National Transportation Safety Board

Office of Aviation Safety
Washington, D.C. 20594-2000
April 10, 2006

METEOROLOGY FACTUAL REPORT

DCA06MA009

A. ACCIDENT

Location: Chicago-Midway Airport, Chicago, Illinois
Date: December 8, 2005
Time: 1914 Central Standard Time (0114Z December 9, 2005)
Aircraft: Southwest Airlines flight 1248, Boeing 737-7H4, registration: N471WN

B. WEATHER GROUP PARTICIPATION

Donald E. Eick
Senior Meteorologist
National Transportation Safety Board
Operational Factors Division, AS-30
490 L'Enfant Plaza East, SW
Washington, D.C. 20594

Michael Tyson
Chief Dispatcher
Southwest Airlines
P.O. Box 36611 HDQ1DP
2702 Love Field Drive
Dallas, TX 75235

Walter Miga
Dispatch Representative
Southwest Airlines Employee Association
Southwest Airlines
P.O. Box 36611 HDQ1DP
2702 Love Field Drive
Dallas, TX 75235

Captain Larry Kline
Pilot
Southwest Airlines Pilots' Association
1450 Empire Central
Suite 737
Dallas, Texas 75247

C. SUMMARY

On December 8, 2005, at 1914 Central Standard Time, Southwest Airlines flight 1248, a Boeing B-737-7H4 registered as N471WN, over ran runway 31C at Chicago Midway International Airport in Chicago, Illinois, during the landing rollout. The airplane departed the end of the runway, rolled through a blast fence, a perimeter fence, and onto the roadway. The airplane came to a stop after impacting one automobile. Instrument meteorological conditions prevailed at the time. The airplane was substantially damaged. The flight was conducted under 14 CFR Part 121 and had departed from the Baltimore/Washington International Thurgood Marshal Airport, Maryland.

D. **DETAILS OF INVESTIGATION**

All the weather data used in this report was obtained from official National Weather Service (NWS) sources including the National Climatic Data Center (NCDC). All times are Coordinated Universal Time (UTC) based upon the 24-hour clock. Local time, Central Standard Time (CST) is + 6 hours to UTC, and UTC=Z. Heights are above mean sea level (MSL) unless otherwise noted. Directions are referenced to true north and distances in nautical miles. Visibility is in statute miles and fractions of statute miles.

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 Hydrometeorological Prediction Center (HPC) located in Camp Springs, 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 00-45.

1.0.1 Surface Analysis Chart

The NWS Surface Analysis Chart issued for 0000Z on December 9, 2005, is included as figure 1 and depicted the main synoptic features at the surface at the approximate time of the accident. The Surface Analysis Chart depicted a 1017-hectopascals (hPa)[1] low pressure system over northwestern Indiana to the south-southeast of the accident site, with an occluded front extending southeastward through Indiana into Kentucky, where the triple point was located and the front split into a warm front to the east and a cold to the south. A second low-pressure system was located at the triple point with a central pressure of 1018-hPa. A trough of low pressure also extended northwest of the low-pressure center over Indiana border, extending into northeast Illinois in the vicinity of the accident site.

[1] The unit of sea level pressure hectopascal (hPa) is interchangeable with the former unit of pressure, millibar (mb).

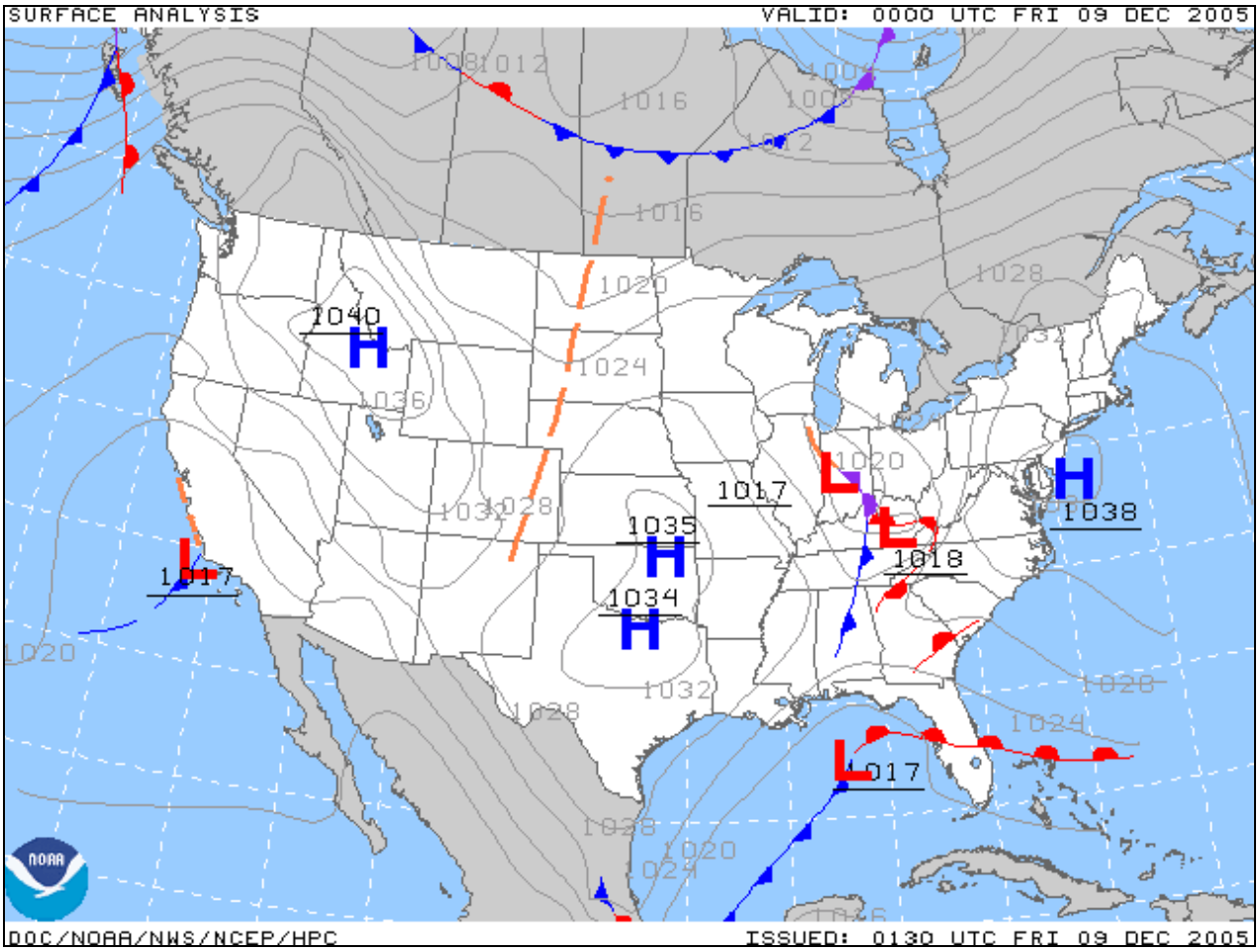

Figure 1 – NWS Surface Analysis Chart for 0000Z

The north central portion of the 0000Z NWS Surface Analysis Chart with higher resolution and station models is included as figure 2. The chart depicted the trough of low pressure west of the Chicago area over northeast Illinois into the low pressure center located in western Indiana. The station models on the chart depicted a cyclonic circulation in the wind flow over the Chicago region with northeasterly winds off Lake Michigan at approximately 10 knots. A wide area of light to moderate snow was depicted extending over eastern Iowa, southern Wisconsin, northeast Illinois, Michigan, Indiana, and into Ohio, with a band of moderate to heavy snow over northeast Illinois, northern Indiana, southern Lake Michigan, and southwestern Michigan.

The station model for Chicago-O'Hare International Airport indicated northeast wind at 10 knots, visibility restricted in moderate snow, temperature 27 degrees Fahrenheit (F), dew point temperature 25 degrees F.

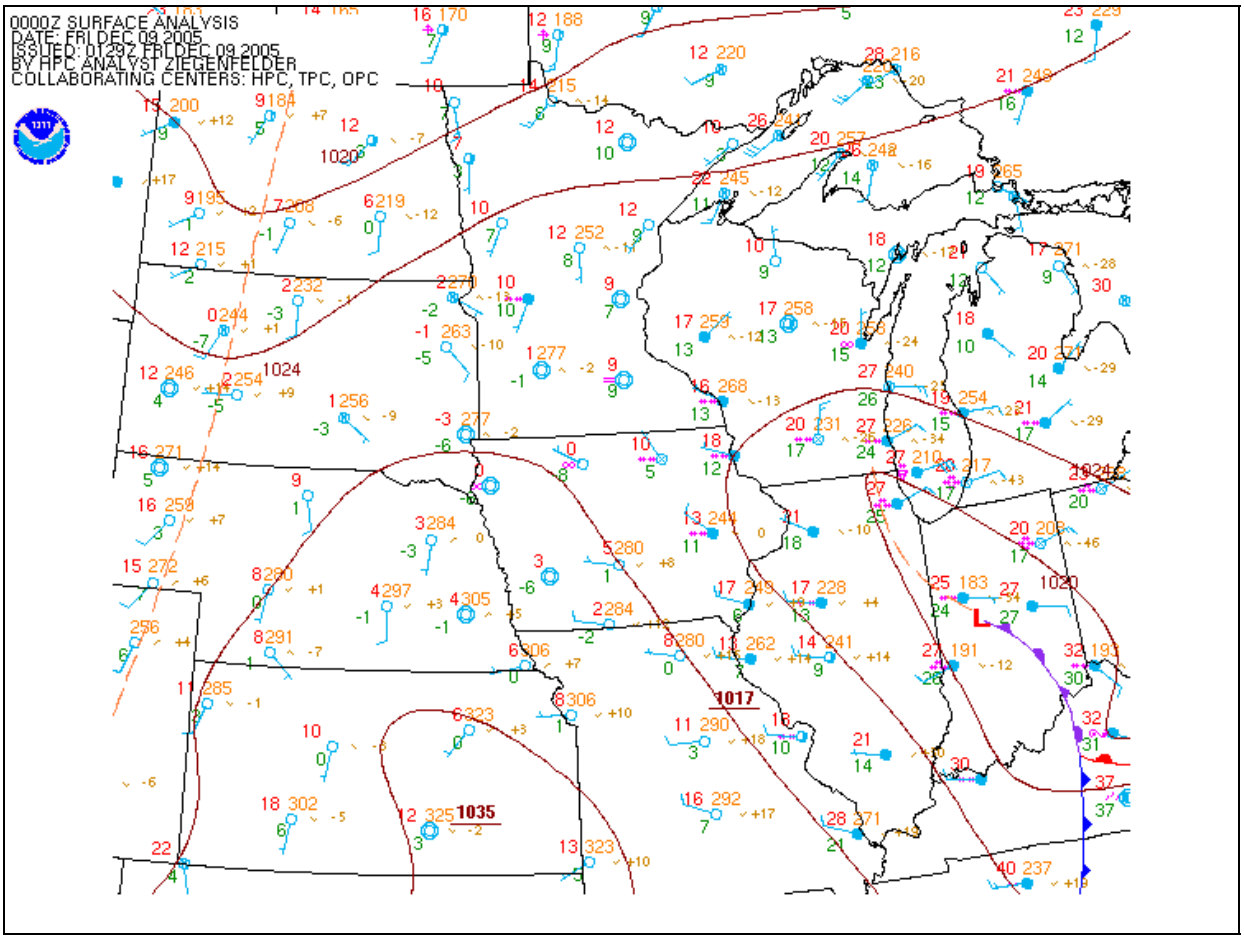

Figure 2 – NWS north central Surface Analysis for 0000Z

1.0.2 Regional Radar Mosaic Chart

The regional weather radar mosaic from the University Center for Atmospheric Research (UCAR) for 0059Z on December 9, 2005, is included as figure 3. The chart depicted a large band of weather echoes extending over southern Wisconsin, northeastern Illinois, Michigan, Indiana, and Ohio. Over northeastern Illinois and Lake Michigan in the immediate vicinity of the accident site radar reflectivities of 15 to 25 dBZ were observed. The area was associated with an area of moderate to heavy snow.

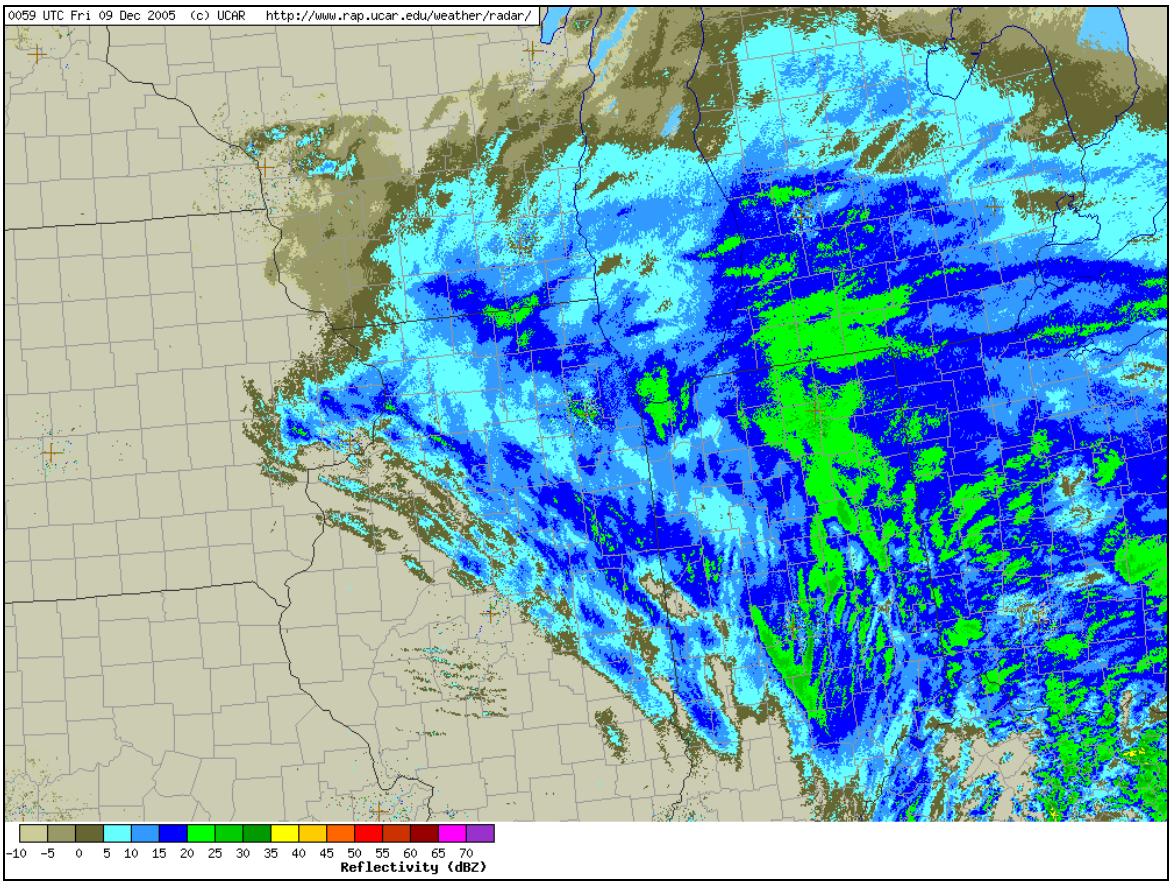

Figure 3 – Weather radar mosaic chart for 0059Z

The NWS WSR-88D single site radar site images surrounding the time of the accident are included in section 5.0 below.

1.0.4 Constant Pressure Charts

The 0000Z December 9, 2005, NWS Constant Pressure Charts for 850-hPa, 500-hPa, and 250-hPa were obtained from the NWS National Climatic Data Center (NCDC) and are reproduced here as figures 4 through 6 respectively. The 850-hPa chart depicted conditions at approximately 5,000 feet, the 500-hPa chart at approximately 18,000 feet, and the 250-hPa chart conditions at approximately 34,000 feet. The 500-hPa chart also depicted conditions for the mean atmosphere based on pressure, and is considered the mean steering level. The 850-hPa chart depicted an upper level low pressure system over northern Illinois and the 500-hPa chart the cut-off upper level low was over the Iowa and Missouri boarder. The 250-hPa chart depicted the upper level cut-off low over western Wisconsin and depicted the position of a 170 knot jet streams moving across the United States to the south of the accident site.

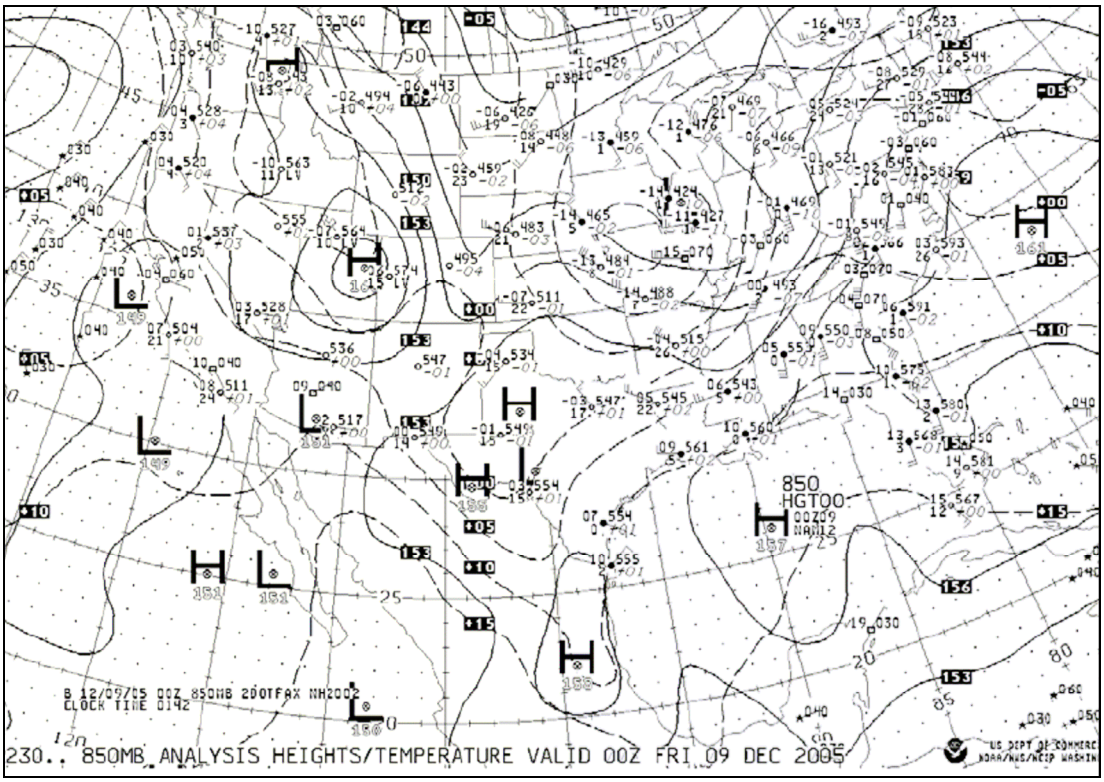

Figure 4 – NWS 850-hPa Chart for 0000Z

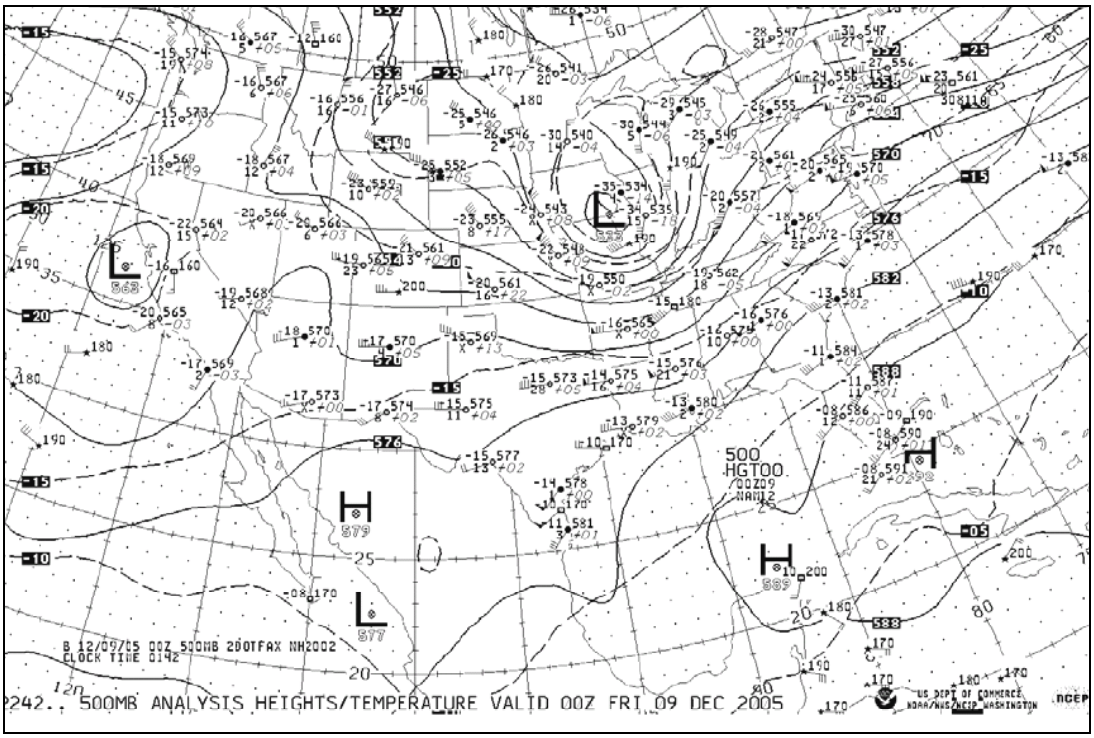

Figure 5 – NWS 500-hPa Chart for 0000Z

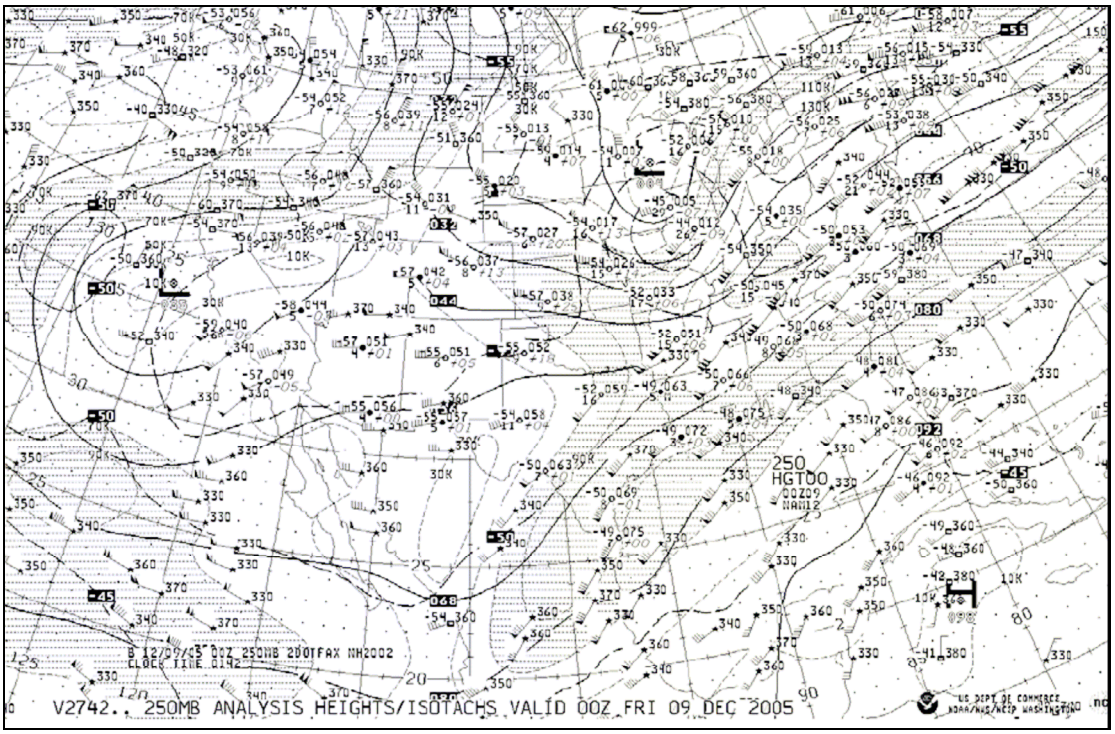

Figure 6 – NWS 250-hPa Chart for 0000Z

1.0.4 NWS 500-hPa Heights and Vorticity Chart

The NWS 500-hPa heights and Vorticity Analysis Chart for 0000Z on December 9, 2005, obtained from the NWS SRRS[2] is included as figure 7. The chart depicted an upper level low over eastern Missouri with a positive vorticity[3] center greater than 33 x 10^-5/s. The area of maximum vorticity was located immediately downstream of the Chicago area, and inferred positive vorticity advection over northern Illinois, Indiana, and lower Michigan, which favored rising motion and the development for moderate to heavy precipitation in the form of snow.

[2] SRRS - The Service Records Retention System (SRRS) is an archive and access system for selected National Weather Service (NWS) operational products maintained at the National Climatic Data Center.

[3] Vorticity - a measure of the local rotation in a fluid flow. In weather analysis and forecasting, it usually refers to the vertical component of rotation (i.e., rotation about a vertical axis) and is used most often in reference to synoptic scale or mesoscale weather systems. By convention, positive values indicate cyclonic rotation.

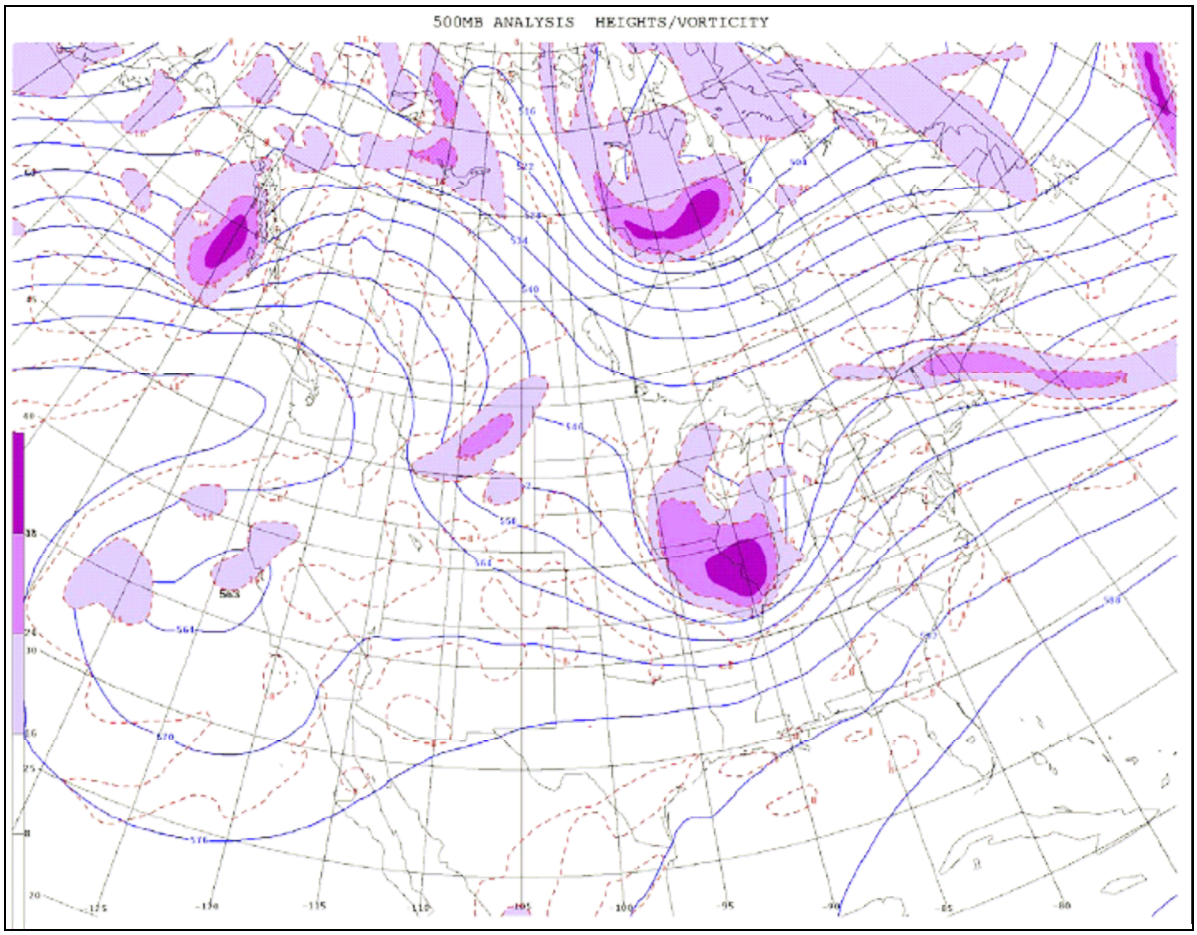

Figure 7 – 0000Z 500-hPa Heights and Vorticity Analysis

2.0 NWS Winter Storm Advisories

On December 8, 2005, at 1220Z the NWS Chicago Regional Forecast Office located at Lewis University (KLOT) began issuing Snow Advisories[4] for northern Illinois, with the snow expecting to begin in the northwest and west-central Illinois during the morning, and spreading into northeastern Illinois or the Chicago metro area by mid-morning, and continue into the evening hours. The advisory further stated that the snowfall rate would increase by mid afternoon, with significant accumulations starting to occur in the Chicago area with travel conditions were expected to deteriorate during the afternoon as the snow intensified.

[4] Snow Advisory - This product is issued by the National Weather Service when a low pressure system produces snow that may cause significant inconveniences, but do not meet warning criteria and if caution is not exercised could lead to life threatening situations. The advisory criteria varies from area to area. If the forecaster feels that it is warranted, he or she can issued it for amounts less than the minimum criteria. For example, it may be issued for the first snow of the season or when snow has not fallen in long while.

At 1553Z and 1753Z the NWS short term forecasts for Chicago continued to indicate that a Snow Advisory was in effect and that heavier snow was expected for northeastern Illinois and northwestern Indiana during the afternoon, continuing into the evening hours.

The next short term forecast issued at 1950Z indicated that the snow had begun across the Chicago area and that the snow was expected to get heavier within the next several hours. The advisory continued to warn that travel conditions were expected to deteriorate throughout the afternoon as the snow intensified. At 2157Z, the forecast indicated that moderate snow had developed across the Chicago region with snow accumulations of 3 to 5 inches expected across most of the area. At 2348Z, an update indicated that a band of moderate snow over much of northeast Illinois and northwest Indiana was reducing visibilities to a quarter mile and expected to produce an additional 2 inches per hour of snow. Accumulations between 3 to 5 inches were still expected across the area, with spotty 6-inch amounts possible in Cook County, Illinois, and in Lake and Porter Counties in Indiana.

At 0019Z the NWS forecast office issued a Winter Weather Advisory[5] for Chicago in their public zone forecast. The advisory indicated that a heavy snow warning was in effect until midnight local. Heavy snow was expected with accumulations from 6 to 9 inches. Temperatures were expected in the middle teens, with winds east at 10 miles per hour, shifting to the west after midnight. Wind chill temperatures were expected in the range from 0 to –10 degrees F.

The accident occurred approximately an hour after this winter weather advisory was issued, at 0114Z.

3.0 Surface Observations

The meteorological aerodrome reports (METARs) and special reports (SPECI) issued for Chicago-Midway International Airport (KMDW) were documented. The airport is located approximately 9 miles southwest of Chicago at an elevation of 620 feet msl, and a variation of 1 degree West. The airport is equipped with a federally installed and maintained Automated Surface Observation System (ASOS), which is located in the center of the field, northeast of the airport reference point, with additional sensors at the approach end of runway 31C. The system is augmented as needed by FAA contracted NWS certified weather observers, located on the 3rd floor of the air traffic control tower. All cloud heights are reported above ground level (agl) in this section. The official weather observations issued surrounding the time of the accident were as follows:

Midway weather observation at 0053Z, winds from 100 degrees at 11 knots, visibility 1/2 mile in moderate snow and freezing fog, ceiling broken at 400 feet, overcast at 1,400 feet,

[5] Winter Weather Advisory - Hazardous winter weather conditions are occurring, imminent or likely. Conditions will cause a significant inconvenience and if caution is not exercised, will result in a potential threat to life and/or property. The generic term, winter weather advisory, is used for a combination of two or more of the following events; snow, freezing rain or drizzle, sleet, blowing snow.

temperature minus 3 degrees C (28 degrees F), dew point temperature minus 4 degrees C (23 degrees F), altimeter 30.06 inches of Mercury (Hg). Remarks: automated observation system, sea level pressure 1019.6-hPa, runway 31C 10-minute averaged runway visual range 4,500 feet, snow increment 1-inch new snow last hour, 10-inches total, hourly liquid precipitation less than 0.01 inches (trace), temperature minus 3.3 degrees C, dew point minus 5.0 degrees C, maintenance indicator.

Midway special weather observation at 0137Z, winds from 160 degrees at 5 knots, visibility 1/4 mile in heavy snow and freezing fog, sky obscured vertical visibility at 200 feet, temperature minus 4 degrees C (25 degrees F), dew point temperature minus 5 degrees C (23 degrees F), altimeter 30.05 inches of Hg. Remarks: automated observation system, runway 31C 10-minute averaged runway visual range 3,000 feet, liquid precipitation less than 0.01 inches (trace), maintenance indicator.

Snow was reported at Chicago-Midway beginning at 1947Z on December 8, 2005, with snow ending at 0726Z on December 9, 2005, with a total of 10 inches of snow reported.

The following weather observation in raw format were reported surrounding the time of the accident:

KMDW 082316Z COR 08010KT 1/2SM SN FZFG BKN002 OVC009 M03/M05 A3011=

KMDW 082353Z COR 10009KT 1/4SM SN FZFG VV001 M03/M04 A3009 RMK AO2 SLP207 R31C/3000FT SNINCR 3/9 4/009 P0000 60000 T10331044 11033 21056 56040=

KMDW 090024Z 09011KT 3/4SM -SN BR OVC003 M03/M04 A3007=

KMDW 090053Z 10011KT 1/2SM SN FZFG BKN004 OVC014 M03/M05 A3006 RMK AO2 SLP196 R31C/4500FT SNINCR 1/10 P0000 T10331050 $=

KMDW 090137Z 16005KT 1/4SM +SN FZFG VV002 M04/M05 A3005 RMK AO2 R31C/3000FT P0000 $= (SPECI)

KMDW 090153Z 23003KT 1/2SM SN FZFG VV002 M04/M05 A3004 RMK AO2 SLP191 R31C/4000V4500FT SNINCR 1/10 P0000 T10391050 $=

KMDW 090233Z 00000KT 1 1/4SM -SN BR BKN004 OVC033 M04/M05 A3003 RMK A02 P0000 $= (SPECI)

KMDW 090253Z 23003KT 3SM -SN BR SCT007 OVC033 M04/M06 A3002 RMK AO2 SLP183 P0000 60000 T10441056 56022 $=

3.0.1 ASOS High Resolution Data

The ASOS 5-minute observations, edit log, and maintenance log were obtained from the NWS regional office. The ASOS edit log was also reviewed and except for the addition of the remarks, no augmentation of the reportable values was done to the reports, and no operational problems were identified with the system. The ASOS system had received routine maintenance and inspected on November 17, 2005, and was re-inspected immediately after the accident and there were no problems identified with the sensors or system.

The ASOS 5-minute observations bracketing the time of the accident are as follows:

KMDW weather observation at 0110Z, wind from 110 degrees at 8 knots, visibility 1/2 mile in moderate snow and freezing fog, ceiling broken at 400 feet, overcast at 1,400 feet, temperature minus 4 degrees C, dew point minus 5 degrees C, altimeter 30.06 inches of Hg, pressure altitude 490 feet, relative humidity 92 percent, density altitude 1,600 feet below sea level, magnetic winds from 110 degrees at 8 knots. Remarks: automated observation system, runway 31C visual range 4,500 feet variable 5,000 feet, hourly precipitation less than 0.01 inches.

KMDW weather observation at 0115Z, wind from 110 degrees at 7 knots, visibility 1/2 mile in moderate snow and freezing fog, sky obscured vertical visibility 300 feet, temperature minus 4 degrees C, dew point minus 5 degrees C, altimeter 30.06 inches of Hg, pressure altitude 490 feet, relative humidity 92 percent, density altitude 1,600 feet below sea level, magnetic winds from 120 degrees at 7 knots. Remarks: automated observation system, runway 31C visual range 4,500 feet variable 5,000 feet, hourly precipitation less than 0.01 inches.

The ASOS 5-minute observation surrounding the time of the accident from 0035Z through 0135Z on December 9, 2005, in standard code are included. The reports include time both in CST (-6 UTC) and with reference to UTC or "Zulu" time. The reports also include auxiliary data after the altimeter setting and prior to the remark section, and include the pressure altitude, relative humidity, density altitude, and magnetic winds. The reports are as follows:

12/08/05 1835:31 5-MIN KMDW 090035Z 10009KT 3/4SM -SN BR BKN004 OVC014 M03/M05 A3007 490 92 –1600 100/09 RMK A02 R31C/5500V6000FT P0000 $

12/08/05 1840:31 5-MIN KMDW 090040Z 10008KT 3/4SM -SN BR BKN004 OVC014 M03/M05 A3007 490 92 –1600 100/08 RMK A02 R31C/5500V6000FT P0000 $

12/08/05 1845:31 5-MIN KMDW 090045Z 09009KT 3/4SM -SN BR BKN004 OVC014 M03/M05 A3007 490 92 –1600 090/09 RMK A02 R31C/5500V6000FT P0000 $

12/08/05 1850:31 5-MIN KMDW 090050Z 10009KT 1/2SM SN FZFG BKN004 OVC014 M03/M05 A3006 490 92 –1600 100/09 RMK A02 R31C/4500FT SNINCR 1/10 P0000 $

12/08/05 1855:31 5-MIN KMDW 090055Z 09010KT 1/2SM SN FZFG BKN004 OVC014 M03/M05 A3006 490 88 –1600 090/10 RMK A02 R31C/4500V5000FT P0000 $

12/08/05 1900:31 5-MIN KMDW 090100Z 11007KT 1/2SM SN FZFG BKN004 OVC014

M03/M05 A3006 490 88 –1600 110/07 RMK A02 R31C/4500V5000FT P0000 $

12/08/05 1905:31 5-MIN KMDW 090105Z 12009KT 1/2SM SN FZFG BKN004 OVC014 M03/M05 A3006 490 88 –1600 120/09 RMK A02 R31C/4500V5000FT P0000 $

12/08/05 1910:31 5-MIN KMDW 090110Z 11008KT 1/2SM SN FZFG BKN004 OVC014 M04/M05 A3006 490 92 –1600 110/08 RMK A02 R31C/4500V5000FT P0000 $

12/08/05 1915:31 5-MIN KMDW 090115Z 11007KT 1/2SM SN FZFG VV003 M04/M05 A3006 490 92 –1600 120/07 RMK A02 R31C/4500V5000FT P0000 $

12/08/05 1920:31 5-MIN KMDW 090120Z 11005KT 1/2SM SN FZFG VV003 M04/M05 A3006 490 92 –1600 110/05 RMK A02 R31C/4500V5000FT P0000 $

12/08/05 1925:31 5-MIN KMDW 090125Z 08004KT 1/2SM SN FZFG VV003 M04/M05 A3006 500 92 –1600 080/04 RMK A02 R31C/4500V5000FT P0000 $

12/08/05 1930:31 5-MIN KMDW 090130Z 13004KT 1/2SM SN FZFG VV003 M04/M04 A3005 500 96 –1600 130/04 RMK A02 R31C/4500V5000FT P0000 $

12/08/05 1935:31 5-MIN KMDW 090135Z 15004KT 1/4SM +SN FZFG VV002 M04/M05 A3005 500 92 –1600 150/04 RMK A02 R31C/3000FT P0000 $

4.0 Upper Air Data

A combination of rawinsonde balloon and aircraft equipped sensor data was used to document the vertical structure of the atmosphere in the vicinity of the accident site.

4.0.1 Rawinsonde Data

The closest NWS upper air sounding or rawinsonde observation (RAOB) was from Lincoln (KILX), Illinois, site number 74560, located approximately 120 miles southwest of the accident site. The 0000Z sounding on December 9, 2005, plotted on a standard Skew-T log P diagram[6] from the surface to 100-hPa is included as figure 8, along with the observed and derived stability parameters. The 0000Z sounding sampled the air mass on the cold air side and west of the occluded front, and south of the 850-hPa upper level low pressure system as depicted in figure 4. The sounding indicated a lifted condensation level (LCL)[7] at 989-hPa or at 280 feet agl, and a

[6] 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.

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

convective condensation level (CCL)[8] at 912-hPa or at approximately 2,300 feet agl. The moisture structure indicated relative humidity of 75 percent or more from the surface to approximately 13,000 feet. The freezing level was at the surface and the entire depth of the sounding was below freezing and through a frontal inversion that was identified between 2,800 and 5,200 feet. The thickness values between 1,000-500 hPa was 5,175 meters (m), and between 1,000-850 hPa was 1,250 m, which supported precipitation in the form of all snow. The Lifted Index (LI)[9] was 18.2 and the K-Index was 7.8, which indicated an absolutely stable atmosphere that supported nimbostratus type clouds, and with the precipitable water value of 0.26 inches. The tropopause height was identified at 19,694 feet.

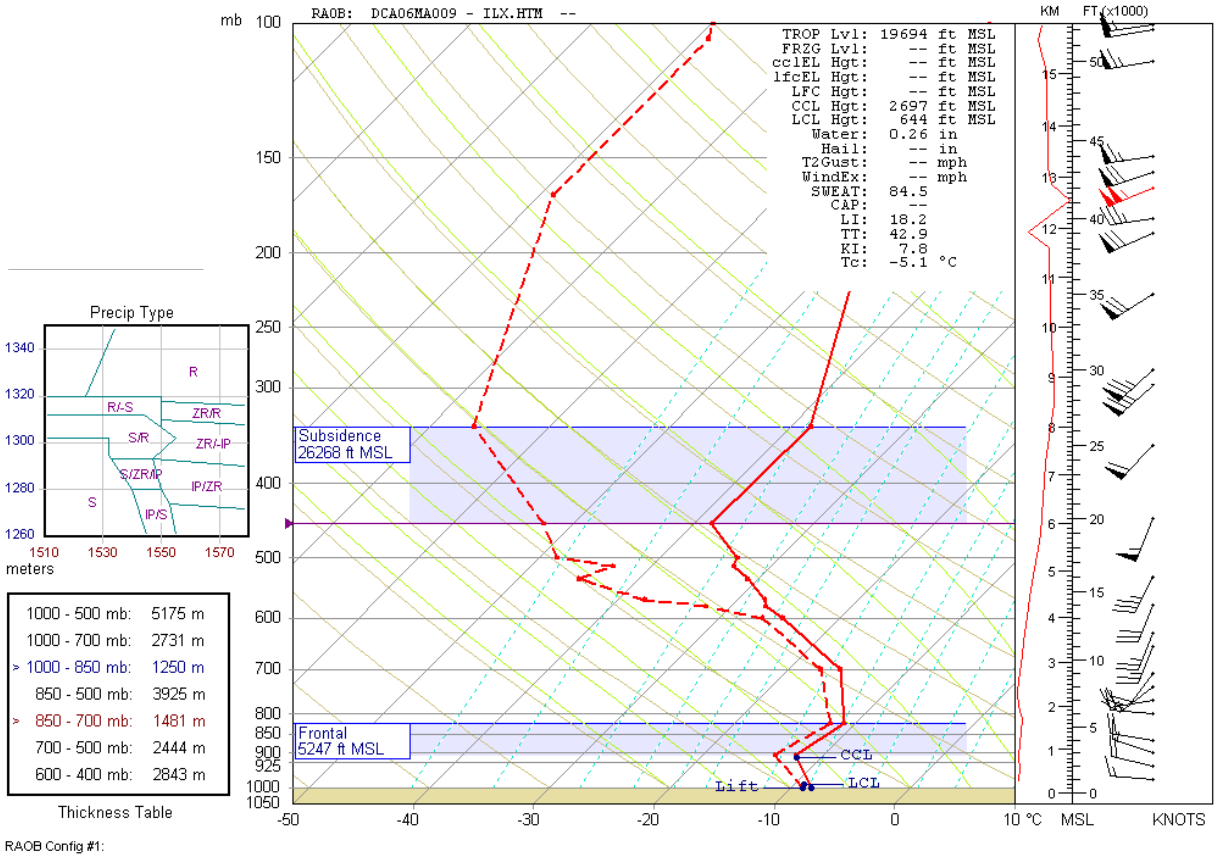

Figure 8 – KILX 0000Z sounding

[8] Convective Condensation Level (CCL) - is the height to which a parcel of air, if heated sufficiently from below, will rise adiabatically until condensation starts. This is typically used to identify the base of cumuliform clouds, which are normally produced from surface heating and thermal convection.

[9] Lifted Index (LI) - A common measure of atmospheric instability. Its value is obtained by computing the temperature that air near the ground would have if it were lifted to some higher level (around 18,000 feet, usually) and comparing that temperature to the actual temperature at that level. Negative values indicate instability - the more negative, the more unstable the air is, and the stronger the updrafts are likely to be with any developing thunderstorms.

The wind profile indicated low-level winds from the west at 15 to 20 knots with little change in direction through 6,000 feet, and then the winds backed to the south-southwest with height and increased in speed to over 50 knots by 18,000 feet. The maximum wind was identified at 42,000 feet in the stratosphere from the southwest at 103 knots. Basic wind theory of Buys-Ballot's law[10] indicated that the sounding location was south of the upper level low pressure system below 18,000 feet, and therefore was not reflective of the wind direction in the vicinity of the accident site.

4.0.2 MDCRS/TAMDAR Data

In order to better document the wind and temperature structure in the vicinity of the accident site due to the upper level low pressure centers over the region, aircraft data was also documented. Special meteorological sensors are installed on certain air carrier aircraft with ACARS (Aircraft Communications Addressing and Reporting System) to automatically report weather, and results in an increase in the density and frequency of atmospheric soundings. The database from these aircraft is called the Meteorological Data Collection and Reporting System (MDCRS) and/or Tropospheric Airborne Meteorological Data Report (TAMDAR), depending on the type of the sensors and the collection source. Several of these MDCARS/TAMDAR aircraft provided additional sounding data in the Chicago area surrounding the time of the accident.

Figure 9 is an ascent sounding from an MDCARS identified as aircraft number 8499, which departed from Chicago Midway Airport (KMDW) at 2241Z on December 8, 2005. The temperature profile indicated a low-level inversion from above the surface to approximately 5,000 feet, with several near isothermal layers above that to approximately 14,000 feet. The entire sounding was below freezing and supported precipitation in the form of snow. No moisture sensor was available to determine cloud heights, relative humidity structure, or provide additional icing data.

The KMDW ascent sounding wind profile indicated easterly flow veering to the south-southwest with height. At 1,500 feet the wind was identified from 080 degrees at 15 knots.

[10] Buys-Ballot's law – A law describing the relationship of the horizontal wind direction in the atmosphere to the pressure distribution; if one stands with his back against the wind, the pressure to the left is lower than to the right in the northern hemisphere. This law was formulated in 1857 by the Dutch meteorologist Buys Ballot and is a qualitative statement of the geostrophic wind equation.

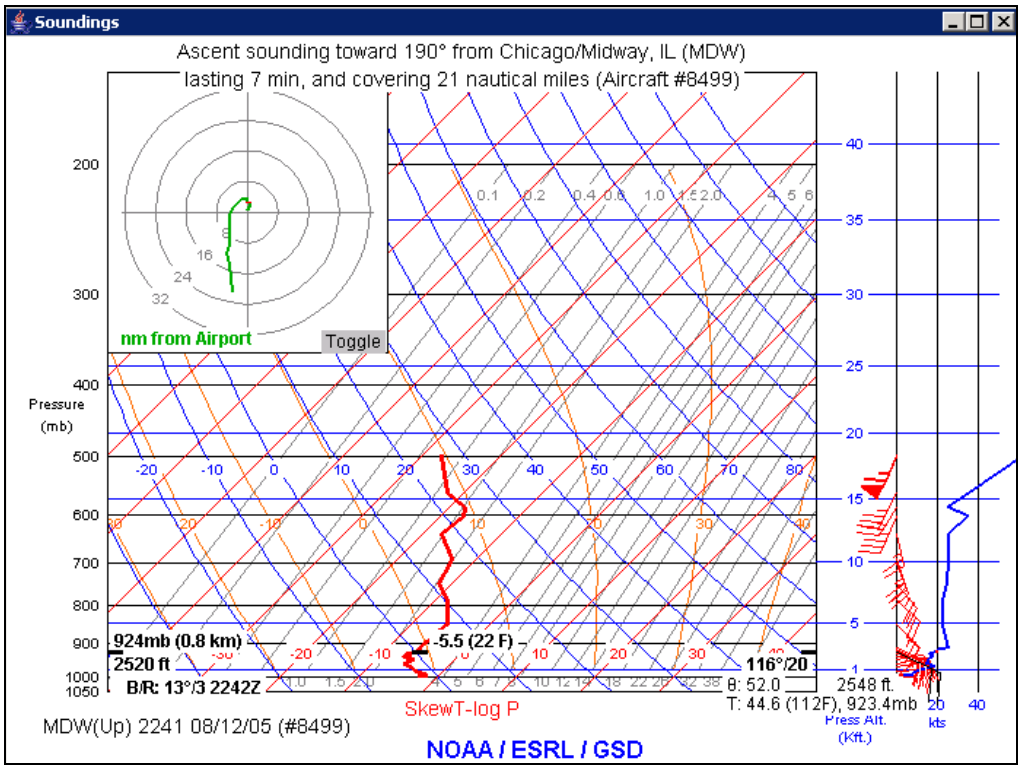

Figure 9 – Ascent sounding from KMDW at 2241Z

The following data was reported from aircraft 8499's ascent:

P alt (ft)	HPa	t/td (°C)	Wind dir/spd (kts)	Time (Z)	Range/Bearing (nm)
440	997	-2.5/na	098°/004	2241	010°/001
450	997	-1.4/na	055°/008	2241	010°/001
570	993	-2.0/na	094°/008	2241	010°/001
840	983	-3.5/na	090°/010	2241	040°/001
1,170	971	-4.6/na	082°/019	2241	024°/001
1,500	960	-5.9/na	080°/015	2241	024°/001
1,810	949	-5.1/na	081°/016	2242	038°/002
2,130	938	-6.9/na	094°/018	2242	028°/002
2,380	929	-6.9/na	103°/017	2242	028°/002
2,500	925	-5.7/na	114°/020		
2,520	924	-5.5/na	116°/020	2242	013°/003
2,620	921	-5.9/na	123°/020	2242	013°/003
2,700	918	-5.9/na	124°/021	2242	002°/003
2,750	917	-5.6/na	117°/022	2242	002°/003
2,790	915	-5.9/na	117°/023	2242	354°/003

2,810	915	-5.9/na	115°/025	2242	346°/003
2,840	913	-5.9/na	114°/026	2242	338°/003
4,781	850	-5.4/na	135°/023		
4,890	847	-5.4/na	136°/023	2243	293°/003
6,880	785	-8.4/na	134°/023	2244	263°/004
8,200	747	-11.6/na	139°/025	2244	236°/005
9.883	700	-12.8/na	158°/026		
10,210	691	-13.0/na	162°/026	2245	220°/007
12,240	638	-17.6/na	167°/026	2245	208°/009
13,670	603	-17.1/na	202°/035	2246	205°/012
14,340	587	-18.0/na	210°/025	2247	198°/014
15,450	562	-22.0/na	206°/036	2247	193°/018
18,289	500	-27.4/na	202°/063		
18,330	499	-27.5/na	202°/063	2248	190°/021

Figure 10 is another MDCARS ascent sounding from an aircraft (aircraft 555) that departed Chicago-O'Hare International Airport (KORD) located approximately 12 miles northwest of the accident site on an easterly bound course at 0127Z. The sounding also indicated low-level temperature inversions and isothermal layers between 3,000 and 6,000 feet, where temperature remained constant with an increase in altitude and indicated an absolutely stable atmosphere. The entire sounding was also below freezing and supported precipitation in the form of snow. The tropopause was identified at approximately 400-hPa or at 24,000 feet. Aircraft 555's ascent sounding also indicated a low-level easterly wind component, which veered to the south-southwest with height.

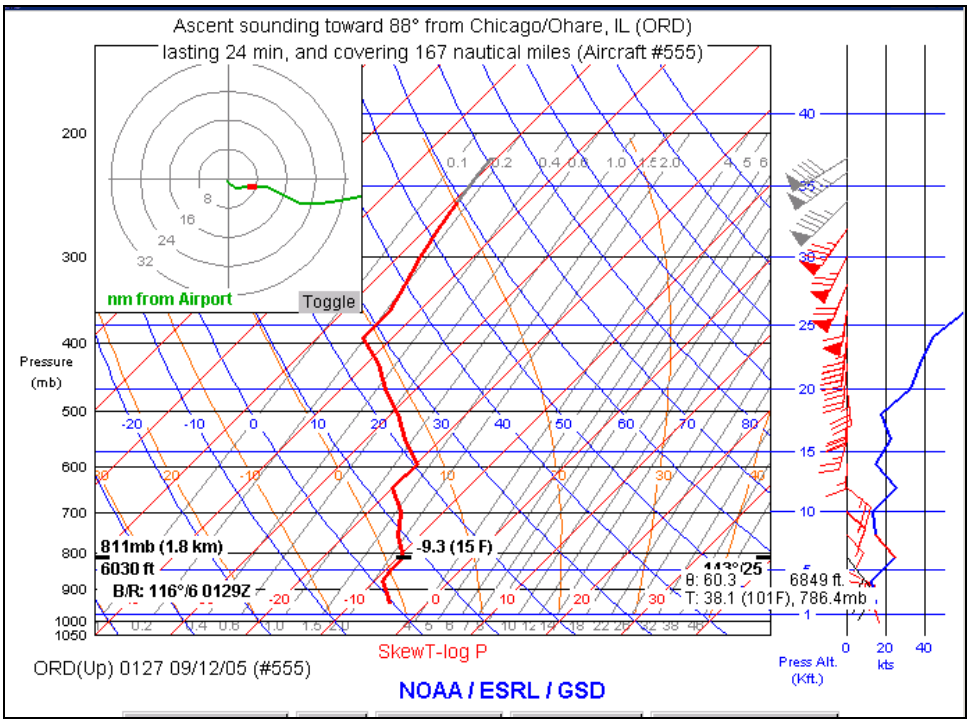

Figure 10 – Ascent sounding from KORD at 0127Z

Aircraft 555 ascent sounding data is as follows:

P alt (ft)	HPa	t/td (°C)	Wind dir/spd (kts)	Time (Z)	Range/Bearing (nm)
2,010	942	-5.0/na	091°/015	0127	195°/001
2,500	925	-6.0/na	093°/015		
4,000	875	-9.0/na	100°/013	0128	146°/003
4,781	850	-9.1/na	116°/018		
6,030	811	-9.3/na	143°/025	0129	116°/006
8,020	752	-13.0/na	138°/015	0129	107°/008
9,883	700	-15.6/na	132°/014		
10,010	697	-15.8/na	132°/014	0130	103°/011
12,010	644	-20.0/na	128°/026	0131	108°/016
14,010	595	-19.8/na	182°/015	0132	110°/021
16,030	548	-24.8/na	193°/023	0133	105°/026
18,020	506	-29.0/na	181°/018	0134	102°/030

5.0 Satellite Data

The Geostationary Operational Environmental Satellite number 12 (GOES-12) data was obtained from the National Transportation Safety Board's Man Computer Interactive Data System (McIDAS) workstation. The infrared (IR) band 4 imagery at a wavelength of 10.7 microns (μm) provided a 4-kilometer (km) resolution and also provided radiative cloud top temperatures. Figure 11 is the GOES-12 infrared image at 0115Z on December 9, 2005, with a standard GMB temperature enhancement curve applied to highlight the higher and colder cloud tops, with a white square placed on the accident location. The satellite imagery depicted an east-to-west band of enhanced clouds extending over the Chicago area, with several embedded north-to-south bands within it. At the approximate time of the accident, the Chicago-Midway Airport was between two of these enhanced bands and had a radiative cloud top temperature of 250 degrees Kelvin (K) or –23 degrees C, which corresponded to cloud tops near 12,000 feet. The north-to-south band features to the west and east of Chicago-Midway Airport (indicated in red) had a radiative cloud top temperature near 230 degrees K or –40 degrees C, or cloud tops near 27,000 feet.

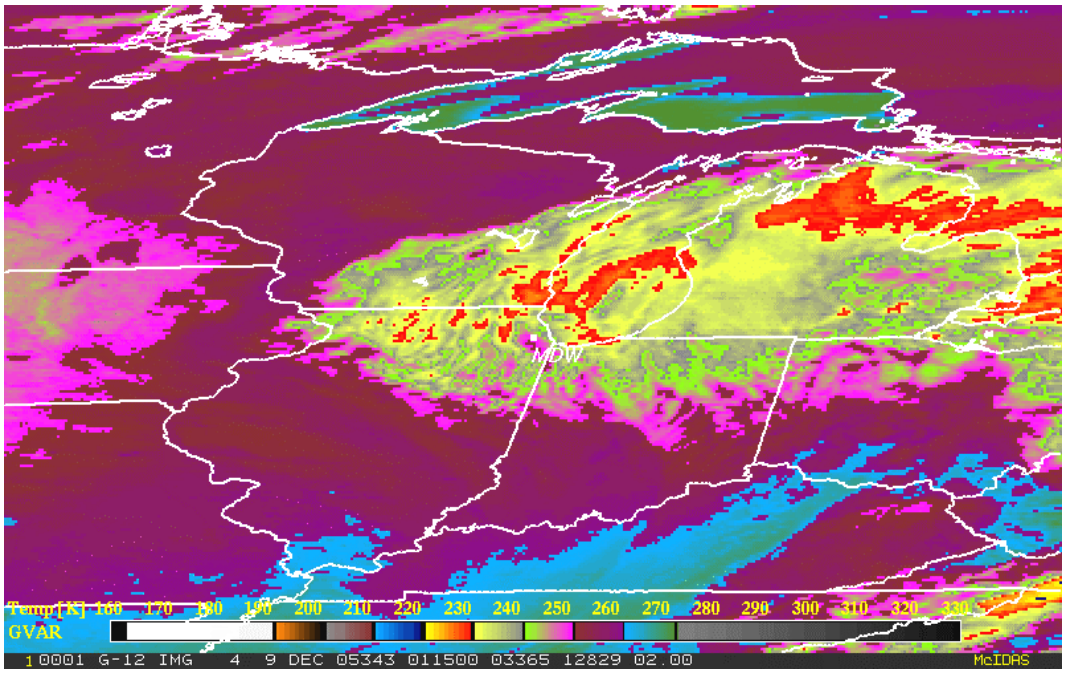

Figure 11 – GOES-12 infrared image at 0115Z

6.0 Weather Radar Information

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D) was Chicago Lewis University (KLOT), located approximately 35 miles southwest of the accident site. The WSR-88D is an S-band 10 centimeter wavelength radar with a 0.95-degree beam width, and a power output of 750,000 watts. The radar produces three basic type of products: reflectivity, radial velocity, and spectral width.

During the period surrounding the accident the KLOT WSR-88D was operating in the precipitation mode.

6.0.1 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors[11] it is a function of the drop size distribution, number of particles

[11] 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. Hydrometers 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:

per unit volume, physical state (ice or water), shape, and aspect ratio. Reflectivity is normally displayed in decibels (dBZ[12]), 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 Moderate	7	35 to 39	.21 in/hr
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	

The base reflectivity images from the KLOT WSR-88D are plan position indicator (PPI) displays of the individual radar scans at various scans, with reflectivities in decibels. The resolution is provided at 1° X 1 kilometer. A color scale is found at the right side of the image depicting the reflectivities from ND (no data) to 75 dBZ. Figures 12 through 15 are the base reflectivity images from 0100Z through 0117Z, and depict echoes ranging from 15 to 20 dBZ extending over the airport surrounding the period. The heaviest bands of snow were noted extending from northern Indiana, southern Lake Michigan, and southeast Illinois in the vicinity of Chicago-Midway Airport.

drifting snow, blowing snow, blowing spray. (g) Liquid or solid deposits on exposed objects: dew, frost, rime, and glaze ice.

[12] dBZ = 10 log Ze

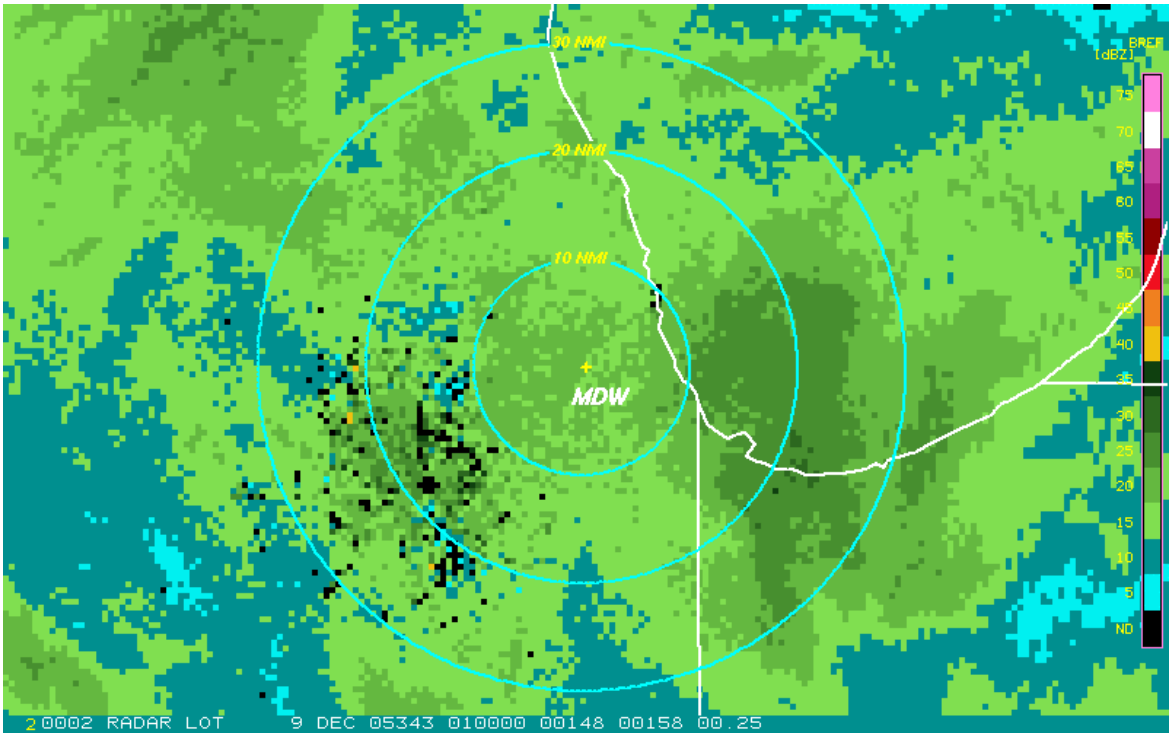

Figure 12 – WSR-88D KLOT base reflectivity image for 0100Z

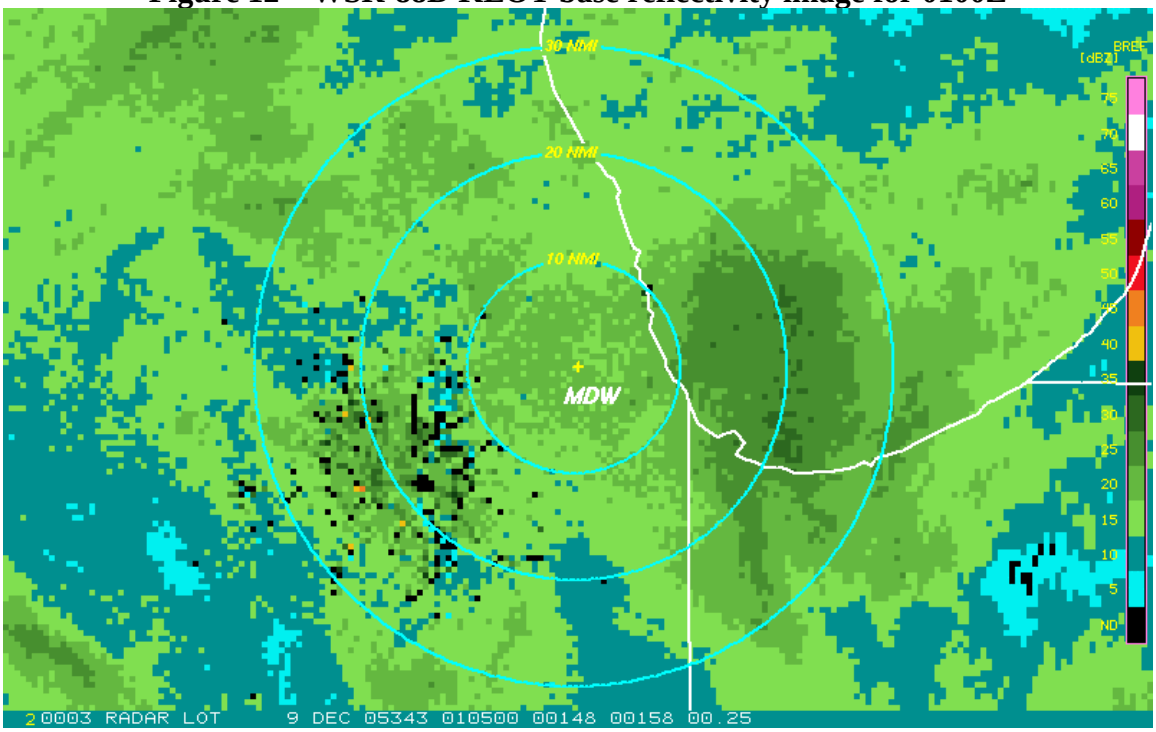

Figure 13 – WSR-88D KLOT base reflectivity image for 0105Z

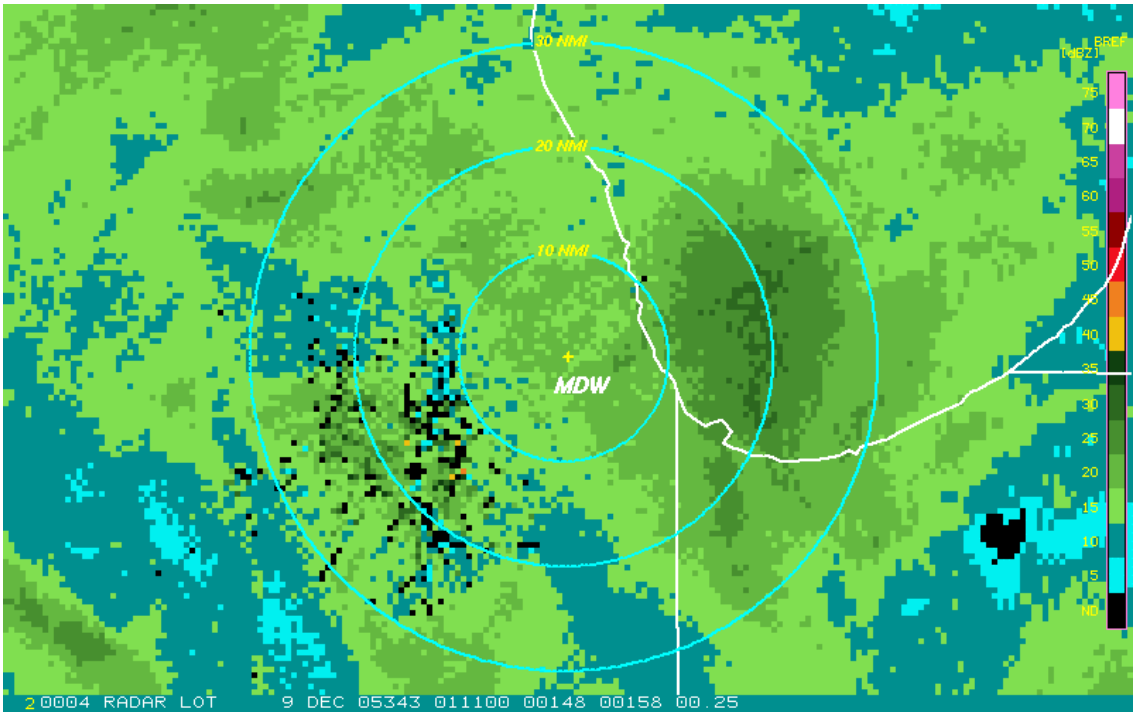

Figure 14 – WSR-88D KLOT base reflectivity image for 0111Z

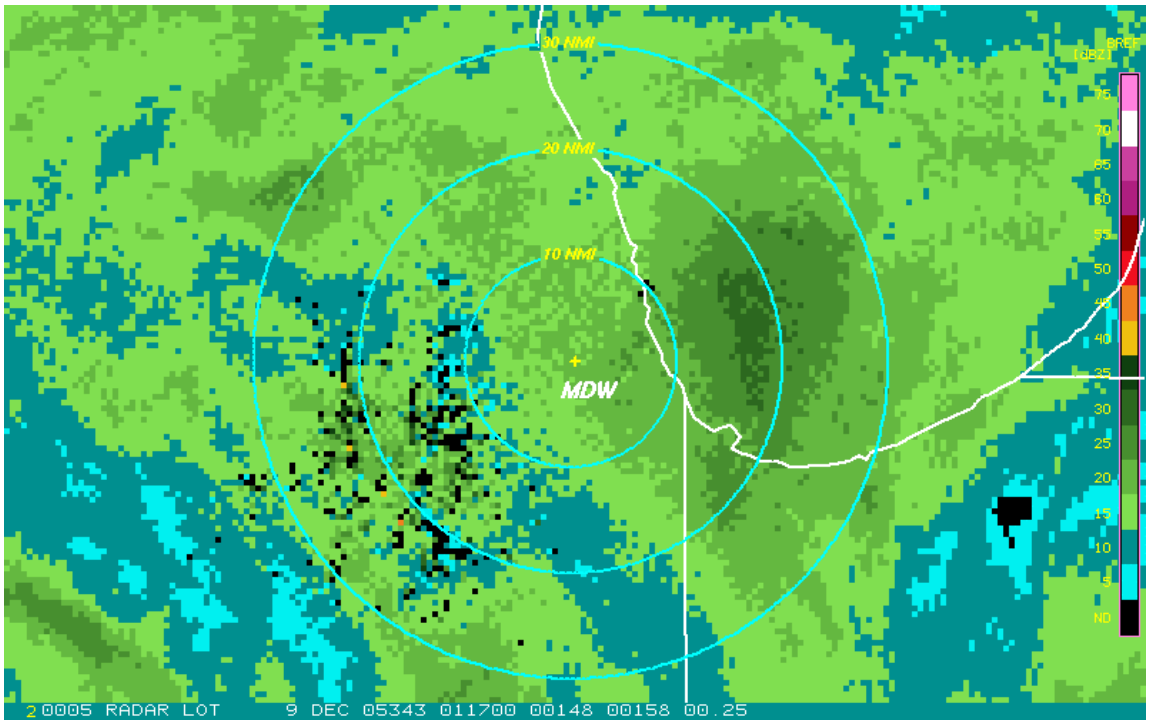

Figure 15 – WSR-88D KLOT base reflectivity image for 0117Z

7.0 Pilot Reports

The following pilot reports (PIREPs) were made surrounding the time of the accident over Illinois. The reports are provided in narrative form, from the standard code format. The reports from 0000Z through 0200Z are as follows:

Kankakee (IKK) routine pilot report (UA); over Peotone (EON); Time – 0011Z; Flight level – unknown; Type aircraft – Airbus medium air carrier aircraft (A-320); Turbulence – light between 18,000 and 23,000 feet.

Champaign (CMI) routine pilot report (UA); Over – Danville (DNV); Time – 0005Z; Flight level – 7,000 feet; Type aircraft – Saab multiengine turboprop commuter aircraft (SF34); Temperature – minus 9 degrees C; Icing – light clear icing.

Champaign (CMI) routine pilot report (UA); Over – CMI; Time – 0005Z; Flight level – 6,000 feet; Type aircraft – Piper Seneca multiengine airplane (PA34); Temperature – minus 9 degrees C; Turbulence – light to moderate; Icing – trace of rime icing; Remarks – heavy snow.

Peoria (PIA) routine pilot report (UA); Over – 7 miles east-southeast of Peoria (PIA); Time – 0040Z; Flight level – 7,000 feet; Type aircraft – Cessna private multiengine airplane (C310); Turbulence – negative; Icing – negative.

Decatur (DEC) routine pilot report (UA); Over – Vandalia (VDA); Time – 0105Z; Flight level – 23,000 feet; Type aircraft – Canadair regional commuter jet (CRJ2); Sky conditions – clear; Turbulence – smooth between 23,000 and 14,000 feet; Remarks – from Kansas City Center (ZKC).

Decatur (DEC) routine pilot report (UA); Over – 30 miles east of Springfield (SPI); Time – 0129Z; Flight level – 38,000 feet; Type aircraft – Gates Learjet executive jet (LJ35); Temperature – minus 49 degrees C; Wind – from 265 degrees at 77 knots; Turbulence – occasional light chop.

Champaign (CMI) routine pilot report (UA); Over – 24 miles east of CMI; Time – 0144Z; Flight level – 10,000 feet; Type aircraft – Saab multiengine turboprop (SF34); Temperature – minus 11 degrees C; Turbulence – minus 11 degrees C; Turbulence – light to moderate; Icing – trace; Remarks – light snow during descent.

Quincy (UIN) routine pilot report (UA); Over – 38 miles southeast of UIN; Time – 0157Z; Flight level –14,000 feet; Type aircraft – British Aerospace Jetstream multiengine turboprop (JS41); Sky condition – sky clear; Turbulence – light; Remarks – from ZKC.

No urgent pilot reports were noted over the region and no significant reports of low-level wind shear, severe turbulence, severe icing, or other hazardous weather conditions were identified.

8.0 Terminal Aerodrome Forecast

The flight was released based on the NWS amended Terminal Aerodrome Forecast (TAF) issued at 2115Z on December 8, 2005, and valid from 2100Z through 1800Z on December 9, 2005. The forecast in plain language is as follows:

> KMDW from 2100Z, wind from 080 degrees at 11 knots, visibility 1/2 mile in moderate snow and freezing fog, ceiling overcast at 400 feet agl, temporarily between 2100Z and 2200Z visibility 1/4 mile in moderate snow and freezing fog, sky obscured vertical visibility 200 feet. From 2200Z, wind from 070 degrees at 8 knots, visibility 1 mile in light snow and mist, ceiling overcast at 500 feet, temporarily between 2200Z and 0100Z of visibility 1/2 mile in moderate snow and freezing fog, sky obscured vertical visibility 400 feet. From 0100Z, wind from 050 degrees at 7 knots, visibility 2 miles in light snow, ceiling overcast at 700 feet. From 0300Z, wind from 340 degrees at 12 knots, visibility better than 6 miles, ceiling overcast at 2,500 feet, temporarily between 0300Z and 0600Z of visibility 3 miles in light snow showers. From 0800Z, wind from 310 degrees at 12 knots, visibility better than 6 miles, ceiling broken at 3,500 feet. From 1700Z, wind from 270 degrees at 10 knots, visibility better than 6 miles, sky clear.

The NWS aviation forecast discussion issued for the 1800Z TAF indicated that the onset of light snow appeared to be slightly delayed; however, the system approaching the Chicago area was still expected to bring significant snow to the area. The new numerical models runs confirmed both the path and strength of the system, with the path of the maximum upward vertical velocities (UVV) centered over northeast Illinois during the late afternoon period and was expected to move rapidly eastward, with the significant snow ending by mid evening. The forecaster indicated that the previous TAF looked reasonable with both the timing and the expected weather impacts, so he only made changes to the first portion of the forecast and at the end, where he began to hint at the clearing trend near the end of the forecast cycle. Once the snow started in earnest, the forecaster expected IFR[13] ceiling and visibilities to develop rapidly, with LIFR[14] in heavier bursts of snow during the 1200Z to 0100Z period. He expected the system to be far enough east, that only light snow or snow flurries were expected during most of the evening hours. A Snow Advisory remained in effect for the afternoon and the evening.

The next schedule TAF was issued at 2338Z, and was valid for a 24-hour period beginning at 0000Z on December 9, 2005.

> KMDW from 0000Z, wind from 060 degrees at 10 knots, visibility 1/2 mile in moderate snow and freezing fog, sky obscured vertical visibility 300 feet agl, temporarily between 0000Z and 0300Z visibility 1 mile in light snow and mist, ceiling overcast at 700 feet. From 0300Z, wind from 030 degrees at 8 knots, visibility 3 miles in light snow, ceiling broken at 700 feet, overcast at 1,200 feet, temporarily between

[13] IFR conditions – means a ceiling less than 1,000 feet agl and/or visibility less than 3 statute mile.

[14] LIFR conditions – means a ceiling less than 500 feet agl and/or visibility less than 1/2 statute mile.

0300Z and 0500Z of visibility 1 mile in light snow and mist. From 0500Z, wind from 330 degrees at 7 knots, visibility 5 miles in light snow, ceiling broken at 1,000 feet, and overcast at 1,500 feet. From 0800Z, wind from 330 degrees at 12 knots, visibility better than 6 miles, ceiling overcast at 2,000 feet. From 1200Z, wind from 290 degrees at 10 knots, visibility better than 6 miles, ceiling broken at 3,000 feet. From 1800Z through 2400Z, wind from 240 degrees at 12 knots, visibility better than 6 miles, scattered clouds at 3,000 feet.

The NWS Forecast Discussion issued for the 0000Z TAF indicated that the ongoing snow event would be the main issue for the 0000Z TAFs, and that ceilings and visibilities were transitioning between LIFR and IFR in the moderate snow area across northeast Illinois. The forecaster indicated that it was a strongly forced event in terms of mid- to upper-level forcing with a dry slot[15] tracking through northern Indiana at this time, with a concern that a deformation snow band may set up and would needed to be monitored for additional snowfall potential. This deformation snow band should extend light snow to at least 0600Z period, although snow should taper off with MVFR conditions[16] by 0500Z. The upper level low and deformation band[17] was expected exit the area by 0800Z, with a dry slot moving through. Therefore, at 0800Z the TAF has the snow ending and increases the ceilings back to the VFR conditions. The winds were expected to continue to back to the northeast during the evening, and then to the northwest. A surface ridge axis of high pressure was expected to build in across the lower Mississippi River Valley on December 9th and keep northern Illinois and western Indiana in a westerly surface wind gradient through the period with wind speed in the 10 to 15 knot range. Sky conditions were expected to clear by Friday morning with subsidence in the wake of the departing wave. The discussion ended with a reminder that the Snow Advisory was in effect for the afternoon and evening hours.

9.0 In-Flight Weather Advisories

The NWS issues in-flight weather advisories designated as Severe Weather Forecast Alerts (AWW's), Convective SIGMET's (WST's), SIGMET's (WS's), Center Weather Advisories (CWA's), and AIRMET's (WA's). In-flight 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 and/or dispatcher to evaluate on the basis of experience and the operational limits of the aircraft.

---

[15] Dry slot - A zone of dry and relatively cloud-free air, which wraps east- or northeastward into the southern and eastern parts of a synoptic scale or mesoscale low pressure system. A dry slot generally is seen best on satellite photographs.

[16] MVFR Conditions – means a ceiling between 1,000 and 3,000 feet inclusive, and/or visibilities between 3 and 5 miles inclusive.

[17] Deformation band – A region of the atmosphere where the stretching or shearing deformation is large in the wind field.

The NWS Aviation Weather Center located in Kansas City, Missouri, issued the following AIRMETs[18] at 2045Z, which were current over the Chicago area. These advisories were also included in Southwest Airlines flight 1248's weather document. The advisories are provided here in plain language:

> AIRMET Tango update 3 was issued for turbulence and was valid until 0300Z, and extended over portions of Wisconsin, Illinois, Michigan, Indiana, Kentucky, Tennessee, and Lake Michigan. The advisory was enclosed by the navigation fixes from Sault Ste Marie, MI (SSM), to 50 miles east of Oscoda, MI (ASP), to 30 miles south-southeast of Peck, MI (ECK), to Detroit, MI (DXO), to Fort Wayne, IN (FWA), to Covington, KY (CVG), to Henderson, WV (HNN), to Holston Mountain, TN (HMV), to Chattanooga, TN (GQO), to Muscle Shoals, AL (MSL), to 60 miles northeast of Dyersburg, TN (DYR), to 40 miles east of Dubuque, IA (DBQ), to 40 miles south of Sawyer, MI (SAW), to Sault Ste Marie, MI (SSM). The advisory warned of occasional moderate turbulence between 16,000 and 37,000 feet due to an upper level trough and jet stream wind shear. The conditions were expected to continue beyond 0300Z, and end between 0400Z and 0600Z over Wisconsin and Lake Michigan portions, and continue elsewhere beyond 0300Z through 0900Z.
>
> AIRMET Zulu for icing conditions over portions of Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, Lake Michigan, and Lake Huron. The advisory was enclosed by the navigation fixes from 60 miles south of Duluth, MN (DLH), to 50 miles east of Oscoda, MI (ASP), to 30 miles south-southeast of Peck, MI (ECK), to Detroit, MI (DXO), to Fort Wayne, IN (FWA), to 30 miles southeast of Decatur, IL (DEC), to Dyersburg, TN (DYR), to Quincy, IL (UIN), to 20 miles east of Fort Dodge, IA (FOD), to 60 miles south of Duluth, MI (DLH). The advisory was issued for occasional moderate rime to mixed icing-in-clouds and in-precipitation below 13,000 feet. The icing conditions were occurring over the southern and western portion of the area and were expected to develop and spread eastward across northern Lake Michigan and lower Michigan by 2200Z to 0100Z, with conditions ending between 0100Z and 0300Z over central Iowa, Missouri, and southwestern Illinois portion. Conditions were expected to continue beyond 0300Z and end between 0500Z and 0700Z over Minnesota and the remainder of Iowa and Illinois, elsewhere conditions were expected to continue beyond 0300Z through 0900Z.

[18] AIRMET (AIRman's METeorological Information) – is a NWS aviation product advises of weather that maybe hazardous, other than convective activity, to single engine, other light aircraft, and Visual Flight Rule (VFR) pilots. However, operators of large aircraft may also be concerned with these phenomena. The NWS issues AIRMETs every 6-hours, with amendments as necessary. AIRMET Sierra bulletin for ceilings less than 1,000 feet and/or visibility less than 3 miles affecting over 50% of the area at one time, and extensive mountain obscuration. AIRMET Tango bulletins are issued for moderate turbulence, sustained surface winds of 30 knots or more at the surface. AIRMET Zulu bulletins are issued for moderate icing and freezing level data. These AIRMET items are considered to be widespread because they must be affecting or be forecast to affect an area of at least 3,000 square miles at any one time. However, if the total area to be affected during the forecast period is very large, it could be that only a small portion of this total area would be affected at any one time.

The NWS also had an AIRMET Sierra current for IFR conditions over the area.

10.0 Center Weather Service Unit (CWSU) Advisories

The Chicago (ZAU) Air Route Traffic Control Center (ARTCC) Center Weather Service Unit (CWSU) issued the following Meteorological Impact Statement (MIS) bulletins surrounding the period:

> Chicago Center Meteorological Impact Statement 1 valid from 2125Z through 0330Z. For ATC planning purposes only. Chicago Center east of a line from 25 miles southwest of Mason City, Iowa (MCW) to 45 miles south of Iowa City, Iowa (IOW), widespread area of IFR and LIFR conditions in moderate snow will move to east of 40 miles north of Dells, Wisconsin (DLL) to 40 miles southwest of Lafayette, Indiana (BVT) by 0330Z. Expect frequent visibility below 1 mile and ceilings based at 400 to 900 feet agl. No updates issued after 0300Z.

> Chicago Center Meteorological Impact Statement 2, valid from 0130Z through 0730Z on December 9, 2005. For ATC planning purposes only. Chicago Center east of a line from the navigation fixes from 25 miles southeast of Mason City, Iowa (MCW) to 10 miles north of Decatur, Illinois (DEC), area of IFR and LIFR conditions in moderate snow will move to east of 65 miles northeast of Milwaukee, Wisconsin (BAE) to 35 miles south of Lafayette, Indiana (BVT) by 0730Z. The lowest conditions with ceilings below 600 feet agl and visibility below 1 mile will move east of Chicago Center airspace by 0730Z. No updates issued after 0300Z.

11.0 Interviews Conducted

The flight dispatchers who shared the responsibility with the pilots' in the planning, release, and operation of the flight, Mr. Phillip Pellegrino and Mr. James F. Johnson were interviewed by the Weather Group on December 10, 2005, to obtain statements of their actions regarding the flight. They were represented by David Watsky, the attorney representing the Southwest Airlines Employee Association. Summaries of those interviews follow.

Flight dispatchers are also responsible for monitoring the progress of each flight and issuing necessary information for the safety of flight, and canceling or redispatching a flight if, in his opinion or the opinion of the pilot-in-command, the flight cannot operate or continue to operate safely as planned or released. They are also responsible for providing the pilot-in-command with all available current information and reports of airport conditions and irregularities, as well as any adverse weather phenomena that may affect the safety of flight.

11.0.1 Releasing Dispatcher

Mr. Phillip Pellegrino, Aircraft Dispatcher/Instructor for Southwest Airlines, was the dispatcher who took over the shift for the initial releasing dispatcher while the aircraft was in Baltimore, and issued an amended release in which the flight was planned. Mr. Pellegrino has been a Dispatcher since 1984, and had worked for Muse Air, TranStar Airlines, and then for AMR before joining Southwest Airlines. He has dispatched domestic as well as international flights during his career, and holds an Aircraft Dispatcher Certificate, has an Associates Degree in Business, and overall 4 years of college education. He obtained his dispatch certificate through self-study, obtaining his certificate in 1983. He was hired by Southwest Airlines as an Assistant Dispatcher in April 1988, and was promoted to Dispatcher in June 1988. His last recurrent training occurred in January 2005.

Mr. Pellegrino was on day 3 of his normal 6 day work cycle, which is 6 days on/3 days off, 6 days on/3 days off, 6 days on/6 days off. His normal shift is from 1900Z to 0400Z (1300 to 2100 CST). On the day of the accident; however, he was to be relieved after 4 hours at 2300Z (1700 CST). He was well rested and had no personal or pressing issues that would have been a distraction to him that day.

Mr. Pellegrino indicated that he obtained weather familiarization by use of the Southwest Airlines workstation, which included Nexrad Radar (WSR-88D imagery), winter mosaic radar images, surface analysis charts, satellite images, 12 and 24-hour prognostic charts, METAR's, and TAFs. He indicated that he has access to the Internet weather products at his workstation, but does not rely on them for operational decisions. Some of the sites he used were: the Aviation Digital Data Services (ADDS), Northwest Airlines Turbulence Plots, and Graphic Turbulence Forecast (GTF) turbulence information. He was unaware of any web sites for field condition reports other than those supplied by Southwest Airlines. He routinely updates the crew via ACARS with any pertinent information regarding the safety of the flight.

On the day and flight in question Mr. Pellegrino recalled that he received a complete and satisfactory briefing from the previous Dispatcher including the winter weather impact on Midway Airport and the use of the Operation Specifications exemption 3585 to release flights into Midway based on the conditional language in the NWS TAF, and the use of two alternate airports. He noticed during his self-briefing that the snow event forecast for Chicago area was moving faster than expected, and that radar was depicting bands of snow just west of St. Louis moving up through the Chicago area. He calculated that it would impact the Midway airport sooner than forecast, but did not contact the National Weather Service to discuss the forecast. He did not see any products that indicated how much snowfall was expected at Midway, outside of the normal aviation products. At the time he began his shift, snow had not yet started at Midway.

Mr. Pellegrino stated that he uses radio and ACARS to communicate with his flight-crews enroute. He feels the ACARS is very reliable, and that radio communications in the KMDW area are approximately 75 percent reliable due to bleed-over from the operations frequency and weak signal strength. He indicated that he communicated with the Captain of flight 1248 before its

departure from Baltimore by ACARS message regarding the revised dispatch release and the Chicago weather.

Mr. Pellegrino indicated that he was busy on the afternoon of the accident, and that he was responsible for approximately 65 flights over the course of the scheduled 8-hour shift. He said there were no problems with his computer equipment, but indicated it was debatable whether his workload was manageable, depending on weather conditions and the circumstances. There is a dispatch procedure to off load work to other Dispatchers if he felt overworked, and he felt no pressure not to use the procedure if needed. He elected not to off load work rather to manage it with the occasional assistance of Dispatchers on either side of him to help with phone calls, which was a normal occurrence. He indicated that Southwest Airlines has specific criteria for suspending operations and that had cancelled flights due to operational concerns. He also indicated that he felt no pressure from management to release flights with which he was uncomfortable, or those with which he had safety concerns. On the evening of the accident all his equipment and workstation was working normally.

He stated that during his shift and once the snow began in Chicago he had one diversion to Detroit, which returned when the weather conditions came above minimums and field conditions improved. There was also airborne holding at low altitude, but it was not a major problem or irregularity, and it was something he deals with on a regular basis.

With regards to his planning and release of flight 1248, Mr. Pellegrino indicated the flight was released by the previous morning dispatcher at 1850Z (1250 CST). After reevaluation of the release and weather, while the flight was being held by air traffic control at the gate in Baltimore, he decided to amend the release, changing one of the two destination alternates from Detroit, since the weather was heading that way, to St. Louis, providing the flight Kansas City and St. Louis as alternates. He also increased the contingency fuel to 90 minutes, so he would have enough fuel for 3 approaches, and any unanticipated airborne holding. Later during the shift, when air traffic control ground stopped traffic to Chicago-Midway Airport, continued the ground stop, extended the ground stop, and then came out with EDCTs (expected departure control time's) due to runway closures for snow removal, he then issued revision 3 of his release. Revision 3 was based on the airport having changed the runway configuration from runway 4R to 31C. He planned for the tailwinds on his release, braking action fair, engine anti-ice on, and issued the new release. He indicated that he only communicated with the flight crew through ACARS, advising them of the current weather, runway visual range, and the current braking action. At that time he called the RVR as being 4,500 feet, and braking action fair on runway 31C. He also called Baltimore operations and advised them a new dispatch release was coming, and they advised they would get the new release and paperwork up to the flight crew. He could not verify that the amended data was actually received by the crew; however, he relied upon the operations agent in Baltimore station to do their job function and deliver the revised flight release to the flight crew. The weather packet was automatically updated with each amended release. He said the flight was delayed and had not departed at the time he was relieved of his duties by the oncoming shift. His concerns for this flight were about aircraft icing because of ATC holding flights at lower altitudes, braking action, tailwind component, and runway snow removal. He relied on his computer flight planning system to calculate stopping distances, and

indicated that the crew would also calculate the data on their Onboard Performance Computer (OPC). He thoroughly briefed the relieving Dispatcher, and did not expect any problems with the operation of the flight.

Mr. Pellegrino was informed of the accident while he was home, well after the accident. He was not drug or alcohol tested, as he was already off duty. He has returned to duty since the accident.

In suggesting any safety action follow-up, Mr. Pellegrino indicated he had concerns regarding the lack of communication between the ground operations coordinators and dispatch regarding obtaining braking action reports in a timely manner.

11.0.2 Flight Following Dispatcher

Mr. James F. Johnson was the dispatcher on duty at the time of the accident, and was responsible for flight following the accident airplane. Mr. Johnson obtained his dispatch license in December 1993, and had previously worked as a dispatcher for Paradise Air and Cayman Airways in Fort Lauderdale, Florida, prior to joining Southwest Airlines in 1999. Where he was first employed as a crew scheduler, and in 2001 he was promoted to Assistant Dispatcher. He was upgraded to into the full Dispatcher position in December 2002. His last recurrent training was in April 2005.

Mr. Johnson was working a mixed rotation of shifts and had two days off prior to working a partial shift of 4 hours between 2300Z to 0300Z (1700 to 2100 CST on December 8, 2005). He reported to work with adequate rest and had no family or personal problems affecting his work performance.

Mr. Johnson stated that at the beginning of his shift he received turnover briefing from Mr. Pellegrino, and then obtained a self briefing utilizing his personalized checklist of weather products, which included NWS surface analysis, weather prognostic charts, upper air charts, satellite imagery, turbulence plots, winter weather radar mosaic, observations (METARs), terminal forecast (TAFs), from Southwest Airlines approved weather sources and other miscellaneous “advisory only” websites to ensure he was fully briefed on all aspects for his sector. He did not consult with the NWS or any other meteorological services regarding the weather conditions.

Mr. Johnson had approximately 10 to 13 flights in the air to flight follow, 17 finished releases with flights that had not departed, and 4 flight releases to issue for his 4 hour shift. All his support and workstation tools were working normally, and he had no operational problems affecting his performance. He indicated that his workload was manageable, and felt no pressure from Southwest Airlines management on releasing flights that he did not feel uncomfortable or considered the conditions unsafe in releasing flights. He indicated he had canceled flights while he was at Cayman Island for operational reasons and would have no problems canceling a flight if he did not feel comfortable dispatching them.

Regarding the flight 1248, he indicated he received an adequate turnover briefing from Phil Pellegrino, who had expressed concerns with the weather, tailwind, and field conditions into Chicago-Midway. The flight was just departing when he started his shift, and he reviewed the release. He thought it was a good release as far as he was concerned, and was pleased that Mr. Pellegrino had plugged in the tail winds and reduced the runway to fair in the performance calculations, which he believed was a better assessment of the runway and reduced the landing weight in order to put the airplane in a safe landing configuration.

Based on the analysis of the weather and field conditions, at the time, Mr. Johnson indicated that he saw no operational limitation or unnecessary concerns for the safe operation of the flight. Mr. Johnson's primary responsibility was for flight following of Southwest flight 1248, and two other flights that were going into Midway, which he considered as "priority flights" based on the conditions. Mr. Johnson indicated that weather was "not good" but within operational limits for air carrier operations, with snow continuing; however, the runway visual range (RVR) was at 4,500 feet and had gone down to a low near 2,800 feet at one point near the start of his shift, and had improved to 5,500 feet for approximately 45 to 60 minutes prior to flight 1248's arrival, the runway had been plowed twice, and the braking action reports were good. He felt the Midway airport was on top of the snow event there and continued to monitor pilot reports, Southwest operations, and air traffic control for information.

He continued to monitor the weather, RVR, and field conditions reports, and was monitoring the company radio frequency for Midway. His first priority flight landed during the period of reduced RVR, and reported braking action poor. The runway was closed for plowing shortly thereafter. The second flight held at two separate times due to runway plowing, but also landed safely. He felt they were on top of the event with the snow into Midway.

He then received an ACARS message advising that flight 1248 was in holding due to plowing on runway 31C. An ACARS diversion plan was sent to the aircraft and was acknowledged by the flight crew. He continued to monitor the flight on his aircraft situational display as the flight left holding and started the approach into Midway, and last observed the flight at approximately 1,500 feet. A short while later a dispatcher nearby advised him that an aircraft was off the runway at Midway, and was soon notified by the Superintendent of Dispatch (SOD) that flight 1248 had indeed gone off the end of the runway. He then delegated his remaining flights to other dispatch sectors, and continued making the necessary notification. He was relieved from duty and administered drug and alcohol testing. Both tests came back with negative results.

Due to Mr. Johnson's relief or rotating schedule, he has not returned to work at the time of the interview. He has met with a crisis counselor and felt fully capable of resuming his dispatch duties.

12.0 Dispatch Release and Weather Document

It was determined that three dispatch releases were issued for flight 1248. The releases were examined and the differences documented to help determine the planning progression, and reasons for the changes. The initial dispatch release was issued by Dispatcher Wayne Jockers at 1819Z for flight 1248 between KBWI and KMDW, aircraft N471WN, with an allowable takeoff gross weight 136,000 pounds. The planned landing weight was 114,500 pounds. The contingency fuel of 1 hour or 4,200 pounds (lbs), minimum departure fuel was 21,300 lbs with a planned arrival fuel of 12,000 lbs. Release was planned on runway 4R with calm winds and runway condition Wet with Good braking action, engine anti-ice ON, en-route icing restriction, flaps 40. The release had two alternates of Kansas City (KMCI) and Detroit (KDTW)

An updated release "revision 1" was issued by the relieving Dispatcher Phillip Pellegrino at 2001Z. Changes from the initial release consisted of changing the destination alternates to Kansas City (KMCI) and St. Louis (KSTL). The minimum fuel remained unchanged. Flap changed to 30 degrees.

Updated release "revision 2" was issued by Dispatcher Phillip Pellegrino at 2027Z. The changes from revision 1 consisted of changing the contingency fuel to 1 hour 30 minutes or 6,400 lbs. This increased the minimum fuel to 23,700 lbs and increased the landing weight to 116,800 lbs.

Updated release "revision 3" issued by Dispatcher Phillip Pellegrino at 2233Z. The changes from revision 2 consisted of updating the planned landing information due to changing weather and runway conditions. Changes consisted of changing planned landing runway to 31C, wind input of 080 degrees at 11 knots, runway condition Wet with fair braking action. Changing the runway and conditions lowered the allowable take-off gross weight to 129,000 lbs. Planned landing weight of 116,800 lbs remained unchanged from revision 2. This was the official planned dispatch release, flight plan, and weather document issued by the dispatcher and are included as attachment 1.

13.0 Flight Updates

The following ACARS messages were transmitted to Southwest Airlines flight 1248:

2014Z	N471WN, 1248, BWI ARRIVE GATE FROM A/C IN GATE MESSAGE RECEIVED FOR N471WN: DEPARTURE AIRPORT: SAN ARRIVAL AIRPORT: BWI IN TIME: N/A FUEL ON BOARD: 7.4
2040Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C MDW ATIS INFO K 2007Z Special. 09009KT 1/2SM SN BKN007 OVC019 M04/M09 A3026 (THREE ZERO TWO SIX). ILS Rwy 4R Apch in use. Lndg and depg rwys 4. Also depg rwy 13C. All Fixed wing departures ctc cd on 121.85. VFR departures indc typ, fld lctn, and reqstd hdg. READBACK ALL RWY HOLD SHORT INSTRUCTIONS. ...ADVS you have INFO K.
2100Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C MDW ATIS INFO M 2053Z. 08008KT 1/4SM SN FZFG VV002 M05/M07 A3021 (THREE ZERO TWO ONE). ILS Rwy 31C Apch in use. Lndg and depg rwys 31. Also depg rwy 4R. All Fixed wing departures ctc cd on121.85. VFR departures indc typ, fld lctn, and reqstd hdg. READBACK ALL RWY HOLD SHORT INSTRUCTIONS. ...ADVS you have INFO M.

2115Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C MDW ATIS INFO M 2053Z. 08008KT 1/4SM SN FZFG VV002 M05/M07 A3021 (THREE ZERO TWO ONE). ILS Rwy 31C Apch in use. Lndg and depg rwys 31. Also depg rwy 4R. All Fixed wing departures ctc cd on 121.85. VFR departures indc typ, fld lctn, and reqstd hdg. READBACK ALL RWY HOLD SHORT INSTRUCTIONS. ...ADVS you have INFO M.
2139Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C MDW ATIS INFO N 2053Z. 08008KT 1/4SM SN FZFG VV002 M05/M07 A3021 (THREE ZERO TWO ONE).ILS Rwy 31C Apch in use. Lndg and depg rwys 31. Also depg rwy 4R. ALL RUNWAYS CLOSED EXCEPT FOUR RIGHT AND THREE ONE CENTER. All Fixed wing departures ctc cd on 121.85. VFR departures indc typ, fld lctn, and reqstd hdg. READBACK ALL RWY HOLD SHORT INSTRUCTIONS. ...ADVS you have INFO N.
2149Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C MDW ATIS INFO N 2053Z.08008KT 1/4SM SN FZFG VV002 M05/M07 A3021 (THREE ZERO TWO ONE).ILS Rwy 31C Apch in use. Lndg and depg rwys 31. Also depg rwy 4R. ALL RUNWAYS CLOSED EXCEPT FOUR RIGHT AND THREE ONE CENTER. All Fixed wing departures ctc cd on 121.85. VFR departures indc typ, fld lctn, and reqstd hdg. READBACK ALL RWY HOLD SHORT INSTRUCTIONS. ...ADVS you have INFO N.
2155Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C IND ATIS INFO X 2129Z Special. 09012KT 1/4SM +SN FZFG VV003 M03/M04 A3012 (THREE ZERO ONE TWO). ILS RWY 5L APCH IN USE. NOTAMS... RWYS 23L AND 5R CLSD, RWYS 14 AND 32 CLSD. BA ADZYS in EFCT. HIWAS. IND ARPT DEICING PLAN IN PROGRESS. ...ADVS you have INFO X.
2202Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C MDW ATIS INFO O 2153Z. 08011KT 1/2SM SN FZFG VV003 M04/M06 A3016(THREE ZERO ONE SIX). ILS Rwy 31C Apch in use. Lndg and depg rwys 31. Also depg rwy 4R. ALL RUNWAYS CLOSED EXCEPT FOUR RIGHT AND THREE ONE CENTER. All Fixed wing departures ctc cd on 121.85. VFR departures indc typ, fld lctn, and reqstd hdg. READBACK ALL RWY HOLD SHORT INSTRUCTIONS. ...ADVS you have INFO O.
2202Z	N471WN, 1248, BWI DISPATCH FREETEXT A/C LATEST 31C BRAF RVR 4500
2249Z	N471WN, 1248, BWI PUSH GATE FROM A/C OUT GATE MESSAGE RECEIVED FOR N471WN
2255Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C MDW ATIS INFO P 2253Z.09012KT 3/4SM -SN BR BKN004 OVC009 M03/M05 A3012 (THREE ZERO ONE TWO). ILS Rwy 31C Apch in use. Lndg and depg rwys 31. Also depg rwy 4R. ALL RUNWAYS CLOSED EXCEPT FOUR RIGHT AND THREE ONE CENTER. All Fixed wing departures ctc cd on 121.85. VFR departures indc typ, fld lctn, and reqstd hdg. READBACK ALL RWY HOLD SHORT INSTRUCTIONS. ...ADVS you have INFO P.
2258Z	N471WN, 1248, BWI WHEELS UP FROM A/C OFF GROUND MESSAGE RECEIVED FOR N471WN: DEPARTURE AIRPORT: BWI ARRIVAL AIRPORT: MDW OFF TIME: N/A FUEL ON BOARD: 23.9
2333Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C MDW ATIS INFO R 2316Z Special. 08010KT 1/2SM SN FZFG BKN002 OVC009 M03/M05 A3011 (THREE ZERO ONE ONE). ILS Rwy 31C Apch in use. Lndg and depg rwys 31. Also depg rwy 4R. NOTAMS... Rwy 4R, 22L Clsd, Rwy 31R, 13L Clsd, Rwy 4L, 22R Clsd, Rwy 31L, 13R Clsd. All Fixed wing departures ctc cd on 121.85. VFR departures indc typ, fld lctn, and reqstd hdg. READBACK ALL RWY HOLD SHORT INSTRUCTIONS. ...ADVS you have INFO R.
2338Z	N471WN, 1248, BWI WEATHER REQUEST METAR FROM A/C SPECI KMDW 082316Z COR 08010KT 1/2SM SN FZFG BKN002 OVC009 M03/M05 A3011 RMK AO2 R31C/3500 SNINCR 2/5 P0000
2343Z	N471WN, 1248, BWI ETA MESSAGE RECEIVED FOR N471WN DEPARTURE: BWI ARRIVAL AIRPORT: MDW ETA: 0050 ESTIMATED ARRIVAL FUEL: 18.4

2346Z	N471WN, 1248, BWI DISPATCH FREETEXT FROM A/C OK WHAT IS MDW STATUS FOR 0050 ETA
2347Z	N471WN, 1248, BWI DISPATCH FREETEXT TO A/C NOT GOOD...BACK TO YOU IN A MIN...
2349Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C STL ATIS INFO Z 2251Z.29014KT 5SM -SN BR BKN023 BKN045 BKN250 M07/M11 A3025 (THREE ZERO TWO FIVE). ILS RY 30R, ILS RY 24 APCH IN USE, DEPG RY 30L. NOTAMS... TWY T CLSD. ACFT TAXI WITH TRANSPONDER ON. BA ADZYS in EFCT. Bird Advisories in effect. ALL AC USE EXTREME CAUTION FOR IN ADVERTANT ALIGNMENT TO NEW RWY CONSTRUCTION WEST OF AIRPORT. USE CAUTION FOR PERSONNEL AND EQUIP ADJ TO RWYS AND TWYS. STL DEICING PROCEDURE, ARE IN EFFECT. ...ADVS you have INFO Z.
2350Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C MCI ATIS INFO U 2253Z.28007KT 10SM CLR M12/M17 A3036 (THREE ZERO THREE SIX). ARRIVALS EXPECT VISUAL APCH Rwy 1R, 1L. SIMUL APPROACHES IN USE. NOTAMS... RWY 9, 27 CLSD. . TAXIWAY ECHO CLOSED. TAXIWAY ALPHA CLOSED. TAXIWAY JULIET CLOSED. TAXIWAY ALPHA TWO CLOSED. MEW READINGS UNAVAILABLE. SNOW REMOVAL IN PROGRESS ON TAXIWAYS AND RAMPS. BA ADZYS in EFCT. MIGRATORY WATERFOWL IN THE KANSAS CITY AREA. ...ADVS you have INFO U.
2353Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C IND ATIS INFO F 2344Z Special. 14010KT 1/4SM SN FZFG BKN004 OVC017 M03/M04 A3003 (THREE ZERO ZERO THREE). ILS RWY 5R APCH IN USE. NOTAMS... RWYS 23R AND 5L CLSD, RWYS 14 AND 32 CLSD. BA ADZYS in EFCT. HIWAS. IND ARPT DEICING PLAN IN PROGRESS...ADVS you have INFO F.
2358Z	N471WN, 1248, BWI WEATHER REQUEST NOTAM FROM A/C MDW ATIS INFO S 2353Z.10009KT 1/4SM SN FZFG VV001 M03/M04 A3009(THREE ZERO ZERO NINER). ILS Rwy 31C Apch in use. Lndg and depg rwys 31. Also depg rwy 4R. NOTAMS... Rwy4R, 22L Clsd, Rwy 31R, 13L Clsd, Rwy 4L, 22R Clsd, Rwy 31L, 13R Clsd. All Fixed wing departures ctc cd on 121.85. VFR departures indc typ, fld lctn, and reqstd hdg. READBACK ALL RWY HOLD SHORT INSTRUCTIONS. ...ADVS you have INFO S.
0000Z	N471WN, 1248, BWI DISPATCH FREETEXT TO A/C COMPANY REPORTS BRA FAIR AFTER PLOWING. ALOHA. JJ
0001Z	N471WN, 1248, BWI DISPATCH FREETEXT FROM A/C HOW BOUT RVR 31C THX
0002Z	N471WN, 1248, BWI DISPATCH FREETEXT TO A/C RIGHT NOW ITS UP AT 5500 BUT ITS FLUX PRETTY RAPIDLY...
0002Z	N471WN, 1248, BWI DISPATCH FREETEXT FROM A/C THX A BUNCH
0004Z	N471WN, 1248, BWI ETA REPORT FROM A/C ETA MESSAGE RECEIVED FOR N471WN: DEPARTURE AIRPORT: BWI ARRIVAL AIRPORT: MDW ETA: 0049 ESTIMATED ARRIVAL FUEL: 16.4
0011Z	N471WN, 1248, BWI WEATHER REQUEST NOTAM FROM A/C MDW 12/042 MDW 13C ILS MM DCMSND WEF 0412200901 MDW 12/017 MDW 4R/22L CLSD MDW 12/016 MDW 13R/31L CLSD MDW 12/015 MDW 13L/31R CLSD MDW 12/014 MDW 4L/22R CLSD MDW 12/013 MDW TMPA SEE ATCCC MSG TIL 0512090359 MDW 12/008 MDW 31C KEDZI NDB/ILS LO DCMSND MDW 11/032 MDW TOWER 883 (289 AGL) 5.5 ESE LGTS OTS (ASR 1063456) TIL 0512101500

0024Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C MDW ATIS INFO T 2353Z.10009KT 1/4SM SN FZFG VV001 M03/M04 A3009 (THREE ZERO ZERO NINER) RMK AO2 SLP207 R31C/3000FT SNINCR 3/9 4/009 P0000 60000 11033 21056 56040. ILS Rwy 31C Apch in use. Lndg and depg rwys 31. Also depg rwy 4R. NOTAMS... Rwy 4R, 22L Clsd, Rwy 31R, 13L Clsd, Rwy 4L,22R Clsd, Rwy 31L, 13R Clsd. All Fixed wing departures ctc cd on 121.85. VFR departures indc typ, fld lctn, and reqstd hdg. READBACK ALL RWY HOLD SHORT INSTRUCTIONS. ...ADVS you have INFO T.
0032Z	N471WN, 1248, BWI INRANGE REPORT FROM A/C INRANGE MESSAGE RECEIVED FOR N471WN: DEPARTURE AIRPORT: BWI ARRIVAL AIRPORT: MDW ETA: 0051 ESTIMATED ARRIVAL FUEL: 15.0
0037Z	N471WN, 1248, BWI HOLDING REPORT FROM A/C HOLDING REPORT FOR N471WN: HOLDING FIX: LUCIT FUEL ON BOARD: 14.7 ESTIMATED CLEAR TIME: 0055 ALTITUDE: 10000 REMARKS: PLOWING
0038Z	N471WN, 1248, BWI DISPATCH FREETEXT TO A/C COPY...STANDBY...
0039Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C IND ATIS INFO G 0002Z Special. 14008KT 1/4SM SN FZFG VV005 M03/M03 A3003 (THREE ZERO ZERO THREE). ILS RWY 5R APCH IN USE. NOTAMS... RWYS 23R AND 5L CLSD, RWYS 14 AND 32 CLSD. BA ADZYS in EFCT. HIWAS. IND ARPT DEICING PLAN IN PROGRESS. ...ADVS you have INFO G.
0039Z	N471WN, 1248, BWI WEATHER REQUEST TAF FROM A/C TAF KIND 082335Z 090024 10012KT 1 1/2SM –SN SCT006 OVC015 TEMPO 0003 3/4SM -SN OVC006 FM0300 25014KT 3SM -SN OVC018 FM0700 25015KT P6SM BKN020 FM1400 25010KT P6SM BKN035 FM2000 23007KT P6SM SCT035
0042Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C STL ATIS INFO B 0009Z Special. 28017KT 9SM SCT025 M08/M13 A3029 (THREE ZERO TWO NINER). ILS RY 30R, ILS RY 24 APCH IN USE, DEPG RY 30L. NOTAMS... TWY T CLSD. ACFT TAXI WITH TRANSPONDER ON. BA ADZYS in EFCT. Bird Advisories in effect. ALL AC USE EXTREME CAUTION FOR IN ADVERTANT ALIGNMENT TO NEW RWY CONSTRUCTION WEST OF AIRPORT. USE CAUTION FOR PERSONNEL AND EQUIP ADJ TO RWYS AND TWYS. STL DEICING PROCEDURE, ARE IN EFFECT. ...ADVS you have INFO B.
0044Z	N471WN, 1248, BWI DIVERSION PLAN TO A/C DIVERSION PLAN SENT TO N471WN WITH THE PARAMETERS: ALTERNATE AIRPORT: STL ORIGINAL DESTINATION: MDW FAF FUEL: 8.5 FAF TIME: ---- FUEL BURN TO ALTERNATE: 3.5 TIME ENTERED: 0045 DISPATCHER INITIALS: JJ DISPATCH REMARKS: ACARS ME AT 9.5
0045Z	N471WN, 1248, BWI DIVERSION RESPONSE FROM A/C AIRCRAFT N471WN HAS ACCEPTED THE PROPOSED DIVERSION PLAN ACCEPTED PARAMETERS ARE: PILOT REMARKS: REJECT REASON: ALTERNATE AIRPORT: STL ORIGINAL DESTINATION: MDW FAF FUEL: 8.5 FAF TIME: ---- FUEL BURN TO ALT: 3.5 TIME ENTERED: 0045 DISPATCHER INITIALS: JJ DISPATCH REMARKS: ACARS ME AT 9.5
0045Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C DTW ATIS INFO W 0035Z Special. 07007KT 1 1/2SM -SN OVC014 M03/M07 A3022 (THREE ZERO TWO TWO). SIMUL ILS APCH IN USE RWY 4L AND RWY 3R. DEPG RWY 4R, RWY 3L . NOTAMS...RWY 27L, 9R CLSD, RWY 27R, 9L CLSD. LGT TO MOD, RIME ICING REPORTED IN THE DTW AREA. BA ADZYS IN EFCT. LCL DEICE PROC IN EFCT. GATE HOLD PROC IN EFCT FOR ATL, MDW, ORD, CVG....ADVS you have INFO W.

0052Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C MDW ATIS INFO U 0024Z Special. 09011KT 3/4SM -SN BR OVC003 M03/M04 A3007 (THREE ZERO ZERO SEVEN). ILS Rwy 31C Apch in use. Lndg and depg rwys 31. Also depg rwy 4R. NOTAMS... Rwy 31R, 13L Clsd, Rwy 4L, 22R Clsd, Rwy 31L, 13R Clsd. All Fixed wing departures ctc cd on 121.85. VFR departures indc typ, fld lctn, and reqstd hdg. READBACK ALL RWY HOLD SHORT INSTRUCTIONS. ...ADVS you have INFO U.
0104Z	N471WN, 1248, BWI WEATHER REQUEST DATIS FROM A/C MDW ATIS INFO V 0053Z. 10011KT 1/2SM SN FZFG BKN004 OVC014 M03/M05 A3006 (THREE ZERO ZERO SIX). ILS Rwy 31C Apch in use. Lndg and depg rwys 31. Also depg rwy 4R. NOTAMS... Rwy 31R,13L Clsd, Rwy 4L, 22R Clsd, Rwy 31L, 13R Clsd. All Fixed wing departures ctc cd on 121.85. VFR departures indc typ, fld lctn, and reqstd hdg. READBACK ALL RWY HOLD SHORT INSTRUCTIONS. ...ADVS you have INFO V.
0114Z	(Accident occurs.)
0123Z	N471WN, 1248, BWI DISPATCH FREETEXT TO A/C CAN WE HELP
0126Z	N471WN, 1248, BWI DISPATCH FREETEXT TO A/C ARINC ERROR: ACARS FREE TEXT COULD NOT BE DELIVERED TO N471WN. AIRCRAFT CANNOT BE REACHED AT THIS TIME. PLEASE TRY AGAIN IN A FEW MINUTES. CAN WE HELP

14.0 Southwest Airlines Operational Restrictions

Under Southwest Airlines Flight Operations Manual (FOM), under section 2.1.1 through 2.2.10 the following landing restrictions are listed:

- Weather conditions are below FAA established landing minima.
- Wind limitations are exceeded.
- Greater than light freezing rain at the airport.
- Known or probable severe icing conditions.
- Known or probable severe turbulence conditions.
- Water or slush[19] greater than 1 inch on runway.
- Wet snow[20] greater than 2 inches on runway.
- Dry snow[21] greater than 6 inches on runway.
- Braking action reported as "NIL".
- Regardless of the First Officers (FO) experience level, the Captain (CA) will land under the following conditions:
  - An engine is shutdown.
  - Visibility is below 3/4 mile or 4,000 feet RVR.

Under the wind restrictions section 2.2.9 of the FOM, the maximum crosswind for a wet runway is 35 knots based on the steady state wind, and the maximum tailwind based on peak gusts is 10 knots. For a contaminated runway the maximum crosswind for landing and takeoff is reduced to 20 knots. With braking action "fair" the crosswind is restricted to 15 knots. With

[19] Slush – is defined by Southwest Airlines (SWA) as snow mixed with water.
[20] Wet snow – is defined by SWA as wet if it can be compacted easily by hand.
[21] Dry snow – is defined by SWA as dry if it cannot be compacted easily by hand.

braking action “poor” the crosswind component is 10 knots, and the maximum tailwind allowed is 5 knots based on peak gusts.

15.0 Chicago-Midway Airport Operations

The Chicago-Midway Airport Operations staff is responsible for overseeing and maintaining the runways and taxiways. The senior airport operations staff were interviewed on December 12 and 13, 2005, regarding the airports snow plan, equipment, staffing, preparation and warnings they received, and their actions on the evening of the accident relating to the winter storm that impacted the area. The staff working during the snow event who were interviewed included:

Mr. Alfonso (Al) Perez – Assistant Commissioner of Airport Operations
Mr. Alberto Rodriguez – Chief Airport Operations Supervisor
Mr. Terry Thomas - Manager of Airport Operations
Mr. Glenn Martin - Airport Operations Supervisor
Mr. Mike Conway - Airport Operations Supervisor

A tour of the airport Operation office indicated that the airport has multiple weather sources from the NWS, commercial weather venders, and contract services from a local retired NWS forecaster and consultant. The office receives all NWS public forecasts and winter weather advisories, and from one of their venders, Surface Systems Inc. (SSI), also receives a forecast every 3-hours during winter weather events. The airport also installed the Surface Scan System from SSI, which provides runway temperature and indication of contamination to help determine the best way to treat the runways. The office also has a Flight Explorer System, which provides a display of aircraft situation display (ASD) of all inbound traffic to the airport, with weather radar overlays and winter mosaic images. All these systems support the airport operations weather watch for activation of their snow plan.

The Operations office also monitors the Chicago-Midway FAA tower and ground frequencies, and has direct “ring-down” phones for rapid communications to emergency services.

The Operations office has an electronic logging system (ELS), which is a web-based system where they can enter NOTAMs and field conditions direct into the FAA circuits and allow users to access to the Information Display System (IDS-4), which provides the latest weather observation, runways in use, runway visual range readings for runways 31C, 13C, 4R, current ATIS, NOTAMs, and field conditions, including MU-meter readings. The system is updated routinely when updated information becomes available, such as field conditions. This system is the airport’s primary source of transmitting airport information and has made the web based system available to every air carrier at Midway Airport, the local fixed base operations (FBO), and local corporate aviation groups. The system is a secured controlled site and is password

protected. Southwest Airlines Station Operations were provided access to the site[22]; however, the Chicago Airport Operations Web site has not been approved by the FAA as a Qualified Internet Communications Provider (QICP), and therefore is not useable for decision making by the airline. It is for intended for informational purposes only, and as such is not required to be monitored by Southwest Airlines. The NOTAM information posted prior to the accident at 0050Z was as follows:

12/08/2005 18:50 CST NOTAM – Field Conditions

4R-22L	Closed – snow removal in progress
4L-22R	Closed
13L-31R	Closed
13C-31C	90% trace – 1/16" wet snow, 10% clear and wet.
	Snow removal in progress.
	MU Friction Value (Bowmonk) 1847hrs .72/.59/.68 avg=.67
13R-31L	Closed
Taxiways	Varying coverage up to 3.0" wet snow
Ramps/Other	Varying coverage up to 3.0" wet snow

The Operations office is staffed continuously, 24-hours per day and 7-day per week. With three 8-hour shifts during routine operations consisting of a duty manager/supervisor and one Airport Operations Supervisor (AOS) on duty. During winter weather alerts the office transitions to 12-hour shifts, with a minimum of four to six Airport Operations Supervisors. With one supervisor stationed in the air traffic control tower, one on the field to monitor and direct the snow removal, one driving the friction testing vehicle to measure runway friction, one at the terminal and hangar ramps area, and one positioned at the Operations office.

Mr. Al Perez, the Assistant Commissioner of Airport Operations, issued the initial snow alert and was out on the field directing the runway cleaning operations. He has over 7 years experience at Chicago-Midway Airport, and is a retired military officer.

Mr. Alberto Rodriguez is the Chief Airport Operations Supervisor, was the second-in-command and was working in the Operations Center and out in the field during the event. Mr. Rodriguez has 7 years experience at Chicago-Midway, and prior to that supported a Marine Aviation wing.

Mr. Glen Martin was the Airport Operations Supervisor assigned to the Air Traffic Control Tower. His primary function there was to coordinate with ATC and ground equipment drivers working between gaps in traffic as best as possible to maintain a clean runway, and logging the events into an Operations log. Mr. Martin has over 10 years experience at Chicago-Midway Airport and 10 years at Chicago-O'Hare International Airport.

[22] A walk through of the Southwest Airlines Station Operations office at Midway after the accident revealed that they were unaware of the Internet access site and were not monitoring the information being provided by the Chicago-Midway Airport Authority. It was noted that this was the first major snow event for the area.

Mr. Terry Thomas is a Manager of Airport Operations and was working from a vehicle supervising the airport operation. He has 17 years experience at Chicago-Midway Airport, has a master degree in Aviation Management from Embry-Riddle Aeronautical University, and a private pilot certificate.

15.0.1 Airport Snow Plan

Initial planning and preparation for the Chicago-Midway Airport snow plan starts in September, with a review and maintenance of the vehicles, and hiring and training of the drivers. The snow plan is reviewed and updated as necessary.

On December 8, 2005, the snow plan began with a forecast of winter weather conditions by a combination of sources (NWS, SSI, consultants) and air traffic control advising Operations of the primary runways that were expected to be used during the event based on the winds and the weather. The assistant Commissioner, Mr. Al Perez, issued the initial alert at approximately 1700Z. Additional drivers were contacted to come to work for the expected snow event. Snow began at 1832Z and treating and brooming of the runways began. A supplemental alert was issued at approximately 2100Z bringing the complement of employees to between 32 and 34 equipment drivers. Operation Managers felt they had adequate staff and equipment to keep up with the snowstorm. Available equipment included 9 brooms, 2 plows, 1 blower, 3 40-foot boom deicers, and 2 friction measuring devices, which are calibrated before each snow event or every twenty-four hours during extended events.

Typical broom vehicle

Typical snow plow used

The criteria the airport utilizes to close a runway classified as “unsafe” was determined to be when visual inspection was deemed necessary, MU-meter readings were under .40, or a pilot report of “nil” braking action. AirTran reported a nil report at 2222Z and the airport took immediate action to address the field conditions. Mr. Martin and Mr. Perez indicated that a runway would receive immediate attention when two or more pilot report indicated “poor” braking.

At the time of the first snowfall, the snow was determined to be wet in nature, and a layer of potassium acetate[23] was applied to the runway surface to prevent the snow from adhering to the runway surface. As snow accumulation developed, it was removed by broom, plow, blower and additional deicer applied as depicted in figure 16. Phase 1 as illustrated, consisted of a lead truck who coordinate with the Airport Operations Supervisor in the tower when traffic gaps existed. The supervisor in the lead truck would be followed by 7 to 8 broom trucks, 2 plows, a blower, and another broom truck to clean up any remaining snow. They would travel between 20 to 25 mph down the runway cleaning the entire runway width of 150 feet. A back-lead vehicle would coordinate between the trucks to close up any gaps between the broom trucks. An Airport Operations Supervisor (AOS) would follow inspecting the brooming and plowing effort. A moderate to heavy snow may require 2 or 3 runs to clear the runway.

Phase 2 would consist of another lead truck followed by 3 deicing trucks with a 40 feet booms that sprayed potassium acetate deicer, followed by 2 back-leads, again to coordinate and to ensure the runway was properly being covered.

Phase 3 would follow a few minutes behind the deicing procedure when an unobstructed run down the runway could be accomplished by the vehicle to obtain the MU-meter reading. The friction measuring run is performed at 40 mph approximately 10 feet off the centerline of the runway (to approximate the main gear braking) and would begin approximately 500 feet from the beginning of the runway and end within 500 feet of the end of the runway, due to braking concerns and decelerations. The entire runway length is broomed, plowed, and deiced. A typical runway clearing took approximately 10-minutes to perform with a friction test taken after each runway treatment and the MU values recorded by the operator, radioed to the Operations Center and the Operations liaison in the control tower, and logged.

[23] Potassium acetate – is a Type 3 deicing fluid, which has a higher viscosity than water and can affect runway friction.

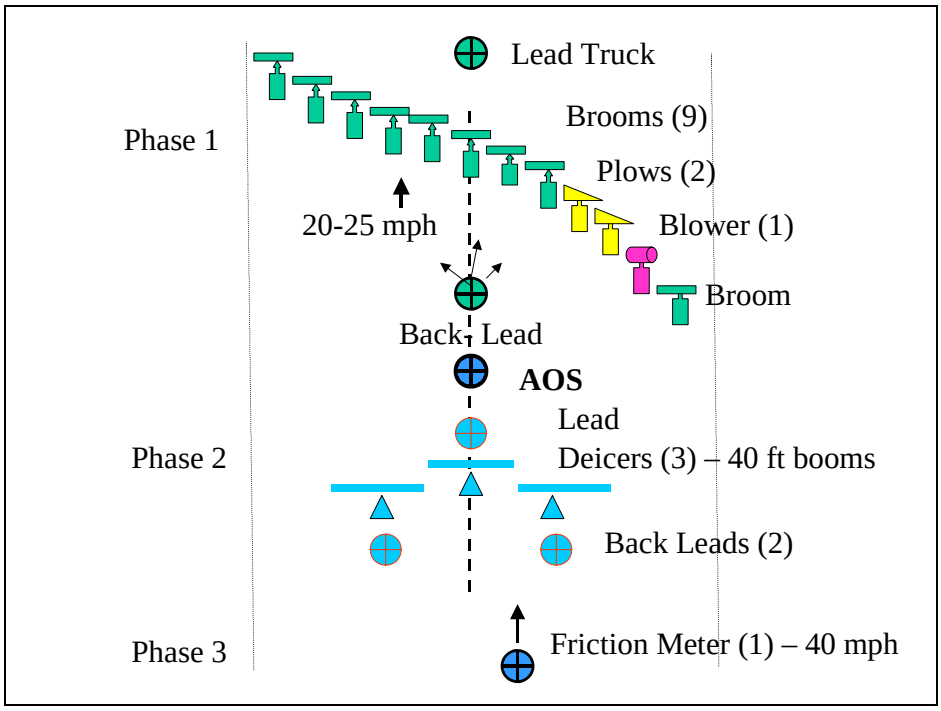

Figure 16 – typical runway plowing diagram

After a typical runway clearing, the brooms would move to a ramp or clear area to clean the "heads" by vibrating or shaking them, which would take approximately 5-minutes. After a heavy wet snow or after extensive runway runs the brooms would move to a ramp or clear area and have ground crews totally clean the brooms by compressed air, washed, and then vibrated. This more extensive cleaning process takes approximately 30 to 45-minutes to accomplish. At 0044Z the brooms were at the ramp undergoing one such broom cleaning process, and were unavailable for any runway treatment.

Two different models of friction measuring devices were used and recorded differing values. One device used was ASFD AB2000 Ford Taurus with a fifth wheel (logged as Ford), and a Bowmonk AFM2 (logged as Bowmonk). Operations stated that the Bowmonk meter is easier to use, provided more reliable readings in their opinions, and was used more frequently for their operational decisions. Pilot braking action reports were also logged on the Operations log in the control tower and are considered when determining the need to retreat runway surfaces and whether to continue or cease flight operations. Operations indicated they gave less weight to pilot reports than friction meters due their subjectivity and inconsistent nature (i.e. appeared to use the same amount of landing distance and turn offs, but report "poor" braking, and the various types of aircraft and operators); however, they were considered in their operational decisions. Operations as a normal practice, does not correlate braking action reports with MU-meter readings, but indicated they were comfortable with MU-meter readings above .40. Anything less than .40 would be addressed immediately.

On this shift, Mr. Thomas stated that they received "a lot of snow fast," and indicated keeping it removed was a challenge. Upon his suggestion, at approximately 2155Z when they experienced heavy snow, it was decided by Operations to close all runways except 31C and

concentrate their efforts on keeping at least one landing runway operational. During this period Southwest Airlines Dispatch indicated that they had between 10 to 12 flight diversions. The following is a summary of events from the Operations Log from the control tower after that time.

UTC	CST	Runway	Action	MU (Average) remarks
0028Z	1828	31C	Pilot report SWA B737	Fair to poor
0032Z	1832	31C	Runway treatment	Equipment on runway; brooms, plow, deicers.
0047Z	1847	31C	Friction test Bowmonk	72/59/68 (67) 1/8 to 1/4 in wet snow on runway
0049Z	1849	31C	Pilot report UAL A319	Not captured.
0053Z	1853	31C	Pilot report SWA B737	Fair/poor at the end
0109Z	1909	31C	Pilot report SWA B737	Good 1st and 2nd thirds, poor last 3rd.
0114Z	1914	31C	SWA flight 1248	Reports off the end of the runway
0122Z	1922	31C	Friction test Bowmonk	41/40/38 (40) 1/8 to 1/4 inch of snow on runway.

Mr. Martin, located in the tower, did not observe the accident airplane land and could identify the aircraft lights as it landed. He indicated that at the time Southwest Airlines 1248 was landing it appeared that a snow squall went through with visibility less than 1/2 mile in moderate snow. Upon hearing that Southwest Airlines 1248 was off the end of the runway, he informed the Mr. Rodriguez, who was coordinating operations on the airport, who immediately notified Mr. Conway to take a friction test on the runway.

Mr. Conway was located on the north end of the terminal in the Bowmonk vehicle and immediately went to runway 31C and performed a friction test at 0122Z (1922 CST). The post accident Bowmonk reading indicated .41/.40/.38, with an average reading of .40. Mr. Conway indicated that the runway was covered with between 1/8 to 1/4 inch of snow and the runway markings were not visible. He also indicated that he observed touchdown marks just past taxiways K (Kilo) and P (Papa) with the track continuing straight down and then off the runway. He was the first Airport Operations personnel at the accident site and observed a police officer at the scene talking to the driver of the car. Mr. Al Perez was also out on the field at the time of the accident and was the second airport responder on the scene.

15.0.2 MU-Meter Readings

Two types of friction measurement equipment are approved to conduct friction surveys during winter operations, Decelerometers (DEC) and Continuous Friction Measurement

Equipment (CFME). Both types essentially provide the same information when braking action becomes marginal. DEC can determine friction values by measuring vehicular deceleration and is a self-contained unit, while CFME uses a 5th-wheel attached to an airport vehicle or a towed device to determine runway friction.

Midway Airport uses both a CFME (Ford Taurus) and a DEC (Bowmonk AFM2) to determine runway friction values. The Bowmonk is a solid state accelerometer that uses a crystal controlled clock. During friction test, the accelerometer measures the deceleration (g-force) experienced by the transporting vehicle, 400 times per second with an accuracy stated by the manufacturer of better than 2 percent. The output is read by a microprocessor and stored in the memory for automatic analysis at the end of the test. The Bowmonk also contains a miniature dot matrix printer that prints individual friction reading, averages for each one third of the runway, and a total average of all friction readings taken.

The CFME device used by Chicago Midway Airport is an ASFT AB2000 that requires an extensive calibration procedure that must be accomplished each time before being used. The Airport used both of these friction-measuring devices the day of the accident and their relative friction readings are logged by various management personnel. Simultaneous test runs by both devices yield MU reading that vary by as much as 40 percent. Comparisons of runway friction appear more relevant when comparing readings by the same device.

Friction is defined as the ratio of the tangential force needed to maintain uniform relative motion between two contacting surfaces such as aircraft tires to the pavement surface. Friction quantifies slipperiness of pavement surfaces. The Greek letter MU is used to designate a friction value representing runway surface conditions.

MU-meter values range from 0.0 to 1.0, where 0.0 is the lowest friction value and 1.0 is the theoretical maximum friction value obtainable. For ease of reporting in the United States, these values are multiplied by 100. The U.S. scale is expressed as whole numbers (e.g. 10, 20, 30). In practice, a good runway pavement with no rubber or other contamination will typically have friction values in the 65 to 90 range, while a runway surface that is contaminated with ice, on top of which there is moisture present would present a friction value in the 10 to 20 range. MU values are presented every 1/3 of an active runway surface on a testing run with a final average MU value given for the runway.

At temperatures below freezing, runway friction depends on the shear strength of compacted snow and ice, which tends to increase as temperatures decrease. The lower the snow or ice temperature, the higher the runway friction level. When temperatures are near the melting point for compacted snow and ice, a thin water film is produced that can greatly reduce runway friction levels through lubrication or viscous hydroplaning effects. As a result, according to a NASA expert[24], the lowest friction performance typically occurs within a few degrees of 0 degrees C.

[24] Thomas J. Yager, Senior Research Engineer, Structural Dynamics Branch, National Aeronautics and Space Administration, Langley Research Center, personal communications.

15.0.3 Braking Action Definitions

The Air Transport Association (ATA) has agreed on the following braking action definitions for use with MU meter friction values:

NORMAL – maximum energy stops possible with little deterioration in certified stopping distance.

GOOD – more braking is available than will be used in the average airline type deceleration. If a maximum energy stop were attempted, some distance in excess of certified stopping distance would be expected.

FAIR – sufficient braking and cornering force is available for a well-flown approach and landing using light braking. However, excess speed or long touchdown would result in an extremely low safety factor depending on runway length and crosswind component. Careful planning and good judgment are required.

POOR – very careful planning, judgment, and execution are absolutely essential. Crosswind becomes a "priority one" consideration. While a safe and successful approach, landing, and stop can be accomplished if all factors are favorable, there is little room for error. Care must be exercised in every facet of the operation and a very careful evaluation of all existing conditions is necessary.

NIL – extremely slippery with poor directional control even while taxiing. This is the kind of report that would be given for an untreated runway with freezing rain with little or no braking action available to the aircraft.

All MU testers have scales that are similar that roughly equate to braking action reports, although note that there is a large overlap in equating MU values to braking reports due to varying slip ratios between the different measuring systems. Typical MU-meter readings imply the following conditions:

>.60	Normal
.65 - .40	Good
.50 - .30	Fair
.35 - .20	Poor
<.25	Nil

Southwest Airlines Flight Operations Manual (FOM) section 3.23.2, states that for frozen contaminants on runway surfaces, a MU-meter value of .40 or less is the level at which aircraft braking performance and directional control begin to deteriorate. The manual also includes the International MU-meter scale for use in approximating runway condition under 3.23.3 (figure 17).

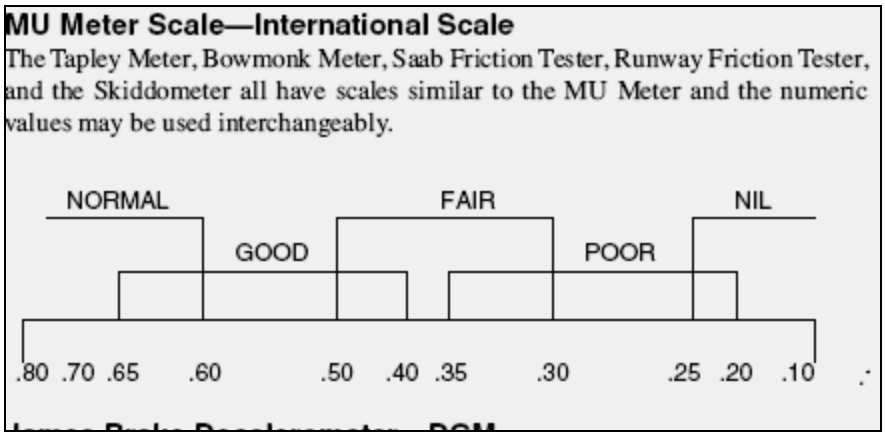

Figure 17 – Southwest Airlines MU-Meter Scale/Braking Action

According to the FAA, there is no exact relationship between the coefficient of friction and actual stopping capability. Reports of braking action are used as advisory information for airport operations as the reports may be subjective in nature due to the differences in aircraft type and reporters' interpretation and perception of braking events. Research and international efforts are underway to standardize the measurement of runway friction and make them applicable to specific aircraft type through an International Runway Friction Index (IRFI), and making the reports available to users in a form similar to that of a SNOWTAM.

15.0.4 ATC Field Condition Reports

When available, ATC furnishes pilots the quality of braking action received from pilots or airport management. The quality of braking action is described by the terms "good," "fair," "poor," and "nil," or a combination of these terms. When tower controllers have received runway braking action reports which include the terms "poor" or "nil", or whenever weather conditions are conducive to deteriorating or rapidly changing runway braking conditions, the tower will include on the ATIS broadcast the statement, *"BRAKING ACTION ADVISORIES ARE IN EFFECT."* These terms will be used when issuing D-NOTAMs (notice to airmen).

For frozen contaminants on runway surfaces, a MU value of .40 or less is the level when the aircraft braking performance starts to deteriorate and directional control begins to be less responsive. The lower the MU value, the less effective braking performance becomes and the more difficult directional control becomes. When the MU value for any one-third zone of an active runway is .40 or less, a report should be given to ATC by airport management for dissemination to pilots. Pilots and dispatchers use MU information with other knowledge including aircraft performance characteristics, type, and weight, previous experience, wind conditions, and aircraft tire type to determine runway suitability.

16.0 NWS Post Analysis of the Snow Event

The NWS Weather Service Forecast Office performed a post analysis of the snowstorm on December 8, 2005. The report is included as attachment 2.

17.0 Snow Intensity and Accumulation Tables

The NWS reports snowfall rate or intensity based on visibility, based on the following:

Light Snow	- Visibility more than 1/2 statute mile
Moderate Snow	- Visibility more than 1/4 to 1/2 statute mile
Heavy Snow	- Visibility 1/4 statute mile or less

Forecasters have used this relationship to estimate snowfall accumulation by visibility, assuming the restriction in visibility is by snow itself and not combined with fog or mist. Moderate to heavy snow will usually quickly overwhelm airport operations and cause rapid field conditions problems, especially when surface temperatures are below freezing based on these accumulation rates.

Visibility (SM)	Snowfall Rate (inches/hour)
3 or more	**Trace**
2	**0.1**
1 1/2	**0.2**
1	**0.3**
3/4	**0.5**
1/2	**0.75 – 1.25**
1/4	**1 – 2**
1/8	**2**

18.0 Astronomical Data

The following astronomical data was obtained from U.S. Naval Observatory located in Washington, D.C., for the Denver, Colorado area.

Sunset:	0020Z (1620 CST)
End of civil Twilight:	0051Z (1651 CST)
Altitude of the sun:	more than 15 degrees below the horizon
Moonrise:	1831Z (1231 CST)
Moonset:	0628Z (0028 CST December 9, 2005)
Altitude of the Moon:	43 degrees above the horizon
Percent illumination:	0.57 percent
Phase of the Moon:	first quarter occurred at 0936Z (0336 CST)