NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

May 26, 2016

Group Chairman's Factual Report

METEOROLOGY

DCA15FA085

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A. ACCIDENT

Location: Flushing, New York
Date: March 5, 2015
Time: About 1102 eastern standard time (1602 UTC[1])
Airplane: Delta Airlines flight 1086, MD88; registration N909DL

B. METEOROLOGY GROUP

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C. SUMMARY

On March 5, 2015, about 1102 eastern standard time (EST), a Boeing MD-88, N909DL, operating as Delta Airlines flight 1086, was landing on runway 13 at LaGuardia Airport, New York, New York, and exited the left side of the runway, contacted the airport perimeter fence, and came to rest with the airplane nose on an embankment next to Flushing Bay. The 129 passengers received either minor injuries or were not injured, and the 3 flight attendants and 2 flight crew were not injured. The airplane was substantially damaged. Flight 1086 was a regularly scheduled passenger flight from Hartsfield-Jackson Atlanta International Airport (ATL) operating under the provisions of 14 Code of Federal Regulations (CFR) Part 121. Instrument meteorological conditions (IMC) prevailed, and an instrument flight rules (IFR) flight plan was filed.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Senior Meteorologist was not on scene for this investigation and conducted the meteorology phase of the investigation from the Washington D.C. office, and collected data from official National Weather Service (NWS) sources including the Weather Prediction Center and the National Climatic Data Center (NCDC). All times used in this report are eastern standard time (EST) 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 both used intermittently in this report as reported by their source.

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

The accident occurred at La Guardia Airport, which lists the following coordinates at latitude 40.7772° N and longitude 73.8726° W.

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 northeast section of the NWS Surface Analysis Chart for 1000 EST (1500Z) on March 5, 2015 centered over the area is included in figure 1, depicting the conditions prior to the accident. The chart depicted a cold front off the east coast with a low pressure system at 1012-hectopascals (hPa) off Virginia and another low at 1010-hPa over western North Carolina. The frontal system had a strong thermal contrast across it with temperatures in the 70's degrees Fahrenheit (F) south of the cold frontal boundary and temperatures in the 30's immediately north of the front, with temperatures in the single digits to -17° F over northern Plains under a high pressure system at 1038-hPa over the Missouri and Iowa border. The frontal system was associated with a major winter storm and had snow and/or freezing precipitation depicted from northern Alabama, central and eastern Tennessee, eastern Kentucky, western and northern Virginia, Maryland, West Virginia, eastern Pennsylvania, Delaware, New Jersey, southeastern New York, Connecticut, into Massachusetts.

The station model for the New York area indicated wind from the north at approximately 10 knots, light snow, overcast clouds, temperature of 28° F, dew point temperature of 24° F. Moderate to heavy snow was reported to the southeast and east over New Jersey, eastern Pennsylvania, northern Maryland and Virginia.

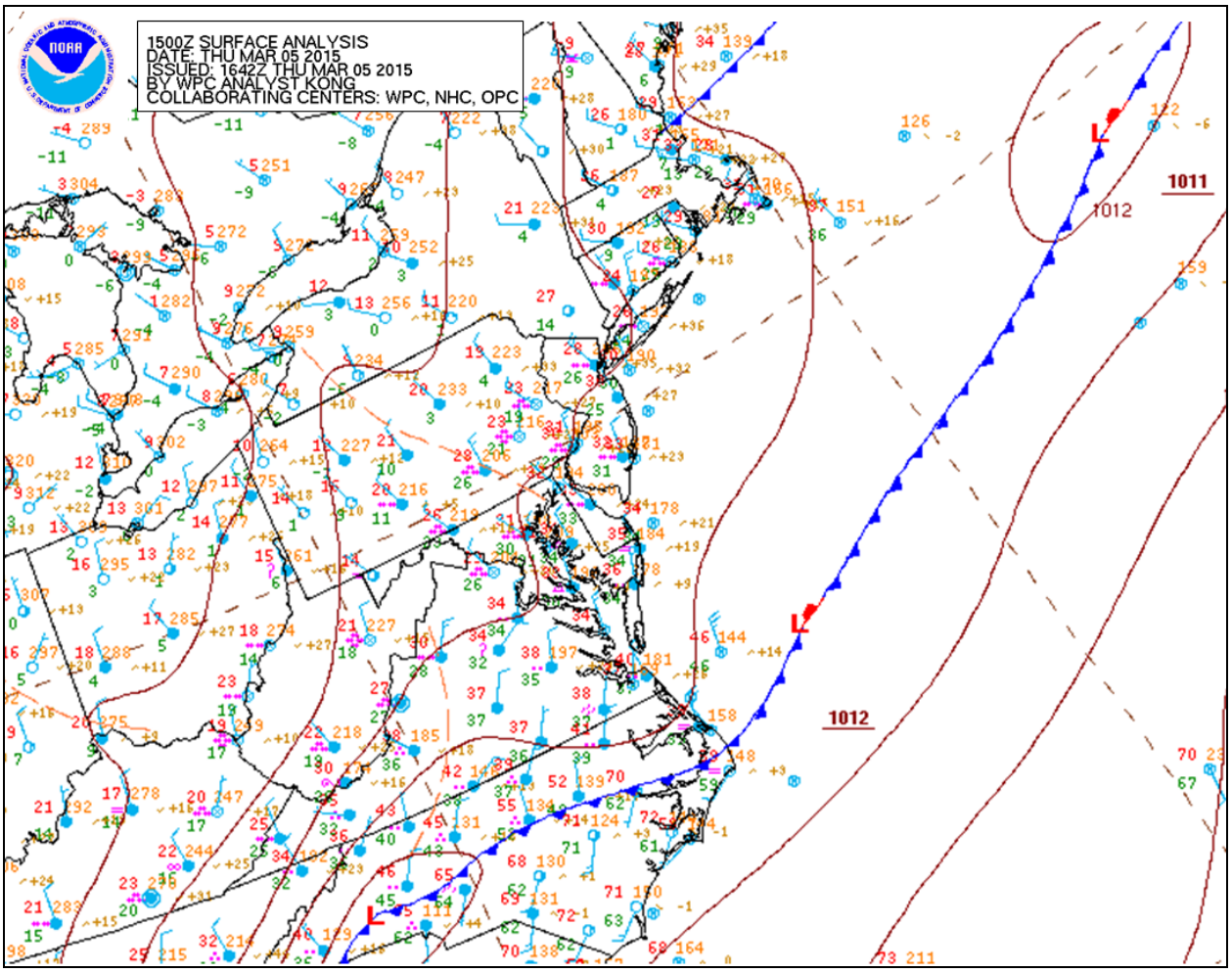

Figure 1 - NWS Surface Analysis Chart for 1000 EST

Figure 2 is the northeast section of the NWS Surface Analysis Chart for 1300 EST (1800Z) depicting the conditions after the accident. The chart continued to depict the cold front south of the New York area with multiple low pressure systems along the front over North Carolina at 1010-hPa. An extensive area of snow and freezing precipitation continued to depict north of the cold front. The station model for the New York area indicated a north-northwesterly wind at approximately 10 knots, moderate snow, overcast clouds, a temperature of 24° F, dew point temperature of 22° F.

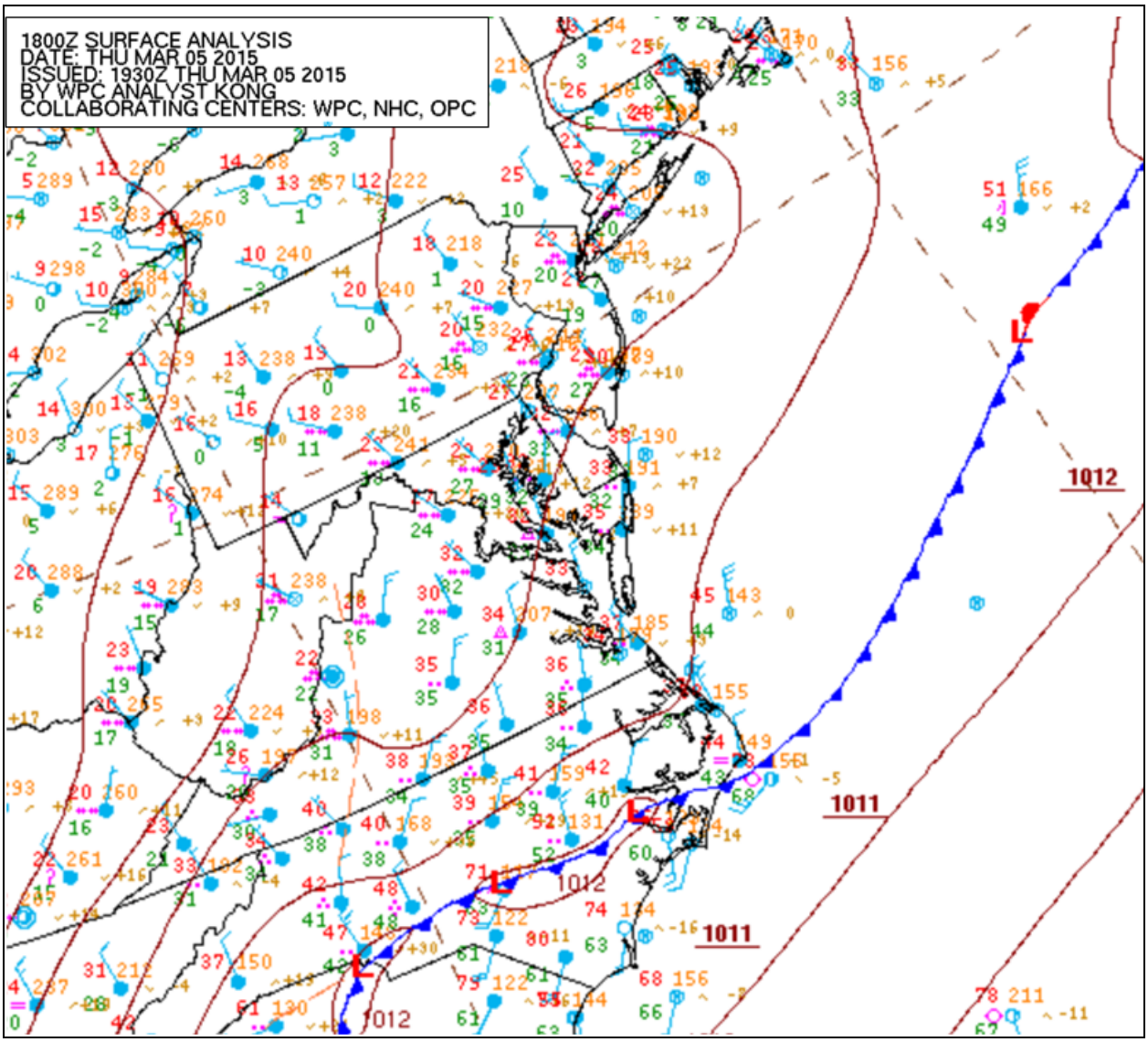

Figure 2 - NWS Surface Analysis Chart for 1300 EST

1.2 Weather Radar Mosaic

The National Center for Atmospheric Research (NCAR) - Research Application Laboratory (RAL) regional radar mosaic image for 1100 EST (1600Z) is included as figure 3. The chart depicted an extensive area of precipitation echoes extending from the region, with echoes of 15 to 25 dBZ over the New York area. Section 5 of this report will further document the closest weather radar imagery at the time of the accident.

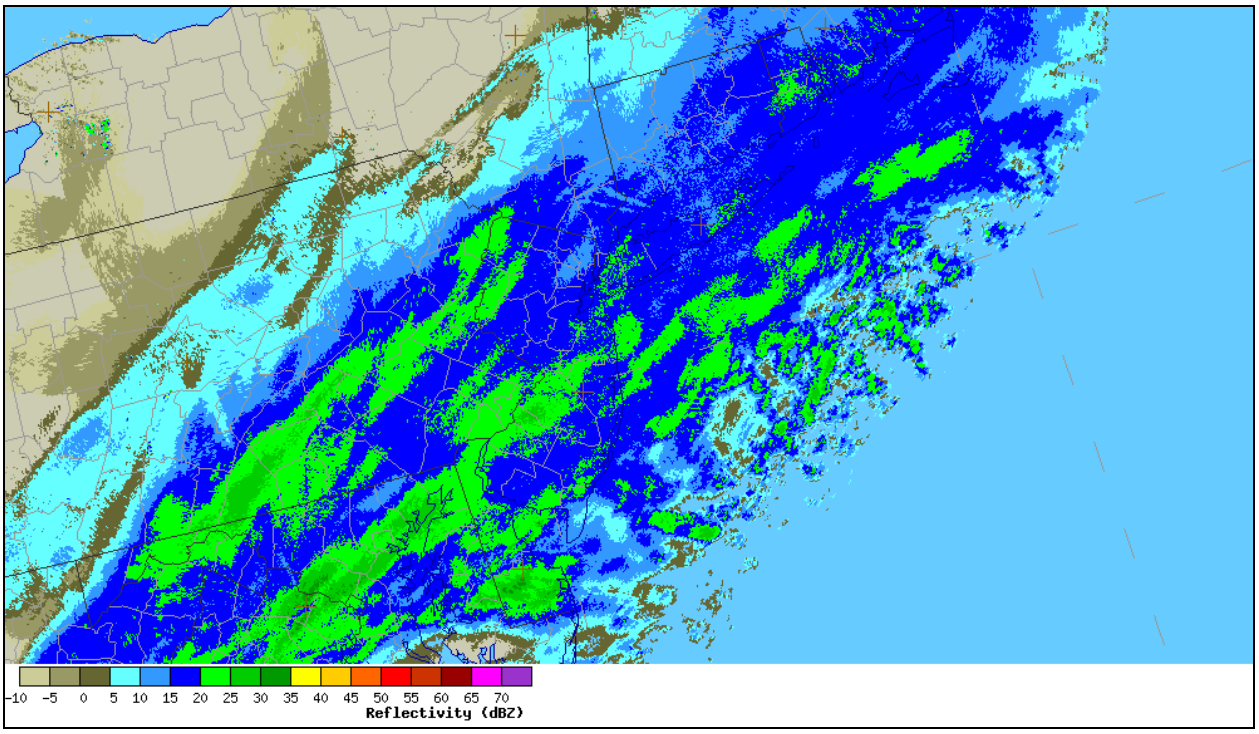

Figure 3 - NCAR regional radar mosaic for 1100 EST

1.3 Prognostic Chart

The NWS 12-hour Prognostic Chart current for 1300 EST on March 5, 2015, is included as figure 4. The chart depicted a low pressure system at 1016-hPa over South Carolina along a frontal wave, with an extensive area of precipitation along and north of the frontal boundary from the Texas coast northeastward through Massachusetts. A band of moderate snow was expected over New York, New Jersey, Maryland, and Virginia associated with a major winter snowstorm for the mid-Atlantic coast.

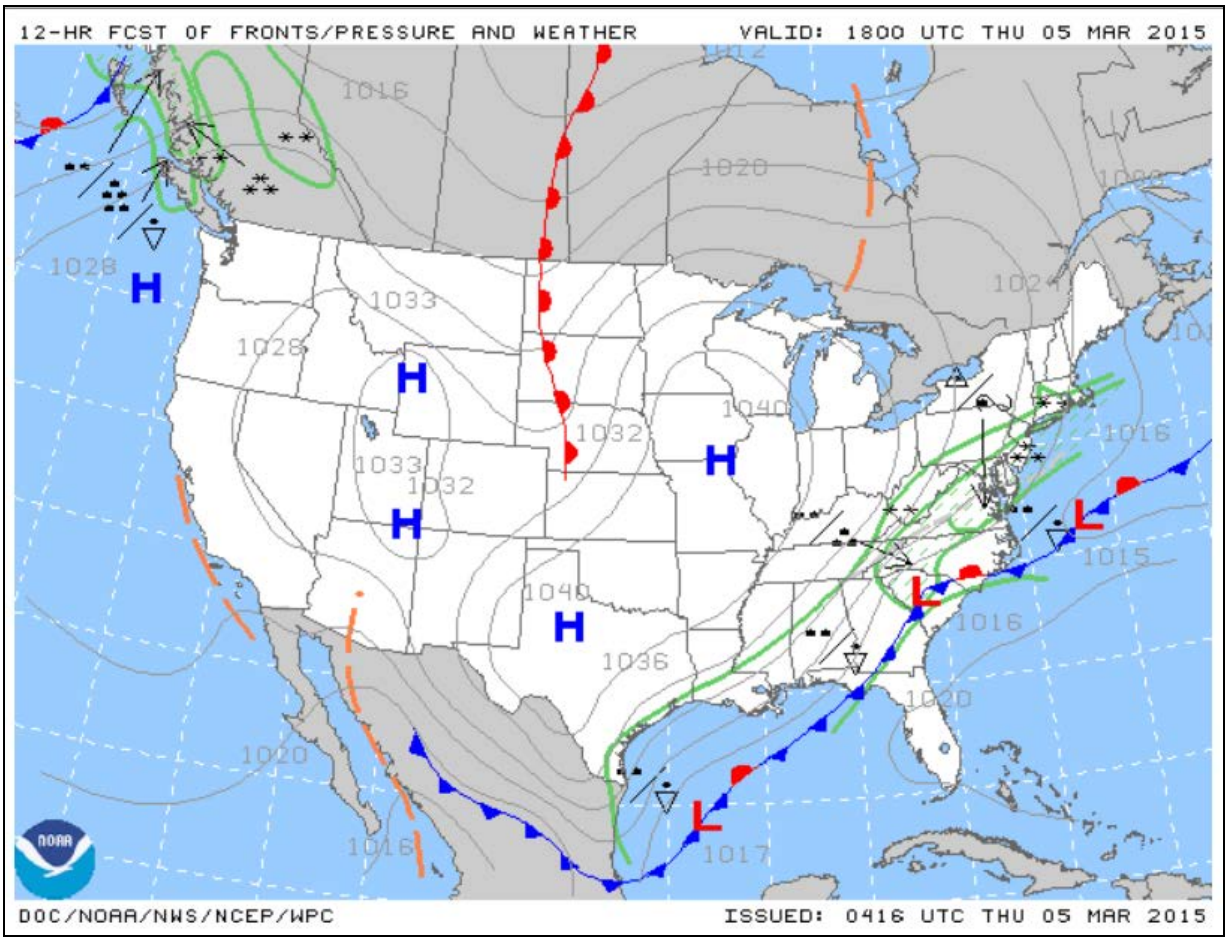

Figure 4 - NWS 12-hour Prognostic Chart valid for 1300 EST

2.0 La Guardia Surface Observations

The official NWS Meteorological Aerodrome Reports (METARs) and special reports (SPECIs) surrounding the period were documented for La Guardia Airport (KLGA), New York, NY. The airport had an Automated Surface Observation System (ASOS) and was augmented by a NWS certified weather observer. The airport lists an elevation of 21 feet and a magnetic variation of 12° West. The following weather conditions were reported immediately prior to Delta flight 1086's landing and was the basis for the Automated Terminal Information System (ATIS) Quebec report, with the exception of the wind information[2]:

La Guardia Airport weather at 1051 EST wind from 010° at 8 knots, visibility 1/4 statute mile, runway 04 visual range (RVR[3]) 2,800 variable 3,500 feet, moderate snow and freezing fog,

[2] The 1051 EST METAR observation reported the wind from 010° (020° magnetic) at 8 knots, the ATIS reported surface wind from 030° at 11 knots.

[3] Runway visual range (RVR) in the METAR report is a 10-minute average value and is reported when visibility is 1 mile or less, and/or if the runway visual range is 6,000 feet or less. The RVR included in the METAR is usually for the primary designated runway, and not all runway RVR's are included or available. The control tower provides a

vertical visibility 900 feet agl[4], temperature -3° Celsius (C), dew point -5° C, altimeter 30.12 inches of mercury (Hg). Remarks; automated observation system, sea level pressure 1019.9-hPa, hourly precipitation 0.06 inches, temperature -3.3° C, dew point -5.0° C.

The raw observations surrounding the period with the general flight categories[5] were as follows:

IFR *METAR KLGA 051151Z 33007KT 1SM R04/5500VP6000FT -SN BR BKN011 OVC016 01/M02 A3003 RMK AO2 SLP167 931004 4/003 P0002 60016 70046 T00061017 10044 20006 53014*

LIFR *SPECI KLGA 051157Z 33007KT 1/2SM R04/5000VP6000FT SN FG BKN010 OVC015 01/M02 A3003 RMK AO2 TWR VIS 3/4 P0000*

LIFR *SPECI KLGA 051218Z 33007KT 1/4SM R04/3500V4500FT SN FG BKN009 OVC014 00/M01 A3004 RMK AO2 TWR VIS 3/4 P0002*

LIFR *SPECI KLGA 051208Z 33007KT 1/2SM R04/4000V5500FT SN FG FEW006 OVC011 00/M02 A3004 RMK AO2 TWR VIS 3/4 P0001*

LIFR *METAR KLGA 051251Z COR 34006KT 1/4SM R04/3000V4000FT SN FG OVC009 00/M01 A3006 RMK AO2 TWR VIS 3/4 SLP178 SNINCR 1/4 P0005 T00001011*

LIFR *SPECI KLGA 051333Z 36011KT 1/4SM R04/3000V5000FT SN FZFG VV007 M01/M03 A3010 RMK AO2 TWR VIS 3/4 PRESRR P0004*

LIFR *SPECI KLGA 051338Z 01013KT 1/2SM R04/3000V5000FT SN FZFG SCT006 OVC010 M02/M03 A3010 RMK AO2 TWR VIS 3/4 P0005*

LIFR *METAR KLGA 051351Z 01014G18KT 1/2SM R04/5000VP6000FT SN FZFG FEW006 OVC014 M02/M03 A3011 RMK AO2 TWR VIS 3/4 SLP195 SNINCR 1/5 P0005 T10171033*

1-minute (40-second) RVR reading for each available runway and if reported is controlling for arrival and departures. The approach minimums published for KLGA runway 4 were a ceiling of 300 feet agl and visibility 1 mile, or a RVR of 5,000 feet. The runway 13 ILS minimums were a ceiling of 200 feet and visibility 1/2 mile, or RVR 2,400 feet.

[4] Cloud heights are reported above ground level (agl) in METARs.

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

- Low Instrument Flight Rules (LIFR*) – ceiling 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.

LIFR SPECI KLGA 051417Z 03012KT 1/4SM R04/2800V4000FT SN FZFG SCT006 OVC012 M02/M03 A3011 RMK AO2 TWR VIS 3/4 P0002

LIFR METAR KLGA 051451Z 03010KT 1/4SM R04/3000V4500FT SN FZFG VV012 M03/M04 A3014 RMK AO2 TWR VIS 3/4 SLP207 P0003 60013 T10281044 53040

LIFR SPECI KLGA 051524Z 04007KT 1/4SM R04/2600V2800FT SN FZFG VV009 M03/M04 A3013 RMK AO2 P0004

LIFR METAR KLGA 051551Z 01008KT 1/4SM R04/2800V3500FT SN FZFG VV009 M03/M05 A3012 RMK AO2 SLP199 P0006 T10331050

Accident 1602Z

LIFR SPECI KLGA 051622Z 01008KT 1/4SM R04/3000VP6000FT SN FZFG VV011 M03/M05 A3012 RMK AO2 SFC VIS 1/2 P0003

LIFR SPECI KLGA 051631Z 36009KT 1/4SM R04/3500VP6000FT SN FZFG VV012 M03/M05 A3012 RMK AO2 SFC VIS 1/2 P0004

LIFR SPECI KLGA 051640Z 32014KT 1/4SM R04/2400V4000FT SN FZFG SCT007 OVC012 M03/M05 A3015 RMK AO2 SFC VIS 1/2 PRESRR P0005

LIFR METAR KLGA 051651Z 32016KT 1/4SM R04/2800V4000FT SN FZFG FEW006 OVC012 M03/M05 A3015 RMK AO2 SLP210 P0005 T10331050 $

LIFR SPECI KLGA 051716Z 33013KT 1/4SM R04/2000V2400FT +SN FZFG VV009 M04/M06 A3016 RMK AO2 TWR VIS 1/4 P0002 $

LIFR METAR KLGA 051751Z COR 30015G21KT 1/4SM R04/2200V2800FT +SN FZFG VV007 M05/M07 A3017 RMK AO2 TWR VIS 1/4 SLP217 931040 4/007 933015 SNINCR 1/7 P0004 60028 T10501067 10006 21050 53010 $

LIFR SPECI KLGA 051832Z 32013KT 1/4SM R04/3000V3500FT +SN FZFG VV008 M05/M07 A3014 RMK AO2 P0003 $

LIFR KLGA 051849Z 31012KT 1/4SM R04/2200V4000FT SN FZFG VV011 M05/M07 A3014 RMK AO2 SFC VIS 1/2 SNINCR 2/9 P0004 $

LIFR KLGA 051851Z 32011KT 1/4SM R04/2200V4500FT SN FZFG VV011 M05/M07 A3014 RMK AO2 SFC VIS 1/2 SLP205 SNINCR 2/9 P0004 T10501072 $

IFR KLGA 051907Z 31008KT 1 1/4SM -SN VV015 M05/M08 A3016 RMK AO2 TWR VIS 2 P0000 $

MVFR KLGA 051937Z 30007KT 5SM R04/3000VP6000FT HZ BKN035 OVC046 M04/M09 A3017 RMK AO2 SNE37 P0000 $

VFR KLGA 051951Z 33004KT 8SM BKN035 OVC042 M04/M09 A3018 RMK AO2 SNE37 SLP218 P0000 T10391089 $

IFR KLGA 052000Z 30005KT 1 1/2SM R04/6000VP6000FT -SN BKN028 OVC038 M04/M09 A3018 RMK AO2 SNB1958 P0000 $

IFR KLGA 052013Z 31009KT 3/4SM R04/4000VP6000FT -SN BKN022 OVC038 M04/M08 A3018 RMK AO2 SNB1958 P0000 $

IFR KLGA 052051Z 32005KT 3/4SM R04/5000VP6000FT -SN VV020 M05/M08 A3019 RMK AO2 SNB1958 SLP222 P0001 60005 T10501078 53018 $

IFR KLGA 052100Z 30007KT 1/2SM R04/3000V5500FT -SN FEW009 OVC017 M05/M08 A3020 RMK AO2 SFC VIS 3/4 P0001 $

IFR KLGA 052112Z 30010KT 1/2SM R04/4000V5500FT SN FZFG VV014 M06/M08 A3018 RMK AO2 P0002$

IFR KLGA 052151Z 32012KT 1/2SM R04/4500V5500FT SN FZFG VV013 M06/M08 A3020 RMK AO2 SLP225 P0003 T10561078 $

IFR KLGA 052251Z 32012KT 1SM R04/P6000FT -SN BR VV017 M06/M08 A3024 RMK AO2PRESRR SLP239 SNINCR 1/11 P0002 T10561078 $

MVFR KLGA 052316Z 33010KT 4SM HZ SCT018 BKN036 OVC095 M06/M09 A3024 RMK AO2 SNE15 P0000 $

A review of the observations of the day indicated that snow began at 0326 EST mixed with rain, and turned to all snow at 0412 EST. Total snow on the ground from previous storms was noted at 3 inches based on an observation at 0651 EST. At 0657 EST moderate snow began with 1 inch of new snowfall reported at 0751 and again at 0851 with a total of 5 inches on the ground. Moderate snow continued through the time of the accident. The next snow depth was reported immediately after the accident at 1251 EST with another 1 inch per hour accumulation rate, and a total of 7 inches of snow on the ground. Heavy snow was reported after the accident between 1216 and 1349, with snow ending at 1815 EST with 8 inches of new snowfall, or a total of 11 inch snow depth.

2.1 NWS Regional Displays of Observations

The NWS Aviation Weather Center (AWC) website display of the observations at 1000, 1100, and 1200 EST are included as figure 5-7. The charts depicted the general flight categories by the color coded station models. The station model for La Guardia indicated wind from the north backing or shifting counterclockwise to the northwest through the period, with visibility 0.3 mile in moderate snow, sky obscured, temperature decreasing from 27° to 26° C, dew point temperature 24° to 23° C, with ceilings from 900 to 1,200 feet during the period. The images also depicted LIFR conditions prevailing at all the New York airports surrounding the period. Heavy snow was also reported immediately west at Teterboro Airport (KTEB), New Jersey, on the 1000 and 1100 EST images.

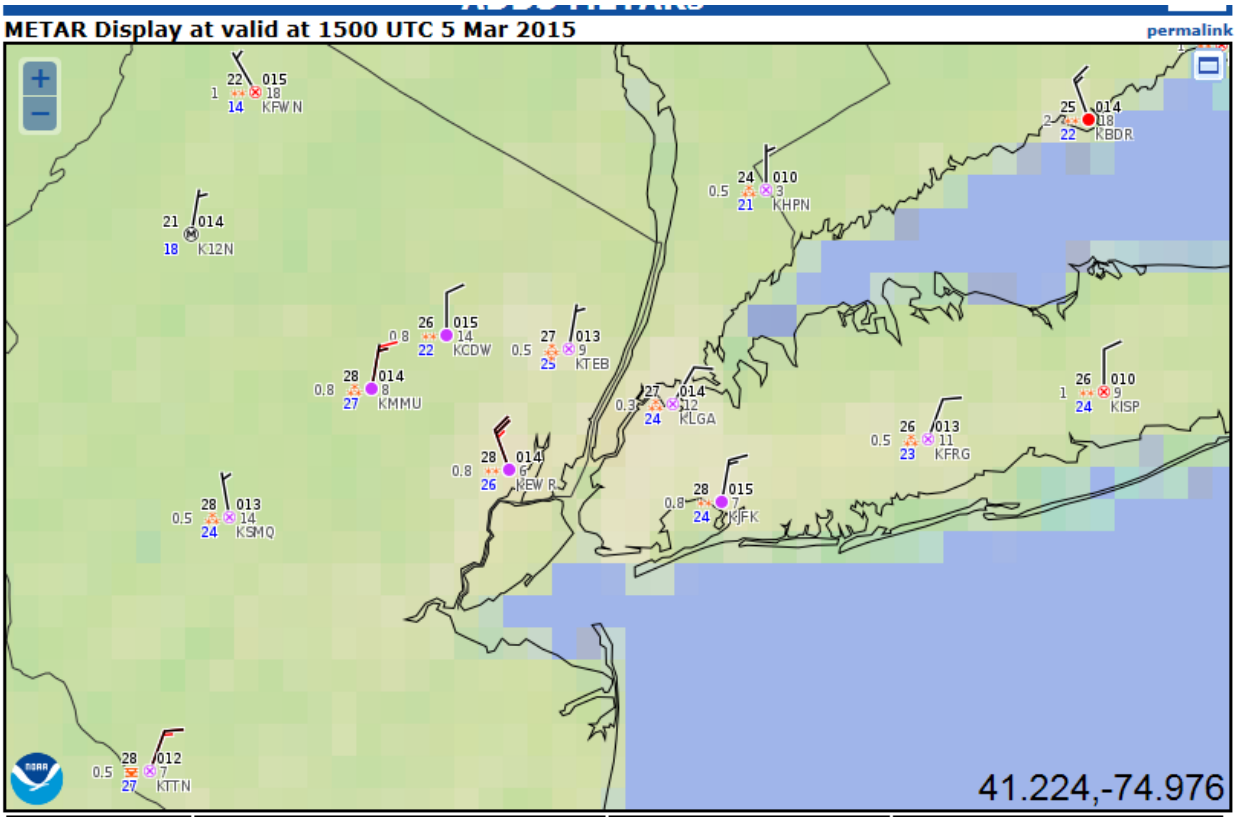

Figure 5 - NWS AWC Observations at 1000 EST

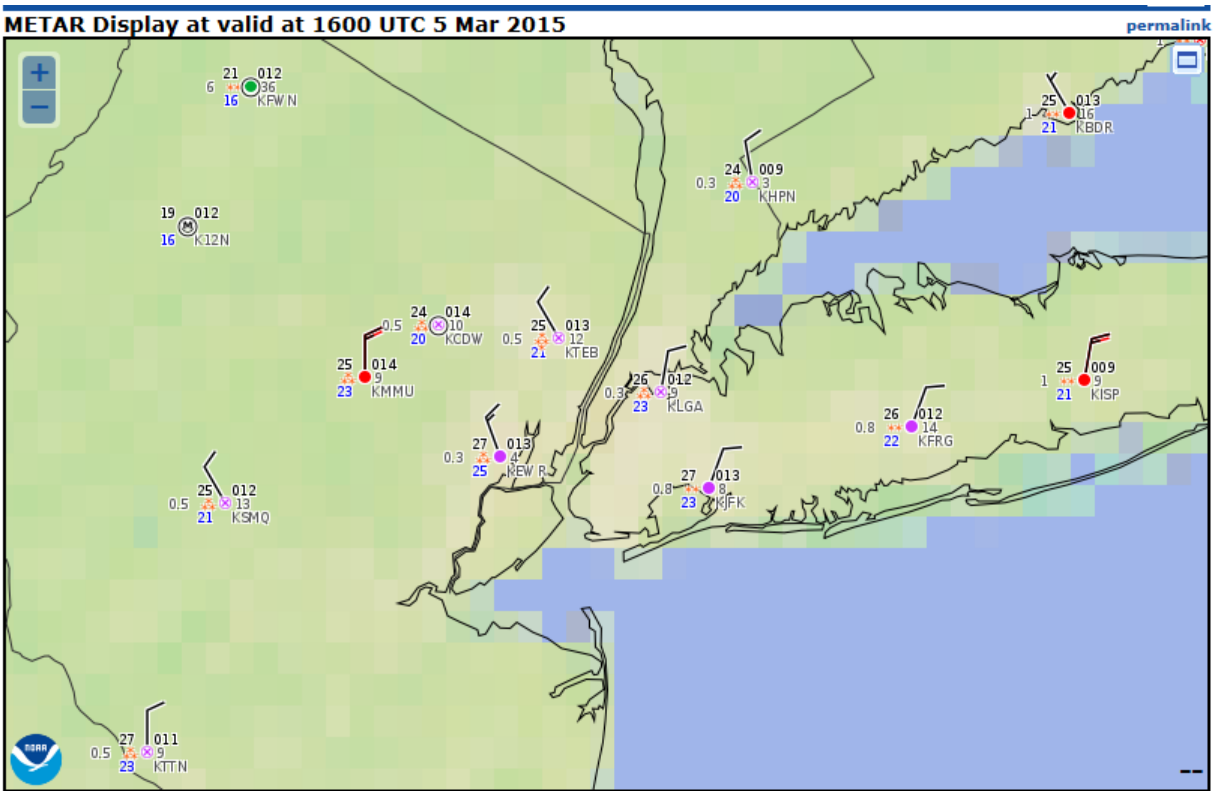

Figure 6 – NWS AWC Surface Observations at 1100 EST

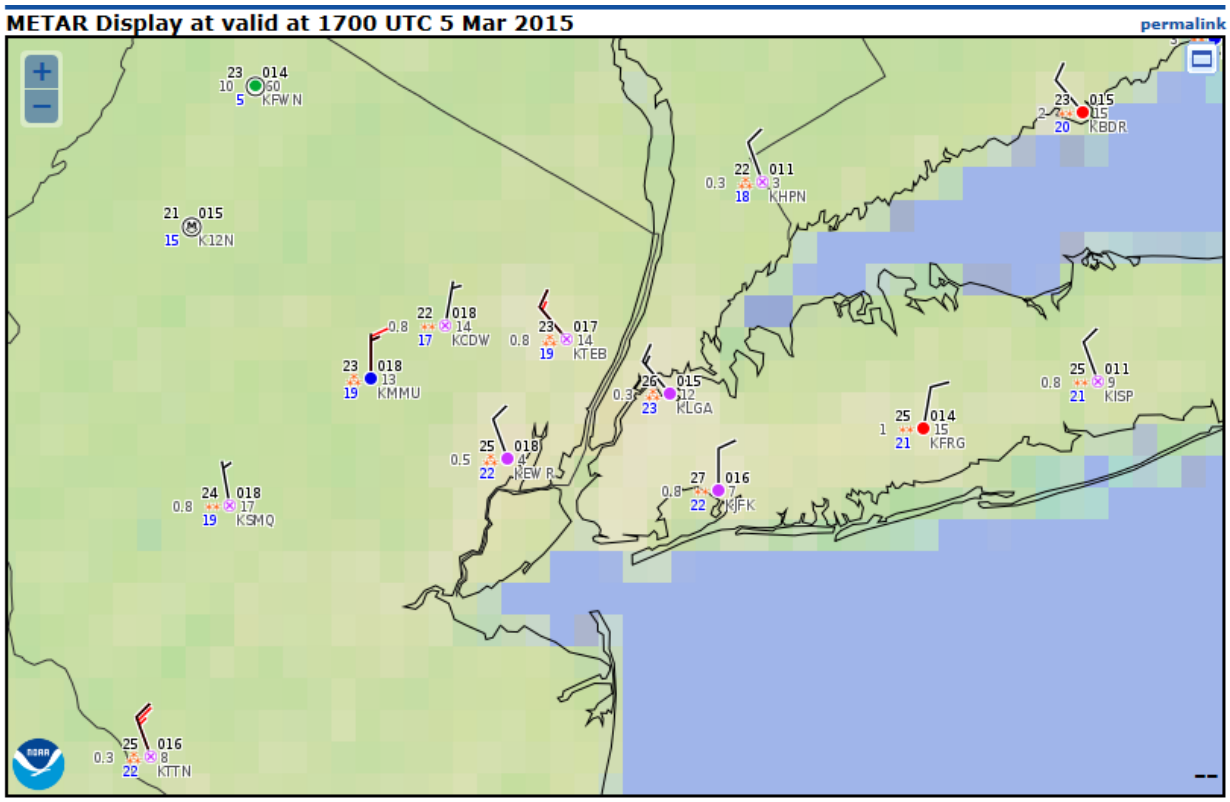

Figure 7 - NWS AWC Observations at 1200 EST

2.2 LaGuardia 5-minute ASOS Observations

The ASOS high resolution data was examined during the period to obtain finer resolution of the weather data during the period. The 5-minute ASOS observations generated by the system and augmented during the period were as follows for the approximate time of the accident:

La Guardia Airport weather at 1100 EST, wind from 020° true at 9 knots, visibility 1/4 mile, runway 4 visual range 3,000 variable 4,500 feet, moderate snow and freezing fog, vertical visibility 900 feet agl, temperature -3° C, dew point -4° C, altimeter 30.12 inches of mercury, the station pressure was at -150 feet based on the standard atmosphere, the relative humidity was 88%, the density altitude was -2,300 feet, magnetic wind from 030° at 9 knots. Remarks; automated observation system, hourly precipitation 0.01 inches.

The raw 5-minute ASOS observations in standard code surrounding the period from 1030 through 1140 EST were as follows:

03/05/15 10:30:31 5-MIN KLGA 051530Z 03006KT 1/4SM R04/2600V3000FT SN FZFG OVC008 M03/M04 A3013 -160 88 -2300 050/06 RMK AO2 P0004

03/05/15 10:35:31 5-MIN KLGA 051535Z 03006KT 1/4SM R04/2800V3500FT SN FZFG OVC008 M03/M04 A3012 -160 88 -2300 040/06 RMK AO2 P0005

03/05/15 10:40:31 5-MIN KLGA 051540Z 36010KT 1/4SM R04/3000V5000FT SN FZFG OVC008 M03/M04 A3013 -160 92 -2400 020/10 RMK AO2 SFC VIS 1/2 P0005

03/05/15 10:45:31 5-MIN KLGA 051545Z 36010KT 1/4SM R04/2800V5000FT SN FZFG VV009 M03/M05 A3013 -160 88 -2400 020/10 RMK AO2 SFC VIS 1/2 SLP201 P0006 T10331050

03/05/15 10:50:31 5-MIN KLGA 051550Z 36009KT 1/4SM R04/2800V4500FT SN FZFG VV009 M03/M05 A3012 -160 88 -2400 020/09 RMK AO2 SLP199 P0006 T10331050

03/05/15 10:55:31 5-MIN KLGA 051555Z 36008KT 1/4SM R04/2800V4500FT SN FZFG VV009 M03/M05 A3012 -160 88 -2400 020/08 RMK AO2 P0001

03/05/15 11:00:31 5-MIN KLGA 051600Z 02009KT 1/4SM R04/3000V4500FT SN FZFG VV009 M03/M04 A3012 -150 88 -2300 030/09 RMK AO2 P0001

Accident 1602Z

03/05/15 11:05:31 5-MIN KLGA 051605Z 01008KT 1/4SM R04/3500V4500FT SN FZFG VV009 M03/M04 A3011 -150 88 -2300 020/08 RMK AO2 SFC VIS 1/2 P0002

03/05/15 11:10:31 5-MIN KLGA 051610Z 02009KT 1/4SM R04/3500V4500FT SN FZFG VV009 M03/M04 A3011 -140 92 -2400 030/09 RMK AO2 SFC VIS 1/2 P0002

03/05/15 11:15:31 5-MIN KLGA 051615Z 01010KT 1/4SM R04/3000V4500FT SN FZFG VV009 M03/M05 A3011 -150 88 -2400 020/10 RMK AO2 SFC VIS 1/2 P0003

03/05/15 11:20:31 5-MIN KLGA 051620Z 01010KT 1/4SM R04/3000VP6000FT SN FZFG VV010 M03/M05 A3012 -150 88 -2400 020/10 RMK AO2 SFC VIS 1/2 P0003

03/05/15 11:22:26 SPECI KLGA 051622Z 01008KT 1/4SM R04/3000VP6000FT SN FZFG VV011 M03/M05 A3012 RMK AO2 SFC VIS 1/2 P0003 (TC)

03/05/15 11:31:26 SPECI KLGA 051631Z 36009KT 1/4SM R04/3500VP6000FT SN FZFG VV012 M03/M05 A3012 RMK AO2 SFC VIS 1/2 (ACFT MSHP) P0004 (TC)

03/05/15 11:40:26 SPECI KLGA 051640Z 32014KT 1/4SM R04/2400V4000FT SN FZFG SCT007 OVC012 M03/M05 A3015 RMK AO2 SFC VIS 1/2 PRESRR (ACFT MSHP) P0005 (TC)

03/05/15 11:51:26 METAR KLGA 051651Z 32016KT 1/4SM R04/2800V4000FT SN FZFG FEW006 OVC012 M03/M05 A3015 RMK AO2 SLP210 P0005 T10331050 $ (TC)

2.3 La Guardia ASOS 1-minute Wind Data

The La Guardia Airport 1-minute ASOS data was also examined for the period surrounding the accident. The ASOS system had 3 visibility sensors to measure extinction coefficient, day/night sensor, and provided the following average 2-minute wind direction and speed, the peak 5-second wind gust, and runway visual range (RVR) every minute. The present weather reported during the period was moderate snow.

At 1102 EST (1602Z) the 2-minute average wind was from 013° at 8 knots, with the peak gust from 016° at 10 knots. A wind gust was not reported in the primary METAR observation, as a gust is defined as a fluctuation between lull and peak wind of 10 knots or more. The peak wind gust value observed by the ASOS provided an estimate of the worst case scenario on landing on runway 13, and would have resulted in a 10 knot crosswind, and 2 knot tailwind component for

Delta flight 1086. The 1-minute RVR value for runway 4 was reported at 4,500 feet at that time of the accident.

Time (UTC)	VIS1	VIS2	VIS3	Wind (Dir/KT)	Peak (Dir/KT)	Rwy RVR (FT)	
1545	4.450 D	2.884 D	4.097 D	002° 10	012° 14	04 2800	
1546	5.081 D	3.043 D	4.390 D	003° 10	001° 11	04 3000	
1547	4.877 D	3.268 D	4.544 D	005° 9	007° 12	04 2800	
1548	5.075 D	3.567 D	4.651 D	005° 10	001° 11	04 3500	
1549	5.119 D	3.572 D	4.609 D	003° 9	000° 10	04 2800	
1550	5.076 D	3.245 D	4.618 D	004° 9	006° 10	04 2800	
1551	4.901 D	3.351 D	4.723 D	007° 8	014° 9	04 3500	
1552	5.323 D	3.304 D	4.900 D	010° 8	024° 10	04 3000	
1553	4.843 D	3.502 D	4.917 D	010° 8	010° 9	04 4500	
1554	5.358 D	3.343 D	4.683 D	005° 8	004° 10	04 4000	
1555	5.477 D	3.195 D	5.508 D	003° 8	012° 10	04 4000	
1556	4.735 D	3.169 D	5.283 D	002° 7	002° 9	04 3500	
1557	4.792 D	3.232 D	4.515 D	004° 8	019° 11	04 3500	
1558	5.056 D	3.380 D	4.476 D	010° 9	025° 11	04 3500	
1559	5.063 D	3.313 D	4.618 D	015° 9	019° 12	04 3500	
1600	5.032 D	3.159 D	4.914 D	016° 9	015° 10	04 4500	
1601	4.164 D	2.801 D	4.428 D	014° 8	008° 10	04 4000	
1602	**3.772 D**	**2.707 D**	**3.962 D**	**013° 8**	**016° 10**	**04 4500**	**Accident**
1603	3.820 D	2.860 D	3.818 D	016° 9	016° 11	04 3500	
1604	4.250 D	2.595 D	3.828 D	016° 9	019° 10	04 4500	
1605	4.042 D	2.595 D	3.978 D	009° 8	008° 10	04 4000	
1606	3.864 D	2.768 D	3.923 D	003° 7	008° 10	04 4000	
1607	4.054 D	2.685 D	3.897 D	003° 9	003° 11	04 3500	
1608	4.093 D	2.667 D	3.995 D	006° 9	008° 11	04 3500	
1609	4.352 D	2.899 D	4.269 D	013° 9	019° 10	04 3500	
1610	4.967 D	3.077 D	4.488 D	018° 9	026° 11	04 4000	
1611	5.177 D	3.297 D	4.774 D	018° 9	019° 11	04 4000	
1612	4.617 D	3.080 D	4.726 D	013° 10	008° 13	04 3500	
1613	4.256 D	2.857 D	4.164 D	010° 10	023° 11	04 3000	
1614	3.921 D	2.666 D	4.013 D	010° 9	015° 11	04 4500	
1615	3.320 D	2.360 D	3.646 D	006° 10	003° 13	04 3500	
1616	3.103 D	2.259 D	3.111 D	004° 9	009° 10	04 4000	
1617	3.167 D	2.308 D	2.872 D	005° 8	009° 10	04 5000	
1618	3.026 D	2.563 D	2.747 D	004° 9	353° 11	04 6000+	
1619	3.213 D	2.851 D	2.994 D	005° 10	007° 12	04 5500	
1620	3.397 D	2.769 D	3.124 D	009° 10	014° 11	04 6000+	
1621	3.174 D	2.520 D	3.221 D	008° 9	013° 11	04 5000	
1622	2.791 D	2.333 D	3.009 D	006° 8	015° 10	04 6000+	
1623	2.885 D	2.452 D	2.690 D	007° 9	010° 11	04 5000	
1624	3.071 D	2.190 D	2.724 D	007° 9	007° 10	04 6000	
1625	3.337 D	2.152 D	2.766 D	010° 8	012° 9	04 4500	
1626	2.874 D	2.267 D	3.095 D	007° 7	002° 9	04 6000+	
1627	2.846 D	2.088 D	2.830 D	005° 7	002° 10	04 4500	
1628	2.784 D	1.970 D	2.846 D	005° 7	008° 8	04 6000	
1629	2.649 D	1.955 D	2.774 D	005° 8	359° 10	04 6000+	
1630	2.891 D	1.940 D	2.680 D	006° 9	008° 11	04 3500	

2.4 La Guardia ASOS and Observers Locations

Figure 8 is a Google Earth image of the La Guardia Airport with the approximate locations of the ASOS, weather observer's office location, runway 13, the accident site, and general wind direction. The ASOS primary sensor location was located approximately 0.2 miles southwest of the touchdown zone of runway 13. The weather observer's location was located on the second floor of the old Marine Air Terminal approximately 0.6 miles southwest of runway 13 and immediately north of the touchdown zone of runway 4, where the primary runway visual range (RVR) system was located.

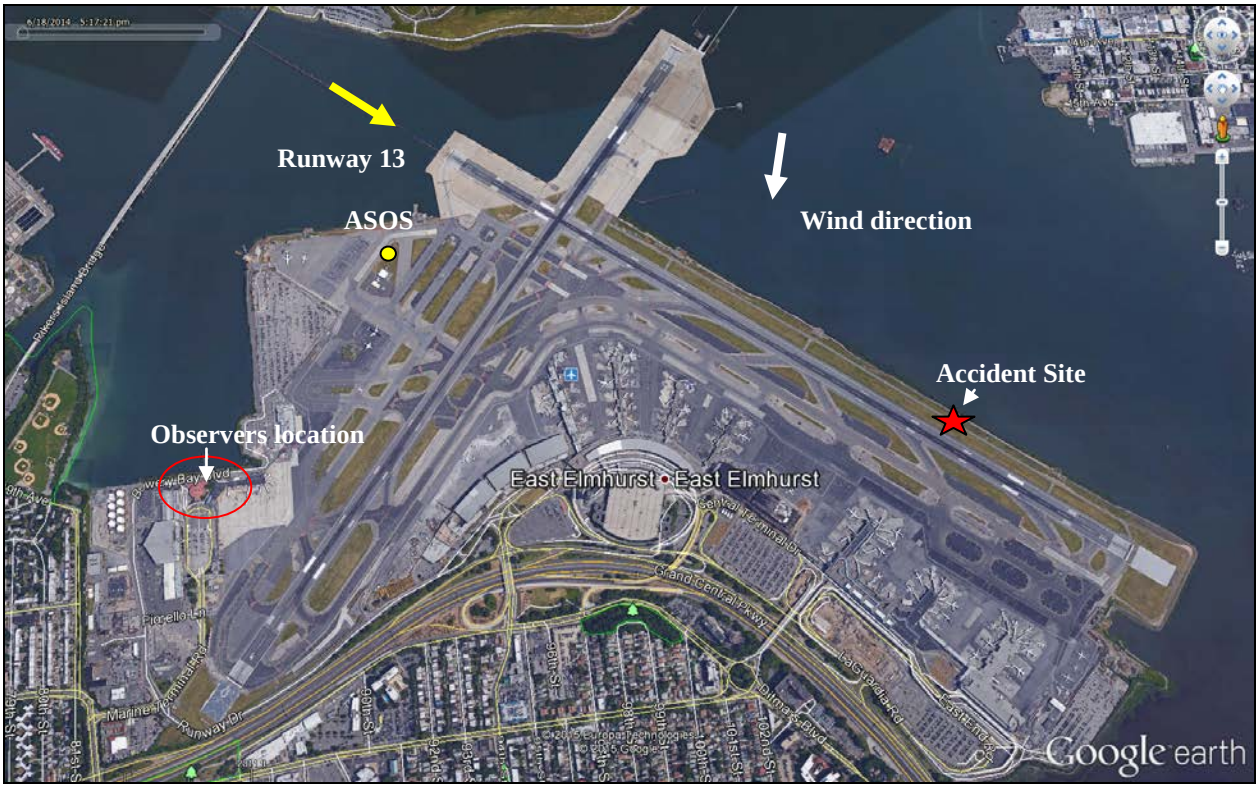

Figure 8 - KLGA Airport showing ASOS and observers location

3.0 Upper Air Data

Upper air data was obtained from the closest official NWS rawinsonde observation (RAOB) site in Upton, New York and from an instrumented aircraft that departed from LaGuardia immediately prior to the accident.

3.1 NWS Balloon Sounding

The closest upper air sounding or rawinsonde observation (RAOB) was from the NWS Brookhaven National Laboratory site (KOKX), in Upton, New York, site number 72501, located approximately 45 miles east of the accident site at an elevation of 66 feet. The 0700 EST

(1200Z) sounding from the surface to 18,000 feet was plotted on a standard Skew-T log P diagram[6] utilizing RAOB[7] software and is included as figure 9.

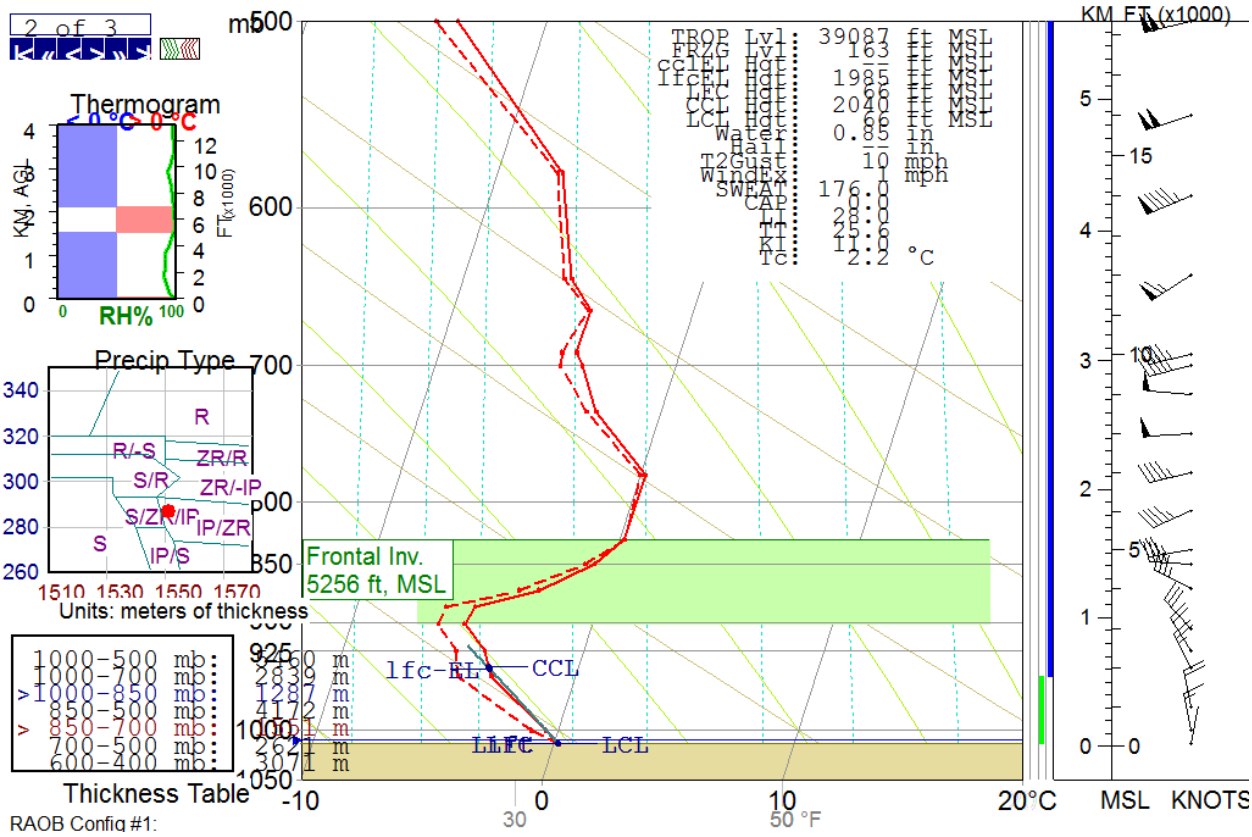

Figure 9 - Upton sounding at 0700 EST

The sounding depicted a surface temperature of 0.2° C with a relative humidity greater than 90% from the surface through 18,000 feet, and between 23,000 and 25,000 feet. The freezing level was identified immediately above the surface at 97 feet agl, with a temperature inversion from 3,200 to 5,256 feet, with the temperatures reaching 0.2° C at the top of the inversion with an isothermal layer or constant temperature through approximately 7,000 feet. As a result of the sounding temperature structure, the most favored type of precipitation was a mixture of snow, ice pellets, and freezing rain. The precipitable water content of the sounding was 0.85 inches of liquid water. The lifted condensation level (LCL)[8] was identified at the surface, and the

[6] Skew T log P diagram – is a standard meteorological plot using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

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

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

convective condensation level (CCL)[9] at 939hPa or 1,974 feet agl. The sounding had a Lifted Index[10] of 28.0 and indicated an absolutely stable environment and favored nimbostratus type clouds.

The sounding wind profile indicated a surface wind from the north or from 010° at 2 knots, with wind direction backing counterclockwise to the west with height through 5,000 feet and with wind speeds increasing with height. A low-level wind maximum was identified at 4,000 feet with wind from 300° at 37 knots. The mean 0 to 6 kilometer or 18,000 feet wind was from 257° at 60 knots, and the maximum wind was identified at the tropopause at 39,000 feet from 275° at 161 knots. The wind at 1,000 feet was identified from 350° at 22 knots, with a temperature of -0.5° C.

Figure 10 is the Brookhaven sounding parameters observed from the sounding from the surface through 18,000 feet. Included are the observed height, pressure, temperature (T), dew point (Td), relative humidity (RH%), wind direction and speed, and derived clear air turbulence (CAT), low-level wind shear (LLWS), and icing potential. The sounding indicated a moderate risk of LLWS below 50 feet, light to moderate turbulence, and icing conditions through most of the depth of the sounding.

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

[10] Lifted Index (LI) - A common measure of atmospheric instability. Its value is obtained by computing the temperature that air near the ground would have if it were lifted to 500-hPa or approximately 18,000 feet and comparing that temperature to the actual temperature at that level. Negative values indicate instability - the more negative, the more unstable the air is, and the stronger the updrafts are likely to be with any developing thunderstorms.

Height (ft-MSL)	Pres (mb)	T (C)	Td (C)	RH (%)	DD/FF (deg/kts)	CAT (AF)	LLWS	Icing - Type (S-F clouds)
66	1013	0.2	0.2	100	10/2		MODRT	
406	1000	-0.5	-1.1	96	350/16			SVR Clear
1000	978				350/22			
1800	948	-3.5	-4.9	90		LGT		LGT Clear
2000	941				335/23	LGT		
2437	925	-4.1	-5.3	91	330/20	L-M		LGT Rime
3000	905				320/30			
3116	901	-5.3	-6.4	92				LGT Rime
3549	886	-5.1	-6.3	91		L-M		LGT Rime
3962	872	-2.7	-3.5	94	300/37	L-M		LGT Rime
4630	850	-0.7	-1.1	97	275/35	L-M		LGT Rime
5000	838				260/35			
5256	830	0.2	0.2	100		L-M		
6000	807				245/44	L-M		
6927	779	0.2	0.0	99	255/44	MDT		
8000	748				265/52			
8557	732	-2.7	-3.1	97		L-M		TRC Rime
9000	720				275/52	MDT		
9719	700	-3.9	-4.8	93	255/45			TRC Rime
10054	691	-4.3	-4.9	96	255/45			LGT Rime
11125	663	-4.3	-4.4	99		MDT		LGT Rime
11916	643	-5.5	-5.8	98	235/63	M-S		LGT Rime
14000	593				245/93			
14565	580	-7.3	-7.5	98		L-M		TRC Rime
16000	548				250/98	L-M		
18318	500	-13.7	-14.6	93	255/106	M-S		TRC Rime

Figure 10 - Sounding parameters

3.2 Aircraft Sounding

A search of the NOAA Earth System Research Laboratory/Global Systems Division (ESRL/GSD) website (http://amdar.noaa.gov/) for Aircraft Meteorological Data Reports (AMDAR) provided an upper air data closer to the time and location to the accident. Figure 11 is an AMDAR ascent sounding from La Guardia from an aircraft identified as #11055 that departed immediately prior to the accident at 1058 EST. The aircraft sounding was similar to the Brookhaven's general profile except the entire depth of the sounding was below freezing, even within the temperature inversion from 3,780 through 8,040 feet, where temperature reached a high of -2.8° C.

The aircraft sounding indicated northerly winds from the surface through 1,200 feet with wind backing to the northwest and then west with height. A low-level wind maximum at 5,400 feet indicated wind from 297° at 42 knots. The wind profile indicated a left quartering tailwind and crosswind component on final approach for runway 13.

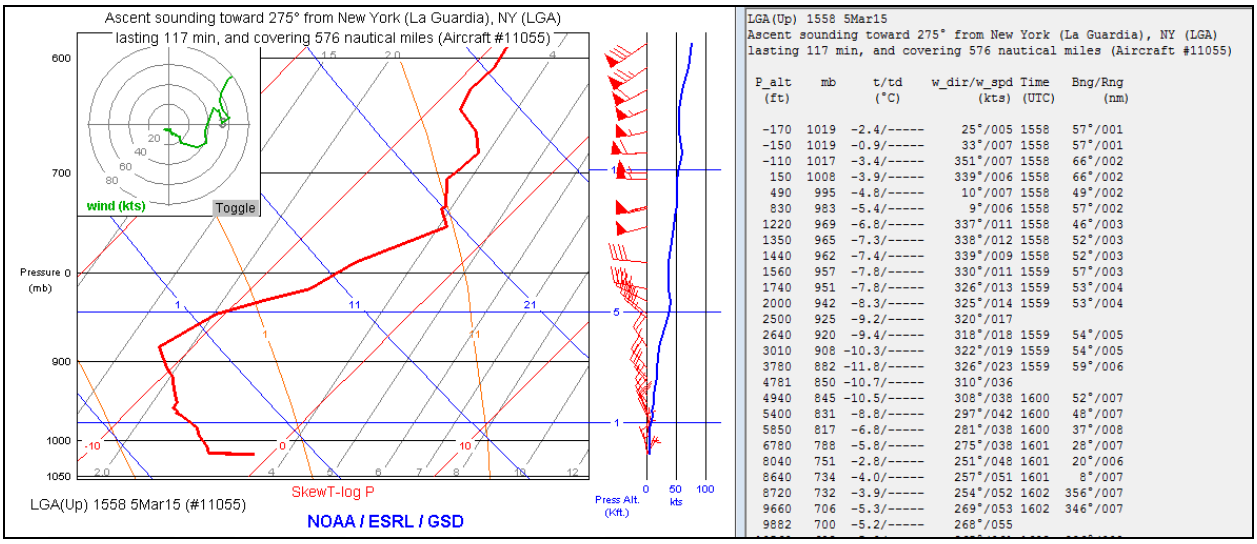

Figure 11 - AMDAR aircraft sounding at La Guardia at 1058 EST

4.0 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. Both the infrared long wave and visible band imagery were obtained surrounding the time of the accident. 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 kilometers (km). The visible imagery (band 1) at a wavelength of 0.65 μm provided a resolution of 1 km.

Figure 12 is the GOES-13 infrared image at 1100 EST at 4X magnification with a standard MB temperature enhancement curve applied to highlight the higher and colder cloud tops associated with high cirriform clouds and/or deep convection. The image depicted an extensive area of low nimbostratus type clouds over the area, and a band of higher cirriform clouds (enhanced area) immediately north of Long Island. The radiative cloud top temperature over the accident site was 247° Kelvin or -26.16° C, which corresponded to cloud tops near 24,000 feet based on the Upton upper air sounding. Figure 13 is the GOES-13 visible image at 2X magnification for the same time period highlighting the extent of the nimbostratus type clouds over the area.

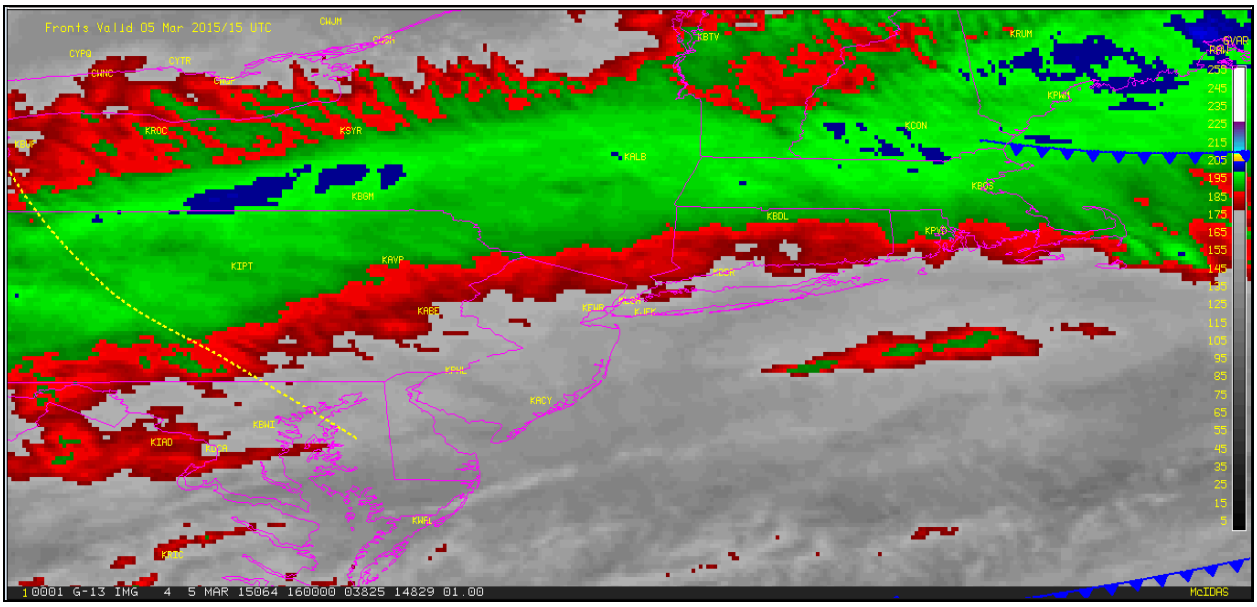

Figure 12 - GOES-13 infrared image at 1100 EST

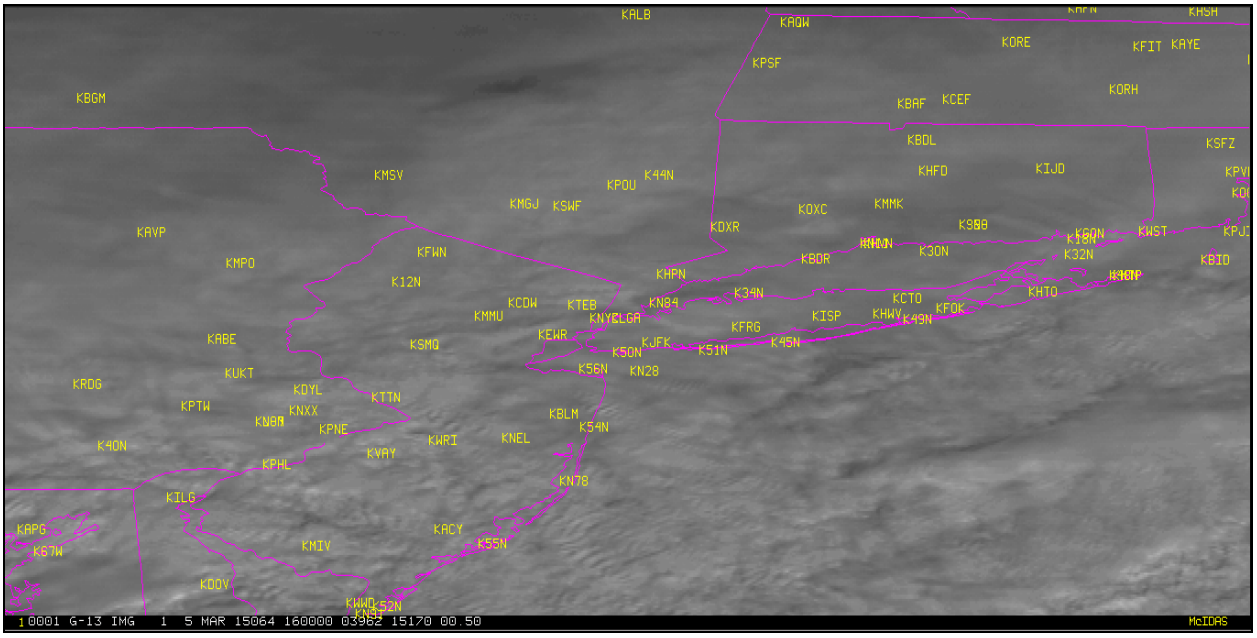

Figure 13 - GOES-13 visible image at 1100 EST

5.0 Weather Radar Information

The closest Weather Surveillance Radar-1988, Doppler (WSR-88D) to the accident site was from the NWS Brookhaven National Laboratory site (KOKX) located approximately 45 miles east of the accident site in Upton, NY. The level II and III 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 a 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.

5.1 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.

During the period surrounding the accident the KOKX WSR-88D radar was operating in the precipitation mode volume coverage pattern 212 (VCP-212), where the radar makes 14 different elevation scans from 0.5° to 19.5° every in 4 ½ minutes. This mode is typically used by the NWS during periods when rapidly evolving wide spread severe convection is expected, and allows for improved low-level vertical resolution of the storms. The following chart provides an indication of the different elevation angles in this VCP, and the approximate height and width of the radar beam with distance from the radar site.

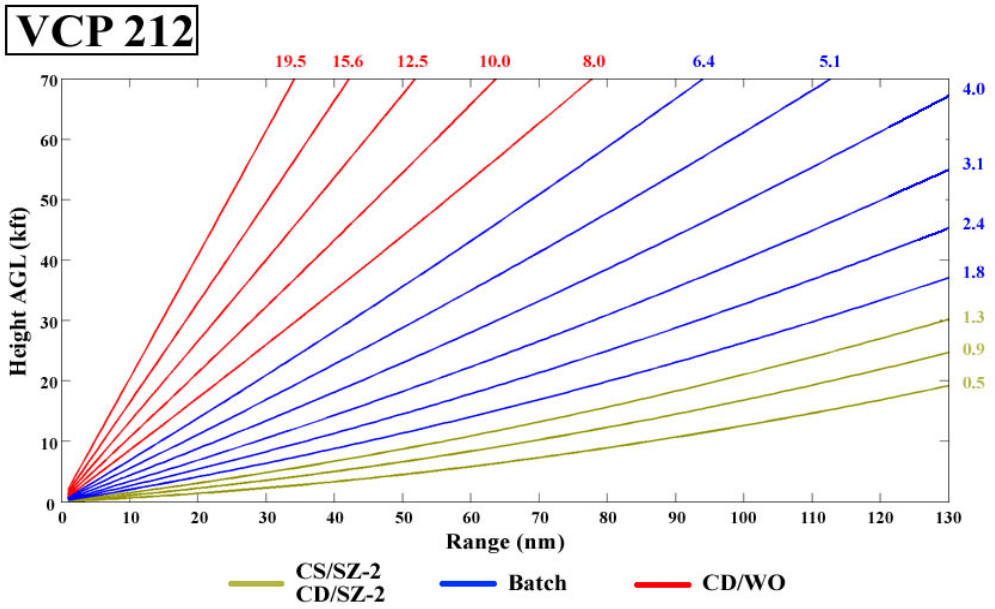

Figure 14- VCP-212 scanning mode

5.2 Beam Height Calculation

Assuming standard refraction[11] of the 0.95° radar beam of the NWS KOKX WSR-88D with an antenna height of 199 feet and a distance of 45 miles and an azimuth of 263° from the radar,

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

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°	3,930 feet	1,660 feet	6,190 feet	4,530 feet

Based on the radar height calculations, the 0.5° elevation scan depicts the conditions encompassing the altitude between 1,660 and 6,190 feet over the accident site.

5.3 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.

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			

[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

6 Extreme	11 12 13 14 15	55 to 59 60 to 64 65 to 69 70 to 74 > 75	>5.67 in/hr

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)

5.4 Base Reflectivity

Figure 15 is the NWS KOKX WSR-88D 0.5° base reflectivity image completed at 1101 EST with the flight track overlaid. The image depicts an extensive area of echoes in the general range of 15 to 30 dBZ, or light intensity echoes over the region and the flight track. A review of the radar images surrounding the period depicts a band of light to moderate echoes of 25 to 32 dBZ moved over the La Guardia area between 1050 and 1101 EST, or immediately prior to the accident.

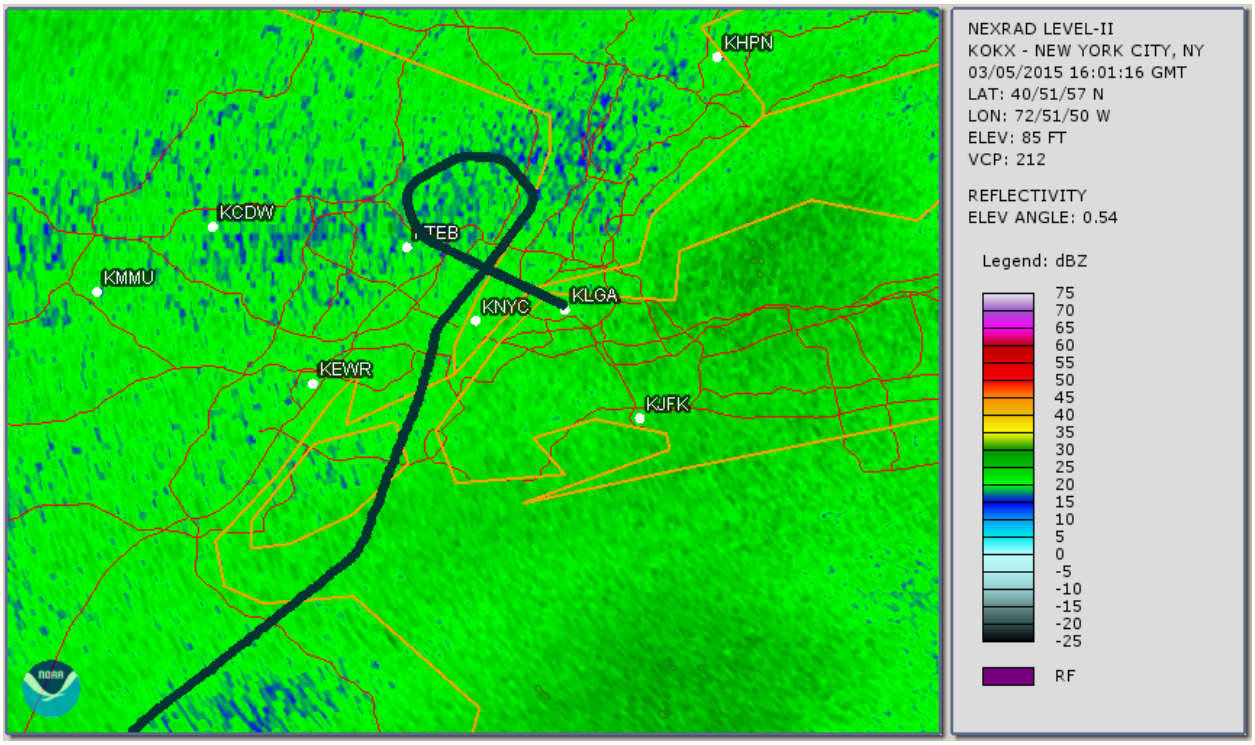

Figure 15 – NWS KOKX WSR-88D 0.5° base reflectivity at 1101 EST

6.0 Pilot Reports

The following pilot reports (PIREPs) were recorded over the New York area surrounding the period between 0740 and 1150 EST. The reports are transcribed from standard code and abbreviations, with time converted to local time. The navigation location identifiers match the city's unless otherwise noted. The reports were as follows:

Republic Airport (FRG), Farmington, NY routine pilot report; Over - Kennedy VORTAC[14] (JFK), New York 135° azimuth (SE) and 15 miles; Time – 0742; Flight level – unknown; Type aircraft – Airbus 320 air carrier jet; Turbulence – moderate turbulence between 4,500 to 3,000 feet.

Republic Airport (FRG), Farmington, NY routine pilot report; Over - JFK VORTAC 120° azimuth (SE) and 15 miles; Time – 0743; Flight level – unknown; Type aircraft – Airbus 320 air carrier jet; Turbulence – moderate turbulence between 4,500 to 3,000 feet.

Francis S. Gabreski Airport (FOK), Westhampton Beach, NY routine pilot report; Over – Calverton (CCC) VORTAC 135° azimuth (SE) at 15 miles; Time – 0810; Flight level – 16,000 feet; Type aircraft – Bombardier Dash 8 multiengine turboprop; Temperature – minus 9° C; Icing – light to moderate rime type icing.

John F. Kennedy International Airport (JFK), New York, NY routine pilot report; Over - JFK VORTAC 156° azimuth (SSE) at 30 miles; Time – 0833; Flight level -16,000 feet; Type aircraft – Boeing 737 air carrier jet; Turbulence – moderate clear air turbulence (CAT).

John F. Kennedy International Airport (JFK), New York, NY routine pilot report; Over - JFK VORTAC 156° azimuth (SSE) at 30 miles; Time – 0909; Flight level -12,000 feet; Type aircraft – Airbus 320 air carrier jet; Turbulence – moderate CAT between 12,000 and 13,500 feet.

John F. Kennedy International Airport (JFK), New York, NY routine pilot report; Over - JFK VORTAC 139° azimuth (SSE) at 30 miles; Time – 0914; Flight level -12,000 feet; Type aircraft – Boeing 737 air carrier jet; Turbulence – moderate CAT between 12,000 and 16,000 feet.

Long Island Mac Arthur Airport (ISP), New York, NY routine pilot report; Over - JFK VORTAC 135° azimuth (SSE) at 40 miles; Time – 0945; Flight level - 39,000 feet; Type aircraft – Boeing 777 heavy air carrier jet; Turbulence – moderate.

Accident 1102 EST

Republic Airport (FRG), Farmington, NY routine pilot report; Over – Deer Park (DPK) VORTAC; Time – 1138; Flight level – 20,000 feet; Type aircraft – Dassault Falcon business jet; Temperature – minus 19° C; Icing – light rime type icing between 20,000 and 19,000 feet.

La Guardia Airport (LGA), New York, NY routine pilot report; Over – LGA VORTAC; Time – 1139; Flight level – 24,000 feet; Type aircraft – Boeing 737 air carrier jet; Temperature – minus 25° C; Icing – light to moderate mixed icing between 24,000 and 23,000 feet.

[14] VORTAC – is a VHF omnidirectional range (VOR) beacon and a tactical air navigation system (TACAN) beacon for distance measuring. The system provides both azimuth and distance for air navigation.

Republic Airport (FRG), Farmington, NY routine pilot report; Over – Deer Park (DPK) VORTAC 225° azimuth (SW) and 10 miles; Time – 1144; Flight level – 22,000 feet; Type aircraft – Boeing 737 air carrier jet; Temperature – minus 19° C; Icing – moderate rime type icing.

Long Island Mac Arthur Airport (ISP), New York, NY routine pilot report; Over - Deer Park (DPK) VORTAC 040° azimuth (NE) at 7 miles; Time – 1149; Flight level - 7,000 feet; Type aircraft – Cessna Citation business jet; Temperature – 0 C; Icing – light rime type icing between 15,000 and 17,000 feet; Remarks – no icing below 7,000 feet.

7.0 Terminal Aerodrome Forecast

The NWS Brookhaven National Laboratory Weather Forecast Office (KOKX), in Upton, NY was responsible for the issuance of the Terminal Aerodrome Forecast (TAF) for La Guardia Airport. The forecast issued at 0641 EST was as follows:

TAF KLGA 051141Z 0512/0612 33012KT 1 1/2SM -SN BR SCT008 OVC015
FM051230 35011G19KT 1/2SM SN FZFG OVC005
TEMPO 0513/0517 1/4SM +SN VV003
FM051700 35012G17KT 1SM -SN BR BKN008 OVC015
FM052100 34012KT 2SM -SN BR BKN020 OVC050
FM060000 33011KT P6SM SCT020 BKN050
FM060800 36009KT P6SM FEW050

The forecast expected LIFR conditions to prevail and from 0730 through 1200 EST expected a wind from 350° at 11 knots gusting to 19 knots, visibility 1/2 mile in moderate snow and freezing fog, ceiling overcast at 500 feet agl, with temporary conditions of 1/4 mile in heavy snow, and vertical visibility 300 feet. Light snow was expected after 1200 EST with snow ending at approximately 1900 EST.

The forecast had a schedule amendment and was updated at 0934 EST with little change to the forecast, and continued to expected LIFR conditions. The forecast was as follows:

KLGA 051434Z 0515/0612 35011G19KT 1/2SM SN FZFG OVC005
TEMPO 0515/0518 1/4SM +SN VV003
FM051800 35012G17KT 1SM -SN BR BKN008 OVC015
FM052100 34012KT 2SM -SN BR BKN020 OVC050
FM060000 33011KT P6SM SCT020 BKN050
FM060800 36009KT P6SM FEW050

Delta Airlines Meteorology Department issues their own TAFs for the major airports where they operate, such as KLGA, and are included in section 14 of this report.

8.0 Aviation Forecast Discussion

The NWS New York Aviation Forecast Discussion (AFD) current for the period is included below and is intended to provide a well-reasoned discussion of the meteorological thinking which went into the preparation of the forecast products, or specifically for aviation the La Guardia TAF.

.AVIATION /15Z THURSDAY THROUGH MONDAY/...
WAVES OF LOW PRESSURE RIDE ALONG THE COLD FRONT SOUTHEAST OF LONG ISLAND. PERIODS OF MODERATE TO HEAVY SNOW THROUGH THE DAY NEAR THE COAST THROUGH THE EARLY AFTERNOON. HAVE EXTENDED PERIOD OF HEAVIER SNOW BY 1 HOUR TO 18Z AT ALL NYC TERMINALS...BASED ON LATEST RADAR TRENDS. KSWF WILL BE NORTH OF THE HEAVIEST SNOW...SO MVFR TO IFR THERE.

SNOW EVENTUALLY TAPERS OFF LATE THIS AFTERNOON INTO EARLY EVENING. CONDITIONS ARE EXPECTED TO SIGNIFICANTLY IMPROVE AFTER 00Z.

WINDS WILL BE OUT OF THE N-NW AROUND 10-12 KT THROUGH TONIGHT WITH SOME GUSTS TO 15-20 KT THIS AFTERNOON. WINDS DIMINISH LATE TONIGHT INTO FRIDAY.

OVERALL...HIGHER CONFIDENCE WITH WINDS AND LOWER CONFIDENCE WITH CATEGORICAL CHANGES WHICH COULD VARY A FEW HOURS WITH SUBSEQUENT FORECASTS.

EXPECTED RUNWAY SNOW ACCUMULATIONS:

KISP...6-8 INCHES.
KJFK/KLGA/KEWR/KTEB/KGON...4-6 INCHES.
KHPN/KBDR...3-5 INCHES.
KSWF...1-2 INCHES.

...NY METRO ENHANCED AVIATION WEATHER SUPPORT...

DETAILED INFORMATION...INCLUDING HOURLY TAF WIND COMPONENT FCSTS CAN BE FOUND AT: HTTP:/WWW.ERH.NOAA.GOV/ZNY/N90 (LOWER CASE)

KJFK FCSTER COMMENTS: FORECAST TIMING OF CATEGORY CHANGES COULD DIFFER 1-3 HRS FROM OBSERVED.

KLGA FCSTER COMMENTS: FORECAST TIMING OF CATEGORY CHANGES COULD DIFFER 1-3 HRS FROM OBSERVED.

9.0 In-Flight Weather Advisories

The NWS issues in-flight weather advisories designated as Severe Weather Forecast Alerts (AWW's), Convective SIGMET's (WST's), SIGMET's (WS's), Center Weather Advisories (CWA's), and AIRMET's (WA's). In-flight advisories serve to notify en route pilots of the possibility of encountering hazardous flying conditions, which may not have been forecast at the time of the preflight briefing. Whether or not the condition described is potentially hazardous to a particular flight is for the pilot to evaluate on the basis of experience and the operational limits of the aircraft.

During the period the only advisories current were a series of AIRMETs, which were as follows:

WAUS41 KKCI 051445 *2015064 1454*
WA1S
-BOSS WA 051445

AIRMET SIERRA UPDT 3 FOR IFR AND MTN OBSCN VALID UNTIL 052100

.

AIRMET IFR...MA RI CT NY NJ PA OH WV MD DC DE VA AND CSTL WTRS
FROM 40ESE BOS TO 60ENE ACK TO 110SSE ACK TO 160SE SIE TO 20NE ECG TO HMV TO HNN TO 40E CVG TO EWC TO 50SSW ALB TO 40ESE BOS
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 21Z THRU 03Z.

.

AIRMET MTN OBSCN...PA WV MD VA
FROM 40S ERI TO 60ESE SLT TO HAR TO CSN TO 20NNW GSO TO HMV TO HNN TO 40S ERI
MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 21Z THRU 03Z.

....

WAUS41 KKCI 051445 2015064 1442
WA1T
-BOST WA 051445
AIRMET TANGO UPDT 2 FOR TURB VALID UNTIL 052100

.

AIRMET TURB...ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA AND CSTL WTRS
FROM 70NW PQI TO 60NE PQI TO 140ENE ACK TO 20S ACK TO HMV TO HNN TO CVG TO FWA TO 30SE ECK TO YOW TO YSC TO 70NW PQI
MOD TURB BTN 160 AND FL370. CONDS CONTG BYD 21Z THRU 03Z.

.

AIRMET TURB...ME NH VT MA RI CT NY NJ PA WV MD DC DE VA AND CSTL WTRS
FROM 40E PQI TO 100SE BGR TO 140E ACK TO 160SE SIE TO 20NE ECG TO HMV TO 20ESE EWC TO MPV TO 40E PQI
MOD TURB BTN 050 AND 160. CONDS CONTG BYD 21Z THRU 03Z.

.

AIRMET TURB...VA NC SC GA AND CSTL WTRS
FROM 20NE ECG TO 140SE ECG TO 40SSW ILM TO SAV TO 30S LGC TO GQO TO HMV TO 20NE ECG
MOD TURB BLW 100. CONDS CONTG BYD 21Z THRU 03Z.

.

OTLK VALID 2100-0300Z
AREA 1...TURB ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA AND CSTL WTRS
BOUNDED BY 70NW PQI-60NE PQI-150ENE ACK-20NE ECG-30NE GSO-HMV-
HNN-CVG-FWA-30SE ECK-YOW-YSC-70NW PQI
MOD TURB BTN 160 AND FL370. CONDS CONTG THRU 03Z.

.

AREA 2...TURB VA NC SC GA AND CSTL WTRS
BOUNDED BY 20NE ECG-140SE ECG-60SSE CHS-40NNW AMG-40SSE LGC-GQO-HMV-20NE ECG
MOD TURB BLW 100. CONDS CONTG THRU 03Z.

.

AREA 3...TURB ME NH VT MA RI CT NY NJ PA WV MD DC DE VA AND CSTL WTRS
BOUNDED BY 40ESE PQI-200SE ACK-160SE SIE-20NE ECG-40SSW PSK-20WNW PSB-40ESE PQI
MOD TURB BTN 050 AND 160. CONDS CONTG THRU 03Z.

....

WAUS41 KKCI 051445 2015064 1454
WA1Z
-BOSZ WA 051445
AIRMET ZULU UPDT 2 FOR ICE AND FRZLVL VALID UNTIL 052100

.

AIRMET ICE...ME NH VT MA RI CT NY NJ PA OH WV MD DC DE VA AND CSTL WTRS
FROM 50ESE BGR TO 110ESE ACK TO SBY TO 40WSW ORF TO HMV TO HNN TO CVG TO 40WSW ROD TO 40ENE EWC TO 50ESE BGR
MOD ICE BTN FRZLVL AND FL250. FRZLVL SFC-100. CONDS CONTG BYD 21Z THRU 03Z.

.

OTLK VALID 2100-0300Z...ICE ME NH VT MA RI CT NY NJ PA OH WV MD DC DE VA AND CSTL WTRS

BOUNDED BY 50ESE BGR-160ENE ACK-150ESE ACK-140SE SIE-20NE ECG-HMV-HNN-30E EWC-50ESE BGR
MOD ICE BTN FRZLVL AND FL250. FRZLVL SFC-100. CONDS CONTG THRU 03Z.
.
FRZLVL...RANGING FROM SFC-110 ACRS AREA
MULT FRZLVL BLW 110 BOUNDED BY 50S PVD-150SSE HTO-150SE SIE-50SE ECG-GQO-HMV-40S HNN-50S PVD
SFC ALG 40S PSK-20E RIC-60SE HTO-140ENE ACK
040 ALG 20SSW ORF-90SE SIE-130SE ACK-160ESE ACK
080 ALG 120SE SBY-140SE SIE-200SE ACK
....

The graphic versions of G-AIRMET of the advisories are included in figures 16-18.

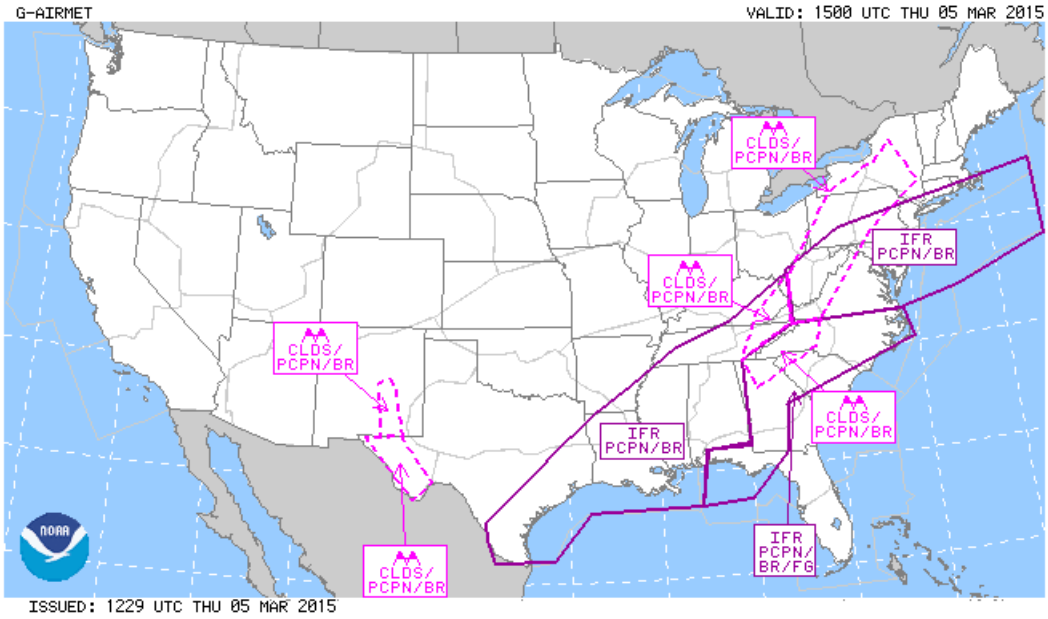

Figure 16 - G-AIRMET Sierra for IFR conditions

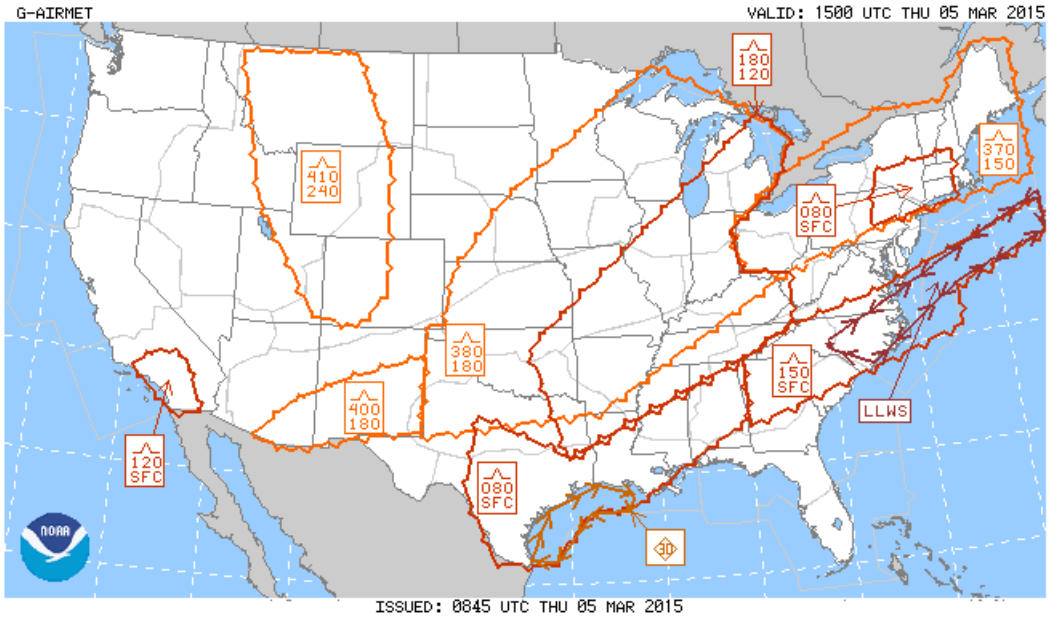

Figure 17 - G-AIRMET Tango for turbulence

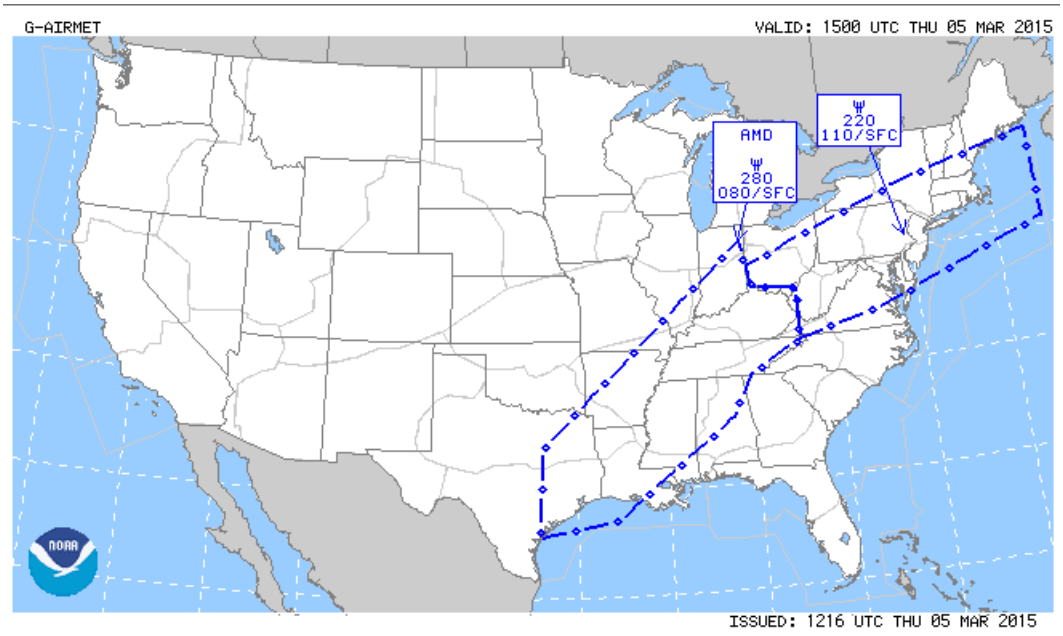

Figure 18 - G-AIRMET Zulu for icing conditions

10.0 Center Weather Service Unit Products

The FAA New York Air Route Traffic Control Center (ARTCC) Center Weather Service Unit (CWSU) issued a Meteorological Impact Statement (MIS) at 0843 EST for the New York area airports. The advisory was as follows:

FAUS20 KZNY 051343 *2015064 1344*
ZNY MIS 02 VALID 051400-052200

...FOR ATC PLANNING PURPOSES ONLY...
SNOW WILL CONTINUE THRU THE DAY FOR MUCH OF ZNY INCLDG NYC AND PHL AIRPORTS...WITH WIDESPREAD IFR-LIFR COND. SNOW ENDG BY 22Z WITH IMPROVEMENT TO VFR AFTER. MOD-LOC SEV ICE SFC-FL280...ESP IN PCPN. MOD TURB 070-FL280. LOC SEV TURB PSBL W OF ZNY AIRSPACE ACRS ZOB/ZID/ZAU...FL240-310. COMPRESSION PSBL DUE TO STRONG WINDS ALOFT...100KT FM THE W AT 150.
MMD

11.0 Winds and Temperatures Aloft Forecast

The NWS Winds and Temperatures Aloft Forecast (FD) bulletin that was current for the period for use between 0300 and 1000 EST, and valid at 0700 EST is provided in figure 15. The forecast wind at 3,000 feet over the New York area or from JFK indicated wind from 350° at 24 knots.

WINDS ALOFT FORECASTS

DATA BASED ON 050600Z
VALID 051200Z FOR USE 0800-1500Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000	45000	53000
ATL	2235	2446+11	2448+06	2449+01	2473-08	2485-21	740137	740147	751454	259259	266571
CSG	2337	2438+11	2441+06	2447+02	2469-08	2379-21	249537	249547	750653		
TYS	0421	2240+08	2459+05	2464-01	2486-10	7402-22	741738	742348	753254		
GSP	2338	2449+11	2451+05	2555-01	2481-09	2489-21	740738	750647	751655		
CAE	2338	2438+11	2535+04	2453+03	2471-09	2478-21	249437	259548	750455	269161	266972
TRI		2238+08	2458+04	2468-01	2486-10	7402-22	741538	741948	753156	751259	268770
ROA	3615	2228+06	2463+03	2472-02	2594-11	7405-23	752339	752548	763656		
RDU	2425	2548+10	2446+04	2555+00	2485-10	2593-21	751038	751048	762256	760060	267571
EKN		2622-03	2636-04	2464-05	7506-14	7416-24	753339	754049	765057		
RIC	0225	2349+09	2458+05	2564-01	2595-11	7502-22	751939	762249	763556	760960	268770
ACY	3524	2626+00	2366+02	2580-01	2698-12	7512-23	762940	763749	774458		
AVP	3525	2944-09	2662-04	2566-08	7504-15	7521-26	764640	766050	775657		
JFK	3524	2735-02	2553-03	2473-03	7506-14	7619-25	763440	764650	774658	762859	771367
BDL	3425	2848-07	2667-04	2576-07	7504-15	7511-26	764841	776451	776158		

Figure 19 - Winds Aloft Forecast current at the time of departure

12.0 Flight Dispatcher Statement

The flight dispatch responsible for the flight planning, release and flight following of the flight was Daniel R. Cannella. His statement regarding the conditions surrounding flight 1086 is included as attached 1. The dispatcher also indicated that the dispatchers were monitoring the La Guardia tower frequency through a remote radio connection, and immediately prior to the accident he heard on the LGA tower frequency the Port Authority indicate that when the runway 13/31 was reopened immediately prior to flight 1086's landing that the runway had only been

"broomed", had not been treated with deicing chemicals, and that there was 1/4 inch of snow on the runway.[15]

13.0 Weather Document

The weather document provided to the captain of flight 1086 is included as Attachment 2. The flight was based on the Delta Airlines Meteorology Terminal Forecast for KLGA, which was the second amended and issued at 0719 EST and valid for a 29 hour period. The forecast was as follows:

KLGA DL 051219Z AMD 2 VALID 051219 – 061700 UTC
FM051200 33012KT 1/2SM SN BR BKN007
FM051700 35012G18KT 1SM –SN BR BKN007
FM052100 33012KT 4SM –SN BR SCT007 BKN012
TEMPO 0521/0523 1SM –SN
FM060100 33013KT P6SM SCT012 BKN025
FM060300 33015G23KT P6SM SCT030 SCT045 BKN100
FM060600 34012KT P6SM SKC
RMK DL TAF BY OLOUGHLIN
DISCUSSION – MOD SNOW THIS MORNING. FALLING TEMPS WILL BOOST ACCUM THIS AFTN WITH 4-7 TOTAL.

The forecast expected from 0700 to 1200 EST, a wind from 330° at 12 knots, visibility 1/2 mile in moderate snow and mist, with a ceiling broken at 700 feet agl at the time of arrival.

The document also included the observations for KLGA at 0700 EST (1200Z) and the surrounding New York area airports (KJFK, KEWR, KISP, and KABE), alternate airports of Albany and Syracuse (KALB and KSYR), departure weather conditions from Atlanta (KATL), selected enroute station observations, and Delta in-flight weather advisories for the route. In addition, the document included company pilot reports, and field conditions reports. The field conditions for La Guardia at the time of issuance were current from 0652 through 1300 EST, and were as follows:

La Guardia – all runways and taxiways have 3 foot snow banks along their edges. All taxiways are wet and have been deiced with liquid chemical. All runways are wet and have been sanded and deiced with solid chemical. Runway 04/22 has been sanded chemically treated. Runway 13/31 has been sanded chemically treated. Primary taxiway system has been chemically treated.

There were no braking action reports noted for LaGuardia, while Syracuse (SYR) one of the alternate airports listed did included braking action reports as "good" from a ground vehicle, and reported dry snow over patchy compacted snow and ice on the runways and aprons.

The weather briefing document was updated at 0834 EST and included observations for KLGA at 0751 EST that reported wind from 340° at 6 knots, visibility 1/4 mile, runway 4 visual

[15] This was in reference to the last runway closure or cleaning operation, and not reflective of the earlier field condition report of the runway treatment at 0858 EST.

range of 3,000 variable 4,000 feet, moderate snow and fog, ceiling overcast at 900 feet agl, temperature 0° C, dew point -1° C, altimeter 30.06 inches of Hg. Remarks; automated observation system, tower visibility 3/4 mile, sea level pressure 1017.8-hPa, snow increment 1 inch during the last hour, total 4 inches of snow, hourly liquid precipitation 0.05 inches, temperature 0.0° C, dew point -1.1° C.

Other observations in the New York area also reported IFR to LIFR conditions in light to moderate snow, with snow accumulation reports of 1 inch of new snow during the hour.

14.0 NWS's Forecasters Statement

The NWS New York Weather Forecast Office (WFO) forecaster who was responsible for issuance of the LaGuardia TAF and the NWS meteorologist assigned to the New York Air Route Traffic Control Center (ARTCC) Center Weather Service Unit (CWSU) both were asked to provide statements regarding their actions and the winter weather impacting the New York area during the period. Their statements are included as Attachments 3 and 4 respectively.

15.0 NWS Reporting of Snow Intensity

At present the NWS and weather observers report and forecast snow intensity based upon visibility and is referenced in the Federal Meteorological Handbook (FMH-1) section 8.4, Present Weather Observing Standards. Light snow is reported when visibility is greater than 1/2 statute mile, moderate snow with visibility less than 1/2 mile but greater than 1/4 mile, and heavy snow when visibility is 1/4 mile or less. The following chart depicts the snow intensities by visibility. The estimate is based on snow by itself and not in combination with fog, as was reported in this case.

FMH-1 Table		
Visibility (Statute Miles)		
> 0.50	> 0.25 – <= 0.50	<= 0.25
Light	**Moderate**	**Heavy**

The following table is used by forecasters to estimate snow accumulation based upon visibility, assuming that the restriction is based upon precipitation alone and not fog at the same time. Based on the ASOS observation the snow accumulation rate exceeded 3/4 inch per hour, and averaged near an inch an hour surrounding the period of the accident.

Visibility (Statute Miles)	Snowfall Rate (inches/hour)
3 or more	trace
2	0.1
1 1/2	0.2
1	0.3
3/4	0.5
1/2	0.75 – 1.25
1/4	1 - 2
1/8	2

Several researchers have been working on improving the reporting of snow intensity and its impact on aviation safety, specifically with contaminating aircraft surfaces after several major air carrier accidents due to winter weather conditions. The figure 20 is a table to estimate the snow intensity based on temperature, visibility, and day/night conditions, based on research from Dr. Rasmussen[16] and the FAA[17], to account for the liquid water equivalent (LWE). While this table is used primarily for de-icing and anti-icing operations by the current U.S. air carriers such as Delta in the use of Type 1, II, III, and IV fluid applications and holdover periods.

Time of Day	Temp.		Visibility in Statute Miles (Meters)									Snowfall Intensity
	Degrees Celsius	Degrees Fahrenheit	≥ 2 ½ (≥ 4000)	2 (3200)	1 ¾ (2800)	1 ½ (2400)	1 ¼ (2000)	1 (1600)	¾ (1200)	½ (800)	≤ ¼ (≤ 400)	
Day	colder/equal -1	colder/equal 30	Very Light	Very Light	Very Light	Light	Light	Light	Moderate	Moderate	**Heavy**	
	warmer than -1	warmer than 30	Very Light	Light	Light	Light	Light	Moderate	Moderate	**Heavy**	**Heavy**	
Night	colder/equal -1	colder/equal 30	Very Light	Light	Light	Moderate	Moderate	Moderate	Moderate	**Heavy**	**Heavy**	
	warmer than -1	warmer than 30	Very Light	Light	Moderate	Moderate	Moderate	Moderate	**Heavy**	**Heavy**	**Heavy**	

NOTE 1: This table is for estimating snowfall intensity. It is based upon the technical report, "The Estimation of Snowfall Rate Using Visibility," Rasmussen, et al., Journal of Applied Meteorology, October 1999 and additional in situ data.

NOTE 2: This table is to be used with Type I, II, III, and IV fluid guidelines.

NOTE 3: If visibility from a source other than the METAR is used, round to the nearest visibility in the table, rounding down if it is right in between two values. For example, .6 and .625 (5/8) would both be rounded to .5 (1/2).

HEAVY = Caution No Holdover Time Guidelines Exist

Figure 20 - FAA Guidance on estimating snow intensity applies to deicing and holdover times

The chart is designed for snow conditions alone and is more conservative than the visibility table from FHM-1 used by the official weather observers in determining snowfall intensities. However; with visibility restricted with snow and some other forms of obscuration (fog, smoke, haze, or freezing fog in this case) the chart does not have to be used to estimate snow intensity for determining holdover times (HOT), as the chart in these cases and will overestimate the actual snowfall intensitity.

[16] Journal of Applied Meteorology, October 1999, "The Estimation of Snowfall Rate Using Visibility", Rasmussen.
[17] FAA N8900.326 – Revised FAA Approved Deicing Program Updates, Winter 2015-2016

F. LIST OF ATTACHMENTS

Attachment 1: Dispatcher Statement
Attachment 2: Flight Release and Weather Document
Attachment 3: NWS Forecasters Statement

Submitted by:

Donald Eick
NTSB Senior Meteorologist