



National Transportation Safety Board

**Office of Aviation Safety
Washington, D.C. 20594-2000**

October 24, 2016

**WEATHER STUDY
CEN16FA276**

A. Accident

Location: Plainfield, Illinois

Date: July 21, 2016

Time: about 1114 central daylight time (1614 UTC¹)

Aircraft: Piper PA-30; N7409Y

B. Meteorological Specialist

Mike Richards

Senior Meteorologist

National Transportation Safety Board

Operational Factors Division, AS-30

Washington, DC 20594-2000

C. Details of the Investigation

The National Transportation Safety Board's meteorological specialist did not travel in support of this accident investigation and gathered all weather data remotely. Unless otherwise noted, all times are in central daylight time (CDT) for July 21, 2016, directions are referenced to true north, distances are in nautical miles and heights are above mean sea level (msl).

Coordinates used for the accident location: 41.555° north latitude, 88.207° west longitude, elevation of about 615 feet.

¹ UTC – abbreviation for Coordinated Universal Time

Synoptic Conditions

The National Weather Service (NWS) Surface Analysis Chart for 1000 CDT is presented in figure 1. Figure 2 presents a 700-hectopascal (hPa) chart, which identifies heights, temperature, dew point temperature and wind observations near 10,000 feet.

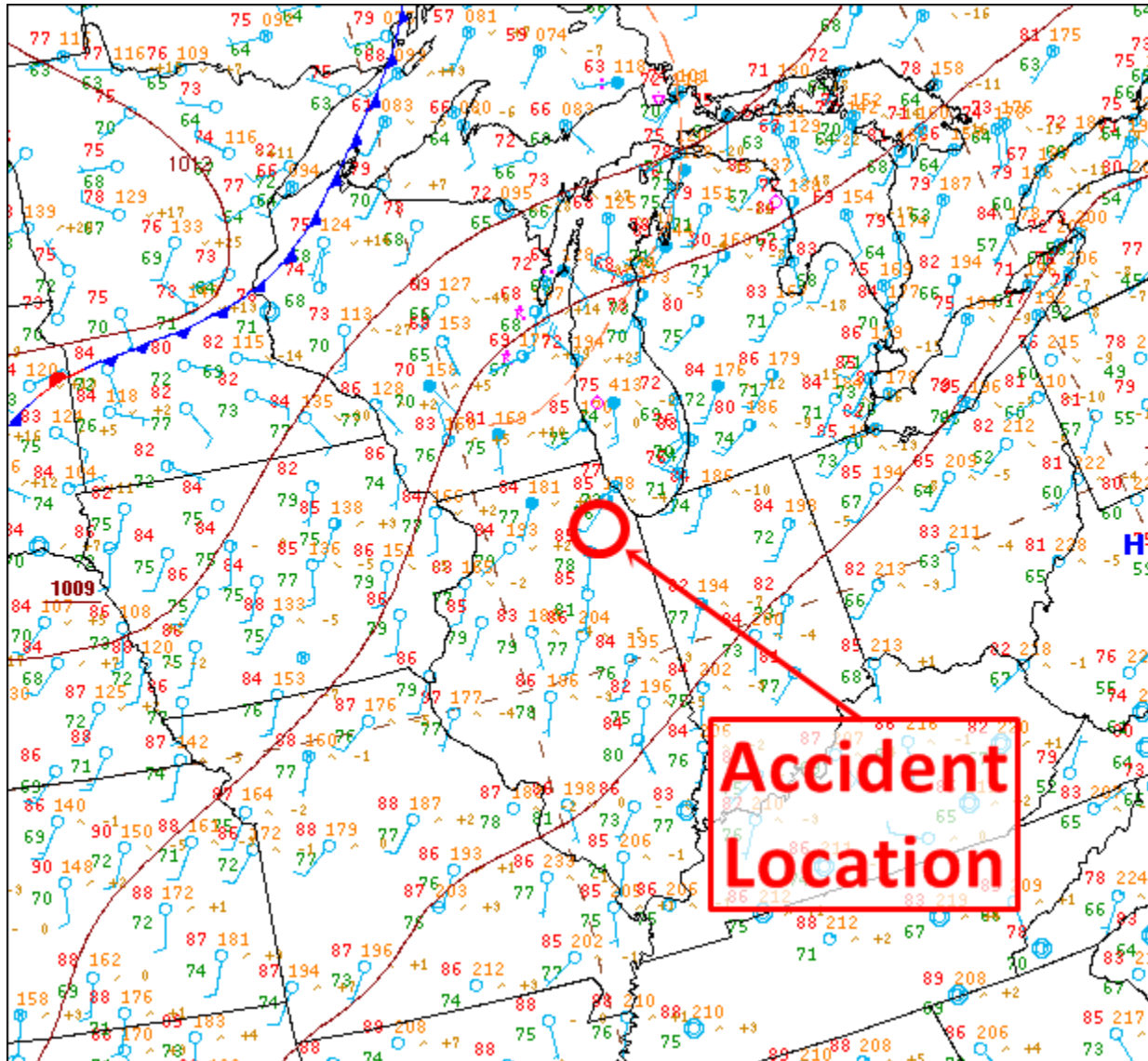


Figure 1 - NWS Surface Analysis Chart for 1000 CDT.

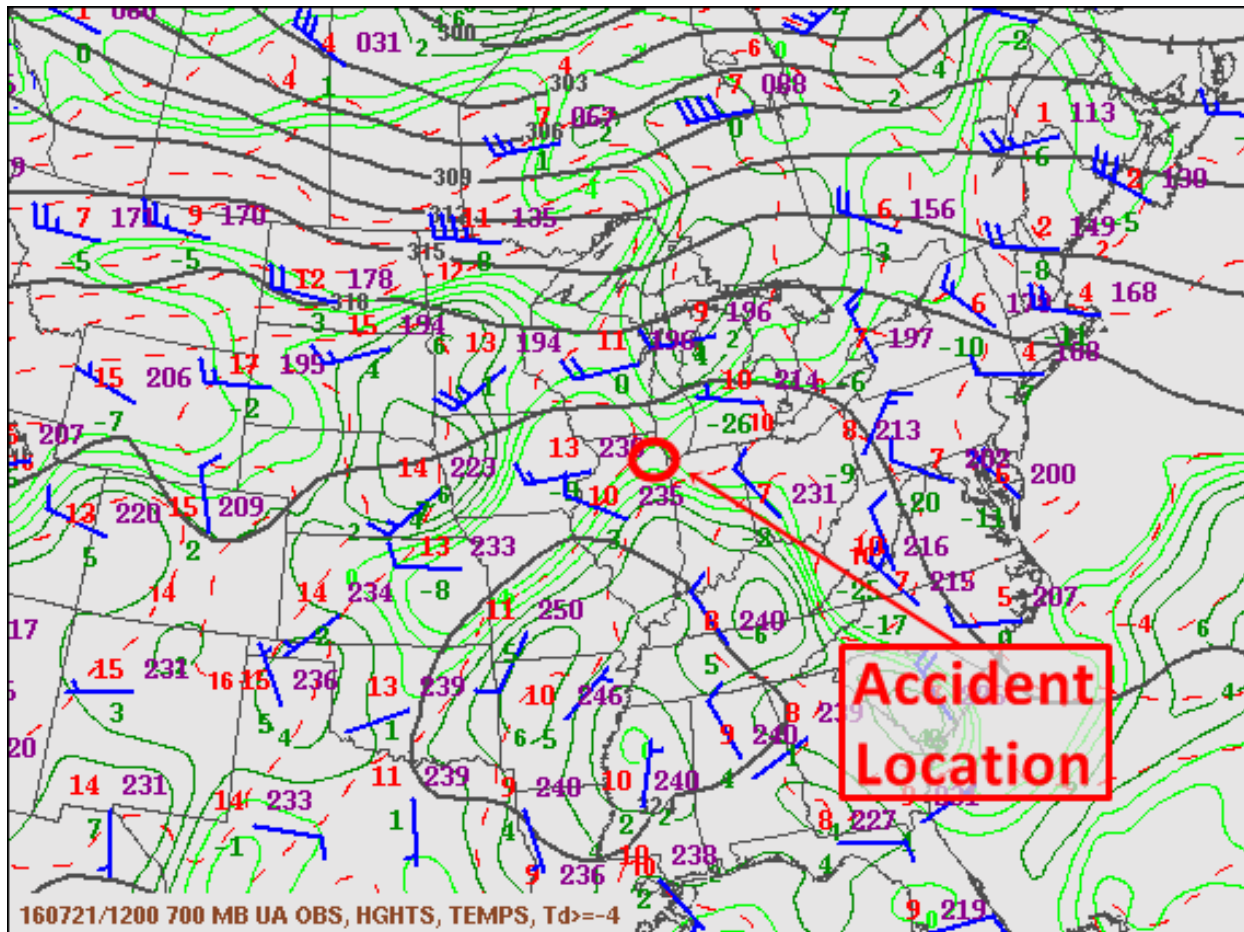


Figure 2 – 700 hPa chart from the Storm Prediction Center (SPC) for 0700 CDT.

Surface Observations

An Automated Weather Observing System (AWOS) was located at Joliet Regional Airport (JOT)² in Joliet, Illinois, about 2.5 miles south-southwest of the accident location at an elevation of 582 feet. Automated reports from JOT during the times surrounding the accident time are presented here:

[1015 CDT] KJOT 211515Z AUTO 23007KT 10SM CLR 31/26 A3009 RMK AO2
T03080259=

[1035 CDT] KJOT 211535Z AUTO 22005KT 10SM CLR 31/26 A3009 RMK AO2
T03060262=

[1055 CDT] KJOT 211555Z AUTO 21005KT 10SM CLR 31/26 A3009 RMK AO2
T03140264=

² The NWS uses the 4-digit International Civil Aviation Organization (ICAO) format for station identifiers (as seen in the body of some formatted weather observations). This report uses the 3-digit International Air Transport Association format for station identification, which does not use the geographic designating digit ("K" for stations in the continental U.S. and "P" for U.S. stations in Alaska and the Pacific region) as found in the ICAO format.

[1115 CDT] KJOT 211615Z AUTO 23007KT 10SM BKN021 32/27 A3010 RMK AO2 T03220267=
[1135 CDT] KJOT 211635Z AUTO 21003KT 10SM VCTS SCT021 BKN042 BKN050 31/27 A3010 RMK AO2 LTG DSNT NE AND E T03080270=
[1155 CDT] KJOT 211655Z AUTO 21004KT 10SM TS SCT020 SCT025 BKN042 31/27 A3009 RMK AO2 LTG DSNT NE AND E T03110271=
[1215 CDT] KJOT 211715Z AUTO 21003KT 10SM SCT021 BKN027 32/27 A3009 RMK AO2 LTG DSNT N THRU E T03150272=

At 1055 CDT, JOT reported a wind from 210° at 5 knots, visibility of 10 statute miles or greater, clear below 12,000 feet above ground level (agl), temperature of 31° Celsius (C) and a dew point temperature of 26°C, altimeter setting of 30.09 inches of mercury; remarks included: station with a precipitation discriminator.

At 1115 CDT, JOT reported a wind from 230° at 7 knots, visibility of 10 statute miles or greater, ceiling broken at 2,100 feet agl, temperature of 32°C and a dew point temperature of 27°C, altimeter setting of 30.10 inches of mercury; remarks included: station with a precipitation discriminator.

At 1135 CDT, JOT reported a wind from 210° at 3 knots, visibility of 10 statute miles or greater, thunderstorms in the vicinity³, scattered clouds at 2,100 feet agl, ceiling broken at 4,200 feet agl, broken clouds at 5,000 feet agl, temperature of 31°C and a dew point temperature of 27°C, altimeter setting of 30.10 inches of mercury; remarks included: station with a precipitation discriminator, distant⁴ lightning to the northeast and east.

At 1155 CDT, JOT reported a wind from 210° at 4 knots, visibility of 10 statute miles or greater, thunderstorm, scattered clouds at 2,000 feet agl, scattered clouds at 2,500 feet agl, ceiling broken at 4,200 feet agl, temperature of 31°C and a dew point temperature of 27°C, altimeter setting of 30.09 inches of mercury; remarks included: station with a precipitation discriminator, distant lightning to the northeast and east.

Five-minute data from the JOT AWOS was provided by DBT Transportation Services for the times surrounding the accident.

[1055 CDT] METAR KJOT 211555Z AUTO 21005KT 10SM CLR 31/26 A3009 RMK AO2 T03140264
[1100 CDT] METAR KJOT 211600Z AUTO 20006KT 10SM SCT021 31/27 A3009 RMK AO2 LTG DSNT NW T03130265
[1105 CDT] METAR KJOT 211605Z AUTO 22006KT 10SM SCT021 32/27 A3009 RMK AO2 LTG DSNT NW T03150266
[1110 CDT] METAR KJOT 211610Z AUTO 22006KT 10SM SCT021 32/27 A3009 RMK AO2 LTG DSNT NW T03190267
[1115 CDT] METAR KJOT 211615Z AUTO 23007KT 10SM BKN021 32/27 A3010 RMK AO2 T03220267

³ "In the vicinity" means between 5 and 10 nautical miles from the reporting station.

⁴ "Distant" means between 10 and 30 nautical miles from the reporting station.

[1120 CDT] METAR KJOT 211620Z AUTO 23006KT 10SM -RA BKN021 31/27 A3010 RMK AO2 T03090267

[1125 CDT] METAR KJOT 211625Z AUTO 23004KT 10SM -RA BKN021 BKN037 30/27 A3009 RMK AO2 T03030266

[1130 CDT] METAR KJOT 211630Z AUTO 22004KT 10SM VCTS BKN021 BKN037 OVC050 30/27 A3010 RMK AO2 T03040269

[1135 CDT] METAR KJOT 211635Z AUTO 21003KT 10SM VCTS SCT021 BKN042 BKN050 31/27 A3010 RMK AO2 LTG DSNT NE AND E T03080270

[1140 CDT] METAR KJOT 211640Z AUTO 21004KT 10SM TS SCT021 BKN039 BKN046 31/27 A3009 RMK AO2 LTG DSNT NE AND E T03070269

[1145 CDT] METAR KJOT 211645Z AUTO 22003KT 10SM TS SCT021 BKN039 BKN046 31/27 A3009 RMK AO2 LTG DSNT NE AND E T03070268

[1150 CDT] METAR KJOT 211650Z AUTO 21004KT 10SM TS SCT021 SCT027 BKN046 31/27 A3009 RMK AO2 LTG DSNT NE AND E T03100271

[1155 CDT] METAR KJOT 211655Z AUTO 21004KT 10SM TS SCT020 SCT025 BKN042 31/27 A3009 RMK AO2 LTG DSNT NE AND E T03110271

Attachment 1 to this report provides the one minute observations (OMO) from the JOT AWOS for the time period 1000-1200 CDT. During this time frame, lightning and/or thunderstorm information was included in the OMO during the time periods 1057-1111 CDT and 1130-1159 CDT.

An AWOS was located at Lewis University Airport (LOT) in Romeoville, Illinois, about 6 miles northwest of the accident location at an elevation of 582 feet. Automated reports from LOT during the times surrounding the accident time are presented here:

[1015 CDT] KLOT 211515Z AUTO 22009KT 10SM SCT049 30/24 A3009 RMK AO2 T02970236=

[1035 CDT] KLOT 211535Z AUTO 22006KT 10SM SCT049 30/24 A3009 RMK AO2 T02970241=

[1055 CDT] KLOT 211555Z AUTO 23009KT 10SM SCT021 SCT038 30/24 A3009 RMK AO2 T03030242=

[1115 CDT] KLOT 211615Z AUTO 24006KT 10SM SCT022 SCT031 BKN042 30/24 A3010 RMK AO2 T03030243=

[1135 CDT] KLOT 211635Z AUTO 25006KT 10SM SCT022 SCT038 BKN044 30/24 A3009 RMK AO2 LTG DSNT E THRU SW T03010244=

[1155 CDT] KLOT 211655Z AUTO 26007KT 10SM TS SCT021 SCT038 SCT047 31/25 A3009 RMK AO2 LTG DSNT E THRU S T03060248=

[1215 CDT] KLOT 211715Z AUTO 21005KT 10SM VCTS SCT020 SCT038 31/25 A3008 RMK AO2 LTG DSNT NE THRU SE T03050248=

At 1055 CDT, LOT reported a wind from 230° at 9 knots, visibility of 10 statute miles or greater, scattered clouds at 2,100 feet agl, scattered clouds at 3,800 feet agl, temperature of 30°C and a

dew point temperature of 24°C, altimeter setting of 30.09 inches of mercury; remarks included: station with a precipitation discriminator.

At 1115 CDT, LOT reported a wind from 240° at 6 knots, visibility of 10 statute miles or greater, scattered clouds at 2,200 feet agl, scattered clouds at 3,100 feet agl, ceiling broken at 4,200 feet agl, temperature of 30°C and a dew point temperature of 24°C, altimeter setting of 30.10 inches of mercury; remarks included: station with a precipitation discriminator.

At 1135 CDT, LOT reported a wind from 250° at 6 knots, visibility of 10 statute miles or greater, scattered clouds at 2,200 feet agl, scattered clouds at 3,800 feet agl, ceiling broken at 4,400 feet agl, temperature of 30°C and a dew point temperature of 24°C, altimeter setting of 30.09 inches of mercury; remarks included: station with a precipitation discriminator, distant lightning to the east through southwest.

At 1155 CDT, LOT reported a wind from 260° at 7 knots, visibility of 10 statute miles or greater, thunderstorm, scattered clouds at 2,100 feet agl, scattered clouds at 3,800 feet agl, scattered clouds at 4,700 feet agl, temperature of 31°C and a dew point temperature of 25°C, altimeter setting of 30.09 inches of mercury; remarks included: station with a precipitation discriminator, distant lightning to the east through south.

Five-minute data from the LOT AWOS was provided by DBT Transportation Services for the times surrounding the accident.

[1055 CDT]	METAR KLOT 211555Z AUTO 23009KT 10SM SCT021 SCT038 30/24 A3009 RMK AO2 T03030242
[1100 CDT]	METAR KLOT 211600Z AUTO 25006KT 10SM SCT038 31/25 A3009 RMK AO2 LTG DSNT N T03070245
[1105 CDT]	METAR KLOT 211605Z AUTO 23004KT 10SM SCT022 SCT031 SCT038 31/25 A3009 RMK AO2 LTG DSNT N T03090246
[1110 CDT]	METAR KLOT 211610Z AUTO 24006KT 10SM SCT022 SCT031 BKN040 31/25 A3010 RMK AO2 LTG DSNT N T03100246
[1115 CDT]	METAR KLOT 211615Z AUTO 24006KT 10SM SCT022 SCT031 BKN042 30/24 A3010 RMK AO2 T03030243
[1120 CDT]	METAR KLOT 211620Z AUTO 24007KT 10SM SCT022 SCT031 BKN044 30/24 A3009 RMK AO2 T03020242
[1125 CDT]	METAR KLOT 211625Z AUTO 27007KT 10SM SCT022 SCT031 BKN042 31/25 A3009 RMK AO2 T03060246
[1130 CDT]	METAR KLOT 211630Z AUTO 25006KT 10SM SCT022 SCT035 BKN042 31/25 A3009 RMK AO2 LTG DSNT SW T03060245
[1135 CDT]	METAR KLOT 211635Z AUTO 25006KT 10SM SCT022 SCT038 BKN044 30/24 A3009 RMK AO2 LTG DSNT E THRU SW T03010244
[1140 CDT]	METAR KLOT 211640Z AUTO 24006KT 10SM TS SCT038 BKN044 SCT075 30/25 A3009 RMK AO2 LTG DSNT E THRU SW T03010245
[1145 CDT]	METAR KLOT 211645Z AUTO 23006KT 10SM TS SCT044 SCT075 31/25 A3009 RMK AO2 LTG DSNT E THRU S T03070251

[1150 CDT] METAR KLOT 211650Z AUTO 24007KT 10SM TS SCT021 SCT040
SCT047 31/25 A3009 RMK AO2 LTG DSNT E THRU S T03100249

[1155 CDT] METAR KLOT 211655Z AUTO 26007KT 10SM TS SCT021 SCT038
SCT047 31/25 A3009 RMK AO2 LTG DSNT E THRU S T03060248

On August 16, 2016, the NTSB discussed the JOT and LOT AWOSs' METAR reporting criteria for thunderstorms and lightning with the stations' field service engineer from DBT Transportation Services.⁵ The field service engineer indicated that both the JOT and LOT AWOSs were AWOS-3pt systems, and both had an "SA-20" lightning detection system installed. The SA-20 sensor provides cloud-to-cloud, cloud-to-ground and cloud-to-air lightning detection. Publically disseminated METARs from JOT and LOT are made every 20 minutes, and lightning must be detected within the previous one minute of the report in order to trigger appropriate thunderstorm and/or lightning parameters in the publically-disseminated METAR. No "specials" are issued from these AWOS stations though internal reports are generated every minute, which are available via radio and phone.

Weather Radar

WSR-88D Level-II weather radar imagery from Chicago, Illinois (KLOT), are presented in figures 3 and 4. KLOT was located approximately 6 miles northeast of the accident site at an elevation of about 633 feet. Assuming standard refraction and considering the 0.95° beam width for the WSR-88D radar beam, the KLOT 9.94° (at 1110:42 CDT) and 0.49° (at 1111:15 CDT) tilts would have "seen" altitudes above the accident location of between about 6,675 and 7,280 feet msl and between about 700 and 1,300 feet msl, respectively. The KLOT imagery surrounding the accident time identified reflectivity features consistent with convection immediately adjacent to the accident aircraft's position immediately prior to the accident time.

⁵ At the time of the accident, this field service engineer worked for Vaisala, who at that time provided maintenance for the JOT and LOT AWOSs.

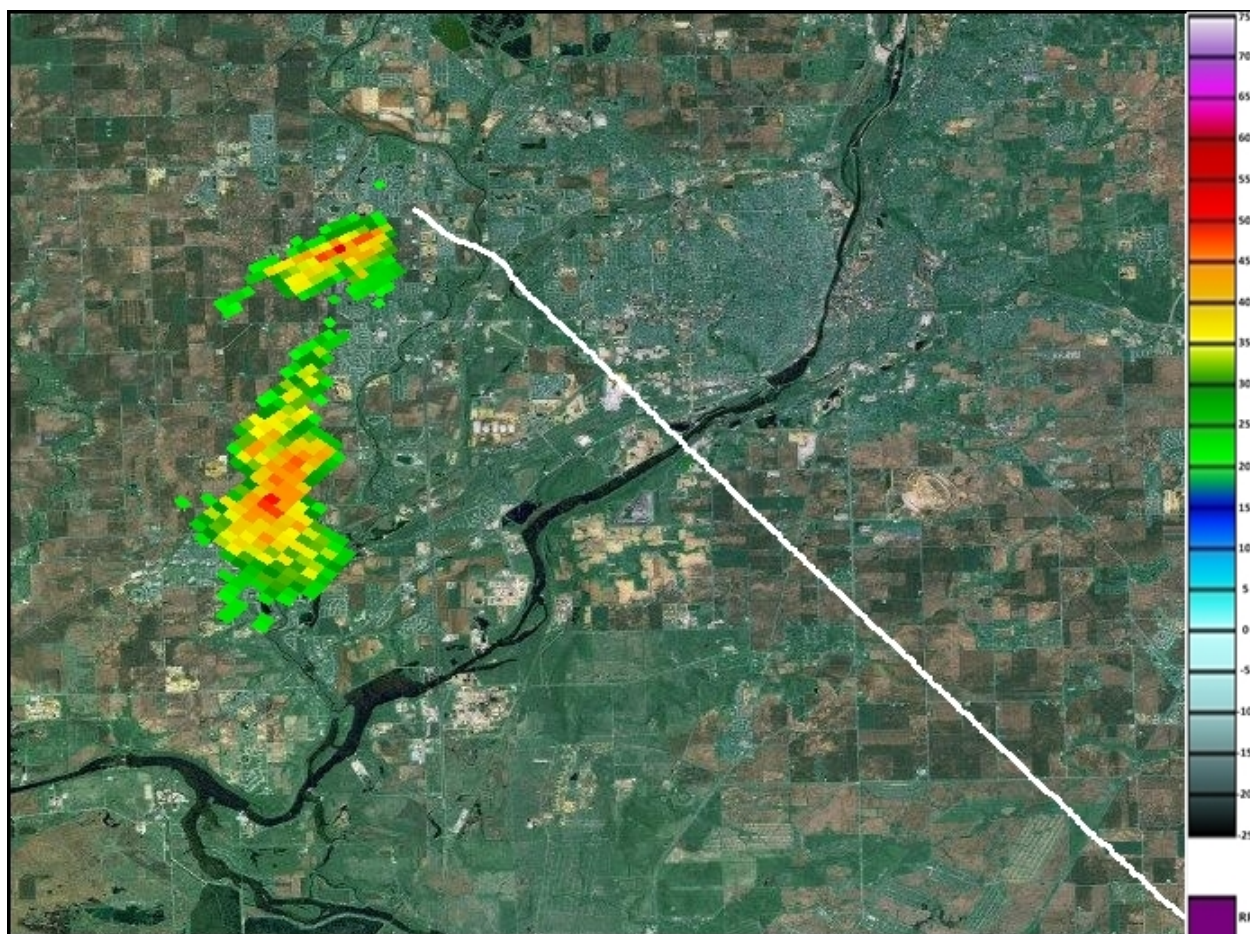


Figure 3 – KLOT 9.94° Level-II reflectivity product from 1110:42 CDT.

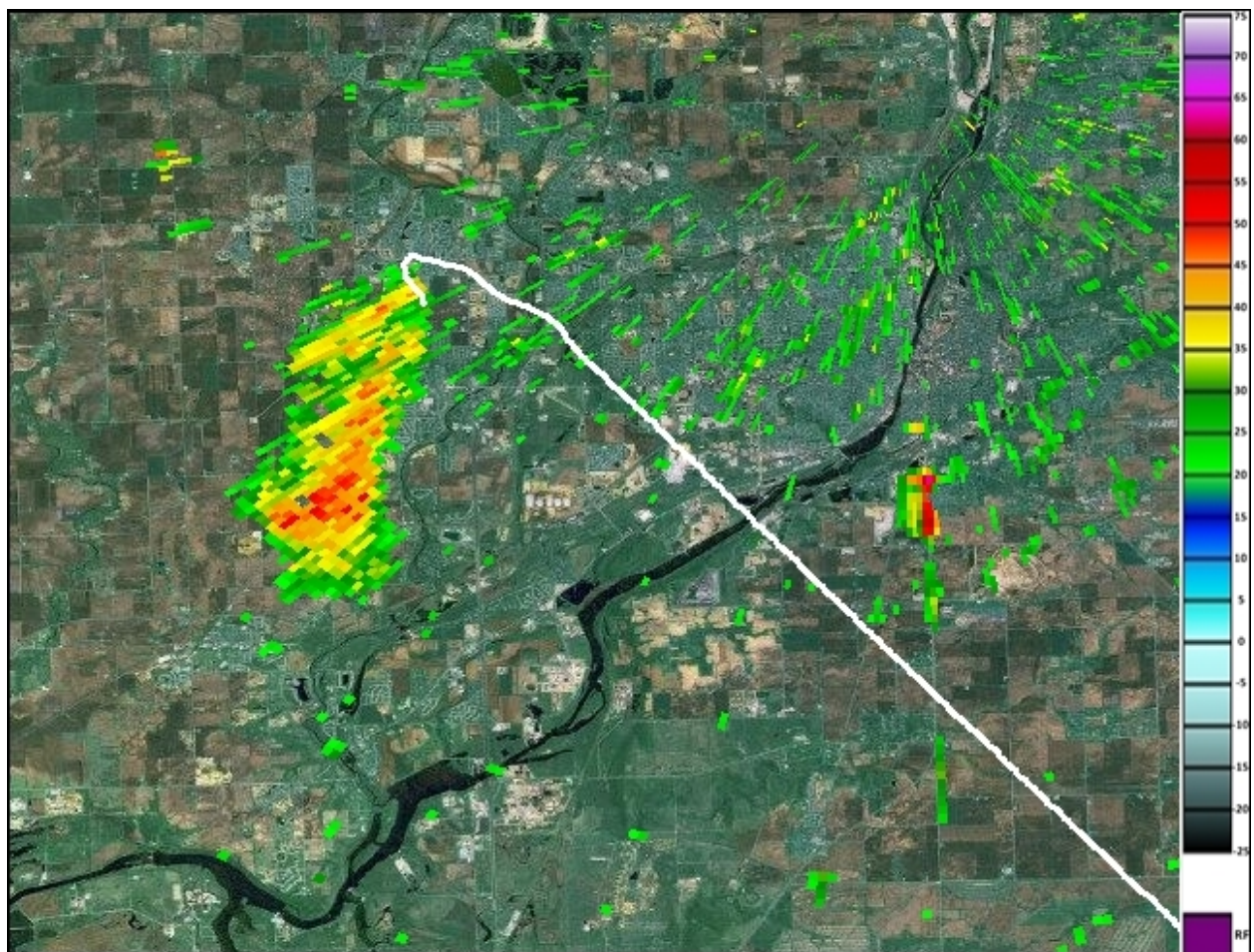


Figure 4 – KLOT 0.49° Level-II reflectivity product from 1111:15 CDT.

Weather radar data obtained from the Standard Terminal Automation Replacement System (STARS) at the Chicago Terminal Radar Approach Control (C90) were provided by the FAA, and replayed by the NTSB using a separate playback program. Replay of weather radar between about 1052 and 1115 CDT from these STARS data, at 5x normal speed and focusing on the convective cell(s) presented in figures 3 and 4, can be found in the docket for this accident, and include weather radar from the following individual radars as well as a “composite”⁶ weather radar product.

Radar ID	Radar Type	Latitude	Longitude	Antenna Height (ft msl)
ORD	ASR-9	41:58:48.57 N	087:55:39.97 W	754
ORN	ASR-9	42:00:30.400 N	087:54:26.080 W	741
JOL	ARSR-3	41:25:21.590 N	088:03:29.770 W	750
MKE	ASR-9	42:56:32.420 N	087:55:06.91 W	804
QXM	ASR-9	41:37:17.380 N	087:46:10.120 W	766
CPV	AN/FPS-66A	43:02:44.140 N	085:59:27.460 W	754
QHZ	ARSR-2	43:26:45.47N	088:29:32.38 W	1,276
DPA	ASR-9	41:53:26.88 N	088:14:40.53 W	844

It should be noted that in these replays available in the docket for this accident, the time stamp is in UTC. In addition, around the 1105:00 CDT (1605:00 UTC) time in each replay, temporary “blanking” of the weather depiction, or several seconds of missing replay may be observed. These are likely owed to the replay reproduction process and not characteristic of the data themselves.

Figure 5 describes how different radar levels are presented in the STARS display. The aforementioned replays present a slightly different color (green/blue) shading, however the solid color/dots are consistent.

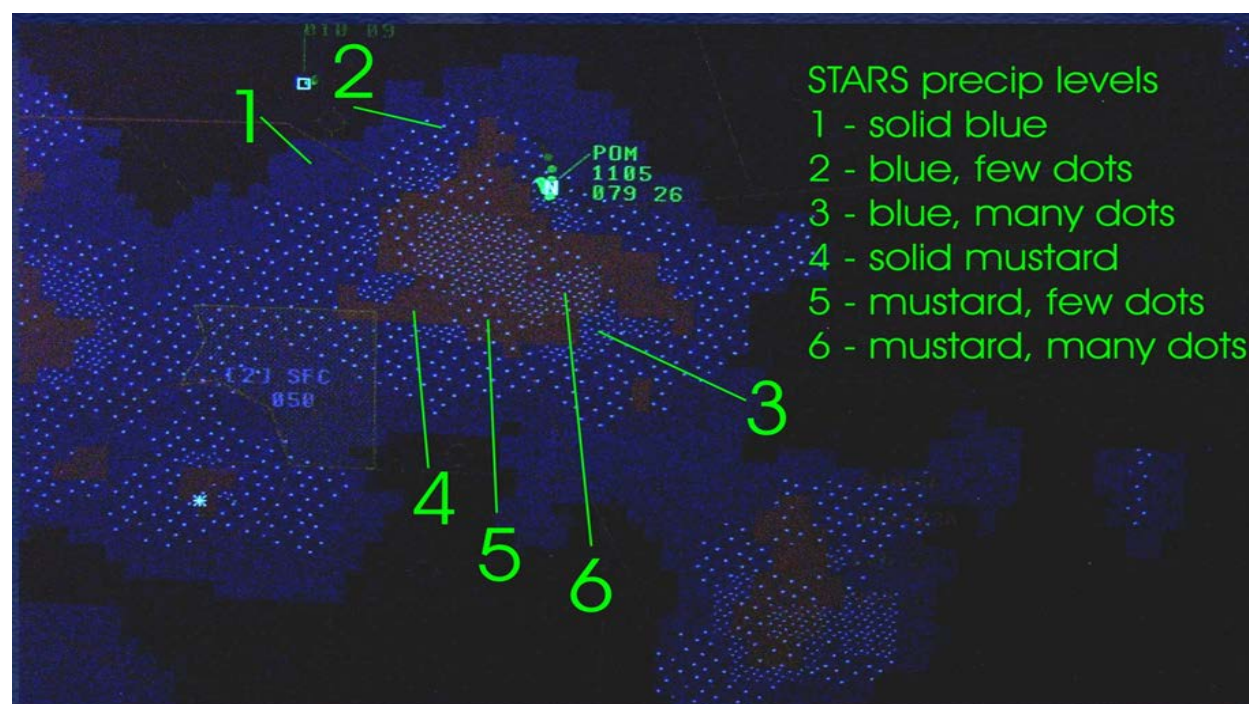


Figure 5 – Example of weather radar presentation in STARS.

⁶ It is not known what radars contribute to the composite radar product.

According to the FAA the dBZ thresholds for the color scale (levels) presented in the STARS display are as follows:

Level 1: 18 < 30 dBZ
Level 2: 30 < 41 dBZ
Level 3: 41 < 46 dBZ
Level 4: 46 < 50 dBZ
Level 5: 50 < 57 dBZ
Level 6: 57+ dBZ

Review of the replays identified the following. The maximum precipitation level depicted in the composite replay was Level 3, which occurred during the time periods of 1101:30 - 1102:31 CDT and 1106:31 - 1106:49 CDT. The only individual radar that depicted a Level 3 precipitation level was ORD, which depicted Level 3 precipitation during the time period of 1101:22 - 1102:19 CDT. The maximum precipitation level depicted in the ORN, QXM and DPA radar replays was Level 2. There was no precipitation depicted in the CPV, JOT, MKE and QHZ radar replays.

The FAA also provided screen shots of the Integrated Terminal Weather System (ITWS) Situation Display applicable to the Chicago area for the time period surrounding the accident. Images from the ITWS Situation Display for 1103 and 1108 CDT are presented in Attachment 2.

Also included in Attachment 2 are radar imagery from KLOT, the Milwaukee, Wisconsin, WSR-88D (KMKX)⁷, the Terminal Doppler Weather Radar (TDWR) located near Chicago O'Hare International Airport (TORD)⁸ and the TDWR located near Chicago Midway International Airport (TMDW)⁹. Attachment 2 contains imagery from almost all tilts¹⁰ available from these radars between about 1052 and 1112 CDT, as well as information regarding the beam height above the accident location for each applicable tilt.

Lightning

Figure 6 presents the total lightning activity detected by the Earth Networks Total Lightning Network (ENTLN) in the accident region between 1030 and 1200 CDT. Lightning activity is identified in the figure by their time stamps (in UTC). Attachment 3 to this report presents these data, including current and lightning type, in tabular form.

⁷ KMKX was located about 86 miles north of the accident location.

⁸ TORD was located about 21 miles northeast of the accident location.

⁹ TMDW was located about 22 miles east-northeast of the accident location.

¹⁰ Tilts above 3.17° for KMKX were not considered.

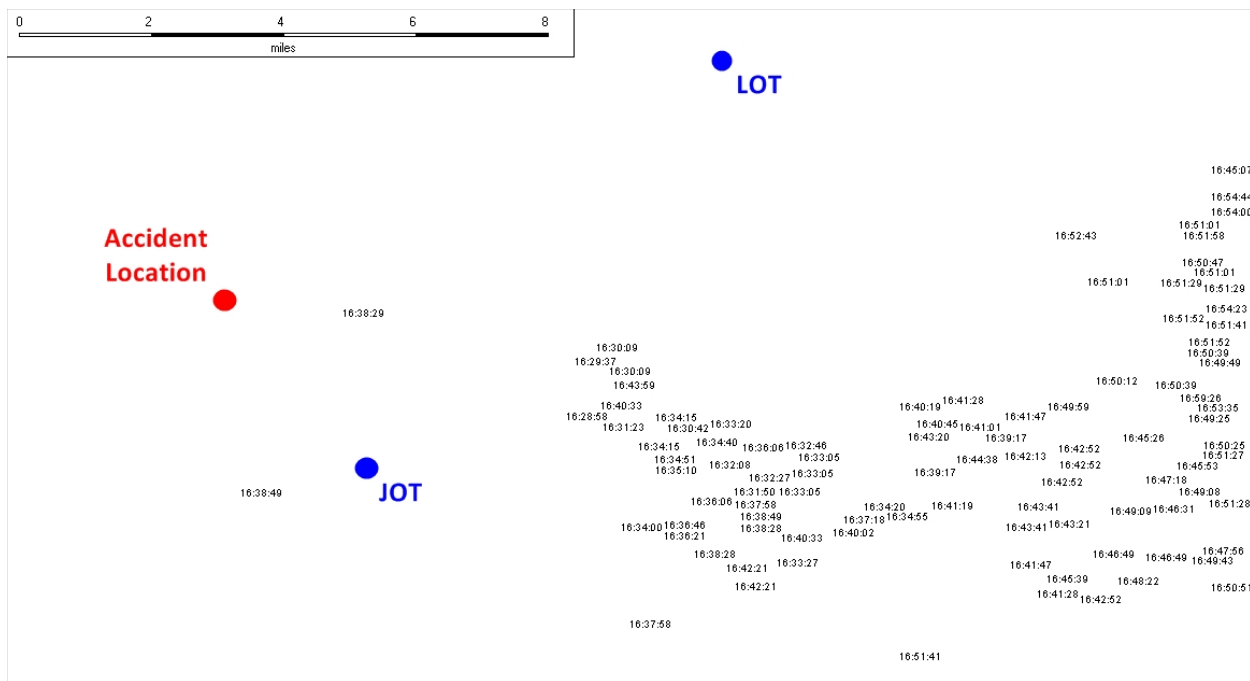


Figure 7 – ENTLN lightning activity between 1030 and 1200 CDT.

Figure 7 presents the total lightning activity detected by the Vaisala's National Lightning Detection Network (NLDN) in the accident region between 1030 and 1200 CDT. Lightning activity is identified in the figure by their time stamps (in UTC). Attachment 4 to this report presents these data, including current and lightning type, in tabular form.

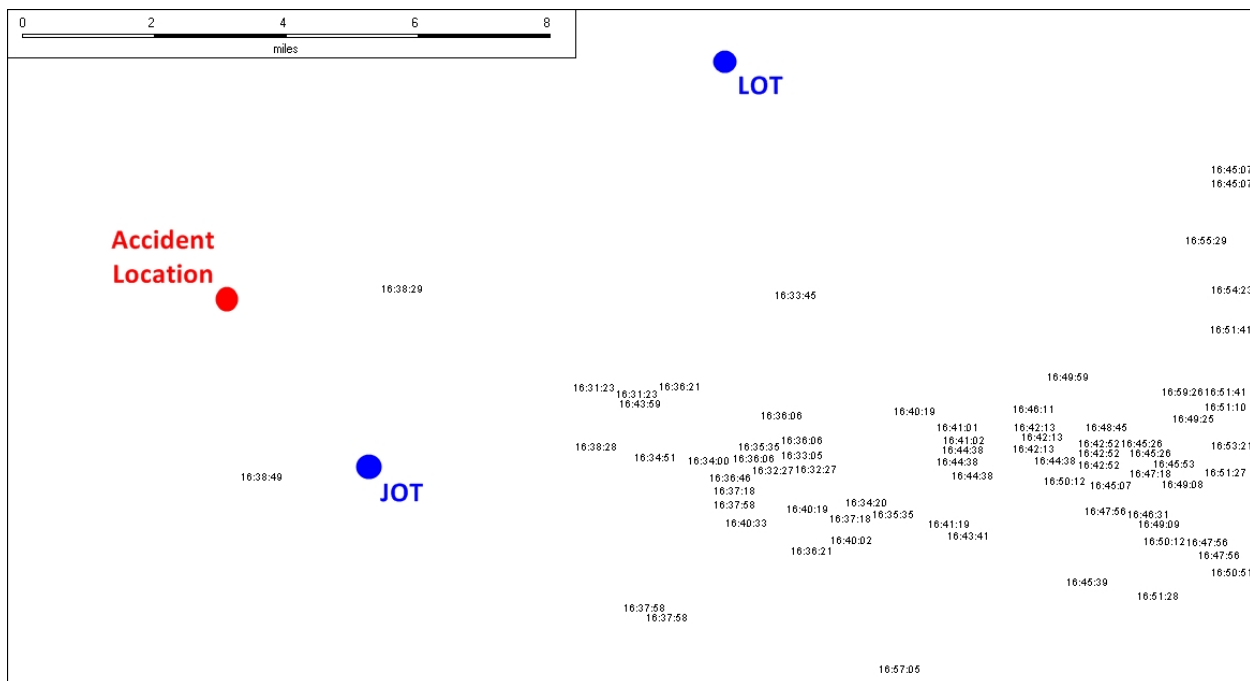


Figure 7 – NLDN lightning activity between 1030 and 1200 CDT.

Pilot Reports

There were no publicly disseminated pilot reports¹¹ made within two hours of the accident time and 50 miles of the accident location.

Upper Air Data

A North American Mesoscale (NAM) model sounding (figure 6) for the accident location at 1000 CDT was retrieved from the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory. Near the surface the wind was from the southwest at about 10 knots. Above this level the wind veered¹² with height and stayed at magnitudes between 10-20 knots, with the wind at about 15,000 feet being from the northwest at about 20 knots. Calculations made by the Rawinsonde OBservation program (RAOB) did not yield any significant areas of non-convective turbulence for this atmosphere. The freezing level was at about 16,000 feet.

The most-unstable Convective Available Potential Energy (CAPE)¹³ parameter was 4,207 Joules/kilogram (from 995 hPa). The Lifting Condensation Level¹⁴ (LCL) and Level of Free Convection¹⁵ (LFC) were calculated to be 2,155 feet and 3,639 feet, respectively. Maximum vertical velocity (MVV) for this atmosphere was calculated as 92 meters/second (about 18,100 feet per minute). Downdraft CAPE (DCAPE)¹⁶ was measured at 1,194 Joules/kilogram.

¹¹ Only pilot reports with the WMO header UBIL** were considered. PIREPs broadcast only over air traffic control frequencies were not considered.

¹² A "veering" wind is a wind that turns clockwise with increasing height.

¹³ Convective Available Potential Energy - A measure of the amount of energy available for convection. CAPE is directly related to the maximum potential vertical speed within an updraft; thus, higher values indicate greater potential for severe weather. 471 Joules/kilogram would be considered relatively weak.

¹⁴ Lifting Condensation Level - The level at which a parcel of moist air lifted dry-adiabatically would become saturated.

¹⁵ Level of Free Convection - The level at which a parcel of air lifted dry-adiabatically until saturated and saturation-adiabatically thereafter would first become warmer than its surroundings in a conditionally unstable atmosphere. On a thermodynamic diagram the level of free convection is given by the point of intersection of the process curve, representing the process followed by the ascending parcel, and the sounding curve, representing the lapse rate of temperature in the environment.

¹⁶ The DCAPE can be used to estimate the potential strength of rain-cooled downdrafts within thunderstorm convection, and is similar to CAPE. Larger DCAPE values are associated with stronger downdrafts. 736 Joules/kilogram would be considered a moderate value.

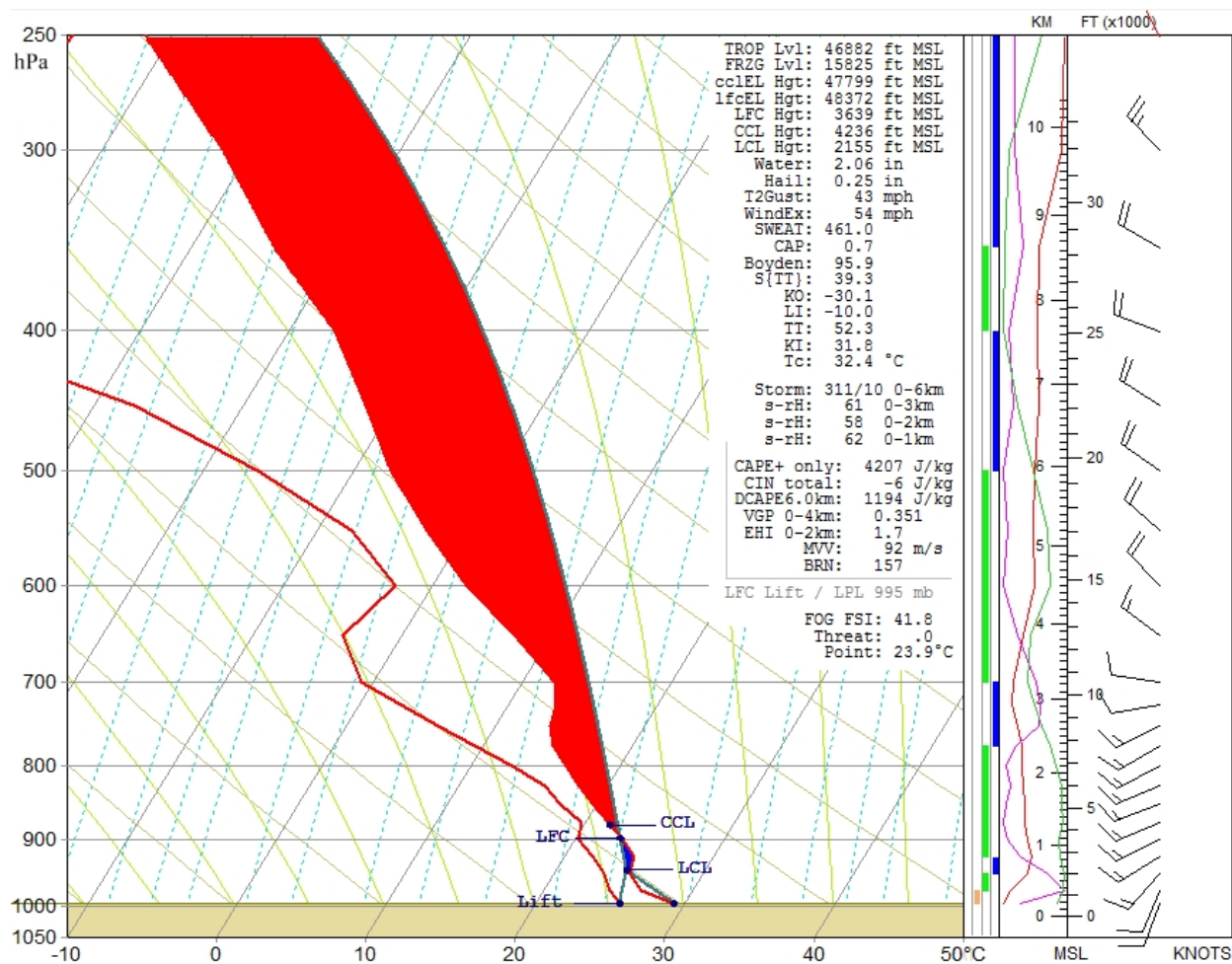


Figure 8 – NAM model sounding data in SkewT/LogP format for 1000 CDT at the accident site, surface to 250 hPa.

Meteorological data (including moisture information) from an AMDAR-reporting¹⁷ aircraft enroute to MDW, which flew through the accident region below 4,000 feet about 25-30 minutes prior to the accident time, are presented in table 1. Altitude is pressure altitude in feet¹⁸, wind direction (W-Dir) is referenced to true north, wind magnitude (W-Mag) is in knots, and temperature (Temp) and dew point temperature (D_Temp) is in °C.

Time	Latitude	Longitude	Altitude	W-Dir	W-Mag	Temp	D_Temp
1013	38.182	-90.051	39000	340°	24	-52.7°	-62.5°
1015	38.382	-89.971	37820	327°	17	-50.7°	-62.1°
1016	38.522	-89.931	36890	330°	18	-48.2°	-63.9°
1017	38.632	-89.891	35950	324°	20	-46.5°	-59.7°
1018	38.752	-89.841	35000	306°	17	-44.0°	-57.9°
1020	39.102	-89.711	34160	302°	16	-42.1°	-56.4°
1021	39.222	-89.671	31250	326°	9	-34.7°	-52.4°
1022	39.352	-89.621	31000	331°	9	-34.0°	-50.1°

¹⁷ AMDAR has been a generally-accepted, worldwide term for automated weather reports from commercial aircraft.

¹⁸ These altitudes are calculated from the aircraft's static pressure according to the International Standard Atmosphere regardless of altitude (1013.25 hPa is always surface pressure).

1023	39.402	-89.601	31010	339°	10	-34.0°	-47.7°
1026	39.722	-89.481	29840	326°	12	-30.7°	-45.0°
1027	39.852	-89.431	28890	303°	12	-28.7°	-41.4°
1028	39.982	-89.411	27860	316°	10	-26.6°	-36.6°
1029	40.102	-89.391	26820	306°	14	-24.0°	-34.8°
1030	40.222	-89.321	25770	307°	13	-22.0°	-40.1°
1031	40.332	-89.241	24750	290°	14	-19.7°	-40.7°
1032	40.432	-89.161	23730	289°	15	-17.6°	-34.8°
1033	40.552	-89.081	22700	290°	14	-15.4°	-32.0°
1034	40.652	-89.001	21130	283°	15	-11.8°	-21.8°
1035	40.752	-88.921	19530	310°	15	-10.9°	-10.9°
1036	40.852	-88.851	16910	304°	19	-4.3°	-6.7°
1037	40.952	-88.781	14380	317°	15	1.1°	-6.6°
1038	41.052	-88.721	11830	306°	16	7.8°	-1.8°
1039	41.132	-88.661	10010	282°	11	12.1°	0.8°
1040	41.222	-88.611	9760	272°	16	11.3°	2.8°
1041	41.282	-88.561	8320	255°	18	12.7°	7.9°
1042	41.372	-88.511	6830	252°	22	15.2°	13.3°
1043	41.422	-88.431	6790	256°	19	15.1°	15.1°
1044	41.472	-88.341	5640	253°	21	17.6°	16.8°
1045	41.522	-88.251	4540	252°	18	19.6°	19.6°
1046	41.552	-88.161	3800	254°	18	21.6°	21.6°
1047	41.602	-88.071	3810	254°	18	21.3°	21.3°
1048	41.632	-87.981	3800	252°	19	21.6°	20.9°
1049	41.682	-87.891	3810	254°	19	21.6°	20.7°
1050	41.722	-87.801	3810	253°	18	21.6°	20.9°
1051	41.752	-87.701	3810	258°	19	21.3°	21.1°
1052	41.752	-87.601	2850	256°	19	23.6°	22.8°
1053	41.752	-87.491	2790	256°	21	23.6°	23.4°
1054	41.802	-87.451	2810	247°	18	23.8°	22.6°
1055	41.832	-87.501	2800	247°	15	22.7°	22.7°
1056	41.832	-87.581	2640	244°	11	23.1°	23.1°
1057	41.832	-87.651	2210	252°	10	24.8°	23.9°
1058	41.822	-87.701	1430	243°	8	26.7°	24.4°
1059	41.782	-87.731	700	215°	9	29.1°	25.0°

Table 1 – AMDAR meteorological data received from AC#11179

The AMDAR data in SkewT/LogP format is presented in figure 9. Near the surface the wind was from the west-southwest at about 8 knots. Above this level the wind veered with height and stayed at magnitudes between about 10-20 knots, with the wind at about 14,000 feet being from the northwest at about 15 knots. Calculations made by the RAOB did not yield any significant areas of non-convective turbulence for this atmosphere. The freezing level was at about 15,800 feet.

The most-unstable CAPE parameter was 3,501 Joules/kilogram (from 913 hPa). The LCL and LFC were calculated to be 3,079 feet and 3,168 feet, respectively. MVV for this atmosphere was calculated as 84 meters/second (about 16,500 feet per minute) and DCAPE was measured at 753 Joules/kilogram.

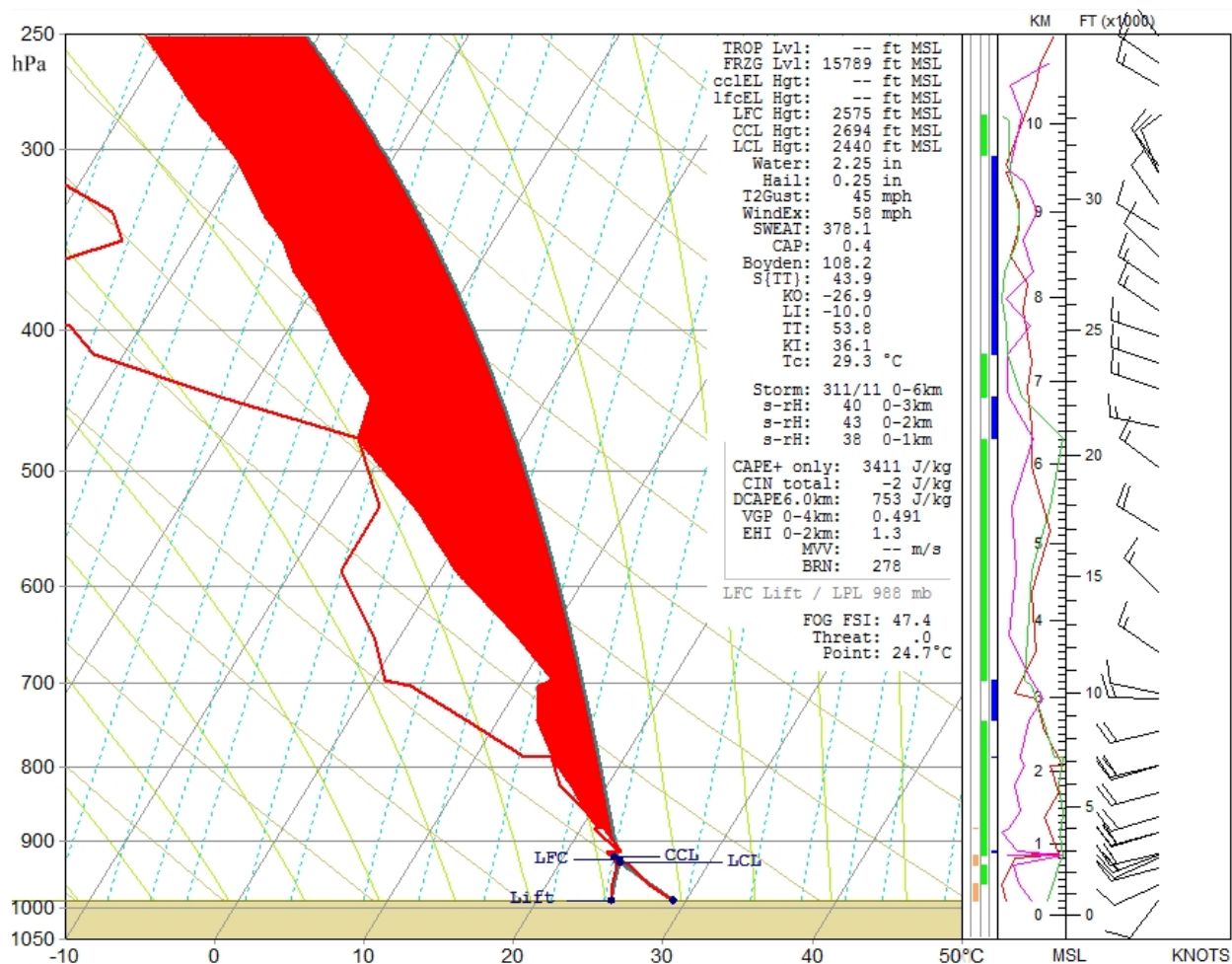


Figure 9 – AMDAR sounding data in SkewT/LogP format, surface to 250 hPa.

Satellite Imagery

Advanced very-high-resolution radiometer (AVHRR) visible (0.63 μ m) data from METOP-B were obtained from the NOAA. Geostationary Operational Environmental Satellite (GOES)-13 visible (0.63 μ m) and infrared (10.7 μ m) data were obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison. Imagery surrounding the time of the accident are presented in figures 10-12. The AVHRR imagery from 1052 CDT (figure 10) depicted relatively clear skies at the accident location about 20 minutes before the accident time. Cumulus-type clouds were seen to the west through north of the accident location at 1052 CDT. The GOES-13 imagery (figures 11 and 12) identified cumulus type clouds over the accident location at near the accident time. The minimum infrared cloud-top temperature near the accident site was -22°C. When considering the NAM model sounding, -22°C corresponded to cloud top heights of about 32,600 feet. It should be noted these figures have not been corrected for any parallax error, however a cloud element 10 kilometers high over the accident site would be shifted about 6 miles to the south-southeast to correct for parallax error in the GOES-13 imagery.



Figure 10 – AVHRR visible imagery from 1052 CDT.

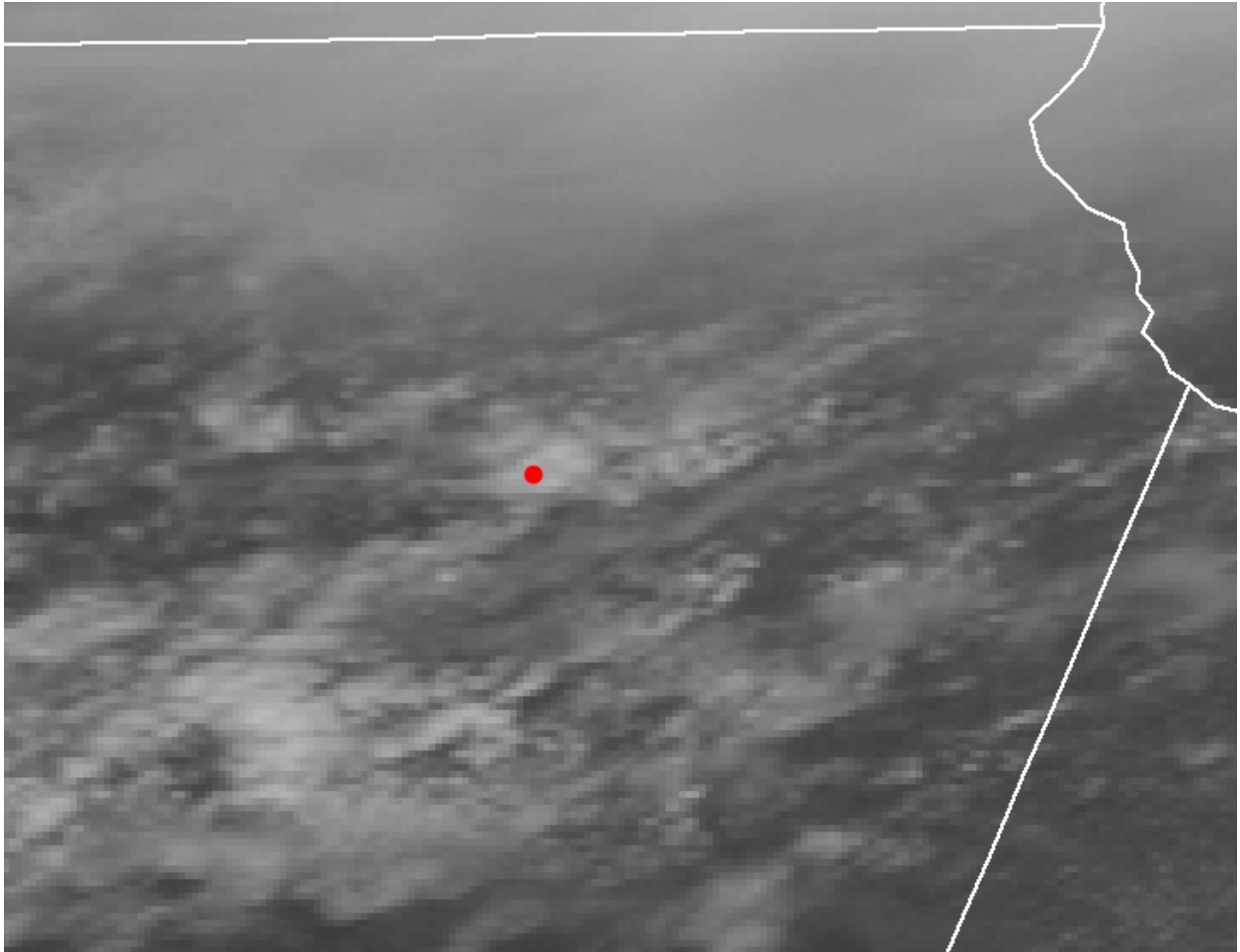


Figure 11 – GOES-13 visible imagery from 1115 CDT.

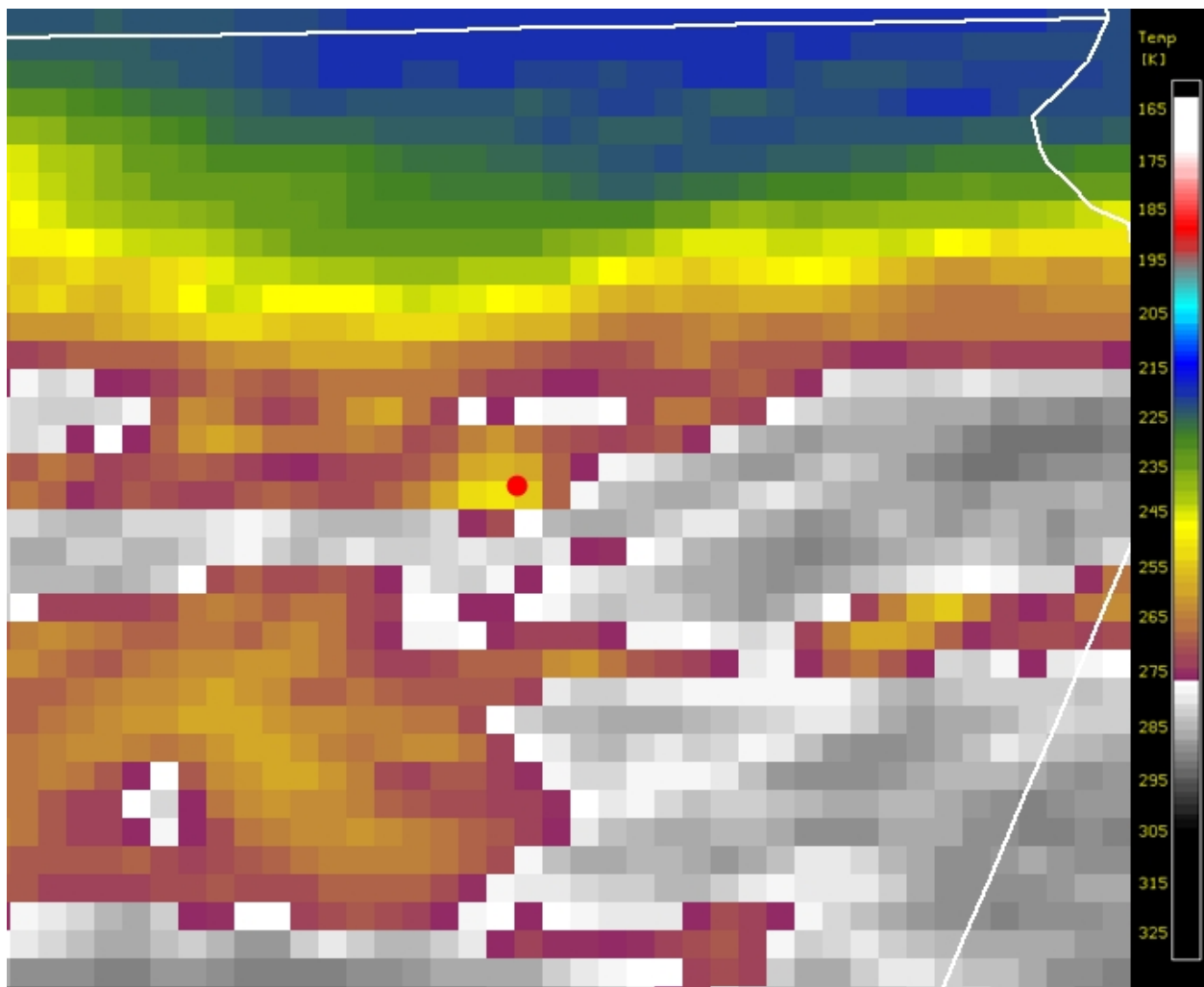


Figure 12 – GOES-13 infrared imagery from 1115 CDT.

AIRMETs

There were no Airmen's Meteorological Information (AIRMET) advisories active for the accident location at the accident time below FL250.

SIGMETs

There were no convective or non-convective Significant Meteorological Information (SIGMET) advisories active for the accident location at the accident time.

Aviation Section of the Area Forecast Discussion

An Area Forecast Discussion (AFD) was issued at 1033 CDT by the NWS Weather Forecast Office in Chicago, Illinois. The aviation portion of the AFD is presented here.

FXUS63 KLOT 211533 AAA
AFDLOT
Area Forecast Discussion...UPDATED
National Weather Service Chicago/Romeoville, IL
1033 AM CDT THU JUL 21 2016

.AVIATION...

For the 12Z TAFs...

Unstable conditions will be in place across the region which will result in thunderstorm chances throughout the day, though confidence in the details is low to medium at best. Most likely scenario for TSRA on station today will be for the line of thunderstorms currently moving south across Wisconsin to continue into northern Illinois by early this afternoon. The southern end of the line has shown some signs of weakening, though, with warming cloud tops noted on IR imagery and outflow outpacing the main line of convection. This adds some uncertainty in how far south the line will make it and how far south outflow will move to serve the focus for renewed thunderstorm development this afternoon. Based on extrapolation, the best timing for this line to reach the terminals would be early this afternoon, around 17Z to 18Z.

South winds will veer to the southwest mid to late this morning with gusts increasing to near 20 kt. Outside of the influence of thunderstorms, except south to southwest winds to continue through the remainder of the day; however, cannot rule out more northerly winds for period associated with thunderstorm outflow. Also of note, this morning fog and low ceilings have developed, mainly over portions of north central Illinois. Only anticipate it to impact RFD and DPA, and it should burn off by around 13Z.

Area Forecast

An Area Forecast that included the forecast for northeastern Illinois was issued by the Aviation Weather Center at 0534 CDT. The forecast applicable for the accident time for northeastern Illinois forecasted scattered clouds at 4,000 above msl and isolated light rain showers until 0900 CDT.

FAUS43 KKCI 211034 AAA
FA3W
-CHIC FA 211034 AMD
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 220400
CLDS/WX VALID UNTIL 212200...OTLK VALID 212200-220400
ND SD NE KS MN IA MO WI LM LS MI LH IL IN KY
.
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...SFC LOW CNTRL SD WITH CDFNT TO XTRM SWRN SD AND
OCFNT TO XTRM SERN ND. SFC TROF XTRM SERN SD-NERN NEB-XTRM
NWRN KS. SFC RDG ALG OH RIVER. 04Z CDFNT CNTRL LS-SERN SD-
NERN CO. SFC RDG ACRS KY.

.
IL

NERN-E CNTRL...SCT040. TIL 14Z ISOL -SHRA. 18Z ISOL -TSRA E CNTRL.
CB TO FL450. OTLK...VFR TSRA.
RMNDR...SKC. VIS 4SM BR. 14Z SCT040. OTLK...VFR TSRA NWRN-W
CNTRL.

CWSU Products

There were no Center Weather Advisories (CWA) or Meteorological Impact Statements issued by the Center Weather Service Unit (CWSU) at the Chicago Air Route Traffic Control Center that were active for the accident site at the accident time.

At 1140 CDT, the following CWA was issued for an isolated thunderstorm with a diameter of 20 miles 9 miles east-southeast of JOT moving from 280° at 15 knots.

FAUS22 KZAU 211640
ZAU2 CWA 211640
ZAU CWA 201 VALID UNTIL 211730
9ESE JOT
ISOL TS. DIAM 20NM. TOPS FL400. MV FROM 28015KT. CONDS CONT
AFTER 1730Z. IL

Collaborative Aviation Weather Statement

A Collaborative Aviation Weather Statement was issued at 1004 CDT.

FAUS11 KKCI 211504
AWSTS
Collaborative Aviation Weather Statement 003
NWS Aviation Weather Center Kansas City MO
1504 UTC Thu 21 Jul 2016
Weather: Thunderstorms
Valid: 1700-1900Z
ARTCCs affected: ZAU, ZMP, ZOB
Terminals affected:
CCFP: 15Z Issuance - Coverage/confidence too low
SUMMARY: CCFP underforecasting thunderstorms over the Great Lakes region.
DISCUSSION: CCFP underforecasting the progress of thunderstorm complex over the Great Lakes region.

Added broken line at 17z. Added a hi/sparse area over sern WI/nern IL/LM for decreasing TS.

Added medium coverage area over MI/LM at 19z.

Northern portion of the activity will be moving to the east and the southern portion of the activity will move to the southeast.

Thunderstorms will impact DTW around 20z. Tops above FL400.

Operations Note - CCFP areas that are not displayed in the CAWS graphic for the valid times posted are deemed to be accurate unless otherwise stated.

BOUNDING BOX: 49.10,-89.89 46.98,-74.33 39.13,-77.11 40.70,-90.76 49.10,-89.89

Convective Outlook

At 0753 CDT the SPC issued a Convective Outlook that identified “marginal” risk for the accident site (figure 13). Figure 14 provides a description of the different categories found in the Convective Outlook. Figure 15 presents an SPC Thunderstorm Outlook issued at 2350 CDT on July 20, 2016, and valid for 1100-1500 CDT on the accident day.

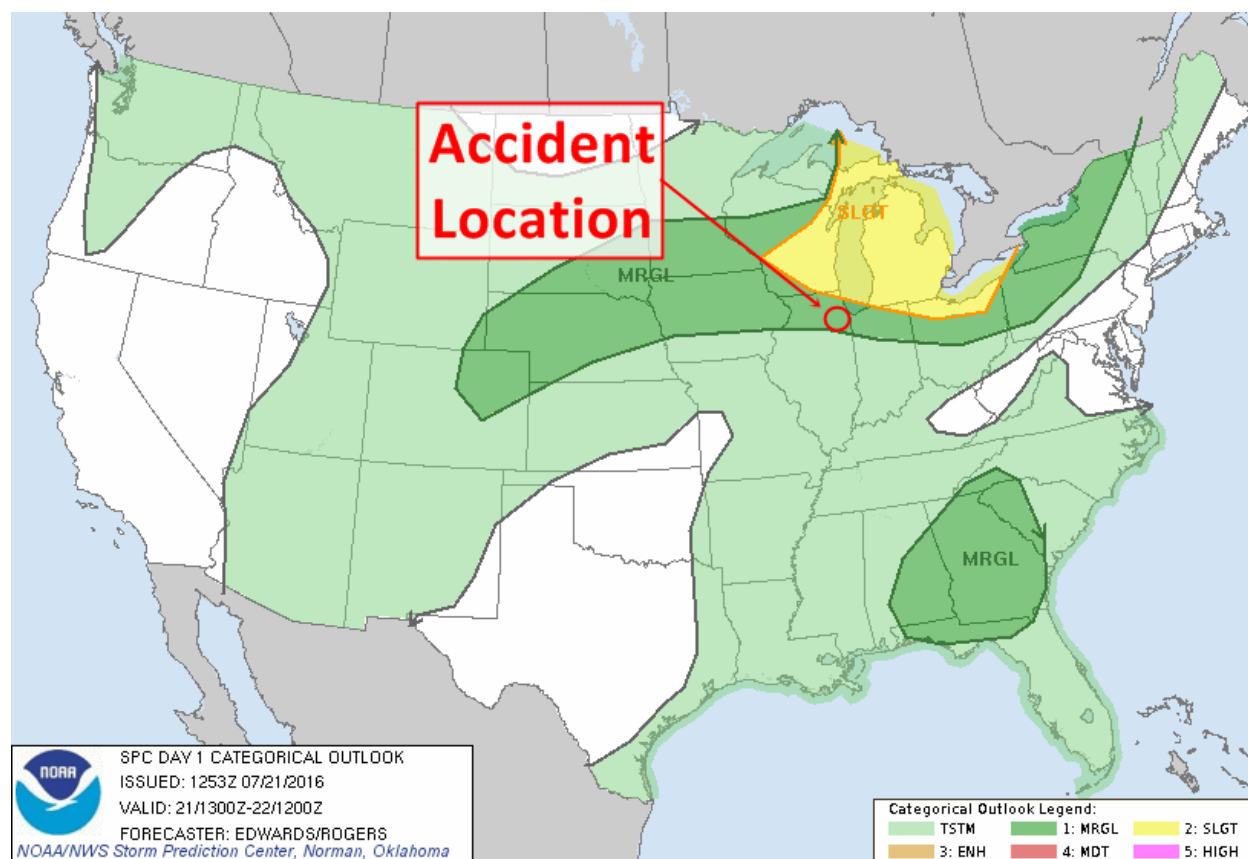


Figure 13 – SPC Convective Outlook issued at 0753 CDT.

Understanding Severe Thunderstorm Risk Categories

THUNDERSTORMS (no label)	1 - MARGINAL (MRGL)	2 - SLIGHT (SLGT)	3 - ENHANCED (ENH)	4 - MODERATE (MDT)	5 - HIGH (HIGH)
No severe* thunderstorms expected	Isolated severe thunderstorms possible	Scattered severe storms possible	Numerous severe storms possible	Widespread severe storms likely	Widespread severe storms expected
Lightning/flooding threats exist with <u>all</u> thunderstorms	Limited in duration and/or coverage and/or intensity	Short-lived and/or not widespread, isolated intense storms possible	More persistent and/or widespread, a few intense	Long-lived, widespread and intense	Long-lived, very widespread and particularly intense
					
• Winds to 40 mph • Small hail	• Winds 40-60 mph • Hail up to 1" • Low tornado risk	• One or two tornadoes • Reports of strong winds/wind damage • Hail ~1", isolated 2"	• A few tornadoes • Several reports of wind damage • Damaging hail, 1 - 2"	• Strong tornadoes • Widespread wind damage • Destructive hail, 2" +	• Tornado outbreak • Derecho

* NWS defines a severe thunderstorm as measured wind gusts to at least 58 mph, and/or hail to at least one inch in diameter, and/or a tornado. All thunderstorm categories imply lightning and the potential for flooding. Categories are also tied to the probability of a severe weather event within 25 miles of your location.

Figure 14 – Convective Outlook categories.

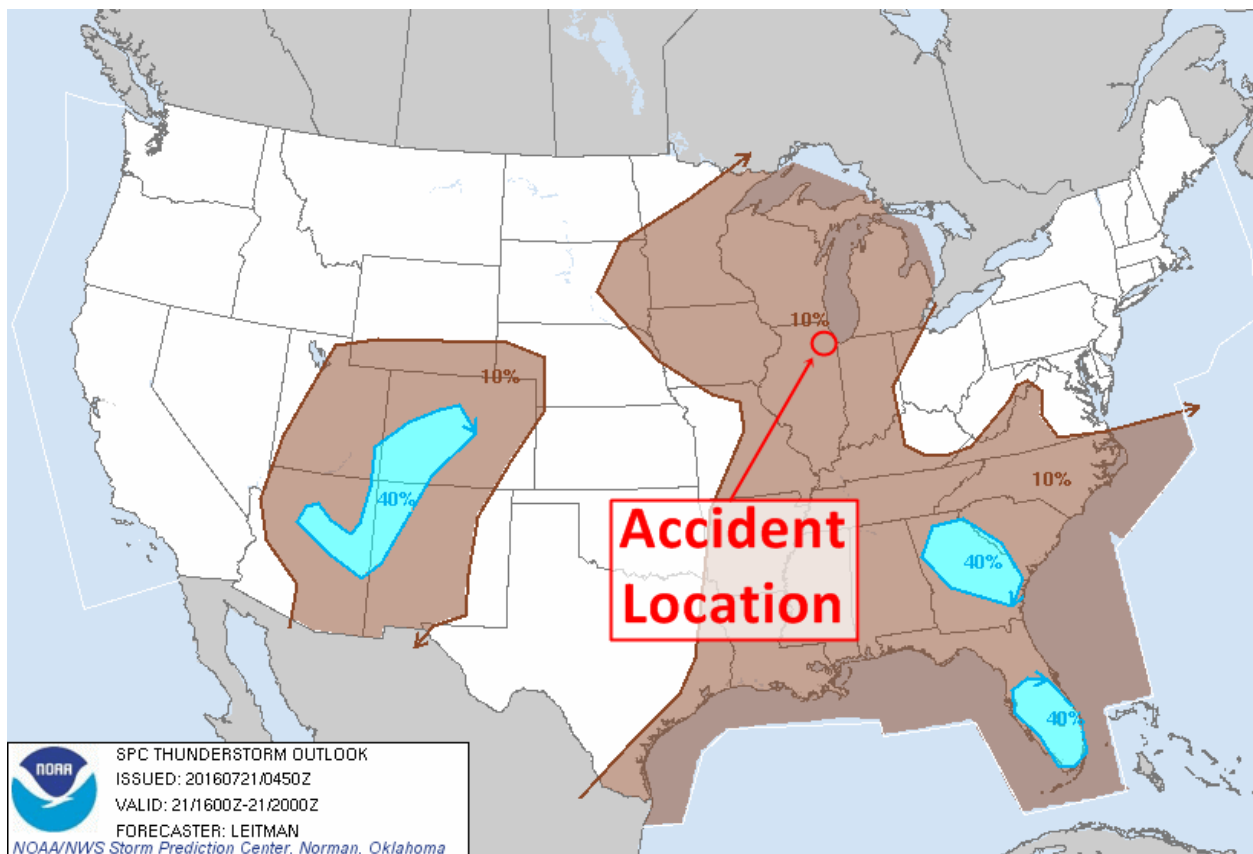


Figure 15 – SPC Thunderstorm Outlook issued at 2350 CDT on July 20, 2016, and valid for 1100-1500 CDT.

Astronomical Data

The astronomical data obtained from the United States Naval Observatory for 41° 33' north latitude and 88° 12' west longitude, indicated the following:

SUN

Sunrise	0538 CDT
Sunset	2020 CDT

MOON

Moonrise	2047 CDT (on July 20, 2015)
Moonset	0727 CDT

*Submitted by: Mike Richards
NTSB, AS-30*