NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

October 27, 2014

Group Chairman's Factual Report

METEOROLOGY

ERA14FA112

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A. ACCIDENT

Location: 1 mile south of Bellevue, Tennessee
Date: February 3, 2014
Time: approximately 1657 central standard time (2257 UTC[1])
Aircraft: Gulfstream 690C, registration: N840V

B. METEOROLOGY GROUP

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C. SUMMARY

For a summary of the accident, refer to the *Accident Summary* report, which is available in the docket for this investigation.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Meteorologist went on scene for this investigation and gathered the weather data for this investigation from the NTSB's Washington D.C. office, the Terminal Radar Approach Control Facilities (TRACON) in Nashville, and from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Climatic Data Center (NCDC). All times are central standard time (CST) on February 3, 2014, and are based upon the 24-hour clock, where local time is -6 hours from UTC, and UTC=Z (unless otherwise noted). Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The accident location was located at latitude 36.04° N, longitude 86.94° W, elevation: 585 feet.

[1] UTC – is an abbreviation for Coordinated Universal Time.

E. FACTUAL INFORMATION

1.0 Synoptic Situation

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 synoptic weather features and in the creation of forecasts and warnings for the NWS. Reference to these charts can be found in the, joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC-0045G CHG 1.

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart for 1800 CST is provided as figure 1, with the approximate location of the accident site marked. The chart depicted a frontal system located across the southeastern United States with a surface trough[2] stretched from central South Carolina west-northwestward into southern Kentucky. A surface high pressure center with a pressure of 1029-hectopascals (hPa) was located in western Illinois with a surface low pressure center with a pressure of 1017 hPa located in central South Carolina. The station models around the accident site depicted air temperatures in the mid 20's to mid 30's Fahrenheit (F), with temperature-dew point spreads of 3° F or less, a north to northeast wind less than 10 knots, cloudy skies, and fog.

[2] Trough – An elongated area of relatively low atmospheric pressure or heights.

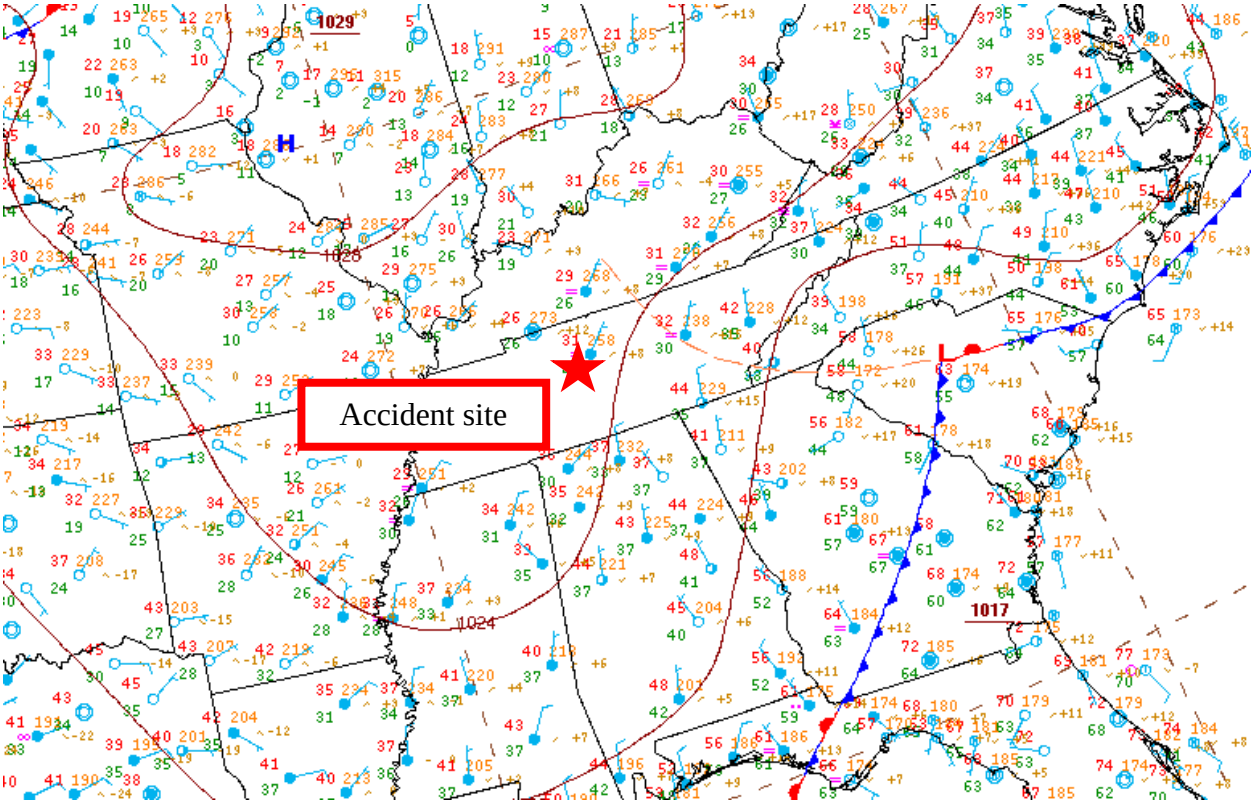


Figure 1 – NWS Surface Analysis Chart for 1800 CST

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 1800 CST at 925-, 850-, 700-, 500-, and 300-hPa are presented in figures 2 through 6. The 925- and 850-hPa charts depicted a north to northeast wind over Tennessee with air temperatures well below freezing. At 850- and 700-hPa a low and mid-level trough was located near the accident site, but by 700-hPa the wind was southwesterly with air temperatures above freezing. Areas near and ahead of trough are typically areas where enhanced lift, clouds, and precipitation can occur. The wind continued to increase through 300-hPa with a southwest wind near 100 knots above the accident site.

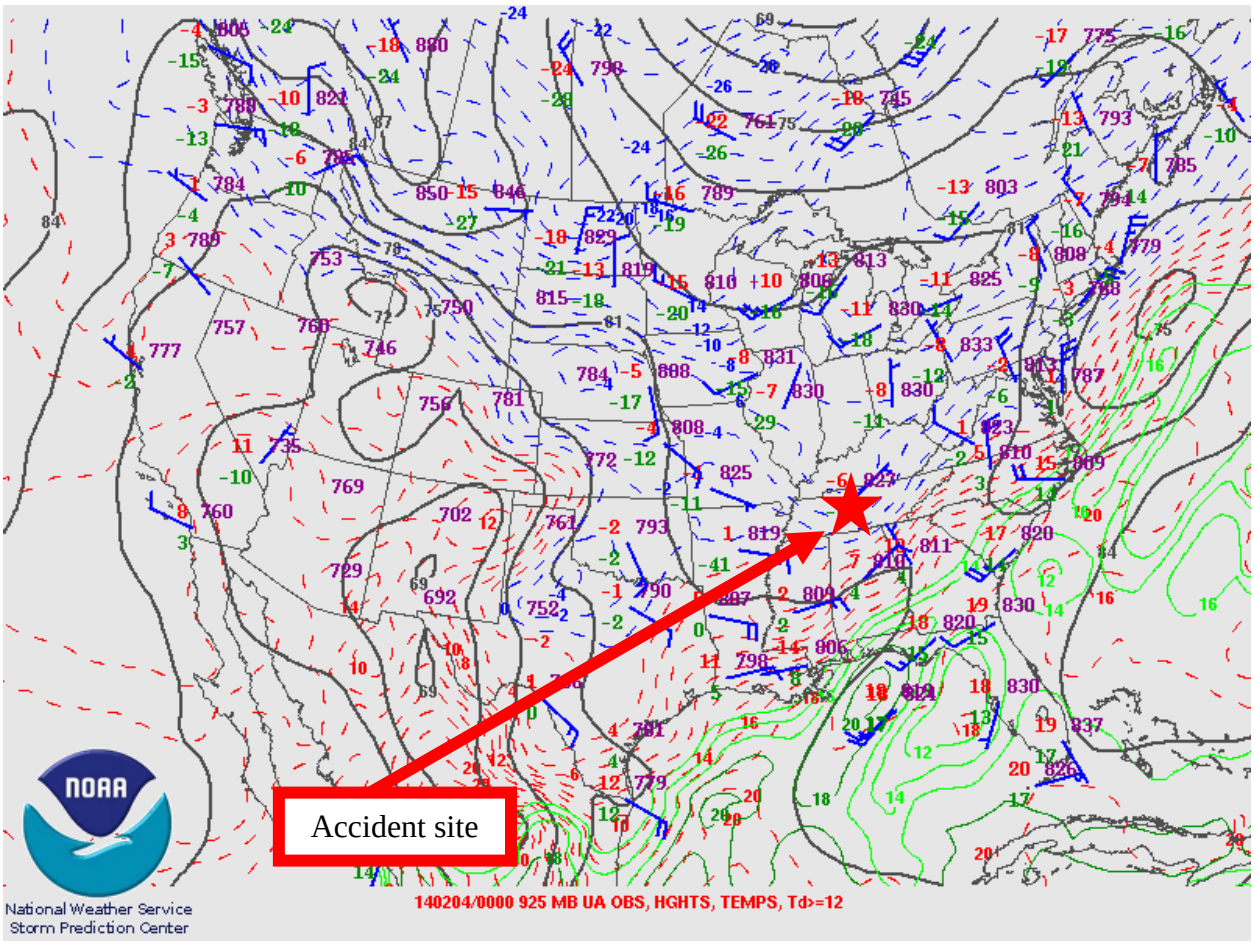


Figure 2 – 925-hPa Constant Pressure Chart for 1800 CST

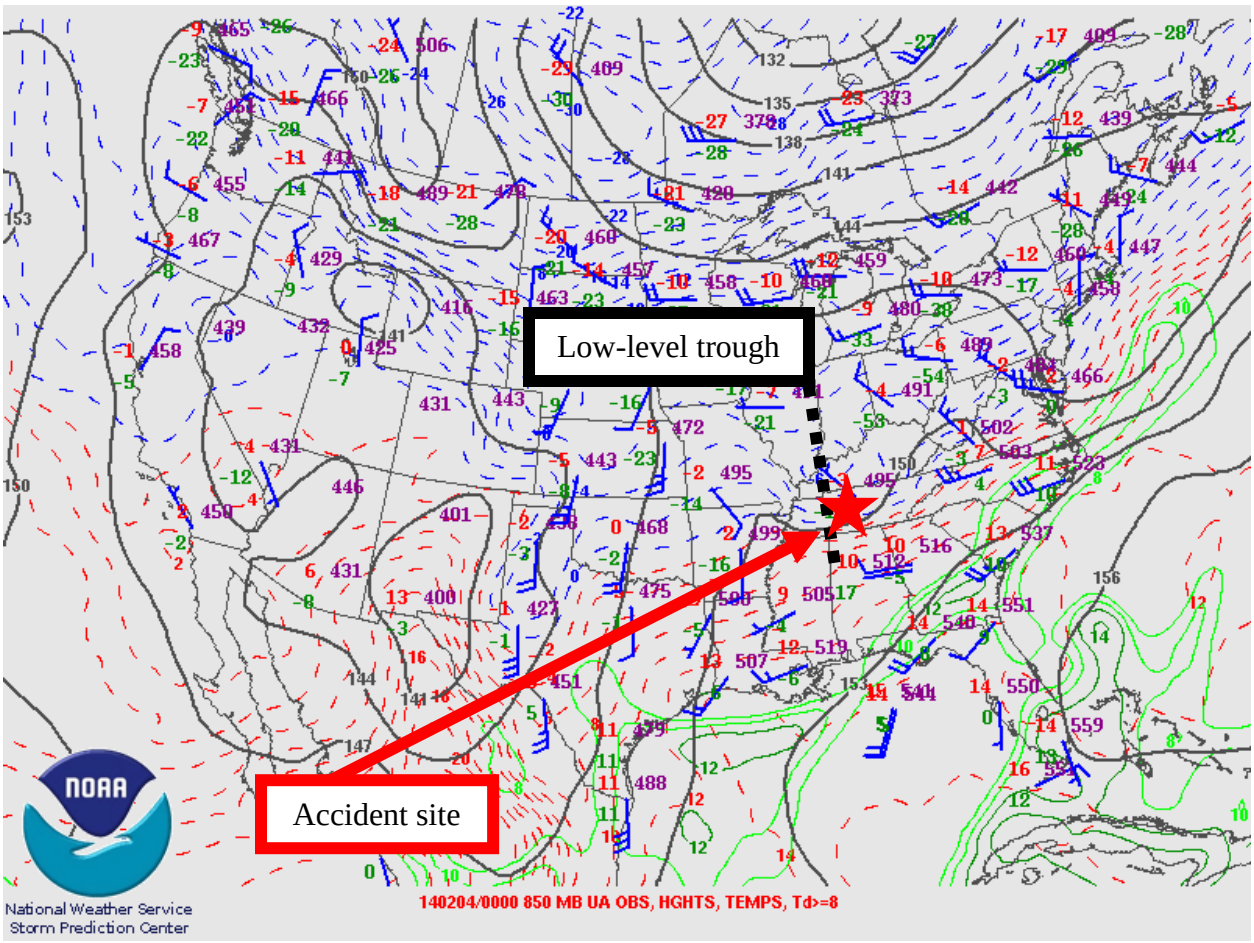


Figure 3 – 850-hPa Constant Pressure Chart for 1800 CST

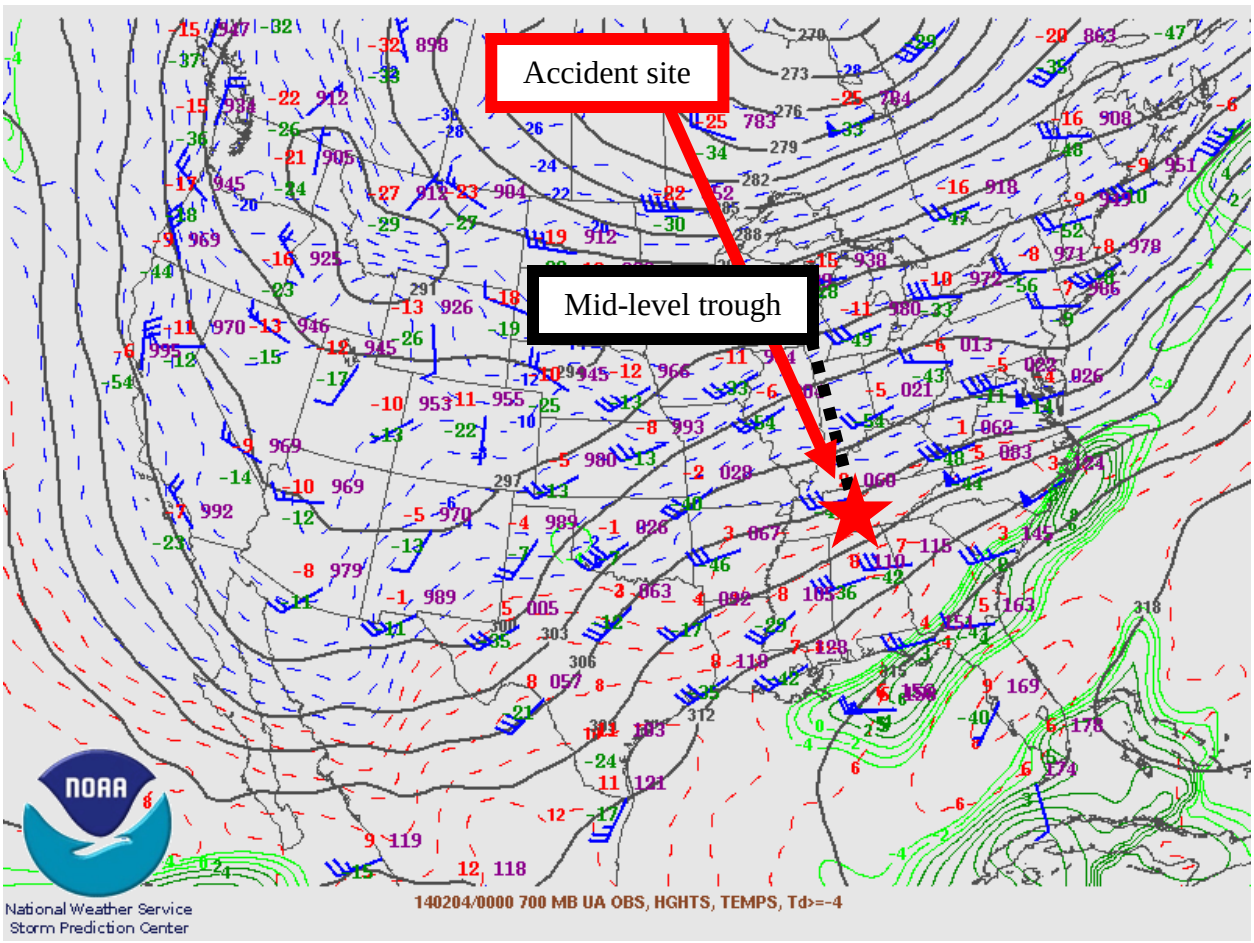


Figure 4 – 700-hPa Constant Pressure Chart for 1800 CST

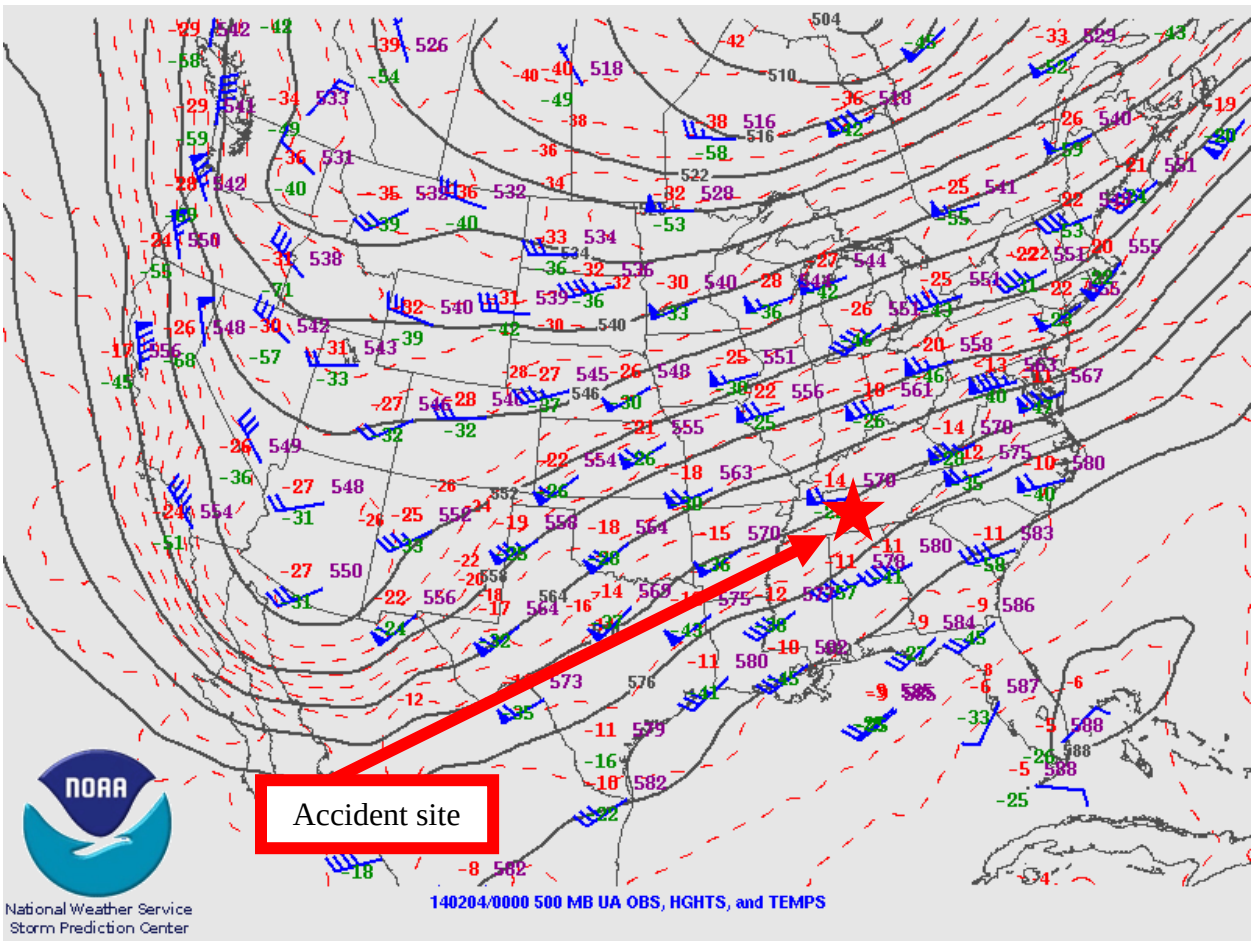


Figure 5 – 500-hPa Constant Pressure Chart for 1800 CST

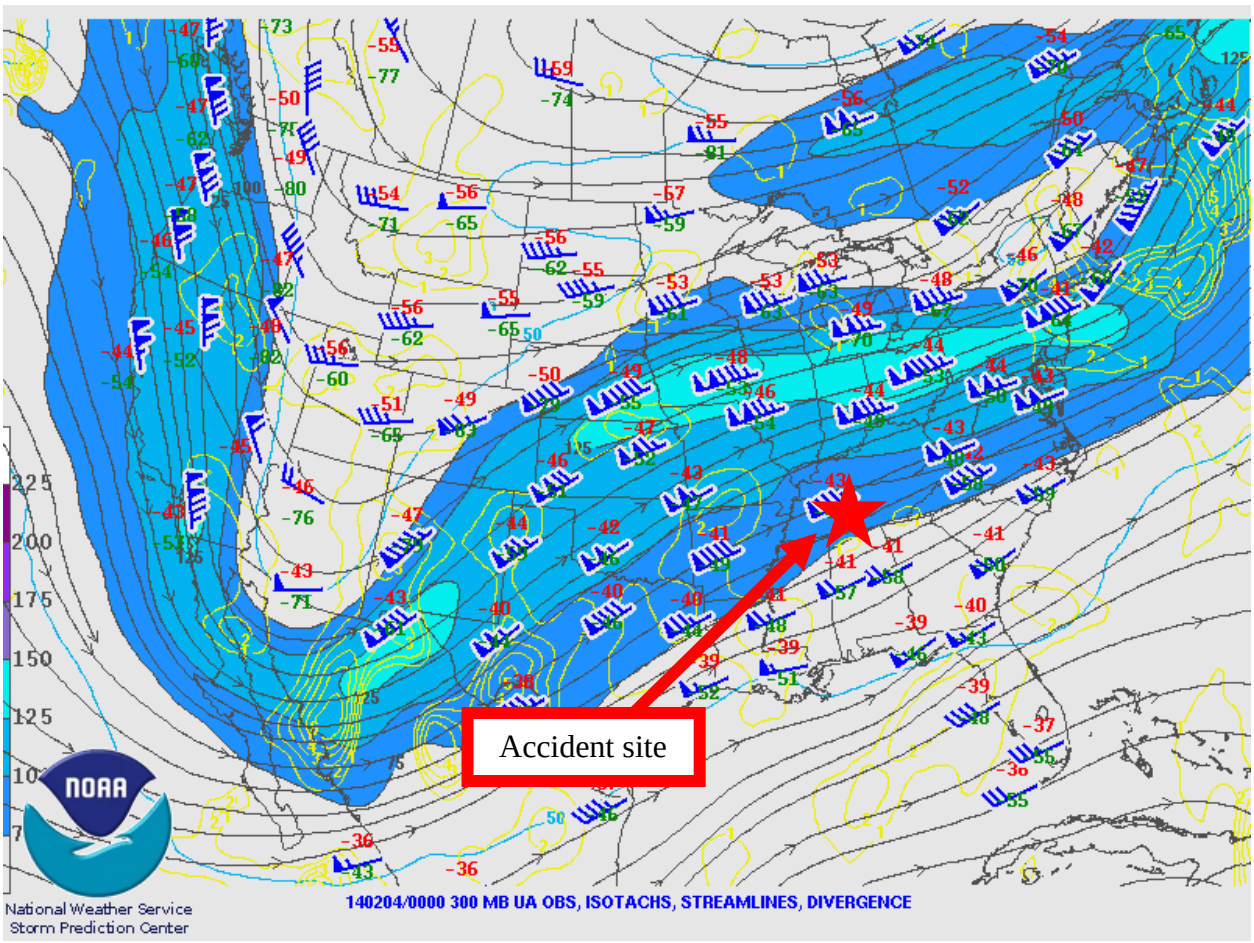


Figure 6 – 300-hPa Constant Pressure Chart for 1800 CST

2.0 Storm Prediction Center Products

No thunderstorms or severe storms were forecast.

3.0 Surface Observations

The area surrounding the accident site was documented utilizing official NWS Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language.

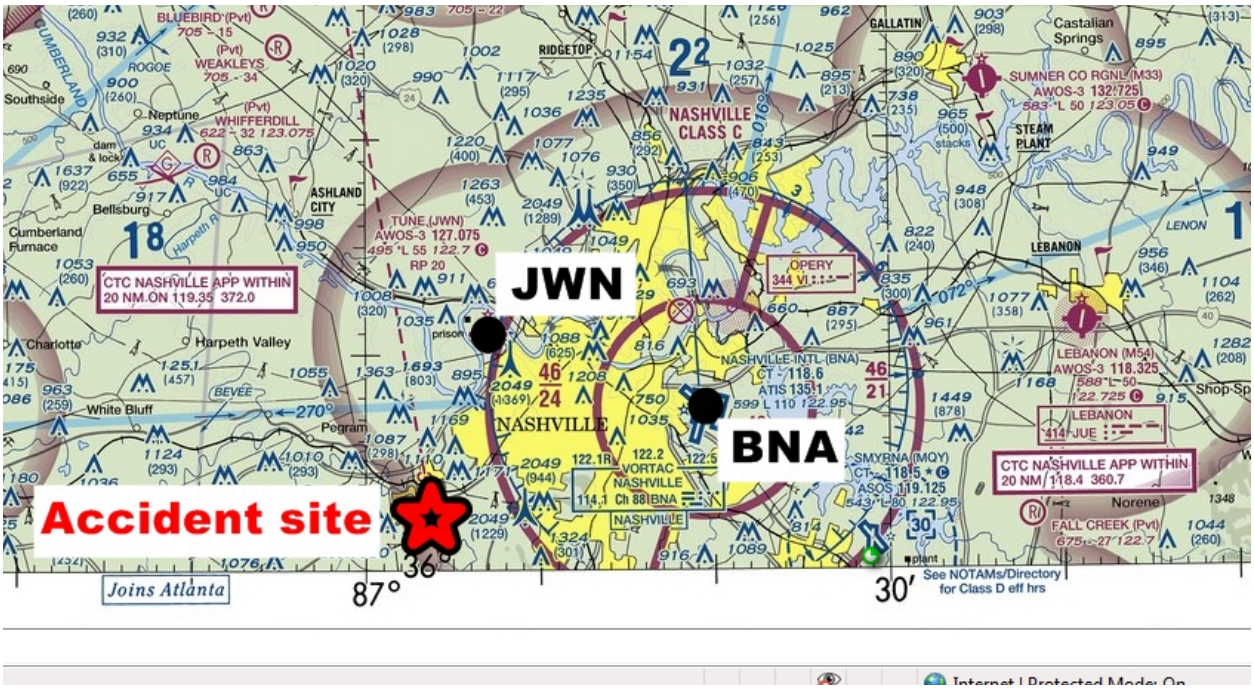


Figure 7 – Map of Tennessee with the location of the accident site, surface observation sites, and upper air sounding location

John C. Tune Airport (KJWN) was the closest official weather station to the accident site located 1 mile northwest of Nashville, Tennessee, and had an Automated Weather Observing System (AWOS[3]) whose reports were not supplemented by a human observer. KJWN was located 9 miles north-northeast of the accident site, at an elevation of 495 feet, and had a 3° westerly magnetic variation[4] (figure 7). The following observations were taken and disseminated during the times surrounding the accident[5]:

[1655 CST] KJWN 032255Z AUTO 36005KT 5SM OVC008 05/M04 A3029 RMK A01 T00501044 $

ACCIDENT TIME 1657 CST

[1700 CST] KJWN 032300Z AUTO 35004KT 6SM OVC008 05/M04 A3029 RMK A01 $

[1705 CST] KJWN 032305Z AUTO 01004KT 6SM OVC008 05/M04 A3029 RMK A01 $

[1710 CST] KJWN 032310Z AUTO 36005KT 6SM OVC008 05/M04 A3029 RMK A01 $

[3] AWOS – Automated Weather Observing System is equipped with meteorological instruments to observe and report temperature, dewpoint, wind speed and direction, visibility, cloud coverage and ceiling up to twelve thousand feet, and altimeter setting.

[4] Magnetic variation – The angle (at a particular location) between magnetic north and true north.

[5] The bold sections in this NWS product and the rest of products in the weather factual report are to highlight the individual sections that directly reference the weather conditions that are or will affect the accident location around the accident time.

[1715 CST] KJWN 032315Z AUTO 01005KT 6SM OVC008 06/M04 A3029 RMK A01 $

[1720 CST] KJWN 032320Z AUTO 01004KT 6SM OVC008 06/M04 A3029 RMK A01 $

[1725 CST] KJWN 032325Z AUTO 00000KT 5SM OVC008 06/M04 A3030 RMK A01 $

KJWN weather at 1655 CST, wind from 360° at 5 knots, 5 miles visibility, an overcast ceiling at 800 above ground level (agl), temperature of 5° Celsius (C), dew point temperature of -4° C, and an altimeter setting of 30.29 inches of mercury. Remarks: automated station without precipitation discriminator, temperature 5.0° C, dew point temperature -4.4° C, maintenance is needed on the system.

KJWN weather at 1700 CST, wind from 350° at 4 knots, 6 miles visibility, an overcast ceiling at 800 agl, temperature of 5° C, dew point temperature of -4° C, and an altimeter setting of 30.29 inches of mercury. Remarks: automated station without precipitation discriminator, maintenance is needed on the system.

KJWN weather at 1705 CST, wind from 010° at 4 knots, 6 miles visibility, an overcast ceiling at 800 agl, temperature of 5° C, dew point temperature of -4° C, and an altimeter setting of 30.29 inches of mercury. Remarks: automated station without precipitation discriminator, maintenance is needed on the system.

Nashville International Airport (KBNA) was located 5 miles southeast of Nashville, Tennessee, and had an Automated Surface Observing System (ASOS[6]) whose reports were supplemented by an official weather observer. KBNA was located 14 miles east-northeast of the accident site, at an elevation of 599 feet, and had a 3° westerly magnetic variation (figure 7). The following observations were taken and disseminated during the times surrounding the accident:

[1153 CST] KBNA 031753Z 36007KT 4SM BR OVC009 M01/M03 A3028 RMK AO2 SLP257 T10061028 11006 21011 58002=

[1253 CST] KBNA 031853Z 36007KT 3SM BR OVC009 M01/M03 A3027 RMK AO2 SLP253 T10061028=

[1353 CST] KBNA 031953Z 02009KT 3SM BR OVC009 M01/M03 A3024 RMK AO2 SLP246 T10061028=

[1453 CST] KBNA 032053Z 03009KT 5SM BR OVC009 00/M03 A3026 RMK AO2 SLP250 T00001028 55007=

[1553 CST] KBNA 032153Z 04007KT 5SM BR OVC009 00/M02 A3026 RMK AO2 SLP252 T00001022=

[6] ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

[1653 CST] KBNA 032253Z 06008KT 5SM BR OVC009 00/M03 A3028 RMK AO2 SLP258 T00001028=

ACCIDENT TIME 1657 CST

[1753 CST] KBNA 032353Z 04007KT 5SM BR OVC009 M01/M03 A3028 RMK AO2 SLP258 T10061028 10000 21006 51008=

[1853 CST] KBNA 040053Z 03006KT 6SM BR OVC009 M01/M02 A3029 RMK AO2 SLP262 T10061022=

[1953 CST] KBNA 040153Z 05005KT 6SM BR OVC009 M01/M03 A3028 RMK AO2 SLP258 T10061028=

[2053 CST] KBNA 040253Z 02006KT 5SM BR OVC008 00/M02 A3030 RMK AO2 SLP266 T00001022 53007=

KBNA weather at 1553 CST, wind from 040° at 7 knots, 5 miles visibility, mist, an overcast ceiling at 900 feet agl, temperature of 0° C, dew point temperature of -2° C, and an altimeter setting of 30.26 inches of mercury. Remarks: automated station with precipitation discriminator, sea level pressure 1025.2 hPa, temperature 0° C, dew point temperature -2.2° C.

KBNA weather at 1653 CST, wind from 060° at 8 knots, 5 miles visibility, mist, an overcast ceiling at 900 feet agl, temperature of 0° C, dew point temperature of -3° C, and an altimeter setting of 30.28 inches of mercury. Remarks: automated station with precipitation discriminator, sea level pressure 1025.8 hPa, temperature 0° C, dew point temperature -2.8° C.

KBNA weather at 1753 CST, wind from 040° at 7 knots, 5 miles visibility, mist, an overcast ceiling at 900 feet agl, temperature of -1° C, dew point temperature of -3° C, and an altimeter setting of 30.28 inches of mercury. Remarks: automated station with precipitation discriminator, sea level pressure 1025.8 hPa, temperature -0.6° C, dew point temperature -2.8° C, 6-hourly maximum temperature of 0.0° C, 6-hourly minimum temperature of -0.6° C, 3-hourly pressure increase of 0.8 hPa.

KBNA weather at 1853 CST, wind from 030° at 6 knots, 6 miles visibility, mist, an overcast ceiling at 900 feet agl, temperature of -1° C, dew point temperature of -2° C, and an altimeter setting of 30.29 inches of mercury. Remarks: automated station with precipitation discriminator, sea level pressure 1026.2 hPa, temperature -0.6° C, dew point temperature -2.2° C.

4.0 Upper Air Data

The closest official upper air sounding to the accident site was from KBNA, with a site number 72327 (figure 7). The 1800 CST sounding from KBNA was plotted on a standard Skew-T log P diagram[7] with the derived stability parameters included in figure 8 (with data from the surface to 600-hPa, or 14,000 feet msl). This data was analyzed utilizing the RAOB[8] software package. The sounding depicted the Lifted Condensation Level (LCL)[9] at 1,244 feet msl, a Convective Condensation Level (CCL)[10] of 2,223 feet, and a Level of Free Convection (LFC)[11] at 1,272 feet. The freezing level was located at the surface. The precipitable water value was 0.28 inches.

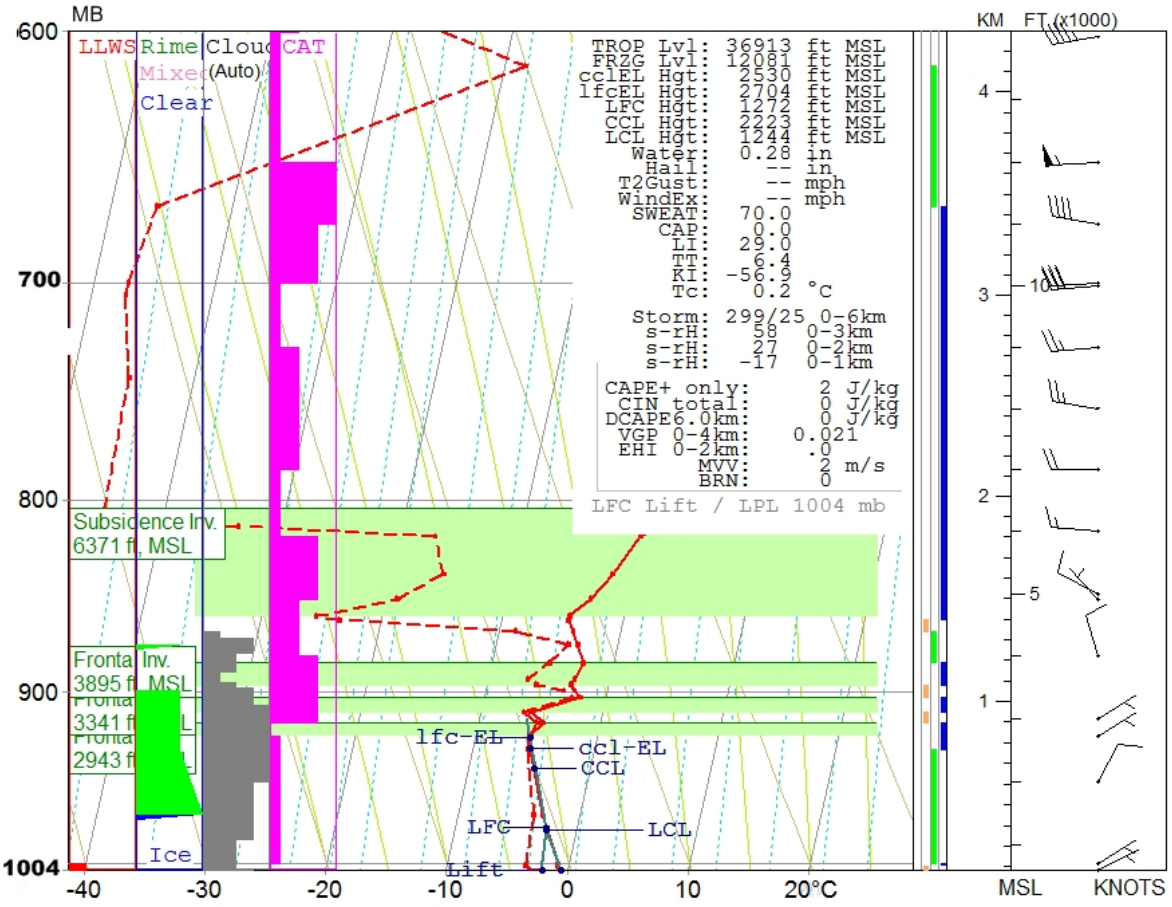


Figure 8 – 1800 CST KBNA sounding

[7] Skew T log P diagram – is a standard meteorological plot 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.

[8] RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamopras, Pennsylvania.

[9] Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

[10] Convective Condensation Level (CCL) – The level in the atmosphere to which an air parcel, if heated from below, will rise dry adiabatically, without becoming colder than its environment just before the parcel becomes saturated.

[11] Level of Free Convection (LFC) – The level at which a parcel of saturated air becomes warmer than the surrounding air and begins to rise freely. This occurs most readily in a conditionally unstable atmosphere.

The 1800 CST KBNA sounding indicated a cold relatively moist vertical environment from the surface through 4,500 feet msl. This environment would have been conducive of cloud formation as indicated by RAOB from the surface to 4,500 feet. Icing (both clear and rime) was indicated by RAOB in areas where there were clouds between 1,500 and 4,000 feet msl. The KBNA sounding was also close to saturation between -2° C and -6° C (between 1,500 and 4,500 feet msl) which would have likely supported the growth of super cooled liquid water droplets (Cober et al. 2001 and Bernstein et al. 2007).[12]

The sounding wind profile indicated there was a surface wind from 060° at 4 knots and the wind backed[13] around to the west and increased to 50 knots by 12,000 feet msl. A small amount of low-level wind shear (LLWS) was indicated by RAOB in the lowest couple hundred feet. Several layers of possible clear-air turbulence were identified by RAOB from the surface through 14,000 feet.

5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 13 (GOES-13) data was obtained from the NCDC and processed with the NTSB's Man-computer Interactive Data Access System (McIDAS) workstation. Visible and infrared imagery (GOES-13 bands 1 and 4) at a wavelength of 0.65 microns (μm) and 10.7 μm retrieved brightness temperatures for the scene. Satellite imagery surrounding the time of the accident, from 1500 CST through 1900 CST at approximately 15-minute intervals, were reviewed and the closest images to the time of the accident are documented here.

Figures 9 and 10 present the GOES-13 visible imagery from 1632 and 1645 CST at 2X magnification with the accident site highlighted with a red square. Inspection of the visible imagery indicated abundant cloud cover over the accident site with the clouds moving from west to east. In addition, the sun is beginning to go down so there is some loss of light on the 1645 CST image (figure 10). Figures 11, 12, and 13 present the GOES-13 infrared imagery from 1632, 1645, and 1702 CST at 6X magnification with the accident site highlighted with a red square. Inspection of the infrared imagery indicated west to east movement on the clouds with a slightly enhanced band of clouds oriented east-northeast to southwest over the accident site around the accident time. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 1800 CST KBNA sounding, the approximate cloud-top heights over the accident site were 19,500 feet at 1702 CST.

[12] S.G. Cober, G. A. Isaac, and J. W. Strapp, Characterizations of Aircraft Icing Environments that Include Supercooled Large Drops (Journal of Applied Meteorology, 2001), pp. 1984-2002.
B.C Bernstein, C.A. Wolff, and F. McDonough, An Inferred Climatology of Icing Conditions Aloft, Including Supercooled Large Drops. Part I: Canada and the Continental United States (Journal of Applied Meteorology and Climatology, 2007), pp. 1857-1878.

[13] Backing wind – Wind which changes in a counter-clockwise direction with time at a given location, or which changes direction in a counter-clockwise sense with height.

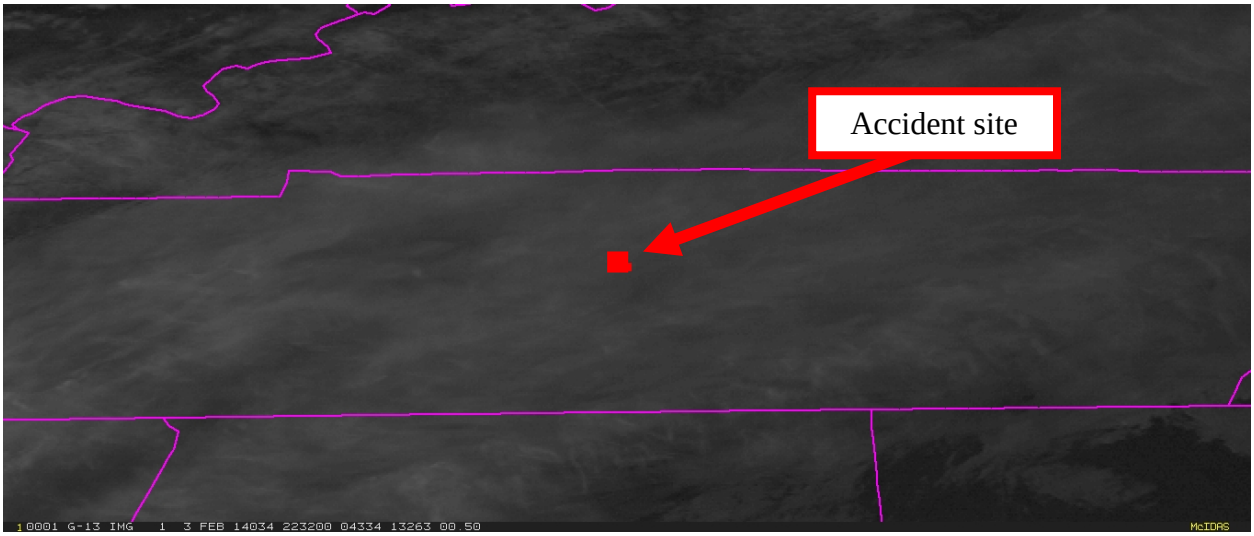


Figure 9 – GOES-13 visible image at 1632 CST

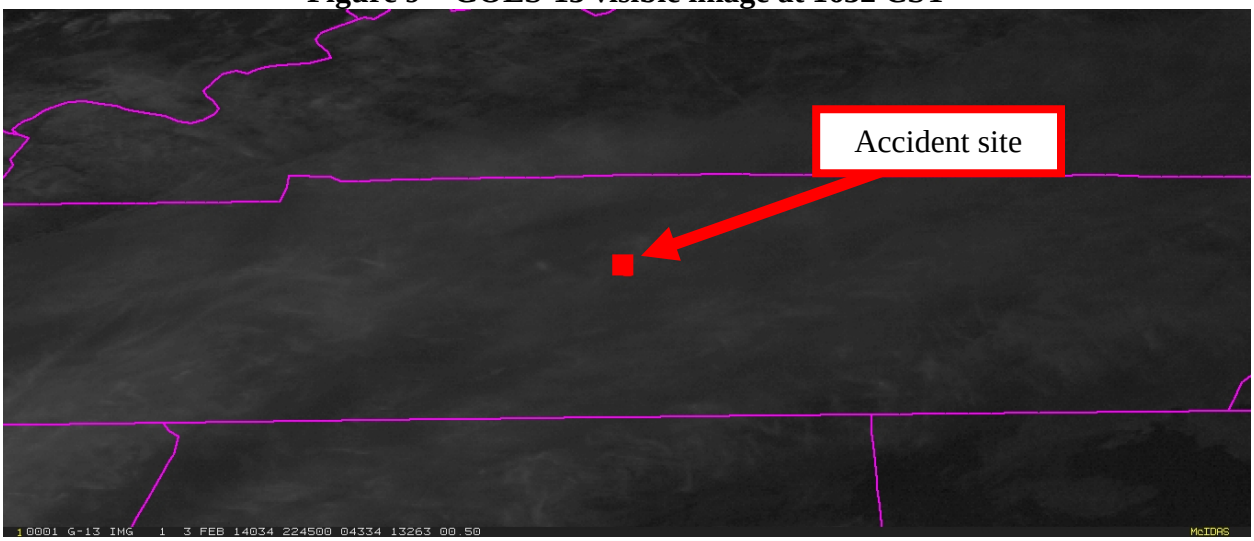


Figure 10 – GOES-13 visible image at 1645 CST

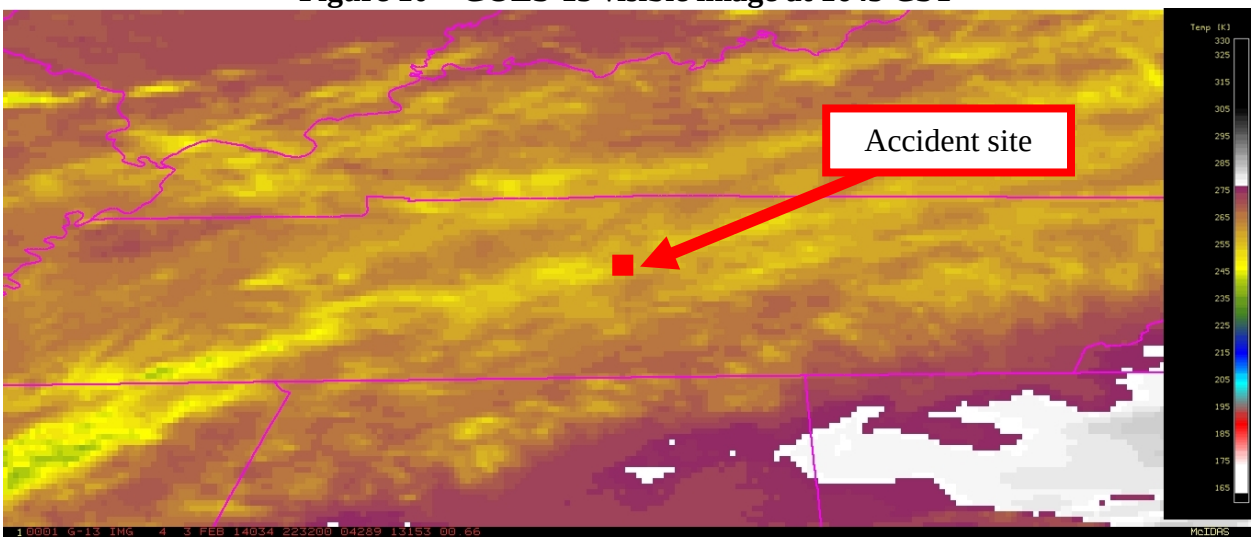


Figure 11 – GOES-13 infrared image at 1632 CST

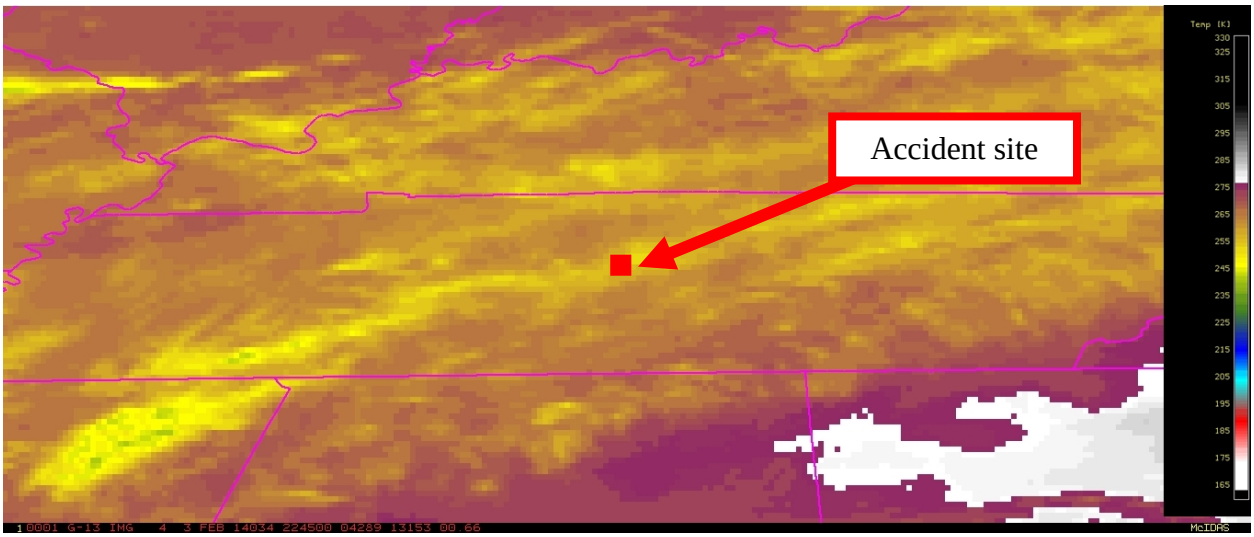


Figure 12 – GOES-13 infrared image at 1645 CST

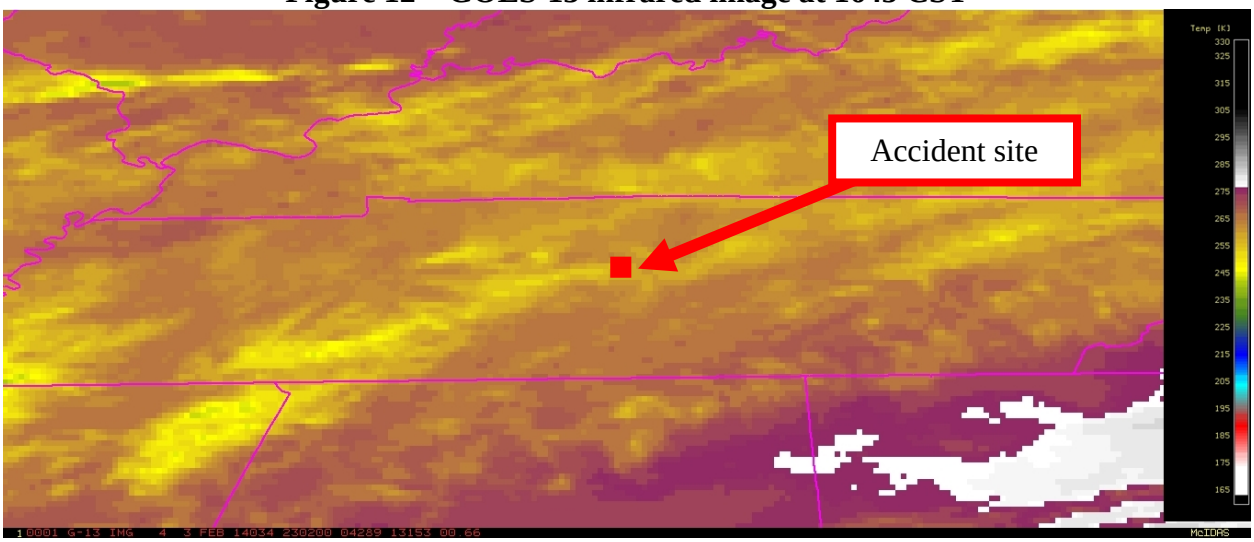


Figure 13 – GOES-13 infrared image at 1702 CST

6.0 Radar Imagery Information

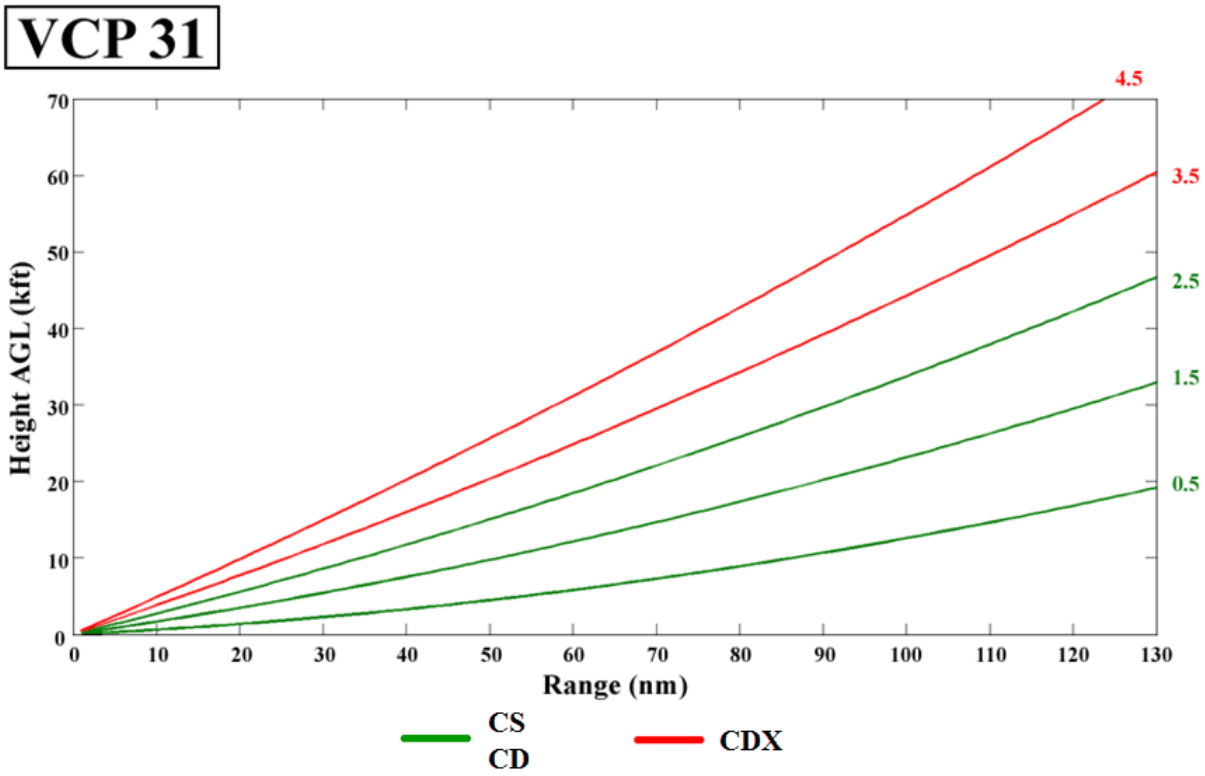
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)[14] was KOHX located 22 miles northeast of the accident site. Level II and III archive radar data was obtained from the NCDC utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

[14] The WSR-88D is an S-band 10-centimeter wavelength radar with a power output of 750,000 watts, and with a 28-foot parabolic antenna that concentrates the energy between a 0.87° and 0.96° beam width. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width.

6.1 Volume Scan Strategy

The WSR-88D is a computer-controlled radar system, which automatically creates a complete series of specific scans in a specific sequence known as a volume scan. Individual elevation scans are immediately available on the WSR-88D's Principle Users Processor (PUP). Products that require data from multiple elevation scans are not available until the end of the five to ten minute volume scan.

The WSR-88D operates in several different scanning modes, identified as Mode A and Mode B. Mode A is the precipitation scan and has two common scanning strategies. The most common is where the radar makes 9 elevation scans from 0.5° to 19.5° every six minutes. This particular scanning strategy is documented as volume coverage pattern 21 (VCP-21). Mode B is the clear-air mode, where the radar makes 5 elevation scans during a ten minute period. During the period surrounding the accident, the KOHX WSR-88D radar was operating in the clear-air mode (Mode B, VCP-31). The following chart provides an indication of the different elevation angles in this VCP, and the approximate height and width of the radar beam with distance from the radar site.



VCP-31 Clear Air Mode Scan Strategy

6.2 Beam Height Calculation

Assuming standard refraction[15] of the WSR-88D 0.95° wide radar beam, the following table shows the approximate beam height and width[16] information[17] of the radar display over the site of the accident. The heights have been rounded to the nearest 10 feet.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP	BEAM WIDTH
0.5°	2,090 feet	1,010 feet	3,180 feet	2,170 feet

Based on the radar height calculations, the 0.5° elevation scan depicted the conditions between 1,010 feet and 3,180 feet msl over the accident site and these are the closest altitudes to the accident flight level before the accident occurred.[18]

[15] Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.
[16] Beam width – A measure of the angular width of a radar beam.
[17] Beamwidth values are shown for legacy resolution products. Super resolution products would an effective beamwidth that would be approximately half these values.
[18] For more information please see the ATC factual.

6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors[19] it is a function of the drop size distribution, number of particles per unit volume, physical state (ice or water), shape, and aspect. Reflectivity is normally displayed in decibels (dBZ[20]), and is a general measure of echo intensity. The chart below relates the NWS video integrator and processor (VIP) intensity levels versus the WSR-88D's display levels, precipitation mode reflectivity in decibels, and rainfall rates.

NWS VIP/DBZ CONVERSION TABLE

NWS VIP	WSR-88D LEVEL	PREC MODE DBZ	RAINFALL
0	0	< 5	
	1	5 to 9	
	2	10 to 14	
1	3	15 to 19	.01 in/hr
Very Light	4	20 to 24	.02 in/hr
	5	25 to 29	.04 in/hr
2	6	30 to 34	.09 in/hr
Light to	7	35 to 39	.21 in/hr
Moderate			
3	8	40 to 44	.48 in/hr
Strong			
4	9	45 to 49	1.10 in/hr
Very Strong			
5	10	50 to 54	2.49 in/hr
Intense			
6	11	55 to 59	>5.67 in/hr
Extreme	12	60 to 64	
	13	65 to 69	
	14	70 to 74	
	15	> 75	

[19] Hydrometeors are any product of condensation or sublimation of atmospheric water vapor, whether formed in the free atmosphere or at the earth's surface; also, any water particles blown by the wind from the earth's surface. Hydrometeors are classified as; (a) Liquid or solid water particles suspended in the air: cloud, water droplets, mist or fog. (b) Liquid precipitation: drizzle and rain. (c) Freezing precipitation: freezing drizzle and freezing rain. (d) Solid (frozen) precipitation: ice pellets, hail, snow, snow pellets, and ice crystals. (e) Falling particles that evaporate before reaching the ground: virga. (f) Liquid or solid water particles lifted by the wind from the earth's surface: drifting snow, blowing snow, blowing spray. (g) Liquid or solid deposits on exposed objects: dew, frost, rime, and glazed ice.

[20] dBZ – A non-dimensional "unit" of radar reflectivity which represents a logarithmic power ratio (in decibels , or dB) with respect to radar reflectivity factor, Z.

The Federal Aviation Administration (FAA) Advisory Circular AC 00-24B titled "Thunderstorms" dated January 2, 1983, also defines the echo intensity levels and potential weather phenomena associated with those levels. If the maximum VIP Level is 1 "weak" and 2 "moderate", then light to moderate turbulence is possible with lightning. VIP Level 3 is "strong" and severe turbulence is possible with lightning. VIP Level 4 is "very heavy" and severe turbulence is likely with lightning. VIP Level 5 is "intense" with severe turbulence, lightning, hail likely, and organized surface wind gusts. VIP Level 6 is "extreme" with severe turbulence, lightning, large hail, extensive surface wind gusts and turbulence.

6.4 Base Reflectivity and Lightning Data

Figure 14 presents the KOHX WSR-88D base reflectivity image for the 0.5° elevation scan initiated at 1701 CST with a resolution of 0.5° X 250 m. The ATC flight track is also included in figure 14 with the arrows pointing in the direction of travel, with the accident flight coming from the left side of the image initially. There are no reflectivity echoes above the accident site. There were no lightning strikes near the accident site at the accident time.

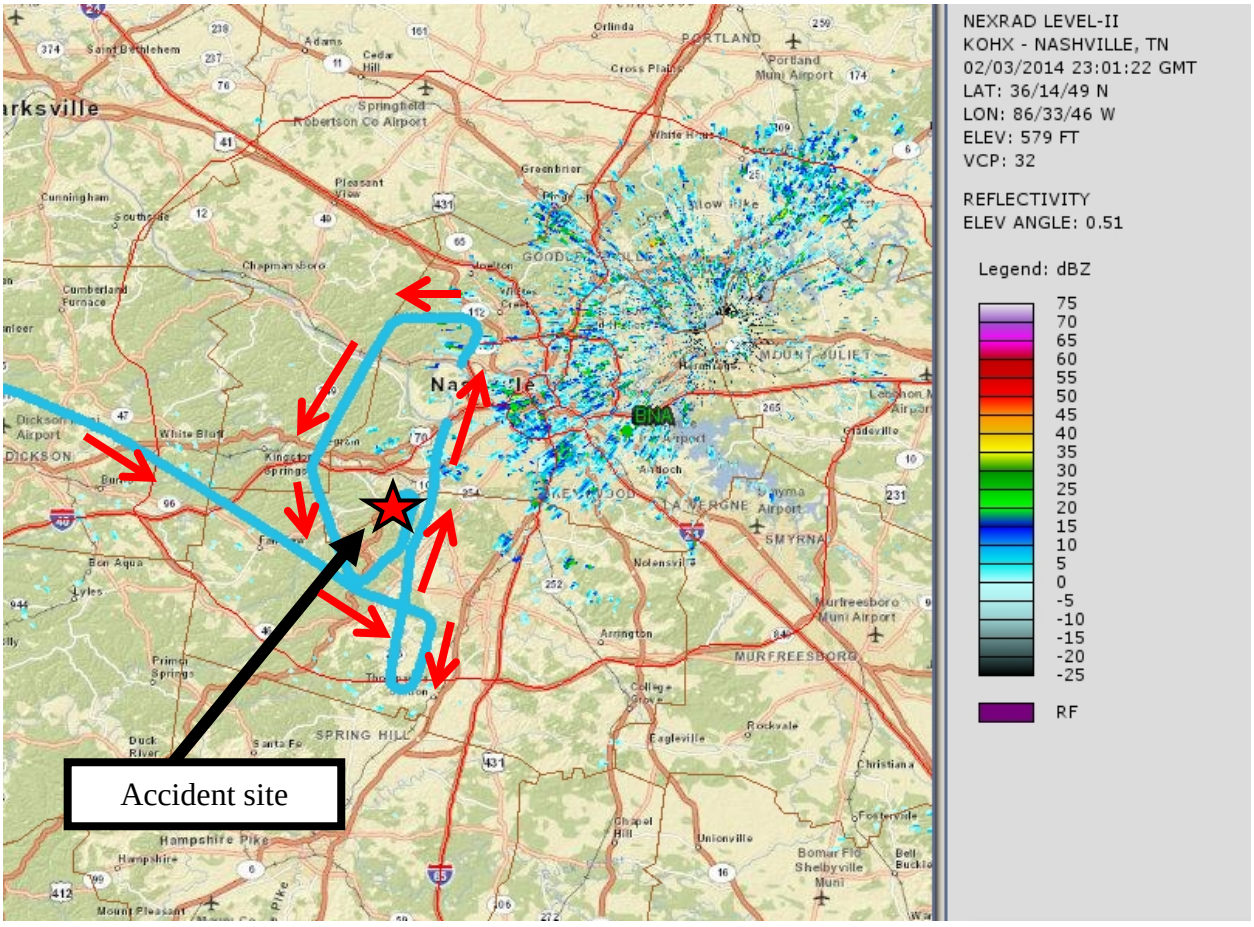


Figure 14 – KOHX WSR-88D reflectivity for the 0.5° elevation scan initiated at 1701 CST with the ATC flight track and arrows pointing in direction of travel

6.5 Terminal Weather Radar

Terminal Doppler Weather Radar (TDWR) data was retrieved for TBNA, located approximately 14 miles east-southeast of the accident site at an elevation of 817 feet. Level III archive radar data was obtained from the NCDC utilizing the Hierarchical Data Storage System (HDSS) and displayed using the NOAA's Weather and Climate Toolkit software.

The TDWR is a 5-centimeter wavelength radar that concentrates the energy into a 0.55° beam width.

Assuming standard refraction of the TDWR 0.55° wide radar beam, the following table shows the approximate beam height and width information of the radar display over the site of the accident. The heights have been rounded to the nearest 10 feet.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP	BEAM WIDTH
TBNA 0.6°	1,850 feet	1,440 feet	2,260 feet	820 feet

Based on the radar height calculations, the TBNA 0.6° elevation scan depicted the conditions between 1,440 and 2,260 feet msl over the accident site and these are the closest altitudes to the accident flight level before the accident occurred.[21]

Figures 15, 16, 17, 18, and 19 present the TBNA TDWR reflectivity data for the 0.6° elevation scans initiated at 1645, 1651, 1657, 1703, 1708 CST. The TDWR indicated very light reflectivity targets to the east of the accident flight path moving southwestward with time. The very light reflectivity targets move towards and across the southern portion of the accident flight track between 1600 and 1800 CST. More discussion on these reflectivities will be addressed in the witness interview section (Section 16.0).

[21] For more information please see the ATC factual.

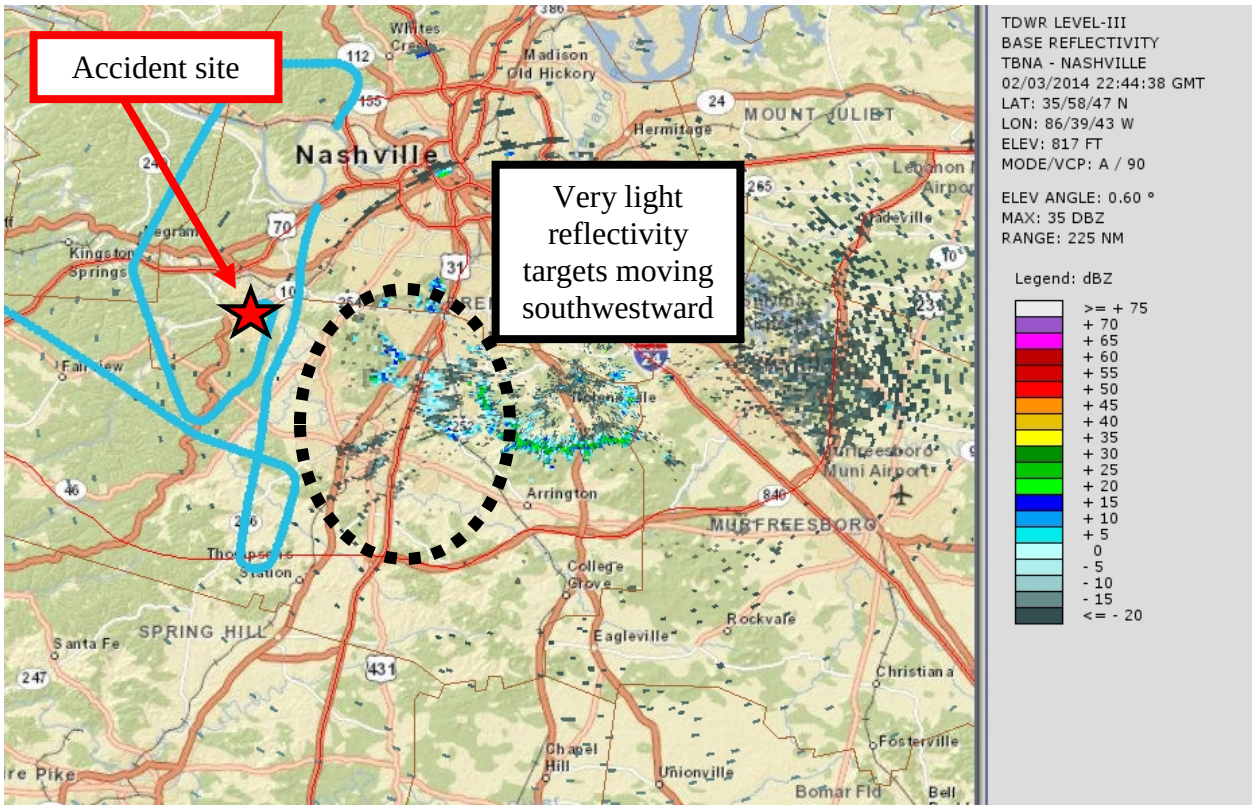


Figure 15 – TBNA TDWR reflectivity for the 0.6° elevation scan initiated at 1645 CST with the ATC flight track

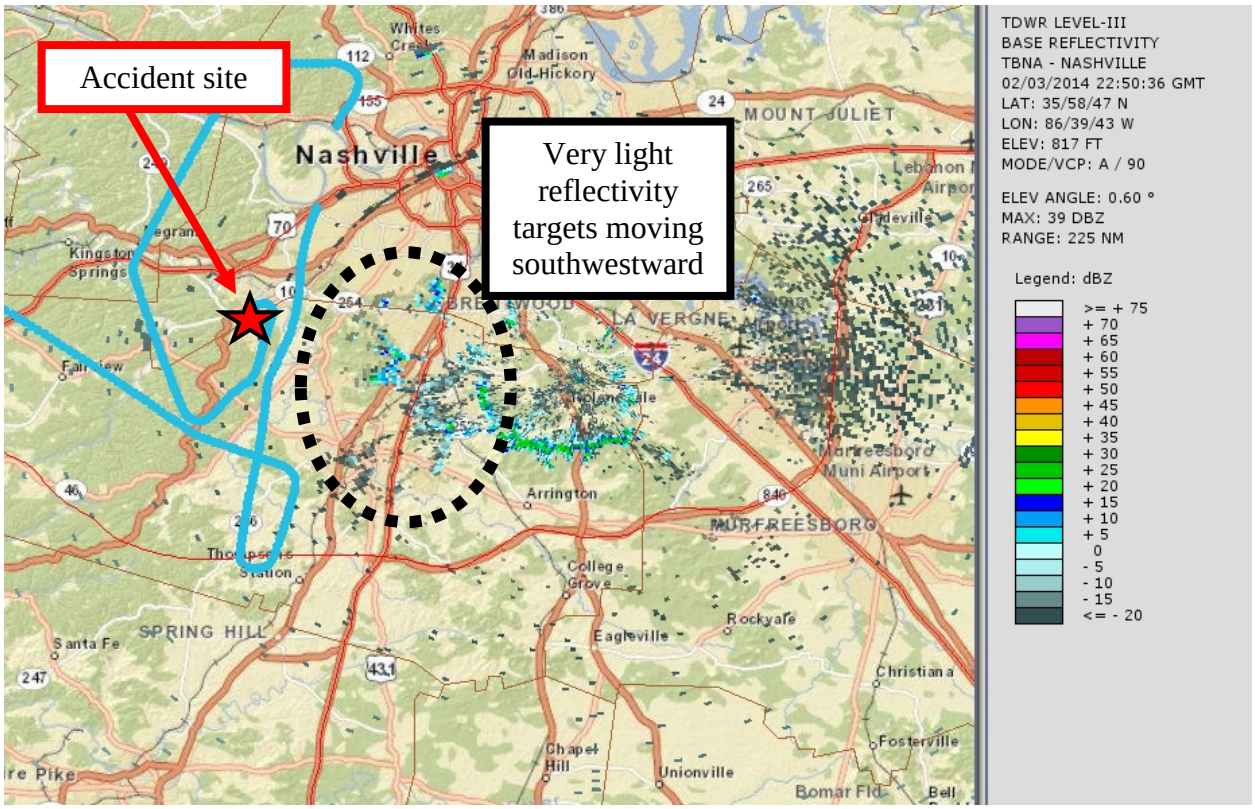


Figure 16 – TBNA TDWR reflectivity for the 0.6° elevation scan initiated at 1651 CST with the ATC flight track

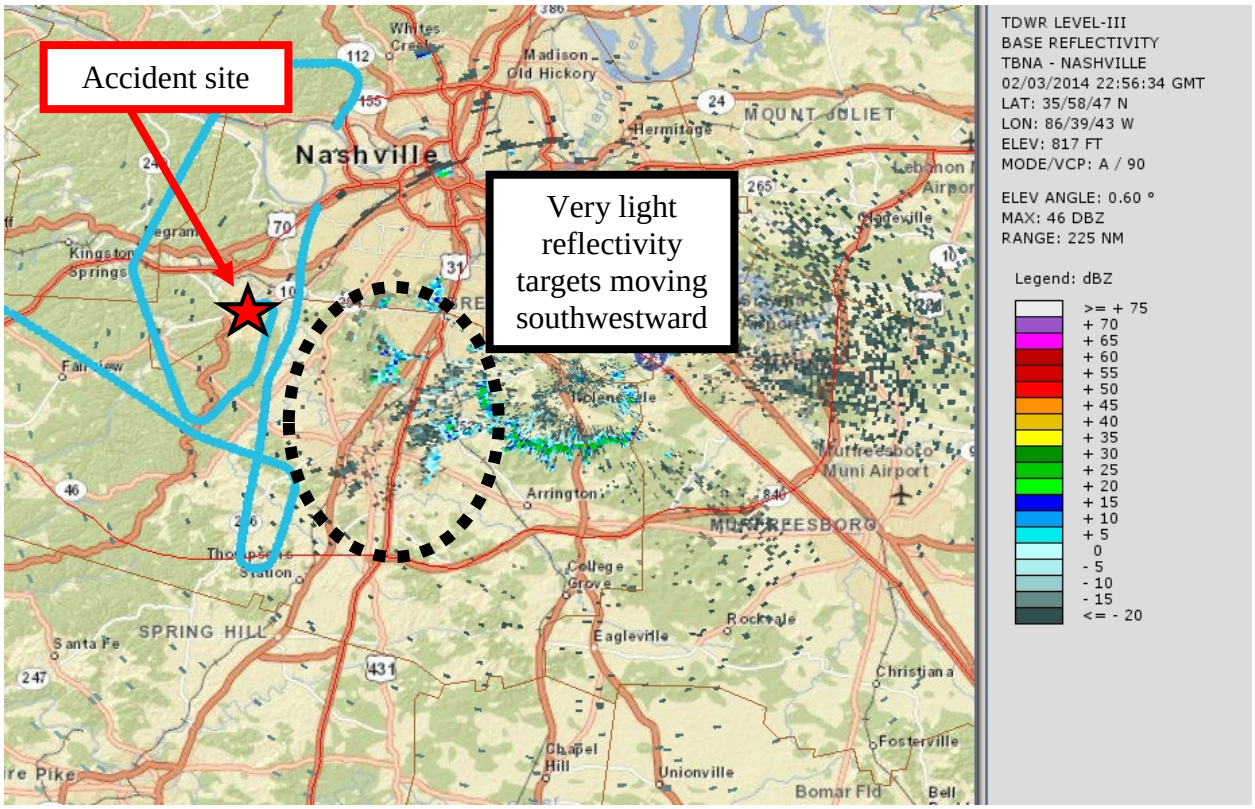


Figure 17 – TBNA TDWR reflectivity for the 0.6° elevation scan initiated at 1657 CST with the ATC flight track

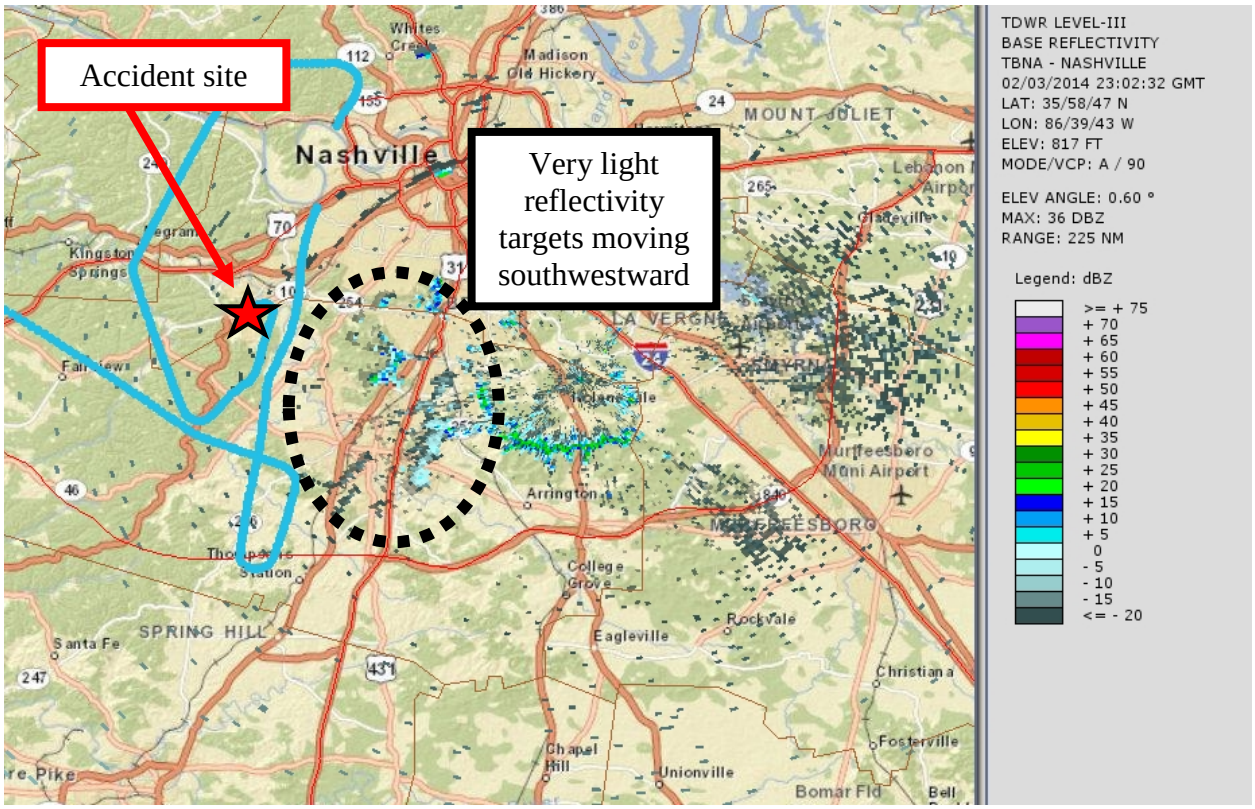


Figure 18 – TBNA TDWR reflectivity for the 0.6° elevation scan initiated at 1703 CST with the ATC flight track

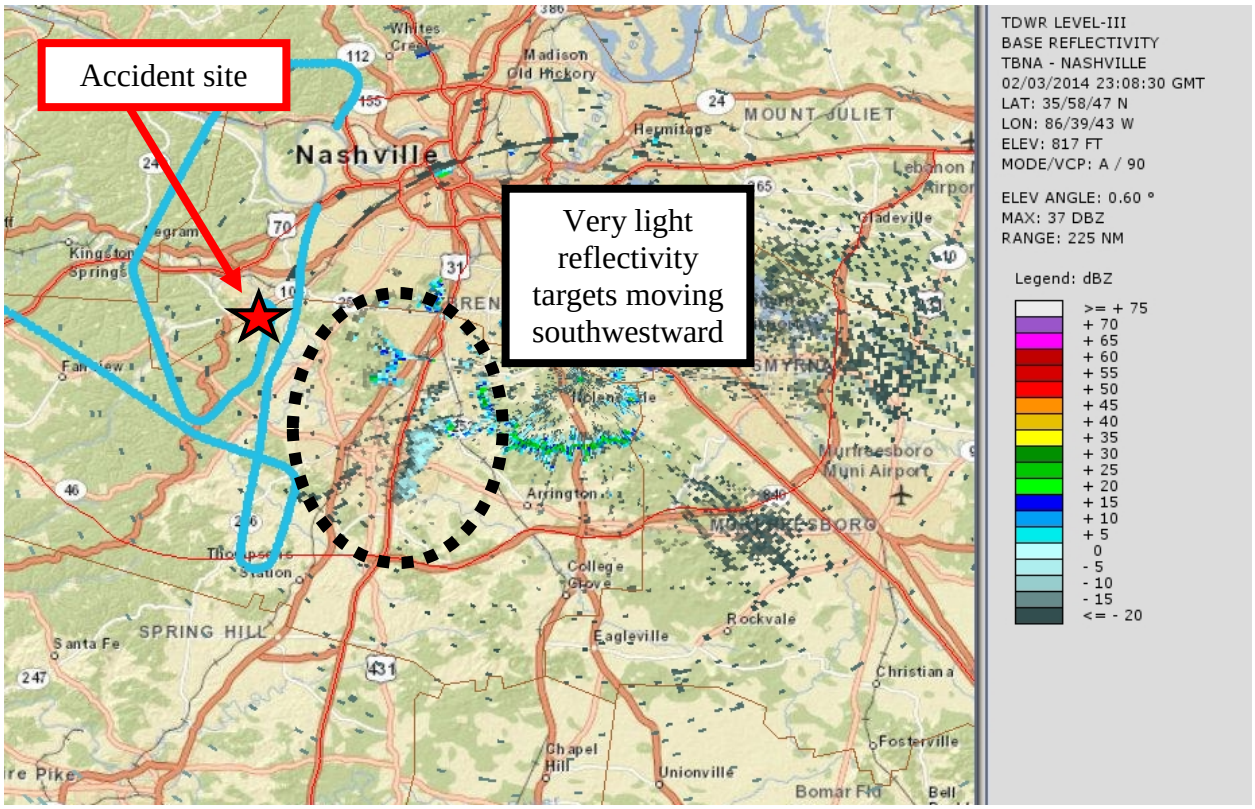


Figure 19 – TBNA TDWR reflectivity for the 0.6° elevation scan initiated at 1708 CST with the ATC flight track

6.6 Dual-Polarization Weather Radar Data

The closest NWS WSR-88D with dual-pol technology was KOHX. Level II and III archive radar data was obtained from the NCDC utilizing the Hierarchical Data Storage System (HDSS) and displayed using the NWS NEXRAD Interactive Viewer and Data Exporter software. Unfortunately, the reflectivity values around the accident site were too weak to display any discernable dual-pol data.

7.0 Pilot Reports

All pilot reports (PIREPs) were reviewed close to the accident site from around three hours prior to the accident time to around three hours after the accident time and are displayed below:

MQY UA /OV MBT /TM 2036 /FL030 /TP BE40 /TA M04 /IC LGT RIME=

MQY UA /OV MQY /TM 2030 /FL013 /TP C182 /SK OVC013-TOP035 /TA UNKN
/IC LGT-MOD MX 020-035=

BNA UA /OV BNA/TM 2100/FL020/TP BE40/IC LGT RIME 020-030/RM ZME=

MQY UA /OV BNA090010 /TM 2116 /FL025 /TP CRJ7 /TA M06 /IC LGT RIME
025-030 /RM TA M07 030=

MKL UA /OV MKL/TM 2218/FLUNKN/TP CL30/SK OVCUNKN-TOP025/RM DURGC
HIGH THIN CLOUDS ABV AWC-WEB:FCTMKL=

MKL UA /OV MKL/TM 2238/FLUNKN/TP PA31/SK OVC009-TOP026/TA M03/IC
LGT RIME BLO 026/RM DURGD GPS 02 AWC-WEB:FCTMKL=

MKL UA /OV MKL/TM 2240/FLUNKN/TP BE30/SK OVC/TA M01/IC TRACE RIME
022/RM DURGD ILS 02 JUST HAIR OF MIXED ICG AWC-WEB:FCTMKL=

BNA UA /OV BNA180005 /TM 2258 /FL025 /TP B737 /TA M02 /IC MOD RIME=

MKL UA /OV MKL/TM 0004/FLUNKN/TP C208/SK OVC010-TOP035/RM DURGD
GPS RWY 02 AWC-WEB:FCTMKL=

BNA UA /OV BNA225010 /TM 0035 /FL030 /TP E135 /SK OVC-TOP033 /TA
M06 /IC LGT RIME /RM DURD=

MEM UA /OV MEM045008 /TM 0108 /FL020 /TP C208 /SK OVC005-TOP025
/TA 00 /WV 05010KT /TB NEG /IC MOD CLR=

MKL UA /OV MKL /TM 0127 /FL025 /TP AC90 /SK OVCUNKN-TOP024 /TA
UNKN /IC LGT RIME /RM DURD PICKED UP ICE DOWN TO MINIMUMS=

Routine pilot report (UA); Over Murfreesboro, Tennessee; Time – 1436 CST (2036Z); Altitude – 3,000 feet; Type aircraft – Beech 400 Beechjet; Temperature – 4° C; Icing – Light rime.

Routine pilot report (UA); Over Smyrna, Tennessee; Time – 1430 CST (2030Z); Altitude – 1,300 feet; Type aircraft – Cessna 182; Sky – Overcast at 1,300 feet with tops to 3,500 feet; Temperature – Unknown; Icing – Light to moderate mixed between 2,000 and 3,500 feet.

Routine pilot report (UA); Over Nashville, Tennessee; Time – 1500 CST (2100Z); Altitude – 2,000 feet; Type aircraft – Beech 400 Beechjet; Icing – Light rime between 2,000 and 3,000 feet.

Routine pilot report (UA); 10 miles from Nashville, Tennessee, on the 090° radial; Time – 1516 CST (2116Z); Altitude – 2,500 feet; Type aircraft – Canadair Regional Jet CRJ-700; Temperature – -6° C; Icing – Light rime between 2,500 and 3,000 feet; Remarks – Temperature -7° C at 3,000 feet.

Routine pilot report (UA); Over Jackson, Tennessee; Time – 1618 CST (2218Z); Altitude – Unknown; Type aircraft – Bombardier Challenger 300; Sky – Overcast unknown tops to 2,500 feet; Remarks – During climb high thin clouds above.

Routine pilot report (UA); Over Jackson, Tennessee; Time – 1638 CST (2238Z); Altitude – Unknown; Type aircraft – Piper PA-31 Navajo; Sky – Overcast at 900 feet with tops at 2,600 feet; Temperature – -3° C; Icing – Light rime below 2,600 feet; Remarks – During GPS descent to runway 02.

Routine pilot report (UA); Over Jackson, Tennessee; Time – 1640 CST (2240Z); Altitude – Unknown; Type aircraft – Beechcraft Super King Air 300; Sky – Overcast; Temperature – -1° C; Icing – Trace rime at 2,200 feet; Remarks – During ILS descent to runway 02 just a hair of mixed icing.

Routine pilot report (UA); 5 miles from Nashville, Tennessee, on the 180° radial; Time – 1658 CST (2258Z); Altitude – 2,500 feet; Type aircraft – Boeing B737; Temperature – -2° C; Icing – Moderate rime.

Routine pilot report (UA); Over Jackson, Tennessee; Time – 1804 CST (0004Z); Altitude – Unknown; Type aircraft – Cessna 208; Sky – Overcast 1,000 feet with tops to 3,500 feet; Remarks – During GPS descent into runway 02.

Routine pilot report (UA); 10 miles from Nashville, Tennessee, on the 225° radial; Time – 1835 CST (0035Z); Altitude – 3,000 feet; Type aircraft – Embraer ERJ-135; Sky – Overcast with tops to 3,300 feet; Temperature – -6° C; Icing – Light rime; Remarks – During descent.

Routine pilot report (UA); 8 miles from Memphis, Tennessee, on the 045° radial; Time – 1908 CST (0108Z); Altitude – 2,000 feet; Type aircraft – Cessna 208; Sky – Overcast at 500 feet with tops to 2,500 feet; Temperature – 0° C; Wind – 050° at 10 knots; Turbulence – Negative; Icing – Moderate clear.

Routine pilot report (UA); Over Jackson, Tennessee; Time – 1927 CST (0127Z); Altitude – 2,500 feet; Type aircraft – Rockwell Turbo Commander 690; Sky – Overcast unknown with tops at 2,400; Temperature – Unknown; Icing – Light rime; Remarks – During descent picked up ice down to minimums.

In addition there were two PIREPs provided to the TRACON in Nashville that were not distributed publically. These two PIREPs were reported and written down on the PIREP forms. Information from these PIREPs is provided below as well as in attachment 1:

Routine pilot report (UA); 85 miles from Nashville, Tennessee; Time – 1540 CST (2140Z); Altitude – 3,000 feet; Type aircraft – Embraer ERJ-145; Sky – Overcast; Temperature – -6° C; Icing – Light clear.

Routine pilot report (UA); 5 miles west of Smyrna, Tennessee; Time – 1840 CST (0040Z); Altitude – 3,000 feet; Type aircraft – Raytheon Hawker 800; Temperature – -3° C; Icing – Light rime.

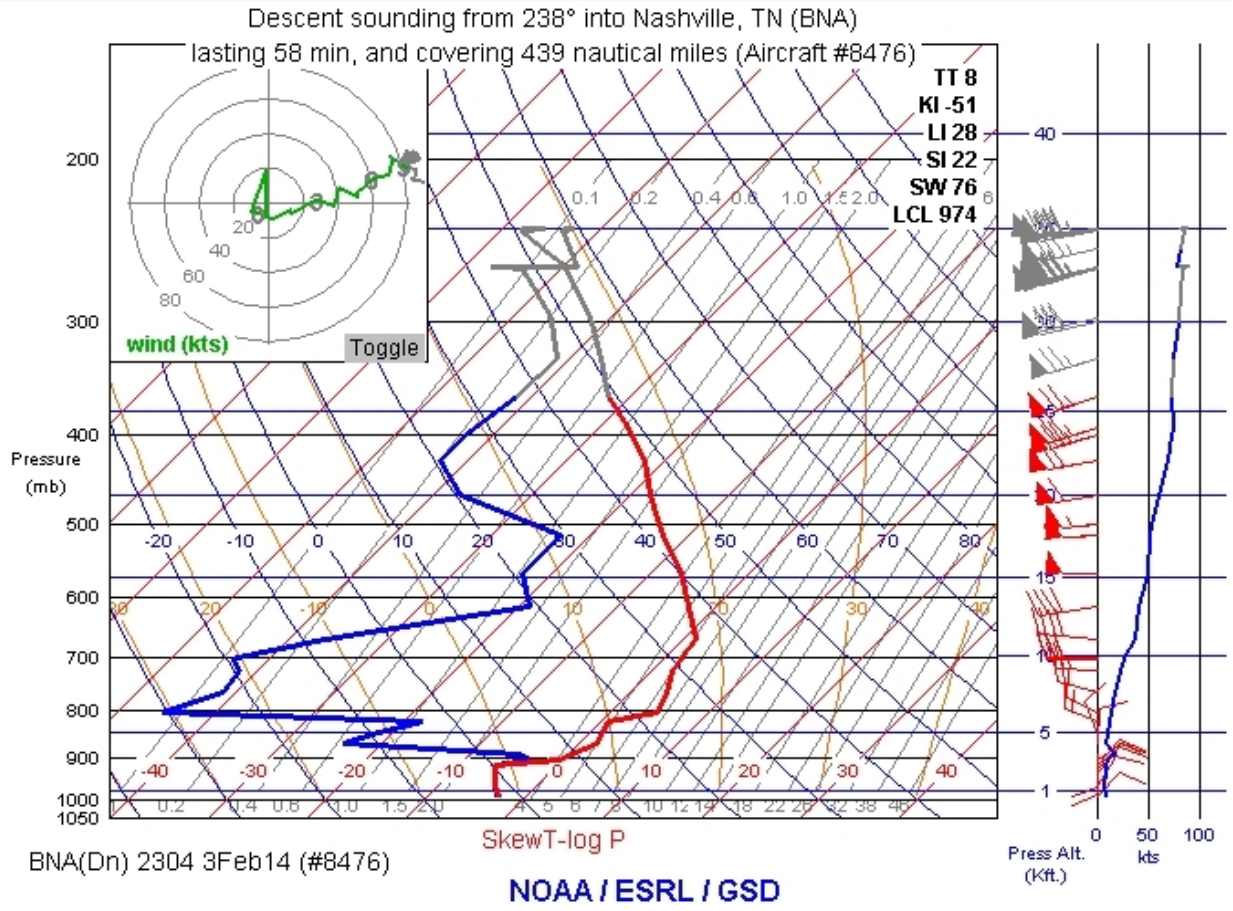
During interviews[22] with Nashville TRACON they stated that once receiving a PIREP, the standard procedure is for the supervisor to call Lockheed Martin Flight Service (LMFS) for LMFS to distribute the PIREP publically and into the NAS. However, during the interviews Nashville TRACON personnel stated that between 20 to 30% of the time LMFS does not answer the phone or is unavailable when calling in to report a PIREP. Attachment 2 discusses LMFS PIREP procedures. In addition, Nashville TRACON personnel stated that when receiving an icing report in one sector they did not believe that that pilot report would be valid in an adjacent sector and therefore would not necessarily pass the PIREP internally. [23]

When reviewing the Nashville TRACON ATC recordings around the time of the accident there were an additional 13 PIREPs that were mentioned by pilots, but none of these PIREPs were written down (like on attachment 1) and only one was distributed publically into the NAS.[24] Dates and times of these additional 13 PIREPs are provided in attachment 3.

8.0 AMDAR Data

An aircraft that provided Aircraft Meteorological Data Reports (AMDAR) identified as aircraft #8476[25] descended into KBNA at 1704 CST (2304Z) approximately 7 minutes after the accident time and retrieved meteorological data on its descent (table 1):

[22] For more information please see ATC Factual and ATC Interview notes and summaries.
[23] For more information please see ATC Factual and ATC Interview notes and summaries.
[24] For more information please see ATC Factual and ATC Interview notes and summaries.
[25] Aircraft #8476 – The aircraft number was determined by the AMDAR data display from the Earth System Research Laboratory's Global Systems Division (ESRL/GSD).



P_alt[26] (ft)	hPa	t/td[27] (°C)	w_dir/w_spd[28] (kts)	Time (UTC)	Bng/Rng[29] (nm)
660	**989**	**-2.8/-3.10**	**45°/010**	**2304**	**216°/012**
1420	**962**	**-4.3/-4.30**	**35°/008**	**2303**	**215°/014**
2210	**935**	**-5.5/-5.50**	**41°/009**	**2302**	**211°/016**
2500	**925**	**-6.0/-6.00**	**42°/009**		
2700	**918**	**-6.3/-6.30**	**43°/009**	**2301**	**210°/018**
3050	906	-0.3/-3.20	58°/011	2300	209°/020
3490	892	0.3/-5.10	180°/018	2259	208°/023
4280	866	1.8/-23.9	6°/009	2258	216°/025

Table 1 – AMDAR meteorological data on a flight descending into KBNA 7 minutes after the accident time

[26] P_alt – Pressure altitude is the indicated altitude when an altimeter is set to an agreed baseline pressure setting. The baseline pressure setting is 1013.25 hPa or 29.92 inches of mercury

[27] t/td – Air temperature and dew point temperature in degrees Celsius.

[28] w_dir/w_spd – Wind direction (reference to true north) and wind speed in knots.

[29] Bng/Rng – The angle and distance from the start point. In this case the start point was KSFO.

At 1704 CST and with a pressure altitude of 660 feet, the pressure was 989 hPa, the air temperature was -2.8° C, the dew point temperature was -3.10° C, and the wind was from 045° at 10 knots.

At 1703 CST and with a pressure altitude of 1,420 feet, the pressure was 962 hPa, the air temperature was -4.3° C, the dew point temperature was -4.30° C, and the wind was from 035° at 8 knots.

At 1702 CST and with a pressure altitude of 2,210 feet, the pressure was 935 hPa, the air temperature was -5.5° C, the dew point temperature was -5.50° C, and the wind was from 041° at 9 knots.

At time unknown and with a pressure altitude of 2,500 feet, the pressure was 925 hPa, the air temperature was -6.0° C, the dew point temperature was -6.00° C, and the wind was from 042° at 9 knots.

At 1701 CST and with a pressure altitude of 2,700 feet, the pressure was 918 hPa, the air temperature was -6.3° C, the dew point temperature was -6.30° C, and the wind was from 043° at 9 knots.

9.0 SIGMET and CWSU Advisory

No SIGMET was valid for the accident site at the accident time.

No Center Weather Service Unit (CWSU) Advisory (CWA) was valid for the accident site at the accident time.

There was a Meteorological Impact Statement (MIS) issued at 1455 CST valid for the accident site at the accident time. The MIS discussed the widespread low ceilings and visibilities with most ceilings ranging from 600 to 1,000 feet:

FAUS20 KZME 032055
ZME MIS 01 VALID 032055-040300
...FOR ATC PLANNING PURPOSES ONLY...
OVER ZME E OF A LINE FROM FAM-MLU
WDSPRD IFR CIGS/PATCHY IFR VIS EXPD TO CONT BYD END OF PD. MOST CIGS RANGING FM 006-010. SEE AIRMETS/CWAS FOR ADNL INFO.
=

10.0 AIRMETs

AIRMET Sierra issued at 1445 CST, and valid at the accident time, forecasted IFR conditions for the accident site with ceilings below 1,000 feet and visibilities below 3 miles with mist:

WAUS44 KKCI 032045
WA4S
_DFWS WA 032045

AIRMET SIERRA UPDT 4 FOR IFR AND MTN OBSCN VALID UNTIL 040300
.
AIRMET IFR...OK TX AR LA MS AL AND CSTL WTRS
FROM 20SW TUL TO ADM TO 40ENE MLU TO 20ESE AEX TO 90SSE SJI TO
170S CEW TO 130SE LEV TO 120SSW LCH TO 80E BRO TO 20NNW BRO TO
60SE ACT TO INK TO 20NW TXO TO 20SW TUL
CIG BLW 010/VIS BLW 3SM BR. CONDS CONTG BYD 03Z ENDG 03-06Z.
.
AIRMET IFR...AR TN LA MS AL MO IL IN KY
FROM CVG TO HNN TO HMV TO 40WNW GQO TO 20WNW CEW TO 30NNE BTR TO
40ENE MLU TO 50SW ARG TO CVG
CIG BLW 010/VIS BLW 3SM BR. CONDS CONTG BYD 03Z THRU 09Z.
.
AIRMET MTN OBSCN...TN KY
FROM HNN TO HMV TO GQO TO LOZ TO HNN
MTNS OBSC BY CLDS. CONDS CONTG BYD 03Z THRU 09Z.
.
OTLK VALID 0300-0900Z
AREA 1...IFR AR TN LA MS AL MO IL IN KY
BOUNDED BY 40E IND-CVG-HNN-HMV-GQO-20NNE LGC-30E SJI-20SSW AEX-
50NNE TXK-50NNW LIT-40W ARG-40E IND
CIG BLW 010/VIS BLW 3SM BR. CONDS CONTG THRU 09Z.
.
AREA 2...IFR OK TX AR LA MS AL AND CSTL WTRS
BOUNDED BY 40SE ICT-60WSW LFK-20S AEX-20E SJI-150ESE LEV-120SSW
LCH-80E BRO-BRO-60SSE LRD-40W JCT-20N INK-30ESE TBE-30WNW LBL-
40SE ICT
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS DVLPG 03-06Z. CONDS CONTG
THRU 09Z.
....
WAUS44 KKCI 032045
WA4T
_DFWT WA 032045
AIRMET TANGO UPDT 3 FOR TURB VALID UNTIL 040300
.
AIRMET TURB...OK TX SD NE KS MN IA MO WI LM LS MI LH IL IN KY
FROM 20NNE SSM TO YVV TO DXO TO FWA TO CVG TO 50W AXC TO 30S MMB
TO 30E TCC TO 30ESE TBE TO 50W LBL TO 50W LBF TO 50SSW BFF TO
60S FAR TO 20NNE SSM
MOD TURB BTN FL180 AND FL360. CONDS CONTG BYD 03Z THRU 09Z.
.
OTLK VALID 0300-0900Z...TURB OK TX SD NE KS MN IA MO WI LM LS MI
LH IL IN
BOUNDED BY 20NNE SSM-YVV-30ESE ECK-FWA-20E IOW-40E CDS-30N INK-
30ESE TBE-50W LBL-40ESE SNY-40ESE CYS-60E ABR-20NNE SSM
MOD TURB BTN FL180 AND FL380. CONDS CONTG THRU 09Z.
....
WAUS44 KKCI 032045
WA4Z
_DFWZ WA 032045
AIRMET ZULU UPDT 3 FOR ICE AND FRZLVL VALID UNTIL 040300
.
NO SGFNT ICE EXP OUTSIDE OF CNVTV ACT.
.
OTLK VALID 0300-0900Z...ICE OK TX AR NE KS IA MO IL
BOUNDED BY 20ENE DSM-30SE STL-30W ELD-70WSW LBB-30ESE TBE-50W

LBL-50E AKO-20ENE DSM
MOD ICE BTN FRZLVL AND FL190. FRZLVL SFC-050. CONDS DVLPG 03-06Z.
CONDS CONTG THRU 09Z.
.
FRZLVL...RANGING FROM SFC-155 ACRS AREA
  MULT FRZLVL BLW 120 BOUNDED BY CVG-HNN-HMV-SQS-20SSE ELD-40NE
    TXK-50WSW TTT-30NE MAF-40NNE INK-20E TCC-GCK-40WNW ICT-40S
    ICT-40SSE BUM-20S FAM-CVG
  SFC ALG 40SE TBE-60WSW LBL-50N AMA-40E TXO-30NE LBB-40SSW TUL-
    40W HMV
  040 ALG 60W LBL-50WSW LBL-40SSW AMA-50SSW CDS-30SSW FSM-40SSW
    LIT-40S LOZ
  080 ALG 50N INK-30ENE MAF-20S ABI-30NW TXK-ELD-50WSW SQS-
    30SSW VXV
  120 ALG 90S MRF-70SW SJT-50SW ACT-60WSW GGG-30W MHZ-20NNW VUZ-
    40S GQO
....

11.0 Area Forecast

The Area Forecast issued at 1345 CST, valid at the accident time, forecasted a broken ceiling at 1,500 feet msl with tops to 3,000 feet:

FAUS44 KKCI 031945
FA4W
_DFWC FA 031945
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 041400
CLDS/WX VALID UNTIL 040800...OTLK VALID 040800-041400
OK TX AR TN LA MS AL
.
SEE AIRMET SIERRA FOR IFR CONDS AND MTN OBSCN.
TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR CONDS.
NON MSL HGTS DENOTED BY AGL OR CIG.
.
SYNOPSIS...CDFNT NERN MN TO SERN ND. HI PRES ELSW. 06Z CDFNT ERN
UP MI-NERN IA-SERN NE-SWRN KS. WRMFNT AL CSTL WTRS TO EXTRM SRN
TX. 14Z CDFNT NRN LH-SWRN IA-SWRN KS. WRMFNT EXTRM SRN MS-SERN
LA-SRN TX
.
OK
PNHDL...OVC050 TOP 080. 06Z OVC040-050 TOP FL200. OTLK...IFR CIG
SN BR.
WRN...BKN040 TOP 060. 06Z OVC030 TOP 100. VIS 3-5SM -FZRA/-SN BR.
OTLK...IFR CIG SN BR.
E...SCT CI. 23Z BKN CI. BECMG 0507 OVC080 TOP FL240. OTLK...VFR
BECMG 0911 IFR CIG SN BR.
.
NWRN TX
PNHDL...BKN045-055 TOP 060. WND S G25KT. 02Z OVC040-045.
OTLK...IFR CIG 09Z SN.
RMNDR...BKN030-040 TOP 070. 05Z VIS 3-5SM -FZDZSN BR. OTLK...IFR
CIG SN BR.
.
SWRN TX

MTNS WWD...OVC060 TOP 080. 05Z BKN CI. OTLK...VFR.
RMNDR...
W PECOS...OVC040 TOP 060. 07Z SCT050. OTLK...VFR.
E PECOS...OVC030 TOP 050. 06Z OVC BKN040. OTLK...MVFR CIG.
.
N CNTRL TX
N HLF...BKN020-030 TOP 050. 05Z OVC015-025 TOP 100. VIS 3-5SM -RA
BR. OTLK...IFR CIG RA BR.
S HLF...OVC015-025 TOP 050. 05Z VIS 3-5SM -RA BR. OTLK...IFR CIG
RA BR.
.
NERN TX
N HLF...SCT020. OTLK...VFR 09Z MVFR CIG BECMG 1113 IFR CIG RA BR.
S HLF...BKN015 TOP 030. 06Z BKN020 TOP 100. OTLK...MVFR CIG BECMG
1113 IFR CIG RA BR.
.
SERN TX
BKN015 TOP 030. OTLK...MVFR CIG 11Z IFR CI.
.
S CNTRL TX
HILL COUNTRY...BKN030 TOP 040. BECMG 0305 OVC030. OTLK...MVFR CIG
09Z IFR CIG.
CSTL PLAIN-LWR RIO GRANDE VLY...BKN020 TOP 060. BECMG 0002
OVC010. VIS 3-5SM -RA BR. OTLK...IFR CIG RA BR.
RMNDR...
W HLF...BKN020 TOP 040. 05Z OVC020. OTLK...MVFR CIG 09Z IFR CIG.
E HLF...BKN030 TOP 060. 03Z OVC020 TOP 080. VIS 3-5SM -DZ BR.
OTLK...MVFR CIG RA DZ BR 10Z IFR CIG RA BR.
.
AR
NW...SCT CI. 07Z OVC100 TOP FL240. OTLK...VFR 09Z MVFR CIG.
NERN-SW...SCT CI. 06Z BKN020 TOP 040. OTLK...MVFR CIG 09Z IFR CIG
FZRA BR.
SE...BKN030 TOP 040. OTLK...MVFR CIG 09Z IFR CIG.
.
LA
WRN...BKN010 TOP 030. 23Z SCT020. 07Z OVC010 TOP 100. OTLK...IFR
CIG 12Z RA.
NERN...BKN020 TOP 030. OTLK...VFR 09Z IFR CIG.
SE...BKN020 TOP 040. BECMG 0406 OVC010 TOP 100. OTLK...IFR CIG
12Z RA.
.
TN
W...BKN015 TOP 020. OTLK..IFR CIG.
MID...BKN015 TOP 030. 03Z BKN CI. OTLK...VFR.
E...BKN035 TOP 050. 03Z SCT030 SCT CI. OTLK...VFR.
.
MS
N HLF...BKN010 TOP 030. 03Z BKN015. OTLK...MVFR CIG 10Z IFR CIG.
S HLF...BKN010 TOP 030. 06Z BKN-OVC010 TOP 030. OTLK...IFR CIG
12Z DZ.
.
AL
N HLF...BKN015 TOP 030. OTLK...MVFR CIG.
S HLF...BKN010 TOP 040. 23Z BKN015. BECMG 0507 OVC010 TOP 070.
OTLK...IFR CIG.

....

12.0 Terminal Aerodrome Forecast

KBNA was the closest site with a NWS TAF. The TAF valid at the time of the accident was issued at 1600 CST and was valid for a 20-hour period beginning at 1600 CST. The TAF forecast for KBNA was as follows:

TAF AMD KBNA 032200Z 0322/0418 **04007KT 5SM BR OVC009**
FM040200 03006KT P6SM SCT015 BKN250=

The forecast expected a wind from 040° at 7 knots, 5 miles visibility, mist, and an overcast ceiling at 900 feet agl around the time of the accident.

13.0 National Weather Service Area Forecast Discussion

The National Weather Service Office in Nashville, Tennessee, issued an Area Forecast Discussion (AFD) at 1549 CST, but the latest AFD which mentioned the aviation forecast was issued at 1150 CST. The aviation section of the AFD at 1150 CST mentioned the clouds being slow to erode with light fog and low ceilings. Both AFDs are below:

FXUS64 KOHX 032149
AFDOHX
AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE NASHVILLE TN
349 PM CST MON FEB 3 2014
.SHORT TERM...IT WAS CLOUDY AND COLD ACROSS THE MID STATE THIS AFTERNOON
AS NORTHERLY SURFACE FLOW KEPT TEMPERATURES PARKED IN THE UPPER
20S TO LOWER 30S OVER MOST OF THE AREA.
EXPECT SOME PARTIAL CLEARING TO COMMENCE OVERNIGHT IN WESTERN
AREAS, HOWEVER MID AND HIGH CLOUDS WILL BE QUICK TO THICKEN AGAIN
AHEAD OF NEXT SHORTWAVE, AS IT PUSHES INTO WEST TEXAS BY 12Z TOMORROW.
A BAND OF RAIN, SOME LOCALLY HEAVY, DEVELOPS NORTHEASTWARD INTO
WESTERN PARTS OF OUR AREA (INCLUDING BENTON COUNTY) BY LATE
TUESDAY AFTERNOON. THIS BAND OF HEAVIEST RAIN PUSHES EASTWARD TO
THE CUMBERLAND PLATEAU TUESDAY NIGHT.
WOULDN'T BE SURPRISED TO HEAR A FEW RUMBLES OF THUNDER TUESDAY
AFTERNOON AND TUESDAY NIGHT DUE TO ISOLATED ELEVATED CONVECTION.
HOWEVER, TEMPS AND DEW POINTS ARE EXPECTED TO REMAIN SUFFICIENTLY
LOW TO NEGATE UPPER LEVEL DYNAMICS OF THIS SYSTEM FROM BEING
REALIZED AT THE SURFACE. WOULDN'T BE SURPRISED TO, PERHAPS, SEE
SOME GUSTY WINDS WITH ANY THUNDERSTORMS THAT MIGHT DEVELOP, BUT
HEAVY DOWNPOURS AND LOCALIZED PONDING WILL BE THE MAIN THING TO
WATCH FOR WITH TUESDAY'S AND TUESDAY NIGHT'S WEATHER.
AS SURFACE TEMPS COOL TO THE FREEZING MARK LATE TUESDAY NIGHT AND
EARLY WEDNESDAY, THERE WILL BE A CHANCE FOR DRIZZLE OR FREEZING
DRIZZLE TO DEVELOP OVER THE NORTHWEST AND ALONG THE HIGHLAND RIM.
AFTER THAT, HOWEVER, THINGS DRY OUT FOR WEDNESDAY AFTERNOON THROUGH
THURSDAY, BEFORE OUR NEXT STORM SYSTEM STARTS TO SWING IN FROM THE
SOUTHWEST.
.LONG TERM...LIGHT RAIN COULD DEVELOP OVER SOUTHERN PARTS OF THE
MID STATE AS EARLY AS FRIDAY, WITH AN INVERTED SURFACE TROUGH AXIS

SETTING UP ACROSS THE MID STATE FRIDAY NIGHT THROUGH SATURDAY AND PRODUCING A SEPARATION BETWEEN RAIN OVER SOUTHERN AND EASTERN AREAS AND SOME POSSIBLE EPISODES OF FREEZING RAIN OVER WESTERN AND NORTHERN AREAS. THE ECMF CONTINUES TO PAINT A MORE SOUTHERN TRACK FOR THE LOW PRESSURE AREA, WHILE THE GFS BRINGS A LOW NORTHEASTWARD FROM THE GULF COASTAL AREA UP ACROSS EASTERN MIDDLE TENNESSEE SATURDAY NIGHT AND SUNDAY. NEEDLESS TO SAY, THE TRACK OF THIS LOW AND THE DEGREE OF COLD AIR THAT COMES IN BEHIND IT WILL HAVE A SIGNIFICANT EFFECT ON NEXT WEEKEND'S FORECAST. FOR RIGHT NOW, IT LOOKS LIKE AT LEAST THE POSSIBILITY FOR SOME FREEZING RAIN AT SOME POINT, AND A CHANCE FOR SNOW AS THE LOW PULLS EAST OF OUR AREA NEXT SUNDAY AND SUNDAY NIGHT.
LOOKS LIKE SOME PRETTY COLD WEATHER FOR AT LEAST THE NORTHWESTERN HALF OF THE MID STATE NEXT WEEKEND, WITH HIGHS EACH DAY ONLY IN THE 30S. OF COURSE, THAT'S ALL DEPENDENT ON WHERE THAT INVERTED TROUGH AXIS SETS UP, AND THE FORECAST POSITION OF THAT FEATURE COULD CHANGE A NUMBER OF TIMES BEFORE NEXT WEEKEND.
&&
.PRELIMINARY POINT TEMPS/POPS...
NASHVILLE 27 43 34 36 / 0 100 100 30
CLARKSVILLE 24 37 29 34 / 0 100 100 30
CROSSVILLE 28 48 36 39 / 0 100 100 50
COLUMBIA 28 46 35 37 / 0 100 100 30
LAWRENCEBURG 28 48 35 38 / 0 100 100 30
WAVERLY 25 39 30 34 / 0 100 100 30
&&
.OHX WATCHES/WARNINGS/ADVISORIES...
NONE.
&&
$$

FXUS64 KOHX
AFDOHX
AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE NASHVILLE TN
1150 AM CST MON FEB 3 2014
.UPDATE...ADDED AVIATION SECTION FOR 18Z TAF'S.
&&
.AVIATION...BNA/CKV/CSV...LOW CLOUDS VERY SLOW TO ERODE FOLLOWING YESTERDAY'S COLD FRONTAL PASSAGE. PRECIPITATION ENDED SEVERAL HOURS AGO, BUT STILL LEFT WITH SOME LIGHT FOG IN ADDITION TO THE LOW CIGS. EXPECT CONDITIONS TO GO VFR GRADUALLY FROM NW TO SE DURING THE AFTERNOON. WINDS SHOULD STAY UP ENOUGH OVERNIGHT TO PREVENT ANY APPRECIABLE FOG, WITH HIGH CLOUDS AHEAD OF THE NEXT SURFACE SYSTEM DEVELOPING IN THE NEXT FEW HOURS.
&&
.PREV DISCUSSION... /ISSUED 604 AM CST MON FEB 3 2014/
UPDATE...FOR 12Z AVIATION DISCUSSION.
AVIATION...12Z AVIATION DISCUSSION.
UNCERTAINTIES...PROGRESSION TIMING TO VFR CEILINGS THRU 04/00Z AND POTENTIAL FREEZING FOG 04/06Z-04/12Z. EXPECT WINTRY MIX POTENTIAL TO END AROUND 03/15Z CSV...WITH RIDGING INFLUENCES SLOWLY BUILDING INTO MID STATE THRU 04/00Z...THUS SLOW PROGRESSION FROM CURRENT LIFR CSV...IFR CKV/BNA...TO VFR CEILINGS BY AROUND 03/19Z. EXPECT ENOUGH LOW LEVEL MOISTURE TO KEEP MVFR CEILINGS CSV THRU 04/00Z. EXPECT ONLY BKN CI AFTER 04/00Z WITH SOME INDICATION...PER RESIDUAL MOISTURE

FROM RECENT RAINFALL SUPPORTING...MVFR FREEZING FOG POTENTIAL
CKV/CSV AFTER 04/06Z.
PREV DISCUSSION... /ISSUED 323 AM CST MON FEB 3 2014/
DISCUSSION...
CURRENTLY...THE WIDESPREAD PRECIPITATION IS GENERALLY ALONG THE
PLATEAU. FREEZING LINE EXTENDS FROM SPRINGFIELD TO DICKSON TO
LOBELVILLE. THIS LINE SHOULD MAKE SOME PROGRESS TOP THE SOUTHEAST
THROUGH ABOUT 8AM BEFORE LIFTING BACK TO THE NORTH.
BASICALLY...ALL OF THE PRECIP ON RADAR RIGHT NOW IS MOSTLY RAIN
BUT SOME LIGHT SNOW SHOWERS ARE OCCURRING ACROSS NW AREAS. SO THE
ADVISORY WILL BE CANCELLED AS OPPOSED TO ALLOWING IT TO TERMINATE
AT 6AM. FOR THE FCST...I WILL STILL INCLUDE EARLY CHANCES FOR A
RAIN AND FREEZING RAIN AND SNOW MIX ACROSS AREAS EAST OF I-65. BUT
MUCH OF THIS PRECIP WILL REMAIN AS JUST RAIN AND WILL BE MOVING
OUT BY 8 AM OR SO. WILL DETERMINE POP PERCENTAGES AS PER THE
LATEST RADAR TRENDS AS WE MOVE TOWARD 4 AM. NAM SOUNDING STILL
SUPPORT THE POTENTIAL FOR A SNOWFLAKE OR TWO ACROSS NORTHERN AREAS
SO I MAY OR MAY NOT INCLUDE A SLIGHT CHANCE OF SNOW. OTW...NO
ACCUM IS EXPECTED.
PARTIAL CLEARING IN THE SOUTH FOR TODAY. CLOUDS ACROSS THE NORTH MAY
HANG ON. AND UNFORTUNATELY...WITH ANOTHER GULF SYSTEM COMING UP ON
TUESDAY...BY TONIGHT...MOSTLY CLOUDY SKIES WILL RETURN FOR THE
ENTIRE MID STATE.
TEMPERATURES TODAY WILL ONLY WARM INTO THE 30S NORTH LOWER TO MID
40S SOUTH. MID 20S TO LOWER 30S FOR LOWS TONIGHT.
NOW...ON TO THE NEXT GULF SYSTEM. INVERTED TROUGH TO DEVELOP WITH
THE AXIS BECOMING ORIENTED FROM THE NORTHWESTERN GULF NNE DIRECTLY
ACROSS THE MID STATE. THIS WILL EVOKE A WARMER RAIN EVENT WITH
PERHAPS EVEN A RUMBLE OR TWO OF THUNDER ON TUESDAY AFTERNOON. LLJ IS
AGAIN VERY STRONG WITH THIS SYSTEM AND 1 TO 2 INCHES OF RAINFALL CAN
BE EXPECTED FOR TUES AND TUES NT.
ON THE BACK SIDE OF THE SYSTEM...A WEAKENING AND RATHER BROAD TROUGH
WILL BE TRAVERSING EASTWARD ACROSS THE NATIONS INTERIOR. THE BETTER
CURVATURE AND SHEAR WILL RESIDE NORTHWEST AND NORTH OF TN.
NEVERTHELESS...SOME BACKSIDE MOISTURE WILL BE IN PLACE AND I WILL
THEREFORE INCLUDE A SLIGHT CHANCE OF SNOW NORTH AND RAIN AND SNOW
SOUTH ON WEDNESDAY.
IN THE EXT FCST...OVERALL PATTERN CONTINUES TO REMAIN THE SAME. AND
THEREBY...MIDDLE TN CONTINUES TO FLIRT WITH WINTER STORM POTENTIAL.
LATEST GFS SHOWS A WEAK GULF WAVE PASSING TO OUR SOUTH THURSDAY AND
FRIDAY WITH PLENTY OF COLD AIR TO THE NORTH. FOR NOW...WILL KEEP
POPS LOW AS THE BULK OF THE MOISTURE IS TO OUR SOUTH.
OVER NEXT WEEKEND...THE GFS...WITH ONLY 1 RUN OF MODEL
CONTINUITY...SHOWS A NICE WINTER WEATHER SCENARIO WHEREBY THE TRACK
OF A STRONG 500 MB LOW MOVES ACROSS NRN MS AND NRN AL. THE EURO
SHOWS MORE OF A LOW LEVEL OVERRUNNING/ISENTROPIC WINTER EVENT AT THE
SAME TIME. BUT AGAIN...6 DAYS OUT AND CONTINUITY AND CONFIDENCE IS
LOW. WILL GO AHEAD AND INCLUDE A 40 OR PERHAPS A 50% CHANCE OF SNOW
FOR SATURDAY AND OR SUNDAY.
&&
.OHX WATCHES/WARNINGS/ADVISORIES...
NONE.
&&
$$

14.0 Pilot Weather Briefing

The pilot was provided the following list of weather information from LMFS (times are included in UTC with accident time at 2257 UTC). In addition to the AIRMET information provided during the abbreviated briefings the following weather information was obtained/provided:

2/3/14, 1157 UTC – N840V filed 2 IFR flight plans and obtained an abbreviated briefing.
- Flight Plan 1 from Oklahoma City, OK, Page airport (RCE) to Great Bend, KS (GBD) with a proposed departure time of 1430 UTC, ETE 00+50 minutes.
- Flight plan 2 from GBD to Nashville, TN, June Tune airport (JWN) with a proposed departure time of 2000 UTC, ETE 2+10 hours.

At 1157 UTC abbreviated briefing, the pilot requested the JWN weather and since JWN does report weather the BNA 1153Z observation was provided. An attempt to provide the BNA TAF was interrupted and the information was not provided.

At 1511 UTC N840V refiled IFR flight plan from RCE to GBD with a new proposed departure time of 1800 UTC. Requested JWN weather, confirmed knowledge of AIRMETs for turbulence and IFR, received the Smyrna, TN (MQY) 1456Z observation and the BNA 1453Z observation and obtained the telephone number to obtain an ATC clearance.

At 1735 UTC clearance requested and obtained from RCE to GBD. An update on the adverse conditions was offered and declined. No weather was provided during this contact.

2/3/14, 1838 UTC – N840V obtained an abbreviated briefing from GBD to JWN.

At 1838 UTC abbreviated briefing, pilot obtained winds aloft at FL180 and FL240.

2/3/14, 2006 UTC – Memphis ARTCC Flight Data call to obtain a telephone number for N840V due to lost communication.

2008 UTC – N804V called, obtained Memphis ARTCC frequency.

2210 UTC – Call to Memphis ARTCC and provided N840V location and frequency. Memphis ARTCC advised they were in contact with aircraft.

2/3/14, 2037 UTC – N840V requested IFR clearance from GBD to JWN. IFR clearance obtained from Kansas City ARTCC and delivered to N840V.

2/3/14, 2138 UTC – N840V obtained an abbreviated briefing from 50 miles east of Springfield, MO to JWN.

At 2138 UTC abbreviated briefing, pilot requested the JWN weather and since JWN does report weather the BNA 2053Z observation was provided, 3 PIREPs for icing in the BNA area were provided, and the BNA TAF was offered and declined.

15.0 Weather Forecaster Statements

There were weather forecasters on duty at the Aviation Weather Center (AWC) in Kansas City, Missouri, and at the CWSU in Memphis, Tennessee, at the time of the accident and both these weather units were responsible for the weather products issued for the accident area at the accident time. The CWSU forecaster mentioned abundant cloud cover was located across the Tennessee Valley however that cloud cover was thinning with time. The CWSU forecaster stated weather computer models did not indicate any major forcing mechanisms for precipitation. He only remembered one PIREP for icing around 1500 CST, but that came in during his afternoon stand up briefing. Between 1500 and 1800 CST most of the CWSU forecaster's attention was focused on the expected cargo push during the overnight hours and the present IFR[30] conditions.

The FA central forecaster on duty at the accident time stated the previous forecaster had just issued an AIRMET for IFR conditions for much of the Tennessee Valley, including the accident site and the Area Forecast seemed consistent with current conditions and cloud tops heights. The PIREPs confirmed those cloud top heights and indicated only light icing. Around the time of the accident was the first report of moderate icing at 2,500 feet msl in the Nashville area. The forecaster treated it as isolated since all the other reports in the area showed only light icing amounts. Once notified of the accident, and considering all other weather information previously mentioned, it was determined that no amendments were necessary.

The AWC lead forecaster stated that after arriving on shift he updated a forecast for IFR conditions along the East Coast and mid-Atlantic region. He then updated a few other products, maintained a weather watch and worked on the Area Forecast for along the East Coast. He mentioned no data interruptions or computer problems occurred during his afternoon/evening shift. One additional duty the AWC lead forecaster had to take care of during his shift was to plan ahead for an expected winter snow event on Tuesday for the Kansas City area and make sure that AWC personnel were aware of the situation, briefed, and hotel preparation were made. Another AWC meteorologist brought to his attention, around 1730 CST, an aviation accident that occurred near Nashville, Tennessee. The AWC lead forecaster then made the FA Central forecaster aware of the accident site and entered the information into the shift log.

For more additional information please see attachments 4 through 6.

[30] Instrument Flight Rules – Refers to the general weather conditions pilots can expect at the surface. IFR criteria means a ceiling below 1,000 feet agl and/or less than 3 miles visibility.

16.0 Witness Interview

A witness, who happened to be a National Weather Service Storm Spotter, was driving around areas south and southwest of Nashville during the accident afternoon and evening. The witness reported weather conditions around the area and those weather conditions are highlighted in figure 20 with the accident flight track, weather radar reflectivity, and accident site location. Between 1400 and 1730 CST when driving around Springhill and Thompson Station the witness noticed ice on street signs in some of the neighborhoods (location marked on figure 20) with the vehicle temperature sensor reading 34° F. There was also a fine mist falling, but evaporating quickly from the windshield. When returning to his home neighborhood around 1730 CST, the witness reported a dusting of snow had fallen on grassy surfaces (location marked on figure 20). However, the witness observed no other areas that had snow when driving between the Springhill area and his home neighborhood. The witness reported seeing two distinct cloud layers that afternoon with the lower cloud layer having a flat base.

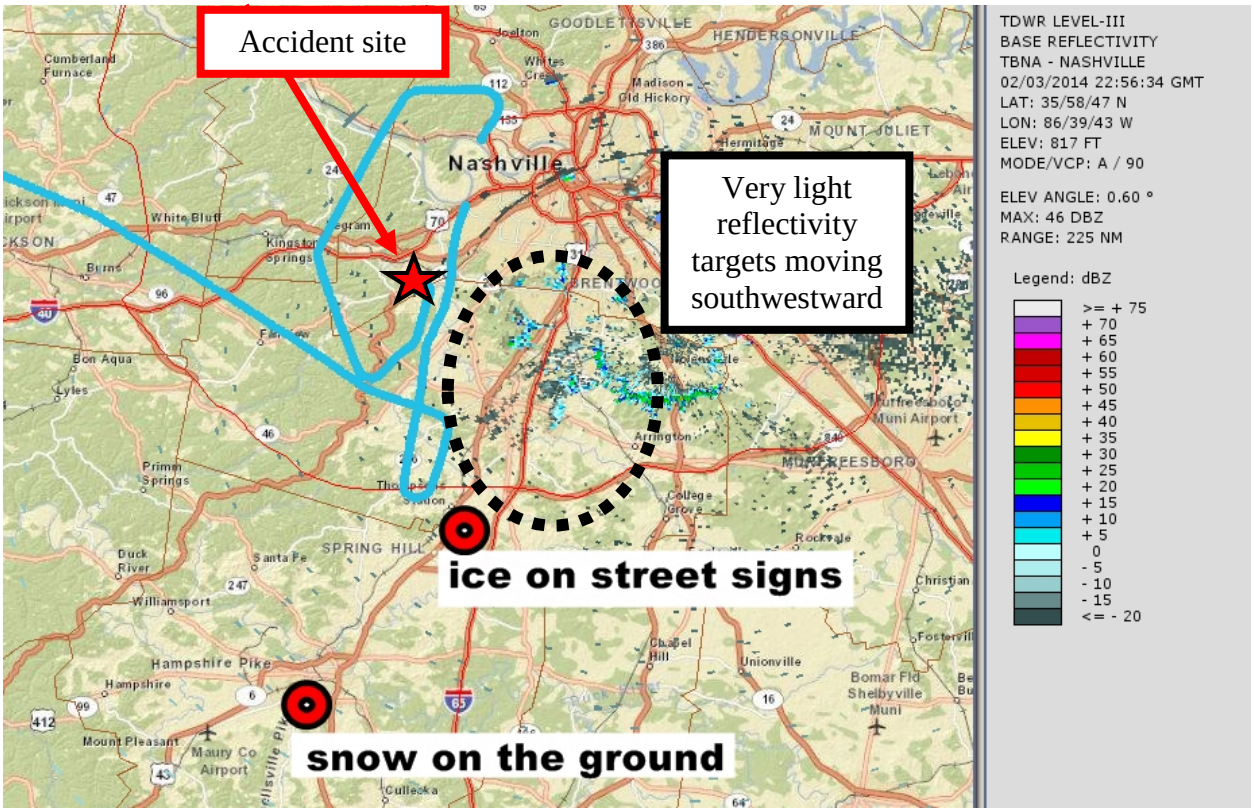


Figure 20 – TBNA TDWR reflectivity for the 0.6° elevation scan initiated at 1657 CST with the witness locations and reports

17.0 Current Icing Potential[31]

Current Icing Potential (CIP) is produced by the NWS' Aviation Weather Center and is intended to be supplemental to other icing advisories (e.g. AIRMETs and SIGMETs). Figures 21 and 22 were the CIP probability valid at 1700 CST at 2,000 and 3,000 feet msl and the CIP indicated 60 to above 85 percent probability of icing at and around the accident site around the time of the accident.

In addition to the CIP showing that icing was likely at 2,000 and 3,000 feet at 1700 CST, the CIP also characterized the icing severity as light to moderate around the accident site at the accident time (figures 23 and 24).

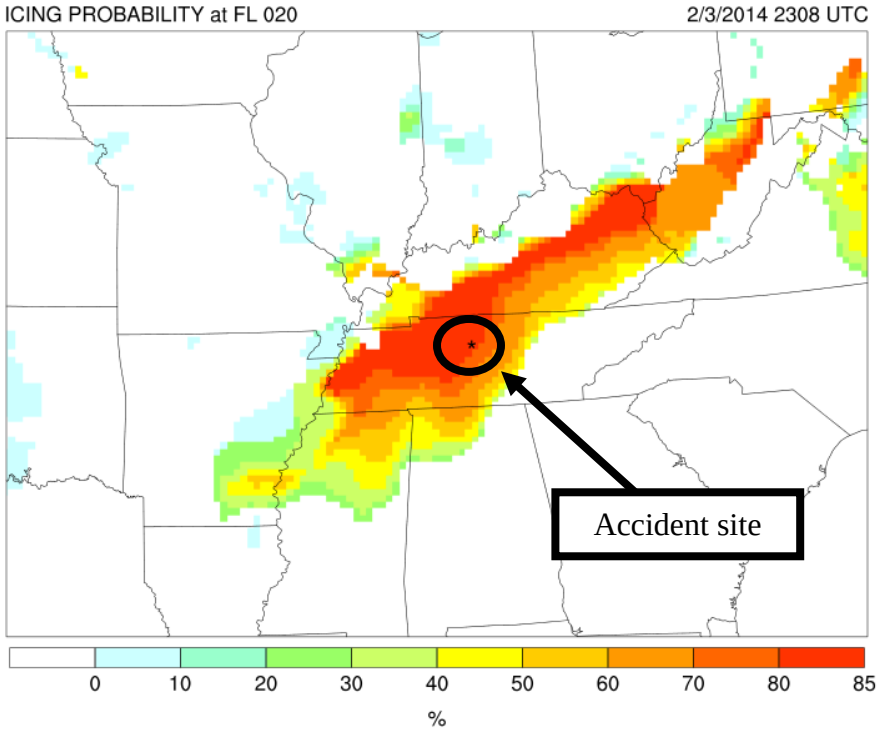


Figure 21 – CIP probability of icing at 2,000 feet msl for 1700 CST

[31] B.C. Bernstein, F. McDonough, M. K. Politovich, B. G. Brown, T. P. Ratvasky, D. R. Miller, C.A. Wolff, and G. Cunning, Current Icing Potential: Algorithm Description and Comparison with Aircraft Observations (Journal of Applied Meteorology, 2005), pp. 969-986.
C.A. Wolff, F. McDonough, M. K. Politovich, B.C. Bernstein, and G. Cunning, FIP Severity Technical Document (Prepared for the Aviation Weather Technology Transfer Technical Review Board), pp. 1-44.

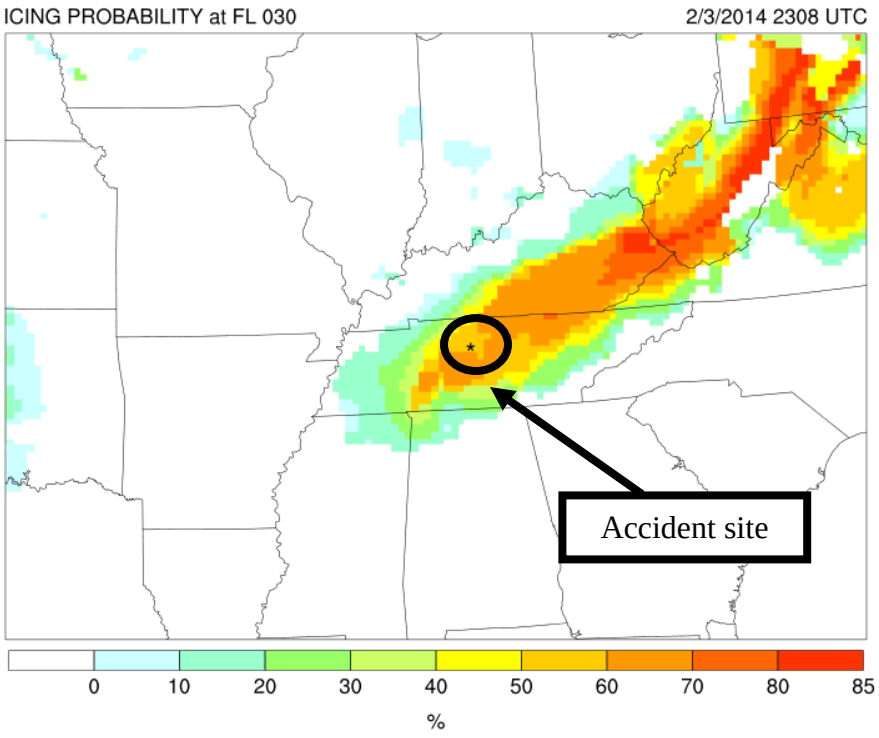


Figure 22 – CIP probability of icing at 3,000 feet msl for 1700 CST

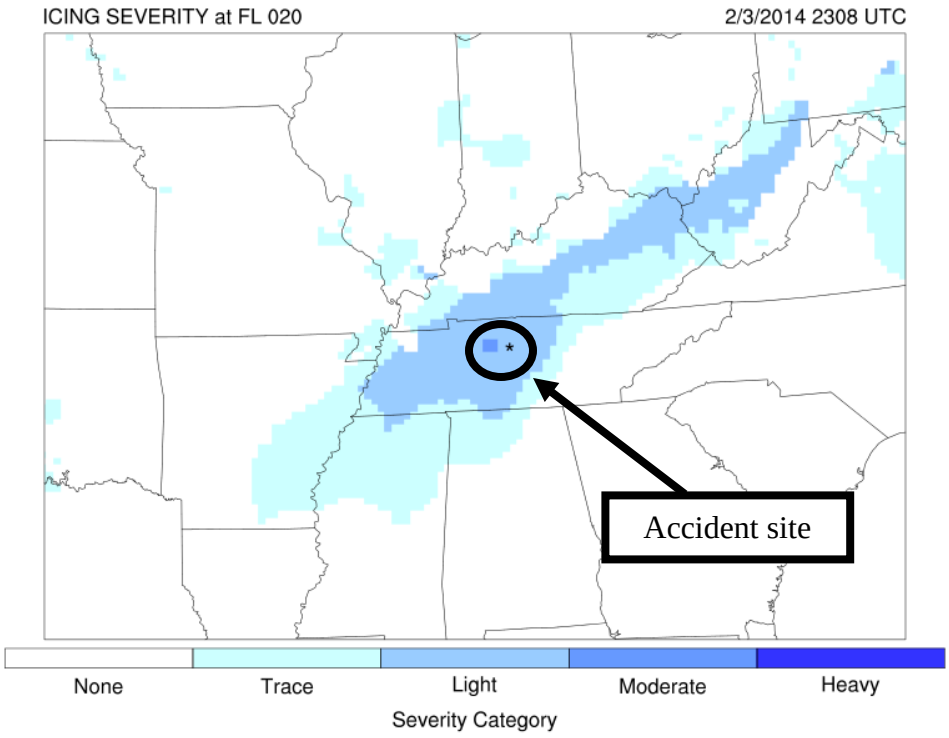


Figure 23 – CIP severity of icing at 2,000 feet msl for 1700 CST

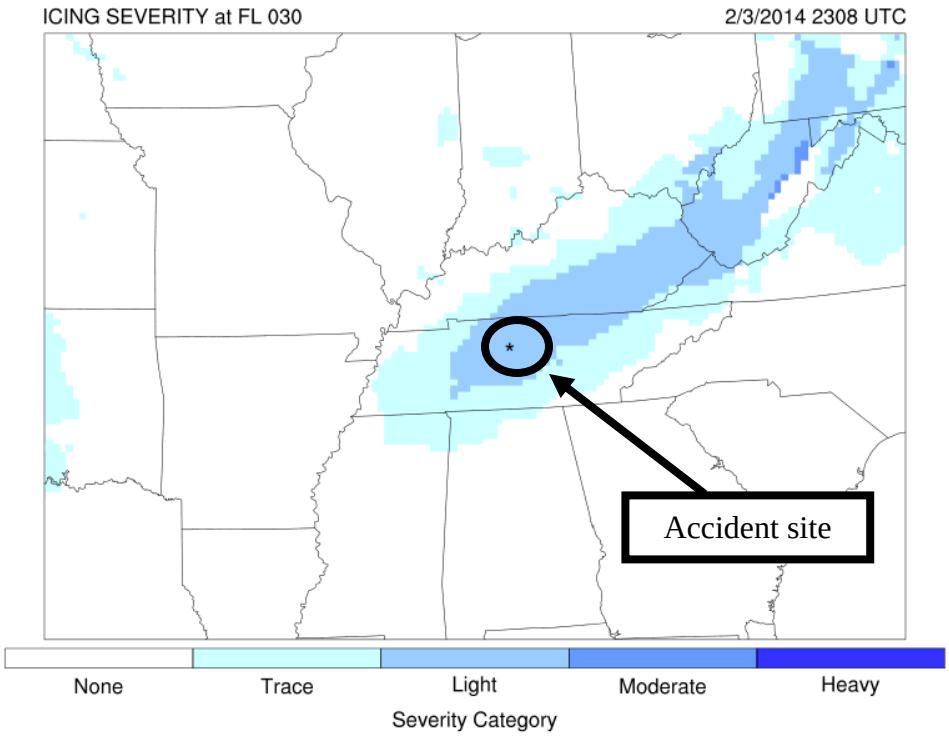


Figure 24 – CIP severity of icing at 3,000 feet msl for 1700 CST

18.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on February 3, 2014, indicated the following:

SUN	
Begin civil twilight	0620 CST
Sunrise	0647 CST
Sun transit	1202 CST
Sunset	1717 CST
End civil twilight	1744 CST

F. LIST OF ATTACHMENTS

Attachment 1 – Handwritten PIREPs from around the accident time taken at Nashville TRACON

Attachment 2 – LMFS PIREP procedures

Attachment 3 – Additional PIREPs from Nashville TRACON ATC recordings from around the accident time

Attachment 4 – Statement from CWSU forecaster

Attachment 5 – Statement from AWC forecaster

Attachment 6 – Statement from AWC forecaster

Paul Suffern
NTSB, AS-30