NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

February 6, 2014

Group Chairman's Factual Report

METEOROLOGY

DCA13MA133

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A. ACCIDENT

Location:	Birmingham, Alabama
Date:	August 14, 2013
Time:	About 0447 central daylight time (0947 UTC[1])
Airplane:	UPS flight 1354, Airbus A300-600F; registration N155UP

B. METEOROLOGY GROUP

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C. SUMMARY

On August, 14, 2013, at about 0447 central daylight time (CDT), United Parcel Service (UPS) flight 1354, an Airbus A300-600, N155UP, crashed short of runway 18 while on approach to Birmingham-Shuttlesworth International Airport (BHM), Birmingham, Alabama. The captain and first officer were fatally injured and the airplane was destroyed. The scheduled cargo flight was operating under the provisions of 14 Code of Federal Regulations (CFR) Part 121 and originated from Louisville International-Standiford Field Airport (SDF), Louisville, Kentucky.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Senior Meteorologist and the United Parcel Service Co. (UPS) Senior Meteorologist were not on scene for this investigation and conducted the meteorology phase of the investigation from the Washington D.C. and UPS Global Operations Center, collecting data from official National Weather Service (NWS) sources including the National Climatic Data Center (NCDC), and UPS. All times are central daylight time (CDT) based upon the 24 hour clock, local time +5 hours to UTC, and UTC=Z. 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. NWS airport and station identifiers use standard International Civil Aviation Organization (ICAO) 4-letter station identifiers versus International Air Transport Association (IATA) 3-letter identifiers which deletes the initial country code designator "K" for U.S. airports. Both codes are used intermittently in this report.

The accident site was located at latitude 33.5841° N and longitude 86.7459° W at an elevation of 764 feet.

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

E. FACTUAL INFORMATION

1.0 Synoptic Situation

The synoptic or large scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction (NCEP) located in College Park, Maryland. These are the base products used in describing weather features and in the creation of forecasts and warnings. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC 00-45G.

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart for 0400 CDT (0900Z) on August 14, 2013 for the southeast is included as figure 1 with the Birmingham area and accident site within the red circle, and the general route of flight provided by a red dashed line. The full chart depicted a low pressure system off the Maine coast at 1003-hectopascals (hPa) with a cold front extending south off the Atlantic coast and into North and South Carolina. The front then became a stationary front across northern Georgia, Alabama, Mississippi, into southern Arkansas, Louisiana, and into Texas where another low pressure system was located. High pressure systems were depicted over Wisconsin and over the Gulf of Mexico at 1024- and 1015-hPa respectively. The Birmingham area was located immediately south of the stationary front in a neutral point between the two highs and lows, or a col, where there was a general weak pressure gradient noted.

The station model for Birmingham depicted wind calm, overcast clouds, a temperature of 74° Fahrenheit (F), a dew point of 71° F, and a sea level pressure of 1013.8-hPa. No significant weather was depicted in the immediate vicinity of Birmingham. Over northwestern Alabama near the front and to the south several stations did report mist (light fog) with temperature-dew point spreads of 2° F.

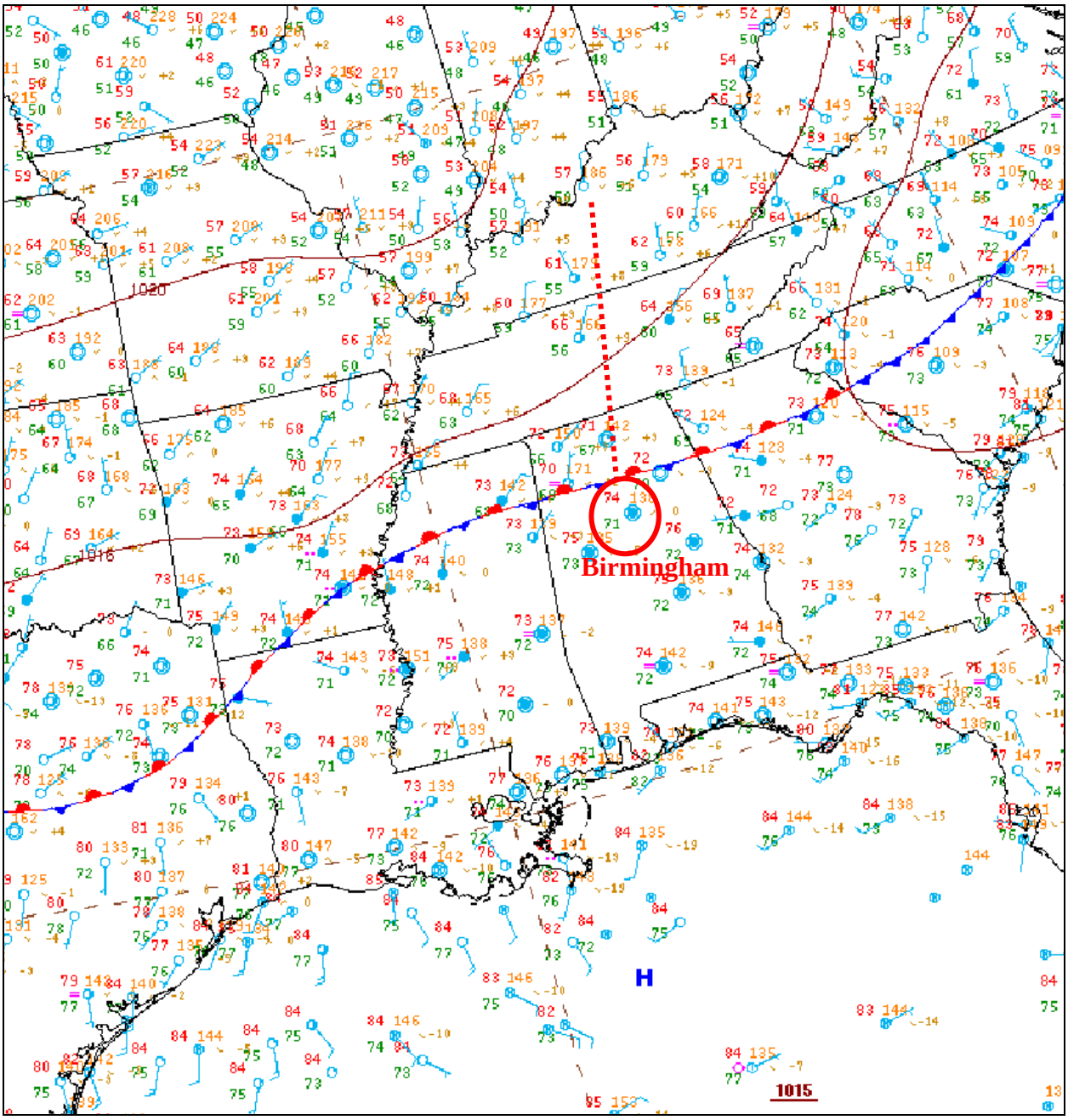

Figure 1 - NWS Surface Analysis Chart for 0400 CDT

1.2 NWS Weather Depiction Charts

Figure 2 is a composite of the southeast NWS Weather Depiction Charts for 0200 CDT (0700Z) and 0500 CDT (1000Z) on August 14, 2013 respectively. The charts provide a depiction of the general flight category[2] or the instrument flight rule (IFR), marginal visual flight

[2] NWS defines the following general flight categories:

rule (MVFR), and reported visual flight rule (VFR) conditions over the country at the reporting time, and the position of the frontal systems from the previous hours Surface Analysis Chart.

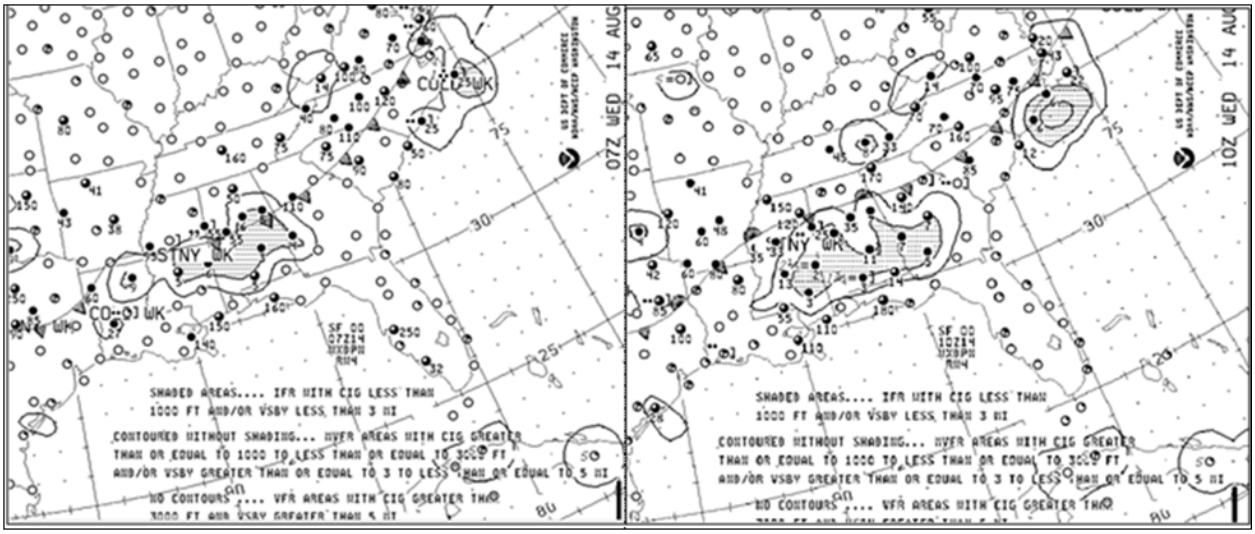

Figure 2 - NWS Weather Depiction Charts for 0200 and 0500 CDT

The chart for 0200 CDT on the left depicted the cold front over or immediately south of the Birmingham area with an area of IFR conditions over central Alabama into Mississippi along and ahead of the cold front depicted by a shaded contour due to general low ceilings, which were depicted in the Birmingham area at 600 feet agl. The area was surrounded by a larger area of MVFR conditions indicated by an unshaded contour. The chart next issued at 0500 CDT on the right, depicted the front as stationary immediately north of Birmingham with the area of IFR conditions spreading into central Georgia with conditions improving in the Birmingham area to MVFR conditions with a ceiling at 3,500 feet. VFR conditions were depicted over most of the route of flight.

1.3 National Radar Mosaic

A section of the National Radar Mosaic for 0445 CDT on August 14, 2013 obtained from the NCDC is included as figure 3 and depicted widely scattered areas of echoes from eastern Texas, Louisiana, southern Arkansas, central and southern Mississippi and Alabama, into western Georgia. One area of echoes was identified immediately west and north of the Birmingham area,

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- Low Instrument Flight Rules (LIFR*) – ceiling or lowest layer of clouds reported as broken, overcast or the vertical visibility into a surface based obscuration below 500 feet agl and/or visibility less than 1 statute mile.
- Instrument Flight Rules (IFR) – ceiling between 500 to below 1,000 feet agl and/or visibility 1 to less than 3 miles.
- Marginal Visual Flight Rules (MVFR**) – ceiling from 1,000 to 3,000 feet agl and/or visibility 3 to 5 miles.
- Visual Flight Rules (VFR) – ceiling greater 3,000 feet agl and visibility greater than 5 miles.

* By definition, IFR is a ceiling less than 1,000 feet agl and/or visibility less than 3 miles while LIFR is a sub-category of IFR.
**By definition, VFR is a ceiling greater than or equal to 3,000 feet agl and visibility greater than 5 miles while MVFR is a sub-category of VFR.

as a result the closest NWS weather radar data will be documented in section 7.0 of this report for potential impacts.

Figure 3- NWS National Radar Mosaic for 0445 CDT

1.4 NWS Low-Level Significant Weather Prognostic Chart

The NWS low-level significant weather prognostic chart issued at approximately 0005 CDT on August 14, 2013 and current for the period for preflight planning is included as figure 4. The chart provided a 12- and 24-hour forecast of general conditions across the United States, with the chart on the left valid for 0700 CDT (1200Z) depicting forecasted conditions for use of the flight. The chart depicted a secondary low pressure system developing over South Carolina along the cold front, with the trailing cold front through southern Alabama into Louisiana, with scattered rain showers and thunderstorms along the front. The chart depicted the front becoming stationary along the Gulf of Mexico coast by 24 hours. The upper left panel of the chart provided expected IFR and MVFR conditions at 0700 CDT and depicted MVFR conditions over the Birmingham area and with an area of IFR conditions over central Mississippi, northern Louisiana, and southern Arkansas.

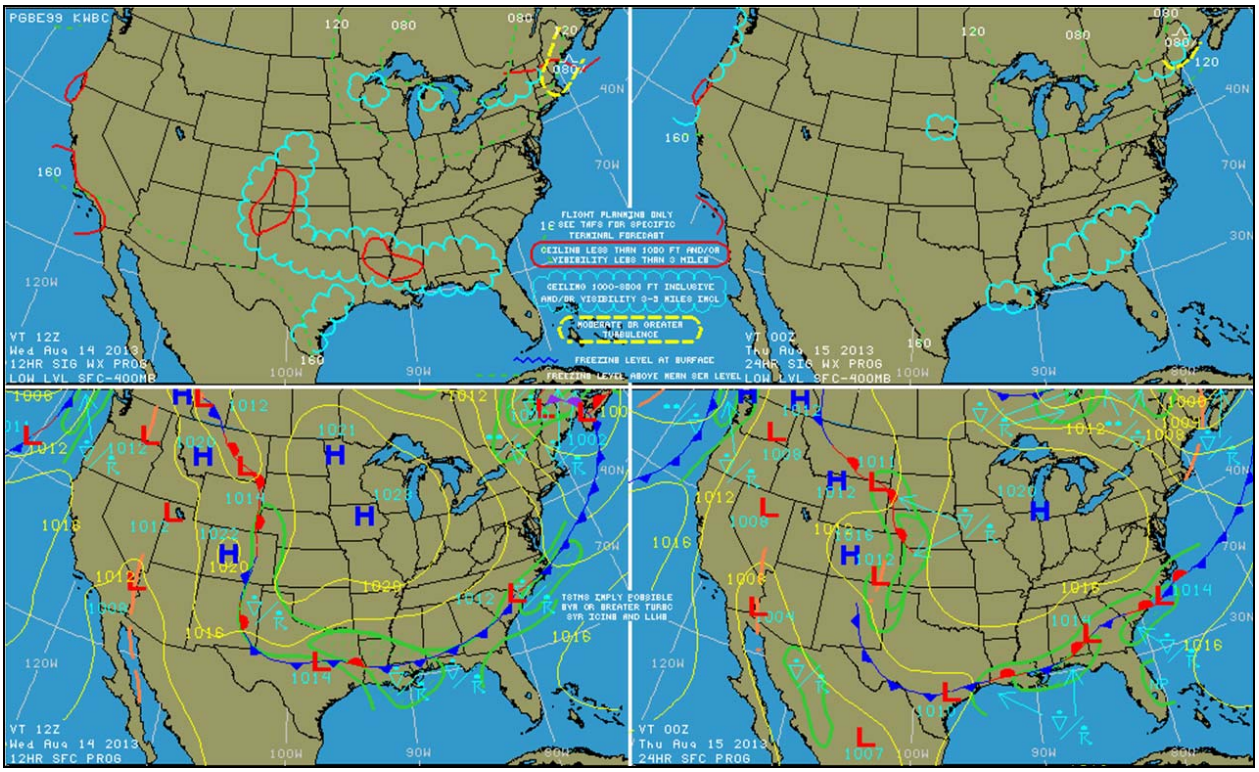

Figure 4 -NWS Low-Level Significant Weather Prognostic Chart valid for 0700 and 1900 CDT

2.0 Surface Observations

The official NWS Meteorological Aerodrome Reports (METARs)[3] and Special reports (SPECIs) surrounding the period were documented for the destination and the closest airports to the accident site. Visibility in report in statute miles and fractions, and cloud heights above ground level (agl).

2.1 Birmingham-Shuttlesworth International Airport (KBHM), Birmingham, AL

The accident occurred as the accident airplane was on approach to the Birmingham-Shuttlesworth International Airport (KBHM). The airport lists an elevation of 650 feet msl and a magnetic variation of 3° west. The airport had a federally installed and maintained Automated Surface Observation System (ASOS) which was augmented by a FAA contracted certified NWS observer. The ASOS Combined Sensor Group (CSG) is located 690 feet east of runway 18-36 centerline near the center of the airport and is shown in figure 5 within the red circle, with the weather observers location also noted in the building immediately south. The ASOS is the single authorized source of official observations at the airport.

[3] METAR code is regulated by the World Meteorological Organization in consort with the International Civil Aviation Organization. In the United States, the code is given authority (with some US national differences from the WMO/ICAO model) under FAA JO 7900.5C (Surface Weather Observing) and NWS Federal Meteorological Handbook No. 1 (FMH-1).

Figure 5 - Location of the KBHM ASOS Combined Sensor Group and weather observer

The official observation issued surrounding the accident for Birmingham-Shuttlesworth International Airport were as follows:

Birmingham-Shuttlesworth International Airport special weather observation at 0353 CDT, wind calm, visibility unrestricted at 10 miles, ceiling broken at 1,000 feet, overcast at 7,500 feet, temperature 23° Celsius (C), dew point temperature 22° C, altimeter 29.97 inches of mercury (Hg).[4] Remarks: automated observation system, ceiling 600 feet variable 1,300 feet, sea level pressure 1013.8-hPa, temperature 23.3° C, dew point 21.7° C, 3-hour pressure tendency rising and falling 0.00-hPa.

Birmingham-Shuttlesworth International Airport special weather observation at 0404 CDT, wind calm, visibility unrestricted at 10 miles, scattered clouds at 1,000 feet, ceiling broken at

[4] The 0353 CDT observation was the basis for the Automated Traffic Information System (ATIS) "Papa" broadcast, without the remarks section.

7,500 feet, temperature 23° C, dew point temperature 22° C, altimeter 29.96 inches of Hg. Remarks: automated observation system.

Birmingham-Shuttlesworth International Airport weather observation at 0453 CDT, wind 340° at 4 knots, visibility unrestricted at 10 miles, a few clouds at 1,100 feet, ceiling broken at 3,500 feet, overcast at 7,500 feet, temperature 23° C, dew point temperature 22° C, altimeter 29.97 inches of Hg. Remarks: automated observation system, sea level pressure 1014.1-hPa, temperature 23.3° C, dew point 22.2° C.

The general flight category and raw observations surrounding the period were as follows:

IFR/LIFR METAR KBHM 140453Z 27004KT 10SM OVC006 23/22 A2998 RMK AO2 CIG 004V008 SLP144 T02330222=

LIFR SPECI KBHM 140507Z 29004KT 10SM OVC004 23/22 A2998 RMK AO2=

LIFR METAR KBHM 140553Z 00000KT 7SM OVC004 23/22 A2998 RMK AO2 SLP142 60002 T02330222 10250 20228 403110228 56005=

IFR METAR KBHM 140653Z 00000KT 10SM OVC006 23/22 A2997 RMK AO2 CIG 005V009 SLP141 T02330217=

MVFR SPECI KBHM 140712Z 00000KT 9SM SCT006 BKN016 23/22 A2997 RMK AO2=

MVFR SPECI KBHM 140734Z 00000KT 10SM BKN010 BKN016 23/22 A2996 RMK AO2=

IFR METAR KBHM 140753Z 00000KT 9SM OVC008 23/22 A2996 RMK AO2 CIG 007V011 SLP137 T02330217=

MVFR/IFR SPECI KBHM 140848Z 33003KT 10SM OVC010 23/22 A2997 RMK AO2 CIG 006V013=

MVFR/IFR METAR KBHM 140853Z 00000KT 10SM BKN010 OVC075 23/22 A2997 RMK AO2 CIG 006V013 SLP138 T02330217 52000=

VFR SPECI KBHM 140904Z 00000KT 10SM SCT010 BKN075 23/22 A2996 RMK AO2=

Accident 0947Z

VFR METAR KBHM 140953Z 34004KT 10SM FEW011 BKN035 OVC075 23/22 A2997 RMK AO2 SLP141 T02330222=

Beginning civil twilight 1043Z

VFR METAR KBHM 141053Z 01003KT 10SM OVC070 23/22 A2999 RMK AO2 SLP146 T02330222=

VFR SPECI KBHM 141106Z 00000KT 9SM FEW005 OVC070 23/22 A2999 RMK AO2 FEW005 FU=

Sunrise 1109Z

MVFR METAR KBHM 141153Z 00000KT 5SM -RA BR OVC065 23/22 A2999 RMK AO2 RAB24 SLP149 P0001 60001 70007 T02330222 10233 20228 52010=

VFR METAR KBHM 141253Z 04004KT 6SM -RA BR FEW010 OVC075 23/22 A3000 RMK AO2 SLP149 FU

FEW010 P0001 T02330222=

VFR KBHM 141353Z 05004KT 6SM -RA BR FEW011 OVC080 23/22 A3001 RMK AO2 SLP153 FU FEW011 P0001 T02330217

MVFR KBHM 141453Z 35004KT 4SM +RA BR FEW011 BKN065 OVC085 23/22 A3002 RMK AO2 SLP157 FU FEW011 P0005 60007 T02330217 53008

2.1.1 Birmingham ASOS 5-minute Data

The high resolution data from the ASOS was also reviewed surrounding the period and indicated no significant changes in visibility during the hour of the accident with no precipitation or mist being reported. The 5-minute observation issued by the system over the airport immediately prior to the accident was as follows:

Birmingham-Shuttlesworth International Airport weather at 0445 CDT, wind calm, visibility 10 statute miles, a few clouds at 1,100 feet, ceiling overcast at 7,500 feet, temperature 23° C, dew point 22° C, altimeter 29.97 inches of Hg. The pressure altitude was 600 feet, the relative humidity 93%, the density altitude 1,700 feet, and the magnetic wind was calm.

The raw 5-minute ASOS observations surrounding the time of the accident were as follows:

KBHM 140930Z 00000KT 9SM BKN075 BKN100 23/22 A2997 600 93 1700 000/00 RMK AO2

KBHM 140935Z 00000KT 9SM BKN075 BKN100 23/22 A2997 600 93 1700 000/00 RMK AO2

KBHM 140940Z 00000KT 10SM FEW011 BKN075 23/22 A2997 600 93 1700 000/00 RMK AO2

KBHM 140945Z 00000KT 10SM FEW011 OVC075 23/22 A2997 600 93 1700 000/00 RMK AO2

Accident 0947Z

KBHM 140950Z 34003KT 10SM FEW011 SCT035 OVC075 23/22 A2997 600 93 1700 340/03 RMK AO2 SLP141 T02330222

KBHM 140955Z 36003KT 10SM FEW011 BKN035 OVC075 23/22 A2998 600 93 1700 360/03 RMK AO2

KBHM 141000Z 35003KT 10SM FEW011 BKN035 OVC075 23/22 A2998 590 93 1700 360/03 RMK AO2

2.1.2 Birmingham ASOS Maintenance

The Birmingham ASOS had received its quarterly preventative maintenance on August 2, 2013. That inspection included checking the ceilometer status, checking the proper angle of the unit, checking the lights on the engine board, and spraying cleaner which was a 50/50 mix of distilled water and isopropyl alcohol on the sensor windows. On August 27, 2013 a site inspection was performed, which included cleaning the lenses of the sensors, removing accumulated water from the All Weather Precipitation Accumulation Gauge (AWPAG), and cutting the grass surrounding the system. The system was found to be operating normally. In checking previous trouble reports, it was found that on July 18, 2013 the system was reported as

indicating false low ceilings. The maintenance technician visited the site and discovered small birds flying in the area of the ASOS. The false readings were duplicated as a bird flew overhead and or a hand was waved over the ceilometer sensor. The problem or false readings no longer occurred after the birds migrated.

2.1.3 ASOS Ceilometer

The ASOS system utilizes a laser ceilometer and processes the ceilometer data through computers and employs mathematical logic, or algorithms, to ascertain the cloud height, the number of layers, and amount of coverage. The ceilometer or cloud height indicator (CHI) transmits a laser skyward with approximately 9,240 pulses in 12 seconds. ASOS then assigns the returned signals, or cloud base “hits”, to one of 252 50-foot interval bins. After the 12 seconds, ASOS produces a profile of the back-scattered signal to help determine if the returned signals were from cloud bases. The present laser ceilometers can detect targets up to an altitude of 25,000 feet; however, the software only allows values up to 12,000 feet to be reported. The system then processes the laser sensor signals into 30-second samples of cloud "hits." Each minute the algorithm processes 30 minutes of the 12- second data samples to create values for sky coverage and cloud height for the observation. By processing 30 minutes of data, the ASOS observation attempts to be more representative of an approximate area 3 to 5 miles around the sensor site. To be more responsive to the latest changes in the weather, the last 10 minutes of the data are double-weighted in the algorithm calculations. ASOS identifies the recorded "hits" by height and processes them into layers. The system may report up to three layers. The system assigns a coverage value of few (FEW), scattered (SCT), broken (BKN), or overcast (OVC), based on time and numbers of hits at the specific level. If no clouds are detected, ASOS transmits clear (CLR) in the observation to indicate no detectable clouds below the lasers height range of 12,000 feet.

The computer algorithm also tests the sensor return for obscurations and variable ceilings. An obscuration occurs when fog/mist or precipitation masks the ability of a surface observer to clearly see the base of the lowest clouds. These same elements can mask the ceilometer from determining clear cloud "hits" in the signal return. The observation will carry a totally obscured sky condition if enough of these hits persist, the visibility is 1 mile or less, and there is a cloud layer at 2,000 feet or less. The ASOS also will determine variable ceilings when a ceiling is below 3,000 feet. If the variability tests are met, the observation will contain a remark such as ceiling 600 variable 1,300 feet (CIG 006V013), as in the Birmingham 0353 CDT (0853Z) observation[5] .

The ASOS ceilometers performance is considered above average and reports sky conditions accurately most of the time. In a formal study of the ASOS performance by the Hughes STX Corp., they found that when the ceilings were less than 5,000 feet, ASOS observations agreed with the human observer approximately 80% of the time. It has also been documented that the ASOS typically issues more special observations than the human observers, as it continuously

[5] The 0353 CDT METAR was used as the basis for the KBHM Automated Terminal Information System (ATIS) “Papa” report; however, that report did not include the pertinent remarks section of the report variable ceiling.

monitors atmospheric conditions and issues a special report for any significant changes in visibility or sky condition that meets specific criteria.

The ASOS will only report weather that passes over the sensors. The ceilometer will not capture cap clouds over distant mountains or low clouds near the airport. In the more tropical regions, where winds aloft are often very light, such as Florida, afternoon cumulus clouds may move slowly and may not be detected until they move over the ceilometer. In such cases, observers have reported up to four tenths of the sky covered by fair weather cumulus when ASOS reported sky conditions clear.

At the transition between scattered and broken cloud coverage (five-tenths) humans often report too much cloud coverage. This is attributed to the "packing effect", a condition where an observer does not see the openings in the cloud decks near the horizon due to the viewing angle. ASOS is not biased by the "packing effect" because it measures only the sky conditions passing over the sensor. ASOS does not view the sky at an angle. Thus human observers and pilots may feel that ASOS does not report enough cloud coverage.

As a result of some limitations in the ASOS system such as its being unable to detecting conditions not over the sensors, and potential failure of key elements of the system, the FAA has contract weather observers at most of the major airports in the United States. As a case in point, the Birmington ASOS does not have a thunderstorm sensor, and cannot detect or report thunderstorm activity without an observer's input into the system. Birmingham, located approximately 300 miles from the Gulf of Mexico, experiences an average of 57 days of thunderstorms per year.

2.2 Shelby County Airport (KEET), Alabaster, AL

The next closest weather reporting location to Birmingham was from Shelby County Airport (KEET) located approximately 23 miles south at an elevation of 586 feet. The airport also had an ASOS that was not augmented by a human observer. The system reported the following conditions at the approximate time of the accident:

Shelby County Airport weather at 0446 CDT, automated, wind calm, visibility 6 miles in mist, ceiling broken at 200 feet, broken at 7,000 feet, temperature 23° C, dew point 22° C, and altimeter 29.95 inches of Hg. Remarks: automated weather observation system.

The flight category and raw observations surrounding the period were as follows:

LIFR METAR KEET 140653Z AUTO 00000KT 5SM BR OVC004 22/22 A2996 RMK AO2 CIG 001V005 SLP136 T02220222=

LIFR SPECI KEET 140732Z AUTO 00000KT 2SM BR OVC002 22/22 A2995 RMK AO2=

LIFR SPECI KEET 140745Z AUTO 00000KT 4SM BR OVC002 22/22 A2995 RMK AO2=

LIFR METAR KEET 140753Z AUTO 00000KT 5SM BR OVC002 23/22 A2995 RMK AO2 SLP132 T02280222=

LIFR SPECI KEET 140844Z AUTO 00000KT 2 1/2SM BR OVC002 23/22 A2995 RMK AO2=

LIFR METAR KEET 140853Z AUTO 00000KT 1 3/4SM BR OVC002 23/22 A2995 RMK AO2 SLP134 T02280222 55005=

LIFR SPECI KEET 140901Z AUTO 00000KT 3SM BR OVC002 23/22 A2994 RMK AO2=

VFR SPECI KEET 140938Z AUTO 00000KT 6SM BR SCT002 BKN070 23/22 A2995 RMK AO2=

LIFR SPECI KEET 140946Z AUTO 00000KT 6SM BR BKN002 BKN070 23/22 A2995 RMK AO2=

Accident 0947Z

LIFR METAR KEET 140953Z AUTO 00000KT 6SM BR BKN002 BKN070 23/22 A2995 RMK AO2 SLP135 T02280222=

LIFR METAR KEET 141053Z AUTO 00000KT 6SM -RA BR OVC004 23/22 A2996 RMK AO2 RAB47 SLP140 P0000 T02280222=

LIFR METAR KEET 141153Z AUTO 00000KT 4SM BR BKN004 BKN050 OVC065 23/23 A2997 RMK AO2 RAE12B33E48 SLP141 P0000 60000 70085 T02330228 10233 20222 53007=

IFR SPECI KEET 141224Z AUTO 00000KT 4SM BR SCT004 BKN008 BKN039 23/22 A2997 RMK AO2 LTG DSNT W P0001=

IFR SPECI KEET 141242Z AUTO 00000KT 4SM BR BKN006 BKN016 OVC044 23/23 A2997 RMK AO2 LTG DSNT W CIG 004V010 P0001=

The TAF current at the time expected LIFR conditions to prevail and was as follows:

TAF AMD KEET 140647Z 1407/1506 VRB03KT 3SM BR BKN003
FM141300 VRB04KT P6SM SCT007 BKN015
FM141500 35005KT P6SM FEW050 SCT250=

2.3 Walker County Airport – Bevill Field (KJFX), Jasper, AL

The next closest reporting location was from Walker County Airport – Bevill Field (KJFX) which was located approximately 35 miles northwest of Birmingham in Jasper, AL, at an elevation of 483 feet. The airport had a non-federal Automated Weather Observation System (AWOS)[6] and issued reports every 20 minutes. The following conditions were reported near the time of the accident:

Walker County Airport weather at 0435 CDT, automated, wind calm, visibility 8 miles, sky clear below 12,000 feet, temperature 23° C, dew point 22° C, and altimeter 29.96 inches of Hg. Remarks: automated weather observation system, system error code "P-128"[7].

[6] AWOS systems are not typically augmented by human weather observers as ASOS at air carrier airports.

[7] The error code "P-128" was identified as a non-standard code and forwarded to the equipment manufacture to be removed during the next scheduled maintenance of the system. Several questionable observations with sky clear during a period of precipitation raises questions regarding the reliability of the ceilometer during the period.

The flight category and raw observations surrounding the period were as follows:

VFR METAR KJFX 140815Z AUTO 00000KT 6SM -RA CLR 24/23 A2995 RMK A02 P-128=

VFR METAR KJFX 140835Z AUTO 00000KT 6SM -RA CLR 23/23 A2995 RMK A02 P-128=

MVFR METAR KJFX 140855Z AUTO 00000KT 5SM -RA CLR 24/23 A2996 RMK A02 P-128=

VFR METAR KJFX 140915Z AUTO 05003KT 7SM CLR 23/22 A2996 RMK A02 P-128=

VFR METAR KJFX 140935Z AUTO 00000KT 8SM CLR 23/22 A2996 RMK A02 P-128=

Accident 0947Z

VFR METAR KJFX 140955Z AUTO 00000KT 7SM FEW034 23/22 A2996 RMK A02 P-128=

VFR METAR KJFX 141015Z AUTO 02004KT 7SM -RA BKN035 23/22 A2997 RMK A02 P-128=

VFR METAR KJFX 141035Z AUTO 04003KT 7SM -RA BKN035 23/22 A2997 RMK A02 P-128=

VFR METAR KJFX 141055Z AUTO 00000KT 6SM BR SCT035 23/22 A2997 RMK A02 LTG DSNT S P-128=

VFR METAR KJFX 141115Z AUTO 00000KT 7SM CLR 23/22 A2998 RMK A02 LTG DSNT S P-128=

MVFR METAR KJFX 141135Z AUTO 03003KT 5SM BR CLR 23/22 A2998 RMK A02 LTG DSNT S P-128=

MVFR METAR KJFX 141155Z AUTO 00000KT 3SM -DZ CLR 22/22 A2999 RMK A02 P-128=

IFR METAR KJFX 141215Z AUTO 02004KT 2 1/2SM -RA CLR 22/22 A2999 RMK A02 P-128=

IFR METAR KJFX 141235Z AUTO 00000KT 2SM RA SCT002 SCT015 22/22 A3000 RMK A02 P-128=

IFR METAR KJFX 141255Z AUTO 03003KT 2 1/2SM -RA CLR 22/22 A3000 RMK A02 P-128=

2.4 Northeast Alabama Regional Airport (KGAD), Gadsden, AL

The next closest station was from Northeast Alabama Regional Airport (KGAD), located in Gadsden, Alabama, approximately 41 miles northeast of Birmingham at an elevation of 569 feet. The airport had an AWOS and issued an observation every 20 minutes. The following observation was issued at the approximate time of the accident:

Northeast Alabama Regional Airport weather observation at 0435 CDT, automated, wind 320° at 3 knots, visibility 9 miles, sky clear below 12,000 feet, temperature 22° C, dew point 20° C, altimeter 29.94 inches of Hg. Remarks: automated observation system without a precipitation discriminator.

The flight category and observations surrounding the period were as follows:

VFR METAR KGAD 140835Z AUTO 00000KT 8SM CLR 22/20 A2994 RMK AO1=

VFR METAR KGAD 140855Z AUTO 00000KT 9SM CLR 22/21 A2994 RMK AO1 57003=

VFR METAR KGAD 140915Z AUTO 00000KT 9SM CLR 22/20 A2993 RMK AO1=

VFR METAR KGAD 140935Z AUTO 32003KT 9SM CLR 22/20 A2994 RMK AO1=

Accident 0947Z

VFR METAR KGAD 140955Z AUTO 35004KT 10SM CLR 22/20 A2995 RMK AO1=

VFR METAR KGAD 141015Z AUTO 36004KT 10SM CLR 22/19 A2995 RMK AO1=

VFR METAR KGAD 141035Z AUTO 01003KT 10SM SCT065 22/19 A2996 RMK AO1=

VFR METAR KGAD 141055Z AUTO 00000KT 9SM FEW065 22/19 A2997 RMK AO1=

VFR METAR KGAD 141115Z AUTO 00000KT 9SM CLR 22/19 A2997 RMK AO1=

VFR METAR KGAD 141135Z AUTO 00000KT 8SM FEW065 SCT120 22/19 A2997 RMK AO1=

VFR METAR KGAD 141155Z AUTO 00000KT 7SM SCT120 22/19 A2998 RMK AO1 10230 20220 52014=

VFR METAR KGAD 141215Z AUTO 00000KT 7SM FEW110 22/19 A2998 RMK AO1=

2.5 Cullman Regional Airport – Folsom Field (KCMD), Cullman, AL

Cullman Regional Airport – Folsom Field, was located 43 miles north of Birmingham in Cullman, AL, at an elevation of 969 feet. The airport had an AWOS and reported the following conditions at the approximate time of the accident:

Cullman Regional Airport – Folsom Field weather at 0435 CDT, automated, wind from 360° at 3 knots, visibility 7 miles, scattered clouds at 5,000 feet, ceiling broken at 6,500 feet, temperature 21° C, dewpoint 20° C, altimeter 29.99 inches of Hg. Remarks: automated observation system, temperature 21.0° C, dew point 19.9° C.

The general flight category and raw observations surrounding the period were as follows:

VFR METAR KCMD 140655Z AUTO 34003KT 10SM CLR 22/21 A2998 RMK AO2 T02220207=

VFR METAR KCMD 140715Z AUTO 36003KT 10SM CLR 22/21 A2998 RMK AO2 T02200205=

VFR METAR KCMD 140735Z AUTO 02003KT 10SM CLR 22/20 A2998 RMK AO2 T02190204=

VFR METAR KCMD 140755Z AUTO 01003KT 7SM CLR 22/20 A2998 RMK AO2 T02170203=

VFR METAR KCMD 140815Z AUTO 00000KT 7SM CLR 22/20 A2998 RMK AO2 T02150202=

VFR METAR KCMD 140835Z AUTO 00000KT 7SM CLR 22/20 A2999 RMK AO2 T02150201=

VFR METAR KCMD 140855Z AUTO 00000KT 7SM SCT055 21/20 A2999 RMK AO2 T02130199=

VFR METAR KCMD 140915Z AUTO 35003KT 7SM SCT048 SCT055 21/20 A2999 RMK AO2 T02110200=

VFR METAR KCMD 140935Z AUTO 36003KT 7SM SCT050 BKN065 21/20 A2999 RMK AO2 T02100199=

Accident 0947Z

VFR METAR KCMD 140955Z AUTO 35003KT 7SM SCT050 SCT060 21/20 A2999 RMK AO2 T02080196=

VFR METAR KCMD 141015Z AUTO 00000KT 7SM CLR 21/20 A3000 RMK AO2 T02050195=

VFR METAR KCMD 141035Z AUTO 36003KT 7SM CLR 21/20 A3001 RMK AO2 T02050195=

VFR METAR KCMD 141055Z AUTO 01003KT 7SM SCT050 20/19 A3001 RMK AO2 LTG DSNT SW T02040194=

VFR METAR KCMD 141115Z AUTO 36004KT 7SM BKN050 20/19 A3002 RMK AO2 T02020193=

MVFR METAR KCMD 141135Z AUTO 01003KT 5SM BR SCT008 SCT050 20/19 A3002 RMK AO2 LTG DSNT S T02010193=

MVFR METAR KCMD 141155Z AUTO 01005KT 5SM BR SCT006 20/19 A3002 RMK AO2 T02000192=

MVFR METAR KCMD 141215Z AUTO 35003KT 5SM BR SCT006 SCT050 20/19 A3002 RMK AO2 T02010192=

VFR METAR KCMD 141235Z AUTO 01005KT 7SM SCT007 SCT050 21/19 A3003 RMK AO2 T02070193=

2.6 Anniston Regional Airport (KANB), Anniston, AL

Anniston Regional Airport (KANB) was located approximately 45 miles east of Birmingham at an elevation of 612 feet. The airport had an ASOS which was not augmented. The following conditions were reported at the approximate time of the accident:

Anniston Regional Airport weather at 0453 CDT, automated, wind from 240° at 5 knots, visibility 9 miles, ceiling broken at 700 feet, overcast at 1,500 feet, temperature and dew point 22° C, altimeter 29.96 inches of Hg. Remarks: automated observation system, ceiling 400 variable 1,000 feet, sea level pressure 1013.5-hPa, temperature 22.2° C, dew point 21.7° C.

The general flight category and raw observations surrounding the period were as follows:

IFR METAR KANB 140653Z AUTO 00000KT 7SM OVC005 23/22 A2995 RMK AO2 RAB22E43 SLP132 P0000 T02280217=

IFR METAR KANB 140753Z AUTO 26004KT 9SM OVC005 23/22 A2995 RMK AO2 SLP132 T02280217=

IFR METAR KANB 140853Z AUTO 00000KT 9SM OVC005 23/22 A2994 RMK AO2 SLP129 60000 T02280217 56007=

Accident 0947Z

IFR/LIFR METAR KANB 140953Z AUTO 24005KT 9SM BKN007 OVC015 22/22 A2996 RMK AO2 CIG 004V010 SLP135 T02220217=

IFR METAR KANB 141053Z AUTO 00000KT 8SM OVC005 22/22 A2997 RMK AO2 SLP140 T02220217=

LIFR SPECI KANB 141144Z AUTO 00000KT 5SM BR OVC003 23/22 A2998 RMK AO2=

LIFR METAR KANB 141153Z AUTO 00000KT 5SM BR OVC003 23/22 A2998 RMK AO2 SLP144 60000 70067 T02280217 10228 20222 51013=

IFR/LIFR SPECI KANB 141216Z AUTO 00000KT 4SM BR BKN005 BKN011 OVC100 23/22 A2998 RMK AO2 CIG 002V008=

The Terminal Aerodrome Forecast (TAF) current at the time was as follows:

TAF AMD KANB 140647Z 1407/1506 VRB03KT P6SM BKN005
FM141300 VRB04KT P6SM SCT009 BKN015
FM141500 02005KT P6SM FEW050 SCT250=

2.7 Albertville Municipal Airport (K8A0), Albertville, AL

Albertville Municipal Airport (K8A0) was located approximately 47 miles northeast of Birmingham at an elevation of 1,032 feet. The airport had an AWOS and reported the following conditions at the approximate time of the accident:

Albertville Municipal Airport (K8A0) weather at 0435 CDT, automated, wind 020° at 5 knots, visibility 7 miles, scattered clouds at 5,000 feet, temperature 22° C, dew point missing, altimeter 29.96 inches of Hg. Remarks: automated observation system.

The general flight category and raw observations surrounding the period were as follows:

VFR METAR K8A0 140655Z AUTO 00000KT 10SM CLR 22/ A2996 RMK AO2=

VFR METAR K8A0 140715Z AUTO 01003KT 10SM CLR 22/ A2996 RMK AO2=

VFR METAR K8A0 140735Z AUTO 02003KT 10SM CLR 22/ A2995 RMK AO2=

VFR METAR K8A0 140755Z AUTO 00000KT 10SM CLR 22/ A2995 RMK AO2=

VFR METAR K8A0 140815Z AUTO 02003KT 10SM CLR 22/ A2995 RMK AO2=

VFR METAR K8A0 140835Z AUTO 02003KT 10SM CLR 22/ A2995 RMK AO2=

VFR METAR K8A0 140855Z AUTO 01004KT 10SM CLR 22/ A2996 RMK AO2=

VFR METAR K8A0 140915Z AUTO 01005KT 10SM SCT050 22/ A2997 RMK AO2=

VFR METAR K8A0 140935Z AUTO 01004KT 7SM SCT050 22/ A2996 RMK AO2=

Accident 0947Z

VFR METAR K8A0 140955Z AUTO 02005KT 10SM SCT043 22/ A2997 RMK AO2=

VFR METAR K8A0 141015Z AUTO 02006KT 10SM SCT043 BKN050 BKN060 22/ A2997 RMK AO2=

VFR METAR K8A0 141035Z AUTO 02008KT 10SM SCT045 BKN050 BKN060 22/ A2998 RMK AO2=

VFR METAR K8A0 141055Z AUTO 02007KT 10SM SCT045 SCT050 21/ A2998 RMK AO2 LTG DSNT W=

VFR METAR K8A0 141115Z AUTO 03004KT 10SM CLR 21/ A2999 RMK AO2=

VFR METAR K8A0 141135Z AUTO 02005KT 7SM SCT049 21/ A2999 RMK AO2 LTG DSNT SW=

VFR METAR K8A0 141155Z AUTO 03005KT 7SM SCT049 21/ A2999 RMK AO2=

2.8 Tuscaloosa Regional Airport (KTCL), Tuscaloosa, AL

Tuscaloosa Regional Airport (KTCL) was located approximately 48 miles southwest of Birmingham in Tuscaloosa, Alabama, at an elevation of 170 feet. The airport had an ASOS and was augmented after 0630 CDT. The following conditions were reported at the approximate time of the accident:

Tuscaloosa Regional Airport weather at 0453 CDT, automated, wind calm, visibility 8 miles, ceiling overcast at 800 feet, temperature 24° C, dew point 23° C, altimeter 29.94 inches of Hg.

Thunderstorms were report at the station between 0510 and 0522 CDT.

The general flight category and raw observations surrounding the period were as follows:

VFR METAR KTCL 140653Z AUTO 00000KT 8SM OVC055 23/23 A2994 RMK AO2 SLP136 T02330228=

VFR METAR KTCL 140753Z AUTO 00000KT 8SM FEW012 OVC060 24/23 A2994 RMK AO2 SLP135 T02390228=

MVFR SPECI KTCL 140806Z AUTO 00000KT 9SM BKN012 OVC060 24/23 A2994 RMK AO2=

IFR SPECI KTCL 140844Z AUTO 00000KT 8SM OVC008 24/23 A2994 RMK AO2=

IFR METAR KTCL 140853Z AUTO 00000KT 7SM OVC008 24/23 A2994 RMK AO2 SLP135 T02390228 55005=

Accident 0947Z

IFR METAR KTCL 140953Z AUTO 00000KT 8SM OVC008 24/23 A2994 RMK AO2 SLP134 T02390228=

IFR/LIFR SPECI KTCL 141016Z AUTO 28006KT 8SM VCTS -RA BKN006 OVC009 24/23 A2995 RMK AO2 TSB10RAB10 CIG 003V007 P0000=

IFR SPECI KTCL 141020Z AUTO 30012G17KT 1 3/4SM VCTS +RA BR BKN006 OVC009 24/23 A2996 RMK AO2 TSB10RAB10 PRESRR P0018=

LIFR SPECI KTCL 141029Z AUTO 26007G17KT 1/2SM +TSRA FG OVC006 23/21 A2996 RMK AO2 TSB10RAB10 P0087=

LIFR SPECI KTCL 141036Z AUTO 00000KT 1/2SM +TSRA FG FEW004 SCT011 OVC016 22/21 A2995 RMK AO2 TSB10RAB10 P0107=

IFR SPECI KTCL 141043Z AUTO 00000KT 2SM -TSRA BR FEW004 BKN029 OVC055 22/21 A2995 RMK AO2 TSB10RAB10 P0107=

VFR SPECI KTCL 141051Z AUTO 00000KT 8SM -TSRA BKN031 BKN050 OVC070 22/21 A2995 RMK AO2 TSB10RAB10 P0107=

VFR METAR KTCL 141053Z AUTO 00000KT 9SM -TSRA BKN031 BKN050 OVC095 22/21 A2995 RMK AO2 TSB10RAB10 SLP139 P0107 T02220211=

MVFR SPECI KTCL 141118Z AUTO 34003KT 10SM VCTS BKN014 BKN022 OVC120 23/22 A2995 RMK AO2 LTG DSNT E RAE15 P0000=

MVFR SPECI KTCL 141122Z AUTO 35003KT 10SM BKN015 BKN120 23/22 A2995 RMK AO2 LTG DSNT E TSE22RAE15 P0000=

MVFR SPECI KTCL 141133Z AUTO 35003KT 10SM OVC013 23/23 A2996 RMK AO2 LTG DSNT E TSE22RAE15 P0000=

IFR/MVFR METAR KTCL 141153Z 36005KT 8SM BKN009 OVC014 24/23 A2996 RMK AO2 TSE22RAE15 CIG 007V012 SLP142 P0000 60107 70123 T02390228 10239 20222 51007=

VFR SPECI KTCL 141231Z 02010KT 7SM -RA SCT009 BKN039 OVC060 24/23 A2996 RMK AO2 LTG DSNT E RAB11 P0000=

The TAFs issued during the period expected MVFR to IFR conditions to prevail at the time of the accident and the TAF was as follows:

TAF KTCL 140533Z 1406/1506 VRB04KT P6SM SCT025 BKN150
FM140700 00000KT 6SM BR VCSH SCT007 BKN025
TEMPO 1408/1412 4SM BR BKN007
FM141500 01006KT P6SM FEW050 SCT250=

2.9 Thomas C. Russell Field Airport (KALX), Alexander City, AL

Thomas C. Russell Field Airport (KALX) was located approximately 56 miles southeast of KBHM at an elevation of 686 feet in Alexander City, AL. The airport had an AWOS and reported the following conditions at the approximate time of the accident:

Thomas Russell Airport weather at 0435 CDT, automated, wind calm, visibility 7 miles, ceiling overcast at 400 feet, temperature 24° C, dew point 22° C, and altimeter 29.96 inches of Hg. Remarks: automated weather system, temperature 24.2° C, dew point 22.4° C.

The general flight category and raw observations surrounding the period were as follows:

VFR METAR KALX 140655Z AUTO 00000KT 10SM CLR 24/22 A2996 RMK AO2 T02420223=

VFR METAR KALX 140715Z AUTO 00000KT 10SM CLR 24/22 A2995 RMK AO2 T02420223=

VFR METAR KALX 140735Z AUTO 00000KT 10SM CLR 24/22 A2995 RMK AO2 T02420223=

VFR METAR KALX 140755Z AUTO 00000KT 10SM SCT004 SCT070 24/22 A2994 RMK AO2 T02420223=

IFR METAR KALX 140815Z AUTO 00000KT 10SM BKN006 BKN070 24/22 A2995 RMK AO2 T02420223=

IFR METAR KALX 140835Z AUTO 00000KT 10SM OVC006 24/22 A2996 RMK AO2 T02420223=

LIFR METAR KALX 140855Z AUTO 00000KT 10SM OVC004 24/22 A2995 RMK AO2 LTG DSNT E P0001 60001 T02420223=

LIFR METAR KALX 140915Z AUTO 00000KT 7SM OVC004 24/22 A2996 RMK AO2 T02420223=

LIFR METAR KALX 140935Z AUTO 00000KT 7SM OVC004 24/22 A2996 RMK AO2 T02420224=

Accident 0947Z

LIFR METAR KALX 140955Z AUTO 00000KT 5SM BR OVC004 24/23 A2996 RMK AO2 T02420225=

LIFR METAR KALX 141015Z AUTO 00000KT 5SM BR OVC004 24/23 A2996 RMK AO2 T02420225=

LIFR METAR KALX 141035Z AUTO 00000KT 4SM BR OVC004 24/23 A2996 RMK AO2 T02420225=

LIFR METAR KALX 141055Z AUTO 00000KT 4SM BR OVC004 24/23 A2997 RMK AO2 LTG DSNT NW T02420225=

LIFR METAR KALX 141115Z AUTO 00000KT 2 1/2SM BR OVC004 24/23 A2997 RMK AO2 LTG DSNT NW T02420225=

LIFR METAR KALX 141135Z AUTO 00000KT 3SM BR OVC004 24/23 A2998 RMK AO2 LTG DSNT NW T02420225=

LIFR METAR KALX 141155Z AUTO 00000KT 3SM BR OVC002 24/23 A2998 RMK AO2 LTG DSNT W 60001 70040 T02420225 10242 20242=

LIFR METAR KALX 141215Z AUTO 00000KT 3SM BR OVC004 24/23 A2998 RMK AO2 T02420225=

2.10 Huntsville International Airport (KHSV), Huntsville, AL

Huntsville International Airport (KHSV) was located approximately 64 miles north of Birmingham at an elevation of 629 feet, and is an air carrier approved airport with adequate runway lengths and services. The airport had an ASOS which was not augmented until after 0550 CDT. The following observation was issued at the approximate time of the accident:

Huntsville International Airport weather at 0453 CDT, automated, wind from 040° at 9 knots, visibility unrestricted at 10 miles, sky clear below 12,000 feet, temperature 22° C, dew point 19° C, altimeter 29.98 inches of Hg. Remarks: automated observation system, sea level pressure 1014.4-hPa, temperature 21.7° C, dew point 18.9° C.

The general flight category and raw observations surrounding the period were as follows:

VFR METAR KHSV 140653Z AUTO 03006KT 10SM BKN050 23/20 A2996 RMK AO2 SLP137 T02330200=

VFR METAR KHSV 140753Z AUTO 02005KT 9SM FEW046 SCT055 22/20 A2996 RMK AO2 SLP137 T02220200=

VFR METAR KHSV 140853Z AUTO 00000KT 8SM FEW060 22/19 A2997 RMK AO2 SLP142 T02170194

53003=

Accident 0947Z

VFR METAR KHSV 140953Z AUTO 04009KT 10SM CLR 22/19 A2998 RMK AO2 SLP144 T02170189=

VFR METAR KHSV 141053Z 02008KT 10SM FEW015 BKN170 21/19 A3000 RMK AO2 SLP151 FIRST T02110189=

VFR METAR KHSV 141153Z 03008KT 9SM FEW013 BKN160 21/19 A3001 RMK AO2 SLP154 T02110189 10239 20211 53010=

MVFR SPECI KHSV 141221Z 03008KT 9SM BKN013 BKN160 21/19 A3001 RMK AO2=

MVFR METAR KHSV 141253Z 04012KT 10SM BKN013 BKN170 21/18 A3002 RMK AO2 SLP159 T02110183=

3.0 Topographical Map

A topographical map of the area and the major weather reporting locations within 50 miles of Birmingham are included in figure 6. The locations of most of the stations in section 2 above are plotted along with the wind, temperature and dew point temperatures at the approximate time of the accident. The other stations not identified are local Remote Automated Weather Stations (RAWS) that do not report visibility or sky cover, and are not fully documented in this report.

The topographical map depicts generally hilly conditions surrounding the Birmingham area, with the city and airport located in a valley between a ridge of hills extending from the northeast to the west, and the Red Mountain Range, which extends from the east to the southwest. The valley is approximately 8 miles long and 2 to 4 miles wide. The Red Mountain Range approaches a height of 600 feet above the valley level or 1,024 feet msl approximately 10 miles east of Birmingham. The Shades Mountain Ridge parallels the Red Mountain Range to the southeast. Rolling terrain also extends southwest and to the west of the area. The hills in the Birmingham area, which extend to the northeast and the north, are the foothills of the Appalachian Mountains and the Cumberland Plateau. The main climatic impact of the terrain surrounding Birmingham is cold air drainage during the winter months and often results in low minimum temperatures across the area.

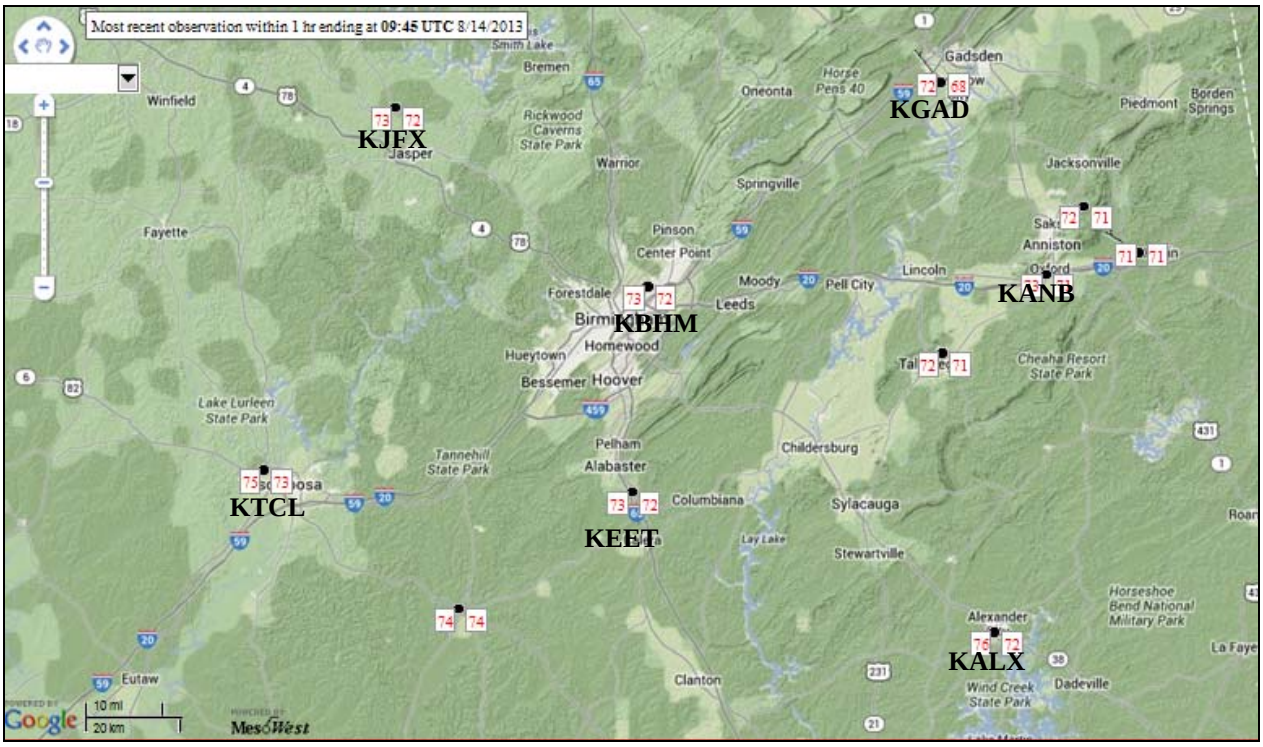

Figure 6 - Topographical map surrounding the Birmingham area with weather reporting locations.

4.0 Upper Air Data

The NWS Birmingham upper air sounding or rawinsonde observation (RAOB), site number 72230, launched at approximately 0700 CDT (1200Z) on August 14, 2013 plotted on a standard Skew-T log P diagram[8] utilizing RAOB[9] software is included as figure 7 from the surface to 500-hPa or 18,000 feet.

[8] 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.

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

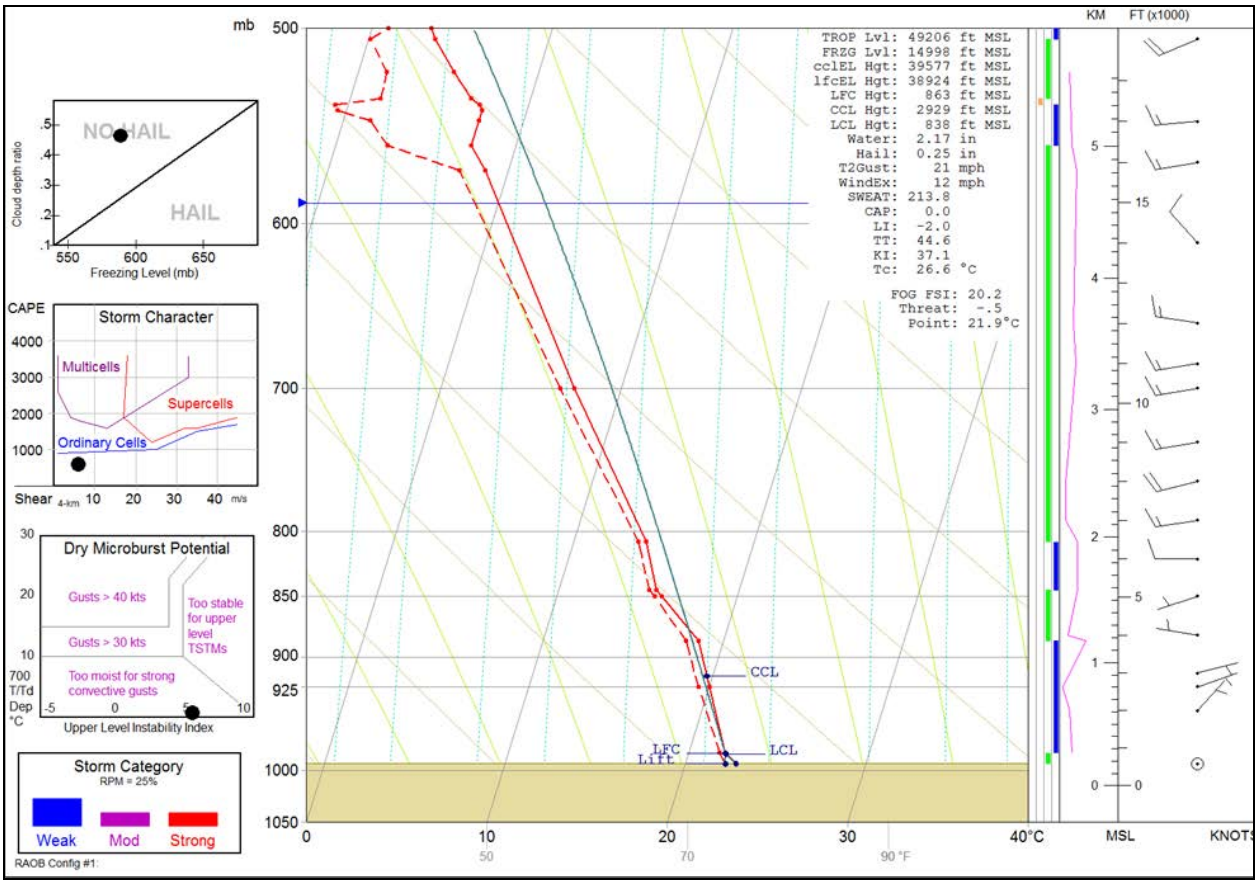

Figure 7 - Birmingham 0600 CDT sounding

The sounding depicted a moist low-level environment with the relative humidity greater than 90 percent from the surface through 15,800 feet msl. The lifted condensation level (LCL) was identified at 985-hPa or 254 feet agl (838 feet msl), the level of free convection (LFC) at 984-hPa or 279 feet agl (863 feet msl), and a convective condensation level (CCL) at 916-hPa or 2,345 feet agl. The equilibrium level (EL) or expected top of convective clouds was at 39,000 feet with the tropopause identified at approximately 49,000 feet. The freezing level was identified at approximately 14,414 feet. The precipitable water content was 2.17 inches. The stability parameters indicated a Lifted Index (LI) of -2.0, and a K-Index of 37.1, which indicated a chance of ordinary air mass type thunderstorms.

The Fog Stability Index (FSI)[10] of 20.2 and the Fog Threat Index of -0.5 were developed for the United States Air Force Weather Agency for use in Germany for radiation type fog forecasting and are used widely by numerous European weather agencies, both indicated a high probability of radiation type fog formation with a fog point of 21.9° C.

The wind profile indicated calm surface wind, with winds from the northeast to east between 2,000 and 3,000 feet, abruptly shifting to the west at 4,000 feet and slowly increasing in speed with altitude. The mean 0 to 6 kilometer wind or 18,000 feet was from 264° at 12 knots. The

[10] Freeman, L.E., Perkines, J.S. Meteorological Techniques, AFWA/TN-98/002, 242 p, online available at http://www.comptus.com/PDF/AFWA_TN_98-002.pdf

level of maximum wind was identified at 44,000 feet with the wind from 305° at 49 knots. The winds, temperature, and dew point values through 18,000 feet are included in a table in figure 8.

Height (ft-MSL)	Pres (mb)	T (C)	Td (C)	RH (%)	DD/FF (deg/kts)	CAT (AF)	LLWS	Icing - Type (S-F clouds)
584	994	22.8	22.2	96	0/0			
874	984	22.0	21.7	98				
2000	946				40/6			
2639	925	20.0	19.4	96	70/7			
3000	913				75/7			
3861	886	18.6	17.9	96				
4000	882				280/3			
5028	850	15.8	15.4	97	250/5			
5193	845	15.4	15.0	97				
6000	821				270/11			
6441	808	14.0	13.6	97				
7000	792				260/17			
8000	763				255/18			
9000	736				260/17			
10379	700	7.4	6.6	95	260/17			
11000	684				260/17			
12000	659				280/15			
14000	611				320/11			
15809	571	-1.3	-2.7	90				LGT Clear
16000	567				260/13			
16411	558	-2.5	-7.1	71				TRC Clear
17026	545	-2.5	-8.5	63	265/17			
17266	540	-2.5	-10.5	54				
17411	537	-2.7	-10.7	54				
17557	534	-3.3	-8.3	68				TRC Clear
18196	521	-4.7	-8.4	75				TRC Clear

Figure 8 - Sounding values through 18,000 feet

5.0 Aircraft Sounding

A search of Aircraft Meteorological Data Reports (AMDAR) for Birmingham immediately surrounding the period provided an ascent report at 0741 CDT departing to the west. Figure 9 is the AMDAR sounding plot on a Skew-T log P diagram for aircraft #10369, which depicted a defined temperature inversion between 1,500 and 2,500 feet, that was not as well defined in the KBHM sounding. The AMDAR equipped aircraft did not have a moisture sensor and thus could not provide more specific cloud information. The winds were less than 10 knots through 15,000 feet and were 5 knots or less below 2,000 feet agl. Figure 10 is the table of the observed parameters for the aircraft #10369 sounding.

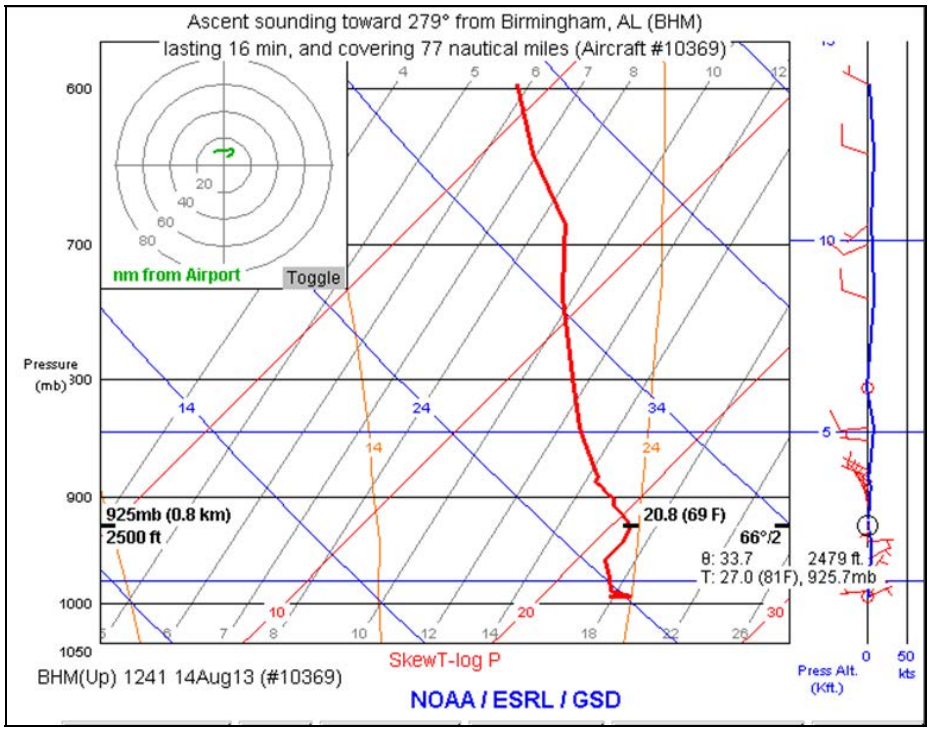

Figure 9 - Aircraft #10369 ascent sounding at 0741 CDT

P_alt (ft)	mb	t/td (°C)	w_dir/w_spd (kts)	Time (UTC)	Bng/Rng (nm)
560	993	22.8/-----	301°/001	1241	33°/006
570	993	23.1/-----	37°/005	1241	33°/006
570	993	23.6/-----	69°/003	1241	33°/006
730	987	22.6/-----	261°/003	1241	34°/007
1110	973	22.0/-----	39°/003	1241	34°/007
1580	957	21.1/-----	62°/007	1241	37°/008
2080	939	21.1/-----	90°/007	1241	37°/008
2500	925	20.8/-----	66°/002		
2500	925	20.8/-----	66°/002	1241	37°/008
2810	915	20.0/-----	177°/003	1241	37°/008
3050	906	19.3/-----	351°/004	1241	40°/009
3230	900	19.0/-----	338°/005	1242	40°/009
3380	895	18.5/-----	330°/005	1242	38°/009
3530	890	18.1/-----	322°/006	1242	40°/009
3680	886	17.6/-----	311°/005	1242	42°/010
3840	880	17.5/-----	290°/003	1242	40°/010
4000	875	17.1/-----	297°/004	1242	42°/011
4780	850	15.5/-----	273°/007		
5120	839	14.8/-----	263°/009	1243	38°/013
6170	807	13.0/-----	201°/001	1243	28°/013
8490	739	9.0/-----	288°/009	1244	17°/011
9880	700	6.9/-----	245°/008		
10390	686	6.1/-----	229°/007	1244	1°/010
12190	640	2.0/-----	289°/009	1245	341°/010
13920	597	-1.4/-----	296°/005	1246	325°/011
15520	560	-2.9/-----	264°/007	1246	313°/013
17100	525	-5.4/-----	249°/014	1247	302°/016
18287	500	-6.8/-----	251°/014		

Figure 10 - Ascent sounding parameters

6.0 Satellite Data

The Geostationary Operational Environmental Satellite number 13 (GOES-13) data was obtained from an archive at the Space Science Engineering Center (SSEC) at the University of Wisconsin-Madison (UW) in Madison, Wisconsin, and processed using the Safety Board's Man-computer Interactive Data Access System (McIDAS) software. The infrared long wave imagery (band 4) at a wavelength of 10.7 microns (μm) provided standard satellite image with radiative cloud top temperatures with a resolution of 4 km.

The GOES-13 infrared image for 0445 CDT at 6X magnification is included as figure 11 with a standard MB temperature enhancement curve applied to highlight the higher and colder clouds associated with cirrus and convective clouds. The image depicted an overcast layer of low to mid-level stratiform clouds over the Birmingham area with a defined area of enhanced clouds to the west at 20 and 50 miles respectively associated with cumulus congestus to cumulonimbus clouds immediately north of Tuscaloosa (KTCL). The radiative cloud top temperature over the accident site was 267.2° Kelvin or -5.96° C, which corresponded to cloud tops near 20,000 feet.

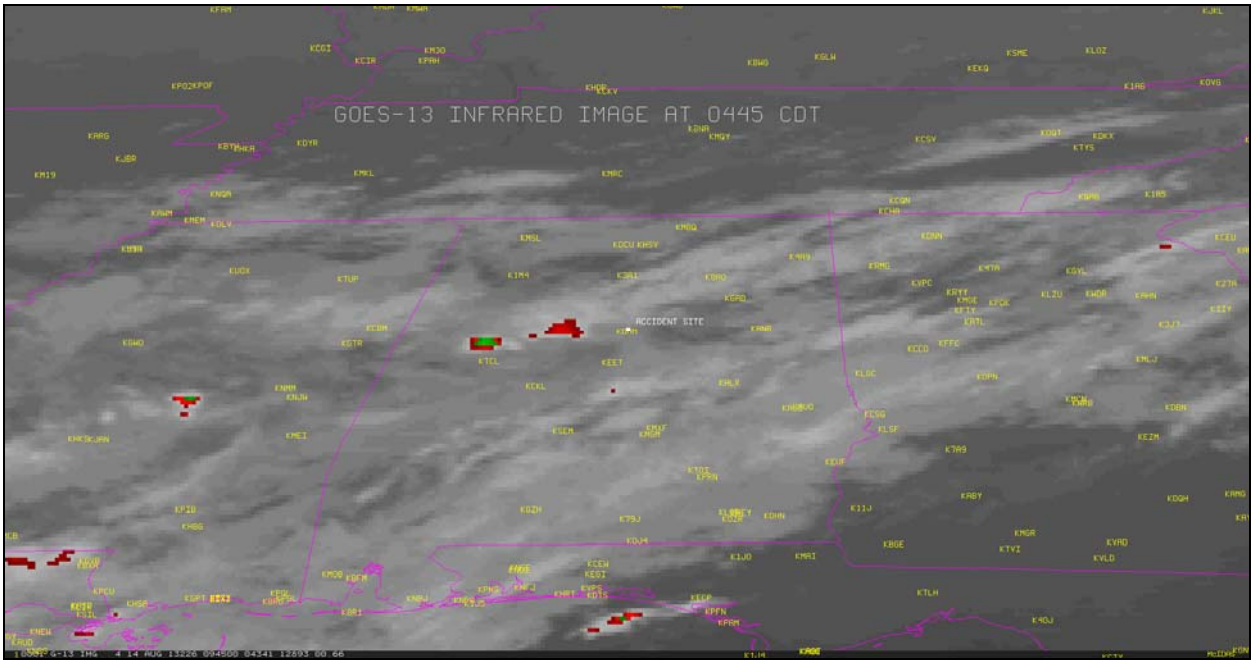

Figure 11 - GOES-13 infrared image at 0445 CDT

7.0 Weather Radar Information

The NWS Birmingham (KBMX) Weather Surveillance Radar-1988, Doppler (WSR-88D) was located approximately 24 miles south of the airport. The level II archive data was obtained from the National Climatic Data Center (NCDC) utilizing the Hierarchical Data Storage System (HDSS) and displayed using the NWS NEXRAD Interactive Viewer and Data Exporter software.

The WSR-88D is an S-band 10 centimeter wavelength radar with a power output of 750,000 watts, with a 28-foot parabolic antenna concentrating the energy into a 0.95° beam width. The radar produces three basic types of products reflectivity, radial velocity, and spectral width.

7.1 Volume Scan Strategy

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

The WSR-88D operates in several different scanning modes, identified as Mode A for precipitation and Mode B for the clear air mode. Mode A is the precipitation scan and has multiple scanning strategies depending on the expected conditions. During the period of the accident the radar was being operated in the non-severe convective mode where the radar makes 9 elevation scans from 0.50° to 19.5° every five minutes. This particular scanning strategy is documented as volume coverage pattern 221 (VCP-221). This mode is typically used by the NWS during periods of widespread precipitation with embedded convection, and allows for improved low-level vertical resolution of the storms. Figure 12 depicts the different elevation angles in this VCP, and the approximate height and width of the radar beam with distance from the radar site.

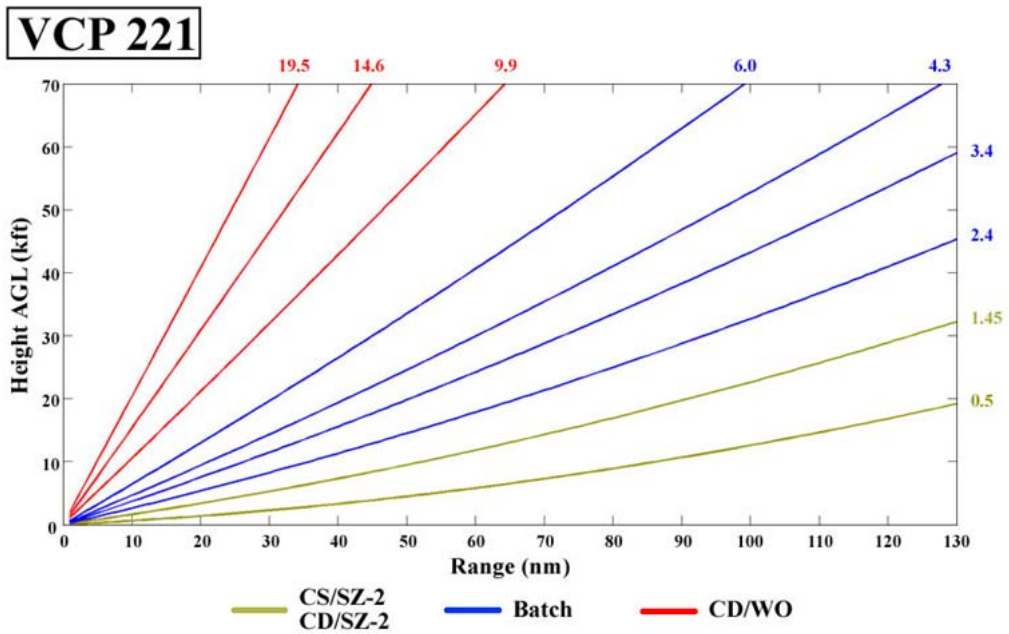

Figure 12 - WSR-88D VCP-221 scanning strategy

7.2 Beam Height Calculation

Assuming standard refraction[11] of the 0.95° radar beam of the KBMX WSR-88D with an antenna height of 645 feet and a distance of 24 miles and an azimuth of 3.4° from the radar, the following table shows the approximate beam height and width information of the radar display over the site of the accident. The heights have been rounded to the nearest 10 feet.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP	BEAM WIDTH
0.5°	2,300 feet	1,090 feet	3,510 feet	2,420 feet
1.4°	4,590 feet	3,380 feet	5,800 feet	2,420 feet
2.4°	7,130 feet	5,920 feet	8,340 feet	2,420 feet
3.4°	9,670 feet	8,460 feet	10,880 feet	2,420 feet

Based on the radar height calculations, the 0.5° elevation scan depicts the conditions encompassing the altitude between 1,090 feet and 3,510 feet over the accident site.

7.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors[12] it is a function of the drop size distribution, number of particles per unit volume, physical state (ice or water), shape, and aspect. Reflectivity is normally displayed in decibels (dBZ[13]), 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.

[11] Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

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

[13] dBZ - 10 log Ze

NWS VIP/DBZ CONVERSION TABLE

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

Air traffic control (ATC) weather display systems also use radar weather processors with the ability to determine precipitation intensity, with controllers instructed to describe the intensity to pilots based on the following scale:

(a) "Light" (< 30 dBZ, NWS VIP level 1)
(b) "Moderate" (30 to 40 dBZ, NWS VIP level 2)
(c) "Heavy" (> 40 to 50 dBZ, NWS VIP level 3 and 4)
(d) "Extreme" (> 50 dBZ, NWS VIP level 5 and 6)

7.4 Base Reflectivity

The KBMX WSR-88D base reflectivity images for the 0.5° elevation scans for 0445 and 0450 CDT are included below as figures 13 and 14 respectively, with the flight track of UPS 1354 overlaid. The maximum reflectivity within 120 miles of the radar was 53 dBZ located approximately 50 miles west of KBHM in the vicinity of Tuscaloosa (KTCL). A small band of echoes of 25 dBZ extended along the flight track as the aircraft descended through 9,600 feet at 0442 CDT, approximately 18 miles north of the airport. The light reflectivity echoes below 20 dBZ surrounding the radar site in a circular pattern in the 0.5° elevation scan, were determined to be non-meteorological echoes associated with the radar beam being ducted towards the ground due to the low level temperature inversion, and referred to as ground clutter.

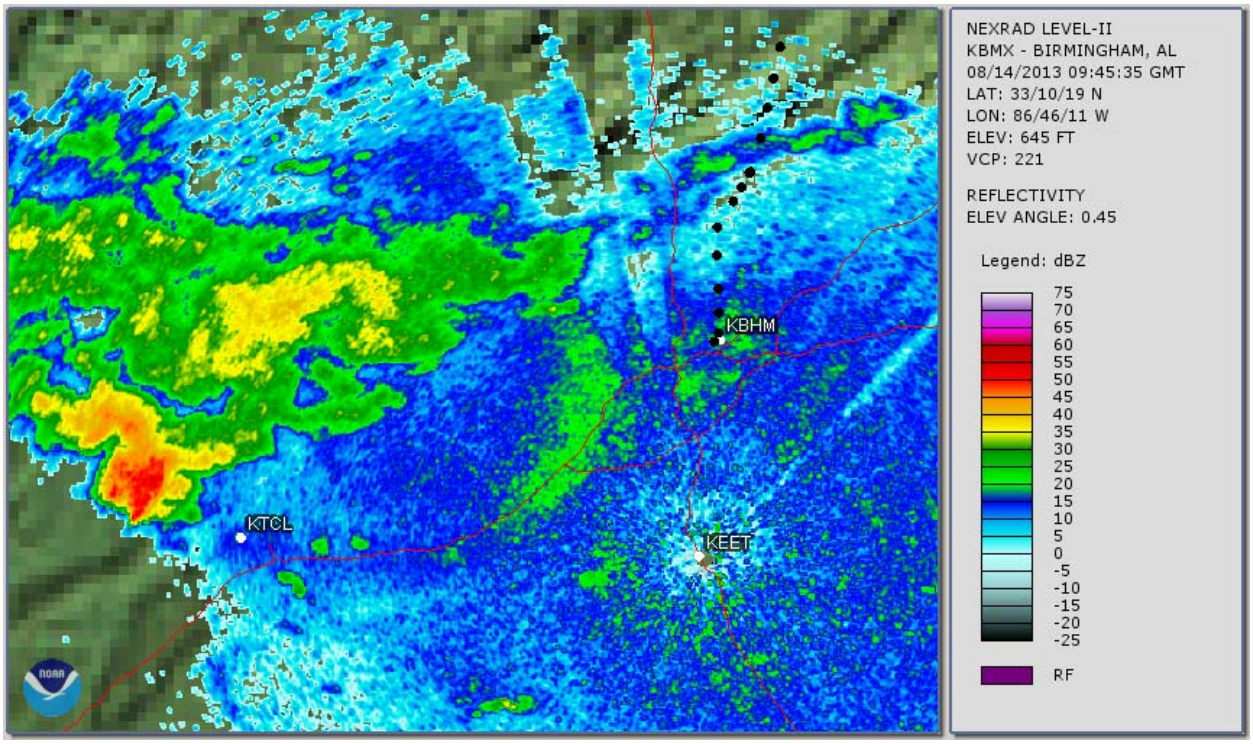

Figure 13 - KBMX WSR-88D 0.5° base reflectivity image at 0445 CDT

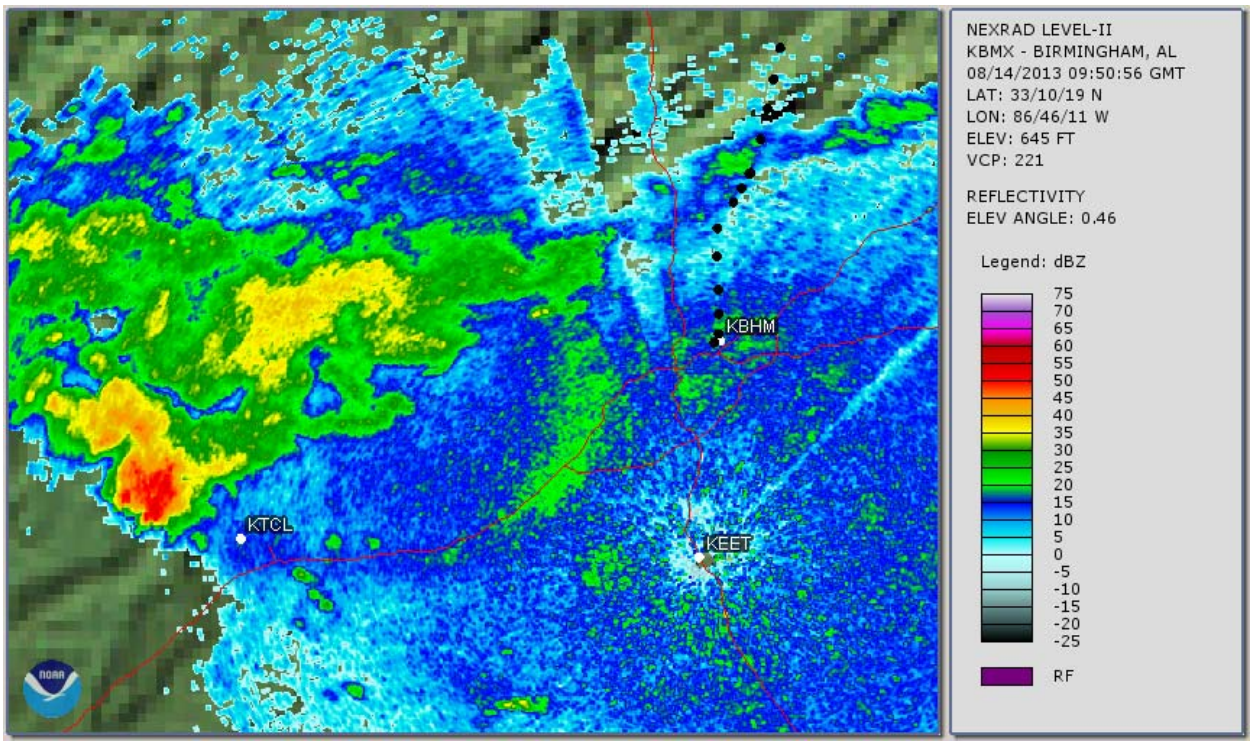

Figure 14 - KBMX WSR-88D 0.5° base reflectivity image at 0450 CDT

Figure 15 is the KBMX WSR-88D base reflectivity elevation scans for 1.4°, 2.4°, 3.4°, and 4.3°. The higher scans continued to depict a defined ground clutter pattern immediately surrounding the radar site, but also depicted an area of very light reflectivity echoes in the range of 5 to 15 dBZ immediately west of the flight track and the accident site. These echoes are consistent with low stratiform clouds of a few thousand feet thick and potential drizzle.

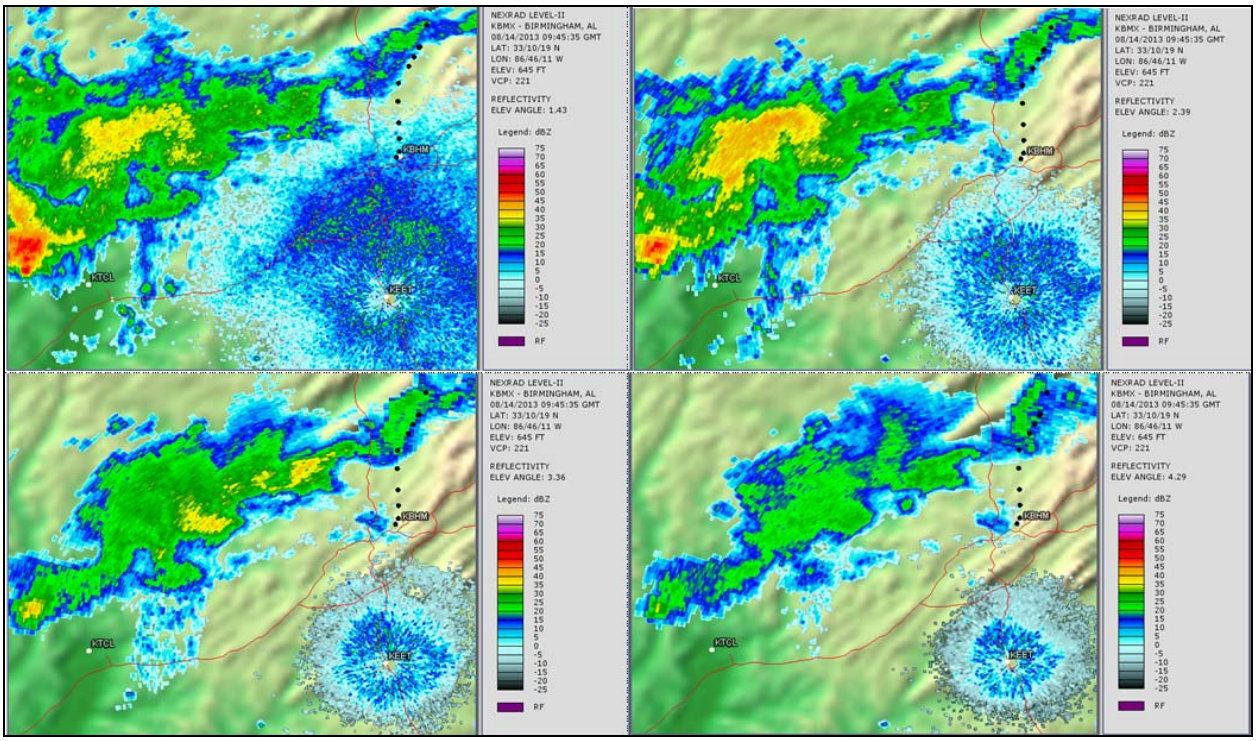

Figure 15- KBMX base reflectivity elevation scans for 1.4°, 2.4°, 3.4°, and 4.3°

7.5 GR2Analysis

Figure 16 is the KBMX WSR-88D 0.5° base reflectivity (left side with star over accident site) and the dual polarization correlation coefficient (CC) product (right side) from GR2Analysis software[14], which provided additional information about the diversity of the hydrometeors in the radar sample at 0445 CDT. The image depicts that the echoes immediately surrounding the radar site were consistent with non-meteorological echoes and the radars hydrometeor classification algorithm (HCA) indicated the echoes within 40 miles were associated with ground clutter or anomalous propagation on the 0.5° elevation scan.

[14] GR2Analysis is an advanced WSR-88D radar analysis program created by Gibson Ridge Software, LLC.

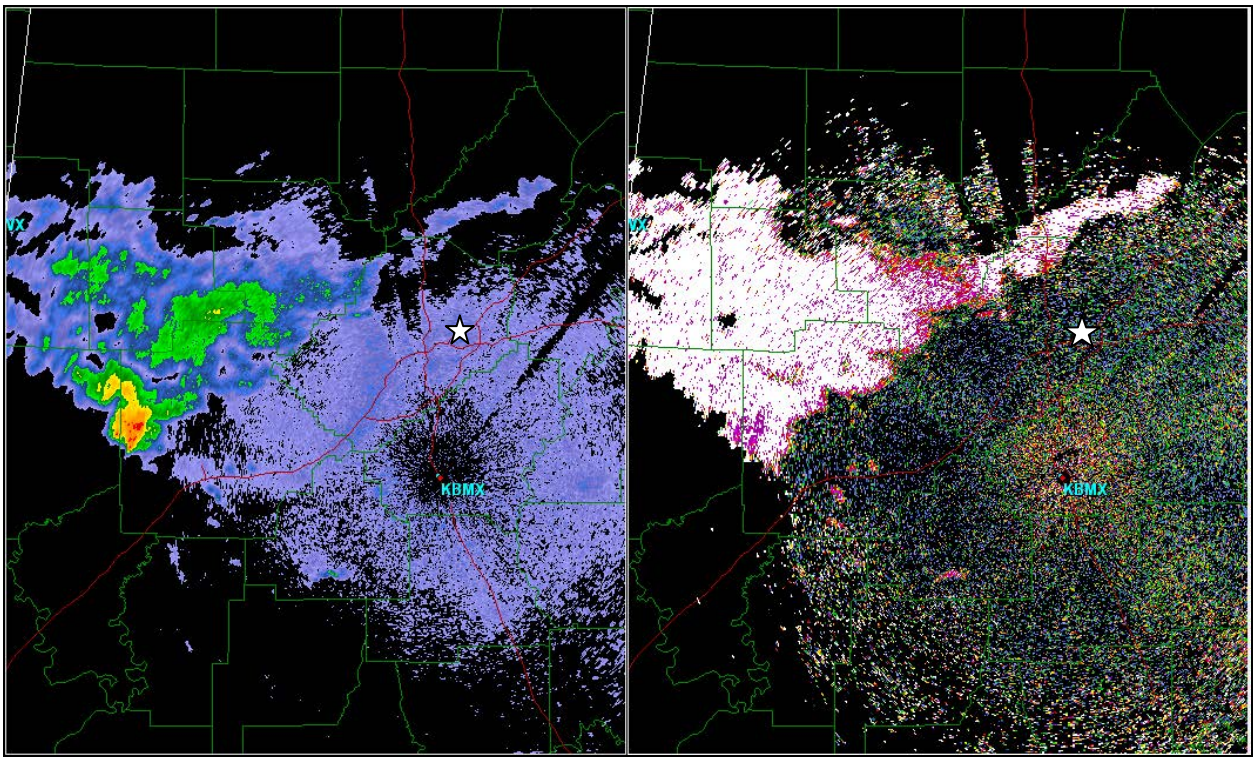

Figure 16 - GR2Analysis of the base reflectivity and correlation coefficient images for 0445 CDT

8.0 Pilot Reports

The following pilot reports (PIREPs) were recorded over Alabama surrounding the period between midnight and 0900 CDT on August 14, 2013. The reports are as follows:

Birmingham routine pilot report (BHM); over – Birmingham (BHM); time – 0043 CDT; Flight level – unknown; Type aircraft – Rockwell Aero Commander (AC-50) multiengine airplane; Sky cover – overcast at 400 feet with tops at 900 feet; remarks – during descent for ILS runway 6 approach.

Birmingham routine pilot report (BHM); over – Vulcan VORTAC (VUZ); time – 0806 CDT; Flight level – 27,000 feet; Type aircraft – Canadair Regional Jet (CRJ2); Temperature – minus 29° C; Icing – light rime icing between 27,000 and 29,000 feet; remarks – entered by Memphis Center.

Anniston routine pilot report (ANB); over – 30 miles southeast of Gadsden VORTAC (GAD); time – 0834 CDT; flight level – 7,000 feet; type aircraft – Piper Cherokee (P28R) single engine airplane; temperature – 16° C; remarks – scattered clouds layer below with overcast clouds between 12,000 and 14,000 feet.

Anniston routine pilot report (ANB); over – 30 miles south of Columbus VORTAC (CSG); time – 0850 CDT; flight level – 6,500 feet; type aircraft – Lancair (LNC2) high performance single engine airplane; weather – flight visibility 20 miles with broken to overcast cloud layer below.

Birmingham routine pilot report (BHM); over – 30 miles north-northeast of Hamilton VORTAC (HAB); time – 0922 CDT; Flight level – 19,000 feet; Type aircraft – Beechcraft King Air (BE20) multiengine turboprop; temperature – minus 15° C; Icing – light rime icing between 19,000 and 21,000 feet; remarks – entered by Memphis Center.

Pilots operating aircraft into Birmingham surrounding the period were also asked to provide statements regarding the conditions they encountered during their flights on the morning of August 14, 2013. The following are summaries of those pilots' comments[15] regarding the weather conditions:

A pilot for Mountain Air Cargo flight 8375, operating an ATR into Birmingham from Memphis flew the ILS approach to runway 6 and landed at approximately 0334 CDT. He recalled responding to a request from the tower for a pilot report and reported the cloud base at the MCDEN final approach fix (FAF) at 1,700 feet agl (2,300 feet msl). He stated that the weather was such that a visual approach could not be considered. He departed approximately 45 minutes later from runway 18 and noted that the weather conditions had improved significantly.

The Air Traffic Controller handling the UPS 1354 in an interview stated that another previous flight, a LabCorp Piper Navajo (PA31/G) multiengine airplane landed on runway 18 at Birmingham at approximately 0412 CDT, and the controller stated he was clearly able to identify him on the approach from approximately 2,300 feet msl to touchdown. The controller did not report any lower clouds or visibility restrictions at the time. The same LabCorp pilot was interviewed but could not confirm what altitude he broke out of the clouds and entered visual meteorological conditions (VMC), and indicated that he encountered nothing out of the ordinary for the approach.

The Captain of FedEx flight 1488, a Boeing 757 that landed immediately after the accident at 0508 CDT also provided a statement. He stated that his flight, which landed after the accident had encountered a solid layer of clouds on descent from 20,000 feet and did not break out of the clouds until 300 feet agl for the ILS approach to runway 06. That pilot also lived in the Birmingham area and had been flying in the area for the last 35 years in all makes and models of aircraft and was very familiar with the local area.

9.0 Terminal Aerodrome Forecast

The NWS Terminal Aerodrome Forecast (TAF) for KBHM was issued by the NWS Weather Forecast Office in Birmingham at 0033 CDT on August 14, 2013 and valid for a 24-hour period. The forecast for KBHM from 0100 through 0800 CDT expected a variable wind at 3 knots, visibility unrestricted at better than 6 miles, ceiling broken at 400 feet agl, with a temporary period between 0100 and 0300 CDT of scattered clouds at 500 feet, and ceiling broken at 2,500

[15] See Operations Factual Report Interview Summaries exhibit 2C and 2D, and Air Traffic Control Factual Report.

feet. MVFR conditions were forecasted after 0800 CDT through 1000 CDT, with VFR conditions after 1000 CDT through the day.

The KBHM forecast was amended at 0147, 0430, and after the accident at 0528 CDT. The amendments at 0147 CDT removed the temporary conditions and expected LIFR conditions with a ceiling broken at 400 feet at the flights estimated time of arrival (ETA). This was technically the controlling forecast at the time of the accident, and was included in the flights weather document. The amendment immediately prior to the accident at 0430 CDT reinserted a temporary improving period of clouds during the period with LIFR conditions still prevailing in the main body of the report. The forecast after the accident at 0528 CDT increased the ceiling to 1,000 feet with a temporary period of improving conditions.

The NWS TAFs issued for KBHM were as follows with the applicable periods in bold type:

TAF KBHM 140533Z 1406/1506 VRB03KT P6SM BKN004
TEMPO 1406/1408 SCT005 BKN025
FM141300 VRB04KT P6SM SCT009 BKN015
FM141500 01007KT P6SM FEW050 SCT250=

TAF AMD KBHM 140647Z 1407/1506 VRB03KT P6SM BKN004
FM141300 VRB04KT P6SM SCT009 BKN015
FM141500 01007KT P6SM FEW050 SCT250=

TAF AMD KBHM 140930Z 1410/1506 VRB03KT P6SM BKN004
TEMPO 1410/1412 SCT010 BKN050
FM141300 VRB04KT P6SM SCT009 BKN015
FM141500 01007KT P6SM FEW050 SCT250=

TAF AMD KBHM 141028Z 1410/1506 VRB03KT P6SM BKN010
TEMPO 1410/1412 SCT010 BKN030
FM141300 VRB04KT P6SM SCT009 BKN015
FM141500 01007KT P6SM FEW050 SCT250=

10.0 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 to evaluate on the basis of experience and the operational limits of the aircraft.

Severe Weather Forecast Alert (AWW) – None issued surrounding the period over Alabama.

Convective SIGMETs – None current for the route or over Alabama surrounding the period.

SIGMETs – None issued surrounding the period.

Center Weather Advisories (CWA) – None current at the time.

AIRMETs – the following advisories were applicable for Alabama:

WAUS44 KKCI 140845
DFWS WA 140845
AIRMET SIERRA UPDT 1 FOR IFR AND MTN OBSCN VALID UNTIL 141500
AIRMET IFR...TX AR LA MS AL
FROM 20SSW FSM TO 40WSW IGB TO 40WNW ATL TO 50SW PZD TO 40W CEW
TO 20NW BTR TO 20SSE EIC TO 30WNW TXK TO 20SSW FSM
CIG BLW 010/VIS BLW 3SM BR. CONDS ENDG 12-15Z.

A plot of AIRMET Sierra update 1 is included as figure 17 over the GOES-13 infrared satellite image at 0345 CDT or the time of issuance of the advisory. The AIRMET for IFR conditions[16] extended over the Birmingham area and included the accident site, and extended into Georgia immediately west of the Atlanta area.

[16] AIRMET Sierra for IFR conditions are typically not a concern for air carriers since all their flights are operated on IFR flight plans, and except for the impact on requiring instrument approaches, alternate requirements, additional fuel requirements, air traffic control delays, and the potential for below minimum conditions, the advisories are not typically disseminated to air carrier flight crews.

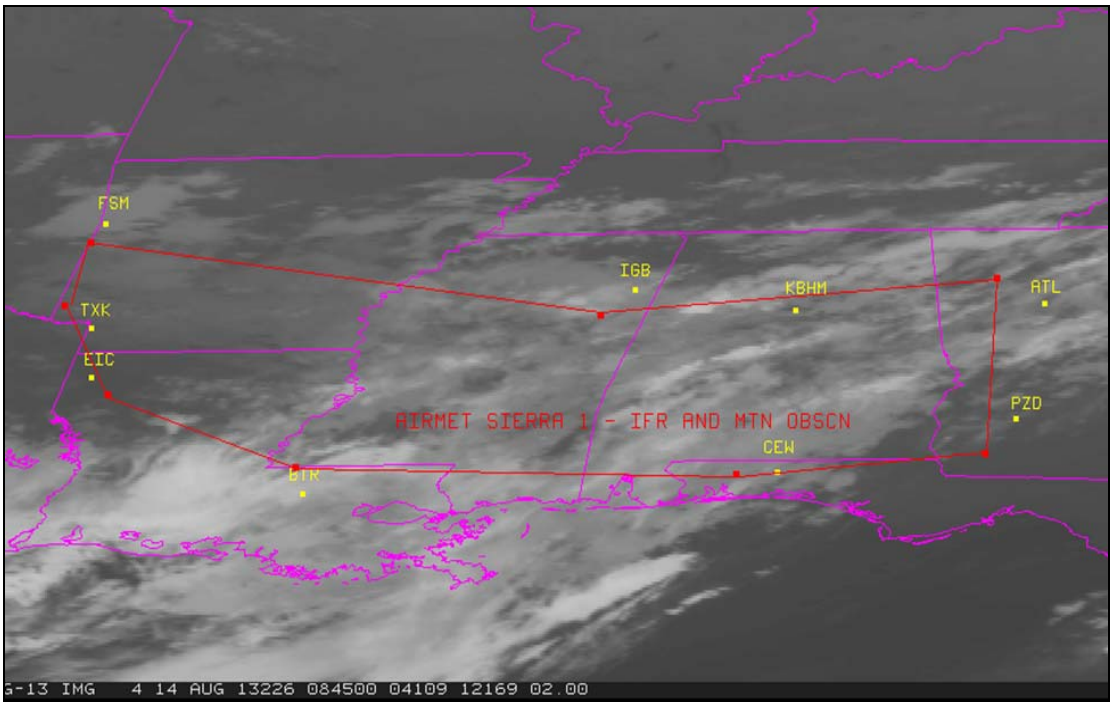

Figure 17 - AIRMET Sierra for IFR conditions over GOES-13 satellite image

11.0 Numerical Model Guidance

The NWS numerical model data issued at midnight for August 14, 2013 used by UPS Meteorology and Flight Dispatchers is included as figure 18. The statistical guidance from the eta based model output statistics (MOS) expected for 0400 CDT (0900Z) a temperature of 70° F, a dew point of 69° F, with wind from 100° at 2 knots, probability of precipitation of 30% ending at 0700 CDT, or a 12 hour probability of 44%, with the 12-hour quantitative precipitation of 0.01 to 0.09 inches. The probability of thunderstorms during the 6-hour period ending at 0700 CDT was 6%, and the conditional probability of a severe thunderstorm was 2%. The expected category for a ceiling (2) was between 200 and 400 feet agl, with the visibility greater than 5 miles with mist.

KBHM ETA MOS GUIDANCE 8/13/2013 1200 UTC

DT	/AUG	13/AUG	14							/AUG	15						/AUG	16	
HR	18	21	00	03	06	09	12	15	18	21	00	03	06	09	12	15	18	21	00	06	12
N/X						69				85					64				85		69
TMP	83	81	77	74	72	70	70	77	82	81	75	71	68	66	66	76	81	81	78	72	70
DPT	70	70	71	70	70	69	68	67	64	62	62	60	59	58	59	61	61	61	63	67	67
CLD	OV	OV	OV	OV	OV	OV	OV	BK	BK	BK	BK	BK	BK	OV	BK	BK	SC	BK	BK	OV	OV
WDR	26	26	28	24	21	10	02	05	03	03	03	04	05	06	03	04	02	03	08	12	10
WSP	09	09	08	04	03	02	03	06	08	09	06	07	04	02	02	04	06	08	06	04	04
P06			47		44		30		8		3		4		6		6		42	28	15
P12							44				9				7				43		49
Q06			1		1		0		0		0		0		0		0		1	0	0
Q12							1				0				0				1		1
T06		47/	6	18/	4	6/	2	8/	2	16/	5	6/	1	6/	2	9/	1	40/	6	12/	2
T12				49/	7			15/	3			16/	5			13/	2		41/	6	
CIG	5	5	5	5	5	2	4	7	8	8	8	8	8	8	8	8	7	8	5	2	
VIS	7	6	6	6	5	5	5	6	7	7	7	7	7	7	7	6	7	7	7	7	5
OBV	N	HZ	HZ	N	BR	BR	BR	HZ	N	N	N	N	N	N	N	HZ	N	N	N	N	BR

Figure 18- NWS Model data for August 14, 2013

12.0 Flight Dispatcher's Statements

The UPS Flight Dispatcher responsible for the flight planning, release and flight following of the flight provided a statement[17] after the accident and was interviewed by the Operations Group. The dispatcher indicated that at approximately 0500 CDT he was advised of an aircraft accident, and he made contact with the Birmingham Air Traffic Control tower at 0510 CDT. He indicated that he was advised the aircraft was 1/2 mile north of the airport on approach and made contact with the ground. He was advised that the reported cloud layers at the time of impact was scattered low clouds. He asked if any hazardous weather phenomena was in the area and was advised there were none. The tower advised him that the aircraft was set up on final approach at 8 miles out to runway 18. He was also advised that crash fire and rescue were already on location, which the tower could confirm from their location.

The UPS Dispatcher indicated that the flight was planned according to proper procedures and FAA protocol. The flight was also planned for a destination alternate airport, which was Atlanta, GA (KATL).

13.0 Preflight Weather Briefing

A copy of the dispatch release and weather document issued to UPS flight 1354 is included as attachment 1, as issued through the airlines approved Lido flight planning system[18]. The dispatch release included Atlanta International Airport (KATL) as the planned destination alternate and included additional reserve fuel. The destination weather briefing for Birmingham included the following information:

KBHM/BHM
SA 140734 00000KT 10SM BKN010 BKN016 23/22 A2996
SA 140712 00000KT 9SM SCT006 BKN016 23/22 A2997
FT 140647 1407/1506 VRB03KT P6SM BKN004
FM141300 VRB04KT P6SM SCT009 BKN015
FM141500 01007KT P6SM FEW050 SCT250
FT 140533 1406/1506 VRB03KT P6SM BKN004
TEMPO 1406/1408 SCT005 BKN025
FM141300 VRB04KT P6SM SCT009 BKN015
FM141500 01007KT P6SM FEW050 SCT250

The UPS/Lido system does not indicate whether the type of report being issued is a regular scheduled (METAR) or a special (SPECI) observation being issued due to changing weather conditions as in the two observations for KBHM above, and also eliminates the remarks section of the report. The Lido system also removed the "amended" forecast header. The system also includes the previous forecast issued for the station. The latest TAF supersedes the previous forecast, and only one forecast is current at a period in time. In reviewing this practice the UPS

[17] See Operations Group Factual Report for the Dispatcher's statement.

[18] Lido flight planning system – was developed by Lufthansa System a subsidiary of Lufthansa Airlines, and was implemented at UPS in flight dispatch on April 24, 2004.

Senior Meteorologist on the Meteorology Group indicated that pilots and dispatchers are expected to know that regular schedule observations are made near the top of the hour, and anything after the hour is likely a special observation.

The removal of the type of report was also noted in the NWS Aviation Weather Center (AWC) Aviation Digital Data Service (ADDS) web site[19], which is an official source of aviation weather information and is also used by UPS flight dispatch.

Other potential limitations in the Lido system was that there were no other local weather reporting sites[20] to the destination included in the document, with the next closest observation station over 140 miles from the destination airport. There were also no pilot reports included in the document or AIRMETs[21]. A review of the Lido system also noted that the system does not contain Center Weather Advisories (CWA)[22] or Meteorological Impact Statements (MIS) on their weather feed for dissemination.

The destination airport notices to airmen included runway 06/24 closure between 0400-0500 CDT. Several Flight Data Center (FDC) NOTAMs were also current for KBHM runway 36 and 24 approaches, but there were no current NOTAMs for runway 18.

The flight data history of the ACARS[23] contained messages received by the flight while enroute to Birmingham. The flight crew requested updated weather for KBHM at 0404 CDT and received the following information:

METAR KBHM 140853Z 00000KT 10SM BKN010 OVC075 23/22 A2997
SPECI KBHM 140848Z 33003KT 10SM OVC010 23/22 A2997
METAR KBHM 140753Z 00000KT 9SM OVC008 23/22 A2996

[19] NWS ADDS web site for METARs (http://aviationweather.gov/adds/metars/)

[20] Of the observations listed in section 2.0 of this report, the Lido system only had access to KBHM, KGAD, KTCL, and KHSV for dissemination. The other airports were available in secondary weather systems like the WSI system utilized by dispatch.

[21] AIRMETs – include forecasts of moderate clear air turbulence, strong surface winds, low-level wind shear, and moderate icing, which are considered adverse weather phenomena applicable to all aircraft. Most Part 121 air carriers omit AIRMETs from their weather documentation due to their aircraft are certified to operate in moderate icing and turbulence conditions, even though the advisories highlight areas of potentially operational significant weather conditions, and the air carrier often issues their own tailored weather advisories in lieu of the AIRMET.

[22] Center Weather Advisories (CWA's) – are issued by NWS Center Weather Service Unit (CWSU) Meteorologists assigned to the air route traffic control centers for hazardous conditions which may not meet the NWS area coverage criteria or intensity but could pose a risk of safety of flight. At present, CWSU's are staffed from 0600 to 2200 daily; however, the NTSB has issued recommendations to the FAA regarding staffing the unit during periods of expected adverse weather.

[23] ACARS – Aircraft Communications Addressing and Reporting System is a digital datalink system for transmission of information between aircraft and ground stations.

The UPS/Lido system used in the data retrieval stripped off the remarks section of the observations, which included information on a variable ceiling from 600 to 1,300 feet agl in all 3 observations. The omission of remarks data can leave out significant weather information not included in the main body of the report such as variable ceilings and visibility, thunderstorms away from the airport, and other weather conditions which are off the airport but in the vicinity. Remarks data provides clarifying information concerning what is reported in the main body. Other numerical synoptic codes such as precipitation amounts, snow accumulation, pressure tendency, and temperature readings are also issued in the remarks and are not easily readable to most users unfamiliar with the information.

14.0 UPS/Lido System and METAR Sources

The UPS Lido system uses a weather feed from the London World Area Forecast Center (WAFC) location as the primary data source, with the Washington WAFS Internet File Service (WIFS) as an additional source. Internationally distributed U.S. METAR data is issued by the NWS which, under international agreement, omits the remarks section for international navigation and flight planning purposes. The NWS sends out both the North American (as documented in section 2.0 of this report) and the international versions, one with remarks and one without the remarks. The Lido system receives multiple weather feeds for redundancy and to provide access to additional stations not always available on a single feed, and as a result gets multiple observations for the same station being received at different times. The Lido system removes the remarks section of the METAR/SPECI reports to reduce the duplicated data processing. As a result the international METAR format without the remarks section is the standard code form displayed in the Lido system.

The North American METARs deviate from the WMO code slightly with the non-compliant elements mostly based on the use of non-standard units of measurement. However, it should be noted that the international code format also includes a section of recent significant weather, which the NWS does not use in the main body of their reports but provides this information in the remark section. The recent weather is typically used to report convective activity, rain showers, and wind shear.

For the initial deployment of Lido at UPS in 2004, there was a user requirement for the North American METARs with the remarks data to be included with the weather data. Lido accomplished this by adding to the existing international weather feed, with North American METARs that included remarks data. The carryover effect of this change was that each U.S. location had duplicate METAR information retained in the Lido system database.

The Lido weather feed also feeds a UPS database that supplies the Flight Departure Papers and ACARS weather requests. In 2008, UPS implemented a change to this weather database system[24]. Prior to the change, weather requests would access the most recent METAR, which typically did not contain the remarks data (the North American METAR is issued first on the hour, with the international version approximately 10 minutes past the hour). The change was to retain in the database the METAR containing the remarks data, instead of automatically retaining the most recent METAR. This resulted in both the Flight Departure Papers and ACARS weather

[24] According to UPS Senior Meteorologist and further documented in the Operations Group Factual Report.

requests receiving METARs with the remark data. The primary purpose of this change was to meet a potential need for information about recent weather during deicing operations and the use of the Holdover tables.

Late in 2010, UPS Flight Control adopted updated dispatcher workflows regarding use of the Lido In-Flight Monitor (IFM) monitoring tool according the UPS Senior Meteorologist. This tool monitors the weather information coming into the system and provides an alerting mechanism for the dispatcher. After adopting this new workflow, it became apparent that when the alerting mechanism was fully configured, the duplicate METAR data also resulted in duplicate alerts. This affected the dispatcher workload in dealing with the alert information. UPS requested that LIDO solve the multiple IFM alerts problem. Lido's solution was to discontinue the supplemental feed of the METAR data that was part of the original requirements, which was acceptable to UPS. This change was accomplished in 2011, which discontinued the North American METARs with the remark data to flight departure papers and ACARS.

The Lido database currently contains data for 865 U.S. airports. The decision to use the international issued METAR data also results in a delay of several minutes into the Lido system versus other domestic weather sources; however, international stations typically are available earlier on the Lido system than other secondary systems.

15.0 UPS Weather Support

Section A10 of the FAA approved Operations Specifications is dedicated to aviation weather information. That section indicates that for 14 Code of Federal Regulations (CFR) Part 121 operations the certificate holder shall use certain sources of aviation weather information. In section A10(b) in accordance with 121.101, the certificate holder conducting domestic or flag operations is authorized to use the following sources of aviation weather informations:

1) For operations within the 48 contiguous United States and the District of Columbia, use weather reports and forecasts prepared by the U.S. National Weather Service or a source approved by the U.S. NWS, in accordance with 121.101(b)(1).

2) Except for provided in subpart b(3) or d of the operations specification, for operations outside the 48 contiguous United States and the District of Columbia, the administrator approves the certificate holder to use the following sources of weather reports
    a. The National Weather Service for those United States and its territories located outside the 48 contiguous States
    b. U.S. and North Atlantic Treaty Organization (NATO) military observing and forecasting services
    c. Members of the World Meteorological Organization (WMO)
    d. Active meteorological offices operated by a foreign state subscribe to the standards and practices of the International Civil Aviation Organization (ICAO) conventions
    e. A meteorological station, or automated observation weather product, authorized by an ICAO member State

3) The certificate holder is approved to use the Adverse Weather Phenomena Reporting and Forecasting System, and an Enhanced Weather Information System (EWINS).

UPS has a FAA approved Adverse Weather and Reporting System as required by 14 CFR section 121.101 and also has an approved Enhanced Weather Information System (EWINS). Under current procedures, selected flight dispatchers receive EWINS training to allow them to issue a Flight Movement Forecast (FMF). The flight dispatcher for this flight was not EWINS qualified.

UPS had a staff of 5 meteorologists who provided strategic planning guidance to the airline, issuing TAFs was not within their area of responsibility, and as a result TAFs were routinely not issued by UPS meteorologists during the time period encompassing the accident. One of the products that they produced is a Fog Assessment, which was issued at 2030 CDT, with the Final Fog Assessment issued by 2400 CDT on August 13, 2013 and is included as figure 19. This Fog Assessment is based on the risk of at least one report in the 04-10 EDT timeframe of a ceiling less than 200 feet agl and/or visibility less than 1/2 mile. Locations are assigned a risk using the threshold of 30 to 40% for moderate risk locations, and 70% for high risk locations. In addition, forecast low ceilings of 200 to 500 feet agl are also depicted. On the night of the accident, Birmingham (KBHM) was not flagged for a fog risk by either the forecaster issuing the Preliminary Fog Assessment, or by the forecaster issuing the Final Fog Assessment. The forecaster worksheet did not indicate any issue with the weather conditions for Birmingham with regards to low ceilings or visibility restrictions. A review of the observations during the period did not indicate any significant visibility restrictions due to fog during the period.

While UPS Meteorologists are not currently EWINS certified[25], the airline has a provision in their adverse weather forecast system to use a vender to issue an amending TAF or "RAMTAF" if for operational reasons they need a forecast.

[25] UPS Meteorologists are not EWINS certified, although 3 of the 5 meteorologists are certified to teach the program to the dispatchers and are considered far more qualified to understand the atmospheric conditions and issue a forecast. There is no FAA requirement for annual or initial training for airline meteorologists, who are required to possess Bachelor of Science degrees in Atmospheric Science or have extensive military forecaster training to receive their titles or qualifications to be a meteorologist. Two of the UPS meteorologists also hold a Master's Degree in Atmospheric Science.

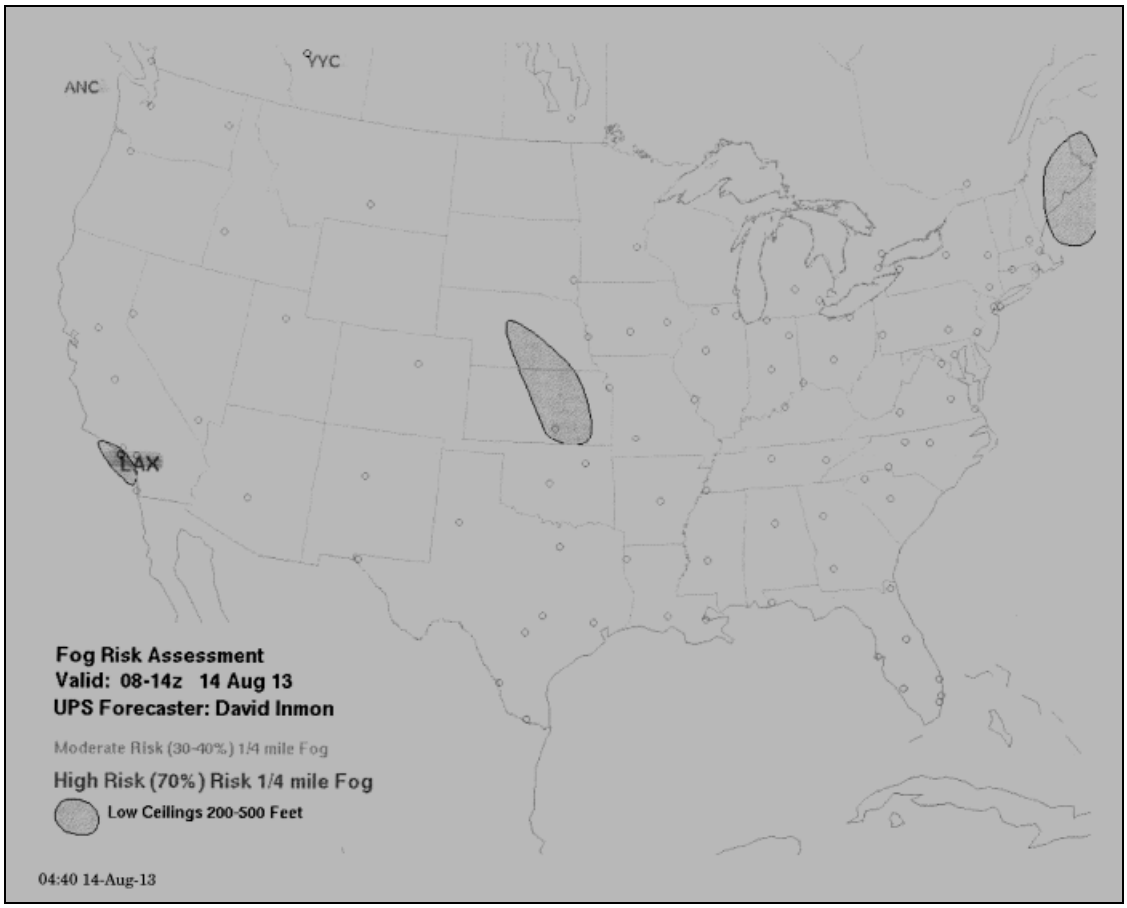

Figure 19 - UPS Fog Assessment issued for August 14, 2013

16.0 Weather Observer Interview

The FAA has a contract weather observer program at Birmingham with Vero Technical Services to provide 24-hour coverage for augmentation and backup of the ASOS. The observer on duty surrounding the time of the accident was interviewed by telephone on August 16, 2013. The observer has worked as a weather observer at Birmingham since 2004 and is certified by the NWS to take weather observations. He also held a degree in Aeronautical Management from the University of Auburn, and held a pilot license with private, commercial, flight instructor pilot ratings and has logged over 3,500 hours of flight time. He previously worked for the FAA in various positions including a flight service station specialist, and basically had over 40 years of experience in aviation in many multiple capacities.

At the time of the accident, the observer worked the midnight shift from 2300 to 0700 CDT from Monday through Saturday, and had been doing so since 2012. He stated that prior to the shift he was well rested and alert. He indicated the shift could be busy depending on the weather conditions impacting the area, but in the morning hours immediately surrounding the accident, the conditions were relatively quiet based on the weather conditions at the airport, which included a general improving weather trend. The office location was in a separate building opposite the terminal building on the north-south runway, with the main observation location on

the roof of the building, where the observer had access to 360° of the prevailing area for weather monitoring.

The airport had visibility markers, which help identify visibility values based on the terrain and local area. He was instrumental in setting up those markers with the help of Global Position System (GPS) equipment. The weather observer's office was equipped with the ASOS monitors, a computer, telephone, and television for local news and weather. No other tower monitor, wind, or other weather monitoring devices were located in the office, such as runway visual range (RVR) readouts.

The observer said he constantly monitored the ASOS system and augmented the observations based on his observations of the surrounding area, which was critical with regards to ceiling, visibility, and weather particularly with thunderstorms, since the local ASOS does not have lightning detection capability and thus cannot detect a thunderstorm other than the rain occurring with the system. The observer utilized a computer to monitor the Birmingham WSR-88D display to assist in monitoring convective activity across the region.

In the morning hour prior to the accident the observer indicated that he normally started getting ready to take the hourly observation at 45 minutes past the hour, and due to the nighttime conditions during his shift, he darkened the room prior to his observation to improve his night vision. He then headed to the roof of the complex and checked, wind, visibility markers, weather conditions, and the sky cover, the main items for the observation which required prevailing conditions and augmentation of the system. In the morning hours immediately prior to the accident he observed no moonlight, dark night conditions; however, the airport lights and surroundings provided enough light on the low clouds to confirm the sky condition and approximate cloud heights, and those agreed with the visibility as being unrestricted at 10 statute miles. He did indicate the best visibility marker they had was to the southwest, and that the higher terrain with the mountains or hills surrounding the airport are within that 10 mile range, but were unrestricted as best that he could see. He did not observe the accident, but did see a fire off the airport and trucks responding, but he was unaware of the aircraft accident at the time. Upon returning to his station he approved or issued the hourly observation in agreement with the ASOS basic observation without augmentation. It was not until he saw the local television broadcast that he became aware of the accident. He did not receive any notification from the tower to make a special aircraft mishap report or special weather observation, but indicated the hourly observation at 0453 CDT would have been the report of the conditions at the time of the accident. After notifying his supervisor he archived the weather conditions prior to and after the accident per guidance from the National Weather Service.

He indicated no equipment problems were noted and the ASOS system was last serviced on August 2nd, during the day shift. He also did not believe weather was a factor in the accident and did not detect any visibility restrictions or low clouds that would have caused instrument meteorological conditions based on the illumination he had of the sky conditions or the ceilometer readings.

The Federal Meteorological Handbook number 1 (FMH-1) details the policy and procedures regarding observations, and the observer stated he had complied with the FMH-1.

17.0 Security Camera Information

Several video images were captured on security cameras of the accident and obtained by the NTSB. Of significance on the images is the observation of the UPS flight 1354's descent through a band of clouds at low altitude or low on the horizon given the rising terrain in the area. The airplane's lights are observed prior to the airplane's impact with the terrain. The resultant fireball momentarily illuminates a band of stratus clouds over the accident site, which is north of the airport. Still frames of the video images are included as figures 20 and 21. These images show a layer of stratiform clouds immediately north of the airport and over the approach path of runway 18.

The security camera images are further documented in the NTSB Performance Chairmen's Aircraft Performance Study.

Figure 20 - Security camera video image at time of accident

Figure 21- Security camera capture of accident

18.0 Astronomical Data

The United Stated Naval Observatory website provided the following astronomical data for Birmingham, Alabama on August 14, 2013:

SUN	
Accident	0447 CDT
Beginning of civil twilight	0543 CDT
Sunrise	0609 CDT
MOON	
Moonset	2333 CDT on August 13, 2013
Moonrise	1342 CDT

At the time of the accident both the Sun and Moon were 15° degrees or more below the horizon and provided no illumination.

19.0 ATIS Weather Reference Material

The following is the standing guidance provided by FAA regarding the issuance of weather in ATIS broadcasts:

FAA Order 7110.65U – Air Traffic Control

2-9-3. CONTENT Include the following in ATIS broadcast as appropriate:

a. Airport/facility name, phonetic letter code, time of weather sequence (UTC). Weather information consisting of wind direction and velocity, visibility, obstructions to vision, present weather, sky condition, temperature, dew point, altimeter, a density altitude advisory when appropriate ***and other pertinent remarks included in the official weather observation.*** *Wind direction, velocity, and altimeter shall be reported from certified direct reading instruments. Temperature and dew point should be reported from certified direct reading sensors when available.* ***Always include weather observation remarks of lightning, cumulonimbus, and towering cumulus clouds.***

The FAA Air Traffic Controller responsible for the KBHM Automated Terminal Information System (ATIS) "Papa" report was based on the 0353 CDT METAR and did not include the pertinent remarks section of the report variable ceiling.

No general guidance for what is and is not "pertinent" could be found in FAA documents. In this case, the remarks of a variable ceiling provided additional information potentially useful for pilot's awareness of the conditions at and surrounding the airport. The weather group believes the FAA should provide clearer guidance to controllers on what are all pertinent remarks and to include any remarks regarding ceiling, visibility, recent weather, or snow increasing rapidly. Remarks of with the exception of the additive data groups, which typically consist of all numeric data such as temperature, precipitation totals, and pressure tendency should not be included in the ATIS broadcast.

A review of several major airport ATIS broadcasts at various times across the country noted remarks primarily dealing with variations in ceiling or visibility were usually omitted. The following table is a sample of encounters with variations in ceiling and visibility in the remarks section of the observations:

ATIS INCLUSION OF REMARKS

Date	ID	Time	Remarks section	METAR RMK in ATIS?		Other Info
11DEC2013	SEA	1516Z	VIS N 2	not voiced		
11DEC2013	PDX	1614Z	SFC VIS 1/2		voiced	
12DEC2013	LAX	1353Z	VIS S 2 1/2 FG BANK SE-S		voiced	
12DEC2013	MCI	2124Z	CIG 007V011	not issued		Old ATIS
19DEC2013	SLC	1405Z	SFC VIS 1		voiced	
19DEC2013	RNO	1355Z	SFC VIS 4	not voiced		
20DEC2013	DTW	1511Z	TWR VIS 2	not voiced		Rime Icing
20DEC2013	MCI	1453Z	SFC VIS 2 1/2	not voiced		
20DEC2013	DEN	1453Z	SFC VIS 5		voiced	Rime Icing
20DEC2013	ONT	1453Z	VIS S-SW 2	not voiced		
20DEC2013	DSM	2028Z	SFC VIS 5	not voiced		Rime Icing
20DEC2013	DTW	2012Z	SFC VIS 1/2	not voiced		Rime Icing
22DEC2013	ORD	1451Z	CIG 006V012	not voiced		Rime Icing
22DEC2013	ONT	1453Z	VIS S 2 1/2	not voiced		
23DEC2013	EWR	1356Z	SFC VIS 3	not voiced		
23DEC2013	JFK	1351Z	SFC VIS 1		voiced	
26DEC2013	DTW	1253Z	TWR VIS 2	not voiced		

26DEC2013	PDX	1306Z	SFC VIS 3/4	voiced
10JAN2014	EWR	1915Z	SFC 1 3/4 CIG 008V013	not voiced

20.0 FMH-1 Coding of METAR Remarks

The NWS Federal Meteorological Handbook number 1 (FMH-1) and FAA 7900.5C are identical in governing the process of weather observations and formatting the observation reports. FMH-1 is consistent with agreements and publications of the World Meteorological Organization (WMO), the International Civil Aviation Organization (ICAO), specifically WMO No. 306 - Manual on Codes, and ICAO Annex 3 - Meteorological Services for International Air Navigation, and civil as well as military weather services. The handbook states that the METAR is the primary observation code used in the United States to satisfy requirements for reporting surface meteorological data. METAR contains a report of wind, visibility, runway visual range, present weather, sky condition, temperature, dew point, and altimeter setting collectively referred to as "the body of the report". In addition, coded and/or plain language information which elaborates on data in the body of the report may be appended to the METAR. This significant information can be found in the section referred to as "Remarks". The contents of the remarks will vary according to the type of weather station and degree of automation.

FMH-1 section 12.7 covers the coding of the remarks section of the METAR. The handbook indicates that remarks shall be included in all METAR and SPECI reports, if appropriate. Present weather coded in the body of the report as vicinity may be further described, such as direction from the station, or distant weather observed. Movement of clouds or weather may also be coded in the remark section of the report. The following remarks (RMK) generally elaborate on parameters reported in the main body of the report:

- Volcanic eruptions
- Funnel clouds, tornadoes, or waterspouts – began/ended/location/movement
- Type of automation station (A01/A02) – precipitation discriminator
- Peak wind – gusts of 25 knots or greater and time of occurrence (PK WND)
- Wind shift or frontal passage and time of occurrence (WSHFT/FROPA)
- Tower or surface visibility when both are reported (TWR/SFC)
- Variable prevailing visibility (VIS)
- Sector visibility or visibility at second location (VIS)
- Lightning – frequency, type, and location (LTG)
- Beginning and ending of precipitation
- Beginning and ending of thunderstorms (TS)
- Thunderstorm location and movement
- Hail size (GR/GS)
- Virga
- Variable ceiling height (CIG)
- Obscurations – such as smoke (FU)
- Variable sky cover (BKN006 V OVC)
- Significant cloud types: cumulonimbus (CB), cumulonimbus mammatus (CBMAM), towering cumulus (TCU), altocumulus castellanus (ACC), standing lenticular (ACSL) or rotor clouds (ROTOR).
- Pressure rising/falling rapidly (PRESRR/PRESFR)

- Sea level pressure (SLP)
- Aircraft mishap notation (ACFT MSHP)
- Snow increasing rapidly (SNINCR) and depth on the ground
- Other significant information – first/last observation from the station

Additive data groups will follow and be reported in the following order:

- Precipitation[26] – amount of liquid precipitation
- Depth of freezing or frozen precipitation – snow depth
- Cloud types
- Duration of sunlight
- Temperature[27] and dew point in tenths of a degree C
- Pressure tendency (3-hour)
- Sensor status indicators (example TSO – lightning/thunderstorm sensor not operative)
- Maintenance indicator

Submitted by:

Donald Eick
NTSB Senior Meteorologist

[26] Precipitation amounts are reported hourly, 3- and 6-hour groups, and 24-hour total precipitation amounts.

[27] Temperature is reported hourly, 6-hour maximum and minimum values, and 24-hour maximum and minimum values