



## **NATIONAL TRANSPORTATION SAFETY BOARD**

Office of Aviation Safety  
Washington, D.C. 20594

March 29, 2018

### **Group Chairman's Factual Report**

# **METEOROLOGY**

WPR18LA010

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## **A. ACCIDENT**

Location: Near Molokai, Hawaii  
Date: October 16, 2017  
Time: 1918 Hawaii standard time  
0518 Coordinated Universal Time (UTC) on October 17, 2017  
Aircraft: Robinson Helicopters R44, N820DF

## **B. METEOROLOGIST**

Paul Suffern  
Senior Meteorologist  
Operational Factors Division (AS-30)  
National Transportation Safety Board

## **C. DETAILS OF THE INVESTIGATION**

The National Transportation Safety Board's (NTSB) Meteorologist did not travel for this investigation and gathered the weather data for this investigation from the NTSB's Washington D.C. office and from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Centers for Environmental Information (NCEI). All times are Hawaii standard time (HST) on October 16, 2017, and are based upon the 24-hour clock, where local time is -10 hours from UTC, and UTC=Z (unless otherwise noted). Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The approximate location of the accident site was at latitude 21.2228° N, longitude 157.1533° W.

## **D. WEATHER INFORMATION**

### **1.0 Synoptic Situation**

The synoptic or large scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction and the Weather Prediction Center, located in College Park, Maryland. These are the base products used in describing synoptic weather features and in the creation of forecasts and warnings for the NWS. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC 00-45H.<sup>1</sup>

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<sup>1</sup>

[https://www.faa.gov/regulations\\_policies/advisory\\_circulars/index.cfm/go/document.information/documentID/1030](https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030)

## 1.1 Surface Analysis Chart

The NOAA Pacific Surface Analysis Chart for 2000 HST is provided as figure 1 with the approximate location of the accident site marked with the red circle. The charts depicted a high-pressure center located north of Hawaii in the central North Pacific Ocean with a surface pressure of 1030-hectopascals (hPa). No low-pressure centers were located near the Hawaiian Islands. Two surface troughs<sup>2</sup> were located between Hawaii and the west coast of the United States. General northeasterly to easterly winds existed over the Hawaiian Island with wind speeds between 10 and 20 knots.

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[235](#)

<sup>2</sup> Trough – An elongated area of relatively low atmospheric pressure or heights.

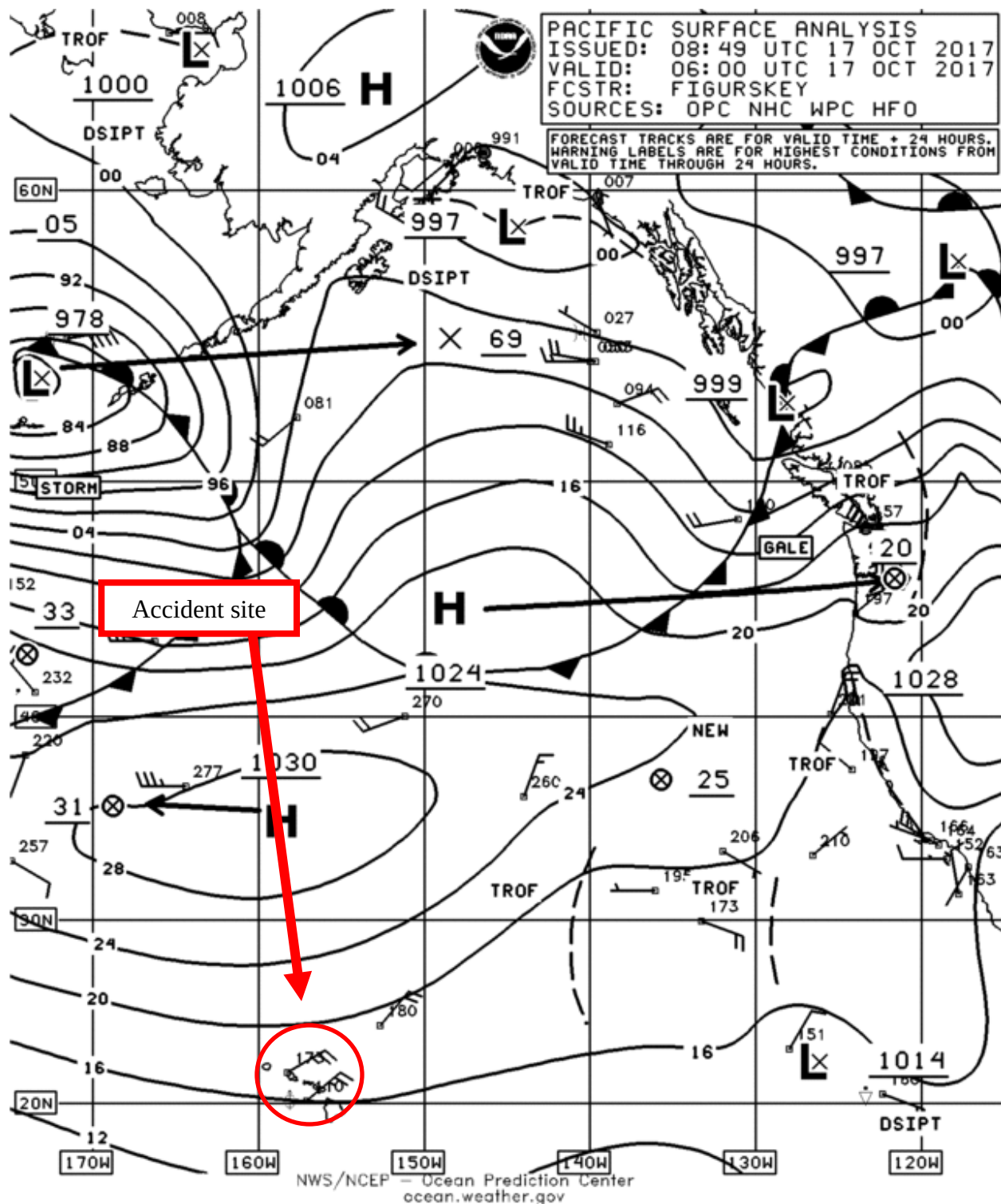


Figure 1 – NOAA North Pacific Surface Analysis Chart for 2000 HST

## 2.0 Surface Observations

The area surrounding the accident site was documented using official Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language with visibility reported in statute miles for this section. Figure 2 is a local sectional chart with the accident site and the closest weather reporting location marked.



**Figure 2 – Sectional map of the accident area with the location of the accident site and surface observation site**

Molokai Airport (PHMK) had the closest official weather station to the accident site located on Molokai Island and was located 6 miles northwest of Kaunakakai, Hawaii. PHMK had an Automated Surface Observing System (ASOS<sup>3</sup>) whose reports were supplemented by air traffic control. PHMK was located 5 miles southeast of the accident site, at an elevation of 454 feet (ft), and had a 11° easterly magnetic variation<sup>4</sup> (figure 2). The following observations were taken and disseminated during the times surrounding the accident:<sup>5</sup>

[1154 HST] METAR PHMK 162154Z 06018G29KT 10SM -RA FEW032 FEW044 BKN060  
28/18 A3002 RMK AO2 PK WND 06032/2057 RAB53 SLP167 P0000  
T02830183=

<sup>3</sup> ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

<sup>4</sup> Magnetic variation – The angle (at a particular location) between magnetic north and true north. 1980, latest measurement taken from <http://www.airnav.com/airport/PHMK>

<sup>5</sup> The bold sections in this NWS product and the rest of products in this report are intended to highlight the sections that directly reference the weather conditions that effected the accident location around the accident time. The local times in section 3.0 next to the METARs are provided for quick reference between UTC and local times around the accident time.

[1254 HST] METAR PHMK 162254Z 05018G29KT 10SM FEW030 SCT038 BKN048 27/18  
A2999 RMK AO2 PK WND 05031/2216 RAE06 SLP158 P0000 T02720183=

[1354 HST] METAR PHMK 162354Z 06019G26KT 10SM FEW029 SCT036 BKN043 24/21  
A2998 RMK AO2 PK WND 04032/2301 RAB28E52 SLP153 P0002  
60002 T02440206 10289 20239 58019=

[1454 HST] METAR PHMK 170054Z 05014G28KT 10SM FEW034 SCT049 28/19 A2997  
RMK AO2 PK WND 08032/0021 SLP147 T02780189=

[1554 HST] METAR PHMK 170154Z 05013G24KT 10SM FEW027 SCT032 BKN043 27/19  
A2997 RMK AO2 PK WND 04028/0121 SLP151 T02720189=

[1654 HST] METAR PHMK 170254Z 05016G27KT 10SM SCT037 26/19 A2999 RMK  
AO2 PK WND 06028/0214 SLP157 T02560189 53004 \$=

**[1754 HST] METAR PHMK 170354Z 06017G24KT 10SM FEW036 SCT050 25/19 A3001  
RMK AO2 PK WND 06027/0303 SLP164 T02500189 \$=**

**[1854 HST] METAR PHMK 170454Z AUTO 03008G21KT 10SM -RA FEW033 BKN060  
BKN070 24/20 A3004 RMK AO2 PK WND 05027/0413 RAB22E31B49  
SLP172 P0000 T02440200 TSNO \$=**

**ACCIDENT TIME 1918 HST**

**[1954 HST] METAR PHMK 170554Z AUTO 04013G24KT 10SM FEW035 FEW042  
SCT070 24/19 A3005 RMK AO2 PK WND 07027/0517 RAE29 SLP179  
P0000 60000 T02440189 10283 20228 51021 TSNO \$=**

**[2054 HST] METAR PHMK 170654Z AUTO 03010G22KT 10SM FEW042 24/19 A3008  
RMK AO2 PK WND 05028/0611 SLP187 T02440189 TSNO \$=**

[2154 HST] METAR PHMK 170754Z AUTO 05014G23KT 10SM FEW039 FEW048  
BKN060 23/20 A3009 RMK AO2 PK WND 06029/0724 RAB04E38  
SLP190 P0002 T02330200 TSNO \$=

[2254 HST] METAR PHMK 170854Z AUTO 06013G26KT 10SM FEW031 SCT047 24/19  
A3009 RMK AO2 PK WND 05026/0849 SLP189 60002 T02390194 50011  
TSNO \$=

PHMK weather at 1754 HST, wind from 060° at 17 knots with gusts to 24 knots, 10 miles visibility or greater, few clouds at 3,600 ft above ground level (agl), scattered clouds at 5,000 ft agl, temperature of 25° Celsius (C), dew point temperature of 19° C, and an altimeter setting of 30.01 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind at 1703 HST from 060° at 27 knots, sea level pressure 1016.4 hPa, temperature 25.0° C, dew point temperature 18.9° C, maintenance is needed on the system.

PHMK weather at 1854 HST, automated, wind from 030° at 8 knots with gusts to 21 knots, 10 miles visibility or greater, light rain, few clouds at 3,300 ft agl, a broken ceiling at 6,000 ft agl, broken skies at 7,000 ft agl, temperature of 24° C, dew point temperature of 20° C, and an altimeter setting of 30.04 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind at 1813 HST from 050° at 27 knots, rain began at 1822 HST, rain ended at 1831 HST, rain began at 1849 HST, sea level pressure 1017.2 hPa, a trace of precipitation since 1754 HST, temperature 24.4° C, dew point temperature 20.0° C, thunderstorm information not available, maintenance is needed on the system.

PHMK weather at 1954 HST, automated, wind from 040° at 13 knots with gusts to 24 knots, 10 miles visibility or greater, few clouds at 3,500 ft agl, few clouds at 4,200 ft agl, scattered clouds at 7,000 ft agl, temperature of 24° C, dew point temperature of 19° C, and an altimeter setting of 30.05 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind at 1917 HST from 070° at 27 knots, rain ended at 1929 HST, sea level pressure 1017.9 hPa, a trace of precipitation since 1854 HST, 6-hourly precipitation of a trace, temperature 24.4° C, dew point temperature 18.9° C, 6-hourly maximum temperature of 28.3° C, 6-hourly minimum temperature of 22.8° C, 3-hourly pressure increase of 2.1 hPa, thunderstorm information not available, maintenance is needed on the system.

PHMK weather at 2054 HST, automated, wind from 030° at 10 knots with gusts to 22 knots, 10 miles visibility or greater, few clouds at 4,200 ft agl, temperature of 24° C, dew point temperature of 19° C, and an altimeter setting of 30.08 inches of mercury. Remarks: automated station with a precipitation discriminator, peak wind at 2011 HST from 050° at 28 knots, sea level pressure 1018.7 hPa, temperature 24.4° C, dew point temperature 18.9° C, thunderstorm information not available, maintenance is needed on the system.

The observations from PHMK surrounding the accident time indicated VFR<sup>6</sup> conditions with periods of light rain and gusty surface winds from the northeast. The rain shower activity near Molokai will be further described in section 5.4 along with the movement and location of the accident flight.

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<sup>6</sup> Visual Flight Rules – Refers to the general weather conditions pilots can expect at the surface. VFR criteria means a ceiling greater than 3,000 feet agl and greater than 5 miles visibility.

### 3.0 Upper Air Data

A Global Data Assimilation System (GDAS) model sounding was created for the accident site for 2000 HST. The 2000 HST sounding was plotted on a standard Skew-T log P diagram<sup>7</sup> with the derived stability parameters included in figure 3 (with data from the surface to 600-hPa, or about 14,000 ft above msl.) This data was analyzed using the RAOB<sup>8</sup> software package. The sounding depicted the lifted condensation level (LCL)<sup>9</sup> at 3,033 ft, a convective condensation level (CCL)<sup>10</sup> of 5,162 ft, and a level of free convection (LFC)<sup>11</sup> at 3,665 ft. The freezing level was located at 16,342 ft. The precipitable water value was 1.06 inches.

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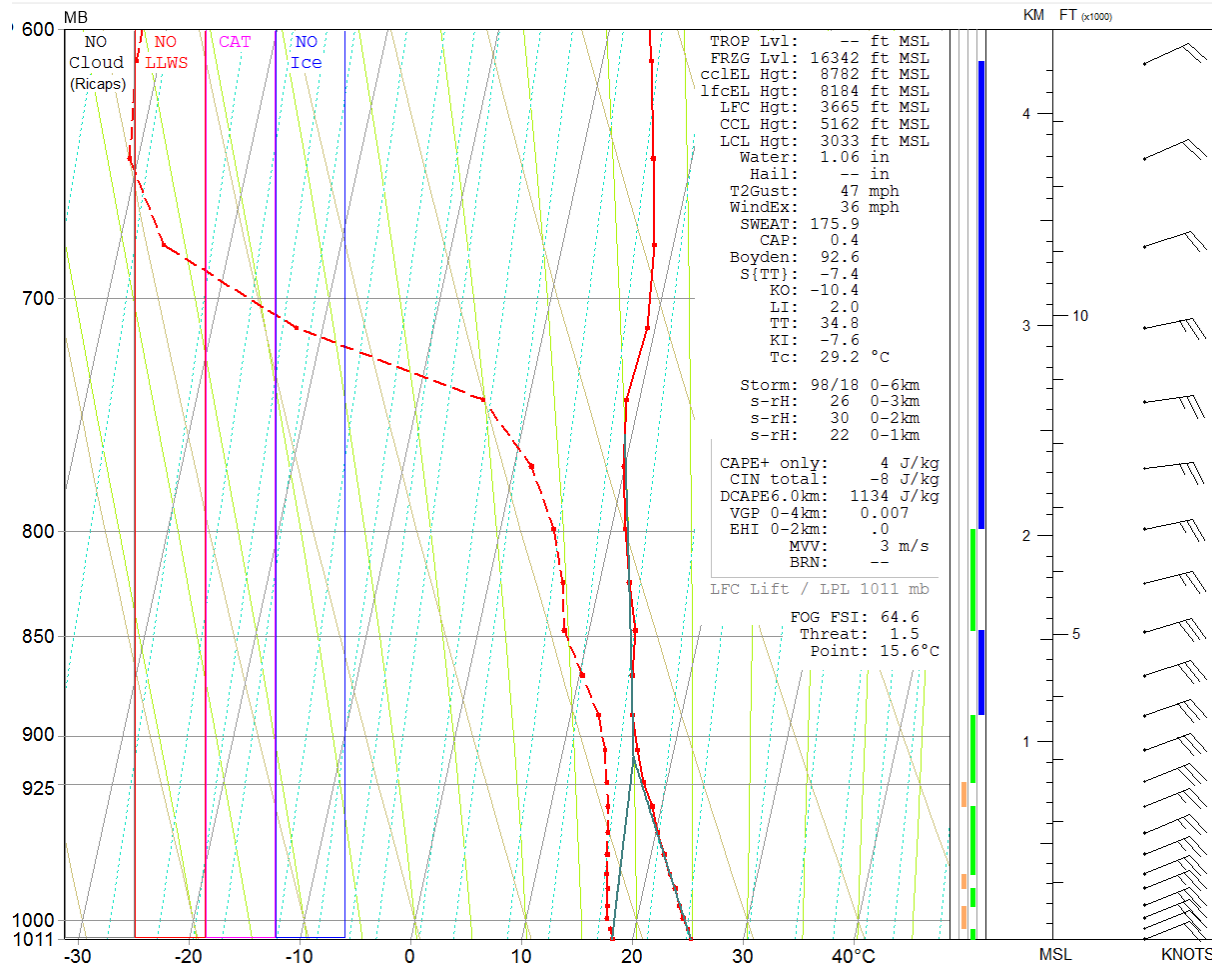
<sup>7</sup> Skew T log P diagram – is a standard meteorological plot using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

<sup>8</sup> RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

<sup>9</sup> Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

<sup>10</sup> Convective Condensation Level (CCL) – The level in the atmosphere to which an air parcel, if heated from below, will rise dry adiabatically, without becoming colder than its environment just before the parcel becomes saturated.

<sup>11</sup> Level of Free Convection (LFC) – The level at which a parcel of saturated air becomes warmer than the surrounding air and begins to rise freely. This occurs most readily in a conditionally unstable atmosphere.



**Figure 3 – 2000 HST GDAS sounding for the accident site**

The 2000 HST GDAS sounding indicated a mix of unstable and conditionally unstable layers between the surface and 4,000 ft with a stable layer between 4,000 and 5,000 ft. 4 Joules/kilogram (J/kg) of CAPE<sup>12</sup> were indicated on the GDAS sounding with the maximum vertical velocity of a rain shower and/or thunderstorm updraft of 3 meters-per-second (~ 6 knots). Downdraft CAPE (DCAPE; 6 kilometers agl)<sup>13</sup> was measured at 1,134 J/kg. RAOB did not identify the possibility of clouds from the surface through about 14,000 ft. No structural icing conditions were identified below 14,000 ft. RAOB identified the possibility of downdrafts coming out of the bottom of rain shower activity with wind gusts to 47 miles per hour (mph) (~ 41 knots) in the T2Gust parameter and wind gusts to 36 mph (~31 knots) in the WindEx parameter.

<sup>12</sup> Convective Available Potential Energy (CAPE) – CAPE is a measure of the amount of energy available for convection and is directly related to the maximum potential vertical speed within an updraft.

<sup>13</sup> The DCAPE can be used to estimate the potential strength of rain-cooled downdrafts within thunderstorm convection, and is similar to CAPE. Larger DCAPE values are associated with stronger downdrafts.

The 2000 HST GDAS sounding wind profile indicated a surface wind from 067° at 21 knots with the wind remaining primarily easterly through about 14,000 ft. The wind speed remained between 20 to 30 knots between the surface and about 14,000 ft. RAOB did not indicate a possibility of low-level wind shear or clear air turbulence outside of rain shower activity below 14,000 ft.

#### 4.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 15 (GOES-15) data was obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the NTSB's Man-computer Interactive Data Access System software. Visible and infrared imagery (GOES-15 band 1 and 4) at wavelengths of 0.65 microns ( $\mu\text{m}$ ) and 10.7  $\mu\text{m}$ , respectively, were retrieved for the period. Satellite imagery surrounding the time of the accident, from 1600 HST through 2200 HST at approximately 15-minute intervals were reviewed, and the closest images to the time of the accident are documented here.

Figures 4, 5, and 6 present the GOES-15 infrared imagery from 1900, 1915, and 1930 HST at 6X magnification with the accident site highlighted with a red square. The infrared imagery indicated the cloud cover was moving from east to west across Molokai Island with cloud cover above the accident site at 1915 HST (figure 5). The colder brightness temperatures (red and yellow colors) were located across the southern portion of the Hawaiian Islands. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 2000 HST GDAS sounding, the approximate cloud-top heights over the accident site were 6,000 ft at 1915 HST. It should be noted these figures have not been corrected for any parallax error.

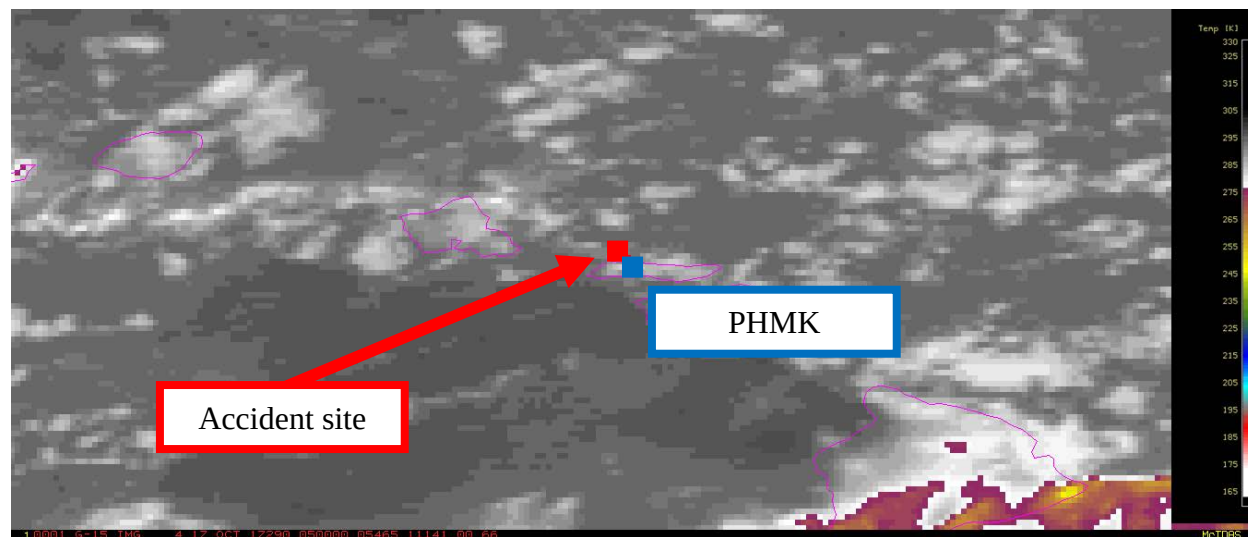
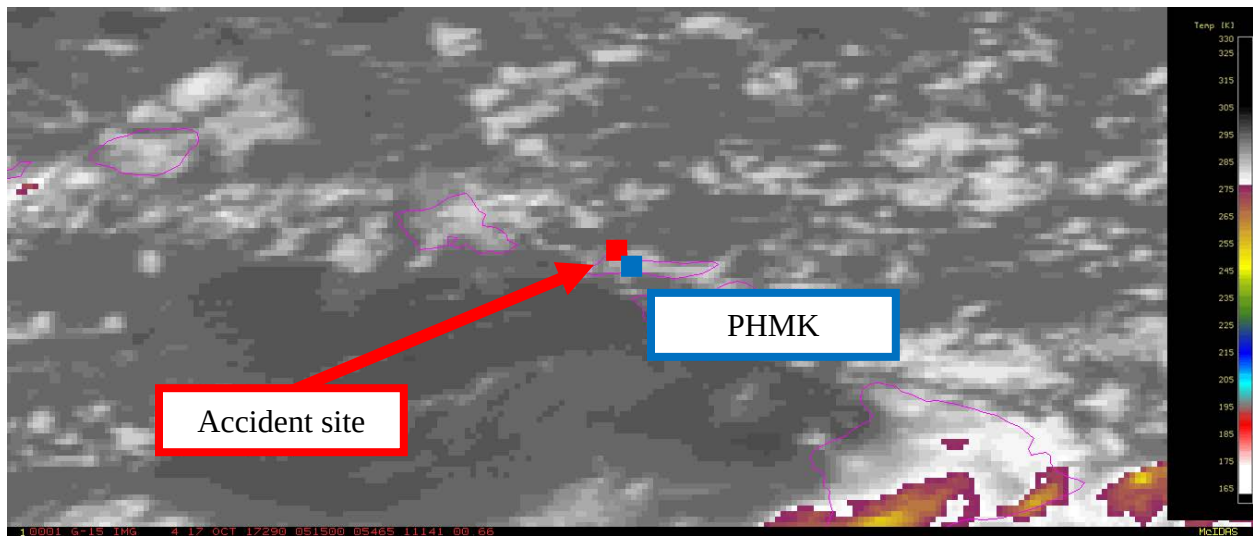
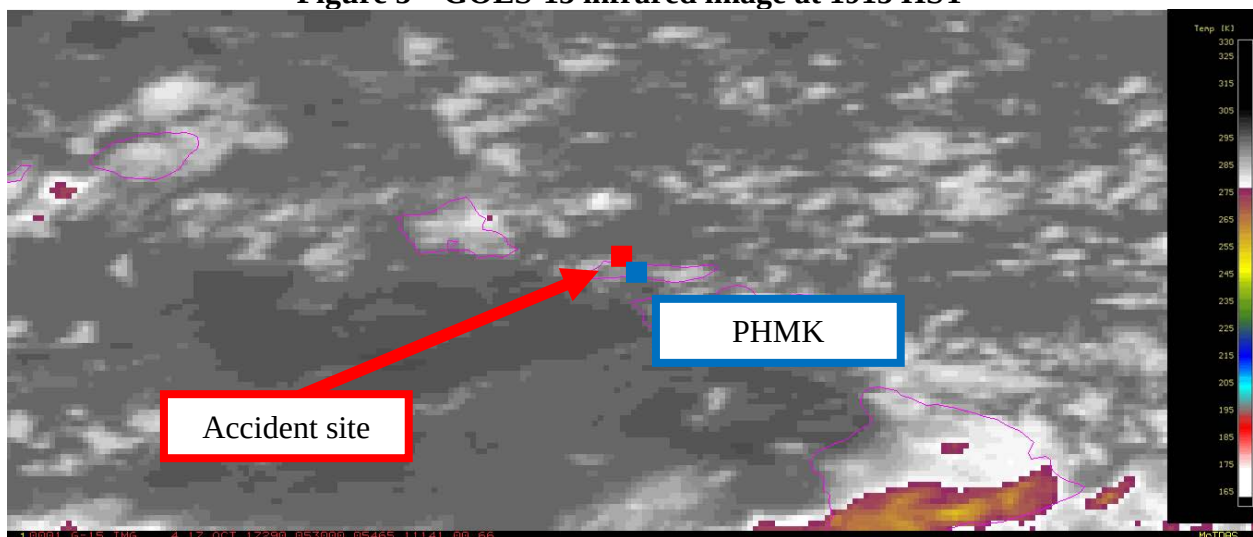


Figure 4 – GOES-15 infrared image at 1900 HST



**Figure 5 – GOES-15 infrared image at 1915 HST**



**Figure 6 – GOES-15 infrared image at 1930 HST**

## 5.0 Radar Imagery Information

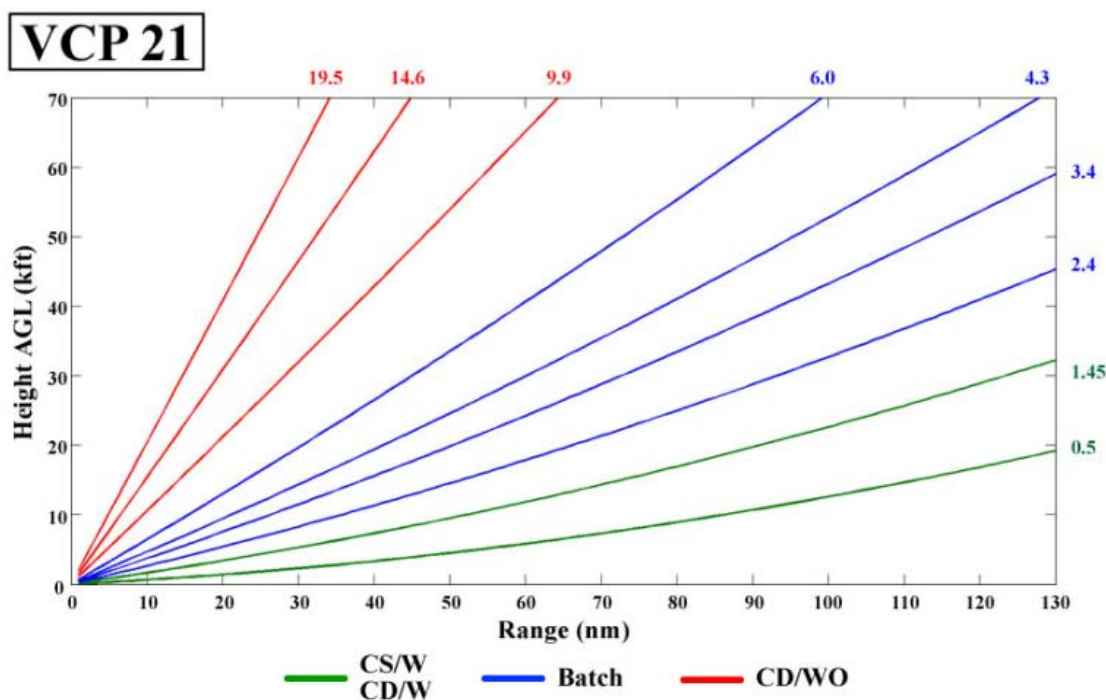
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)<sup>14</sup> to the accident site was the Molokai, Hawaii, radar (PHMO), which was located 6 miles south-southwest of the accident site at an elevation of 1,363 ft. Level II and III archive radar data were obtained from the NCEI using the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

<sup>14</sup> The WSR-88D is an S-band 10-centimeter wavelength radar with a power output of 750,000 watts, and with a 28-foot parabolic antenna that concentrates the energy between a 0.87° and 0.96° beam width. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width.

## 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 five to ten-minute volume scan.

The WSR-88D operates in several different scanning modes, identified as Mode A and Mode B. Mode A is the precipitation scan and has three common scanning strategies. The most common is where the radar makes 9 elevation scans from 0.5° to 19.5° every six minutes. This particular scanning strategy is documented as volume coverage pattern 21 (VCP-21). Mode B is the clear-air mode, where the radar makes 5 elevation scans during a ten-minute period. During the period surrounding the accident, the PHMO WSR-88D radar was operating in the precipitation mode (Mode A, VCP-21). 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.



VCP-21 Precipitation Mode Scan Strategy<sup>15</sup>

<sup>15</sup> Contiguous Surveillance (CS)--The low Pulse Repetition Frequency (PRF) scan of the split cut. Gives a high  $R_{max}$  value to determine proper target location and intensity, but a low  $V_{max}$  value limits the velocities that can be measured. Contiguous Doppler (CD)--The high PRF scan of the split cut. Gives a low  $R_{max}$  value causing more range folded (multiple trip) echoes, but a high  $V_{max}$  value to get higher, more accurate velocity values.

Batch Mode – Uses alternating low and high PRFs on each radial for one full rotation at each elevation angle. The two resulting data sets (low PRF and high PRF) are combined to resolve range ambiguity. Used in the middle elevation angles.

W – With range unfolding (W)

WO – Without range unfolding (WO)

## 5.2 Beam Height Calculation

Assuming standard refraction<sup>16</sup> of the WSR-88D 0.95° wide radar beam, the following table shows the approximate beam height and width<sup>17</sup> information<sup>18</sup> of the radar display over the site of the accident. The heights have been rounded to the nearest 10 ft.

| ANTENNA ELEVATION | BEAM CENTER | BEAM BASE | BEAM TOP | BEAM WIDTH |
|-------------------|-------------|-----------|----------|------------|
| 0.5°              | 1,700 ft    | 1,400 ft  | 2,000 ft | 600 ft     |
| 1.5°              | 2,340 ft    | 2,040 ft  | 2,640 ft | 600 ft     |
| 2.4°              | 2,910 ft    | 2,610 ft  | 3,210 ft | 600 ft     |
| 3.4°              | 3,540 ft    | 3,240 ft  | 3,840 ft | 600 ft     |
| 4.3°              | 4,110 ft    | 3,810 ft  | 4,410 ft | 600 ft     |

Based on the radar height calculations, the 0.5° through 4.3° elevation scans depicted the conditions between 1,400 ft and 4,410 ft over the accident site. The 3.4° and 4.3° elevation scans “saw” the altitudes closest to the accident flight level before the accident occurred.<sup>19</sup>

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<sup>16</sup> Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

<sup>17</sup> Beam width – A measure of the angular width of a radar beam.

<sup>18</sup> Beamwidth values are shown for legacy resolution products. Super resolution products would have an effective beamwidth that would be approximately half these values.

<sup>19</sup> For more information, please see the air traffic control (ATC) data located in the docket for this accident.

### 5.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors<sup>20</sup> 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<sup>21</sup>), and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C<sup>22</sup>, “Thunderstorms,” dated February 19, 2013, also defines the echo intensity levels and weather radar echo intensity terminology associated with those levels. For dBZ values less than 30 the weather radar echo intensity terminology should be “light.” For dBZ values between 30 and 40, the terminology should be “moderate.” “Heavy” terminology is used for dBZ values greater than 40 dBZ but less than 50 dBZ, inclusive. Finally, any dBZ values above 50 dBZ shall be described as “extreme.” From the NWS, precipitation conditions at the surface can be inferred from VIP Levels described in the chart below:

- VIP 1 (Level 1, 18-30 dBZ) - Light precipitation
- VIP 2 (Level 2, 30-38 dBZ) - Light to moderate rain.
- VIP 3 (Level 3, 38-44 dBZ) - Moderate to heavy rain.
- VIP 4 (Level 4, 44-50 dBZ) - Heavy rain
- VIP 5 (Level 5, 50-57 dBZ) - Very heavy rain; hail possible.
- VIP 6 (Level 6, >57 dBZ) - Very heavy rain and hail; large hail possible.

### 5.4 Base Reflectivity and Lightning Data

Figures 7 through 17 present the PHMO WSR-88D base reflectivity images for the 0.5°, 1.5°, 2.4°, 3.4°, and 4.3° elevation scans initiated between 1906 and 1919 HST, with a resolution of 0.5° X 250 m. Base reflectivity values between 30 to 50 dBZ were located above the accident site around the accident time. The rain shower (red circle in figures 7 through 17) moved west-southwestward with time and was located between 5 and 10 miles east-northeast of the accident site at 1906 HST. Rain showers and convective clouds produce outflow boundaries and gust fronts throughout their life cycle. An outflow boundary or gust front can create an environment favorable for unexpected changes in wind direction and speed (figure 18). There were no lightning strikes around the accident site at the accident time.<sup>23</sup>

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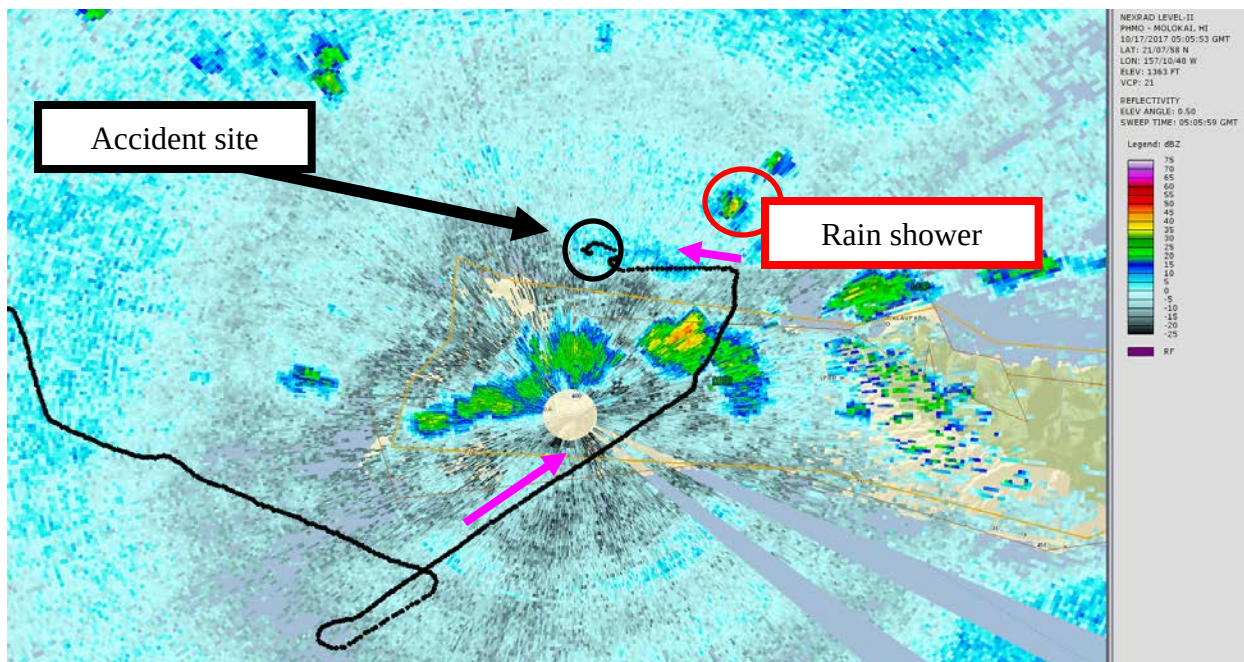
<sup>20</sup> Hydrometeors are any product of condensation or sublimation of atmospheric water vapor, whether formed in the free atmosphere or at the earth’s surface; also, any water particles blown by the wind from the earth’s surface. Hydrometeors are classified as; (a) Liquid or solid water particles 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 glazed ice.

<sup>21</sup> dBZ – A non-dimensional “unit” of radar reflectivity which represents a logarithmic power ratio (in decibels , or dB) with respect to radar reflectivity factor, Z.

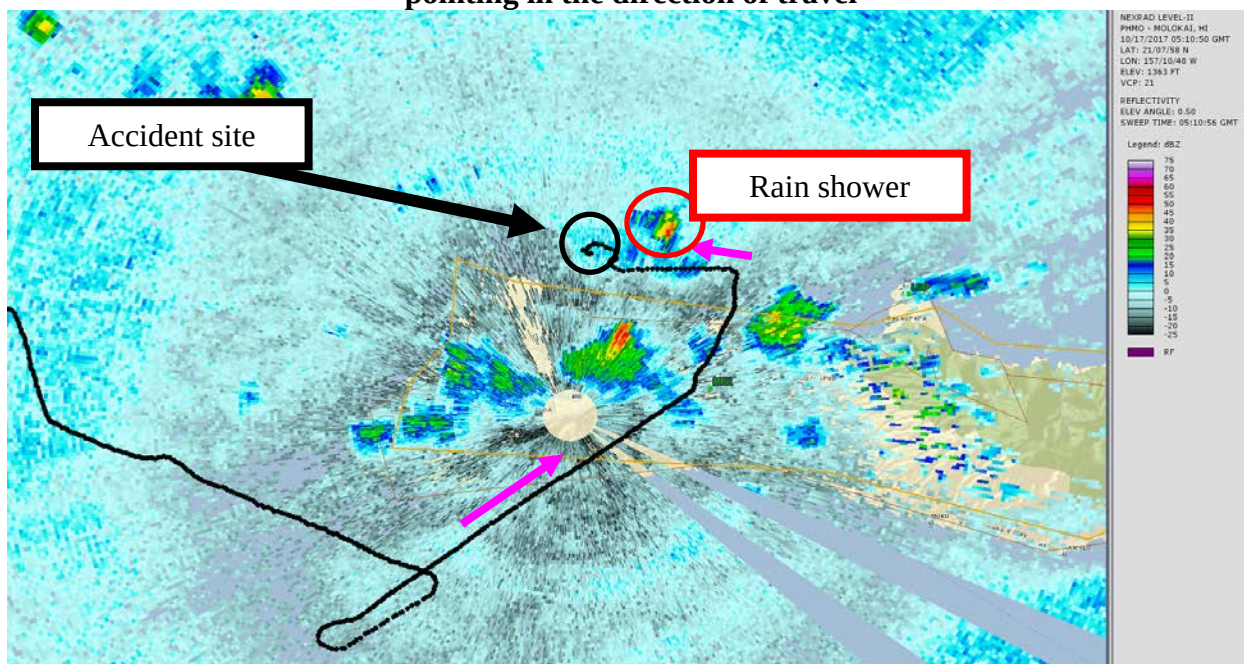
<sup>22</sup>

[https://www.faa.gov/regulations\\_policies/advisory\\_circulars/index.cfm/go/document.information/documentID/1030235](https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030235)

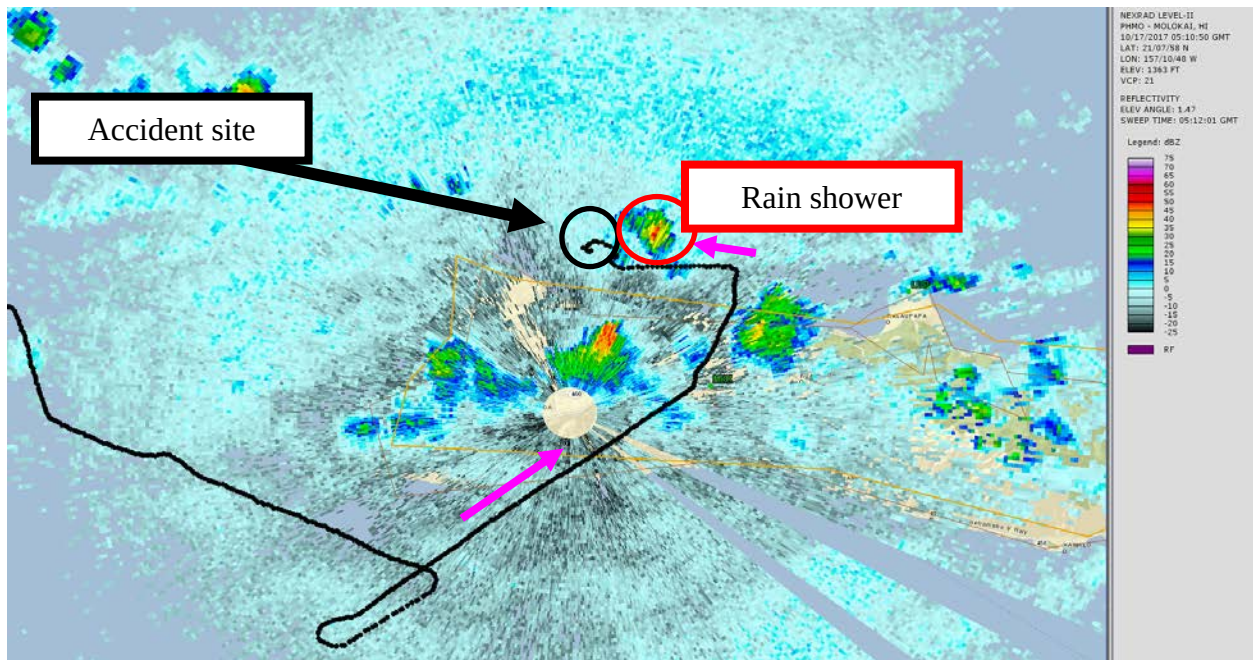
<sup>23</sup> A review of data from the Earth Networks Total Lightning Network was performed.



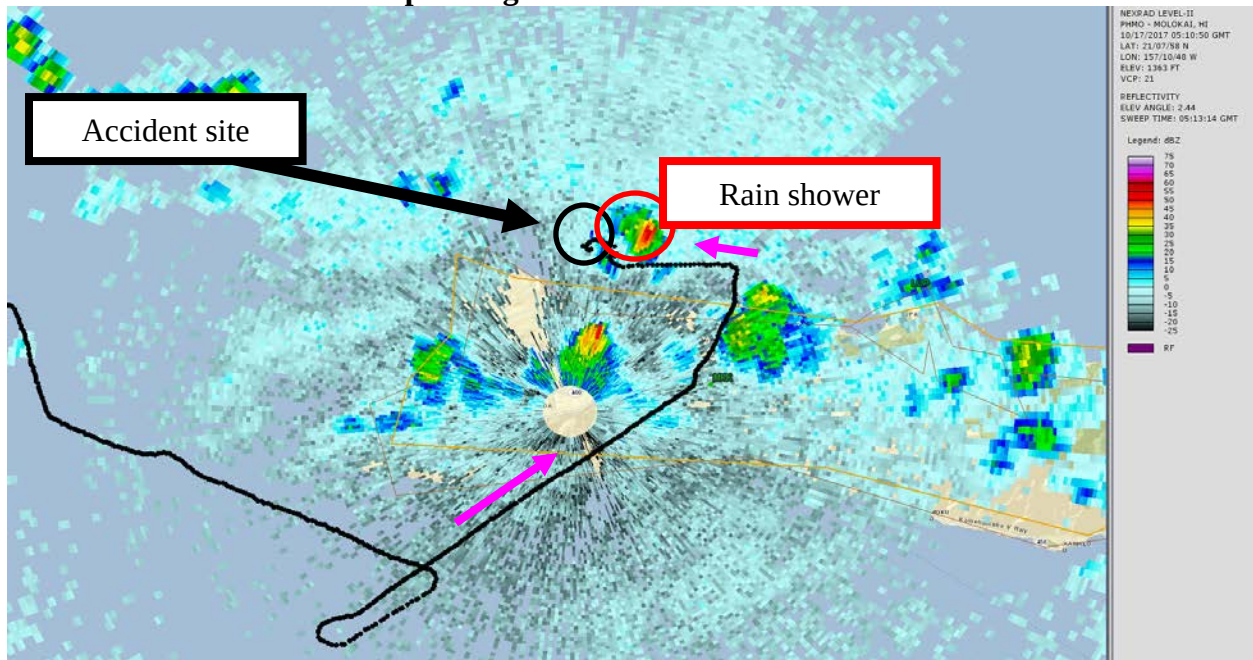
**Figure 7 – PHMO WSR-88D reflectivity for the 0.5° elevation scan initiated at 1906 HST with the accident site marked with black circle and ATC track as black dots with arrows pointing in the direction of travel**



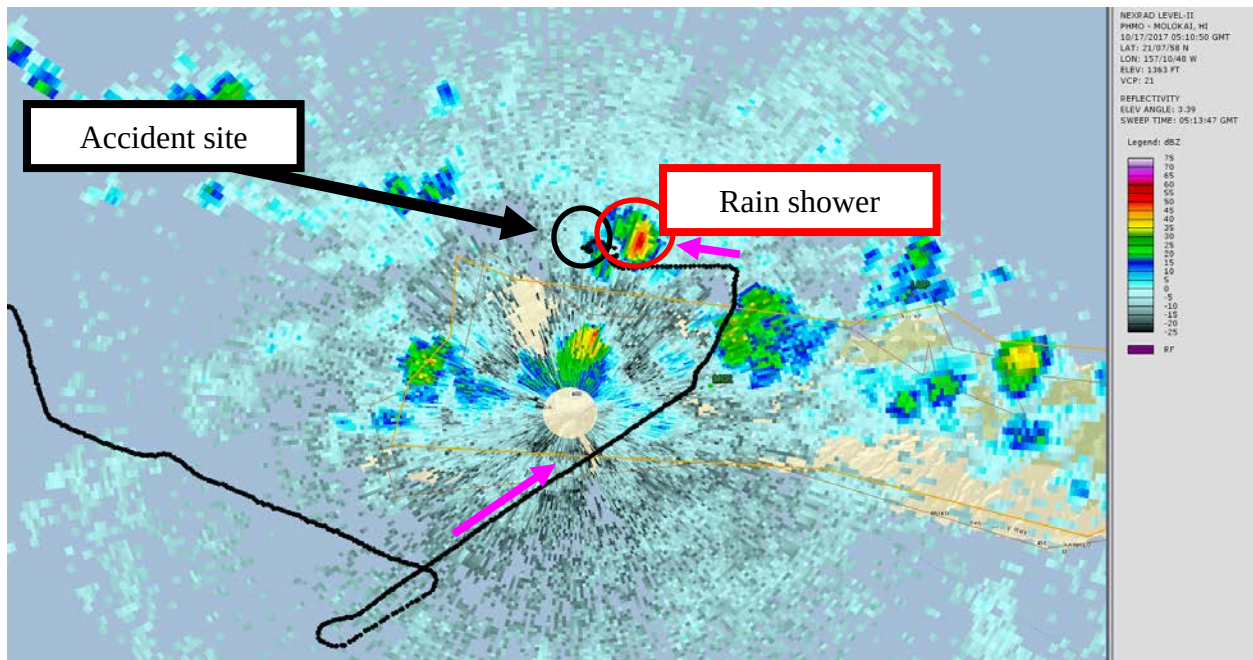
**Figure 8 – PHMO WSR-88D reflectivity for the 0.5° elevation scan initiated at 1911 HST with the accident site marked with black circle and ATC track as black dots with arrows pointing in the direction of travel**



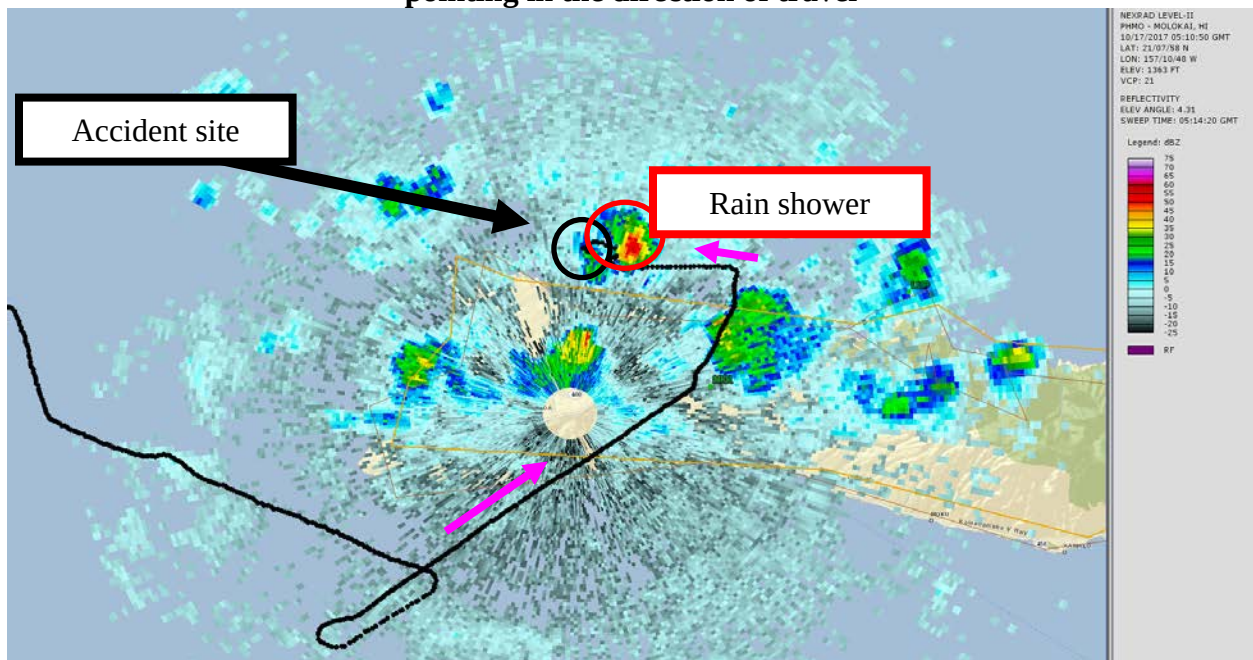
**Figure 9 – PHMO WSR-88D reflectivity for the 1.5° elevation scan initiated at 1912 HST with the accident site marked with black circle and ATC track as black dots with arrows pointing in the direction of travel**



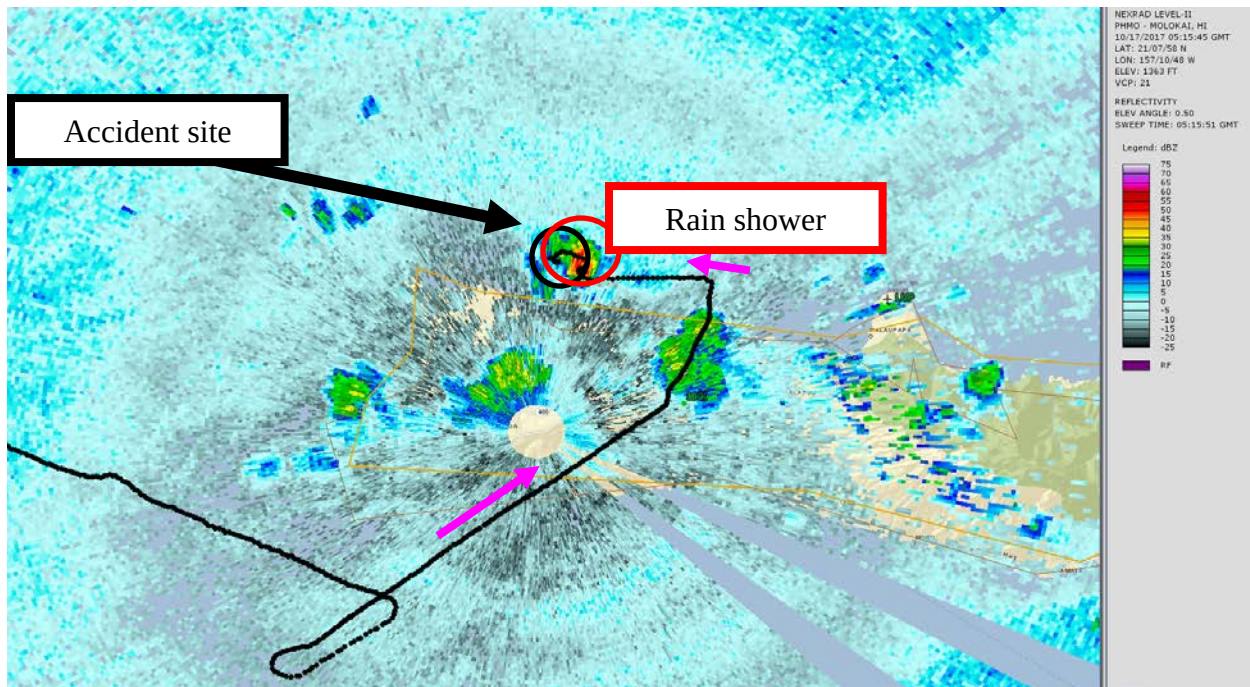
**Figure 10 – PHMO WSR-88D reflectivity for the 2.4° elevation scan initiated at 1913 HST with the accident site marked with black circle and ATC track as black dots with arrows pointing in the direction of travel**



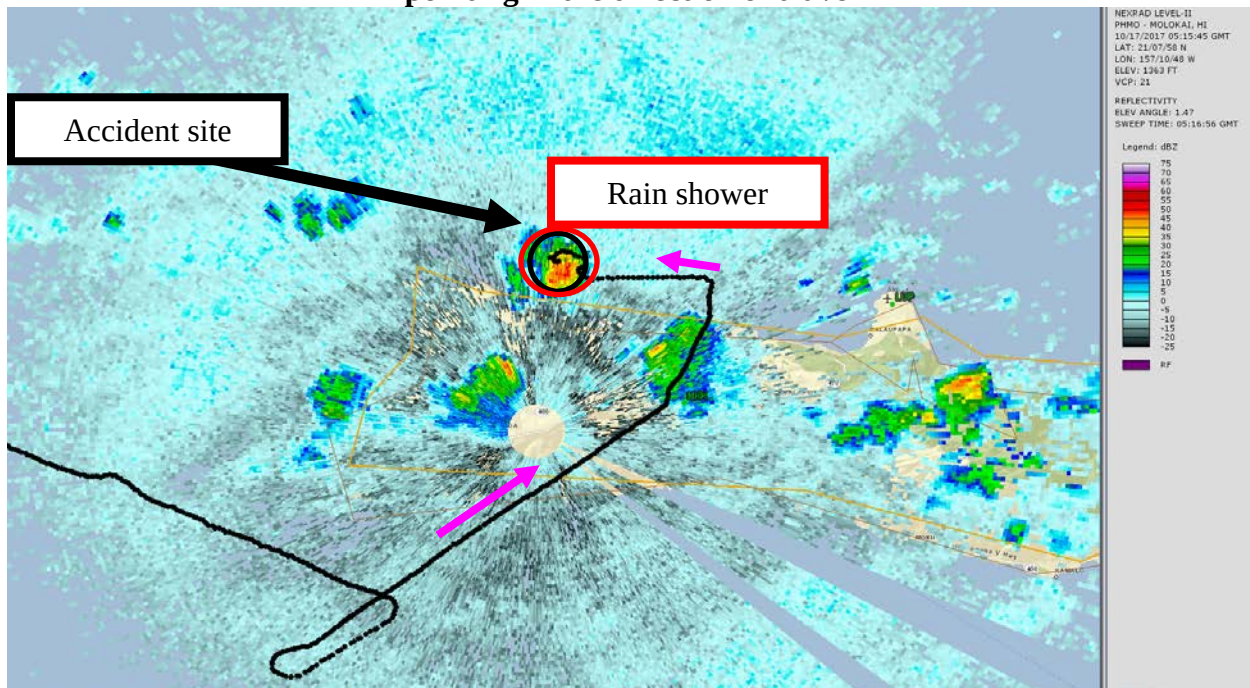
**Figure 11 – PHMO WSR-88D reflectivity for the 3.4° elevation scan initiated at 1914 HST with the accident site marked with black circle and ATC track as black dots with arrows pointing in the direction of travel**



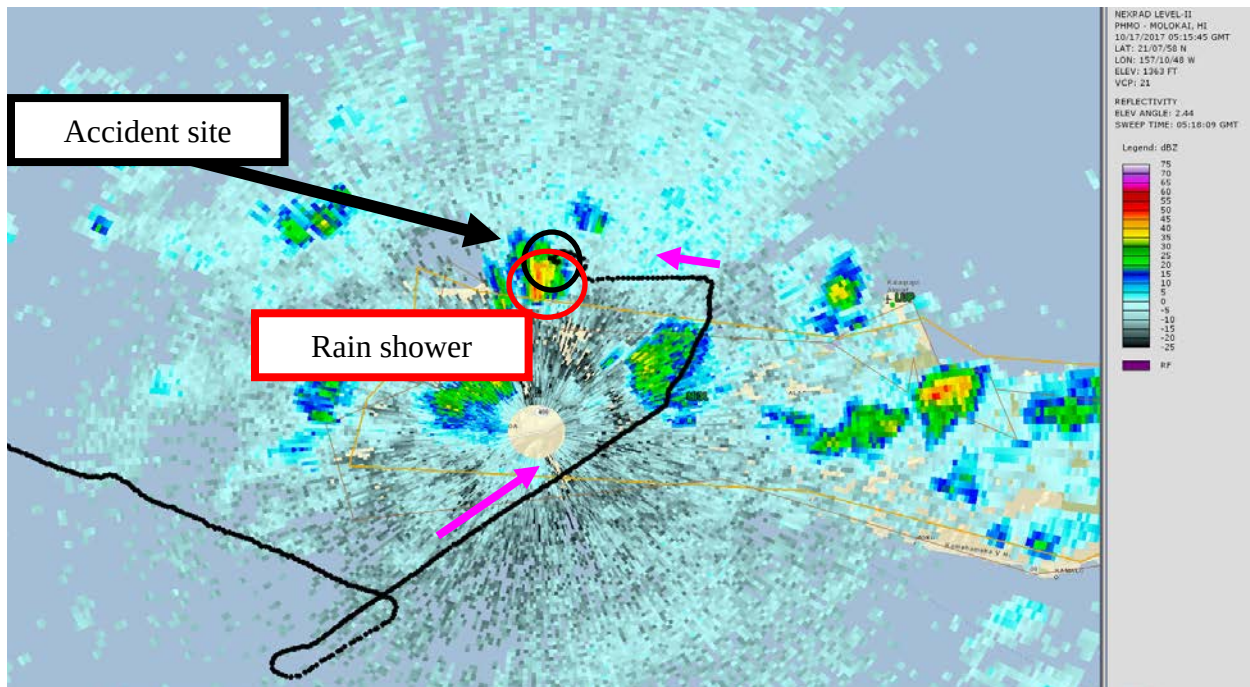
**Figure 12 – PHMO WSR-88D reflectivity for the 4.3° elevation scan initiated at 1914 HST with the accident site marked with black circle and ATC track as black dots with arrows pointing in the direction of travel**



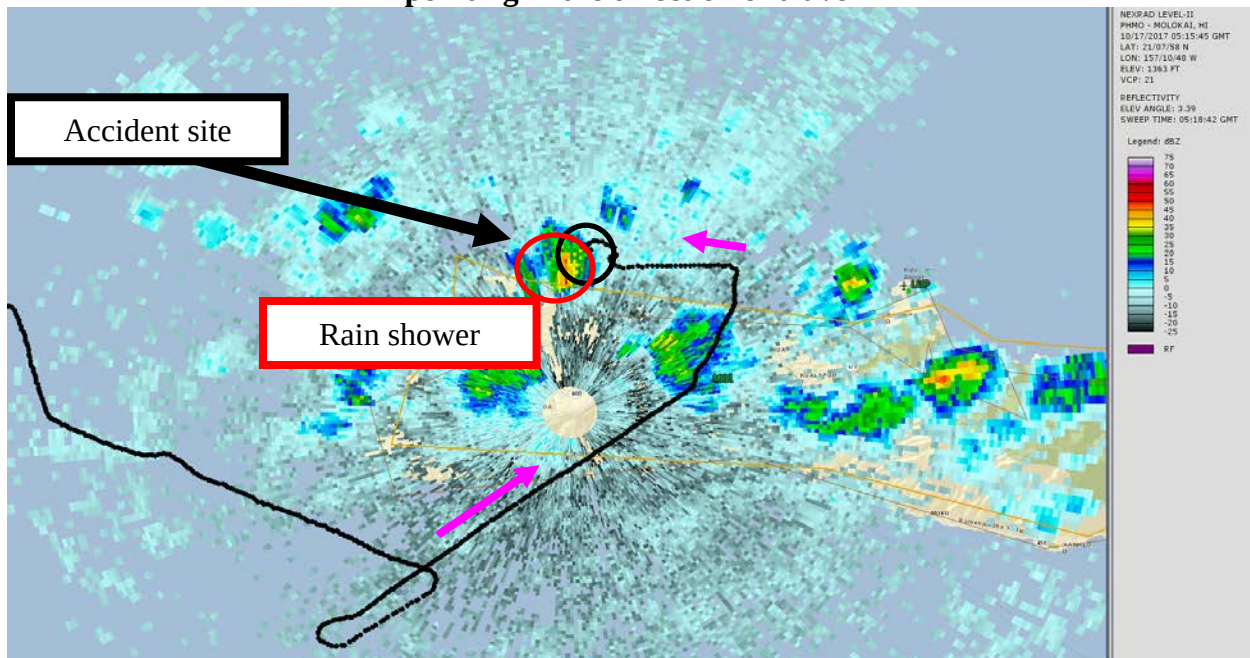
**Figure 13 – PHMO WSR-88D reflectivity for the 0.5° elevation scan initiated at 1916 HST with the accident site marked with black circle and ATC track as black dots with arrows pointing in the direction of travel**



**Figure 14 – PHMO WSR-88D reflectivity for the 1.5° elevation scan initiated at 1917 HST with the accident site marked with black circle and ATC track as black dots with arrows pointing in the direction of travel**



**Figure 15 – PHMO WSR-88D reflectivity for the 2.4° elevation scan initiated at 1918 HST with the accident site marked with black circle and ATC track as black dots with arrows pointing in the direction of travel**



**Figure 16 – PHMO WSR-88D reflectivity for the 3.4° elevation scan initiated at 1919 HST with the accident site marked with black circle and ATC track as black dots with arrows pointing in the direction of travel**

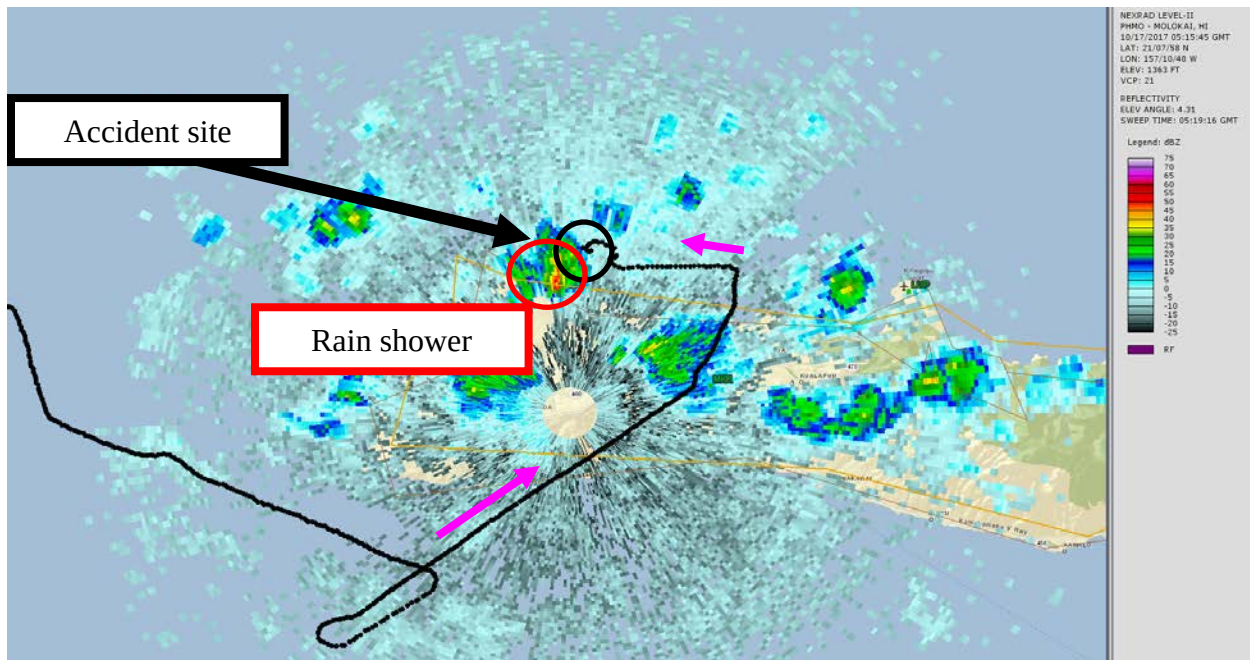


Figure 17 – PHMO WSR-88D reflectivity for the 4.3° elevation scan initiated at 1919 HST with the accident site marked with black circle and ATC track as black dots with arrows pointing in the direction of travel

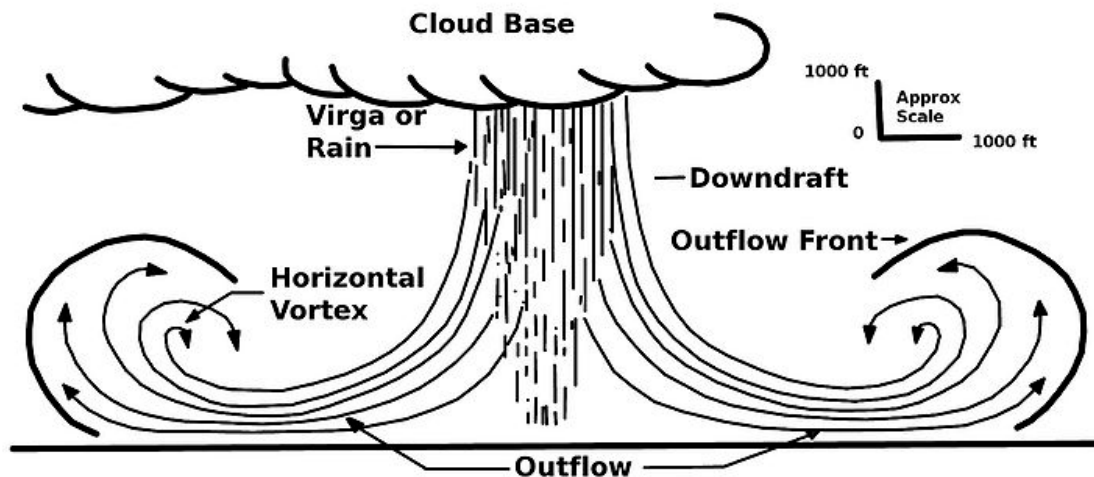


Figure 18 – Exemplar diagram of a downburst and outflow

## 6.0 Pilot Reports<sup>24</sup>

All pilot reports (PIREPs) within 200 miles of the accident site from about two hours prior to the accident time to about two hours after the accident time for below FL180<sup>25</sup> are provided below:

<sup>24</sup> Only pilot reports with the WMO header UBHI\*\* identifier were considered.

<sup>25</sup> Flight Level – A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of ft. This altitude is calculated from the International standard pressure datum of 1013.25 hPa (29.92 inHg), the average sea-level pressure, and therefore is not necessarily the same as the aircraft's true altitude either above mean sea level or above ground

HNL UA /OV 4 NE HNL/TM 0412/FL020/TP C208/WX 10SM -RA/TB LT CHOP=

HNL UA /OV OKALA/TM 0555/FL090/TP BE9L/TB MOD/RM MOD RAIN=

Routine pilot report (UA); 4 miles northeast of Honolulu, Hawaii; Time – 1812 HST (0412Z); Altitude – 2,000 ft; Type aircraft – Cessna 208; Weather – 10 miles visibility with light rain; Turbulence – Light chop.

Routine pilot report (UA); Over Okala, Hawaii; Time – 1955 HST (0555Z); Altitude – 9,000 ft; Type aircraft – Beech 90 King Air; Turbulence – Moderate; Remarks – Moderate rain.

One additional PIREP for below FL180 was received and documented by air traffic control at the Honolulu Air Route Traffic Control Center (ARTCC), but this additional PIREP was not distributed into the national airspace. The PIREP is located in attachment 1 and is summarized below:

Routine pilot report (UA); 4 miles on the 360° radial from Kahului, Hawaii; Time – 1824 HST (0424Z); Altitude – 5,500 ft; Type aircraft – Boeing B717-200; Sky Cover – Scattered clouds at 2,000 ft with tops at 7,500 ft.

## 7.0 SIGMET and CWSU Advisory

There were no SIGMETs valid for the accident site at the accident time.

There were no Center Weather Service Unit (CWSU) Meteorological Impact Statements that were valid for the accident site at the accident time. No Center Weather Advisories were valid for the accident site at the accident time.

## 8.0 AIRMETs

An AIRMET Tango was issued at 1718 HST and was valid at the accident time for the accident site. The AIRMET Tango warned of temporary moderate turbulence below 8,000 ft:

WAHW31 PHFO 170318

WA0HI

HNLS WA 170400

AIRMET SIERRA FOR IFR VALID UNTIL 171000

.

NO SIGNIFICANT IFR EXP.

=HNLT WA 170400

AIRMET TANGO FOR TURB VALID UNTIL 171000

.

**AIRMET TURB...HI**

**OVR AND IMT S THRU W OF MTN ALL ISLANDS.**

**TEMPO MOD TURB BLW 080. COND CONT BEYOND 1000Z.**

---

level.

=HNLZ WA 170400  
AIRMET ZULU FOR ICE AND FZLVL VALID UNTIL 171000

.  
NO SIGNIFICANT ICE EXP.

.  
FZLVL...158-155.

## **9.0 Area Forecast**

The Area Forecast issued at 1718 HST, valid at the accident time, forecasted scattered clouds at 2,500 ft, with scattered clouds to a broken ceiling at 4,500 ft to 6,000 ft with tops at 10,000 ft. Temporary conditions of a broken ceiling at 2,500 ft with tops to 12,000 ft and visibilities between 3 and 5 miles with moderate rain showers and mist were also forecast. Isolated conditions were forecast to be visibilities below 3 miles with moderate rain showers and mist:

FAHW31 PHFO 170318  
FA0HI

HNLC FA 170335  
SYNOPSIS AND VFR CLD/WX  
SYNOPSIS VALID UNTIL 172200  
CLD/WX VALID UNTIL 171600...OUTLOOK VALID 171600-172200

.  
SEE AIRMET SIERRA FOR IFR CLD AND MT OBSC.  
TS IMPLY SEV OR GREATER TURB SEV ICE LOW LEVEL WS AND IFR COND.  
NON MSL HGT INDICATED BY AGL OR CEILING.

.  
SYNOPSIS...HIGH PRESSURE N OF THE AREA WILL DELIVER STRONG  
TRADE WINDS OVER THE STATE. CLOUDS AND SHOWERS WILL FAVOR  
WINDWARD AND MAUKA AREAS.

.  
ENTIRE AREA.  
SFC WIND OVR MTN RIDGES AND THRU VALLEYS NORTHEAST 20-30 KT  
WITH HIGHER GUSTS.

.  
BIG ISLAND AND ADJ WATERS.  
SCT-BKN250. LOWER CLOUD AND WX TO FOLLOW.

.  
BIG ISLAND INTERIOR ABV 100.  
SCT100. OUTLOOK...VFR.

.  
BIG ISLAND LOWER SLOPES...COAST...AND ADJ WATERS FROM UPOLU  
POINT TO CAPE KUMUKAHI TO APUA POINT.  
SCT025 BKN045 BKN080 TOPS 100-120 TEMPO BKN025 OVC035 VIS  
3-5SM SHRA BR ISOL VIS BLW 3SM +SHRA BR.  
OUTLOOK...VFR WIND.

.  
BIG ISLAND LOWER SLOPES AND COAST FROM APUA POINT TO SOUTH CAPE.  
FEW030 SCT045 ISOL BKN045 TOPS 100. OUTLOOK...VFR WIND.

.  
BIG ISLAND LOWER SLOPES AND COAST FROM SOUTH CAPE TO PHKO.  
SCT030 BKN050-070 TOPS 100 ISOL BKN030 VIS 5SM -SHRA. 06Z FEW030  
SCT050-070 ISOL BKN050 TOPS 100. 10Z FEW050. OUTLOOK...VFR WIND.

.  
MTN...N THRU E SECTIONS...AND ADJ WATERS OF MAUI LANAI MOLOKAI  
OAHU AND KAUAI.

SCT025 BKN-SCT045-060 TOPS 100 TEMPO BKN025 TOPS 120 VIS 3-5SM  
SHRA BR ISOL VIS BLW 3SM SHRA BR. OUTLOOK...VFR WIND.

.  
REST OF AREA.

FEW025 SCT040 ISOL BKN040 TOPS 100 -SHRA. OUTLOOK...VFR WIND.

## 10.0 Terminal Aerodrome Forecast

PHMK was the closest site to the accident site with a NWS Terminal Aerodrome Forecast (TAF). The TAF valid at the time of the accident was issued at 1331 HST and was valid for a 24-hour period beginning at 1400 HST. The TAF for PHMK was as follows:

TAF PHMK 162331Z 1700/1724 05022G30KT P6SM VCSH SCT025 BKN045  
**FM170500 05015G23KT P6SM VCSH SCT025 BKN045**  
FM171900 04022G30KT P6SM VCSH SCT025 BKN045=

The forecast expected a wind from 050° at 15 knots with gusts to 23 knots, greater than 6 miles visibility, showers in the vicinity<sup>26</sup>, scattered clouds at 2,500 ft agl, and a broken ceiling at 4,500 ft agl.

## 11.0 NWS Area Forecast Discussion

The NWS office in Honolulu, Hawaii, issued the following Area Forecast Discussion (AFD) at 1600 HST (closest AFD to the accident time). The aviation section of the AFD discussed that the trade winds would continue and bring strong gusty northeast winds and AIRMET Tango was valid for that. Scattered rain showers were forecast to continue through the day with reduced ceilings and visibilities in the showers:

FXHW60 PHFO 170200  
AFDHFO

Area Forecast Discussion  
National Weather Service Honolulu HI  
400 PM HST Mon Oct 16 2017

.SYNOPSIS...

High pressure north of Hawaii will keep a windy trade wind pattern in place through much of the upcoming work week, with the trades trending down slightly Friday and weakening further over the weekend. Clouds and showers will favor windward and mauka areas through the period, but showers will reach leeward areas from time to time as well due to the strength of the trades.

&&

.DISCUSSION...

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<sup>26</sup> In the vicinity of the airport is defined as a weather phenomenon within 5-10 miles of the airfield, but not over the airfield.

A 1029 mb surface high centered around 925 miles north of Honolulu, is driving windy trades across the island chain. Visible satellite imagery shows partly to mostly cloudy skies, with cloud cover most prevalent over windward and mauka sections. Scattered showers continue to focus over windward areas, occasionally passing to leeward sides of the smaller islands due to the strong trades.

High pressure north of the state will slowly move southwest over the next couple of days, with a re-enforcing high building in behind it midweek. The high will then move southeast and weaken Friday, and especially over the weekend as a cold front approaches from the northwest. As a result, a tight pressure gradient will remain in place over Hawaii, and will persist the windy trades through Thursday. A Wind Advisory remains in effect for the entire state with the exception of the Haleakala and Big Island summits through 10 pm this evening. The Wind Advisory will likely be need to be extended for some areas of the state for Tuesday, and possibly on Wednesday and Thursday. Trades will taper off on Friday, and then weaken further over the weekend.

As for sensible weather details, fairly typical trade wind weather is expected continue through the next several days, with clouds and showers favoring windward and mauka areas. Showers coverage will be greatest at night, and then tapering off during the daytime.

The latest GFS solution indicates that some tropical moisture may try to lift northward into the islands by Sunday as winds shift southeast ahead of an approaching cold front. The ECMWF solution delays the moisture arrival until Monday. Will keep the forecast featuring typical trade wind weather through next weekend and await better model agreement before deviating away from climatology.

&&

#### **.AVIATION...**

**Strong and gusty NE trade winds will continue through most of the week. AIRMET TANGO for low level turbulence is posted across the state.**

**Scattered showers will continue to move over with the trades. Most clouds and showers will focus along the windward and mauka areas; the strong trade winds will carry a few showers to leeward areas. Periods of MVFR CIGS/VIS can be expected in passing showers. Otherwise, VFR conditions will prevail.**

&&

#### **.MARINE...**

Very strong and gusty trade winds will continue through much of this week due to a nearly-stationary, strong surface high N of the main Hawaiian Islands. This high will be replaced by another strong on Wednesday night, continuing the windy conditions for an additional day or so. Gale warnings are posted for the Pailolo

and Alenuihaha channels Thursday afternoon, while a Small Craft Advisory remains in effect for the remaining Hawaiian waters through the same time. Trades should begin on Friday as the high starts to weaken and move off to the east.

The strong to gale-force trade winds are also causing very rough, choppy, and dangerous seas around the islands. Surf is also elevated along E facing shores of all islands, with a high surf advisory in effect through Wednesday afternoon. This advisory will likely be extended toward midweek.

A long-period S swell will peak this evening through Tuesday morning around 4 feet. The High Surf Advisory for the S facing shores of all islands has been extended through Tuesday due to the lingering swell. The next S swell will be a smaller and is slated for the upcoming weekend.

The current NNW swell is on its way down with a shorter period. The next NNW swell is slated to arrive Thursday night, building to a peak of around 6 feet early Friday with a long period of 16 to 19 seconds. Expect moderate size surf from this swell, but remaining below advisory level. A somewhat larger NW swell is due in Sunday night and Monday of next week, with the surf potentially approaching high surf advisory levels along the N and W facing shores.

The Oahu Surf Discussion (SRDHFO) has detailed information regarding the swell sources.

&&

#### .FIRE WEATHER...

Strong trade winds coupled with a drier airmass pushing over the state will allow minimum relative humidity to drop into the 40 to 45 percent range during the next few afternoon. These conditions create potential for a fire to ignite easier than usual and to spread quickly if they do. The windy and relatively dry conditions will continue through the end of the work week before the trade winds weaken. The Keetch- Byram Drought Index, or KBDI, is at 572 today (and would need to be at 600 for Red Flag Warning criteria). Keep in mind that we will be close to these conditions each afternoon.

&&

#### .HFO WATCHES/WARNINGS/ADVISORIES...

Wind Advisory until 10 PM HST tonight for all portions of the state except for the Big Island summits and Haleakala summit.

High Surf Advisory until 6 PM HST Tuesday for south facing shores of Niihau, Kauai, Oahu, Molokai, Lanai, Kahoolawe and the Big Island.

High Surf Advisory until 6 PM HST Wednesday for east facing shores of Kauai, Oahu, Molokai, Maui and the Big Island.

Gale Warning until 6 AM HST Thursday for Pailolo Channel and Alenuihaha Channel.

Small Craft Advisory until 6 AM HST Thursday for all remaining coastal waters.

&&

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## 12.0 Winds and Temperature Aloft Forecast

The NWS 1602 HST Winds and Temperature Aloft forecast valid for the accident flight is included below:

FBHW31 KWN0 170202  
FD1HW1  
DATA BASED ON 170000Z  
VALID 170600Z FOR USE 0200-0900Z. TEMPS NEG ABV 24000

|            |             |             |             |             |                |                |                |                |                |                |
|------------|-------------|-------------|-------------|-------------|----------------|----------------|----------------|----------------|----------------|----------------|
| FT         | 1000        | 1500        | 2000        | 3000        | 6000           | 9000           | 12000          | 15000          | 18000          | 24000          |
| LIH        | 0724        | 0728        | 0730        | 0731        | 0824+11        | 0825+12        | 0720+07        | 0622+03        | 0619-06        | 0311-19        |
| <b>HNL</b> | <b>0629</b> | <b>0631</b> | <b>0632</b> | <b>0734</b> | <b>0724+11</b> | <b>0725+11</b> | <b>0619+07</b> | <b>0621+03</b> | <b>0519-06</b> | <b>3613-18</b> |
| <b>LNy</b> |             |             | <b>0634</b> | <b>0736</b> | <b>0726+12</b> | <b>0821+10</b> | <b>0619+08</b> | <b>0621+03</b> | <b>0519-06</b> | <b>3415-18</b> |
| OGG        | 0726        | 0728        | 0729        | 0732        | 0729+12        | 0724+10        | 0618+08        | 0619+03        | 0520-06        | 3517-18        |
| KOA        | 0518        | 0619        | 0616        | 0714        | 0809+13        | 0807+08        | 0616+08        | 0518+04        | 0414-05        | 3215-18        |
| ITO        | 0512        | 0513        | 0614        | 0620        | 0615+09        | 0513+07        | 0615+08        | 0519+03        | 0315-05        | 3216-18        |

The accident site was between the forecast point at Honolulu, Hawaii, (HNL), and the forecast point at Lanai City, Hawaii, (LNy). The 1602 HST HNL forecast indicated a wind from 060° at 29 knots at 1,000 ft, a wind from 060° at 31 knots at 1,500 ft, a wind from 060° at 32 knots at 2,000 ft, a wind from 070° at 34 knots at 3,000 ft, and a wind from 070° at 24 knots with a temperature of 11° C at 6,000 ft. The 1602 HST LNy forecast indicated a wind from 060° at 34 knots at 2,000 ft, a wind from 070° at 36 knots at 3,000 ft, and a wind from 070° at 26 knots at 6,000 ft with a temperature of 12° C.

## 13.0 Pilot Weather Briefing and Witness Information

A search of official weather briefing sources, such as Leidos Flight Service and Direct User Access Terminal Service (DUATS), revealed that the accident pilot did not request an official weather briefing from Leidos or DUATS.

In addition, a request was sent to ForeFlight to see if the accident pilot requested any weather information. The accident pilot requested ForeFlight weather information at 1803 HST (attachments 2 and 3). The weather briefing information from ForeFlight contained all the standard information including the latest METARs, AIRMETs, PIREPs, Area Forecast, TAFs, and Winds Aloft Forecast. It is unknown if the accident pilot checked any other weather information before or during the accident flight.

#### **14.0 Astronomical Data**

The astronomical data obtained from the United States Naval Observatory for the accident site on October 16, 2017, indicated the following:

##### **SUN**

|                      |          |
|----------------------|----------|
| Begin civil twilight | 0602 HST |
| Sunrise              | 0625 HST |
| Sun transit          | 1214 HST |
| Sunset               | 1803 HST |
| End civil twilight   | 1825 HST |
| Accident time        | 1918 HST |

##### **MOON**

|               |          |
|---------------|----------|
| Moonrise      | 0343 HST |
| Moon transit  | 1007 HST |
| Moonset       | 1627 HST |
| Accident time | 1918 HST |

#### **E. LIST OF ATTACHMENTS**

Attachment 1 – Additional Honolulu ARTCC PIREP

Attachment 2 – ForeFlight weather briefing from 1803 HST

Attachment 3 – Additional document of ForeFlight weather briefing from 1803 HST

Submitted by:

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Paul Suffern  
Senior Meteorologist

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