NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

February 26, 2020

Weather Study

METEOROLOGY

ERA20FA074

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A. ACCIDENT

Location: Mechanicsburg, Pennsylvania
Date: January 9, 2020
Time: 2029 eastern standard time
0129 Universal Coordinated Time (UTC) on January 10, 2020
Aircraft: Robinson R66; Registration: N450MC

B. METEOROLOGIST

Don Eick
Meteorologist Specialist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. SUMMARY

On January 9, 2020, about 2029 eastern standard time, a Robinson R66, N450MC, experienced an in-flight break-up near Mechanicsburg, Pennsylvania. The private pilot and one passenger were fatally injured, and the helicopter was destroyed. The helicopter was operated under the provisions of title 14 *Code of Federal Regulations* Part 91 personal flight. Night visual meteorological conditions prevailed at the time and no flight plan was filed for the flight. The flight originated about 1958 from Martin State Airport (KMTN), Baltimore, Maryland, and was destined for Buffalo Niagara International Airport (KBUF), Buffalo, New York.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's Senior Meteorologist was not on scene for this investigation and conducted the meteorology phase of the investigation from the Washington D.C. office, collecting data from official National Weather Service (NWS) sources including the Weather Prediction Center (WPC) and the National Center for Environmental Information (NCEI). All times are eastern standard time (EST) based upon the 24-hour clock, local time is -5 hours from UTC, and UTC=Z. NWS airport and station identifiers use the standard International Civil Aviation Organization 4-letter station identifiers versus the International Air Transport Association 3-letter identifiers, which deletes the initial country code designator "K" for U.S. airports. Directions are referenced to true north and distances in nautical miles. Heights are in feet (ft) above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The accident site was located at latitude 40.227871° N and longitude 77.020398° W, at an elevation of approximately 410 ft.

E. WEATHER INFORMATION

1.0 Synoptic Conditions

The synoptic or large-scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction (NCEP) and the Weather Prediction Center (WPC) located in College Park, Maryland. These are the base products used in describing weather features and in the creation of forecasts and warnings. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC 00-45H change 2.

1.1 Surface Analysis Chart

The northeast section of the NWS Surface Analysis Chart for 1900 EST is included as figure 1 with the approximate accident site marked by a red star and the departure and the planned destination airports also marked. The chart depicted a low pressure system at 1005-hectopascals (hPa)[1] over western Lake Superior associated with an occluded frontal system which extending southward into Wisconsin to the triple point with a cold front continuing southwestward into Iowa. A warm front extended eastward, from the triple point in Wisconsin, across Lake Michigan, into Michigan, Lake Erie, into extreme northwestern Pennsylvania. A high pressure system was located off the New Jersey Atlantic coast at 1042-hPa and dominated over the northeast with a ridge extending southwestward into New Jersey and Maryland. The accident site was located between the high pressure system to the east and to the southeast of the warm frontal boundary in the warm air sector of the front.

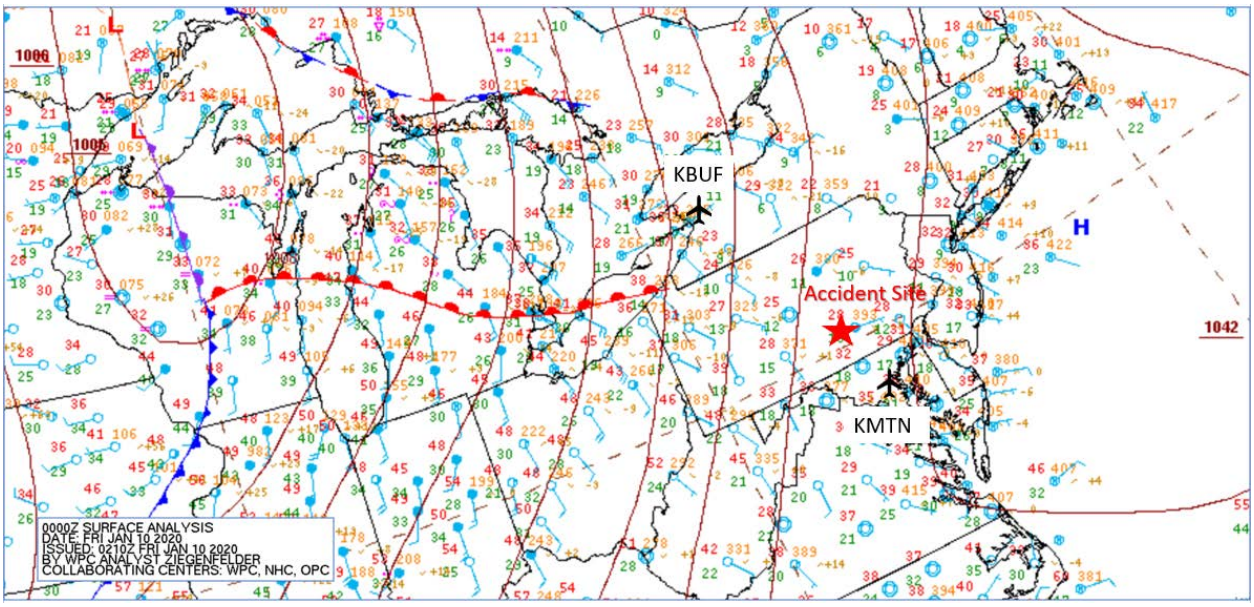

Figure 1 - Northeast section of the NWS Surface Analysis Chart for 1900 EST

[1] Hectopascals is the new NWS reference for reporting sea level pressure and is interchangeable with the former term millibar (mb) with the same units. Standard sea-level pressure is 1013.25-hPa at 59º Fahrenheit (F) or 15º Celsius (C).

The station models depicted a large area of snow and freezing precipitation along and north of the occluded and the warm front over Wisconsin and Michigan associated with the winter storm. The station models over Pennsylvania and New York depicted relatively clear skies, no visibility restrictions or precipitation, with light east to southeasterly winds of 5 knots. The closest station model to the accident site indicated an east wind at 5 knots, clear skies, temperature of 28° F, and a dew point of 13° F.

1.2 National Composite Radar Image

Figure 2 is the National Composite radar Mosaic for 2030 EST with the approximate accident site marked by a red star. A review of the NWS National Composite Radar Mosaic depicted a band of precipitation extending from immediately west of Toronto, Canada, southwestward towards Detroit, Michigan, to Indianapolis, Indiana. No weather echoes were detected in the vicinity of the accident site or along the planned route of flight.

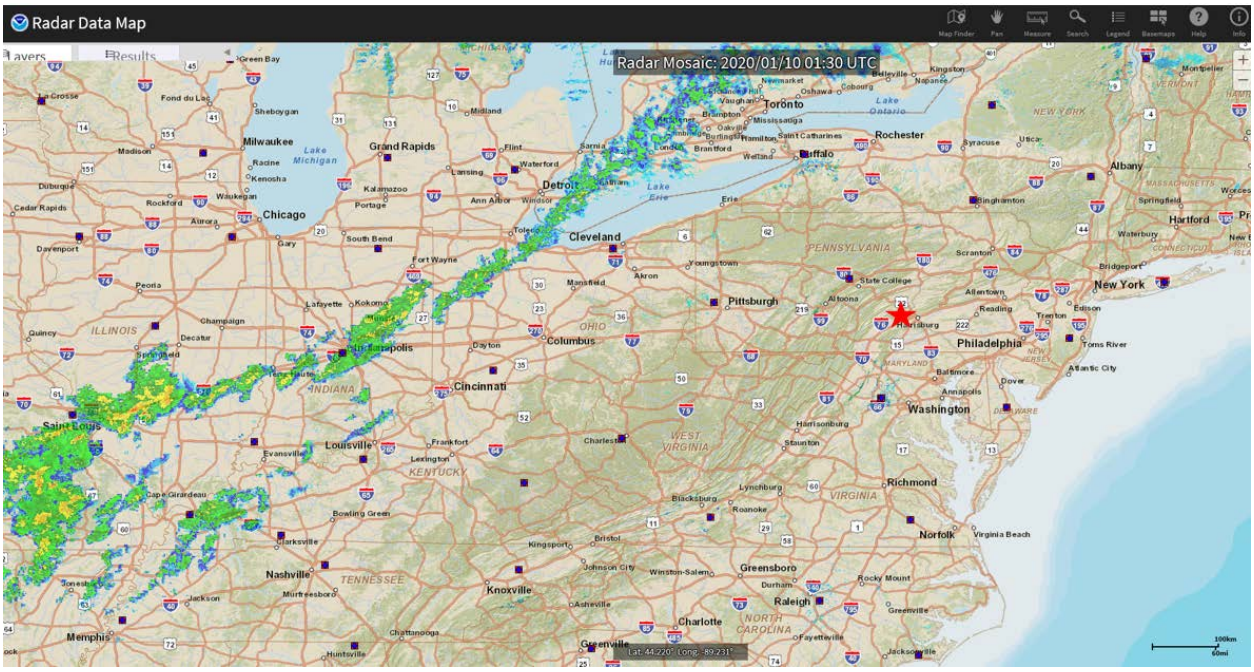

Figure 2 - National Composite Radar Mosaic image for 2030 EST with the approximate accident site marked

A further review of the closest NWS weather surveillance radar (WSR-88D) over the region, also verified that no meteorological echoes were detected along the flight path or over the accident site.

2.0 Observations

The official observations issued surrounding the accident site were documented using standard meteorological aerodrome reports (METARs) and specials (SPECI). Cloud heights are reported above ground level (agl) in the following section, and the magnetic variation over the area was 11º west based on the latest sectional chart for the area.

2.1 Capital City Airport, Harrisburg, Pennsylvania

The closest weather reporting facility was Capital City Airport (KCXY), Harrisburg, Pennsylvania, located approximately 8 miles east of the accident site at an elevation of 347 ft. The airport had a federally installed and maintained Automated Surface Observation System (ASOS), which was augmented by air traffic control personnel during normal hours of operation. The following conditions were reported at the approximate time of the accident.

> *Weather observation for KCXY at 1956 EST, wind from 120° at 7 knots, visibility 10 miles or more, sky clear below 12,000 ft agl, temperature -2° C, dew point temperature -10° C, altimeter 30.68 inches of mercury (Hg). Remarks: automated station with a precipitation discriminator, sea level pressure 1039.5-hPa, temperature -1.7° C, dew point -10.0° C.*

The general flight categories[2] and raw observations from approximately 1500 through 2300 EST were as follows.

VFR METAR KCXY 091956Z 11006KT 10SM CLR M01/M11 A3068 RMK AO2 SLP397 T10111111=

VFR METAR KCXY 092056Z 12006KT 10SM CLR M01/M10 A3069 RMK AO2 SLP398 T10111100 55011=

VFR METAR KCXY 092156Z 13006KT 10SM CLR M01/M11 A3069 RMK AO2 SLP398 T10111106=

VFR METAR KCXY 092256Z 11005KT 10SM CLR M02/M11 A3067 RMK AO2 SLP394 T10171106=

VFR METAR KCXY 092356Z 10005KT 10SM CLR M02/M10 A3068 RMK AO2 SLP396 T10221100 11011 21022 55003=

VFR ***METAR KCXY 100056Z 12007KT 10SM CLR M02/M10 A3068 RMK AO2 SLP395 T10171100=***

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VFR METAR KCXY 100156Z 11005KT 10SM CLR M02/M09 A3067 RMK AO2 SLP393 T10221094=

VFR METAR KCXY 100256Z AUTO 09006KT 10SM CLR M02/M09 A3066 RMK AO2 SLP389 T10171089 58005=

VFR METAR KCXY 100356Z AUTO 00000KT 10SM CLR M02/M09 A3064 RMK AO2 SLP382 T10171089=

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[2] As defined by the NWS and the FAA Aeronautical Information Manual (AIM) section 7-1-7 defines the following general flight categories based on weather conditions reported:

- Low Instrument Flight Rules (LIFR*) – ceiling below 500 ft above ground level (agl) and/or visibility less than 1 statute mile.
- Instrument Flight Rules (IFR) – ceiling between 500 to below 1,000 feet agl and/or visibility 1 to less than 3 miles.
- Marginal Visual Flight Rules (MVFR**) – ceiling from 1,000 to 3,000 ft agl and/or visibility 3 to 5 miles.
- Visual Flight Rules (VFR) – ceiling greater 3,000 ft agl and visibility greater than 5 miles.

* By definition, IFR is a ceiling less than 1,000 ft agl and/or visibility less than 3 miles while LIFR is a sub-category of IFR.

**By definition, VFR is a ceiling greater than or equal to 3,000 ft agl and visibility greater than 5 miles while MVFR is a sub-category of VFR.

A review of the observations indicated that VFR conditions prevailed throughout the period, with no rainfall reported in the past 24 hours. The high temperature was reported as -1° C (30° F), with temperatures remaining below freezing during the period and was at -2° C (28° F) at the time of the accident. The surface conditions were consistent of being on the western edge of a cold-core high pressure system off the New York Atlantic coast.

2.2 Harrisburg International Airport, Harrisburg, Pennsylvania

The next closest station was Harrisburg International Airport (KMDT), Harrisburg, Pennsylvania, located approximately 12 miles east of the accident site at an elevation of 310 ft. The airport also had a federally installed ASOS and was augmented by air traffic control personnel. The following conditions were reported at the approximate time of the accident.

> *Weather observation for KMDT at 1956 EST, wind from 100° at 5 knots, visibility 10 miles or more, ceiling broken at 25,000 ft agl, temperature -2° C, dew point temperature -10° C, altimeter 30.67 inches of Hg. Remarks: automated station with a precipitation discriminator, sea level pressure 1039.3-hPa, temperature -2.2° C, dew point -10.0° C.*

The general flight categories and raw observations from approximately 1500 through 2300 EST were as follows.

VFR METAR KMDT 091956Z 13007KT 10SM SCT100 OVC250 M02/M11 A3068 RMK AO2 SLP396 T10171106=

VFR METAR KMDT 092056Z 13006KT 10SM FEW100 OVC250 M02/M11 A3068 RMK AO2 SLP395 T10171106 56011=

VFR METAR KMDT 092156Z 12006KT 10SM FEW100 OVC250 M02/M11 A3068 RMK AO2 SLP395 T10171106=

VFR METAR KMDT 092256Z 12008KT 10SM BKN250 M02/M11 A3067 RMK AO2 SLP391 T10221106=

VFR METAR KMDT 092356Z 10005KT 10SM BKN250 M02/M11 A3067 RMK AO2 SLP393 4/001 T10221106 11011 21028 55003=

VFR METAR KMDT 100056Z 10005KT 10SM BKN250 M02/M10 A3067 RMK AO2 SLP393 T10221100=

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VFR METAR KMDT 100156Z 14003KT 10SM SCT250 M02/M09 A3067 RMK AO2 SLP390 T10171089=

VFR METAR KMDT 100256Z 10005KT 10SM BKN200 M02/M08 A3066 RMK AO2 SLP387 T10221083 58005=

VFR METAR KMDT 100356Z 14004KT 10SM BKN190 OVC250 M01/M08 A3064 RMK AO2 SLP379 T10111083=

The observations differed slightly at KMDT versus KCXY in that the high cloud cover was reported near 25,000 ft. The temperatures were also below freezing with the temperature at -2° C (28° F) at the time of the accident.

2.3 Martin State Airport, Baltimore, Maryland

The accident helicopter took off from Martin State Airport (KMTN), Baltimore, Maryland, at approximately 1958 EST. The airport had an elevation of 22 ft and had an Automated Weather Observation System, which was not augmented by any human observers and issued observations every 20-minutes. The following conditions were reported at the time of departure.

> *Weather Observation for KMTN at 1954 EST, wind calm, visibility 10 miles or more, sky clear below 12,000 ft agl, temperature 0° C, dew point -4° C, altimeter 30.74 inches of Hg.*

The raw observations surrounding the period were as follows.

VFR METAR KMTN 092254Z 00000KT 10SM SCT180 BKN200 00/M07 A3073=

VFR METAR KMTN 092354Z 00000KT 10SM SKC 00/M06 A3073=

VFR METAR KMTN 100054Z 00000KT 10SM SKC 00/M04 A3074=

Departure 0058Z

VFR METAR KMTN 100154Z 11007KT 10SM SKC 01/M02 A3073=

3.0 Sounding

To determine the vertical structure and state of the atmosphere over the accident site a High-Resolution Rapid Refresh (HRRR)[3] numerical model data was retrieved from the NOAA Air Resources Laboratory and plotted on a standard Skew T log P diagram[4] using the complete Rawinsonde Observation RAOB program software[5]. Figure 3 is the HRRR numerical model for 2000 EST from the surface through 450-hPa or 21,000 ft.

[3] The HRRR is a National Oceanic and Atmospheric Administration (NOAA) real-time three-kilometer resolution, hourly-updated, cloud-resolving, convection-allowing atmospheric model, initialized by three-kilometer grids with three-kilometer radar assimilation. Radar data is assimilated in the HRRR every 15 minutes over a one-hour period.
[4] Skew T log P diagram – is a standard meteorological plot or thermodynamic diagram using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.
[5] RAOB software – The complete RAwinsonde OBservation program is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania, for plotting and analyzing upper air data

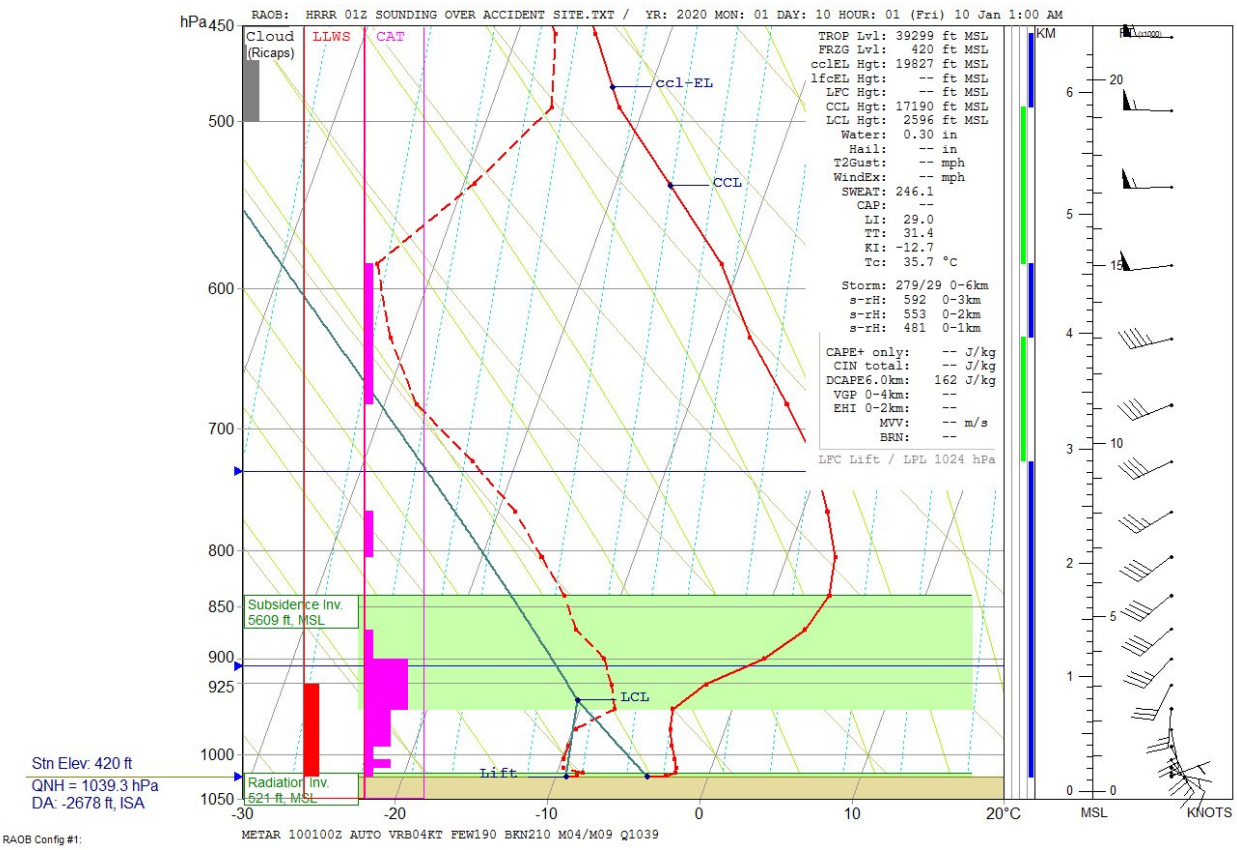

Figure 3 - HRRR numerical model sounding for 2000 EST

The HRRR numerical model estimated a surface elevation of 420 ft, with a near surface temperature of -4.0° C (25° F), a dew point of -9.3° C (15° F), with a relative humidity of 67%. The lifted condensation level (LCL)[6] was identified at 2,176 ft agl and near the base of a temperature inversion due to subsidence which extended to 5,610 ft. The temperature increased above freezing between 3,500 ft and 9,000 ft. Above this the convective condensation level (CCL) was identified at 16,770 ft agl (17,190 ft msl). The sounding supported scattered to broken clouds between 19,000 and 21,000 ft. The precipitable water content was 0.30 inches. The atmosphere was characterized as stable with a Lifted Index[7] of 29.0.

The HRRR wind profile indicated a surface wind from approximately 070° at 4 knots with winds veering clockwise rapidly to the southwest with increasing wind speeds with height immediately above the surface. A low-level wind maximum was identified near 5,000 ft with a wind from 230° at 40 knots at approximately 5,200 ft near the top of the inversion. The wind continued to veer to the west with wind speeds in excess of 50 knots above 15,000 ft, with the level of maximum wind near the tropopause at 39,000 ft from 270° at 105 knots. The mean 0 to 6 kilometer or 18,000 ft wind was from 250° at 38 knots.

[6] Lifted Condensation Level (LCL) - the level at which a lifted parcel becomes saturated. The LCL height corresponds to cloud base height for forced ascent.

[7] Lifted Index (LI) - the difference between the lifted parcel temperature at 500 hPa and the 500 hPa temperature in the sounding. Negative values denote parcels that are warmer than the background 500 hPa temperatures and are thus buoyant or "unstable".

Figure 4 is a table of the observed sounding parameters of height, pressure (Pres), temperature (T), dew point (Td), relative humidity (RH), wind direction and speed (DD/FF), and RAOB derived clear air turbulence (CAT), low-level wind shear (LLWS), and icing potential.

Height (ft-AGL)	Pres (hPa)	T (C)	Td (C)	RH (%)	DD / FF (deg / kts)	CAT (FAA)	LLWS	Icing - Type (AFGWC method)
0	1024	-4.0	-9.3	67	68 / 4			
25	1023	-2.8	-8.6	64	68 / 4	LGT	LIGHT	
101	1020	-2.2	-8.3	63	103 / 6	LGT	LIGHT	
255	1014	-2.3	-9.7	57	128 / 9	MDT	LIGHT	
487	1005	-2.6	-9.9	57	147 / 14	LGT	LIGHT	
878	990	-3.1	-9.9	59	157 / 19	MDT	LIGHT	
1354	972	-3.6	-9.8	62	170 / 23	MDT	LIGHT	
1920	951	-3.9	-7.7	75	184 / 26	SVR	LIGHT	
2612	926	-2.3	-8.5	62	205 / 30	SVR		
3359	900	0.9	-9.6	45	221 / 35	LGT		
4195	872	2.9	-12.1	32	227 / 39			
5189	840	3.7	-13.7	27	228 / 40			

Figure 4 - HRRR model parameters through 6,000 ft

At the helicopters initial cruising altitude at 2,300 ft the wind was from approximately 190° at 27 knots with a temperature of -3° C, where the RAOB algorithm indicated an 87% probability of moderate to severe turbulence at that level. The accident helicopter began a descent at 2018 EST to 1,150 ft where the wind was estimated at 150° at 15 knots with a temperature of -2.7° C, and likely moderate turbulence based on the HRRR data and the RAOB algorithm.

4.0 Satellite Imagery

The Geostationary Operational Environmental Satellite number 16 (GOES-16) data was obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System (McIDAS) software. The infrared and water vapor long wave were obtained surrounding the time of the accident, with the images closest to the time of the accident documented below. The infrared long wave imagery (band 13) at a wavelength of 10.3 microns (μm) provided radiative cloud top temperatures with a nominal spatial resolution of 2 km. The low-level tropospheric water vapor imagery (band 10) at a wavelength of 7.3 μm images at a resolution of 2 km. Due to the low light conditions at the time of the accident, the visible imagery was not usable during the period.

Figures 5 and 6 are the GOES-16 infrared and water vapor imagery at 2X magnification for 2031 EST. The images depicted scattered to broken layers of high cirriform type clouds over the region. The radiative cloud top temperature over the accident site was 240° Kelvin or -33.16° C, which corresponded to cloud tops near 26,000 ft based on the HRRR sounding.

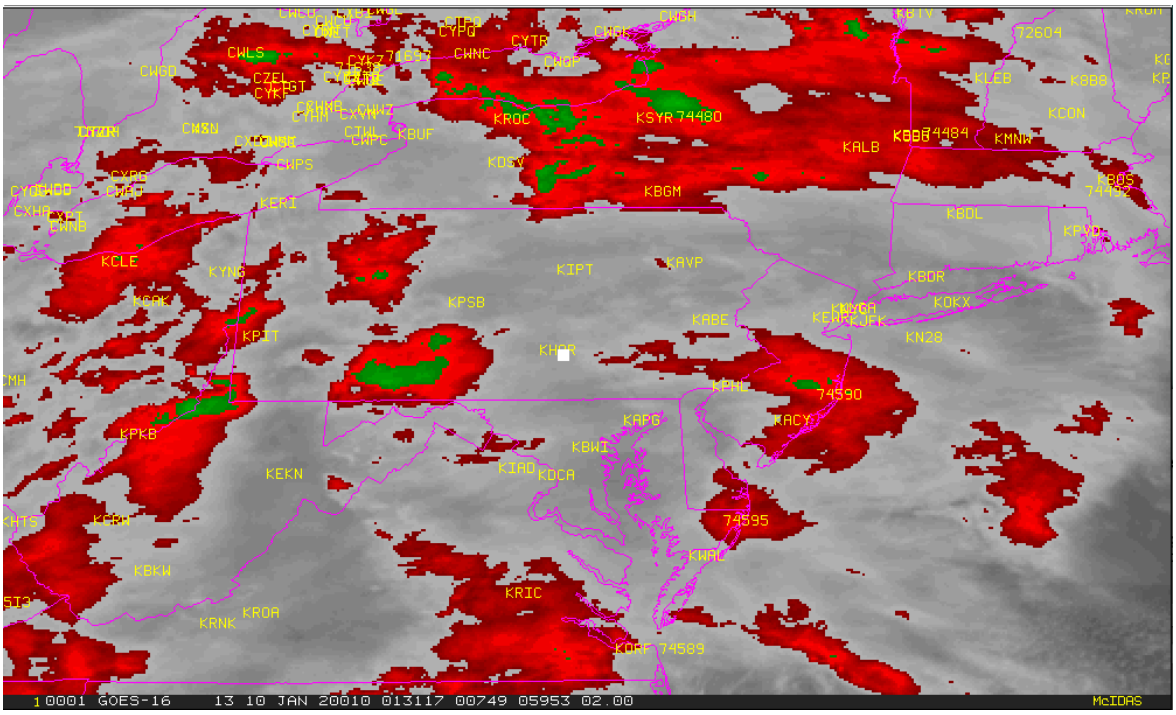

Figure 5 - GOES-16 infrared image for 2031 EST at 2X magnification

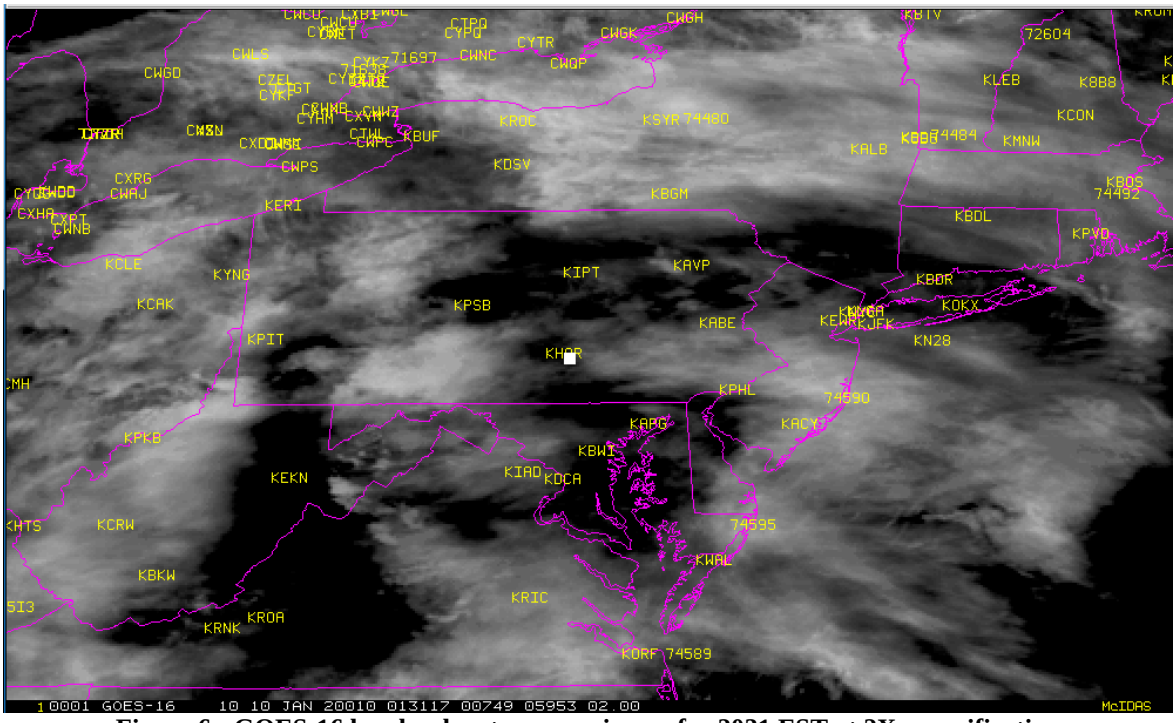

Figure 6 - GOES-16 low-level water vapor image for 2031 EST at 2X magnification

5.0 Pilot Reports

The following pilot reports (PIREPs) were recorded within 150 miles and below 10,000 ft surrounding the period of the accident. The reports are provided in standard code and abbreviations with time in UTC, then decoded and time converted to local.

PHL UA /OV PHL268@015/TM 2055/FL100/TP E145/TB LGT TURBULENCE

Philadelphia International Airport (PHL) routine pilot report; Over - 268° at 15 miles from PHL VORTAC[8]; Time – 1555 EST; Altitude – 10,000 ft; Type aircraft – Embraer ERJ-145 regional jet; Turbulence – light turbulence.

EWR UA /OV TEB/TM 2352/FL020/TP FA8X/WV +15 KTS WS

Newark Liberty International Airport (EWR) routine pilot report; Over – Teterboro Airport (TEB), Teterboro, NJ; Time – 1852 EST; Altitude – 2,000 ft; Type aircraft – Dassault falcon 8X business jet; Wind – +15 knot wind shear.

EWR UUA /OV TEB/TM 2352/FL020/TP FA8X/RM LLWS +15 KTS

EWR urgent pilot report; Over – TEB; Time – 1852 EST; Altitude – 2,000 ft; Type aircraft – Dassault falcon 8X business jet; Remarks – LLWS +15 knot.

MMU UUA /OV MMU /TM 0115/FL004/TP CL30/WV LLWS/RM +/- 10 KTS AOB 400 FT FINAL RY 31

Morristown Municipal Airport (MMU), Morristown, NJ urgent pilot report; Over – MMU; Time – 2015 EST; Type aircraft – Bombardier Challenger 300 business jet; Wind – LLWS; Remarks – plus/minus 10 knot airspeed at or below 400 ft on final to runway 31.

EWR UA /OV 10 N CDW/TM 0125/FL030/TP C560/TB MOD

EWR routine pilot report; Over – 10 miles north of Essex County Airport (CDW), Caldwell, NJ; Time – 2025 EST; Altitude – 3,000 ft; Type aircraft – Cessna Citation business jet; Turbulence – moderate.

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IPT UA /OV IPT/TM 1324/FL023/TP C208/TB MOD-SEV 023-030

Williamsport Regional Airport (IPT), Williamsport, PA routine pilot report; Over – IPT; Time – 0824 EST January 10, 2020; Altitude – 2,300 ft; Type aircraft – Cessna 208 Caravan turboprop; Turbulence – moderate to severe between 2,300 and 3,000 ft.

The pilot reports confirmed the HRRR numerical model information of strong to severe LLWS[9] and moderate to severe turbulence between 2,300 ft to 3,000 ft during the overnight and early morning hours over the accident area.

The Airmen's Information Manual (AIM) section 7-1-10, Safety of Flight, provides the following definitions of turbulence intensity, aircraft reaction, and conditions within the cabin in the following chart (figure 7).

[8] A VORTAC is a radio-based navigational aid for aircraft pilots consisting of a co-located VHF omnidirectional range (VOR) beacon for azimuth data and a tactical air navigation system (TACAN) beacon for distance.

[9] AC 00-54 Pilot Windshear Guide – defined "Severe Windshear" as a rapid change in wind direction or velocity causing airspeed changes greater than 15 knots or vertical speed changes greater than 500 feet per minute.

Intensity	Aircraft Reaction	Inside Aircraft
Light	Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw). Report as **Light Turbulence;** or Turbulence that causes slight, rapid and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude. Report as **Light Chop**.	Occupants may feel a slight strain against seat belts or shoulder straps. Unsecured objects may be displaced slightly. Food service may be conducted and little or no difficulty is encountered in walking.
Moderate	Turbulence that is similar to Light Turbulence but of greater intensity. Changes in altitude and/or attitude occur but the aircraft remains in positive control at all times. It usually causes variation in indicated airspeed. Report as **Moderate Turbulence**; or Turbulence that is similar to Light Chop but of greater intensity. It causes rapid bumps or jolts without appreciable changes in aircraft altitude or attitude. Reports as **Moderate Chop**.	Occupants feel definite strain against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.
Severe	Turbulence that causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control. Report as **Severe Turbulence.**	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food service and walking are impossible.
Extreme	Turbulence in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage. Reports as **Extreme Turbulence.**	
	High level turbulence above 15,000 feet not associated with cumuliform clouds, including thunderstorms, should be reported as CAT (clear air turbulence) preceded by the appropriate intensity.	**Reporting Term – Definition** Occasional – less than 1/3 or the time. Intermittent – 1/3 to 2/3. Continuous – More than 2/3.

Figure 7 - Airmen's Information Manual (AIM) Turbulence Definitions

6.0 NWS Forecasts

6.1 Terminal Aerodrome Forecasts

The NWS State College (KCTP), Pennsylvania Weather Forecast Office (WFO) was responsible for the issuance of the Terminal Aerodrome Forecast (TAF) for KMDT. A TAF is a concise statement of the expected meteorological conditions at an airport during a specified period (usually 24 hours). TAFs are valid for a 5 mile radius around an airport's center point. The forecasts issued at 1826 EST and was current at the time of the accident was as follows.

TAF KMDT 092326Z 1000/1024 VRB03KT P6SM BKN200
FM100200 10003KT P6SM BKN200 WS010/16025KT
FM101000 12003KT P6SM BKN150 WS010/18035KT
FM101200 14004KT P6SM BKN070 OVC120 WS012/19035KT
FM101800 17004KT P6SM OVC050=

The forecast for KMDT from 1900 EST expected wind variable at 3 knots, visibility 6 miles or more, ceiling broken at 20,000 ft agl. From 2100 EST wind from 100° at 3 knots, visibility 6 miles

or more, ceiling broken at 20,000 ft, wind shear at 1,000 ft with wind from 160° at 25 knots. The wind shear was expected to continue through the morning on January 10, 2020.

6.2 Area Forecast Discussion

The NWS Area Forecast Discussions (AFD) are issued by each WFO to describe the short term weather conditions within their region with an aviation section that includes the general conditions as it relates to the creation of the TAF. These are useful for additional aviation-related issues that cannot be encoded into the TAF. The discussion also gives some reasoning behind the forecast. These are generated roughly every 6 hours and corresponds to the release of the latest TAFs for that office. The long term section has been excluded. The forecast discussion issued by KCTP WFO at 1839 EST was as follows.

FXUS61 KCTP 092339
AFDCTP

Area Forecast Discussion
National Weather Service State College PA
639 PM EST Thu Jan 9 2020

.SYNOPSIS...
High pressure is moving to our east and a warm up will start on Friday. A slow moving frontal boundary to our west this weekend will lead to several bouts of rain and temperatures much above normal.

.NEAR TERM /UNTIL 6 AM FRIDAY MORNING/...
SSE wind picking up over the west, but temps not rising too fast. High cloudiness will probably thin out a little early tonight, then get thicker through the night. The temps will probably cool off nicely despite the high clouds, mainly due to the light wind in the east tonight and the snow on the ground. Have delayed precip just an hour or two. The only places to the rain before sunrise will be NW of Coudersport and DuBois. The trickier part of the forecast is whether or not to post a winter weather advy for --ZR which could happen early Fri AM. At this point, any ZR looks to be patchy. Will hold off on an advy.

.SHORT TERM /6 AM FRIDAY MORNING THROUGH 6 PM FRIDAY/...
The first volley of rain will roll up and over the NW half of the area through the day. The most recent NAM run brings precip a little farther south than other models, but we do have chc PoPs pretty far to the south in the area. If there is any patchy, light ZR around in the NC/NE mtns in the morning, the threat will end well before noon. Temps rise much above normal, perhaps not to return back to normal for almost a week. QPF is pretty light for the day, heaviest in the NW. No risk of flooding, even with snow melt.

.AVIATION /00Z FRIDAY THROUGH TUESDAY/...
High pressure will continue to move off to the east. A core of strong winds aloft associated with low pressure lifting across the Grt Lks is likely to result in low level wind shear across western Pa this evening. The eastern valleys will stay decoupled and nearly calm all night. There is a very small threat of ZR in the late night/early AM of Friday north of IPT and generally east of BFD. But, it is not out of the question that BFD may report -ZR before sunrise. Temps will warm nicely Fri, ending the threat of ZR.

.Outlook...

Fri...LLWS possible, mainly early. Rain/low cigs possible N Mtns.
Sat...AM low cigs possible, mainly N Mtns.
Sun...AM lows cigs/showers possible, then windy.
Mon...No sig wx expected.
Mon PM-Tues...RA/low cigs poss.

.CTP WATCHES/WARNINGS/ADVISORIES...None.

The discussion indicated that the high pressure system dominating across the area was expected to continue to move off to the east with a core of strong winds aloft associated with the Great Lakes low pressure system moving over western Pennsylvania and result in the threat of low level wind shear during the evening hours and into Friday morning.

6.3 Winds and Temperature Aloft Forecast

The NWS Winds and Temperature Aloft Forecast[10] current for the route was valid for 1900 EST on January 9, 2020 and for use between 1500 and 2200 EST.

WINDS ALOFT FORECASTS
DATA BASED ON 091800Z
VALID 100000Z FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
ACY	2110	2521+03	2630-02	2736-05	2953-19	2958-31	288444	289753	781363
AVP	1925	2431+02	2638-03	2642-07	2860-20	2864-32	279345	780154	782063

The closest station forecast was for Wilkes-Barre/Scranton (AVP), Pennsylvania, located approximately 85 miles northeast of the accident site. The AVP forecast for 3,000 ft expected a wind from 190° at 25 knots, at 6,000 ft the wind was from 240° at 31 knots with a temperature +2° C.

7.0 NWS Inflight Weather Advisories

Inflight Aviation Weather Advisories are forecasts to advise en route aircraft of development of potentially hazardous weather. Inflight aviation weather advisories in the conterminous U.S. are issued by the NWS AWC, as well as from the Center Weather Service Units (CWSU) associated with FAA ARTCCs. There are four basic types of inflight aviation weather advisories: the Significant Meteorological Information (SIGMET), the Convective SIGMET, the Airman's Meteorological Information (AIRMET), and the Center Weather Advisory (CWA). Inflight advisories serve to notify en route pilots of the possibility of encountering hazardous flying conditions which may not have been forecast at the time of the preflight briefing. Whether or not the condition described is potentially hazardous to a particular flight is for the pilot to evaluate on the basis of experience and the operational limits of the aircraft.

During the period the NWS had no SIGMET, Convective SIGMET, or CWA's current for the region that included the accident site. In addition, there were no AIRMETs for any significant instrument flight rule conditions or icing conditions outside of convective activity. The NWS did

[10] Taken from NWS bulletin FBUS31 KWNO

have AIRMET Tango series current for moderate turbulence below 18,000 ft and for low level wind shear[11] expected over the area with conditions continuing beyond 2200 through 0400 EST.

WAUS41 KKCI 092045
WA1T
-BOST WA 092045
AIRMET TANGO UPDT 5 FOR TURB AND LLWS VALID UNTIL 100300
.
AIRMET TURB...ME NH VT MA NY LO LE AND CSTL WTRS
FROM 40ESE YQB TO 60SSE BGR TO 40NNE ACK TO 30E JHW TO 30SE ECK
TO YOW TO YSC TO 40ESE YQB
MOD TURB BTN FL240 AND FL390. CONDS DVLPG 21-00Z. CONDS CONTG
BYD 03Z THRU 09Z.
.
AIRMET TURB...NY LO PA OH LE WV MD DC VA NC SC GA
FROM 50WSW YOW TO 20NNE SYR TO 30SSE HNK TO 20SW DCA TO 20SE CLT
TO 30SSE ODF TO LGC TO GQO TO HMV TO HNN TO CVG TO FWA TO 30SE
ECK TO 50WSW YOW
MOD TURB BLW FL180. CONDS CONTG BYD 03Z THRU 09Z.
.
LLWS POTENTIAL...NH VT MA NY LO NJ PA OH LE WV MD VA NC SC GA
BOUNDED BY YSC-20NNW CON-CSN-30W GSO-30W ATL-GQO-HMV-HNN-CVG-FWA-
30SE ECK-YOW-YSC
LLWS EXP. CONDS CONTG BYD 03Z THRU 09Z.
.
OTLK VALID 0300-0900Z
AREA 1...TURB NY LO PA OH LE WV
BOUNDED BY 40E YYZ-20ESE BUF-30NNW JST-30NNE HNN-40W HNN-CVG-FWA-
30SE ECK-40E YYZ
MOD TURB BTN FL250 AND FL380. CONDS DVLPG AFT 03Z. CONDS CONTG
THRU 09Z.
.
AREA 2...TURB ME NH VT MA RI CT NY LO AND CSTL WTRS
BOUNDED BY 60ENE YQB-40ESE HUL-150E ACK-20ESE SYR-20WNW YYZ-YOW-
YSC-60ENE YQB
MOD TURB BTN FL240 AND FL390. CONDS CONTG THRU 09Z.
.
AREA 3...TURB ME NH VT MA CT NY LO NJ PA OH LE WV MD DC DE VA NC
SC GA
BOUNDED BY 70NW PQI-60E PQI-50SSW BGR-30S CSN-20SE CLT-40WNW ATL-
GQO-HMV-HNN-CVG-FWA-20ESE ECK-YOW-YSC-70NW PQI
MOD TURB BLW FL180. CONDS CONTG THRU 09Z.
....

Figures 8 and 9 are the Graphic or G-AIRMET[12] Tango issued for moderate turbulence and low level wind shear issued at 1545 EST and valid for 1900 and 2100 EST respectively.

[11] The NWS advisory for LLWS is defined as wind shear below 2,000 feet agl, other than convectively induced, resulting in an air speed loss or gain of 20 knots or more.

[12] A G-AIRMET is a graphical advisory of weather that may be hazardous to aircraft, but are less severe than SIGMETs issued by the NWS AWC for the lower 48 states and adjacent coastal waters. They are only valid at specific time "snapshots". Forecasters create graphical objects depicting the areas and attributes of AIRMET hazards, which are distributed in BUFR file format. G-AIRMETs are issued at discrete times 3 hours apart for a period of up to 12 hours into the future (00, 03, 06, 09, and 12 hours). They are issued at 03:00, 09:00, 15:00 and 21:00 UTC , with updates issued as necessary.

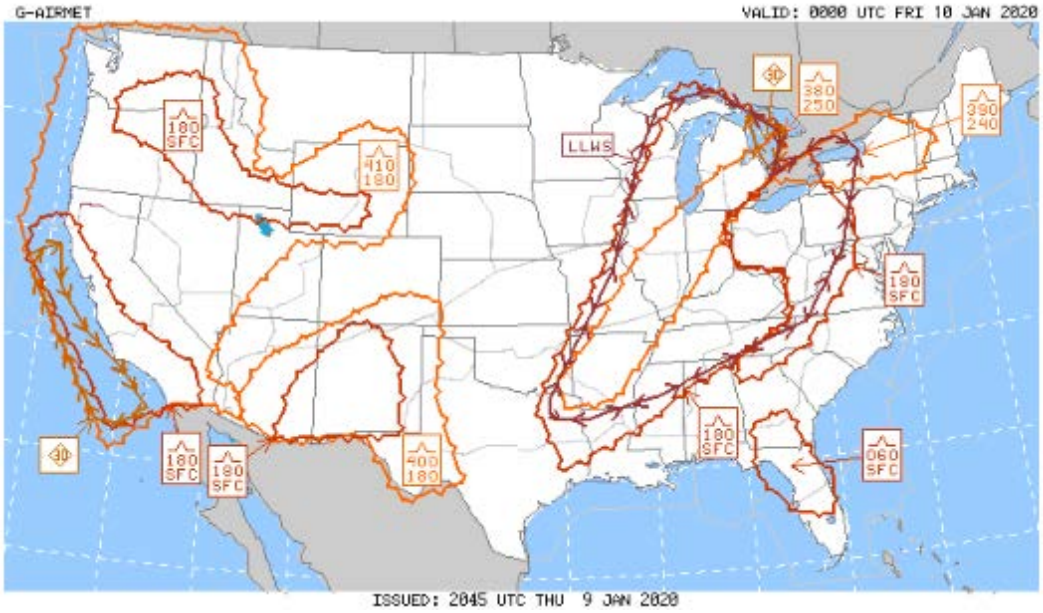

Figure 8 - G-AIRMET Tango valid for 1900 EST

TANGO 2020-01-10 03:00:00

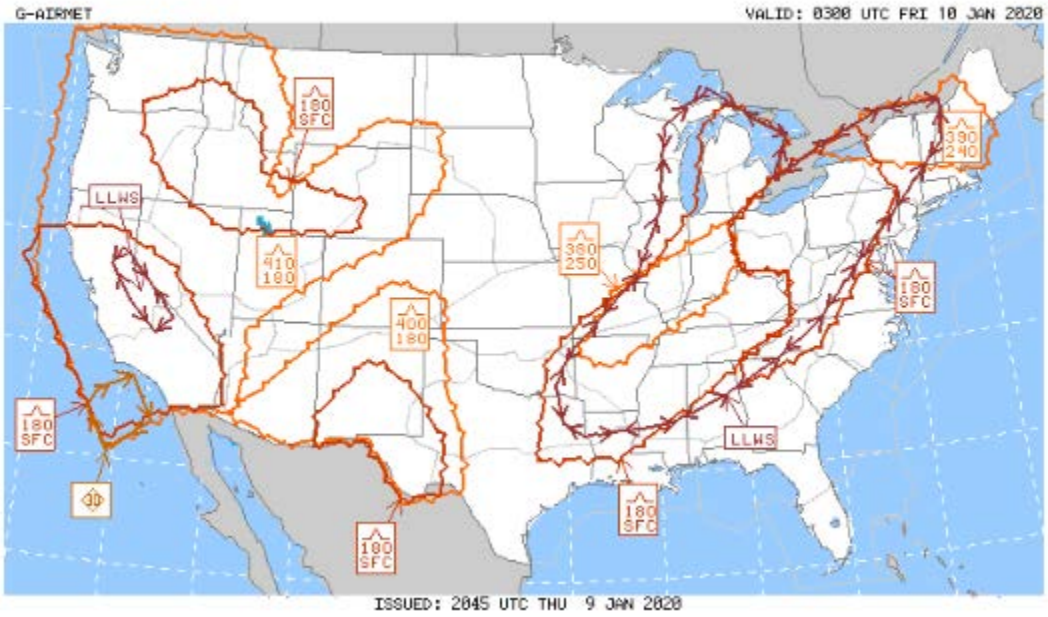

Figure 9 - G-AIRMET Tango issued for 2200 EST

8.0 Graphic Turbulence Guidance

The Graphic Turbulence Guidance (GTG) was developed by the National Center for Atmospheric Research (NCAR) and is now run operationally at NOAA NCEP and is available to users on the AWC website from the surface to 45,000 ft. The current GTG version 3.0 model is

generated from the NOAA Rapid Refresh numerical model with a horizontal spacing of 13.5 kilometers with 50 vertical levels, and provides a computer-generated four-dimensional forecast related to the expected intensity of atmospheric turbulence provided in eddy dissipation rate (EDR). Typical EDR varies from close to 0, "smooth", to near 1, "extreme" for most aircraft types. NCAR defines the following EDR values to various aircraft weight classes and turbulence intensities and is included as figure 10.

AC weight class	Estimated EDR Threshold * 100			
	Light	Moderate	Severe	Extreme
Light	13	16	36	64
Medium (Large)	15	20	44	79
Heavy	17	24	54	96

Figure 10 - EDR values verses turbulence intensity for various weight classes

The NWS does not archive the GTG images so the NCAR was contacted and requested to re-run the model over the accident site and evaluate its operational performance during the period. Attachment 1 is the NCAR PowerPoint images of the 3-hour forecast and GTG analysis and for 2000 and 2100 EST for 1000 ft, 3000 ft, and 5000 ft of clear air turbulence, mountain wave, and eddy dissipation parameter provided in values of EDR for a light category aircraft[13]. Figure 11 is another representation of the EDR scale for a light aircraft with the general turbulence intensity. Moderate turbulence is typically encountered with EDR values between 13 and 35, severe between 36 and 62.

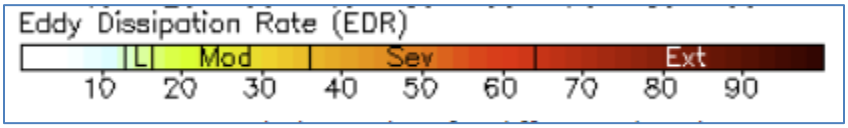

Figure 11 - EDR scale for a light category aircraft

The NCAR GTG 3-hour forecast issued at 1700 EST and valid for 2000 EST depicted a northeast-to-southwest band of EDR values over 0.20 running from central New York into Pennsylvania, extreme western Maryland, and into West Virginia. A maximum value of EDR of 0.30 to 0.40 was located at 3,000 ft over West Virginia. The accident site was on the border of clear air turbulence EDR values of 0.20 to 0.30 or moderate turbulence at 1,000 ft (slide 2), and values less than 0.20 at 3,000 ft and 5,000 ft (slides 3 and 4 respectively). The 3-hour GTG forecast issued at 2100 EST and valid for 2100 EST continued to depict similar conditions with the accident site on the border of EDR values of 0.20 to 0.30 at 1,000 ft (slides 5-7).

The GTG analysis for 2000 EST (slides 8-10) depicted the accident site on the border of EDR values of 0.20 to 0.30 at 2000 EST (0100Z) at 1,000 ft, with an area of EDR of 0.30 to 0.40 or moderate to severe turbulence immediately southwest of the accident site. At 3,000 ft and 5,000 ft the EDR values were less than 0.20 suggesting light turbulence potential. A maximum value of EDR of 0.50 to 0.60 was located over West Virginia at 3,000 ft to the south of the accident site.

[13] Light category aircraft – is defined as an aircraft with a maximum takeoff weight less than 15,500 lbs.

The GTG analysis for 2100 EST (slides 11-13) depicted the accident site within the area of EDR values of 0.20 to 0.30 at 1,000 ft, with values of 0.10 to 0.20 at 3,000 ft and 5,000 ft.

9.0 Preflight Weather Briefing

A search of the FAA Automated Flight Service Station (AFSS) contract provider Leidos had no contact with the pilot of N450MC for any weather briefing during the period from January 8-10, 2020, and no third party vendors utilized their system for weather data or to file any flight plans. A separate check of other weather vendors ForeFlight and Flt.Plan.com also indicated that they had no contact with the pilot during the same period. Therefore, it is unknown what the pilot may have used in familiarizing himself regarding the weather conditions prior to departure.

10.0 Astronomical Conditions

The astronomical data for Harrisburg, Cumberland County, Pennsylvania on January 09, 2020 obtained from the United States Naval Observatory software[14] provided the following information. The time of the accident has been added in italic bold print for reference.

Sun	Time (EST)
Begin of civil twilight	0700
Sunrise	0730
Transition	1214
Sunset	1659
End civil twilight	1729
Accident	***2029***
Moon	
Moonrise	1559
Accident	***2029***
Transition	2341
Moonset	0622 January 10, 2020

At the time of the accident the Sun had already set, and the Moon was approximately 49° above the horizon at an azimuth of 95° and was 99% illuminated.

F. Attachments

1. Attachment 1 is the NCAR Graphic Turbulence Guidance (GTG) 3-hour forecast and analysis and for 2000 EST (0100Z) and 2100 EST (0200Z) for 1,000 ft, 3,000 ft, and 5,000 ft of clear air turbulence, mountain wave, and eddy dissipation parameter EDR values.

[14] United States Naval Observatory software program: Multiyear Interactive Computer Almanac (MICA).

Submitted by:

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