NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

October 4, 2016

Weather Study

METEOROLOGY

WPR16FA144

Table Of Contents

A. ACCIDENT

Location: Logan, Utah
Date: July 18, 2016
Time: 1121 mountain daylight time
1721 Coordinated Universal Time (UTC)
Airplane: Diamond DA-40 N419FP

B. METEOROLOGIST

Paul Suffern
Group Chairman
Operational Factors Division (AS-30)
National Transportation Safety Board

C. SUMMARY

On July 18, 2016 about 1121 mountain daylight time, a Diamond DA40, N419FP, was destroyed when it impacted terrain while maneuvering near Logan, Utah. The private pilot, the sole occupant, was fatally injured. The airplane was registered to and operated by Utah State University as a 14 Code of Federal Regulations (CFR) Part 91 personal flight. Visual meteorological conditions prevailed for the flight, and no flight plan filed. The local flight originated from Logan- Cache Airport (LGU), Logan, Utah at about 1045.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Meteorologist did not travel for this investigation and gathered the weather data for this investigation from the NTSB's Washington D.C. office and from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Centers for Environmental Information (NCEI). All times are mountain daylight time (MDT) on July 18, 2016, and are based upon the 24-hour clock, where local time is -6 hours from UTC, and UTC=Z (unless otherwise noted). Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles

The accident site was located at latitude 41.59° N, longitude 111.89° W, at an approximate elevation of 4,740 feet.

E. FACTUAL INFORMATION

1.0 Synoptic Situation

The synoptic or large scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction, and the Weather Prediction Center located in College Park, Maryland. These are the base products used in describing synoptic weather features and in the creation of forecasts and warnings for the NWS. Reference to these charts can be found in the, joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC-0045G CHG 2.

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart for 1200 MDT is provided as figure 1 with the approximate location of the accident site marked. The chart indicated a surface low pressure center just southwest of the accident site near Salt Lake City, Utah, with a surface pressure of 1010-hectopascals (hPa). A surface high pressure center was located in northwestern Colorado with a surface pressure of 1023-hPa. A warm front stretched eastward from central Idaho into Wyoming, then southeastward into northern Kansas. This warm front was moving northward and had just passed north of the accident site at 0900 MDT (figure 2).

The station models around the accident site at 1200 MDT depicted air temperatures in the low 80's to low 90's degrees Fahrenheit (°F), with temperature-dew point spreads of 34° F or more, a southwest to southeast wind between 10 and 20 knots, and mostly clear skies. With a warm frontal boundary moving northward past the accident site before the accident time (figure 2) and a surface low pressure and surface high pressure center areas relatively close together at the accident time (figure 1), gusty low-level wind conditions would be expected over the mountainous terrain. The gusty low-level winds will be further discussed in section 4.0.

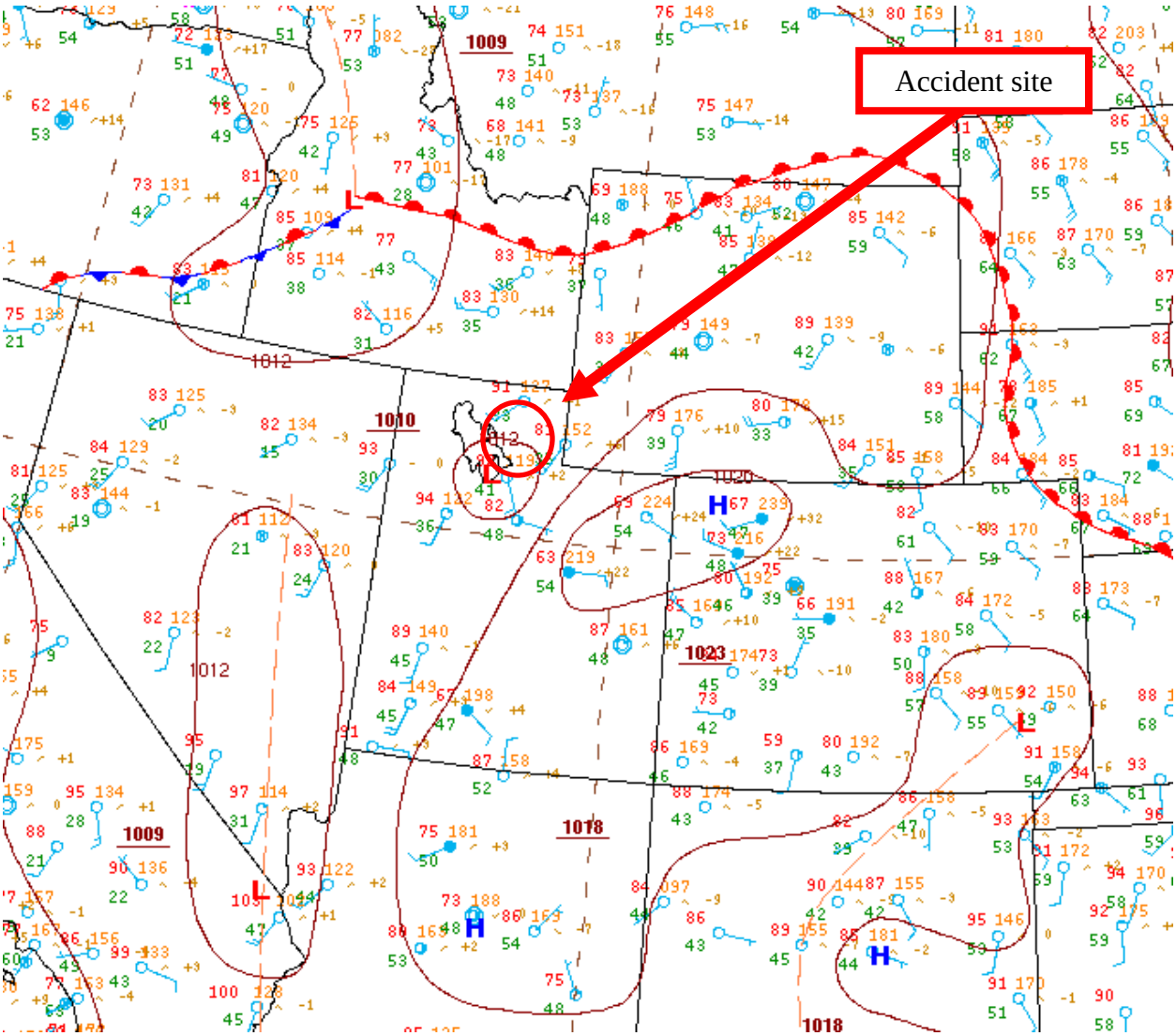

Figure 1 – NWS Surface Analysis Chart for 1200 MDT

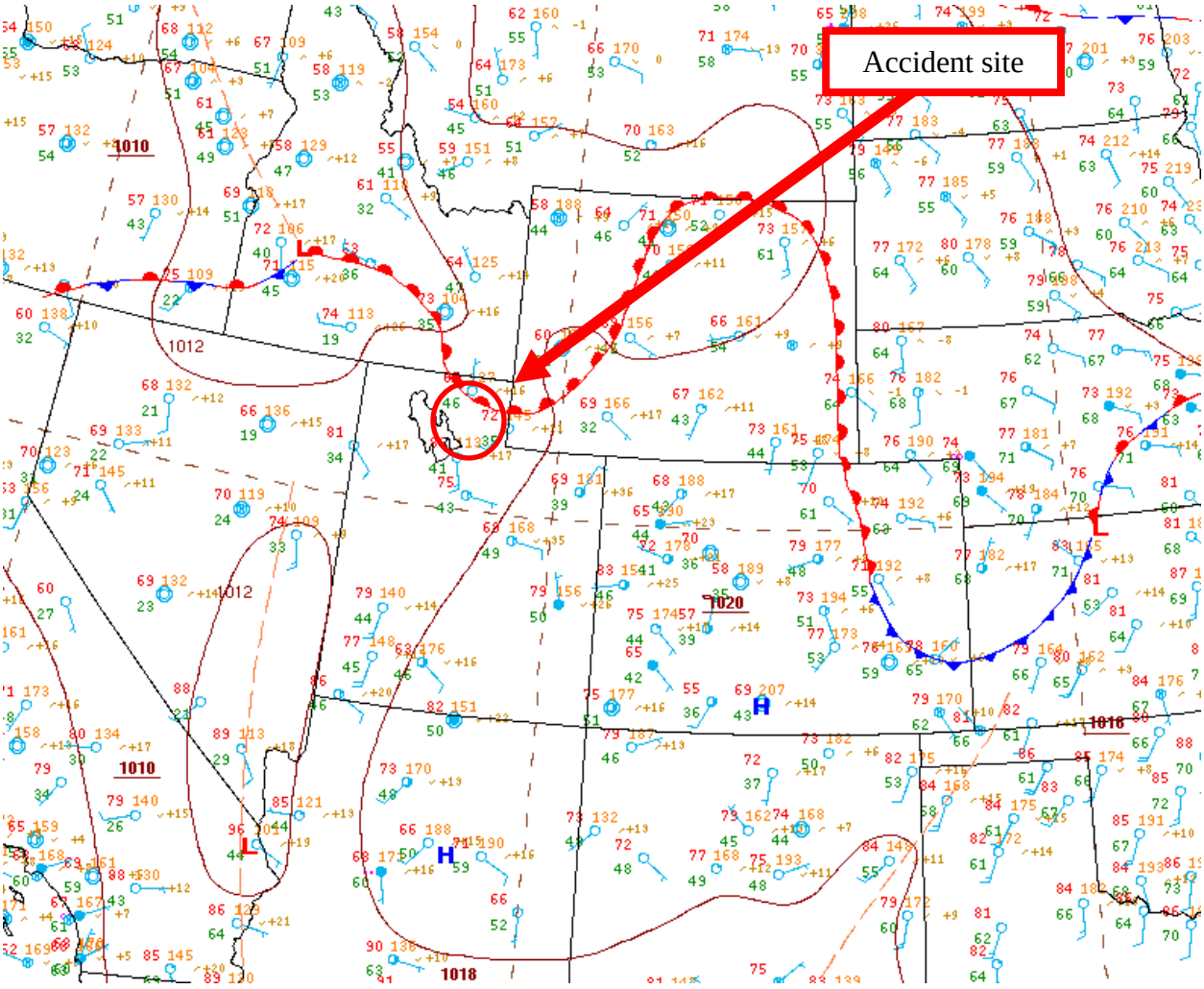

Figure 2 – NWS Surface Analysis Chart for 0900 MDT

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 0600 MDT at 850-, 700-, 500-, and 300-hPa are presented in figures 3 through 6. The 850-hPa chart depicted low-level troughs[1] just southwest and northeast of the accident site. Troughs typically act as lifting mechanisms where enhanced lift, gusty winds, fronts, clouds, and precipitation can occur. Troughs and frontal boundary close to the surface and near mountainous terrain also act to aid in the mixing of low-level air, allowing for the possibility of low-level wind shear (LLWS) and turbulence. In addition, at 700- and 500-hPa, there was a mid-level trough southwest of the accident site. Low and mid-level moisture was lacking (section 4.0), hence the lack of cloud cover at the accident time (section 3.0) around the accident site. There was a south wind around 30 knots at 850-hPa with the wind becoming southwesterly by 700-hPa and remaining southwesterly through 300-hPa. The wind increased to 35 knots by 500-hPa with the highest wind speed of 55 knots at 300-hPa.

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

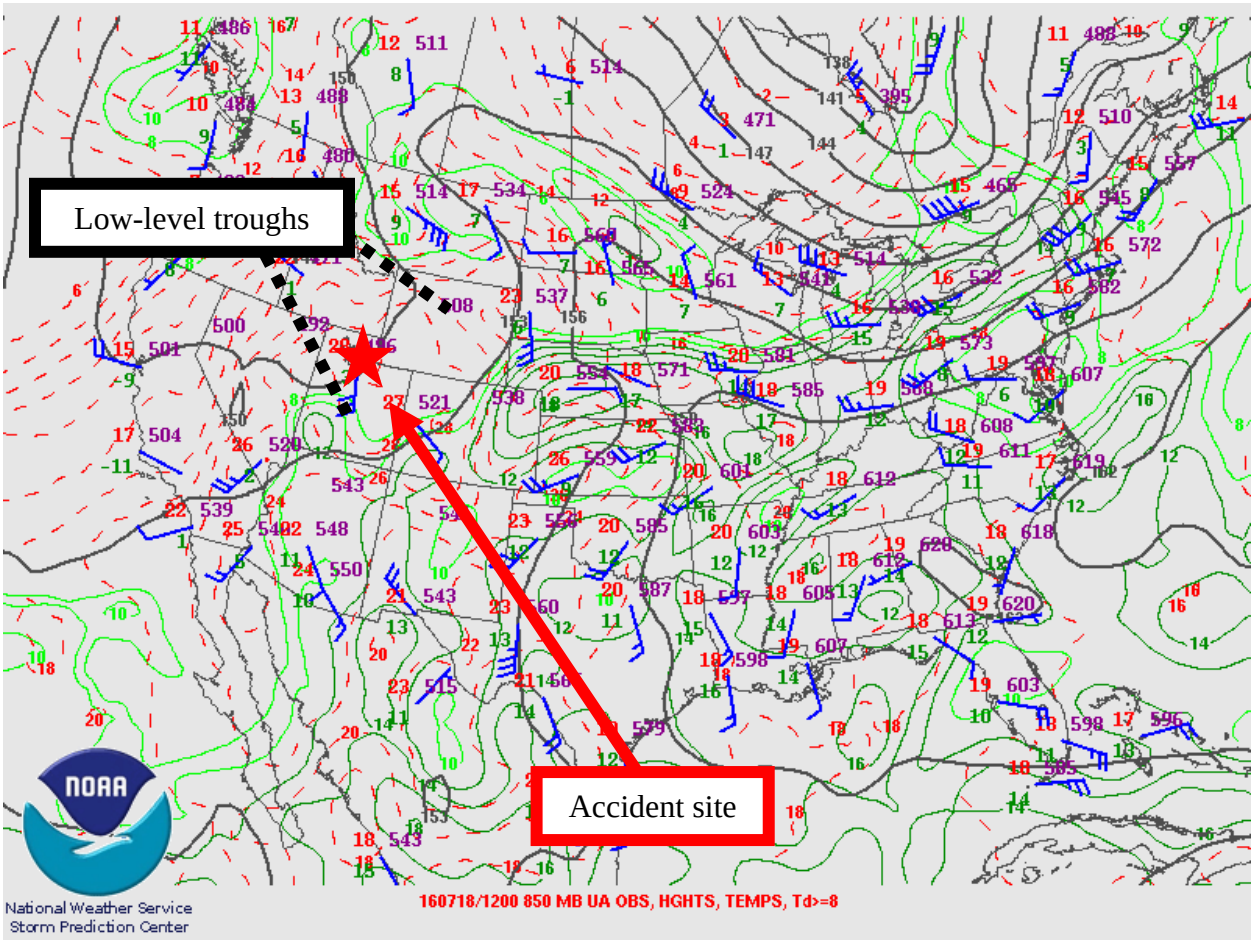

Figure 3 – 850-hPa Constant Pressure Chart for 0600 MDT

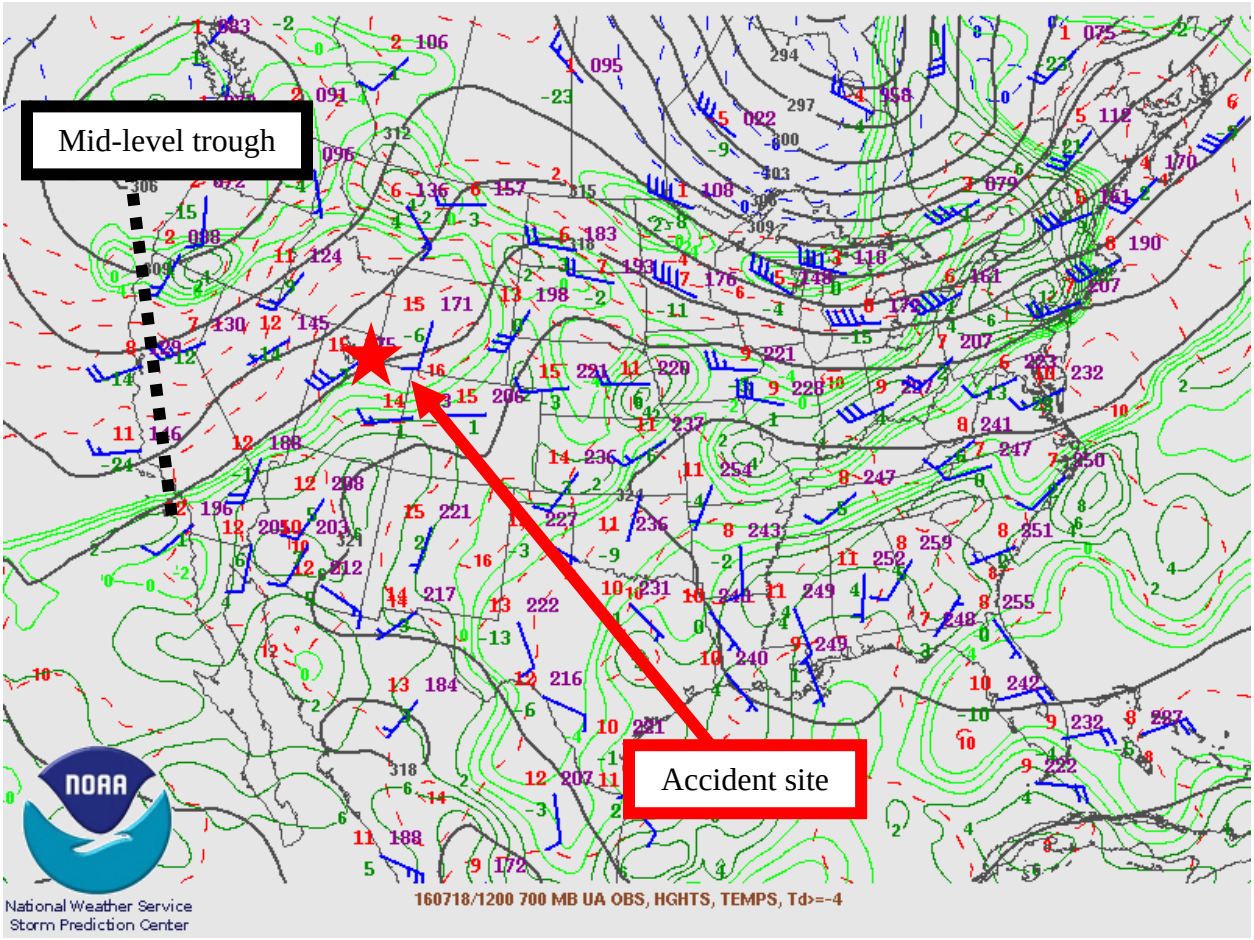

Figure 4 – 700-hPa Constant Pressure Chart for 0600 MDT

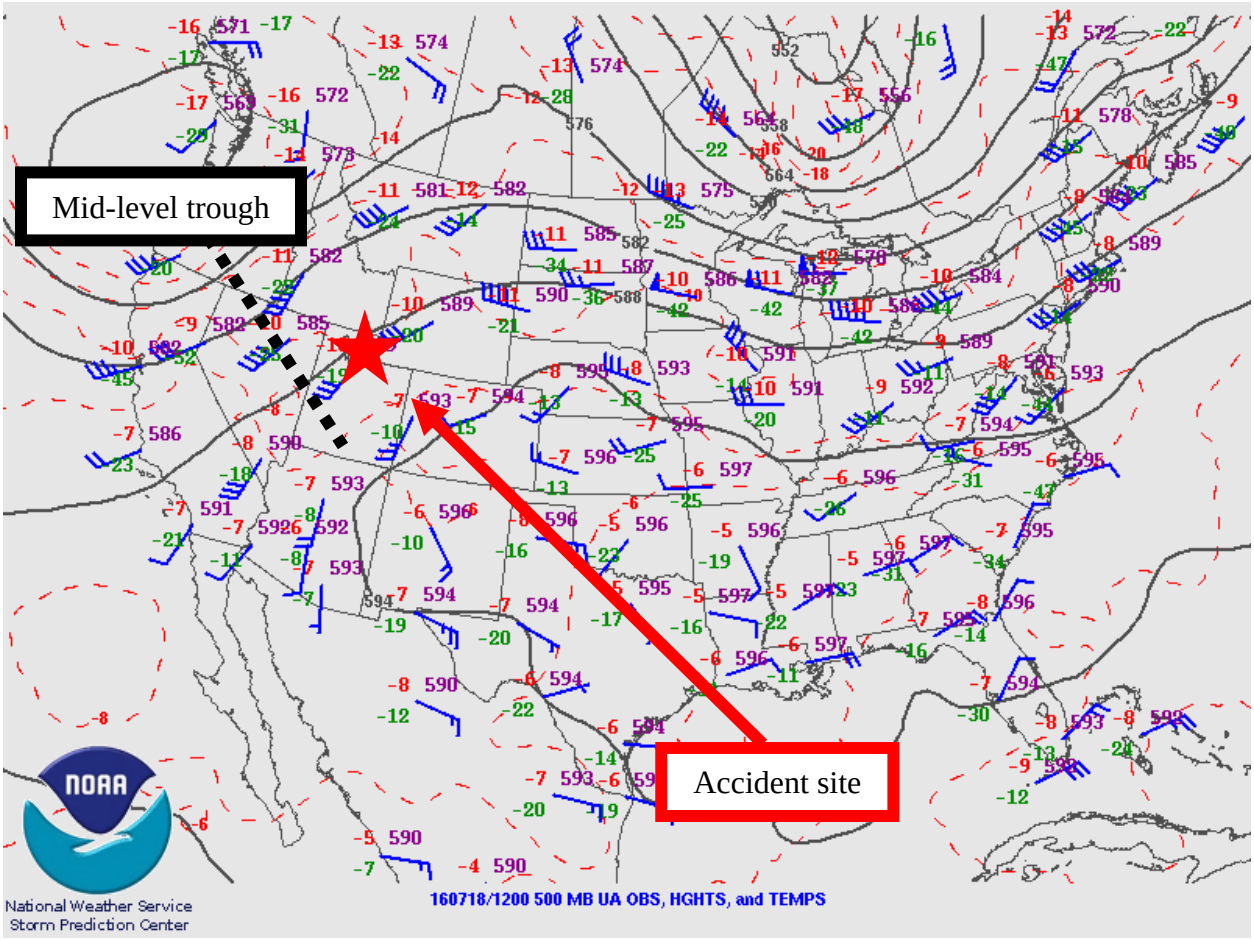

Figure 5 – 500-hPa Constant Pressure Chart for 0600 MDT

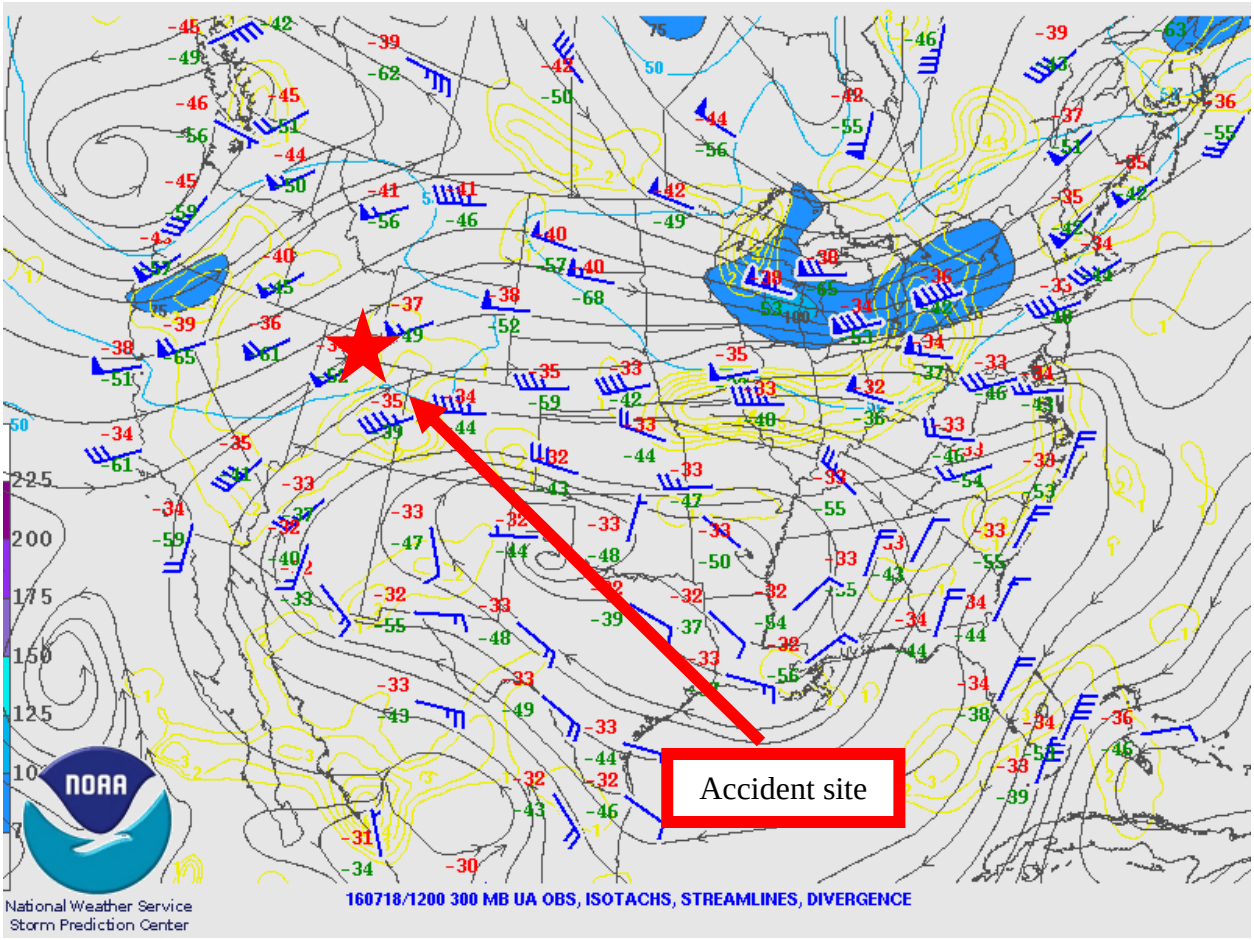

Figure 6 – 300-hPa Constant Pressure Chart for 0600 MDT

2.0 Storm Prediction Center Products

SPC issued the following Day 1 Convective Outlook at 1023 MDT (figure 7) with areas of general thunderstorms forecast for the Salt Lake City area, including the accident site, during the afternoon hours and after the accident time. SPC did not forecast thunderstorms to become severe at the surface on the accident day around the accident site:

SPC AC 181623

DAY 1 CONVECTIVE OUTLOOK
NWS STORM PREDICTION CENTER NORMAN OK
1123 AM CDT MON JUL 18 2016

VALID 181630Z - 191200Z

...THERE IS A SLGT RISK OF SVR TSTMS OVER MUCH OF THE NORTHEAST STATES...

...THERE IS A MRGL RISK OF SVR TSTMS ALONG A CORRIDOR FROM THE MID ATLANTIC...INTO THE MID MS VALLEY...THEN INTO THE CENTRAL AND NORTHERN HIGH PLAINS REGION...INTO EASTERN OREGON...

...SUMMARY...
DAMAGING GUSTS WILL BE THE MAIN THREAT TODAY FROM STORMS IN THE CORRIDOR EXTENDING FROM THE UPPER OHIO VALLEY ACROSS NEW ENGLAND. ISOLATED SEVERE THUNDERSTORMS WILL BE POSSIBLE IN A LONG...CURVING CORRIDOR FROM THE LOWER OHIO VALLEY TO THE NORTHERN GREAT PLAINS...NORTHERN ROCKIES AND INTERIOR NORTHWEST.

...NORTHEAST STATES...
RELATIVELY MINOR CHANGES TO THE OUTLOOK HAVE BEEN MADE FOR THIS UPDATE. STRONG WINDS ALOFT AND SUFFICIENT INSTABILITY ARE PRESENT OVER A LARGE PART OF THE NORTHEAST UNITED STATES TODAY. THIS WILL LEAD TO SEVERAL CLUSTERS OF STRONG TO SEVERE STORMS. 12Z MODEL SOLUTIONS DIFFER ON THE MESOSCALE DETAILS OF WHERE ACTIVITY WILL BE MOST INTENSE...BUT IT IS LIKELY THAT THE STRONGEST STORMS ACROSS THE REGION WILL POSE A RISK OF LOCALLY DAMAGING WIND GUSTS AND HAIL. REFER TO WW/S 394 AND 395...AS WELL AS RECENT MCDS FOR FURTHER DETAILS.

...CENTRAL HIGH PLAINS...
SCATTERED THUNDERSTORMS ARE EXPECTED THIS AFTERNOON OVER THE FOOTHILLS OF CENTRAL CO INTO EASTERN WY...AND OVER THE BLACK HILLS. AMPLE LOW LEVEL MOISTURE/INSTABILITY IS PRESENT IN THIS REGION...ALONG WITH FAVORABLE DEEP LAYER VERTICAL SHEAR. BUT SIMILAR TO YESTERDAY...THE AREA WILL EXPERIENCE MID LEVEL HEIGHT RISES ALL DAY AS THE UPPER RIDGE BUILDS OVER THE CENTRAL STATES. ISOLATED SEVERE STORMS ARE EXPECTED IN THIS AREA...BUT COVERAGE IS HIGHLY UNCERTAIN AT THIS TIME. PORTIONS OF THIS AREA WILL BE RE-EVALUATED FOR AN UPGRADE TO SLIGHT RISK AT 20Z.

...NORTHWEST STATES...
ISOLATED STRONG TO SEVERE STORMS ARE POSSIBLE THIS AFTERNOON AND EVENING ALONG A CORRIDOR FROM EASTERN OREGON INTO WESTERN AND CENTRAL MT...AS A SERIES OF MID LEVEL SHORTWAVE TROUGHS AFFECT THE AREA. THE STRONGEST CELLS MAY PRODUCE GUSTY WINDS AND HAIL.

..HART/COOK.. 07/18/2016

CLICK TO GET WUUS01 PTSDY1 PRODUCT

NOTE: THE NEXT DAY 1 OUTLOOK IS SCHEDULED BY 2000Z

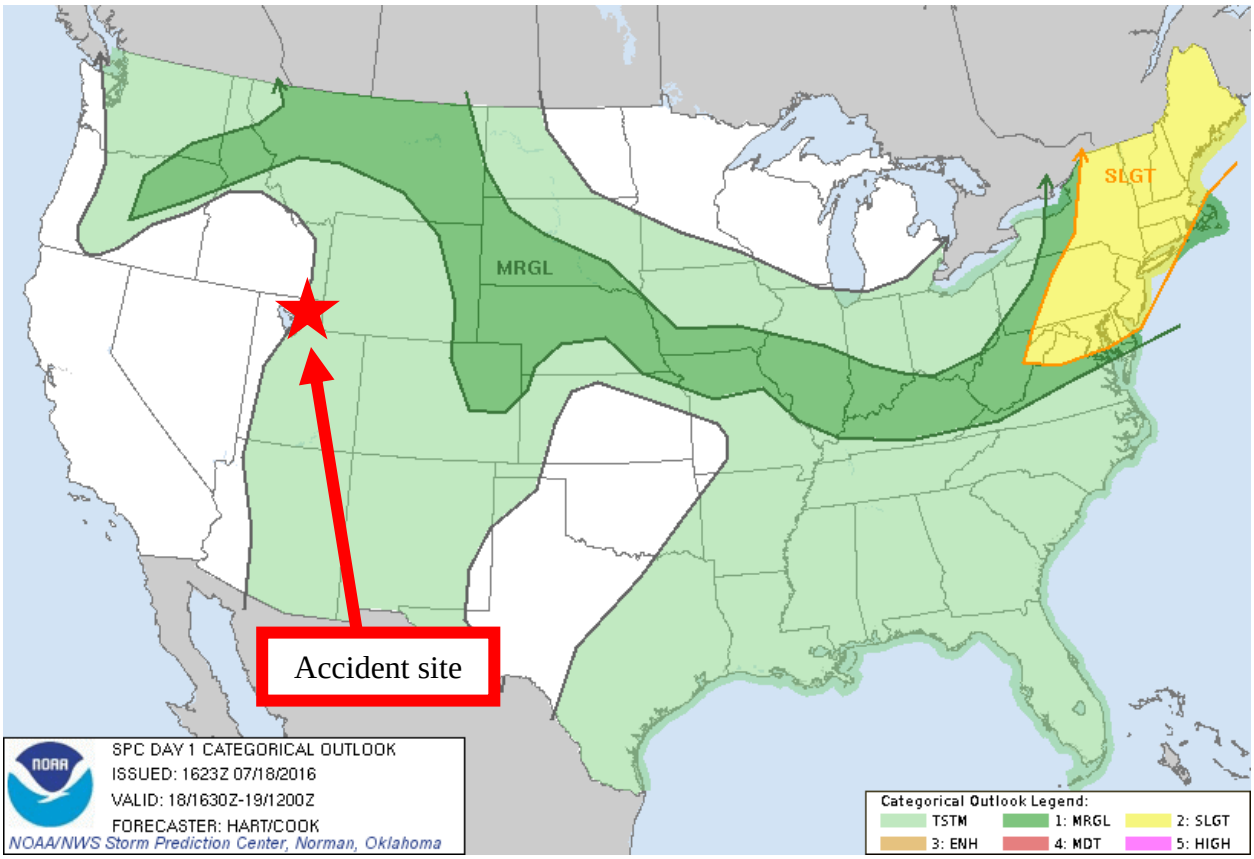

Figure 7 – Storm Prediction Center day 1 Convective Outlook valid at the time of the accident

3.0 Surface Observations

The area surrounding the accident site was documented utilizing official NWS Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language. Figure 8 is a view of the regional sectional map with the nearest official weather reporting sites and the accident site.

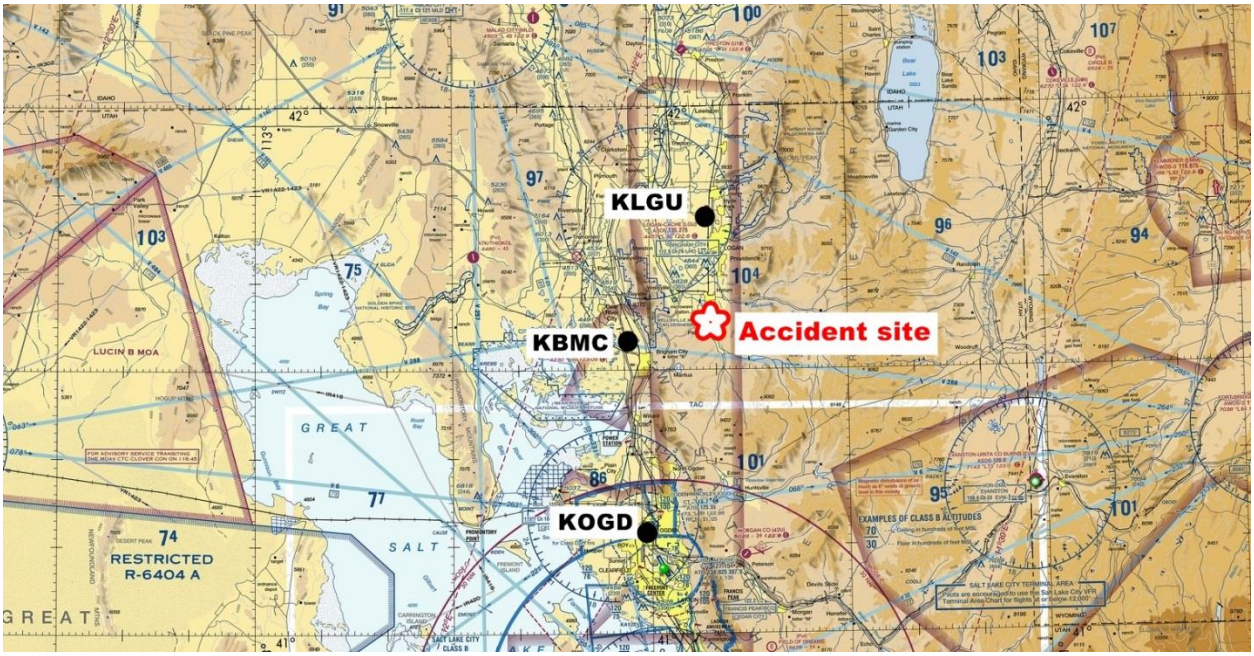

Figure 8 – Sectional Chart of northeastern Utah with the location of the accident site and surface observation sites

Brigham City Airport (KBMC) had the closest official weather station to the accident site. KBMC had an Automated Weather Observing System (AWOS[2]) whose reports were not supplemented. KBMC was located 10 miles west-southwest of the accident site, at an elevation of 4,230 feet, and had a 13° easterly magnetic variation[3] (figure 8). KBMC did not have a ceilometer to be able to detect sky cover. The following observations were taken and disseminated during the times surrounding the accident: [4]

[0855 MDT] KBMC 181455Z AUTO 18017G23KT 10SM 29/00 A3005 RMK AO1 T02930000=

[0915 MDT] KBMC 181515Z AUTO 18018G24KT 10SM 30/00 A3006 RMK AO1 T02990002=

[0935 MDT] KBMC 181535Z AUTO 18018G24KT 10SM 30/00 A3006 RMK AO1 T03020000=

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

[3] Magnetic variation – The angle (at a particular location) between magnetic north and true north. 2010, latest measurement taken from http://www.airnav.com/airport/KBMC

[4] The bold sections in this NWS product and the rest of products in this report are intended to highlight the sections that directly reference the weather conditions that affected the accident location around the accident time. The local times in section 3.0 next to the METARs are provided for quick reference between UTC and local times around the accident time.

[0955 MDT] KBMC 181555Z AUTO 18016G23KT 10SM 31/00 A3006 RMK AO1 T03060001=

[1015 MDT] KBMC 181615Z AUTO 19018G21KT 10SM 31/00 A3006 RMK AO1 T03120004=

[1035 MDT] KBMC 181635Z AUTO 19019G25KT 10SM 32/00 A3006 RMK AO1 T03180004=

[1055 MDT] KBMC 181655Z AUTO 18017G25KT 10SM 32/00 A3006 RMK AO1 T03201004=

[1115 MDT] KBMC 181715Z AUTO 18017G24KT 10SM 32/00 A3006 RMK AO1 T03221001=

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[1135 MDT] KBMC 181735Z AUTO 19016G24KT 10SM 33/00 A3007 RMK AO1 T03261001=

[1155 MDT] KBMC 181755Z AUTO 18020G25KT 10SM 33/00 A3007 RMK AO1 T03290002 10371 20086=

[1215 MDT] KBMC 181815Z AUTO 18018G22KT 10SM 33/00 A3007 RMK AO1 T03311002=

[1235 MDT] KBMC 181835Z AUTO 18018G27KT 10SM 33/00 A3006 RMK AO1 T03331002=

KBMC weather at 1055 MDT, wind from 180° at 17 knots with gusts to 25 knots, 10 miles visibility, temperature of 32° Celsius (C), dew point temperature of 0° C, and an altimeter setting of 30.06 inches of mercury. Remarks: automated station without a precipitation discriminator, temperature 32.0° C, dew point temperature -0.4° C.

KBMC weather at 1115 MDT, wind from 180° at 17 knots with gusts to 24 knots, 10 miles visibility, temperature of 32° C, dew point temperature of 0° C, and an altimeter setting of 30.06 inches of mercury. Remarks: automated station without a precipitation discriminator, temperature 32.2° C, dew point temperature -0.1° C.

KBMC weather at 1135 MDT, wind from 190° at 16 knots with gusts to 24 knots, 10 miles visibility, temperature of 33° C, dew point temperature of 0° C, and an altimeter setting of 30.07 inches of mercury. Remarks: automated station without a precipitation discriminator, temperature 32.6° C, dew point temperature -0.1° C.

KBMC weather at 1155 MDT, wind from 180° at 20 knots with gusts to 25 knots, 10 miles visibility, temperature of 33° C, dew point temperature of 0° C, and an altimeter setting of 30.07 inches of mercury. Remarks: automated station without a precipitation discriminator, temperature 32.9° C, dew point temperature 0.2° C, 6-hourly maximum temperature of 37.1° C, 6-hourly minimum temperature of 8.6° C.

Logan-Cache Airport (KLGU) was the second closest official weather station to the accident site and was the accident aircraft's departure airport. KLGU had an Automated Surface Observing System (ASOS[5]) whose reports were not supplemented. KLGU was located 12 miles north of the accident site, at an elevation of 4,457 feet, and had an 11° easterly magnetic variation[6] (figure 8). The following observations were taken and disseminated during the times surrounding the accident:

[0351 MDT] KLGU 180951Z AUTO 06005KT 10SM CLR 11/06 A2998 RMK AO2 SLP102 T01110061=

[0451 MDT] KLGU 181051Z AUTO 02003KT 10SM CLR 12/06 A3000 RMK AO2 SLP105 T01220061=

[0551 MDT] KLGU 181151Z AUTO VRB04KT 10SM CLR 11/05 A3002 RMK AO2 SLP111 T01060050 10189 20106 53010=

[0651 MDT] KLGU 181251Z AUTO 30004KT 10SM CLR 10/06 A3004 RMK AO2 SLP122 T01000056=

[0751 MDT] KLGU 181351Z AUTO 00000KT 10SM CLR 14/08 A3006 RMK AO2 SLP125 T01390078=

[0851 MDT] KLGU 181451Z AUTO 36003KT 10SM CLR 19/08 A3007 RMK AO2 SLP127 T01940078 51016=

[0951 MDT] KLGU 181551Z AUTO 34006KT 10SM CLR 25/06 A3008 RMK AO2 SLP128 T02500056=

[1051 MDT] KLGU 181651Z AUTO 18005KT 10SM CLR 30/05 A3007 RMK AO2 SLP124 T03000050=

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[1151 MDT] KLGU 181751Z AUTO 23014G31KT 10SM CLR 33/01 A3007 RMK AO2 PK WND 20031/1746 SLP127 T03280006 10333 20089 51001=

[5] ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.
[6] Magnetic variation – The angle (at a particular location) between magnetic north and true north. 2020, latest measurement taken from http://www.airnav.com/airport/KLGU

[1251 MDT] KLGU 181851Z AUTO 22018G25KT 10SM CLR 33/03 A3007 RMK AO2 SLP121 T03330028=

[1351 MDT] KLGU 181951Z AUTO 21014G22KT 10SM CLR 34/04 A3007 RMK AO2 PK WND 20027/1903 SLP126 T03390044=

[1451 MDT] KLGU 182051Z AUTO 21013G23KT 10SM CLR 34/03 A3005 RMK AO2 PK WND 18029/2008 SLP120 T03440028 58005=

KLGU weather at 0951 MDT, wind from 340° at 6 knots, 10 miles visibility, clear skies below 12,000 feet above ground level (agl), temperature of 25° C, dew point temperature of 6° C, and an altimeter setting of 30.08 inches of mercury. Remarks: automated station with a precipitation discriminator, sea level pressure 1012.8 hPa, temperature 25.0° C, dew point temperature 5.6° C.

KLGU weather at 1051 MDT, wind from 180° at 5 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of 30° C, dew point temperature of 5° C, and an altimeter setting of 30.07 inches of mercury. Remarks: automated station with a precipitation discriminator, sea level pressure 1012.4 hPa, temperature 30.0° C, dew point temperature 5.0° C.

KLGU weather at 1151 MDT, wind from 230° at 14 knots with gusts to 31 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of 33° C, dew point temperature of 1° C, and an altimeter setting of 30.07 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind from 200° at 31 knots at 1246 MDT, sea level pressure 1012.7 hPa, temperature 32.8° C, dew point temperature 0.6° C, 6-hourly maximum temperature of 33.3° C, 6-hourly minimum temperature of 8.9° C, 3-hourly pressure change of 0.1 hPa.

KLGU weather at 1251 MDT, wind from 220° at 18 knots with gusts to 25 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of 33° C, dew point temperature of 3° C, and an altimeter setting of 30.07 inches of mercury. Remarks: automated station with a precipitation discriminator, sea level pressure 1012.1 hPa, temperature 33.3° C, dew point temperature 2.8° C.

Ogden-Hinckley Airport (KOGD) had an ASOS where air traffic control was logged onto the system and able to supplement weather observations. KOGD was located 25 miles south-southwest of the accident site, at an elevation of 4,473 feet, and had a 14° easterly magnetic variation[7] (figure 8). The following observations were taken and disseminated during the times surrounding the accident:

[0453 MDT] KOGD 181053Z 17010KT 10SM CLR 21/01 A2999 RMK AO2 SLP088 T02060006=

[0553 MDT] KOGD 181153Z 16010KT 10SM CLR 21/01 A3001 RMK AO2 SLP094 T02060006 10244 20200 53015=

[7] Magnetic variation – The angle (at a particular location) between magnetic north and true north. 1985, latest measurement taken from http://www.airnav.com/airport/KOGD

[0653 MDT] KOGD 181253Z 16011KT 10SM CLR 21/01 A3003 RMK AO2 SLP101 T02110011=

[0753 MDT] KOGD 181353Z 16013KT 10SM CLR 24/03 A3005 RMK AO2 SLP104 T02440033=

[0853 MDT] KOGD 181453Z 18017G22KT 10SM CLR 29/05 A3007 RMK AO2 SLP111 T02890050 51018=

[0953 MDT] KOGD 181553Z 17020G26KT 10SM CLR 31/06 A3008 RMK AO2 PK WND 17026/1539 SLP116 T03060056=

[1053 MDT] KOGD 181653Z 16021G27KT 10SM CLR 32/06 A3008 RMK AO2 PK WND 17030/1620 SLP114 T03170056=

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[1153 MDT] KOGD 181753Z 16023G30KT 10SM CLR 33/06 A3008 RMK AO2 PK WND 18030/1738 SLP115 T03280056 10328 20200 51003=

[1253 MDT] KOGD 181853Z 16021G27KT 10SM CLR 34/05 A3007 RMK AO2 PK WND 15030/1756 SLP111 T03390050=

[1353 MDT] KOGD 181953Z 18020G29KT 10SM CLR 34/04 A3006 RMK AO2 PK WND 15030/1854 SLP107 T03440044=

[1453 MDT] KOGD 182053Z 17020G29KT 10SM CLR 35/04 A3005 RMK AO2 PK WND 18030/2011 SLP105 T03500044 56009=

KOGD weather at 0953 MDT, wind from 170° at 20 knots with gusts to 26 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of 31° C, dew point temperature of 6° C, and an altimeter setting of 30.08 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind from 170° at 26 knots at 0939 MDT, sea level pressure 1011.6 hPa, temperature 30.6° C, dew point temperature 5.6° C.

KOGD weather at 1053 MDT, wind from 160° at 21 knots with gusts to 27 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of 32° C, dew point temperature of 6° C, and an altimeter setting of 30.08 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind from 170° at 30 knots at 1020 MDT, sea level pressure 1011.4 hPa, temperature 31.7° C, dew point temperature 5.6° C.

KOGD weather at 1153 MDT, wind from 160° at 23 knots with gusts to 30 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of 33° C, dew point temperature of 6° C, and an altimeter setting of 30.08 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind from 180° at 30 knots at 1138 MDT, sea level pressure 1011.5 hPa, temperature 32.8° C, dew point temperature 5.6° C, 6-hourly maximum temperature of 32.8° C, 6-hourly minimum temperature of 20.0° C, 3-hourly pressure change of 0.3 hPa.

KLGU weather at 1253 MDT, wind from 160° at 21 knots with gusts to 27 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of 34° C, dew point temperature of 5° C, and an altimeter setting of 30.07 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind from 150° at 30 knots at 1156 MDT, sea level pressure 1011.1 hPa, temperature 33.9° C, dew point temperature 5.0° C.

3.1 One Minute Wind Observations

The one-minute KLGU ASOS surface data was provided by the NWS for the time surrounding the accident. One-minute raw wind data was provided with two separate magnitudes and wind directions[8]. The first wind data in table 1 is the two-minute average wind speed, which was updated every 5 seconds and reported once a minute. The second source of one-minute wind data is the five-second maximum wind average, which was updated every five seconds and reported once every minute (table 1). The following table provides the meteorological data in local time (MST)[9] as well as UTC time.

[8] The wind directions are in reference to true north.
[9] The one-minute wind observations from an ASOS are not automatically reported in daylight time.

Time (MST)	Time (UTC)	Dir of 2min avg wind	Speed of 2 min avg wind (knots)	Dir of max 5 sec avg wind	Speed of max 5 sec avg wind (knots)
0954	1654	202	5	196	6
0955	1655	203	3	138	3
0956	1656	179	3	173	5
0957	1657	192	3	183	3
0958	1658	209	3	228	6
0959	1659	212	5	217	8
1000	1700	209	7	189	12
1001	1701	189	10	174	15
1002	1702	191	12	201	14
1003	1703	199	12	201	13
1004	1704	196	11	205	12
1005	1705	200	10	201	12
1006	1706	209	11	221	15
1007	1707	212	11	218	14
1008	1708	213	12	214	16
1009	1709	214	13	215	16
1010	1710	212	12	219	16
1011	1711	204	13	215	15
1012	1712	199	13	197	17
1013	1713	201	15	203	18
1014	1714	205	15	206	16
1015	1715	209	14	207	15
1016	1716	213	13	221	14
1017	1717	211	14	201	18
1018	1718	209	14	217	17
1019	1719	217	13	216	16
1020	1720	216	13	207	17
1021	1721	208	13	196	16
1022	1722	204	15	197	19
1023	1723	203	14	194	15
1024	1724	208	13	221	18
1025	1725	221	15	237	18
1026	1726	228	15	235	16
1027	1727	224	13	214	16
1028	1728	215	13	200	18
1029	1729	210	14	201	18

Table 1 – One-minute KLGU ASOS data for the time surrounding the accident

At 1120 MDT, KLGU reported the two-minute average wind from 216° at 13 knots and a five-second maximum average wind from 207° at 17 knots.

At 1121 MDT, KLGU reported the two-minute average wind from 208° at 13 knots and a five-second maximum average wind from 196° at 16 knots.

At 1122 MDT, KLGU reported the two-minute average wind from 204° at 15 knots and a five-second maximum average wind from 197° at 19 knots.

For additional KLGU observations surrounding the accident time please see attachment 1.

The observations from KBMC, KLGU, and KOGD surrounding the accident time indicated VFR[10] ceilings and visibilities. Each site had a south to southwest surface wind with wind gusts as high as 31 knots around the accident time. With the strong south to southwest wind over the terrain, low-level turbulence and LLWS conditions would be expected. There remained a north wind in place at KLGU until the surface temperature warmed up enough to end the near-surface inversion[11] (section 4.0). This loss of the near-surface inversion lead to increasingly strong south surface wind at KLGU, with the wind shift from north to south beginning around 1025 to 1035 MDT (attachment 1), and then wind speed increase to above 10 knots out of the south by 1100 MDT. There was no inversion in place during the early morning hours at KBMC or KOGD so their surface winds remained out of the south gusting to 25 knots. Given the low- and mid-level troughs in the area of the accident site (section 1.2), a warm front moving northward from the accident site (section 1.1), increasing south winds from stations surrounding the accident site before takeoff, and the contributions from the mountainous terrain and strong wind flow likely lead to LLWS conditions and turbulence that would have been expected.

4.0 Upper Air Data

The closest official upper air sounding to the accident site was from Salt Lake City, Utah, (KSLC), located 50 miles south-southwest of the accident site, with a site number 72572, and an elevation of 4,226 feet. The 0600 MDT sounding was plotted on a standard Skew-T log P diagram[12] with the derived stability parameters included in figure 9 (with data from the surface to 600-hPa, or 14,000 feet msl.) This data was analyzed utilizing the RAOB[13] software package. The sounding depicted the Lifted Condensation Level (LCL)[14] at 14,138 feet msl and a Convective Condensation Level (CCL)[15] of 17,163 feet. The freezing level was located at 15,611 feet. The precipitable water value was 0.59 inches.

[10] Visual Flight Rules – Refers to the general weather conditions pilots can expect at the surface. VFR criteria means a ceiling greater than 3,000 feet agl and greater than 5 miles visibility.
[11] Inversion - Generally, a departure from the usual increase or decrease in an atmospheric property with altitude. Specifically it almost always refers to a temperature inversion, i.e., an increase in temperature with height, or to the layer within which such an increase occurs.
[12] 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.
[13] RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamopras, Pennsylvania.
[14] Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.
[15] Convective Condensation Level (CCL) – The level in the atmosphere to which an air parcel, if heated from below, will rise dry adiabatically, without becoming colder than its environment just before the parcel becomes saturated.

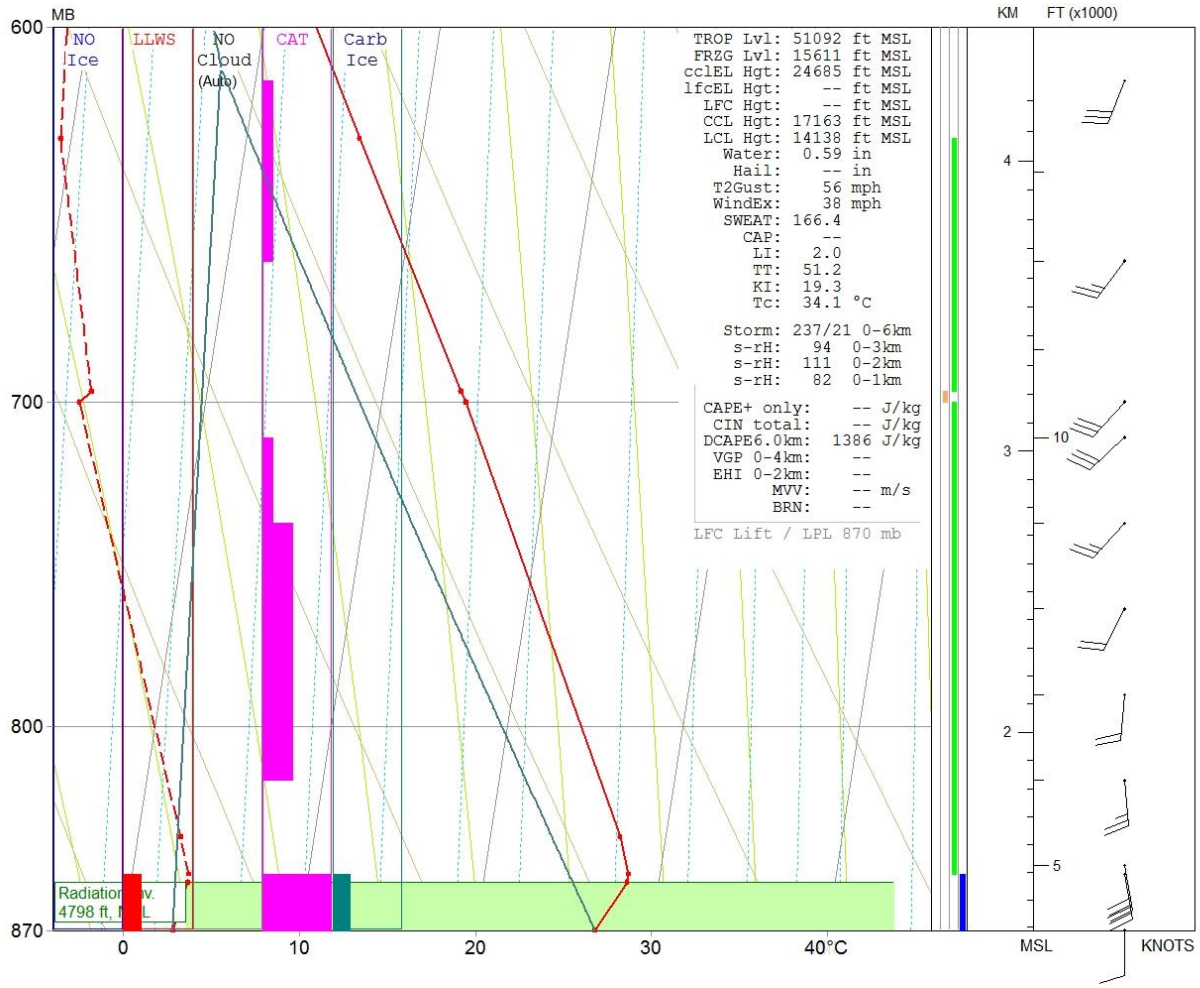

Figure 9 – 0600 MDT KSLC sounding

The 0600 MDT KSLC sounding indicated a generally conditionally unstable environment above the near-surface inversion, from 4,900 feet through 14,000 feet. It was a very dry environment below 14,000 feet with no relative humidity values above 20 percent. This environment would not have been supportive of cloud formation below 14,000 feet without an increase in moisture. The low- and mid-level troughs as well as the mountainous terrain did act as lifting mechanisms for cloud formation, however the cloud cover would have had bases above 14,000 feet (section 5.0). No icing conditions were indicated by RAOB below 14,000 feet msl, nor would any icing conditions be expected.

The sounding wind profile indicated a surface wind at KSLC from 180° at 9 knots with an increase in wind speed to 28 knots by 4,900 feet or approximately 670 feet agl. LLWS was identified by RAOB between the surface and 5,000 feet or below 1,000 feet agl, and several layers of clear air turbulence were indicated by RAOB between the surface and 14,000 feet. Given the surface observation data of switching wind directions at KLGU, an inversion dissipating by 1100 MDT, and an increasing wind speed at the surface around the accident site, LLWS and low-level turbulence in the mountainous terrain were likely at the accident site at the accident time.

The 0600 MDT KSLC sounding provided the following table information with RAOB indicating that mountain wave conditions likely near 10,000 feet msl with updraft and downdrafts around 1,750 feet per minute. Mountain wave conditions were also indicated around 12,000 feet msl. Given the weather satellite information (section 5.0) and the pilot report information (section 7.0), the accident flight likely encountered mountain wave conditions while flying between 8,500 and 12,000 feet msl around the accident time:

Height (ft-MSL)	Pres (mb)	T (F)	Td (F)	RH (%)	DD/FF (deg/kts)	CAT (FAA)	LLWS	Icing - Type (AFGWC method)	Wave/x—W—Turb nm fpm max
4226	870	80.2	37.0	21	180/9				
4798	853	82.8	37.8	20		XTR	LIGHT		
4900	850	82.8	37.8	20	170/28				
5347	837	81.3	36.3	20					
6000	818				175/26	MDT			
7000	790				185/21	MDT			
8000	762				205/21	MDT			
9000	736				220/26	LGT			
10000	710				225/29				6.74 1754 MD-SV
10414	700	58.6	19.0	21	220/29				
10533	697	57.9	20.1	23					
12000	661				215/25				10.03 1808 MD-SV
13379	628	43.5	12.9	28		LGT			
14000	613				200/28				

Table 2 – 0600 MDT KSLC sounding table information

5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 15 (GOES-15) data was obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the NTSB's Man-computer Interactive Data Access System software. Visible and infrared imagery (GOES-15 band 1 and 4) at wavelengths of 0.65 microns (μm) and 10.7 μm, respectively, were retrieved for the scene. Satellite imagery surrounding the time of the accident, from 0900 MDT through 1400 MDT at approximately 15-minute intervals were reviewed, and the closest visible images to the time of the accident are documented here.

Figures 10, 11, and 12 present the GOES-15 visible imagery from 1111, 1115, and 1130 MDT at 3X magnification. Inspection of the visible imagery indicated cumuliform type cloud cover south and east of the accident site and KLGU, KBMC, and KOGD. The cumuliform cloud cover remained over southwestern Wyoming and northeastern Utah through 1200 MDT (attachment 2). The cumuliform cloud cover moved generally from south to north between 1015 and 1230 MDT over the mountainous terrain, with the cumuliform cloud cover having a northwest to southeast banding structure indicative of mountain wave conditions. It should be noted these figures have not been corrected for any parallax error.

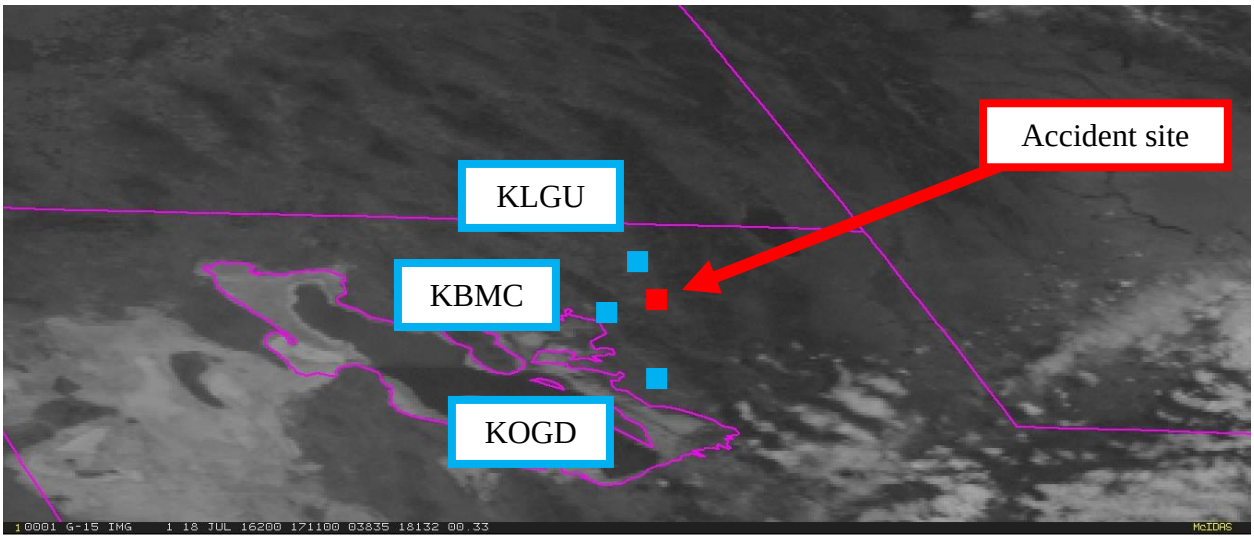

Figure 10 – GOES-15 visible image at 1111 MDT

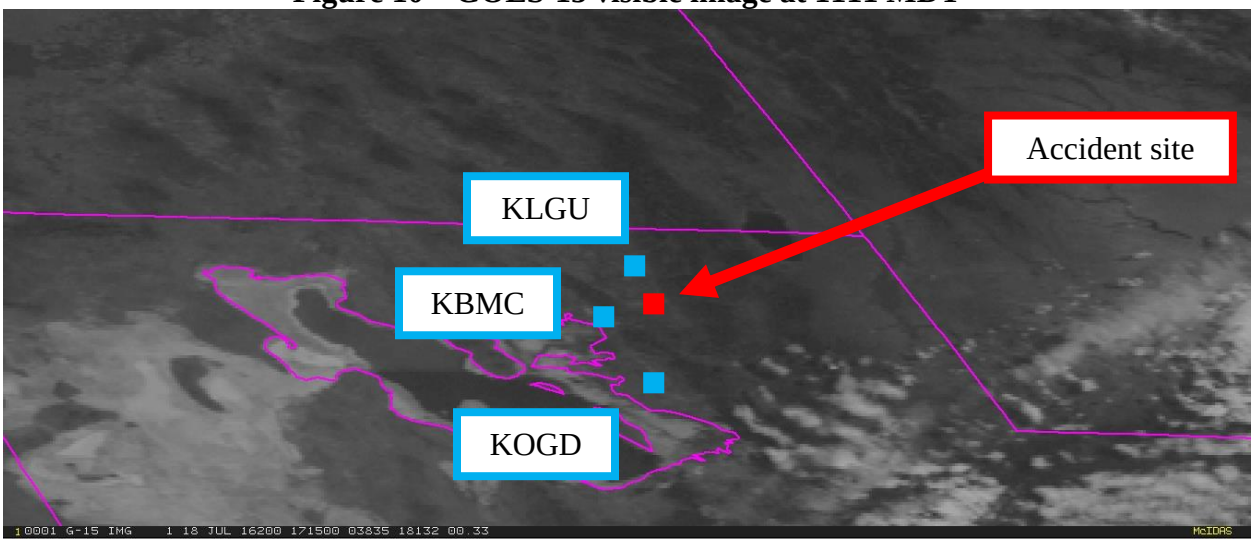

Figure 11 – GOES-15 visible image at 1115 MDT

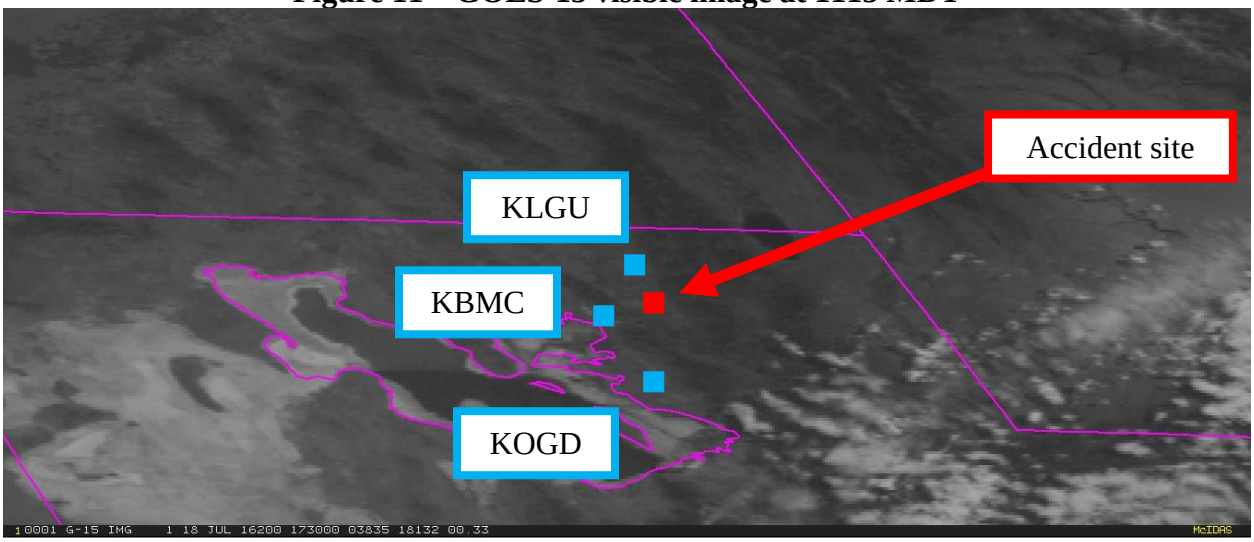

Figure 12 – GOES-15 visible image at 1130 MDT

6.0 Radar Imagery Information

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)[16] was Elder County, Utah, radar (KMTX) located 34 miles west-southwest of the accident site at an elevation of 6,460 feet. Level II and III archive radar data was obtained from the NCDC utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software. No precipitation targets were present above the accident site at the accident time.

7.0 Pilot Reports

All pilot reports (PIREPs) close to the accident site from around three hours prior to the accident time to around three hours after the accident time for below FL200[17] are provided below:

IDA UA /OV IDA/TM 1602/FL095/TP P28A/TB LGT/RM 20KT HEADWIND SOUTHBOUND

PUC UA /OV PUC171025/TM 1603/FL160/TP C210/TA M01/IC LGT RIME/RM IMC CONDITIONS /ZLC

LGU UA /OV LGU/TM 1647/FL085/TP P28A/TB NEG

FBR UA /OV EMM/TM 1716/FL145/TP PA34/TB MOD/RM ZLC

EVW UUA /OV EVW330015/TM 1732/FL100/TP PA34/TB MOD-SEV CHOP /ZLC

SLC UA /OV OGD/TM 1925/FL110/TP CRJ2/TB LGT TURB

Routine pilot report (UA); Over Idaho Falls, Idaho; Time – 1002 MDT (1602Z); Altitude – 9,500 pressure feet msl; Type aircraft – Piper PA-28 Cherokee; Turbulence – Light; Remarks – 20 knot headwind southbound.

Routine pilot report (UA); 25 miles from Price, Utah, on the 171° radial; Time – 1003 MDT (1603Z); Altitude – 16,000 pressure feet msl; Type aircraft – Cessna 210; Temperature – -1° C; Icing – Light rime; Remarks – In instrument meteorological conditions.

Routine pilot report (UA); Over Logan, Utah; Time – 1047 MDT (1647Z); Altitude – 8,500 pressure feet msl; Type aircraft – Piper PA-28 Cherokee; Turbulence – Negative.

Routine pilot report (UA); Over Kemmerer, Wyoming; Time – 1116 MDT (1716Z); Altitude – 14,500 pressure feet msl; Type aircraft – Piper PA-34 Seneca; Turbulence – Moderate.

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

[17] Flight Level – A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of feet. This altitude is calculated from the International standard pressure datum of 1013.25 hPa (29.92 inHg), the average sea-level pressure, and therefore is not necessarily the same as the aircraft's true altitude either above mean sea level or above ground level.

Urgent pilot report (UUA); 15 miles from Evanston, Wyoming, on the 330° radial; Time – 1132 MDT (1732Z); Altitude – 10,000 pressure feet msl; Type aircraft – Piper PA-34 Seneca; Turbulence – Moderate to severe chop.

Routine pilot report (UA); Ogden, Utah; Time – 1325 MDT (1925Z); Altitude – 11,000 pressure feet msl; Type aircraft – Bombardier CRJ200; Turbulence – Light turbulence.

The 1116 and 1132 MDT PIREPs were likely indicative of the conditions experienced by the accident flight as they were located in mountainous terrain just east of the accident site at similar altitudes[18] that the accident flight was flying.

8.0 SIGMET and CWSU Advisory

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

No Meteorological Impact Statement (MIS) or Center Weather Service Unit (CWSU) Advisory (CWA) was valid for the accident site at the accident time.

At 1141 MDT, 20 minutes after the accident time, the CWSU in Salt Lake City (ZLC) issued a weather story (figure 13) on their Twitter account and Facebook pages. The ZLC weather story discussed a chance of thunderstorms throughout the airspace, gusty surface winds, possible turbulence in mountain waves, and LLWS. The social media information issued by CWSUs is considered supplemental information, but does provide weather information in a graphic format for pilots.

[18] For more information please see the ATC data contained in the docket for this accident.

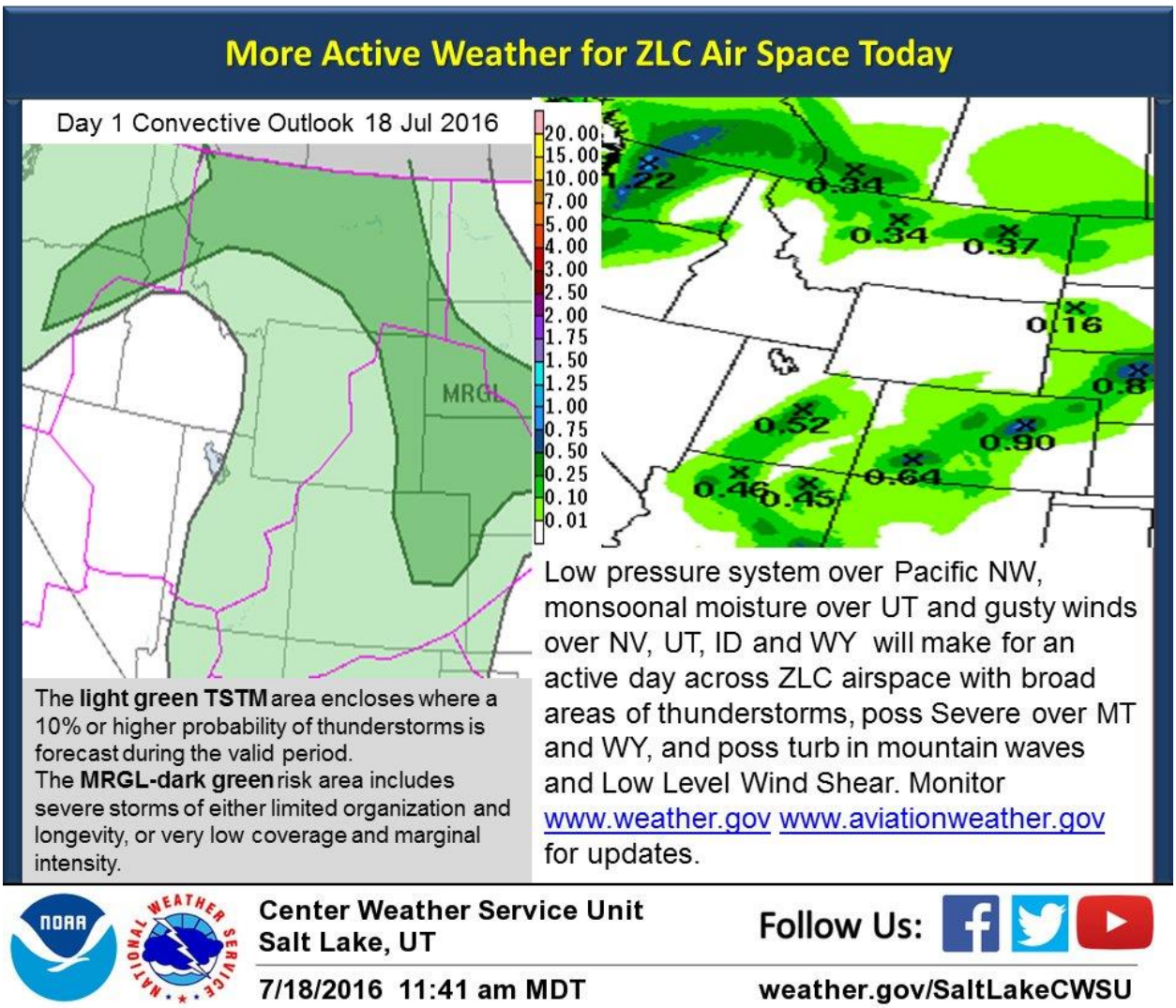

Figure 13 – CWSU ZLC weather story from 1141 MDT

9.0 AIRMETs

No AIRMETs were valid for the accident site at the accident time.

10.0 Area Forecast

The Area Forecast issued at 0730 MDT, valid at the accident time, forecasted scattered clouds at 15,000 feet msl with a southwest wind gusting to 25 knots:

FAUS45 KKCI 181330 AAA
FA5W
_SLCC FA 181330 AMD
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 190500
CLDS/WX VALID UNTIL 182300...OTLK VALID 182300-190500
ID MT WY NV UT CO AZ NM
.

SEE AIRMET SIERRA FOR IFR CONDS AND MTN OBSCN.
TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR CONDS.
NON MSL HGTS DENOTED BY AGL OR CIG.
.
SYNOPSIS...THERMAL TROF NERN WA-NERN NV-SRN NV-SW IS. STNR FNT SM LOW PRES NERN NV-SE ID-SCNTRL WY-NCNTRL CO. CDFNT NCNTRL CO-SE CO-LOW PRES NW KS. HI PRES NW NM. TROF NERN NM-LOW PRES SE NM. CDFNT SW SASK-80N ISN-NERN ND. 18Z WRMFNT FM LOW PRES ECNTRL OR-SW MT-NCNTRL WY. STNR FNT NCNTRL WY-NCNTRL CO-LOW PRES SE CO-SW IA. TROF NW UT-SRN NV-SW AZ. HI PRES SW CO. LOW PRES NR ELP. 05Z STNR FNT FM LOW PRES 70SW GGW-HLN-30N BOI-SE OR. LOW PRES SCNTRL ID. HI PRES WRN CO. TROF FM LOW PRES NW KS-NERN NM.
.
ID
PNHDL...SCT CI. 20Z BKN100 TOP FL200. ISOL -SHRA/-TSRA BECMG 22Z WDLY SCT. CB TOP FL370. OTLK...VFR TIL 04Z SHRA TSRA.
CNTRL MTNS...SCT120. 21Z SCT160. ISOL -TSRA. CB TOP FL370. OTLK...VFR TIL 02Z TSRA.
SWRN...SKC. OTLK...VFR.
SERN...SKC. 19Z WND SW G25KT. OTLK...VFR TIL 03Z WND.
.
MT...UPDT
NW OF CONTDVD...BKN130 TOP FL200. ISOL -SHRA/-TSRA. CB TOP FL250. 12Z BKN150. 21Z OVC100. WDLY SCT -SHRA/ISOL -TSRA. CB TOP FL320. OTLK...VFR SHRA TSRA.
SWRN MTNS...SKC. 20Z SCT100. WDLY SCT -SHRA/ISOL -TSRA. WND S G25KT. OTLK...VFR SHRA TSRA WND 02Z VFR.
ERN SLPS...SCT060 BKN100 TOP 150. 12Z SCT120. OTLK...VFR TSRA.
CNTRL
NRN...OVC080 TOP FL200. SCT -TSRA. CB TOP FL370. 13Z BKN120. 18Z SCT100. OTLK...VFR.
SRN...SCT CI. 18Z SCT100. ISOL -TSRA. CB TOP FL380. OTLK...VFR TIL 03Z TSRA.
NERN...SCT080 BKN140 TOPS FL200. WDLY SCT -TSRA. CB TOPS FL420. 17Z SCT150 SCT CI. OTLK...VFR.
SERN...SKC OR SCT CI. OTLK...VFR.
.
WY
TETONS...SKC. 20Z SCT160. OTLK...VFR.
RMNDR WRN...SCT150. 13Z SKC. 19Z SCT150. ISOL -TSRA. CB TOP FL400. OTLK...VFR TIL 03Z TSRA.
NERN...SKC. OTLK...VFR.
SERN...CIG BKN010 TOP 090. VIS 3-5SM BR. 15Z SCT140. 20Z BKN100. WDLY SCT -TSRA. CB TOP FL400. OTLK...VFR TSRA.
.
NV
WRN...SKC. 20Z SCT150. ISOL -TSRA. CB TOP FL340. WND W 20G30KT. OTLK...VFR TIL 02Z TSRA WND.
ERN-SRN...SKC. 18Z WND S G25-30KT. OTLK...VFR WND.
.
UT...UPDT
NWRN...SKC. 18Z WND S G25-30KT. OTLK...VFR WND.
NCNTRL...SKC. 18Z SCT150. WND SW G25KT. OTLK...VFR TIL 02Z WND.
NERN...SCT140. 17Z BKN140 TOPS FL200. ISOL-SHRA. 20Z ISOL -TSRA. CB TOPS FL380. OTLK...VFR TSRA WND TIL 03Z.
SRN...BKN130-150 TOPS FL200. ISOL -SHRA. 21Z SCT110 BKN-SCT140.

ISOL TO WDLY SCT -SHRA/-TSRA. CB TOPS FL380. OTLK...VFR SHRA
TSRA.
.
CO...UPDT
MTNS WWD...BKN130-150 TOPS FL200. ISOL -SHRA. BECMG 1922 SCT110
BKN150. WDLY SCT -SHRA/-TSRA. CB TOPS FL380. OTLK...VFR SHRA
TSRA.
NERN PLAINS...OVC060 TOP 080. VIS 3-5SM BR. 15Z SCT120. 19Z
BKN140 TOP FL200. WDLY SCT -TSRA. CB TOP FL450. WND E G25KT.
OTLK...VFR TSRA.
SERN PLAINS...SKC. 19Z SCT140. ISOL -TSRA. CB TOP FL400.
OTLK...VFR TSRA.
.
AZ...UPDT
NRN HLF...BKN120-140 TOP FL240. ISOL -SHRA. BECMG 1821 SCT100
BKN140. WDLY SCT TO SCT -SHRA/-TSRA. CB TOPS FL380. OTLK...VFR
TIL 03Z TSRA.
SWRN...SCT-BKN120-140 TOPS FL180. ISOL -SHRA. 20Z ISOL -TSRA. CB
TOPS FL380. OTLK...VFR.
SCNTRL...BKN120 TOP FL200. WDLY SCT -SHRA/ISOL -TSRA. CB TOP
FL350. OTLK...VFR
SERN...BKN100 OVC130 TOP FL200. ISOL-SHRA. BECMG 2022 SCT100
BKN140. WDLY SCT -SHRA/-TSRA. CB TOP FL380. OTLK...VFR SHRA TSRA.
.
NM
NWRN...BKN160 TOP FL250. 19Z ISOL -TSRA. CB TOP FL380. OTLK...VFR
TSRA.
SWRN...BKN160 TOP FL250. 14Z SCT160 SCT-BKN CI. 21Z SCT110
BKN150. WDLY SCT -TSRA. CB TOP FL400. OTLK...VFR TSRA.
NERN...BKN150 TOP FL260. ISOL -SHRA. 19Z SCT150. WND S G25KT.
OTLK...VFR WND.
SERN...SCT CI. OTLK...VFR.
....

11.0 Terminal Aerodrome Forecast

KLGU was the closest site to the accident site with a NWS TAF. The TAF valid at the time of the accident was issued at 0520 MDT and was valid for a 24-hour period beginning at 0600 MDT. The TAF for KLGU was as follows:

TAF KLGU 181120Z 1812/1912 **VRB05KT P6SM SKC**
FM182100 22010G16KT P6SM FEW100 SCT120
FM190300 VRB05KT P6SM FEW100 SCT120=

The forecast expected a variable wind at 5 knots, greater than 6 miles visibility, and sky clear. The increasing southerly wind and wind gusts were not forecast by NWS until 1500 MDT.

KOGD was the next closest TAF site. The TAF valid at the time of the accident was issued at 0911 MDT and was valid for a 21-hour period beginning at 0900 MDT. The TAF for KOGD was as follows:

KOGD 181511Z 1815/1912 **18015G24KT P6SM SKC**
FM190200 18010KT P6SM SCT140=

The forecast expected wind from 180° at 15 knots with gusts to 24 knots, greater than 6 miles visibility, and sky clear. The KOGD TAF was more representative of the surface wind conditions near the accident site at the accident time, but still under-estimated the wind gusts.

12.0 NWS Area Forecast Discussion

The NWS Office in Salt Lake City, Utah, issued the following Area Forecast Discussion (AFD) at 0944 MDT (closest AFD to the accident time), and the AFD discussed gusty southerly winds at the Salt Lake City Airport Terminal with periodic wind gusts above 35 mph at times:

FXUS65 KSLC 181544
AFDSLC
Area Forecast Discussion
National Weather Service Salt Lake City UT
944 AM MDT MON JUL 18 2016
.SYNOPSIS...High pressure over the southern plains with an upper level trough settling into the Pacific Northwest will leave the Great Basin under a southwest flow through much of the week. Moisture will spread across southern and eastern Utah today, and remain in place through much of the week.
&&
.DISCUSSION...The region is under southwest flow this morning in between the ridge over the central United States and the large trough just off the Pacific Northwest coast. This flow is drawing deep moisture into southern and eastern portions of the forecast area. Satellite derived PWs are already in excess of 1.0 inch over far southeast Utah, with PWs up to 0.8 inch extending into central Utah. Instability is not particularly impressive, but showers with a few thunderstorms persist over southeast Utah, primarily along the moisture axis. However, given the dry sub cloud layer little if any precip is hitting the ground.
Moisture will continue to spread northward today, with PWs in excess of 0.8 inch expected this afternoon across all but far northwest Utah. Showers will continue to develop with the heating of the day this afternoon through the early evening, but instability is expected to remain limited, so convection will be on the weak side with the best coverage over the higher terrain. Given the very dry lower levels, however, microburst winds will be a threat with any convection that develops. The potential for thunderstorms developing after a long dry period will result in areas of critical fire weather conditions. See the fire weather section of the AFD for more details.
Little change in the overall pattern is expected through at least midweek with the Pacific Northwest trough and the central US ridge moving little. As a result, the forecast area will continue to see good moisture, particularly over southeast Utah, with enough instability to produce showers and thunderstorms, primarily over the higher terrain. Temperatures are progged to remain on the warm side over northern Utah, with maxes running 5-8F above seasonal norms. Temperature should be closer to climo over southern Utah.
No updates expected to the forecast this morning.

&&
.AVIATION...Gusty southerly winds will prevail at the SLC terminal through the forecast period. Periodic gusts above 35 mph remain possible through 02z this evening. Additionally, there is a 10 percent chance that convection will develop over the Oquirrh Mountains to the southwest of SLC terminal and bring a threat of gusty erratic outflow winds between 20z-02z.
&&
.FIRE WEATHER...Southwesterly flow will prevail across the region through much of the upcoming week. Moisture within this flow will spread northward from Arizona today bringing an increased threat for thunderstorms. Along the northern and western edge of this moisture surge thunderstorms may initially be dry today with lightning and gusty microburst winds possible, however as moisture continues to increase storms should transition to wet across most areas. Given the recent dry spell lightning associated with these storms will pose a significant risk for new starts prompting a red flag warning across much of central and eastern Utah. Meanwhile dry and breezy conditions will continue across northwest and west central Utah resulting in critical fire weather conditions.
Moisture will remain in place across the eastern half of the area through much of the remainder of the week maintaining a threat for showers and thunderstorms each day. These storms will be capable of producing wetting rains given the moisture in place.
&&
.SLC Watches/Warnings/Advisories...
UT...Red Flag Warning until 9 PM MDT this evening for UTZ479-483-489-493-498.
Red Flag Warning until 9 PM MDT this evening for UTZ478-492.
Red Flag Warning until 9 PM MDT this evening for UTZ480-482-484.
WY...None.
&&
$$

13.0 Winds and Temperature Aloft Forecast

The NWS 0802 MDT Winds and Temperature Aloft forecast valid for the flight is included below:

FBUS31 KWNO 181402
FD1US1
DATA BASED ON 181200Z
VALID 181800Z FOR USE 1400-2100Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
SLC		2009	2120+17	2124+09	2129-08	2238-20	225136	225543	225652

The Salt Lake City, Utah, (SLC) forecast point (closest Winds and Temperature Aloft forecast point to the departure and accident site) indicated a wind at 6,000 feet from 200° at 9 knots, and a wind at 9,000 feet from 210° at 20 knots with a temperature of 17° C.

14.0 Pilot Weather Briefing and Information

A search of official weather briefing sources, such as Lockheed Martin Flight Service (LMFS) and Direct User Access Terminal Service (DUATS), revealed that the accident pilot did not contact LMFS or DUATS. There is no record of the accident pilot receiving or retrieving any other weather information before the accident flight.

15.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on July 18, 2016, indicated the following:

SUN	
Begin civil twilight	0537 MDT
Sunrise	0609 MDT
Sun transit	1334 MDT
Sunset	2057 MDT
End civil twilight	2130 MDT

F. LIST OF ATTACHMENTS

Attachment 1 – KLGU 1 and 5 minute ASOS data surrounding the accident time

Attachment 2 – GOES-15 visible satellite animation from 1015 to 1230 MDT

Submitted by:

_____

Paul Suffern
Senior Meteorologist

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