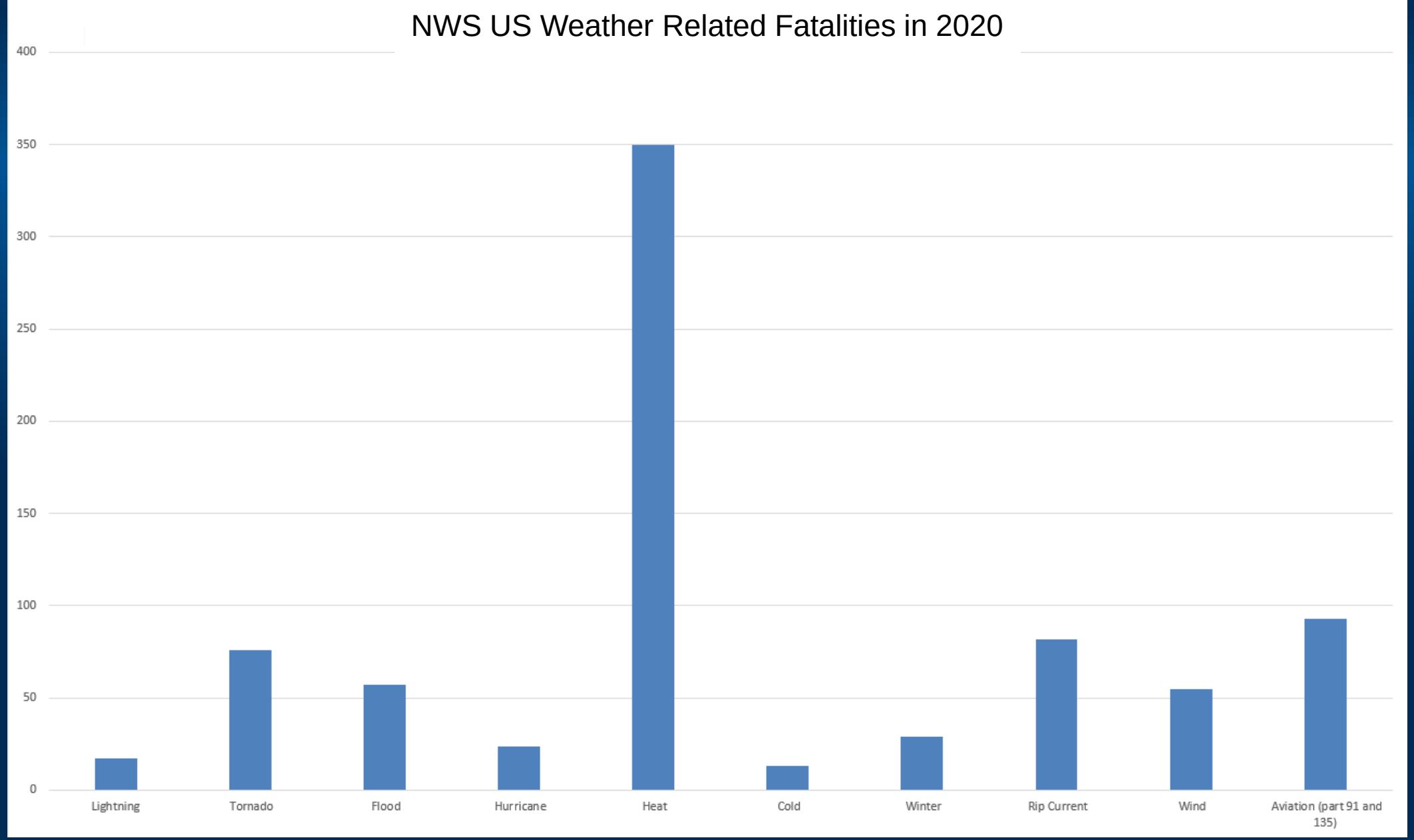


- Low Ceilings/Visibility
- Turbulence
- Precip
- General Wx
- Adverse Winds
- White Out/Flat light
- Light Condition (Dark)

Low ceilings & Visibility – includes below minimum conditions, fog, obscurations and clouds

NTSB

NWS US Weather Related Fatalities in 2020



ERA22LA395
Diamond Aircraft Industries DA 42, N43RG
Orlando, Florida
September 2022

Local instructional flight from ORL

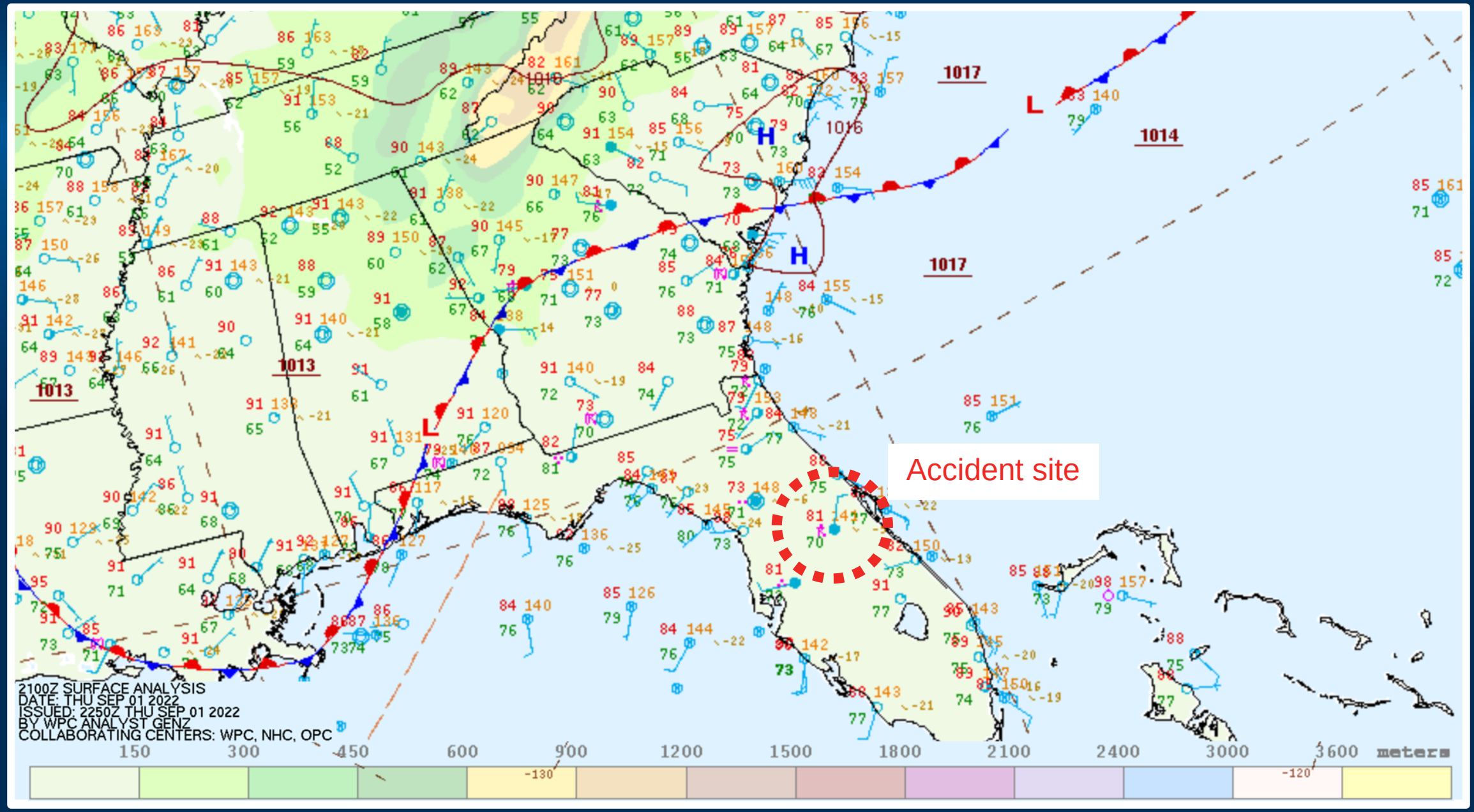
Student pilot ~3000 hrs, 6 hours make/model

Received wx briefing through ForeFlight

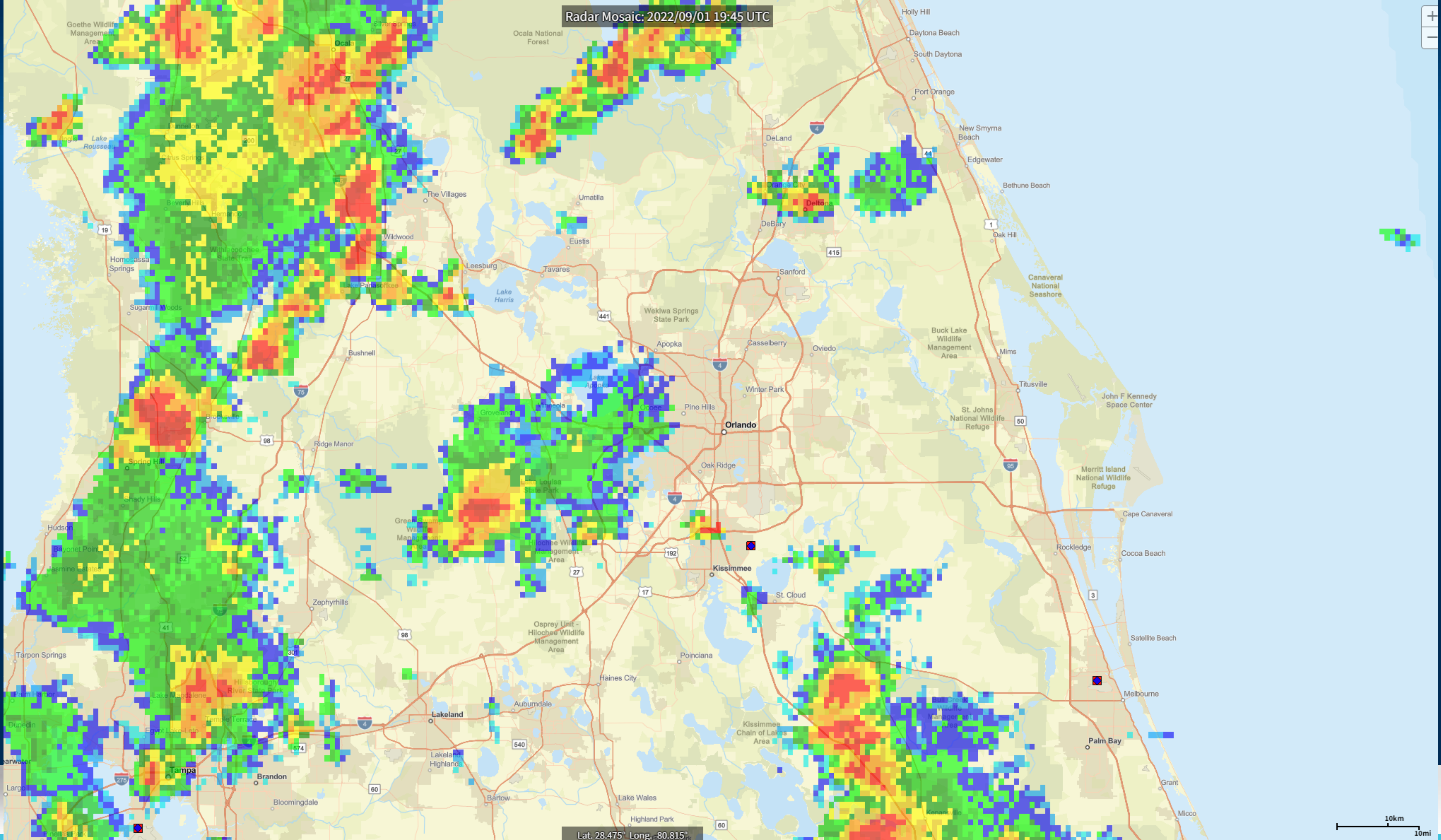
1-Fatal, 1-Serious

SPECI KORL 012059Z 10032G54KT 060V130 1/4SM R07/0400VP6000FT +TSRA FG SCT017 BKN029 OVC060 23/21 A3000 RMK AO2 PK WND 12054/2055 LTG DSNT ALQDS PRESRR P0039 T02280206

NTSB


Accident site
2100Z SURFACE ANALYSIS
DATE: THU SEP 01 2022
ISSUED: 2250Z THU SEP 01 2022
BY WPC ANALYST GENZ
COLLABORATING CENTERS: WPC, NHC, OPC
150 300 450 600 900 1200 1500 1800 2100 2400 3000 3600 meters
1017
1014
1013
1016
L
H

NTSB

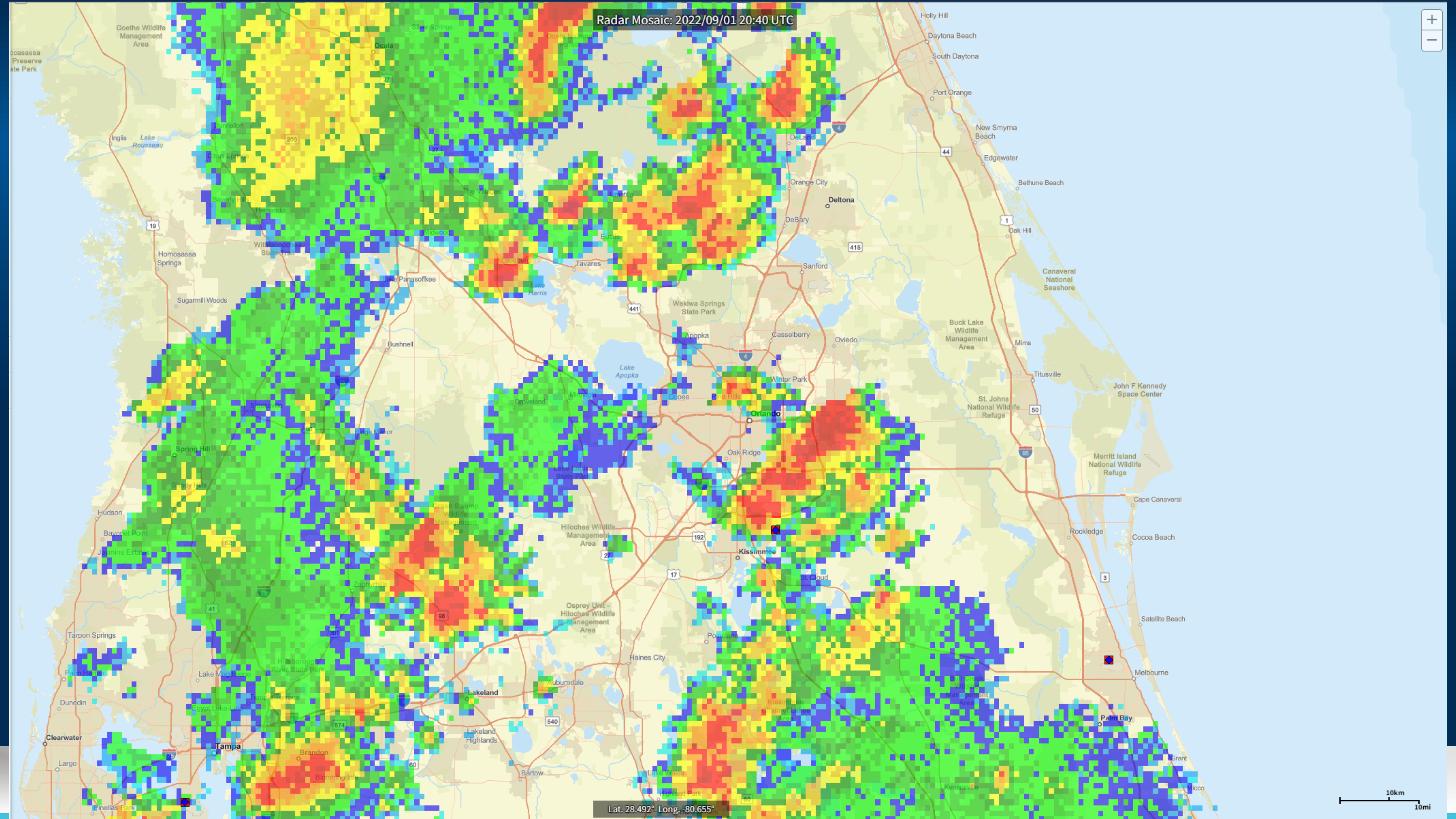

Radar Mosaic: 2022/09/01 19:45 UTC
Holly Hill
Daytona Beach
South Daytona
Port Orange
New Smyrna Beach
Edgewater
Bethune Beach
Ocala National Forest
DeLand
Deltona
DeBary
Oak Hill
Umatilla
The Villages
Eustis
Wildwood
Leesburg
Tavares
Lake Harris
Sanford
Canaveral National Seashore
Homosassa Springs
Sugarmill Woods
Wekiwa Springs State Park
Apopka
Casselberry
Oviedo
Buck Lake Wildlife Management Area
Mims
Bushnell
Winter Park
Titusville
John F Kennedy Space Center
Pine Hills
Orlando
St. Johns National Wildlife Refuge
Ridge Manor
Oak Ridge
Merritt Island National Wildlife Refuge
Cape Canaveral
Rockledge
Cocoa Beach
Kissimmee
St. Cloud
Zephyrhills
Osprey Unit - Hilochee Wildlife Management Area
Satellite Beach
Tarpon Springs
Poinciana
Haines City
Melbourne
Lakeland
Auburndale
Kissimmee Chain of Lakes Area
Palm Bay
Lakeland Highlands
Tampa
Brandon
Bloomingdale
Bartow
Lake Wales
Highland Park
Grant
Micco
10km
10mi
Lat. 28.475° Long. -80.815°

Requested and received weather briefing through ForeFlight at 1542 EDT

A small area of precipitation, about 2 nm in diameter, over Orlando International Airport (MCO), located 7 miles south of ORL, which was slowly moving north

Cell didn’t appear to be growing

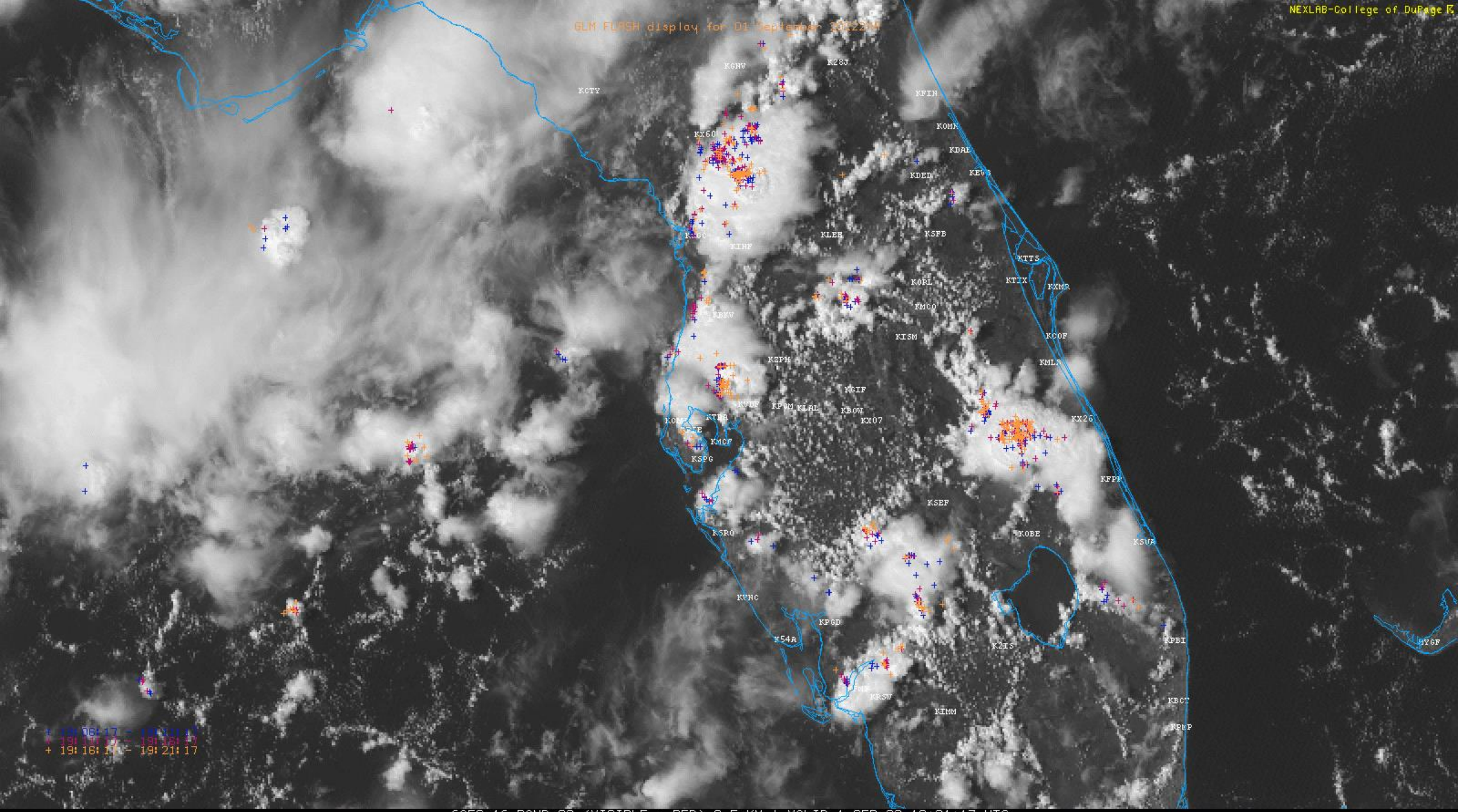
Started engines around 1621 EDT and held on taxiway around 1640 EDT


Radar Mosaic: 2022/09/01 20:40 UTC
Holly Hill
Daytona Beach
South Daytona
Port Orange
New Smyrna Beach
Edgewater
Bethune Beach
Ocala
Goethe Wildlife Management Area
Inglis
Lake Rousseau
Orange City
Deltona
DeBary
Oak Hill
Homosassa Springs
Tavares
Sanford
Canaveral National Seashore
Sugarmill Woods
Wekiwa Springs State Park
Buck Lake Wildlife Management Area
Apopka
Casselberry
Oviedo
Mims
Bushnell
Lake Apopka
Winter Park
Titusville
John F Kennedy Space Center
St. Johns National Wildlife Refuge
Orlando
Ocoee
Groveland
Oak Ridge
Spring Hill
Merritt Island National Wildlife Refuge
Hudson
Cape Canaveral
Hilochee Wildlife Management Area
Rockledge
Cocoa Beach
Kissimmee
St. Cloud
Osprey Unit - Hilochee Wildlife Management Area
Satellite Beach
Tarpon Springs
Haines City
Melbourne
Lakeland
Auburndale
Dunedin
Palm Bay
Clearwater
Tampa
Brandon
Lakeland Highlands
Largo
Bartow
Lat. 28.492° Long. -80.655°
10km
10mi

About 1645, they completed their pre-takeoff checks

The crew observed precipitation over the departure end of the runway, so they elected to hold in place rather than attempt to taxi back to the ramp

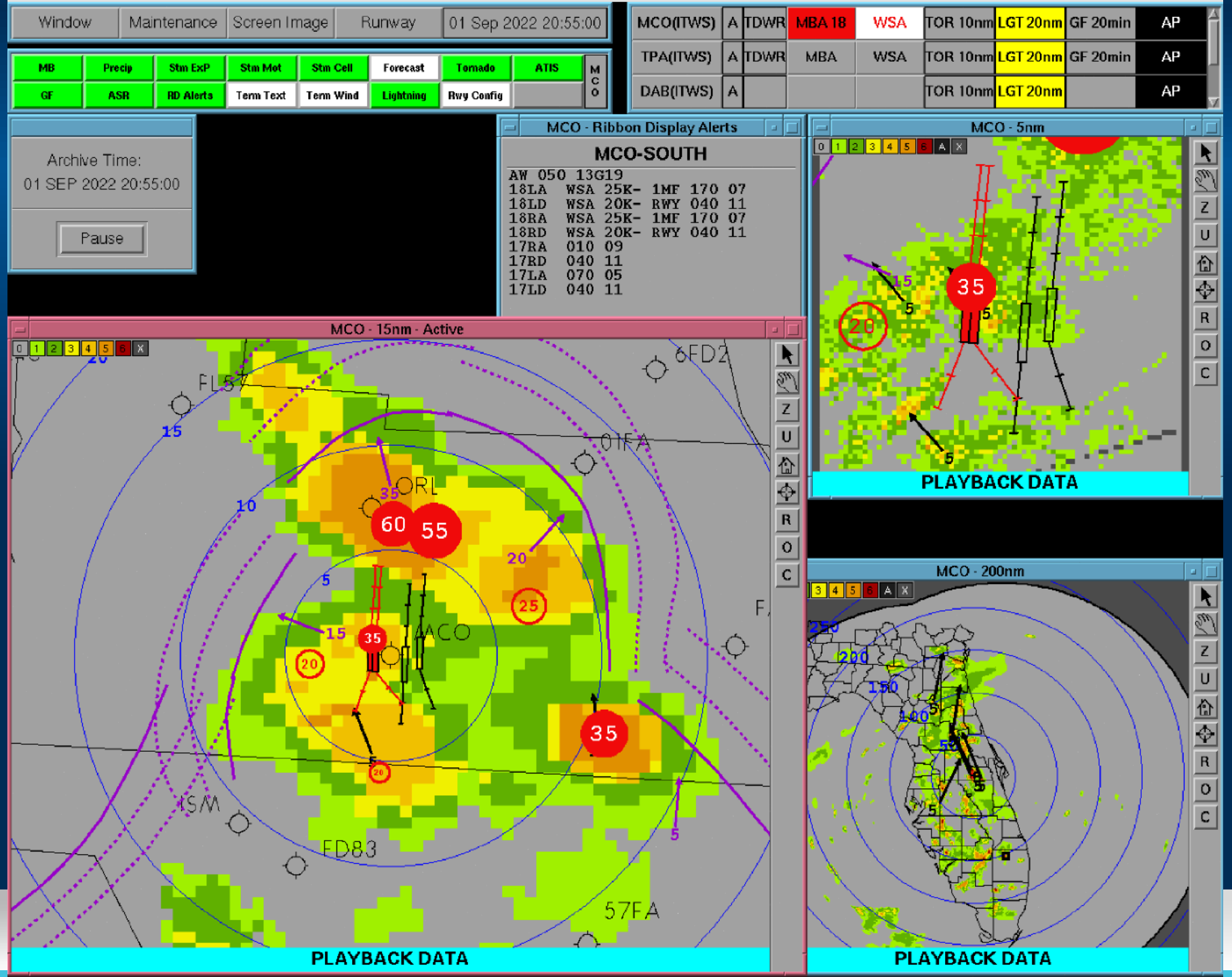
The wind gusts increased to 60 knots. The airplane's left wing then lifted and the airplane rolled to the right. The flight instructor attempted to shut down the engines, and the airplane rolled over inverted



GOES-16 BAND 02 (VISIBLE - RED) 0.5 KM | VALID 1 SEP 22 19:21:17 UTC

The National Transportation Safety Board determines the probable cause(s) of this accident as follows:

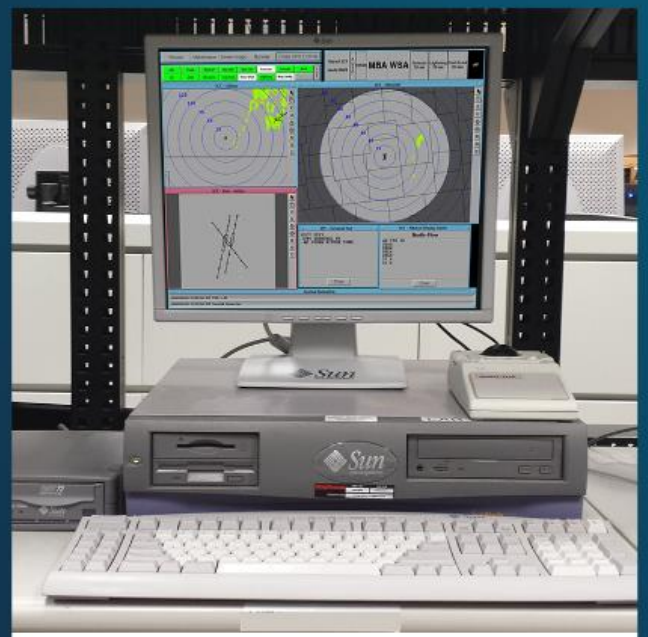
The flight crew's insufficient evaluation of the deteriorating weather conditions in the area, which resulted in an encounter with a microburst.


Window
Maintenance
Screen Image
Runway
01 Sep 2022 20:55:00
MB
Precip
Stm ExP
Stm Mot
Stm Cell
Forecast
Tornado
ATIS
GF
ASR
RD Alerts
Term Text
Term Wind
Lightning
Rwy Config
MCO
MCO(ITWS) A TDWR MBA 18 WSA TOR 10nm LGT 20nm GF 20min AP
TPA(ITWS) A TDWR MBA WSA TOR 10nm LGT 20nm GF 20min AP
DAB(ITWS) A TOR 10nm LGT 20nm AP
Archive Time:
01 SEP 2022 20:55:00
Pause
MCO - Ribbon Display Alerts
MCO-SOUTH
AW 050 13G19
18LA WSA 25K- 1MF 170 07
18LD WSA 20K- RWY 040 11
18RA WSA 25K- 1MF 170 07
18RD WSA 20K- RWY 040 11
17RA 010 09
17RD 040 11
17LA 070 05
17LD 040 11
MCO - 5nm
PLAYBACK DATA
MCO - 15nm - Active
ORL
MCO
PLAYBACK DATA
MCO - 200nm
PLAYBACK DATA

NTSB

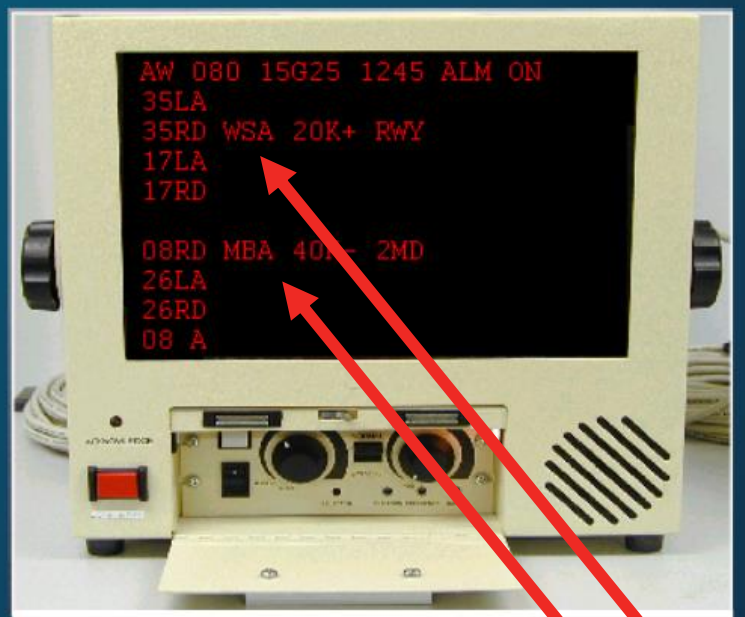
Integrated Terminal Weather System (ITWS)

System Equipment

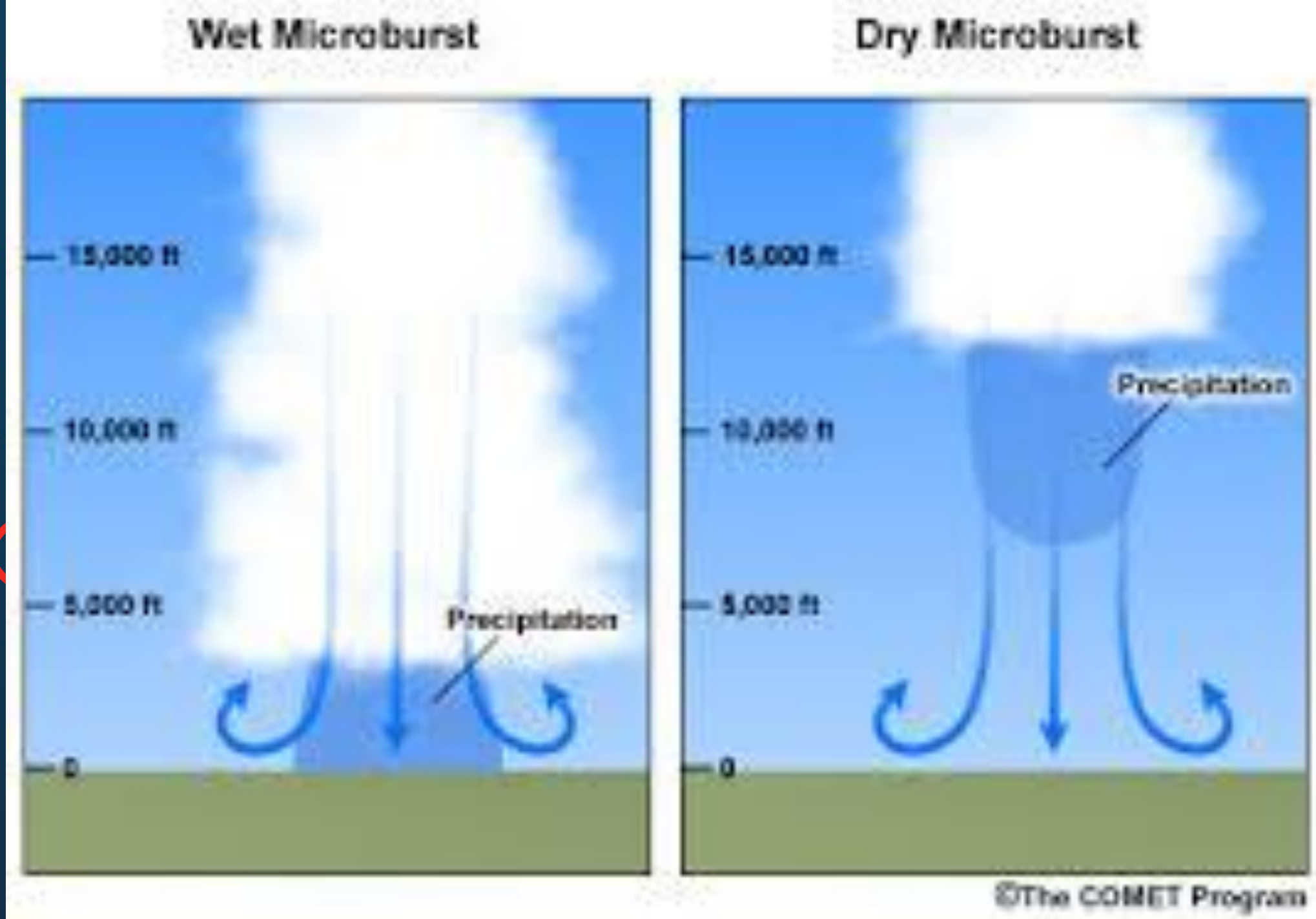


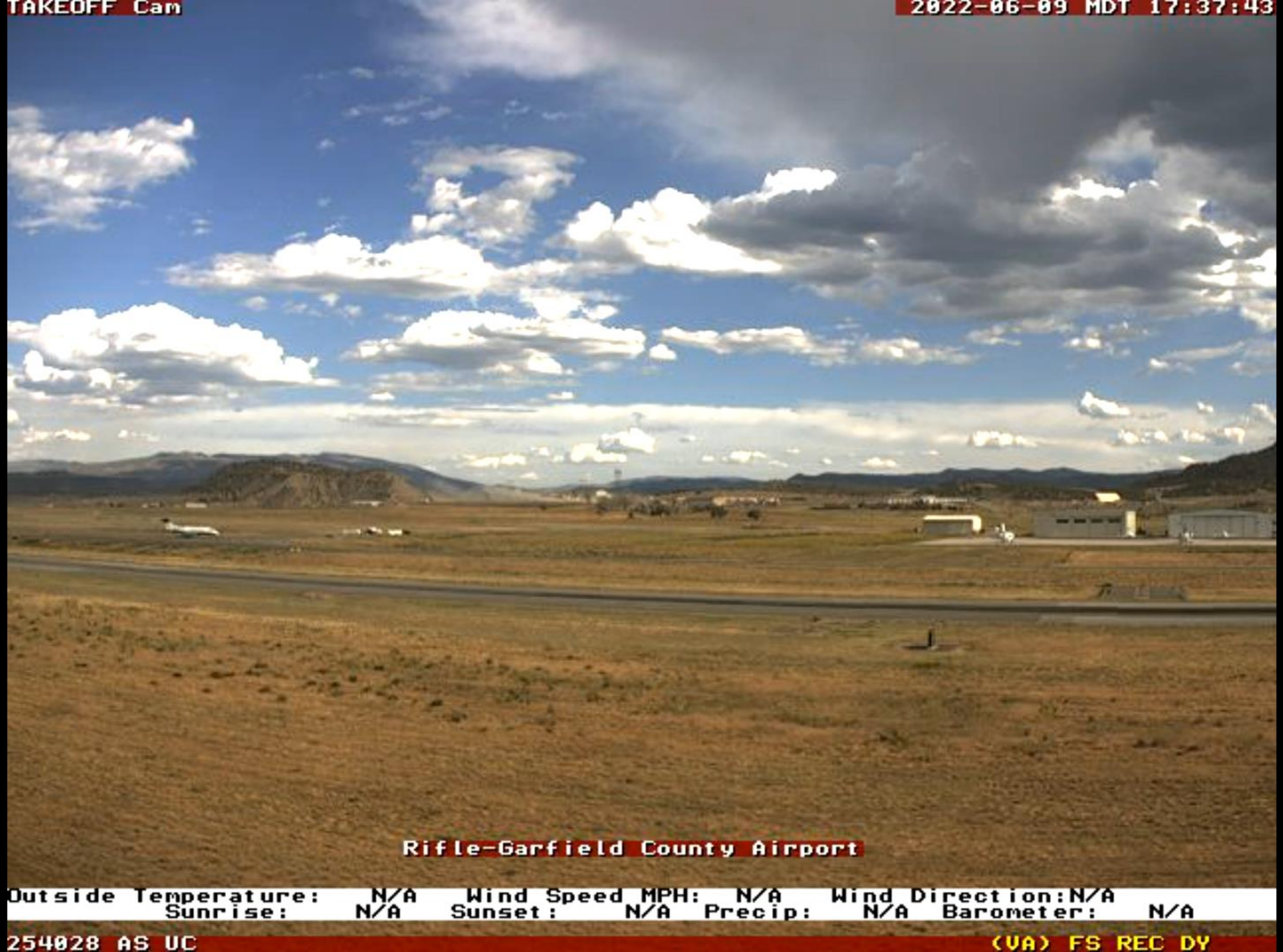
Situation Display

Product Generator



Ribbon Display Terminal (RDT)


Wet Microburst
15,000 ft
10,000 ft
5,000 ft
0
Precipitation
Dry Microburst
15,000 ft
10,000 ft
5,000 ft
0
Precipitation
©The COMET Program


TAKEOFF Cam
2022-06-09 MDT 17:37:43
Rifle-Garfield County Airport
Outside Temperature: N/A Wind Speed MPH: N/A Wind Direction:N/A
Sunrise: N/A Sunset: N/A Precip: N/A Barometer: N/A
254028 AS UC
(VA) FS REC DY

	Done.					
Loadsheet	Not done, but supposed within limits by experience.		0	**Sheet load must be calculated. Chek that actual performance are compliant with flight profile**		0
	Not done and near aircraft limitation.					
	Well under limits.					
Performance (weight and density altitude)	Close to limits only in cruise conditions.		0	**Study another strategy to comply with flight profile and training program. If you cannot, cancelled the flight (No Go)**		0
	Close to limits during operations.					
ENVIRONMENT						
	Day.					
Time of flight	Dawn or dusk.		0	**Strong studies of flight profile with accurate weather forecasts are mandatory, check that captain respects IFR minimum training requirements or single pilot night requirements**		0
	Night.					
	Good.					
Meteorological conditions	Marginal VMC.		0	**Strong studies of flight profile with accurate weather forecasts are mandatory, check that captain respects IFR minimum training requirements**		0
	IMC.					
	Light.					
Wind	Sustained.		0	**Strong studies of flight profile with accurate weather forecasts are mandatory**		0
	Strong or gusting.					
	No rain.					
Rain	Light rain.		0			0
	Showers or thunderstorms.			**Stop! Cancel the flight**		
	Good.					
Meteorological conditions	Marginal VMC.		0	**Strong studies of flight profile with accurate weather forecasts are mandatory, check that captain respects IFR minimum training requirements**		0
	IMC.					
	No snow					
Snow	Light snow		0			0
	Heavy snow			**Stop! Cancel the flight**		
	No clouds within working altitude.					
Clouds	Marginal ceiling.		0	Strong studies of flight profile with accurate weather forecasts are mandatory, check that captain respects IFR minimum training requirements		0
	Flight between or on top the clouds. Mountains obscured.					
	No icing conditions.					
Icing	Marginal icing conditions.		0			0
	Probable icing if entering in visible moisture conditions.			**Stop! Cancel the flight**		
	Rural (flat…)					
Terrain	City, suburban		0	Check your performance, equipments to be compliant with flight safety. If not, No Go.		0
	Mountainous, overwater, tropical forest, desert…					
EXTERNAL PRESSURE						
	Low value mission. Easily cancelable flight.					
Mission importance	Medium value mission but alternate transport or flight delay are feasible.		0	Particular attention during the flight. Try to delay the flight if possible. If not, NO GO		0
	High value. To be completed as soon as possible.					
TOTAL SCORE:	ACCEPTABLE		0	ACCEPTABLE		3
Questions number:			29			29
Questions missing:			28			26

NTSB

https://www.ntsb.gov/Advocacy/safety-alerts/Documents/SA-017.pdf

https://www.ntsb.gov/Advocacy/safety-alerts/Documents/SA-064.pdf

https://www.ntsb.gov/Advocacy/safety-alerts/Documents/SA-082.pdf

https://www.ntsb.gov/safety/safety-studies/Pages/DCA18SS003.aspx

SAFETY ALERT

NTSB National Transportation Safety Board

SA088 | December 2023

AVIATION HIGHWAY MARINE RAILROAD PIPELINE

Dust Devils: Silent Sky Snares

Understanding their threat to aviation safety

The problem

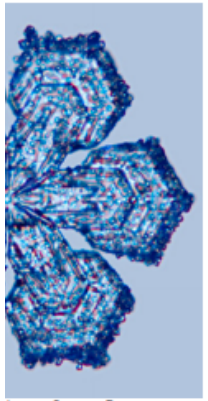
Dust devils, while often considered a harmless phenomenon, present significant hazards to aviation and have been present in more than 170 accidents the National Transportation Safety Board has investigated since 1982.

- Their spiraling updrafts, as shown in figure 1, can disrupt the flight of small aircraft. For pilots unfamiliar with or inattentive to the presence of dust devils, especially when operating at low altitudes, the consequences can be catastrophic.
- Dust devils, also referred to as whirlwinds, can occur under clear skies and warm conditions, especially in areas with flat terrain, and can be as strong as tornadoes and waterspouts. They typically form in areas of strong surface heating, such as between different surface types like asphalt or dirt.
- Given their often invisible nature (unless they pick up dust and debris), dust devils pose a risk of sudden and unexpected turbulence for pilots and aircraft, which may lead to rapid loss of lift, uncommanded roll or yaw, or other disturbances.

Figure 1. Dust devil (Source: NOAA).

How to detect dust devils with no or minimal visible debris

- **Shadow on the ground**: Dust devils can cast a shadow on the ground if the sun's angle is right. Even if the dust devil doesn't have visible debris, the vortex itself can cause enough air density and temperature differences to create a visible shadow.
- **Tracks**: In some environments, dust devils leave tracks or marks on the ground even if they don't lift visible debris. Observing these signs can provide an indirect method to estimate a dust devil's presence, size, and direction.



IN THE CLOUDS PHOTOGRAPHY

Board

Pilot W

The problem

- Sparse reporting a
  of PIREPs (brief r
  improving weather
- Pilots submit relati
  - Pilots may b
    good or "as
  - Pilots may l
  - Pilots may
    methods.
  - Pilots may t

Preventing Turbulence-Related Injuries in Air Carrier Operations Conducted Under Title 14 *Code of Federal Regulations* Part 121

Safety Research Report

NTSB/SS-21/01
PB2021-100927

National

https://www.ntsb.gov/Advocacy/safety-alerts/Documents/SA-083.pdf

NTSB Accident Dashboard

https://www.ntsb.gov/safety/StatisticalReviews/Pages/CivilAviationDashboard.aspx

Any Questions?

My email: paul.suffern@ntsb.gov

https://www.ntsb.gov/safety/StatisticalReviews/Pages/CivilAviationDashboard.aspx

https://www.ntsb.gov/safety/data/Pages/generalaviationdashboard.aspx

NTSB


NATIONAL TRANSPORTATION
SAFETY BOARD
E PLURIBUS UNUM