



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

April 10, 2019

Specialist's Factual Report

METEOROLOGY

WPR18LA163

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A. ACCIDENT

Location: Mountain Home, Idaho
Date: June 2, 2018
Time: 1338 mountain daylight time
1938 Universal Coordinated Time (UTC)
Airplane: amateur-built North Wing Pulse 10 Meter Glider; registration: N62073

B. METEOROLOGIST

Don Eick
Meteorology Specialist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. SUMMARY

On June 2, 2018, about 1338 mountain daylight time, an experimental amateur-built North Wing Pulse 10 Meter hang glider, N62073, collided with the ground while participating in an airshow at Mountain Home Air Force Base (KMUO), Mountain Home, Idaho. The commercial pilot sustained fatal injuries and the hang glider sustained substantial damage. The hang glider was registered to and operated by the pilot under the provisions of Title 14 *Code of Federal Regulations* Part 91. The local flight departed KMUO, about 1332. Visual meteorological conditions prevailed, and no flight plan had been filed.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's Senior Meteorologist was not on scene for this investigation and conducted the meteorology phase of the investigation from the Washington D.C. office, collecting data from official National Weather Service (NWS) sources including the Weather Prediction Center and the National Center for Environmental Information. All times are mountain daylight time (MDT) based upon the 24-hour clock, local time is -6 hours from UTC, and UTC=Z. NWS airport and station identifiers use the standard International Civil Aviation Organization 4-letter station identifiers versus the International Air Transport Association 3-letter identifiers, which deletes the initial country code designator "K" for U.S. airports. Directions are referenced to true north and distances in nautical miles. Heights are in feet (ft) above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The accident site was located at latitude 43.041667° N and longitude 115.871667° W, at an elevation of approximately 2,996 ft.

E. WEATHER INFORMATION

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 00-45H.

1.0 Surface Analysis Chart

The northwest section of the NWS Surface Analysis Chart for 1200 MDT (1800Z) on June 2, 2018, depicted two high pressure systems over Idaho and western Wyoming at 1028- and 1030-hectopascals (hPa)¹ respectively, dominating over the area with a weak pressure gradient. No other significant boundaries were identified over the area. High pressure systems are areas of subsiding air, and thus typically produce clear skies with light anticyclonic or counterclockwise winds outward from the “high’s”.

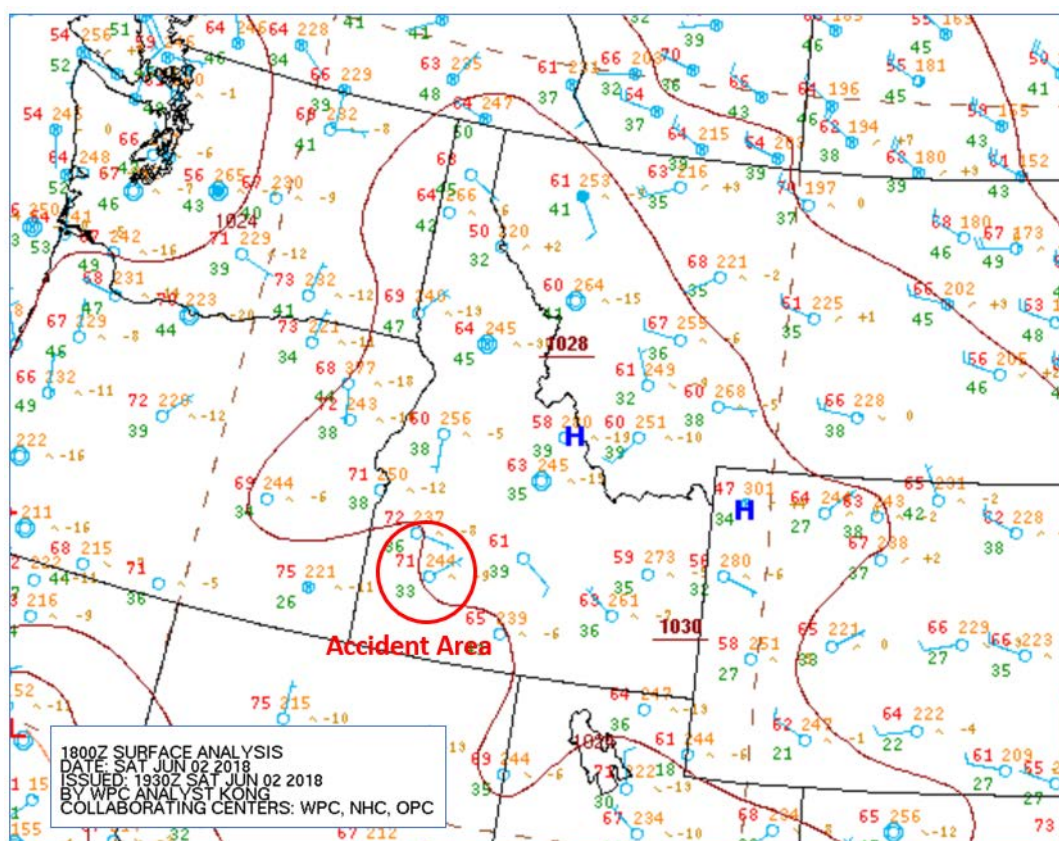


Figure 1- NWS Surface Analysis Chart for 1200 MDT

¹ Hectopascals is the standard term for reporting sea-level pressure and is interchangeable with the term millibar (mb) with the same units. Standard sea-level pressure is 1013.25-hPa.

The station models surrounding the accident site depicted clear skies and temperatures in the 70's degrees Fahrenheit (F), with surface wind from the east to northeast at 5 knots or less.

1.1 Weather Radar Image

A review of the imagery surrounding the period from the NWS Boise (KCBX) Weather Surveillance Radar 1988 Doppler (WSR-88D), which was located approximately 30 miles northwest of the accident site, depicted no significant meteorological echoes associated with any precipitation or defined boundaries over the area. Figure 2 is the KCBW WSR-88D 0.4° base reflectivity image at 1332 MDT, or at the approximate time of the accident. Very light intensity echoes less than 20.0 dBZ have been eliminated from the image to reduce the impact from ground clutter and other false returns associated with non-meteorological echoes and ducting of the radar beam.

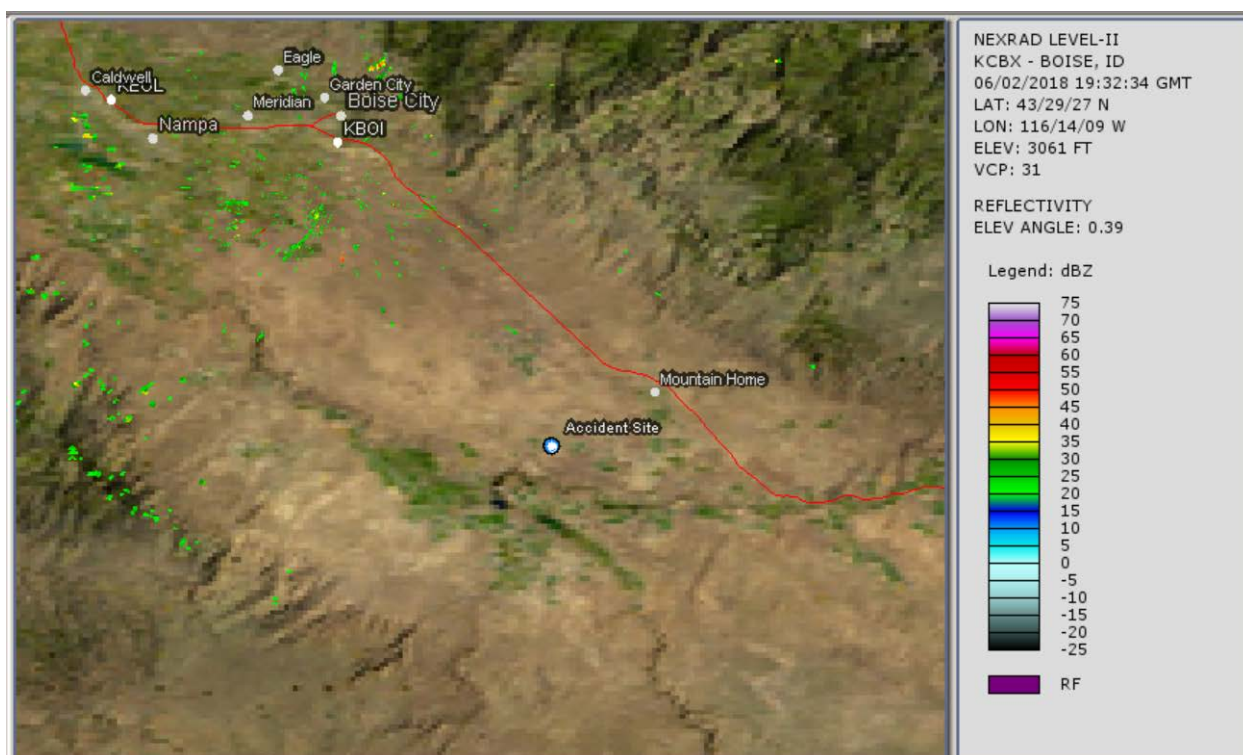


Figure 2 – NWS Boise WSR-88D 0.4° base reflectivity image at 1332 MDT

2.0 Surface Observations

2.1 Mountain Home (KMUO) METAR Observations

Mountain Home Air Force Base (KMUO), Mountain Home, Idaho, listed an elevation of 2,996 feet and a magnetic variation of 13.5° East. The airport had an automated weather observation system² and was supplemented by human observers. The remarks section of the airport facility directory (AFD) for the airport indicated that the weather observations were augmented by human observers during operational hours only and warned that the human observers' surface visibility is

² AN/FMQ-19 Automated Meteorological Station

limited between 310° and 090°³. The following weather observations were reported surrounding the time of the accident:

KMUO weather observation at 1258 MDT (1858Z), automated, wind from 070° true at 4 knots, visibility 10 miles or more, skies clear below 12,000 ft agl, temperature 23° Celsius (C), dew point of 1° C, altimeter 30.27 inches of mercury (Hg). Remarks; automated observation system with a precipitation discriminator, drizzle began at 1245 MDT, sea level pressure 1024.0-hPa, hourly precipitation less than 0.01 inches, temperature 22.8° C, dew point 00.6° C, maintenance indicator⁴.

KMUO special weather observation at 1349 MDT (1949Z), wind from 230° at 3 knots, visibility 10 miles or more, a few clouds at less than 100 ft agl, temperature 24° C, dew point of 0° C, altimeter 30.25 inches of Hg. Remarks; automated observation system with a precipitation discriminator and augmented by a human observer, smoke, a few clouds at less than 100 ft agl, sea level pressure 1023.2-hPa, maintenance indicator.

The raw observations surrounding the period were as follows (time in UTC):

METAR KMUO 021458Z AUTO 12011KT 10SM CLR 15/03 A3032 RMK AO2 SLP256 T01500028 51009 \$

METAR KMUO 021558Z AUTO 09010KT 10SM CLR 18/03 A3032 RMK AO2 SLP254 T01840031 \$

METAR KMUO 021658Z AUTO 10008KT 10SM CLR 21/01 A3030 RMK AO2 SLP249 T02050014 \$

METAR KMUO 021758Z AUTO 05006KT 10SM CLR 22/01 A3029 RMK AO2 SLP244 T02160007 10217 20049 58009 \$=

METAR KMUO 021858Z AUTO 07004KT 10SM CLR 23/01 A3027 RMK AO2 DZB45 SLP240 P0000 T02280006 \$

Accident 1938Z

SPECI KMUO 021949Z 23003KT 10SM FEW000 24/00 A3025 RMK AO2A FU FEW000 SLP232 \$=

METAR KMUO 021958Z 17005KT 10SM FEW200 24/00 A3024 RMK AO2A SLP228 T02401004 \$=

METAR KMUO 022058Z 11007KT 10SM FEW180 25/01 A3022 RMK AO2A SLP223 T02530007 57021 \$=

2.2 1-minute Observations

The following 1-minute observations from KMUO were obtained from the United States Air Force (USAF) from the automated weather observation system surrounding the period. The observations from 1307 through 1344 MDT were as follows:

[1307 MDT]	KMUO 021907Z 00000KT 10SM CLR 23/00 A3027 RMK SLP237 P0000 T02320003 \$
[1308 MDT]	KMUO 021908Z VRB04KT 9SM CLR 23/00 A3027 RMK SLP237 P0000 T02310002 \$
[1309 MDT]	KMUO 021909Z 10004KT 8SM CLR 23/00 A3026 RMK SLP235 P0000 T02310002 \$

³ Hangars block the view from the ramp in these directions.

⁴ Maintenance indicator (\$) indicates that one or more of the sensors are out of calibration or reporting a problem and maintenance required is flagged.

[1310 MDT] K MUO 021910Z 11005KT 7SM CLR 23/00 A3026 RMK SLP235 P0000 T02320003 \$
 [1311 MDT] K MUO 021911Z VRB04KT 7SM CLR 23/00 A3026 RMK SLP235 P0000 T02330004 \$
 [1312 MDT] K MUO 021912Z VRB03KT 6SM HZ CLR 24/01 A3026 RMK SLP233 P0000 T02350005 \$
 [1313 MDT] K MUO 021913Z VRB05KT 5SM HZ CLR 24/01 A3026 RMK SLP235 P0000 T02360006 \$
 [1314 MDT] K MUO 021914Z 05005KT 4SM HZ CLR 24/00 A3026 RMK SLP235 P0000 T02380001 \$
 [1315 MDT] K MUO 021915Z 05004KT 3SM HZ CLR 24/00 A3026 RMK SLP235 P0000 T02380001 \$
 [1316 MDT] K MUO 021916Z 05003KT 2 1/2SM HZ CLR 24/00 A3026 RMK VIS 2 1/2V10 SLP235 P0000
 T02370001 \$
 [1317 MDT] K MUO 021917Z VRB03KT 1 7/8SM HZ CLR 24/01 A3026 RMK VIS 1 7/8V9 SLP235 P0000
 T02360006 \$
 [1318 MDT] K MUO 021918Z VRB03KT 1 7/8SM HZ CLR 24/01 A3026 RMK VIS 1 7/8V8 SLP235 P0000
 T02350005 \$
 [1319 MDT] K MUO 021919Z VRB03KT 1 7/8SM HZ CLR 23/01 A3026 RMK VIS 1 7/8V7 SLP235 P0000
 T02340005 \$
 [1320 MDT] K MUO 021920Z VRB03KT 2SM HZ CLR 23/01 A3026 RMK VIS 1 7/8V7 SLP235 P0000
 T02340005 \$
 [1321 MDT] K MUO 021921Z VRB04KT 2 1/4SM HZ CLR 24/01 A3026 RMK VIS 1 7/8V6 SLP235 P0000
 T02350005 \$
 [1322 MDT] K MUO 021922Z 11004KT 2 1/4SM HZ CLR 24/01 A3026 RMK VIS 1 7/8V5 SLP235 P0000
 T02350005 \$
 [1323 MDT] K MUO 021923Z 12006KT 2 1/2SM HZ CLR 24/00 A3026 RMK VIS 1 7/8V4 SLP235 P0000
 T02360000 \$
 [1324 MDT] K MUO 021924Z 12008KT 2 3/4SM HZ CLR 24/00 A3026 RMK VIS 1 7/8V3 SLP235 P0000
 T02380001 \$
 [1325 MDT] K MUO 021925Z VRB06KT 3SM HZ CLR 24/00 A3026 RMK SLP235 P0000 T02390002 \$
 [1326 MDT] K MUO 021926Z VRB06KT 3SM HZ CLR 24/00 A3026 RMK SLP235 P0000 T02390002 \$
 [1327 MDT] K MUO 021927Z VRB05KT 4SM HZ CLR 24/00 A3026 RMK SLP235 P0000 T02400003 \$
 [1328 MDT] K MUO 021928Z VRB04KT 4SM HZ CLR 24/00 A3025 RMK SLP232 P0000 T02400003 \$
 [1329 MDT] K MUO 021929Z VRB04KT 4SM HZ CLR 24/00 A3025 RMK SLP232 P0000 T02390002 \$
 [1330 MDT] K MUO 021930Z 14005KT 4SM HZ CLR 24/00 A3026 RMK SLP235 P0000 T02380001 \$
 [1331 MDT] K MUO 021931Z VRB05KT 4SM HZ CLR 24/00 A3026 RMK SLP235 P0000 T02370001 \$
 [1332 MDT] K MUO 021932Z VRB05KT 4SM HZ CLR 24/00 A3025 RMK SLP232 P0000 T02360000 \$
 [1333 MDT] K MUO 021933Z VRB04KT 4SM HZ CLR 24/00 A3025 RMK SLP232 P0000 T02360000 \$
 [1334 MDT] K MUO 021934Z VRB03KT 4SM HZ CLR 24/00 A3025 RMK SLP232 P0000 T02360000 \$
 [1335 MDT] K MUO 021935Z VRB03KT 4SM HZ CLR 24/00 A3025 RMK SLP232 P0000 T02370001 \$
 [1336 MDT] K MUO 021936Z VRB04KT 4SM HZ CLR 24/00 A3025 RMK SLP232 P0000 T02390002 \$
 [1337 MDT] K MUO 021937Z 05005KT 4SM HZ CLR 24/00 A3025 RMK SLP232 P0000 T02410004 \$
[1338 MDT] K MUO 021938Z 04005KT 4SM HZ CLR 24/01 A3025 RMK SLP232 P0000 T02420005 \$
 [1339 MDT] K MUO 021939Z VRB06KT 4SM HZ CLR 24/01 A3025 RMK SLP232 P0000 T02430006 \$
 [1340 MDT] K MUO 021940Z 07007KT 4SM HZ CLR 24/01 A3025 RMK SLP232 P0000 T02430006 \$
 [1341 MDT] K MUO 021941Z 09005KT 4SM HZ CLR 24/01 A3025 RMK SLP232 P0000 T02430006 \$
 [1342 MDT] K MUO 021942Z 09003KT 5SM HZ CLR 24/01 A3025 RMK SLP232 P0000 T02430006 \$
 [1343 MDT] K MUO 021943Z 00000KT 5SM HZ CLR 24/01 A3025 RMK SLP232 P0000 T02430006 \$
 [1344 MDT] K MUO 021944Z 00000KT 5SM HZ CLR 24/01 A3025 RMK SLP232 P0000 T02420005 \$

The observations documented a period after 1300 MDT through the time of the accident, where visibility was noted to deteriorate less than 10 statute miles in haze. This was also noted to occur during the period after a pyrotechnic display for the “Tora Tora Tora” reenactment on the western side of the runway, which preceded the accident pilots act which also caused a grass fire. The human observer augmented the visibility and reported prevailing visibility of 10 miles or more during the period, as noted in section 2.1. The maintenance indicator was flagged on all the observations during the period for unknown reasons.

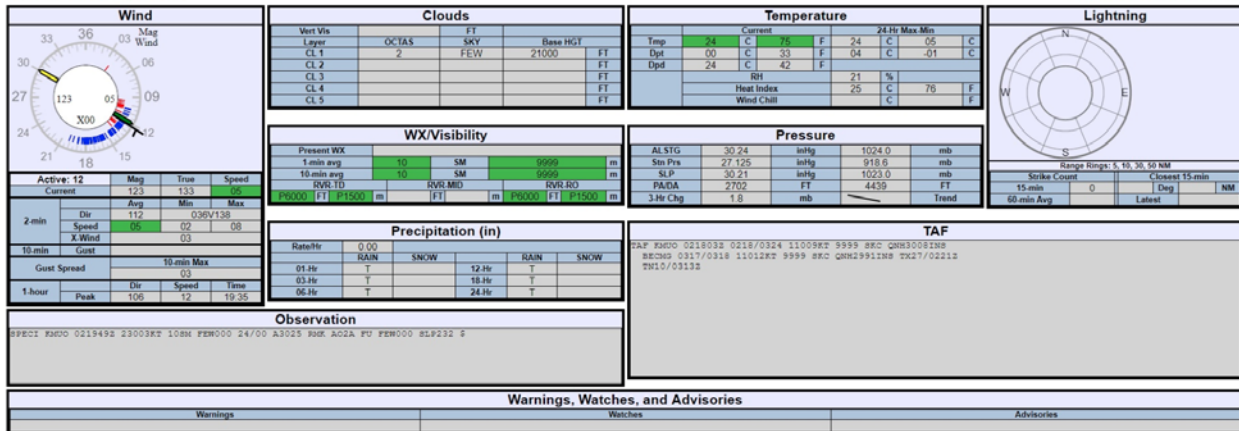


Figure 4 - KMUO Runway 30 weather display at 1350 MDT

The KMUO runway 30 weather display at 1350 MDT indicated a 2-minute average wind from 130° at 5 knots, visibility 10 miles or more, a few clouds at 21,000 ft agl, temperature of 24° C, a dew point of 0° C, altimeter 30.24 inches of Hg. The display also indicated a relative humidity of 21%, and a density altitude of 4,439 ft. The 1-hour maximum wind was noted from 106° at 12 knots occurred at 1335 MDT.

3.0 Upper Air Observations

United States Air Force (USAF) “Drop Winds” observations for KMOU and a NWS numerical model sounding were obtained and documented to determine the vertical structure of the atmosphere over the accident site.

3.1 Drop Winds

The following winds aloft forecast or “Drop Winds” (figure 5) from the surface to 15,000 ft agl was provided by the USAF. The forecast is based on the nearest winds aloft forecast data and is designed primarily for skydivers and parachutists, and for other aircraft performing at the airshow. The Drop Winds indicated southeasterly winds below 4,000 ft agl at 5 knots or less.

KMUO – VT:1800Z

HEIGHT (PRESS) (KFT AGL) (MB)	DIR (DEG)	SPEED (KNOTS)
SFC (919)	123	5
1 (887)	124	5
2 (856)	127	5
3 (825)	123	4
4 (795)	113	2
5 (767)	94	2
6 (739)	49	1
7 (712)	297	2
8 (686)	285	4
9 (660)	283	7
10 (636)	282	10
11 (612)	282	12
12 (589)	282	14
13 (566)	281	16
14 (545)	279	18
15 (524)	277	19

Figure 5 - Drop Winds over KMOU for 1200 MDT

3.2 HRRR Numerical Model Sounding

High Resolution Rapid Refresh (HRRR) numerical model⁵ output was obtained from the NOAA Air Resource Laboratory for 1300 and 1400 MDT and reviewed. Figure 6 is the 1300 MDT HRRR sounding over the accident site plotted on a Skew T log P diagram⁶ using the complete Rawinsonde Observation (RAOB) software⁷ from the surface to 500-hPa (about 18,000 ft).

⁵ The HRRR is a National Oceanic and Atmospheric Administration (NOAA) real-time three-kilometer resolution, hourly-updated, cloud-resolving, convection-allowing atmospheric model, initialized by three-kilometer grids with three-kilometer radar assimilation. Radar data is assimilated in the HRRR every 15 minutes over a one-hour period.

⁶ Skew T log P diagram – is a standard meteorological plot or thermodynamic diagram 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 software – The complete RAwinsonde OBservation program is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania, for plotting and analyzing upper air data.

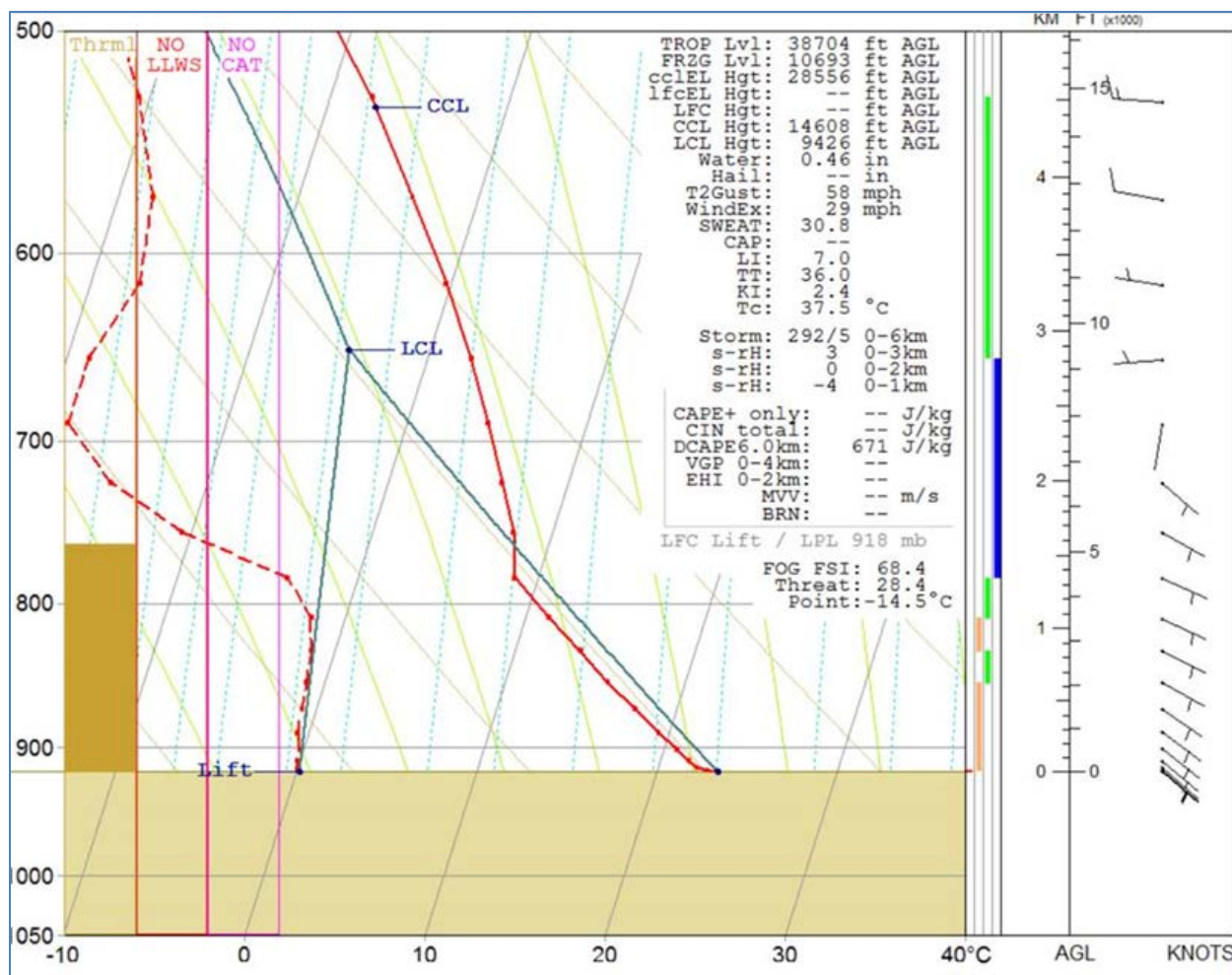


Figure 6 - HRRR numerical model sounding for 1300 MDT over the accident site

The 1300 MDT HRRR model sounding produced a surface temperature of 23.4° C (74° F), a dew point temperature of 0.2° C (32° F), and a relative humidity of 22%, which provided a density altitude of 4,376 ft based on the International Standard Atmosphere (ISA). The lifted condensation level (LCL) was at 9,426 ft agl, with the convective condensation level (CCL) at 14,608 ft agl. The freezing level or height of the 0° C isotherm was at 10,693 ft agl (13,692 ft). The precipitable water content was 0.46 inches. The moisture profile did not depict any favorable conditions for clouds (where relative humidity exceeded 80%) through 18,000 ft. While the HRRR sounding was overall characterized as stable based on the Lifted Index of +7, the layer from the surface through 4,400 ft agl (7,400 ft) was extremely unstable (indicated by the red and yellow bars on the right side of the diagram) with a lapse rate that exceeded the dry adiabat and supported strong thermal activity through 5,000 ft agl (also indicated on the left side of the sounding in brown).

The HRRR model wind profile indicated a surface wind from 134° at 5 knots, with little variation in direction through 7,000 ft, with wind speeds less than 10 knots. Above 7,000 ft the winds veered (clockwise) to the west and gradually increased in speed. The level of maximum wind was identified at 41,400 ft from 260° at 41 knots, which was located immediately below the tropopause at 41,700 ft. The mean 0 to 6 kilometer (km) wind was from 260° at 7 knots, with the low-level wind from the surface to 500 meter wind from 130° at 5 knots. The wind profile did not depict

any significant wind shears below 18,000 ft for any organized clear air turbulence or low-level wind shear; other than light turbulence produced by thermal convection or heating of the surface.

Figure 7 is a table of the HRRR parameters from the sounding through 10,000 ft with regards to height, pressure, temperature (T), dew point temperature (Td), relative humidity (RH), wind direction and speed, CAT, LLWS, icing, and mountain wave potential.

Height (ft-MSL)	Pres (mb)	T (C)	Td (C)	RH (%)	DD / FF (deg / kts)	CAT (FAA)	LLWS	Icing - Type (AFGWC method)	Wave/x---w---Turb nm fpm max
2999	918	23.4	0.2	22	134 / 5				
3030	917	22.8	0.0	22	134 / 5				
3092	915	22.2	0.0	23	134 / 5				
3248	910	21.6	-0.1	24	132 / 5				
3530	901	20.7	-0.2	25	131 / 5				
3909	889	19.4	-0.6	26	129 / 5				
4452	872	17.7	-0.8	28	127 / 6				
5067	853	15.7	-1.0	32	122 / 6				
5791	831	13.6	-1.3	36	119 / 6				
6529	809	11.3	-1.9	40	117 / 7				
7420	783	8.7	-3.9	41	116 / 7				
8442	754	7.8	-10.6	26	122 / 7				
9536	724	6.3	-15.4	19	134 / 4				
10825	690	4.5	-18.8	17	189 / 2				

Figure 7 - HRRR numerical model parameters through 10,000 ft

The HRRR sounding for 1400 MDT indicated similar conditions, with minor changes in temperature with surface temperature of 24.4° C (76° F), dew point temperature of -0.6° C (31° F) with a relative humidity of 24%, and the surface wind from 097° at 4 knots. A comparison of the soundings is plotted in figure 8. The layer from the surface through approximately 5,000 ft agl remained unstable and supported strong thermals.

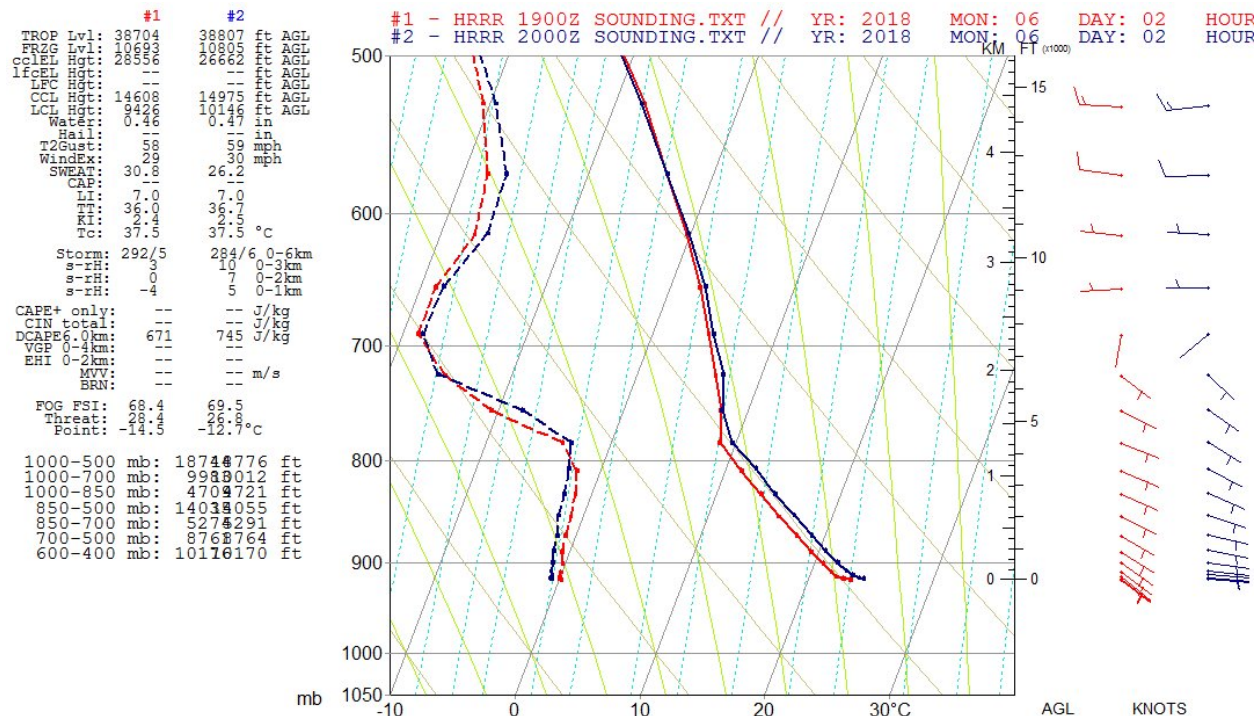


Figure 8 - Comparison of the 1300 and 1400 MDT HRRR soundings

4.0 Satellite Imagery

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 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. Figure 9 is the GOES-16 visible image at 1530 MDT at 2X magnification centered over KMUO. The image depicted clear skies over the accident site, with snow-capped mountains indicated to the north and northeast.

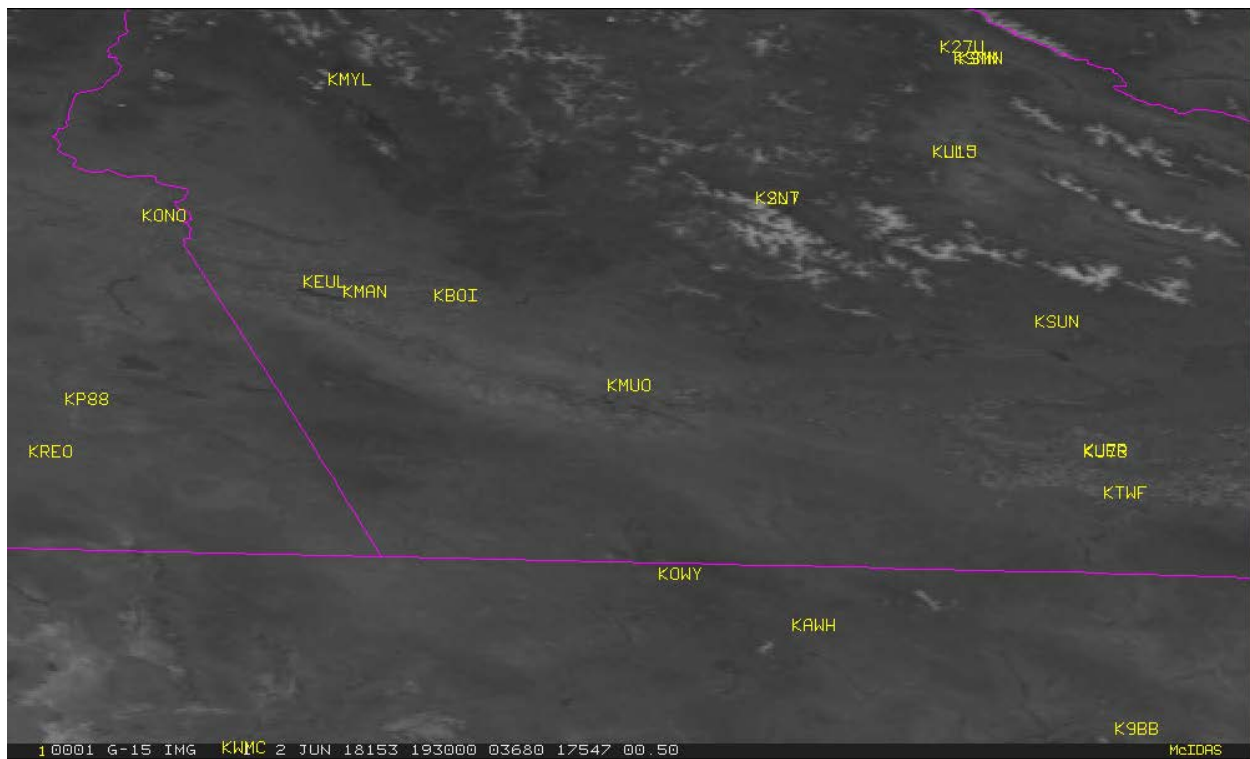


Figure 9 - GOES-15 visible image at 1330 MDT

5.0 Pilot Reports

A search of the NWS data base indicated no pilot reports (or PIREPs) issued over Idaho for the 4 hours prior to and after the time of the accident.

6.0 Terminal Aerodrome Forecast

The Terminal Aerodrome Forecast (TAF) for KMUO issued by the USAF Air Weather Service at 1203 MDT was as follows:

*TAF KMUO 021803Z 0218/0324 11009KT 9999⁸ SKC QNH3008INS
 BECMG 0317/0318 11012KT 9999 SKC QNH2991INS
 TX27/0221Z TN10/0313Z=*

The forecast valid at the time of the accident expected a wind from 110° at 9 knots, visibility better than 6 miles (10 kilometers or more), sky clear below 12,000 ft agl, forecast lowest altimeter setting of 30.08 inches of Hg (QNH).

⁸ At military and international stations outside of North America visibility is typically forecast in meters. Visibility code 9999 is the greatest value forecast and indicates visibility is 10 kilometers or more, which converts to greater than 6 statute miles. The USAF typically displays this as visibility unrestricted at 7 statute miles.

A graphic depiction of the USAF forecast expected for the period is included in figure 10. This graphic was used during a weather briefing for pilots participating in the airshow, and part of the USAF briefing package provided regarding the weather conditions.

MHAFB (LOCAL TIME)	10-12L		12-14L		14-16L		16-18L	
Sfc Wind (kt)	11006		11006		11006		11006	
Cigs (AGL)	NONE		NONE		NONE		NONE	
Vis	7		7		7		7	
Wx	NSW		NSW		NSW		NSW	
Max Temp (C)	17°C	21°C	22°C	25°C	26°C	27°C	27°C	27°C
Max Temp (F)	63°F	69°F	72°F	76°F	78°F	80°F	81°F	81°F
Min Altimeter	30.24		30.18		30.15		30.11	
Max PA	2701		2757		2784		2821	

Figure 10 - Graphic depiction of the forecast conditions during the period

7.0 Winds Aloft Forecast

The NWS Winds and Temperature Aloft Forecast product current for the period was as follows:

WINDS ALOFT FORECASTS

DATA BASED ON 021200Z

VALID 021800Z FOR USE 1400-2100Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
BOI		1606+12	9900+07	2809+02	2823-12	2730-24	273639	263849	264758

The winds aloft forecast for Boise (KBOI), Idaho valid for the period between 0800 and 1500 MDT for 6,000 ft expected a wind from 160° at 6 knots, with a temperature of +12° C. At 9,000 ft the wind was light and variable or less than 10 knots. No winds are forecast within 1,500 ft of the station elevation, and no temperatures are forecast for the 3,000 ft level or for any level within 2,500 ft of station elevation.

8.0 In-flight Weather Advisories

A review of the NWS inflight weather advisories indicated that there were no Significant Meteorological Information (SIGMET), Convective SIGMETs, Center Weather Advisories (CWA), or Airmen Meteorological Information (AIRMET) advisories current over Idaho during the period. The NWS does not issue any inflight weather advisories for thermals or dust devils.

9.0 Dust Devils

According to the American Meteorological Society, a dust devil is defined as: A well-developed dust whirl; a small but vigorous whirlwind, usually of short duration, rendered visible by dust, sand, and debris picked up from the ground. Wind speed range from an average of 40 knots and can exceed 50 knots in intense dust devils which can be occasionally strong enough to cause minor damage (up to EF0 on the Enhanced Fujita scale). Diameters range from about 10 ft to greater than 100 ft; their average height is about 600 ft, but a few have been observed as high as 3,000 ft

or more. They have been observed to rotate anti-cyclonically as well as cyclonically. Although the vertical velocity is predominantly upward, the flow along the axis of large dust devils may be downward. Large dust devils may also contain secondary vortices. Dust devils are best developed on a hot, calm afternoon with clear skies, in a dry region when intense surface heating causes a very steep lapse rate of temperature in the lowest 3,000 ft of the atmosphere.

In the United States dust devils have been reported in every state but are most frequently reported in the deserts and flat terrain of the southwest, with Arizona reporting the highest frequency of occurrences. The atmospheric conditions that commonly increase the likelihood of dust devil formation include; flat barren terrain, clear skies, and calm to light winds under 10 knots, and surface air temperatures over 90° F (32° C). Since dust devils are associated with intense solar heating, the maximum occurrence typically occurs between 1300 and 1400 local, at the time of maximum soil temperatures and the convective heat flux. They are also most frequent between the months of June through August in Arizona⁹ where the study was conducted.

Figure 11 is a photograph of dust devil in Arizona, which had a diameter of 40 ft and extended several hundred feet in the vertical.



Figure 11 - Dust Devil

⁹ NWS data and Peter C. Sinclair “General Characteristics of Dust Devils”, Journal of Applied Meteorology, published in 1969.

The creation of eddies of sufficient magnitude have also been documented to trigger dust devil formation due to the increase in relative vorticity¹⁰. Such eddies could come from hot aircraft exhaust, the local grass fire, or from the emergency response vehicles.

Dust devils have been implicated as a cause or contributing factor in approximately 52 aircraft accidents between 2000 and 2017 according to the NTSB database. While most of the events result in a loss of control on landing and cause a runway excursion, several loss of control events have resulted in serious to fatal injuries. According to the United States Parachute Association¹¹ dust devils are also considered major hazards among skydivers and paragliding pilots as they can cause a parachute or a glider to collapse with little to no warning, at altitudes considered too low to cut away, and contribute to the serious injury or death of many parachutists.

List of several recent NTSB accidents and incidents related to dust devil encounters and substantial damage and/or injuries:

NTSB Case	Location	Date	Aircraft	Fatal
GAA17CA380	Tucson, AZ	July 2, 2017	Cessna 172	
GAA16CA464	Perris, CA	September 3, 2016	North American SNJ	
WPR16FA130	Wikieup, AZ	June 23, 2016	Robinson R66	2
GAA15CA270	Jackpot, NV	September 21, 2015	Piper PA-32	
GAA15CA024	Fairfield, UT	March 27, 2015	Zenith CH701	
WPR14CA399	Thermal, CA	September 30, 2014	Cessna 172	
WPR14CA344	Pine Bluffs, WY	August 13, 2014	Cessna 177	
WPR14CA215	Novato, CA	May 27, 2014	Piper PA-28	
CEN13CA494	Santa Teresa, NM	August 18, 2013	Globe CG-18	
CEN13LA409	Taos, NM	July 10, 2013	Flight Design GMBH	1
CEN13CA223	Albuquerque, NM	April 20, 2013	Cessna 175A	
CEN11CA408	Truth or Consequences, NM	June 18, 2011	Cessna 206	
WPR11CA024	Fort Thomas, AZ	October 22, 2010	Cessna 185	
CEN10CA411	Blackstone, IL	July 14, 2010	Helicopter MK6B	

10.0 Witness Statements and Videos

Several witnesses provided statements concerning the weather conditions surrounding the period, a summary of some of the reports are included below the full interviews are available in the docket.

¹⁰ Relative Vorticity – is the sum of the rotation of an air parcel about the axis of the pressure system and the rotation of the parcel about its own axis.

¹¹ Dust Devils – July 9, 2012, United States Parachute Association.

10.1 Witness #1

A statement from a witness, identified as #1 who was a volunteer for his squadron at the airshow, witnessed a dust devil to the west of the runway before accident pilot started his part of the airshow in a location past the air traffic control tower. He identified that the dust devil had a well-defined vortex that was not visible from the ground to about 200 ft agl. At about 200 ft agl there was a small amount of dust that outlines the vortex's shape. The witness pointed it out to one of his co-workers at the time, who also witnessed it.

A few minutes after sighting the dust devil, he walked from the hangar area to the concession area located near the runway, as he watched the accident pilot perform his routine. He indicated that as the glider was heading west at 10 to 15 ft for what appeared to him as a good landing approach, the glider suddenly picked up and climbed to about 30 to 40 ft of altitude, and apparently stalled due to the extreme angle of attack, and fell off on to one wing, pointing straight down and impacted hard.

The witness indicated that he has been flying a hang glider since 1980 and possess an advanced rating and is aware of the dangers imposed by dust devils. He also had a close call encountering a dust devil in the 1990's near Flagstaff, Arizona. He provided a link to a video showing hang gliders and paragliders encountering a dust devil.

10.2 Witness #2

Another witness #2 who was a performer at the show and was parked in his P-51 Mustang at show center about 1,000 ft away from the accident site facing the crowd, with the accident site directly behind him. He stated that he saw the emergency response vehicle responding to the accident. He looked around and saw the accident glider on the ground behind him. He indicated that he did not witness the accident sequence.

He indicated that the winds were variable and uncommonly light for the area of Mountain Home, Idaho. He also noticed several large dust devils in the area and indicated that the pyro field had contributed to generating some strong vertical wind flow in the area.

He stated that once he checked in with the airboss and learned that the accident pilot had crashed, he then waited in the cockpit for a short period in case the pilot was OK and the air show would resume. While waiting, he noticed a large dust devil go across the crowd line about 1,000 ft left of show center, or to the southeast of his position. It appeared to be traveling away from his position in such a way that it convinced him that it had been in the vicinity of the accident site, and at the time of the accident. He indicated that it was a large lumbering dust devil without a clear core. He stated that he believes it may have been a factor in the accident.

The witness provided an image (figure 12) to show his position on the airport and the approximate position of the dust devil's path he observed and his position relative to the accident site. He also indicated that the dust devil he observed had a diameter of 40 to 80 ft and extended from 300 to 1,000 ft high. He described it further as somewhat of a "lazy" dust devil, in that it was not tight and obvious. However, he did observe it blowing dust, and disturbing paper or flyers,

hats being grabbed by people in the crowd, and the like, but not picking up tents and other larger objects. He was able to observe the slow-moving dust devil for about 5 to 10 minutes before losing sight of it as it moved towards the parking lot.



Figure 11 – P-51 performer's position and path of observed dust devil

He also commented on the pyro field and indicated that it was hot with winds calm during the period, and that the smoke was generally moving towards the west but mostly vertically. He also indicated that the pyro field also seemed to trigger mini thermal flow and contributed to confused winds in the area.

10.3 Video Images

The NTSB received six videos of the accident sequence. The videos were reviewed for any additional meteorological information such as wind or dust devils that might be visible during the period. The following comments and observations were made based on those videos which are included as attachments 1 through 6.

10.3.1 Video #1

Video #1 showed the USAF F-22 “Raptor” taxi out from a position immediately left (south) of a P-51 “Mustang”, and in the final seconds of the video captures the hang glider crash behind the P-51. Figure 13 is a still from the video #1 looking northwest with dust and/or haze noted to the north-northwest (right side of frame) obscured the higher terrain in the distance in figure 13. The video captures the hand glider in a left bank in figure 14 looking southwest behind the P-51 Mustang’s position.



Figure 12 – Video #1 frame 0:24 looking northwest

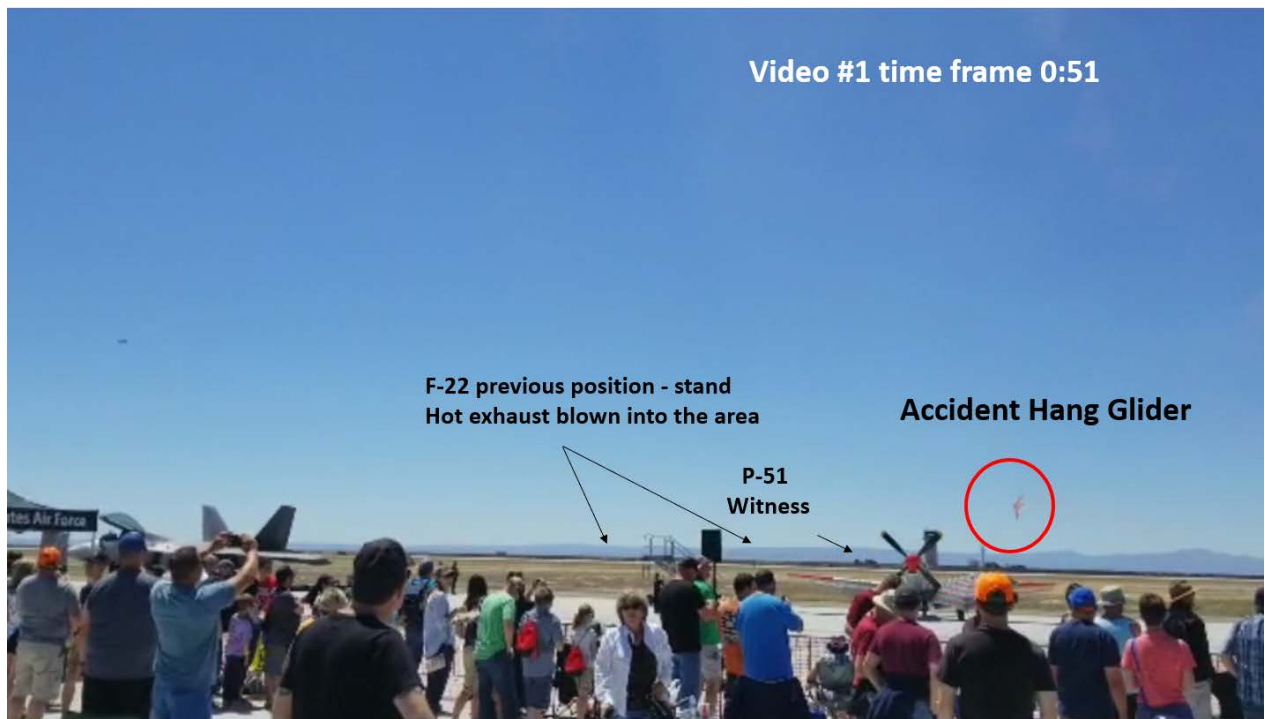


Figure 13 – Video #1 Frame 0:54 looking southwest

10.3.2 Video #2

Video #2 was a 0:38 video that was also concentrating on the F-22 taxiing past the viewing area and captured the accident in the background. Figure 15 is a frame of video #2 at 0:08 with the accident glider having impacted the ground. As the F-22 taxis to the right looking northwest dust obscures the horizon in the distance. The video does not show any indication of any wind in the viewing area or on the field.



Figure 14 – Video #2 of possible dust devil

10.3.3 Video #3

Video #3 shows the accident hang glider make a low approach and banks left over 90° and drop vertically to the ground (figure 16). Dust or haze is observed low on the horizon. The video shows that once the accident glider had made ground contact it appears to be lifted or blown to the southwest (leftward) with the wind for a moment after the initial impact. The smoke tracers also continue to be blown to the southwest or opposite of the direction of the reported surface winds at the time. The video continued after the accident and noted two emergency response vehicles traveling from the southwest near the tower converge on the accident site, with dust behind the vehicle blown or drifting to the southeast in the video (figure 17). The dark burn area from the pyrotechnic show is also observed west of the field. Other than the wind blowing the glider, dust, and smoke flares, there was no indicated of any wind were the spectators were located at this time. The video also pans to the northwest towards where the Thunderbirds were parked and shows the higher terrain obscured to the northwest by dust as in the previous video.

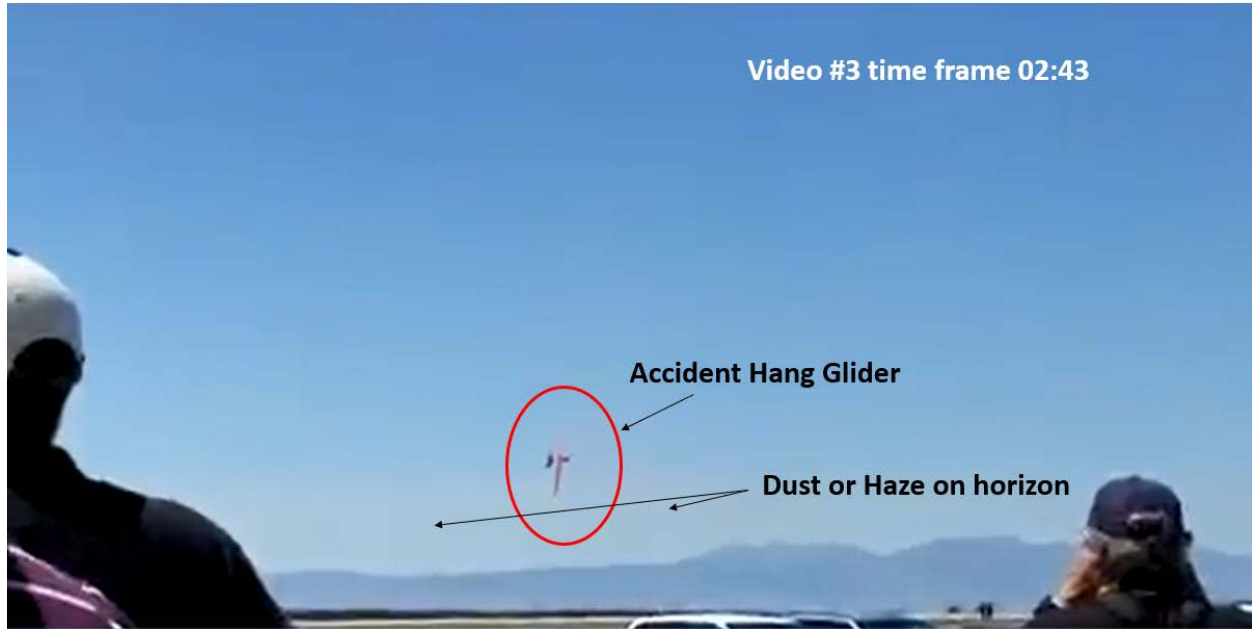


Figure 15 - Video #3 time frame 02:43 looking southwest



Figure 16 - Video #3 time frame 03:20 looking southwest

10.3.4 Video #4

Video #4 of the accident shows a defined dust devil in the distance south of the control tower and behind the accident location to the southwest of the viewing location (figure 18). The video ends at the time of impact.



Figure 17 - Video #4 with dust devil in background

10.3.5 Video #5

Video #5 was only 0:03 seconds long and concentrated on the F-22 passing, it also captured a dust devil to the south of the tower in the left portion of the frames with very little dust being lifted into the core of the system. The dust devil height was as high as the control tower as noted before and was located to the southwest. The accident glider was captured in the background prior to impacting the surface in figure 19.



Figure 19 – Video #5 of F-22 and dust devil

10.3.6 KMUO Tower Video #6

A high resolution 8:35 long video #6 from the control tower looking northeast also captured the accident hang glider. The burnt area associated with the pyrotechnic display is evident between the tower and the runway and accident site, with small smoke plumes observed rising and drifting to the left or towards the northwest. Visibility is unrestricted with the higher terrain clearly visible in the distance approximately 22 miles from the tower. The video at frame 01:29 (figure 20) captures the aircraft performing with the glider making a low pass over the runway. The F-22's departure from the ramp was immediately northwest of the accident site and is identified at frame 02:47, with the accident being captured at frame 03:35. The accident hang glider is also observed after the initial impact, the glider appears to be blown towards the right or the south with the wing structure blowing in the wind. The emergency response vehicles are seen responding from near the tower and the small antenna at the bottom of the frame 03:48 (figure 21) and travel northeastward across the burn area to the accident site. Dust is observed behind the emergency response vehicles initially blown to the left or northward on the far side of the field and as the approach the accident site the dust cloud is blown to the right or towards the south (figure 22). The smoke flares from the accident hang glider are also observed blowing to the south during this period.

Near the end of the video in frame 07:41 the smoke from the flares rises vertically at the accident site and drifts to the north or to the left.



Figure 20 - KMUO tower video #6 at frame 01:29

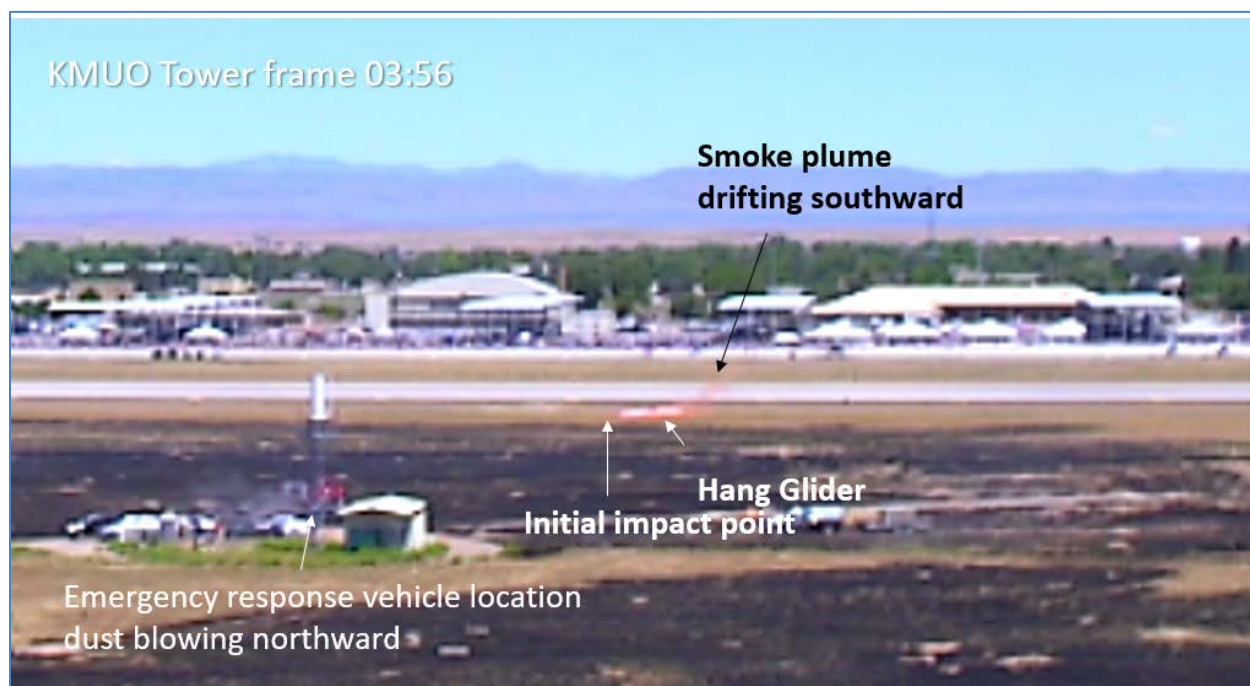


Figure 18 - KMUO tower video at frame 03:56



Figure 19 - KMUO Tower video at frame 04:30

11.0 Astronomical Conditions

The following astronomical conditions were reported on June 2, 2018 for Mountain Home, Idaho.

Beginning of civil twilight	0532 MDT
Sunrise	0606 MDT
Sun transit	1341 MDT
Sunset	2116 MDT
End of civil twilight	2151 MDT

F. List of Attachments

The following videos were provided for the investigation.

Attachment 1 – video #1

Attachment 2 – Video #2

Attachment 3 – Video #3

Attachment 4 – Video #4

Attachment 5 – Video #5

Attachment 6 – KTMUO Tower video #6

Submitted by:

Don Eick
Senior Meteorologist