NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

January 7, 2014

GPS Factual Report

Specialist's Factual Report
by Bill Tuccio, Ph.D.

A. EVENT

Location:	Bondurant, Wyoming
Date:	November 17, 2012
Aircraft:	Cessna 182D
Registration:	N61LN
Operator:	Private
NTSB Number:	WPR13FA053

B. GROUP - No Group

C. SUMMARY

On November 17, 2012, about 1345 mountain standard time, a Cessna 182D, N61LN, was substantially damaged when it collided with terrain south of Bondurant, Wyoming. The airplane was registered to and operated by the pilot under the provisions of Title 14 *Code of Federal Regulations* Part 91 as a personal flight. The private pilot, sole occupant of the airplane, was fatally injured. Visual and instrument meteorological conditions prevailed throughout the route of flight and a flight plan was not filed. The cross-country flight originated from Stevensville, Montana, about 1130 with an intended destination of Pinedale, Wyoming.

D. DETAILS OF INVESTIGATION

The NTSB Vehicle Recorder Laboratory received the following device:

GPS Manufacturer/Model:	Garmin GPSMAP XXX[1]
Serial Number:	19729613

[1] Due to damage, the exact model could not be determined. The device was believed to be a Garmin GPSMAP 496; however, other possible variants include the Garmin GPSMAP 495, 396, or 395.

Garmin GPSMAP XXX Device Description

The Garmin GPSMAP XXX is a battery-powered portable 12-channel GPS receiver. The unit includes a built-in Jeppesen database. The unit stores date, route-of-flight, and flight-time information for up to 50 flights. A flight record is triggered when groundspeed exceeds 30 knots and altitude exceeds 500 feet, and ends when groundspeed drops below 30 knots for 10 minutes or more. A detailed tracklog – including latitude, longitude, date, time, and GPS altitude information for an unspecified number of points – is stored within the unit whenever the receiver has a lock on the GPS navigation signal. Position is updated within the tracklog as a function of time or distance moved, depending on how the unit has been configured. Once the current tracklog memory becomes full, new information either overwrites the oldest information or the recording stops, depending on how the unit is configured. The current tracklog can be saved to long-term memory and 15 saved tracklogs can be maintained in addition to the current tracklog. Tracklog storage may be activated or de-activated at user discretion. All recorded data is stored in non-volatile memory[2]. The unit contains hardware and software permitting the download of recorded waypoint, route, and tracklog information to a PC via a built-in serial port using the NMEA 0183 version 2.0 protocol. The unit can also communicate with external devices such as a computer using a built in USB port. An internal button-battery is used to back-up power to the internal memory and real-time clock during those periods when main power is removed.

GPS Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed the unit had sustained significant impact damage, as shown in figure 1. The device was disassembled, as shown in figure 2. Figure 2 annotates the non-volatile memory chip. The non-volatile memory chip was removed from the internal board, shown in figure 3. The memory chip was an ST Microelectronics model M58LR128K. The 56-ball grid array (BGA) was re-balled, as shown in figure 4. The re-balled chip's memory image was read with an EPROM programming device. The memory image was decoded using NTSB algorithms and information from the GPS manufacturer.

[2] Non-volatile memory is semiconductor memory that does not require external power for data retention.

Figure 1. Photo of Garmin XXX.

Figure 2. Garmin XXX disassembled.

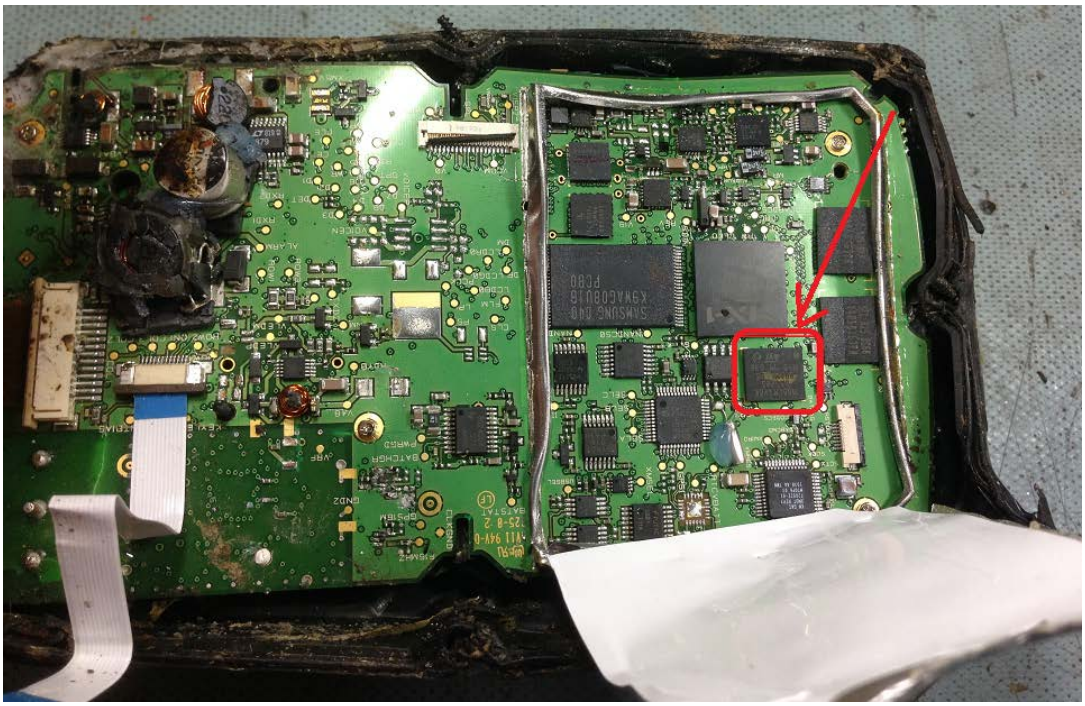


Figure 3. Garmin XXX non-volatile memory chip.

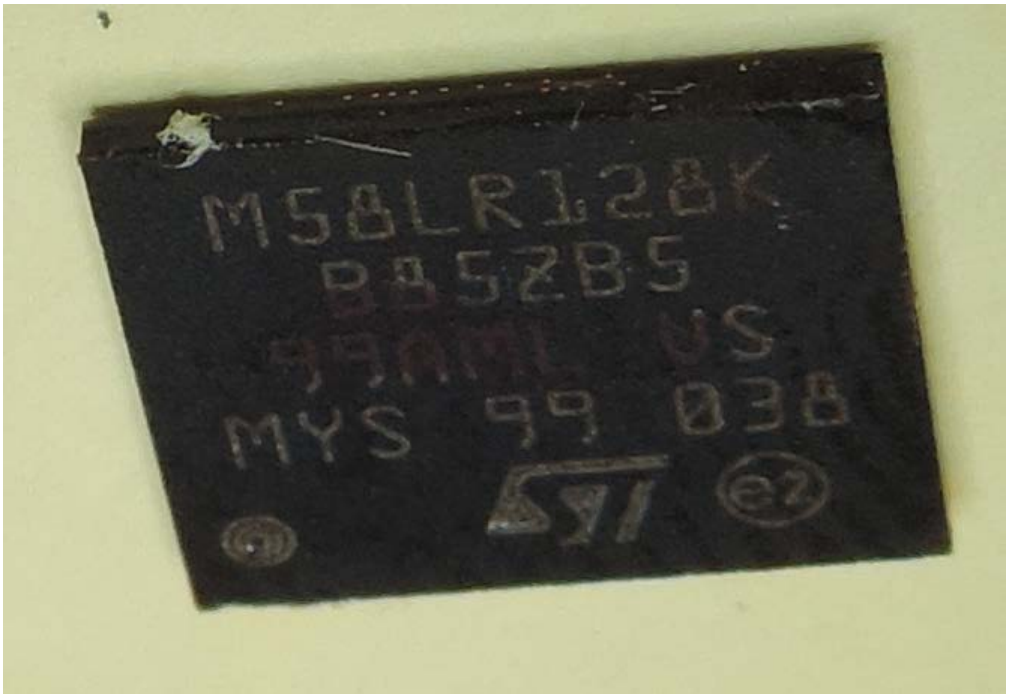
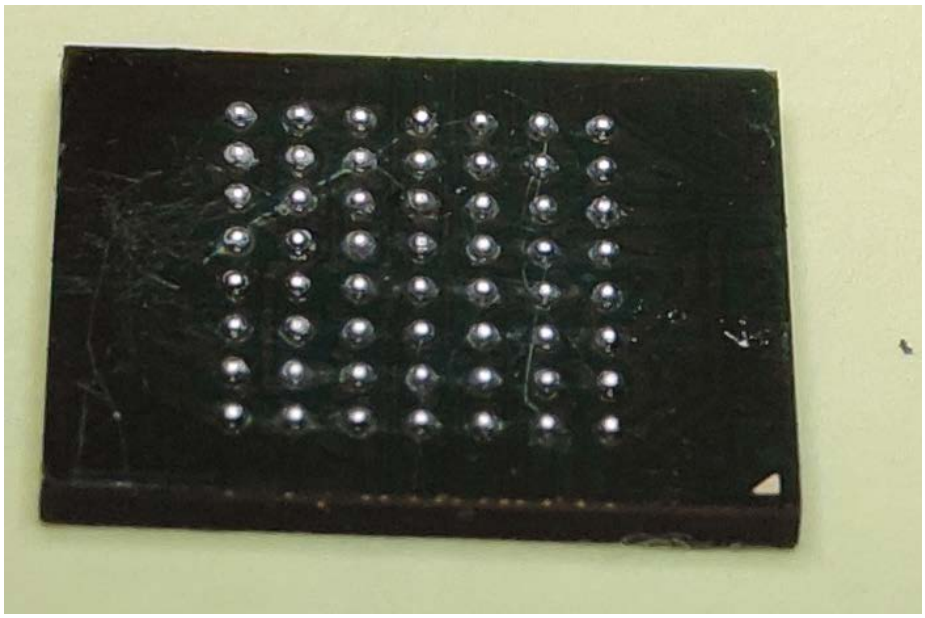


Figure 4. Garmin XXX non-volatile memory chip with BGA re-balled.



GPS Data Description

The data extracted included 47 sessions (12,620 data points) from March 23, 2011[3] through November 17, 2012. Many sessions were recorded in February, 2012, with the last February, 2012 session ending on February 27, 2012; the session history resumed on November 15, 2012. The accident flight was the last flight recorded, starting at 17:41:40 UTC and ending at 20:38:24 UTC on November 17, 2012. Only the accident flight is examined for this report.

GPS Parameters Provided

Table 1 describes data parameters provided by the GPS device. Date, Time, Latitude, Longitude, and GPS Altitude are recorded by the device. Groundspeed and Track are derived from the recorded parameters.

Table 1: GPS Data Parameters

Parameter Name	Parameter Description
Date	Date for recorded data point (MM/DD/YYYY)
Time	Time (UTC) for recorded data point (HH:MM:SS)
Latitude	Recorded latitude (degrees)
Longitude	Recorded longitude (degrees)
GPS Alt	Recorded geometric altitude above mean sea level (MSL) (feet)
Groundspeed	Average groundspeed between current and previous data point (knots)
Track	Average true course between current and previous data point (degrees)

OVERLAYS AND TABULAR DATA

The graphical overlays shown in figures 4 through 6 were made with Google Earth. The overlays are orientated west up.

Figure 4 shows an overview of the entire flight. The recording began at 17:41:40 UTC near Missoula, Montana and ended at 20:38:24 UTC near Freedom, Wyoming.

Figure 5 shows the departure of the accident flight from the Stevensville, Montana. The recording began at 17:41:40 UTC. By 18:33:38 UTC, the aircraft was in a departure climb through 3,640 feet turning south.

Figure 6 shows the end of the recording. At 20:35:53 UTC, the aircraft was climbing through 12,062 feet and continued to climb until the end of the recording. The last point recorded was at 20:38:24 UTC, at an altitude of 13,450 feet as the ground track was turning left towards the east.

[3] All dates and times are referenced to Coordinated Universal Time (UTC).

Figure 7 shows a plot of groundspeed and altitude for the entire flight. By about 18:45 UTC, the aircraft had climbed to an initial altitude of about 9,500 feet. At around 19:15 UTC, the recorded altitude increased to 10,500 feet for about 2 minutes, then decreased to about 8,000 feet by 19:20 UTC. Between about 19:20 UTC and 19:40 UTC, the recorded altitude varied between 8,000 and 9,000 feet. At about 19:40 UTC, the recorded altitude began to increase; reaching about 12,800 feet by 19:49 UTC. Thereafter, the recorded altitude decreased until about 20:11 UTC, reaching a minimum altitude of about 8,600 feet. The aircraft then climbed until the end of the recording, with an intermediate level off at about 20:35 UTC at about 12,000 feet.

Tabular data used to generate figures four through seven are included as Attachment 1. This attachment is provided in electronic comma-delimited (.CSV) format.

Figure 4. Google Earth overlay showing accident flight.

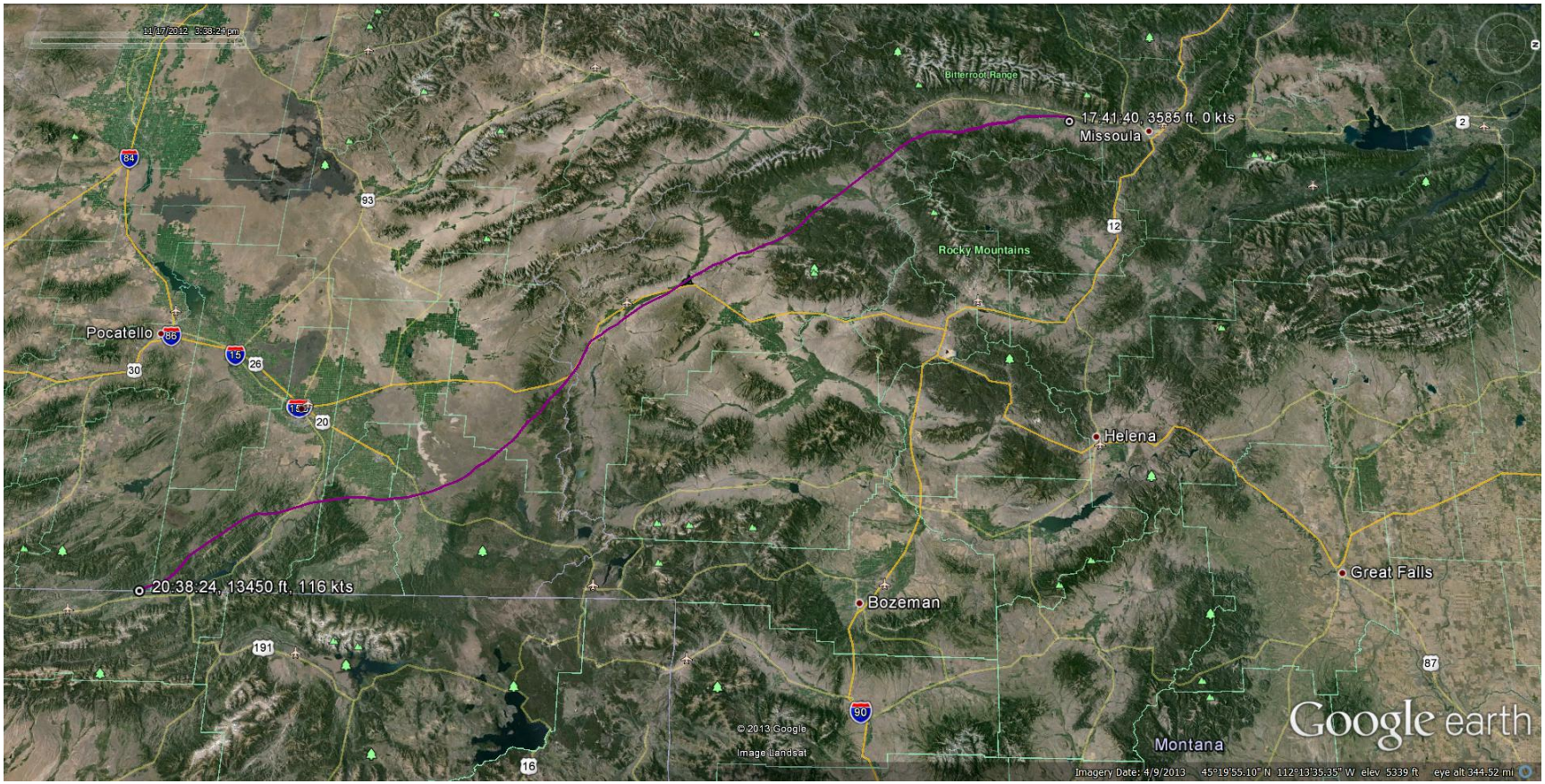


Figure 5. Google Earth overlay showing departure of the accident flight.

Figure 6. Google Earth overlay of end of the recording.

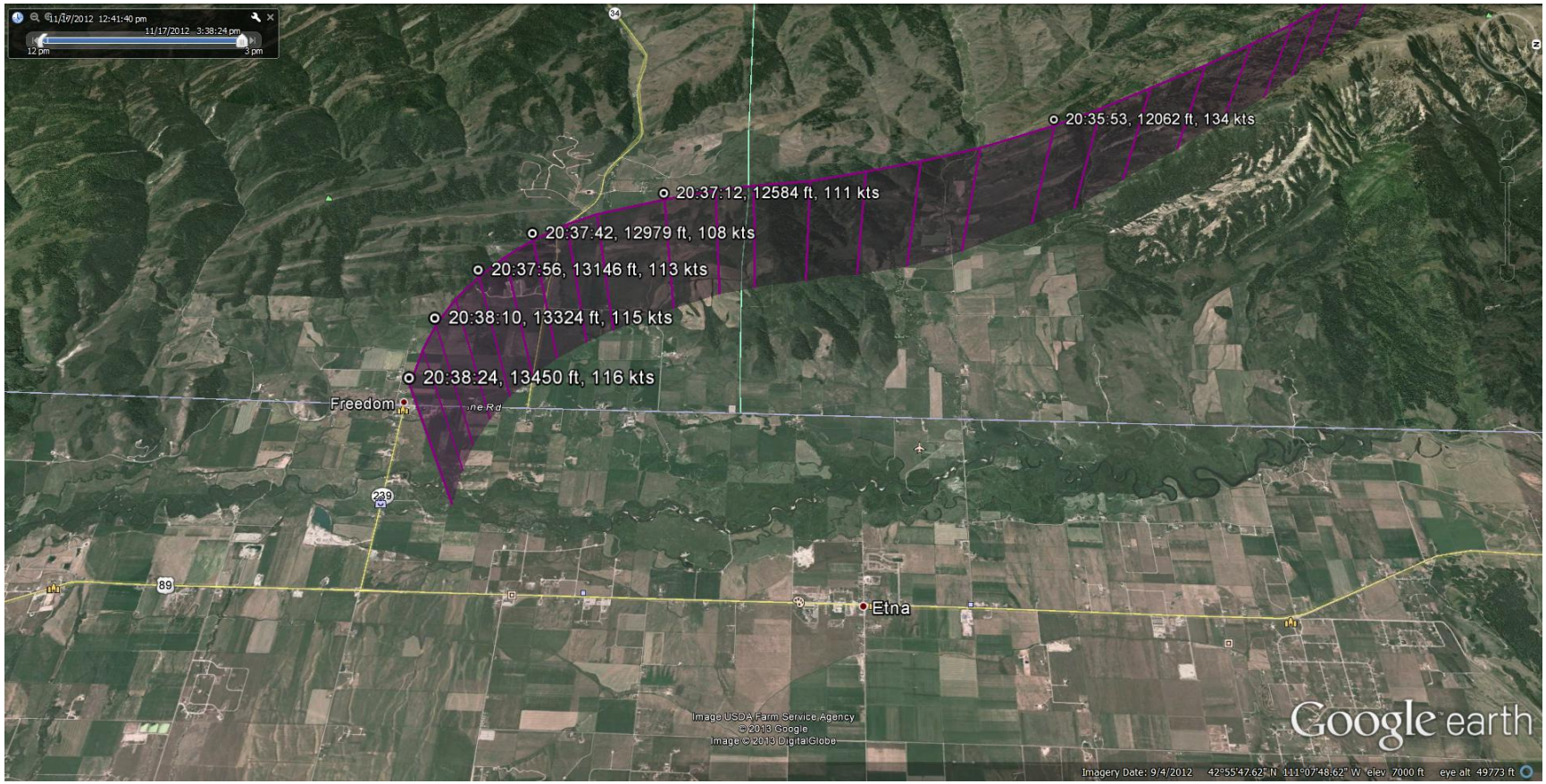


Figure 7. Plot of groundspeed and GPS altitude for accident flight.