NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

January 4, 2022

Specialist's Factual Report

METEOROLOGY

CEN21FA360

A. ACCIDENT

Location: Victoria, Minnesota
Date: August 7, 2021
Time: 1740 central daylight time (CDT)
2240 coordinated universal time (UTC)
Airplane: Mooney M20M; Registration: N9156Z

B. METEOROLOGY SPECIALIST

Donald Eick
Operational Factors Division (AS-30)
National Transportation Safety Board
Washington, DC

C. 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 remotely, 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 reported as CDT 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 main wreckage site was located at latitude 44.859028° N, longitude 93.663395°, at an elevation of approximately 990 ft.

D. FACTUAL 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 NWS Surface Analysis Chart for 1600 CDT is included as figure 1 with the approximate accident site marked by a red star. The chart depicted a low-pressure system at 1004-hectopascals (hPa)[1] over North Dakota along a stationary front that extended east-southeast through southern Minnesota and Wisconsin. The accident site was located north of the stationary front on the cool-air side of the front.

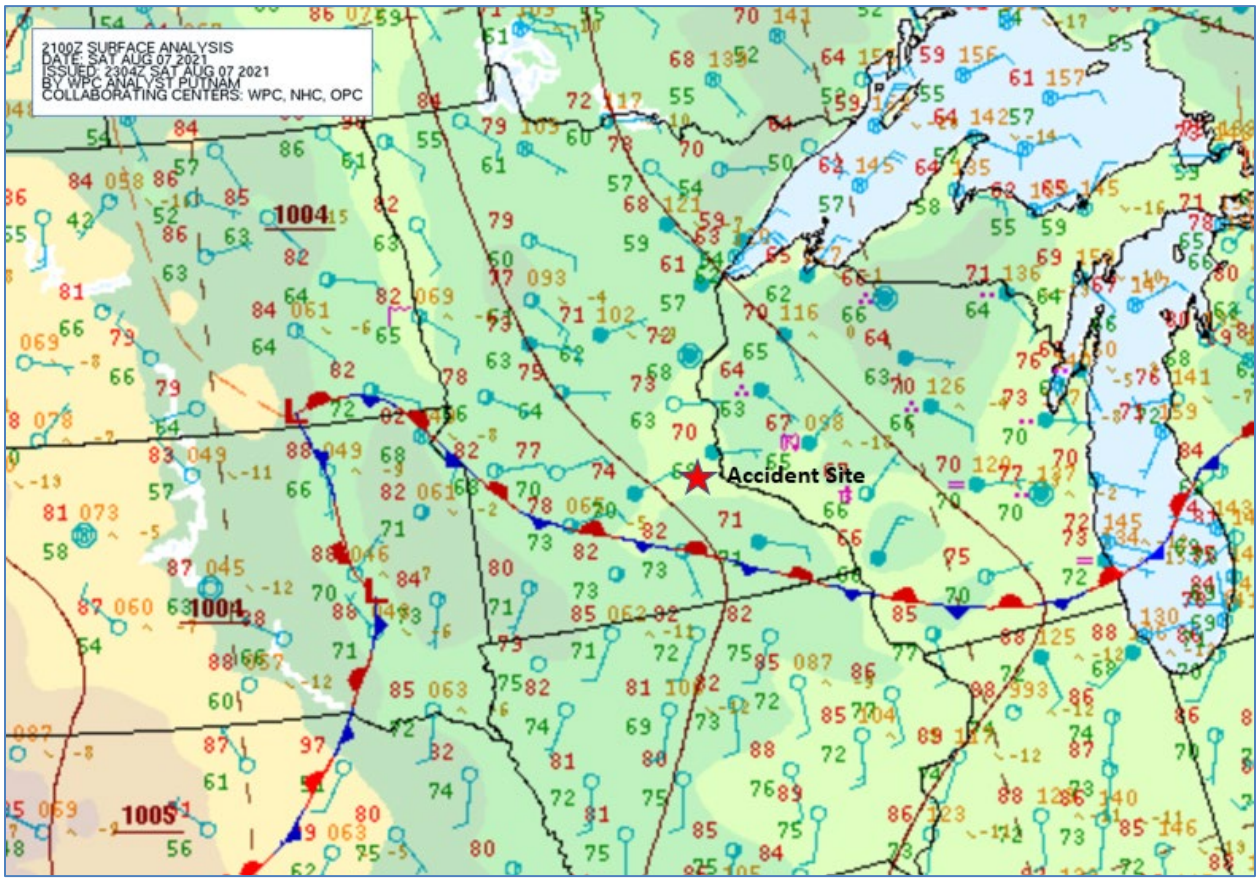

Figure 1 - NWS Surface Analysis Chart for 1600 CDT with the accident site marked by a star.

The station model in the immediate vicinity of the accident site depicted an easterly wind of 5 knots, overcast clouds with temperatures of 70° Fahrenheit (F) and dew point temperature of 66° F. Immediately northeast through southeast of the accident site, numerous stations over Wisconsin reported thunderstorms, light to moderate rain, and mist.

1.2 National Reflectivity Radar Mosaic

The National Reflectivity Mosaic for the area at 1740 CDT is included as figure 2 with the approximate accident site marked. The image depicted an east-to-west band of intense to extreme echoes over Wisconsin. No meteorological echoes were depicted over the accident site. The

[1] Hectopascals is the standard unit 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 59° Fahrenheit (F) or 15° Celsius (C).

closest echoes to the accident site were a small band of echoes less than 15 dBZ, identified about 25 miles east-southeast of the accident site.

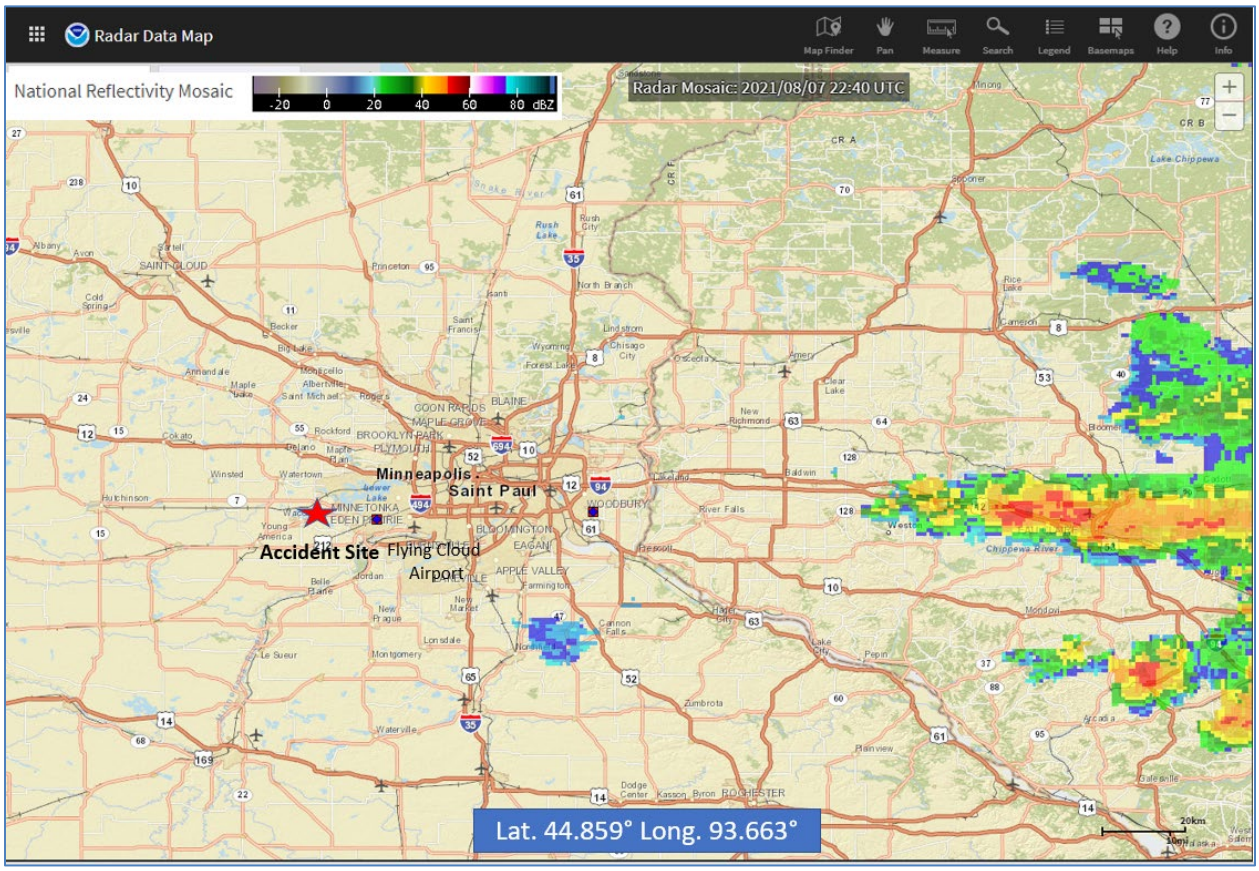

Figure 2 - Regional view of National Composite Radar Mosaic for 1740 CDT with accident site marked.

1.3 Low-Level Significant Weather Prognostic Chart

The NWS Low-Level Significant Weather Prognostic Chart valid during the period is included as figure 3. The chart provided a 12-hour and 24-hour depiction of the general flight categories[2] expected, the freezing level, and areas of turbulence below 24,000 ft. The 12-hour forecast left panel of the chart was valid for 1900 CDT and depicted a red contour depicted an area of expected instrument flight rule (IFR) conditions over Minnesota and Wisconsin, surrounded by a larger blue scalloped area of marginal flight rule (MVFR) conditions over most of Minnesota and Wisconsin. The freezing level was depicted between 12,000 ft and 16,000 ft over Minnesota. No significant

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

- 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.

areas of clear air turbulence were depicted on the chart. The right panel or 24-hour panel valid for 0700 CDT on August 8, 2021, depicted the IFR conditions expanding and covering eastern North and South Dakota, all of Minnesota, northern Iowa, Wisconsin, and Michigan.

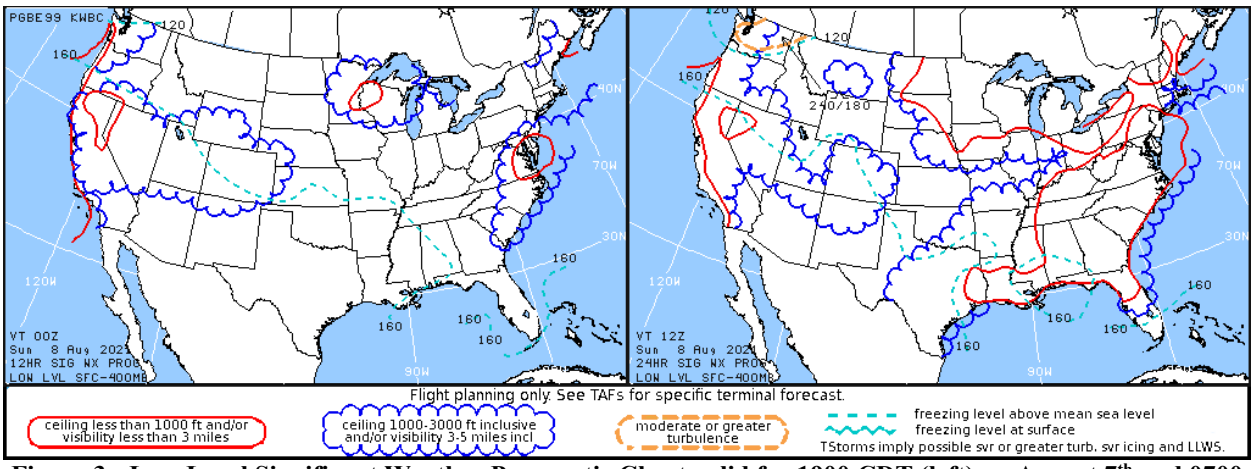

Figure 3 - Low Level Significant Weather Prognostic Chart valid for 1900 CDT (left) on August 7th and 0700 CDT (right) on August 8th depicting the general flight categories, freezing level, and potential turbulence.

2.0 Surface Observations

The area was documented using Aviation Routine Weather Observations (METAR[3]) and Special Reports (SPECI). Cloud heights are reported in height above ground level (agl) in the following section, and the magnetic variation over the area was estimated as 2° east based on the sectional chart over the area.

2.1 Minneapolis, MN

The accident occurred on approach into Flying Cloud Airport (KFCM), Minneapolis, MN, which was located approximately 8 miles east of the accident site at an elevation of 906 ft msl. The airport had an Automated Surface Observation System (ASOS) which was augmented by tower personnel during normal operating hours. The following conditions were reported surrounding the time of the accident.

KFCM weather at 1653 CDT, wind from 080° at 10 knots, visibility 9 miles, ceiling[4] overcast at 1,100 ft agl, temperature 22° Celsius (C), dew point 20° C, altimeter 29.77 inches of mercury (inHg). Remarks: automated station with a precipitation discriminator, sea level pressure 1007.8-hPa, temperature 22.2° C, dew point temperature 20.0° C.

Accident 1740 CDT

[3] Abbreviation for Meteorological Aerodrome Report, the international standard format for weather observations.
[4] Ceiling is defined as the lowest layer of clouds reported as broken or overcast, or the vertical visibility into a surface obscuration.

KFCM weather at 1753 CDT, wind from 060° at 7 knots, visibility 10 miles or more, ceiling overcast at 1,300 ft agl, temperature 23° C, dew point 19° C, altimeter 29.76 inHg. Remarks: automated station with a precipitation discriminator, sea level pressure 1007.5-hPa, temperature 22.8° C, dew point temperature 19.4° C.

The general flight categories and raw observations surrounding the period were as follows, with the observations and time of the accident in UTC in bold italic type.

IFR METAR KFCM 071753Z 06008KT 6SM BR OVC009 22/20 A2979 RMK AO2 SLP084 60014 T02220200 10222 20194 58008=

MVFR SPECI KFCM 071848Z 09009KT 5SM BR OVC010 22/21 A2979 RMK AO2=

MVFR METAR KFCM 071853Z 08009KT 5SM BR OVC011 22/21 A2980 RMK AO2 SLP085 T02220206=

IFR SPECI KFCM 071909Z 08008KT 6SM BR OVC009 22/21 A2980 RMK AO2 T02220206=

IFR METAR KFCM 071953Z 07006KT 6SM BR OVC009 23/21 A2979 RMK AO2 SLP083 T02280206=

IFR METAR KFCM 072053Z 10010G18KT 9SM OVC009 22/19 A2978 RMK AO2 SLP081 T02220194 58004=

MVFR SPECI KFCM 072100Z 08009G17KT 10SM OVC011 22/19 A2978 RMK AO2 T02220194=

MVFR METAR KFCM 072153Z 08010KT 9SM OVC011 22/20 A2977 RMK AO2 SLP078 T02220200=

Accident 2240Z

MVFR METAR KFCM 072253Z 06007KT 10SM OVC013 23/19 A2976 RMK AO2 SLP075 T02280194=

MVFR METAR KFCM 072353Z 09007KT 9SM OVC012 22/19 A2977 RMK AO2 SLP077 T02220194 10228 20217 55005=

The raw METARs and SPECI's indicated that MVFR to IFR conditions prevailed prior to the accident due to visibilities restricted in mist with low overcast clouds with MVFR conditions continuing at the time of the accident due to the overcast clouds.

2.2 NWS Aviation Weather Center Display

A display of the observations over the region at 1745 CDT from the NWS Aviation Weather Center's (AWC) website[5] is included as figure 4 with the regional radar display overlaid for the period. The station models depicted the general flight conditions and observed weather data plotted in a standard station model. The chart depicted MVFR to IFR conditions over the area, with most of the stations west of the accident site reporting IFR conditions due to ceilings between 600 to 900 ft agl.

[5] https://www.aviationweather.gov/metar?gis=on

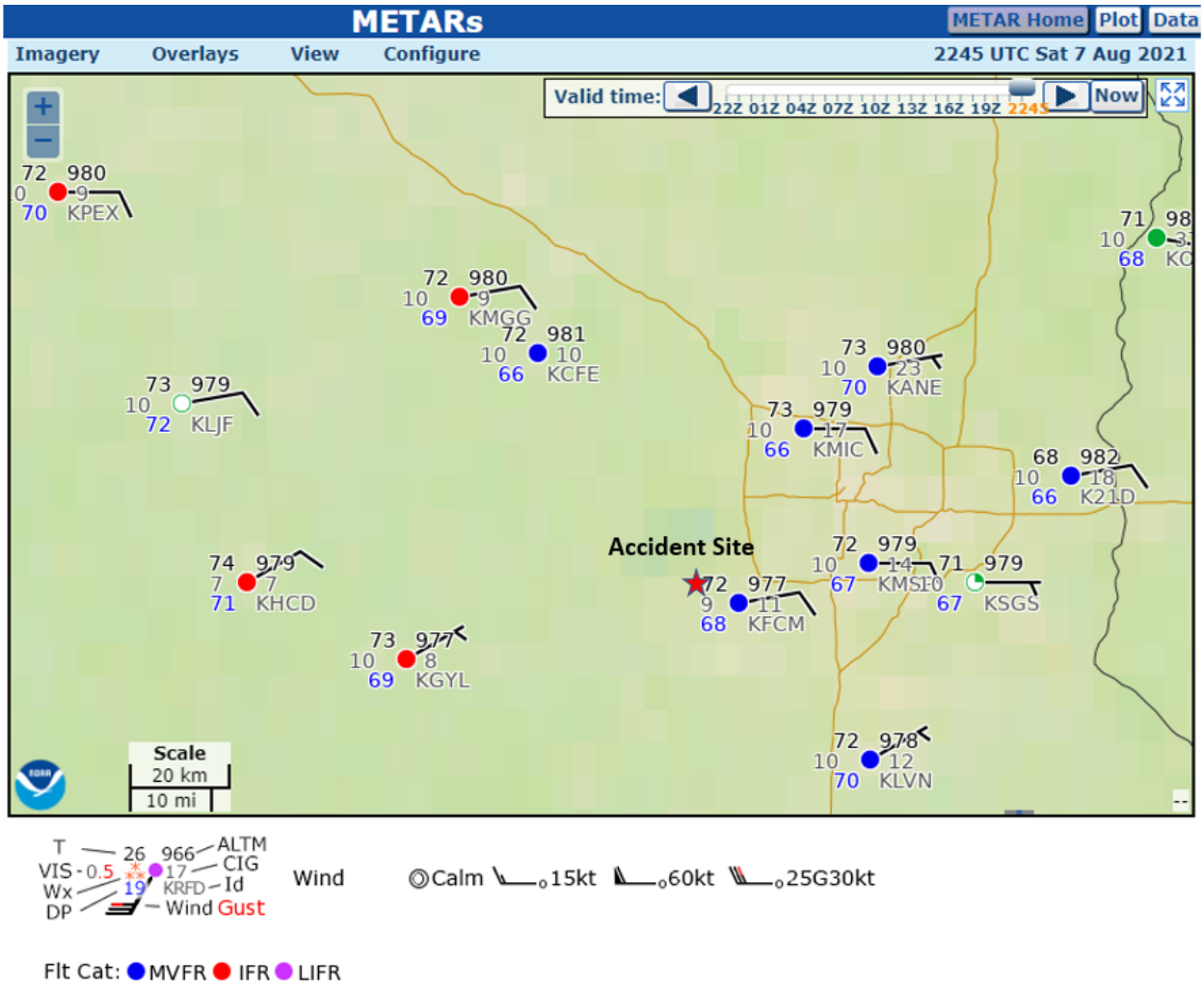

Figure 4 - NWS Aviation Weather Center's METAR display at 1745 CDT with approximate accident site.

3.0 Sounding

To determine the vertical structure and state of the atmosphere over the accident site a High-Resolution Rapid Refresh (HRRR)[6] numerical model data was retrieved from the NOAA Air Resources Laboratory using the closest grid point to the accident site coordinates at 44.86° N, 93.66° W for 1700 CDT. The closest NWS observed sounding from Chanhassen (KMPX), MN, site number 72649 for 1900 CDT, located approximately 4 miles east of the accident site was also documented. The sounding data was then plotted on a standard Skew T log P diagram[7] using the complete Rawinsonde Observation RAOB program software[8] from the surface to 450-hPa or

[6] 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.

[7] 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.

[8] RAOB – (The Universal RAwinsonde OBservation program) is an interactive sounding analysis program developed

approximately 20,000 ft. Figure 5 is the HRRR numerical model sounding for 1700 CDT and figure 6 is the KMPX observed sounding after the accident at 1900 CDT.

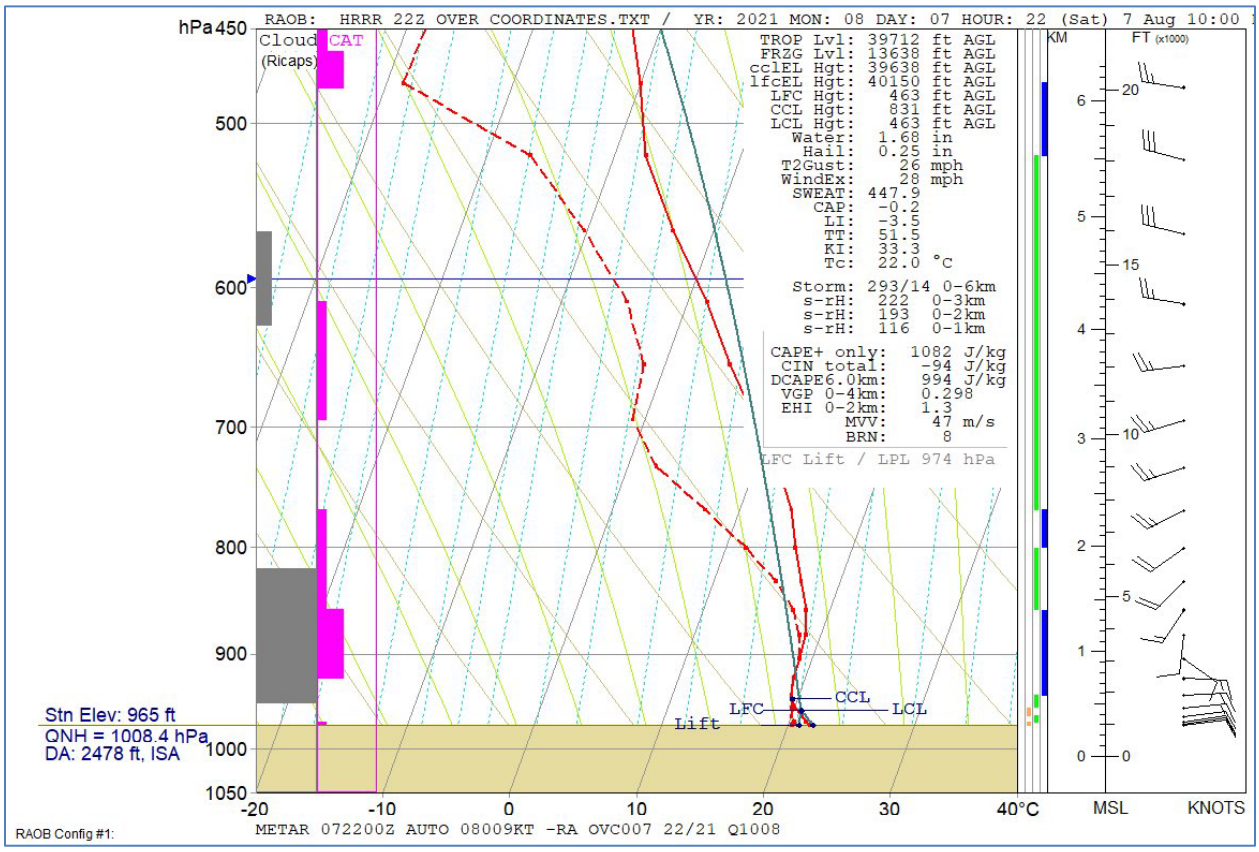

Figure 5 - HRRR numerical model sounding for 1700 CDT over the approximate accident site.

The 1700 CDT HRRR numerical model sounding depicted an elevation of 965 ft over the grid point with a near surface temperature of 22°C (71.6° F), a dew point of 21°C (69.6° F), with a relative humidity of 93%, and a density altitude of 2,478 ft. The sounding depicted a lifted condensation level (LCL)[9] and level of free convection (LFC)[10] at 463 ft agl, with a convective condensation level (CCL)[11] at 831 ft agl. The sounding indicated a nearly isothermal layer from the CCL through 4,000 ft, with saturated conditions between the CCL and 6,000 ft, which the RAOB analysis program indicated an overcast layer of clouds between 700 ft agl through 6,000 ft msl (indicated gray on left axis). The freezing level was at approximately 14,600 ft msl well above the accident airplane's cruising level, and the precipitable water content was 1.68 inches. The atmosphere was characterized as conditionally unstable with a Lifted Index[12] of -3.5, with the convective available potential energy of 1,082 Joules/kilogram.

by Eosonde Research Services (ERS) previously known as Environmental Research Services, The Villages, Florida.

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

[10] Level of Free Convection (LFC) - the last level where a parcel becomes buoyant, or "warmer" than the environmental temperature at the same level. The LFC represents the bottom of the layer containing CAPE.

[11] Convective Condensation Level - 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.

[12] Lifted Index (LI) - A common measure of atmospheric instability. Its value is obtained by computing the temperature

The HRRR sounding wind profile indicated surface wind from 080° at 9 knots with winds shifting to the south and southwest above 4,000 ft msl, then to the west with slowly increasing in wind speed with height. The mean 0 to 6 km (or 18,000 ft) winds were from 260° at 19 knots. The RAOB analysis program indicated a greater than 95% probability of moderate turbulence between 2,500 through 4,500 ft in the identified isothermal layer, where the winds shifted from the east, southwest and then west. At the accident airplane's last reported altitude of 2,500 ft the wind was from approximately 090° at 13 knots, and a temperature of 19°C, with 100% relative humidity.

The HRRR parameters of height, pressure, temperature (T), dew point temperature (Td), relative humidity (RH), wind direction and speed, and derived clear air turbulence (CAT), and low-level wind shear (LLWS) potential from the surface through 6,500 ft were as follows.

Height (ft msl)	Pres (hPa)	T (°C)	Td (°C)	RH (%)	Wind (deg/kts)	CAT (FAA)	LLWS (FAA)
965	974	22.0	20.9	93	081/ 9		LIGHT
994	973	21.7	20.3	92	080/ 8	LGT	LIGHT
1082	970	21.3	20.4	95	081/ 11		
1259	964	20.8	20.0	95	082/ 12		
1526	955	20.0	19.8	99	084/ 13		
1915	942	19.4	19.4	100	086/ 14		
2462	924	19.1	19.1	100	093/ 13	MDT	LIGHT
3082	904	19.0	19.0	100	128/ 9	MDT	
3812	881	18.8	18.3	97	187/ 9	MDT	
4593	857	18.1	17.1	94	211/ 14	LGT	
5494	830	16.9	14.9	88	222/ 18	LGT	
6525	800	15.5	11.6	78	233/ 20	LGT	

The observed NWS KMPX sounding at 1900 CDT depicted an elevation of 942 ft, with a temperature 22.8°C (73°F), a dew point temperature of 19.8°C (68°F), with a relative humidity of 83%. The sounding indicated a CCL and LFC at 1,042 ft agl, and a LFC at 1,260 ft agl. The sounding depicted a defined frontal inversion at 1,775 ft agl, with several other inversions due to subsidence below 8,000 ft, which were not depicted in the HRRR sounding. RAOB identified clouds between the CCL and 6,000 ft msl. The KMPX sounding wind profile indicated a surface wind from 080° at 3 knots, with winds shifting to the southwest and then to the west above the frontal inversion. The mean 0 to 6 km wind was from 265° at 10 knots. A low-level wind maximum was identified near 6,000 ft msl from 250° at 18 knots.

that air near the ground would have if it were lifted to 500-hPa or approximately 18,000 feet and comparing that temperature to the actual temperature at that level.

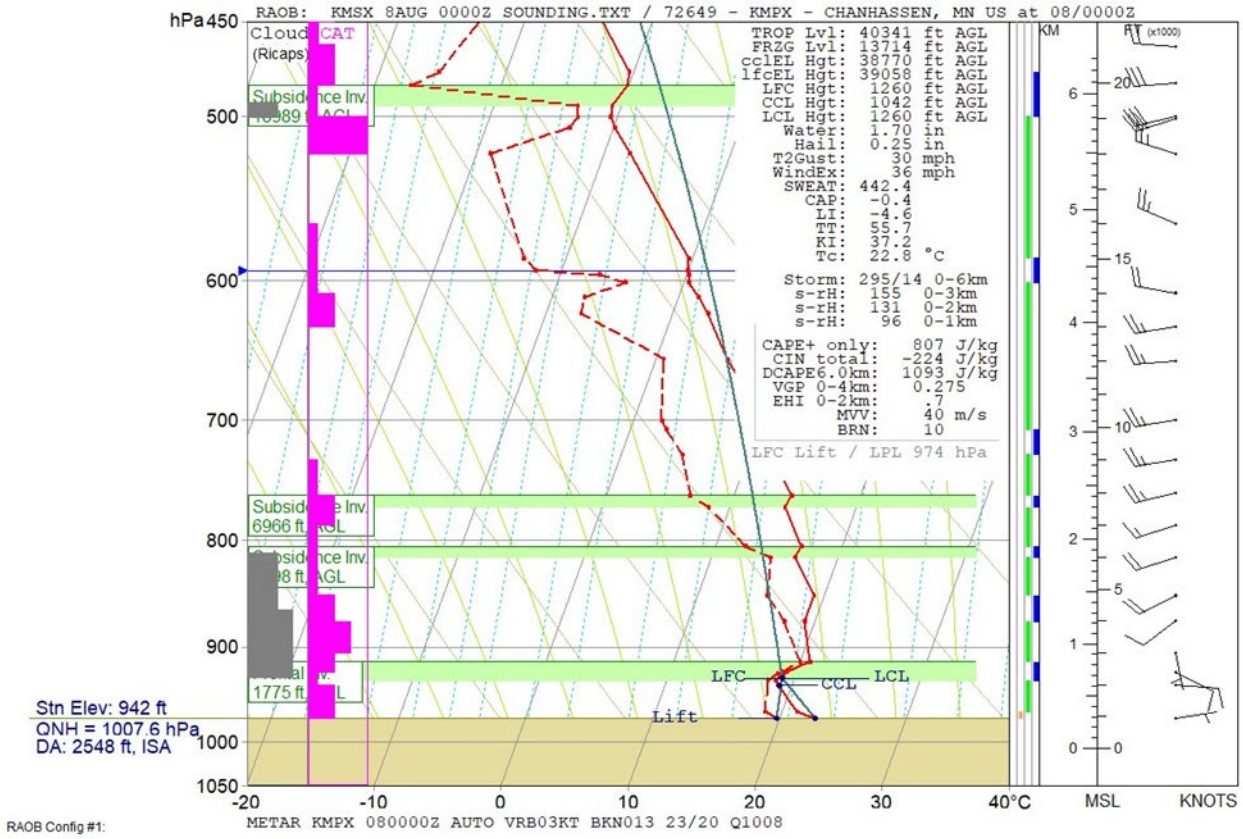

Figure 6 – NWS KMPX observed sounding for 1900 CDT.

The KMPX observed sounding parameters of height, pressure, temperature (T), dew point temperature (Td), relative humidity (RH), wind direction and speed, and derived clear air turbulence (CAT), and low-level wind shear (LLWS) potential from the surface through 6,500 ft were as follows.

Height (ft msl)	Pres (hPa)	T (°C)	Td (°C)	RH (%)	Wind (deg/kts)	CAT (FAA)	LLWS (FAA)
942	974	22.8	19.8	83	080/ 3		
1148	967	21.2	18.7	86		MDT	
2000	938				095/ 10		
2134	934	18.6	18.0	96			
2347	927	19.0	18.6	98		LGT	LIGHT
2408	925	19.2	18.9	98	120/ 8		
2717	915	20.8	20.0	95		MDT	LIGHT
3000	906				170/ 7	SVR	
3988	875	19.2	17.6	90	230/ 12	MDT	
4809	850	19.2	15.5	79	240/ 18	LGT	
5994	815	16.6	14.7	89	250/ 21		
6340	805	16.8	12.4	75			LGT

The RAOB analysis program indicated high probability of moderate-to-severe turbulence in the clouds between 2,700 and 4,000 ft near the frontal inversion due to a strong vertical wind shear of 10.4 kt/1000 ft.

4.0 Satellite Imagery

The Geostationary Operational Environmental Satellite number 16 (GOES-16) imagery were obtained from an archive at the Space Science Engineering Center (SSEC) at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System (McIDAS) software. The infrared and visible imagery were reviewed surrounding the period, and the closest images to the accident time documented. The infrared long wave imagery (band 13) at a wavelength of 12.3 microns (µm) provided radiative cloud top temperatures with a nominal spatial resolution of 2 km. The visible (band 2) at a wavelength of 0.64 µm provided images at a resolution of 0.5 km.

The GOES-16 infrared and visible imagery at 1741 CDT at 4X magnification with a standard MB temperature enhancement curve applied is included as figure 7 with the fronts overlaid from 1600 CDT. Over the accident site (white square) a low band of overcast clouds with a radiative cloud top temperature of 274 K or 0.8°C, which corresponded to cloud tops near 14,000 ft. A large, enhanced area of clouds was depicted east and west of the accident site. The enhanced area to the east of Minneapolis (KMSP) and over Wisconsin was associated with convection and significant precipitation (as depicted in figure 2).

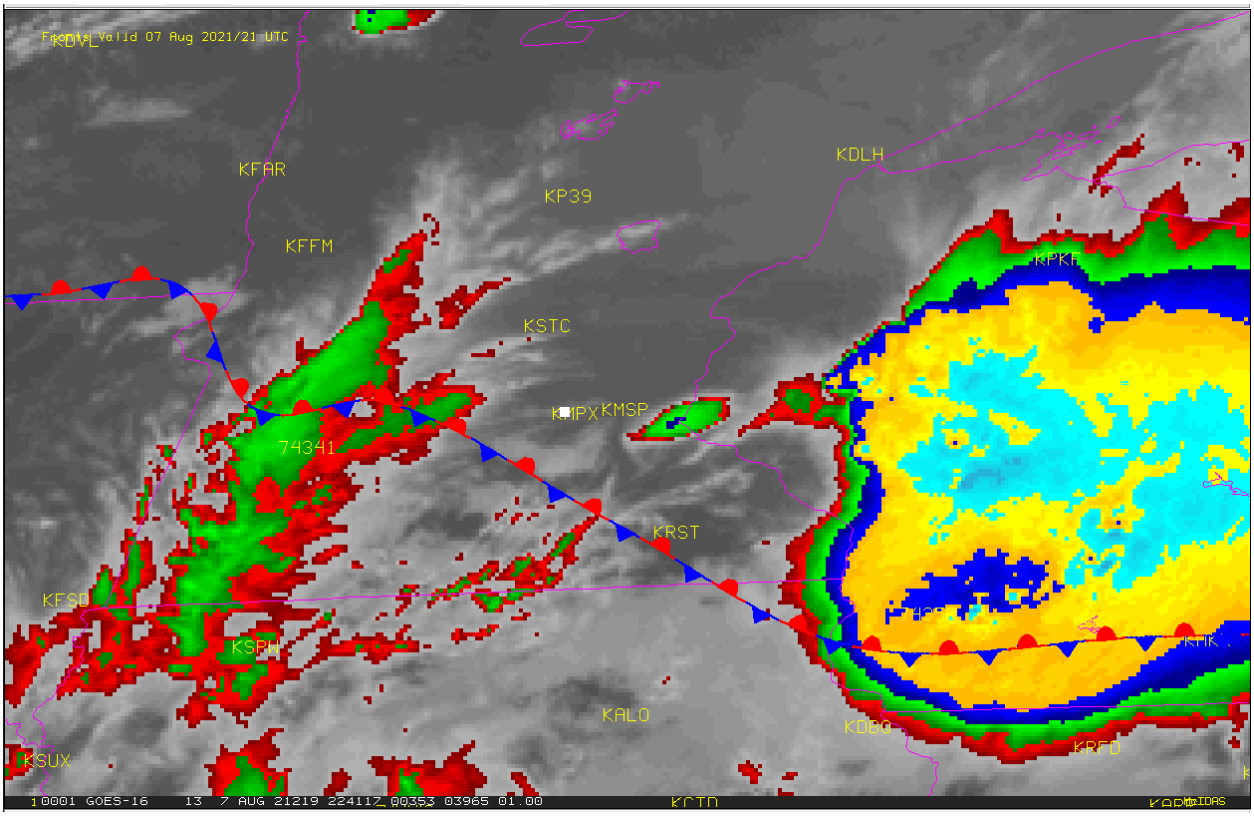

Figure 7 - GOES-16 infrared band satellite image for 1741 CDT at 4X magnification.

Figure 8 is the GOES-16 visible band image for 1741 CDT at 2X magnification. A band of low-level stratiform type clouds is depicted over the accident site, with a thin layer of higher cirriform clouds above. To the east of the accident site and KMSP was an area of cumulus type

clouds with vertical development, with significant convective clouds near Eau Claire (KEAU), Wisconsin, with the cumulonimbus clouds with overshooting cloud tops.

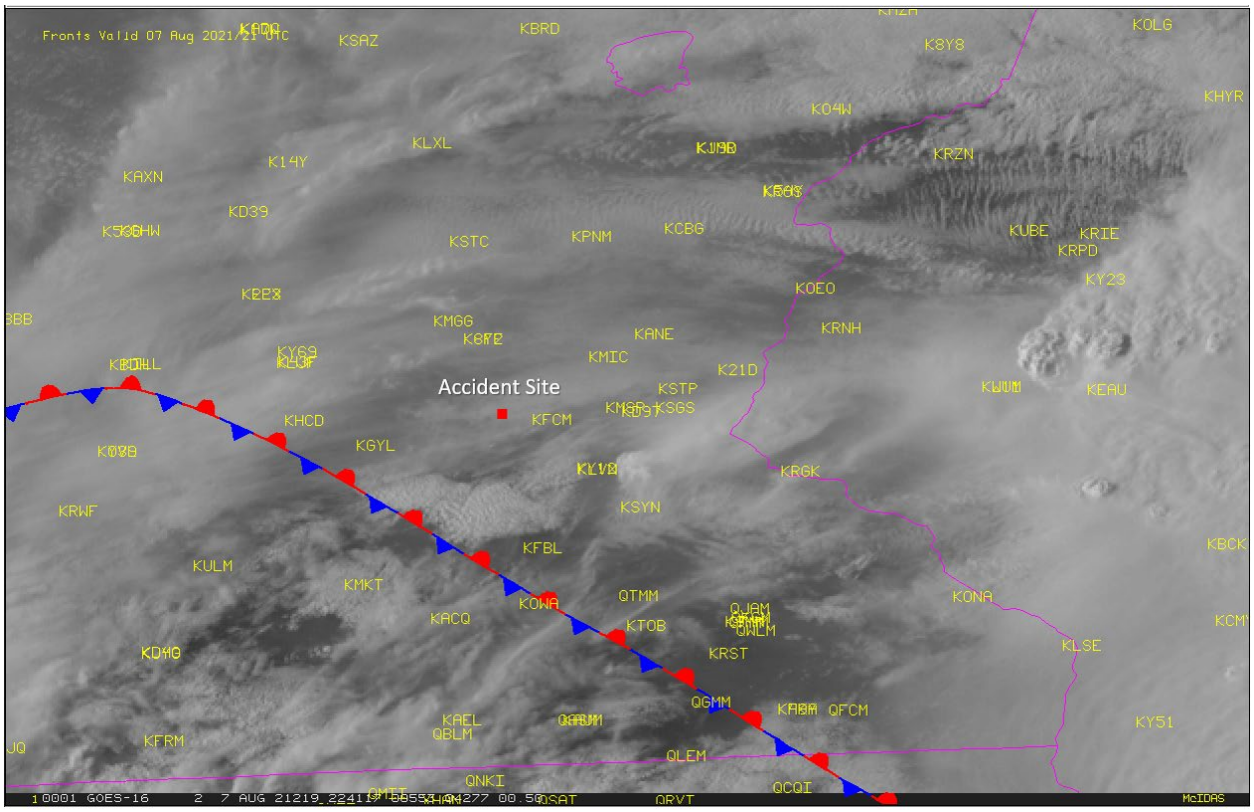

Figure 8 - GOES-16 visible band image for 1741 CDT at 2X magnification.

5.0 Pilot Reports

The following pilot reports[13] or PIREPS were recorded within 100 miles of the accident site between 1400 through 1900 CDT below 18,000 ft. The reports are in standard code and abbreviations with cloud heights referenced to msl, with the time of the accident added in bold italic type. The reports were as follows.

MSP UA /OV FGT180020/TM 1635/FL130/TP CRJ7/WX MODERATE RAIN 130 DURD/TB LIGHT TURB
MSP UA /OV MSP300050/TM 1838/FL010/TP B767/RM CEILING OVC AT 1000 FEET AGL.
MSP UA /OV MSP190010/TM 1843/FLDURC/TP E755/SK SCT B040-T060/TB NEG
CBG UA /OV CBG/TM 1901/FL050/TP P28B/TB MOD
FCM UA /OV FCM280001/TM 1902/FL018/TP C25B/SK OVC009/RM DURD
MSP UA /OV MSP300025/TM 1920/FL060/TP B737/TB MOD CHOP
MIC UA /OV 2NW KMIC/TM 2001/FL019/TP C82R/SK OVC019
MSP UA /OV MSP300050/TM 2007/FL018/TP A321/SK BKN/RM BASES 1800 FEET REPORTED RAGGED.
MSP UA /OV MSP135015/TM 2115/FL065/TP A321/TB MOD CHOP/RM DURC
BRD UA /OV BRD/TM 2127/FL050/TP T206/SK OVC035-TOP044/RM DURC
Accident 2240Z

[13] Includes PIREPs making into the NWS database and may not include "ride reports" or other reports made on radio frequency to air traffic control and not formally entered as a PIREP into the national database.

MSP UA /OV MSP300050/TM 0100/FL019/TP A319/RM CEILING 1900 OVC
MSP UA /OV MSP180015/TM 0120/FL90/TP CRJ9/TB MOD TURB
BRD UA /OV BRD/TM 0308/FL000/TP CRJ2/SK OVC005-TOPUNKN

Surrounding the period there were no urgent PIREPs noted. There were 3 pilots that reported moderate turbulence between 6,000 ft and 6,500 ft with cloud tops reported near 6,000 ft. After the accident, there was another report of moderate turbulence at 9,000 ft at 2020 CDT.

6.0 NWS Forecasts

6.1 Terminal Aerodrome Forecast

The NWS Twin Cities/Chanhassen (KMPX), MN, Weather Forecast Office (WFO) was responsible for the county where the accident occurred. The NWS KMPX WFO does not issue a Terminal Aerodrome Forecast (TAF) for KFCM. The closest TAF to the accident site was issued for Minneapolis-St Paul International Airport (KMSP), Minneapolis, MN, located approximately 11 miles east of KFCM. While a TAF is only valid for a 5-statute mile radius around an airport, it often provides pilots a quick evaluation of the forecast conditions near the destination airport. The forecasts valid for KMSP during the period were as follows, with the section applicable to the time of the accident in bold italic type.

AMD TAF KMSP 071841Z 0719/0824 10010KT P6SM BKN010 OVC050
TEMPO 0719/0721 SCT012 OVC070
FM072100 13010KT P6SM SCT025 BKN100
TEMPO 0723/0803 3SM -TSRA BR BKN030CB OVC100
FM080500 13007KT P6SM SCT019 OVC035
PROB30 0810/0813 5SM -TSRA BKN020CB
FM081600 17006KT P6SM SCT021 BKN050
FM081900 18007KT P6SM SCT100 BKN200=

The KMSP amended TAF issued at 1341 CDT and available at the time of departure expected from 1600 through 2400 CDT a wind from 130° at 10 knots, visibility 6 miles or more, scattered clouds at 2,500 ft agl, ceiling broken at 10,000 ft, with a temporary period between 1800 and 2200 CDT of visibility 3 miles in thunderstorm, light rain and mist, with a ceiling broken at 3,000 ft agl in cumulonimbus cloud, and overcast at 10,000 ft.

The forecast was amended again at 1605 CDT and became as follows.

AMD TAF KMSP 072105Z 0721/0824 10013KT P6SM BKN010 OVC028
FM080000 13010KT P6SM SCT025 BKN050
TEMPO 0800/0804 3SM -TSRA BR BKN020CB OVC050
FM080500 13007KT P6SM SCT019 OVC035
PROB30 0810/0813 5SM -TSRA BKN020CB
FM081600 17006KT P6SM SCT021 BKN050
FM081900 18007KT P6SM SCT100 BKN200

The forecast for KMSP from 1600 through 1900 CDT expected a wind from 100° at 13 knots, visibility 6 miles or more, ceiling broken at 1,000 ft agl, and overcast at 2,800 ft. Thunderstorms were expected between 1900 through 2300 CDT, and between 0500 and 0800 CDT on August 8, 2021.

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 and provide some reasoning behind the forecast. The AFD are typically generated every 6 hours and corresponds to the release of the latest TAFs for that office. The NWS KMPX AFD issued at 1430 CDT was as follows.

FXUS63 KMPX 071930
AFDMPX

Area Forecast Discussion
National Weather Service Twin Cities/Chanhassen MN
230 PM CDT Sat Aug 7 2021

.SHORT TERM...(This evening through Sunday night)
Issued at 230 PM CDT Sat Aug 7 2021

Short term concerns haven't changed much, and continue to focus on potential for convection (possibly severe) this afternoon into tonight. Latest mesoanalyses and satellite imagery show the surface warm front near the Minnesota Valley at the current time. It continues to make some progress northward, and should get near the south metro by later this afternoon. MLCAPE south of the boundary is in excess of 3000 J/Kg, but decent values exist on the "cool side" of the boundary as well given the high dewpoints north of the front. The best deep layer shear (per effective bulk shear) is mainly north/east of the surface boundary, but there is some overlap where greater than 35 kt is available to storms. The best low level shear (per 0-1 km bulk shear) is to the south in western Iowa and to the southeast of the area. However, there is a ribbon along the frontal boundary where winds are backed and values near 20 kt are indicated. So, there is certainly sufficient instability for some severe storms capable of large hail and downburst winds, and there is also at least a portion of the area where supercells could produce isolated tornadoes late this afternoon into this evening. The CAMs have struggled, as usual, with much of the elevated convection we've seen, which makes it tough to rely on their handling of redevelopment of boundary layer-rooted convection this afternoon/evening. The HRRR has been reasonably consistent in its runs today, and does manage to generate isolated storms near the warm frontal boundary around/after 22Z, with more widespread activity near and after sunset as the low-level jet increases with the upper trough to the west getting closer. Given that heights are currently rising a bit in southwest Minnesota ahead of that trough (and the cap is strengthening per model soundings in that area), it seems later timing make sense (other than perhaps some isolated earlier storms forced along the boundary. All of the CAMs increase the coverage of activity later this evening into the overnight, so everything could certainly evolve more toward a heavy rain scenario as the night progresses. The best chance for storms on Sunday will be over the eastern portion of the area, but some low PoPs seem warranted across most of the area given lingering instability.

.LONG TERM...(Monday through Saturday)
Issued at 230 PM CDT Sat Aug 7 2021

Although we currently have an upper trough moving through it, the large scale flow across the CONUS is predominantly zonal and looks to remain that way through Tuesday. At that point, the upper low along the British Columbia coast will be making its way into our region, and looks to push through late Tuesday into early Wednesday, bringing a renewed chance for precipitation as it drags a cold front through the area. Ridging builds in the western CONUS and Canada in the wake of that system, setting up northwest flow our area, which looks to linger into next weekend. This should bring warm and dry weather for the second half of the week in to next weekend with any precip chances looking too low to mention at this point (tied to weak shortwave troughs dropping southeast with the upper flow).

.AVIATION...(For the 18Z TAFS through 18Z Sunday afternoon)
Issued at 1215 PM CDT Sat Aug 7 2021

Lower ceilings and SHRA/TSRA currently working east across the area, with the backside of things correlating with the back edge of the influence of the MCV just crossing into Wisconsin. Still expect to see a break in activity for most of the area through at least mid afternoon before additional scattered convection develops in association with the warm front lifting north and upper trough approaching from the west. Should see a window of scattered convection from around 22Z through 05Z or so, although there remains quite a bit of uncertainty on timing and location of things. A period of stratus also seems likely from late tonight into the morning on Sunday, and it's tough to say how long that will linger (wouldn't be surprised to see it last over the north/east portion of the area through 18Z Sunday).

KMSP...The main issue with this forecast is uncertainty on the occurrence, timing, and location of convection later today and this evening, and the possibility of a period of IFR stratus in its wake later tonight into Sunday morning. Confidence is not particularly high at this time, but will hopefully improve once convective trends are more apparent later this afternoon.

/OUTLOOK FOR KMSP/
Sunday night...VFR. Southeast wind less than 10 kt.
Monday...VFR. Variable wind less than 10 kt becoming east.
Monday night...VFR. Southeast wind less than 10 kt.
Tuesday...VFR. South wind around 10 kt shifting west.
Tuesday night...VFR. Variable wind less than 10 kt.
Wednesday...VFR. Northwest wind around 5 kt.

.MPX WATCHES/WARNINGS/ADVISORIES...
MN...None.
WI...None.

6.3 Graphic Forecast for Aviation

The NWS Graphical Forecast for Aviation (GFA) are graphical depictions of surface wind, predominant precipitation and weather, color coded general flight categories of visibility, and cloud cover bases and tops, with the Graphical-Airmen's Meteorological Information (G-AIRMET)[14] for IFR conditions, mountain obscuration, icing conditions, and strong surface wind overlaid for the enroute phase of flight. The GFA are available at the NWS AWC website and through other weather briefing services and are provided every 3-hours out to 18-hours. The GFA charts issued at approximately 1400 CDT and valid during the period of the accident are included below.

The GFA Surface Forecast valid for 1600 CDT is included as figure 9 with the approximate accident site noted by the red star. The chart depicted southeasterly winds of 10 knots, with visibility better than 5 miles with a chance of thunderstorms over the area. An area of visibilities less than 3 miles was indicated over Wisconsin to the east of the accident site with numerous

[14] AIRman's METeorological Information (AIRMET) is a concise description of weather phenomena that are occurring or may occur (forecast) along an air route that may affect aircraft safety. Compared to SIGMETs, AIRMETs cover less severe weather: moderate turbulence and icing, sustained surface winds of 30 knots or more, low-level wind shear, widespread instrument flight rule conditions due to low ceilings or restricted visibility, or mountain obscuration conditions.

thunderstorms. No G-AIRMETs for IFR conditions or surface winds of 30 knots or greater outside of convective activity were depicted at the time the chart was issued.

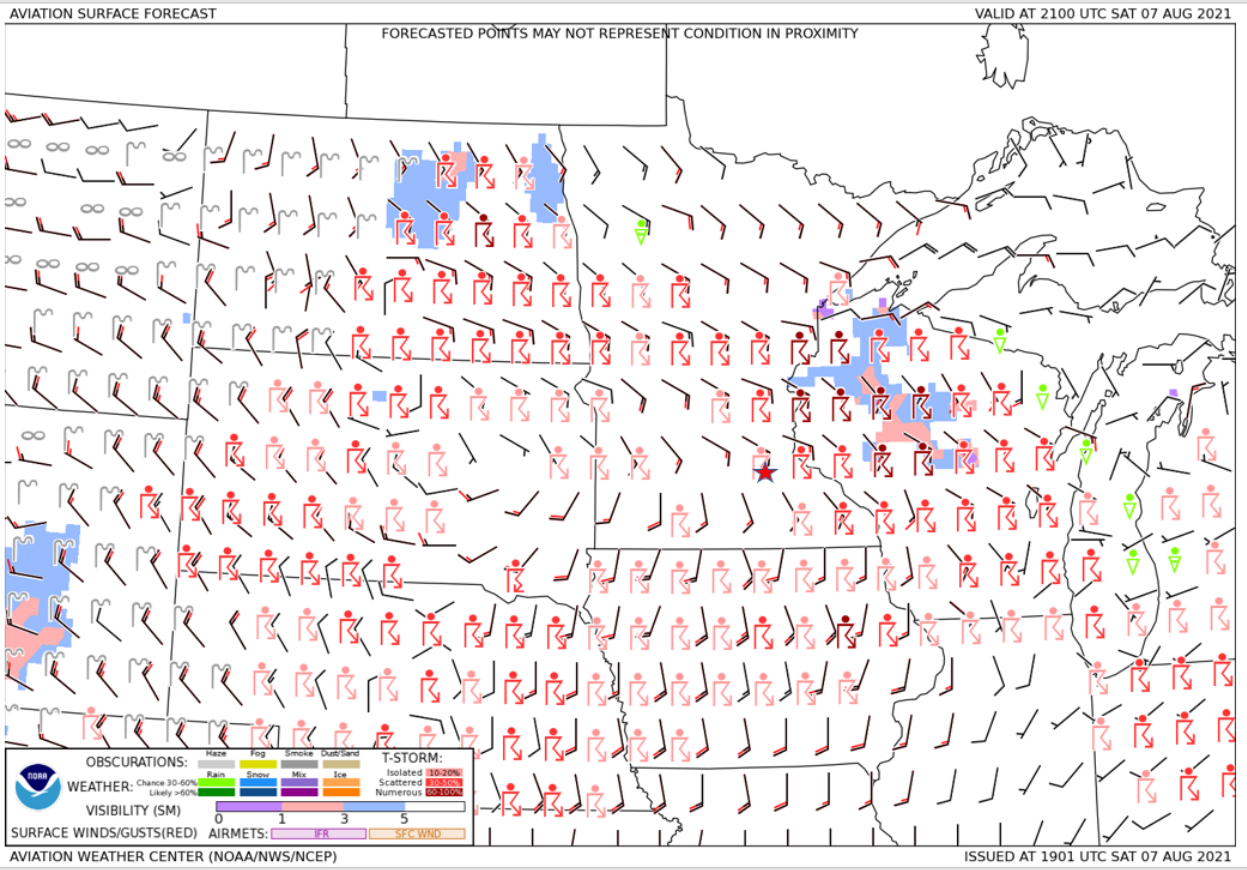

Figure 9 - Graphic Forecast for Aviation Surface Forecast valid for 1600 CDT.

The GFA Cloud Forecast valid for 1600 CDT is included as figure 10 with the approximate accident site marked by the red star. The chart depicted overcast clouds with bases near 1,500 ft with tops near 8,000 ft in the general vicinity of the accident site. No G-AIRMETs for icing or mountain obscuration conditions were indicated over the area at the time of the accident.

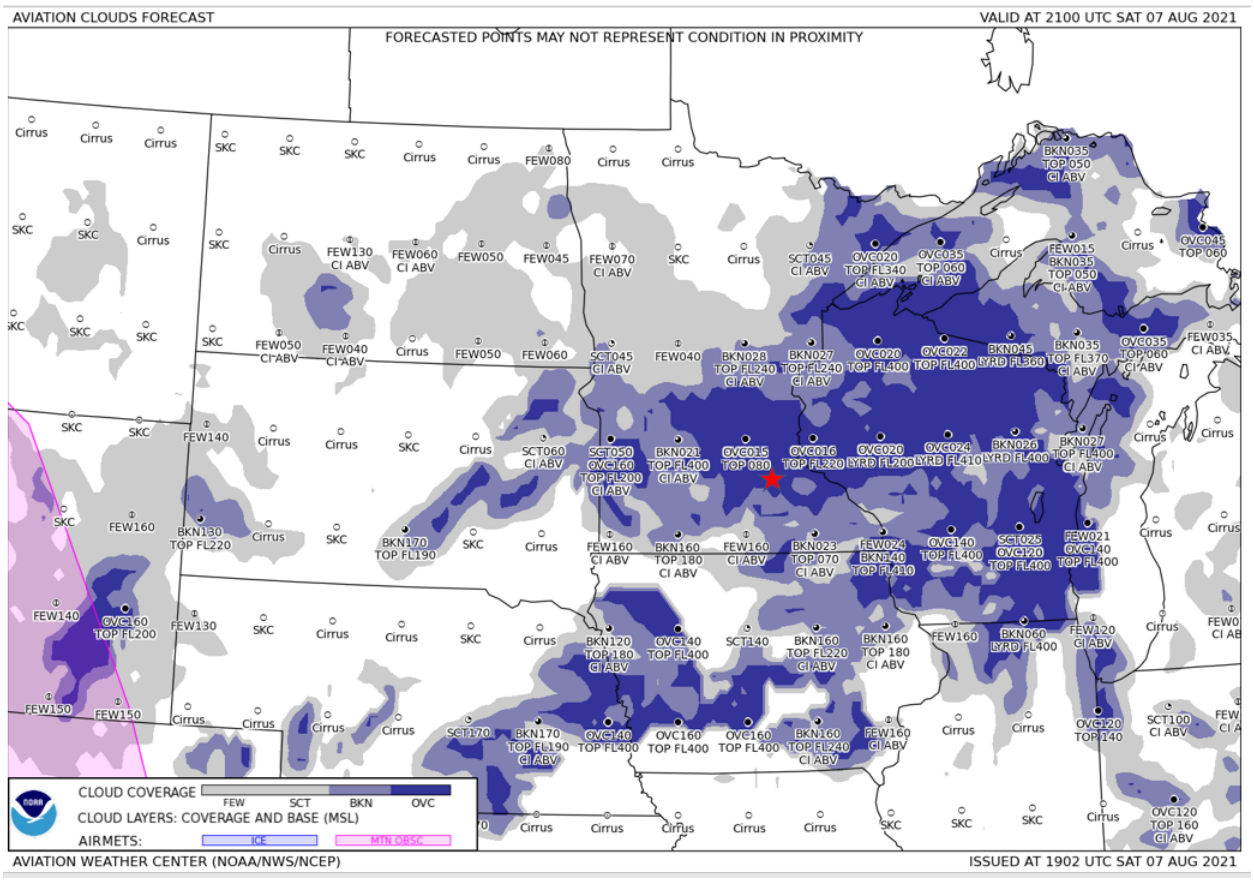

Figure 10 - Graphic Forecast for Aviation Cloud Forecast valid for 1600 CDT.

6.4 Winds and Temperature Aloft Forecast

The NWS Wind and Temperature Aloft Forecasts (FB) are computer-prepared forecasts of wind direction, wind speed, and temperature at specified times, altitudes, and locations. The forecast valid for 1900 CDT and for use between 1500 and 2200 CDT for the route of flight were as follows.

WINDS ALOFT FORECASTS
DATA BASED ON 071800Z
VALID 080000Z FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
AXN	1120	2213+18	2420+11	2419+05	2632-09	2326-19	243037	234547	235456
MSP	1611	2315+17	2623+11	2621+05	2825-09	2524-19	233635	244846	235457

The closest forecast point was for Minneapolis-St Paul International Airport (MSP), Minneapolis, MN, located approximately 19 miles east of the accident site. The forecast for 3,000 ft expected wind from 160° at 11 knots, and at 6,000 ft from 230° at 15 knots with a temperature of 17°C.

7.0 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 air route traffic control centers (ARTCCs). There are four basic types of inflight aviation weather advisories: the Significant Meteorological Information (SIGMET), the Convective SIGMET, the 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. The following advisories were current during the period.

7.1 Convective SIGMET

The NWS AWC had Convective SIGMET 9C current over portions of Wisconsin, Minnesota, and Iowa at 1655 CDT and valid until 1855 CDT, and subsequently updated at 1755 CDT. The advisory extended well to the east of the accident site over extreme eastern Minnesota and Iowa, and over Wisconsin and is depicted over the GOES-16 visible satellite image at the time of issuance in figure 11.

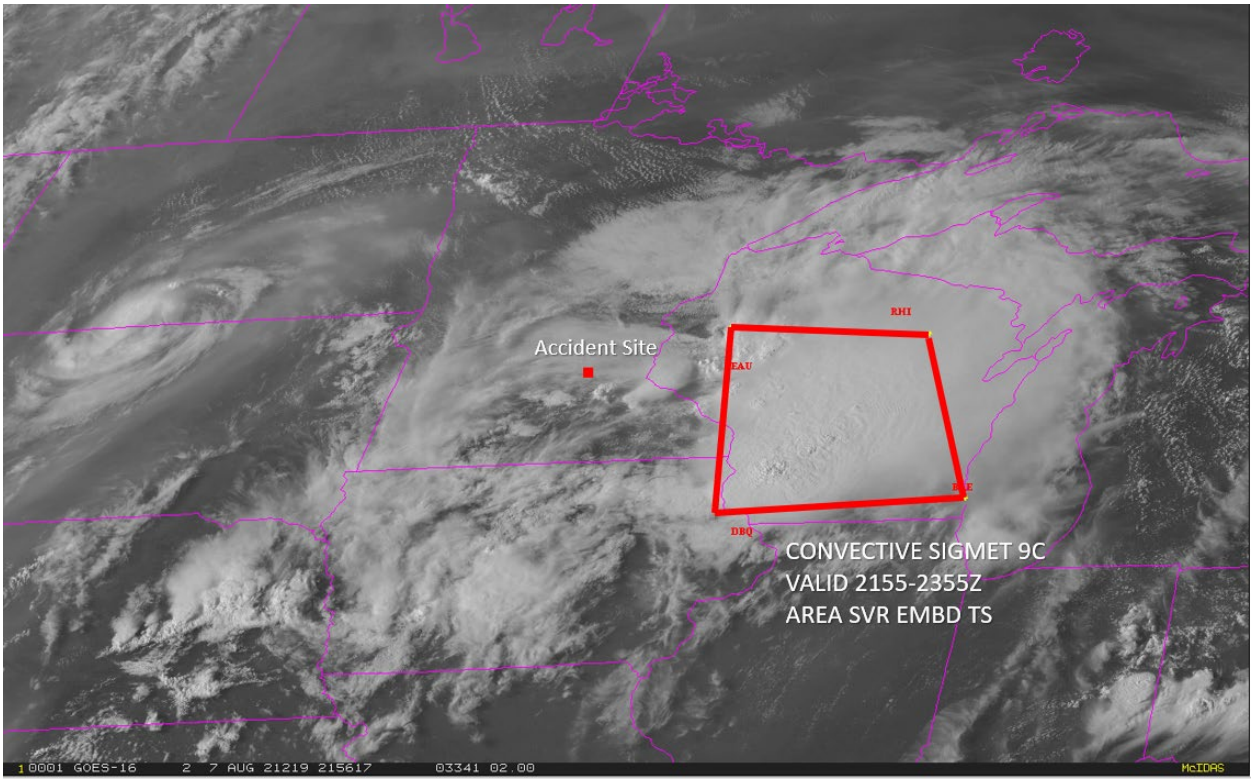

Figure 11 - Convective SIGMET 9C over the GOES-16 visible satellite image at 1656 CDT.

The text of the advisory was as follows.

WSUS32 KKCI 072155
SIGC
-MKCC WST 072155
CONVECTIVE SIGMET 09C
VALID UNTIL 2355Z
WI MN IA
FROM 40NNW EAU-30SE RHI-10SSE BAE-30NW DBQ-40NNW EAU
AREA SEV EMBD TS MOV FROM 29020KT. TOPS ABV FL450.
TORNADOES...HAIL TO 1 IN...WIND GUSTS TO 50KT POSS.

7.2 AIRMETs

The NWS Aviation Weather Center (AWC) issued a G-AIRMET Sierra[15] at 1545 CDT over the region for instrument flight rule conditions (IFR) due to low ceilings below 1,000 ft and visibility below 3 miles in precipitation and mist and is depicted in figure 12 with the approximate accident site marked by the red star.

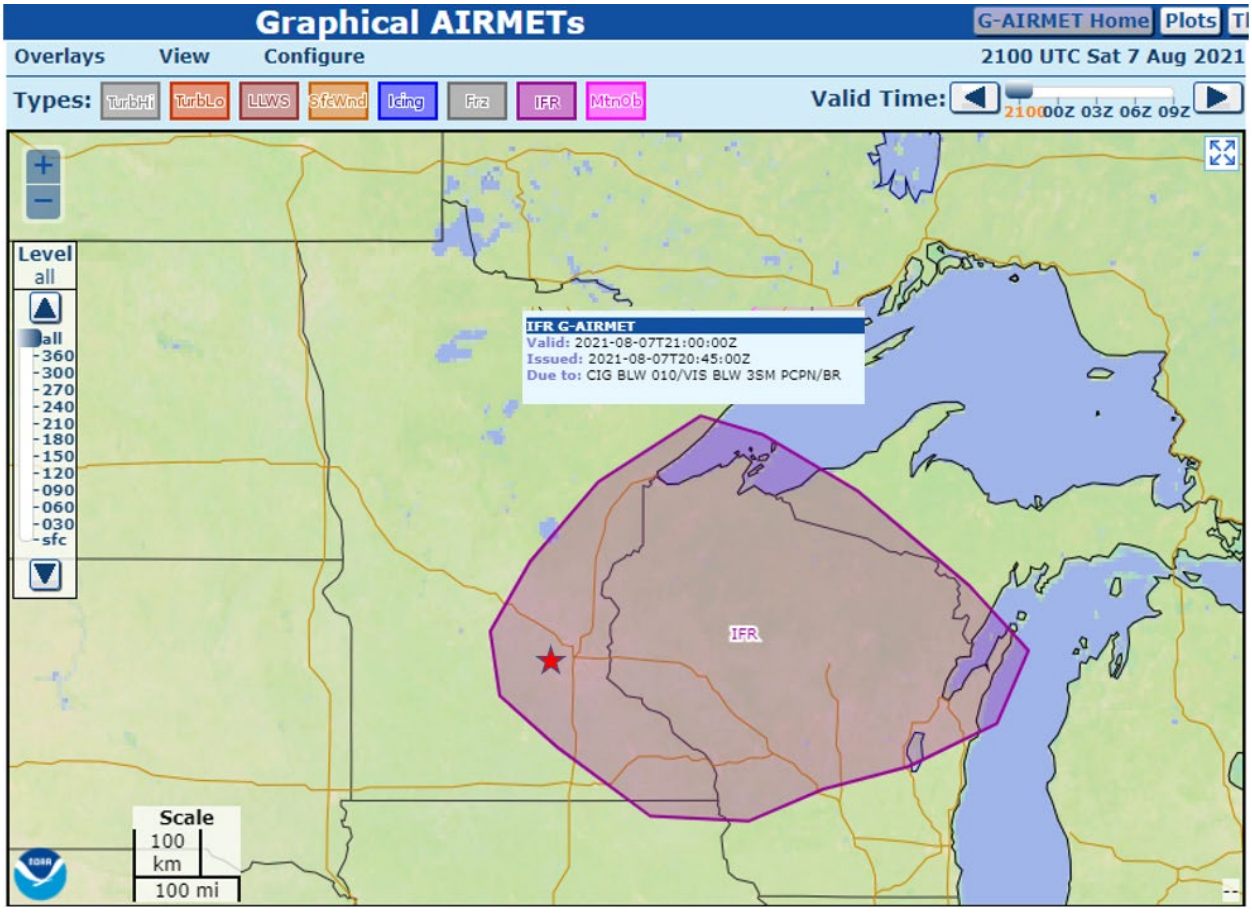

Figure 12 - G-AIRMET Sierra for IFR conditions valid at 1600 CDT with the accident site.

[15] It is unknown why the GFA Surface Forecast did not depict G-AIRMET Sierra for IFR conditions.

8.0 Astronomical Conditions

The astronomical conditions were calculated using the United States Naval Observatory's Multiyear Interactive Computer Alamac (MICA) software for Minneapolis, MN. The time of the accident has been added for reference in italic bold type.

Sun	Time
Begin civil twilight	0533 CDT
Sunrise	0605 CDT
Culmination	1318 CDT
Accident	***1740 CDT***
Sunset	2031 CDT
End civil twilight	2103 CDT

At the time of the accident the Sun was 28° above the horizon at an azimuth of 264°.

9.0 Preflight Weather Briefing

A search of the FAA contract Automated Flight Service Station (AFSS) provider Leidos indicated that they had no contact with the accident pilot of N9156Z for any preflight weather or inflight contacts on the day of the accident. They did indicate that a 3rd party vendor, Garmin had filed an IFR flight plan for the flight utilizing their system. It is unknown what weather information the pilot may have reviewed prior to departure or may have obtained for the flight. A separate search of ForeFlight indicated that the pilot did not have an account with the company and did not use their services for any weather briefing products.

10.0 Witness Statement

The pilots who landed in a King Air immediately ahead of the accident airplane were interviewed regarding the conditions they encountered on approach and what they heard on frequency as they landed. Their full interviews are included in the docket.

The pilot flying the King Air with almost 40 years of flying experience and over 12,000 hours logged, indicated that they were cleared for the ILS approach into KFCM and entered clouds about 4,500 ft and broke out at 1,000 ft msl. He indicated that after they were cleared for the approach and to land when they heard the Mooney accident pilot on the radio. The King Air pilot indicated that the Mooney pilot seemed to be under pressure and indicated that the KFCM tower called the accident pilot several times, with the accident pilot coming back with a non-standard response of "roger". They then heard the controller provided a low altitude warning to the accident airplane and was again surprised by the accident pilot's response as just a "roger". The King Air pilot indicated that "things didn't seem right" and they waited on the ramp to see the Mooney land, which never occurred.

The King Air's copilot who was the pilot monitoring the approach indicated he remembered entering the clouds around 4,100 ft and breaking out near 2,100 ft msl, with instrument meteorological conditions in the clouds. He indicated that the layer of clouds was smooth with no turbulence while in the clouds. He also indicated that he heard the Mooney pilot and stated the

verbiage was not standard and the pilot seemed stressed. He remembered that the Mooney pilot on checking in on the approach frequency just said, “with you”. He heard ATC call the Mooney three times, before the Mooney acknowledged with “go ahead”. He also heard ATC call out a low altitude alert to the Mooney, which was answered by a short replay like “got it”. He summarized that the accident pilot seemed confused.

Submitted by:

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