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

April 23, 2014

17 - GPS Factual Report

Specialist's Factual Report
by Joe Gregor

1. EVENT

Location:	Auburn, California
Date:	May 18, 2013
Aircraft:	Cessna 170B
Registration:	N2865C
Operator:	Private
NTSB Number:	WPR13FA236

On May 18, 2013, about 1838 Pacific Daylight Time, a Cessna 170B airplane, N2865C, was substantially damaged when it impacted terrain while on final approach to landing at the Auburn Municipal Airport (AUN), Auburn, California. The cross-country flight originated from the Crazy Creek Gliderport, near Middletown, California, about 1754 with an intended destination of AUN.

2. DETAILS OF DEVICE INVESTIGATION

The Safety Board's Vehicle Recorder Division received the following devices:

Device:	Garmin GPSMAP 296
Device S/N:	67009449

2.1. Garmin GPSMAP 296 Device Description

The Garmin GPSMAP 296 is a hand-portable GPS unit equipped with a detachable antenna, a 256 color TFT LCD display, built in base map and an internal Jeppesen aviation database. The unit employs a parallel 12 channel receiver and can be operated using external power, or alternatively by using an internal Li-Ion rechargeable battery. The GPSMAP 296 is capable of storing date, route of flight, and flight time information for up to 50 individual flights in the form of a flight log. Flight logging begins when the GPS unit senses a speed increase to greater than 30 knots together with an altitude gain of greater than 500 feet. The record is saved when the speed is sensed to decrease to below 30 knots, and a new log will be started if more

than 10 minutes passes from this time. A detailed track log – including latitude, longitude, date, time, and groundspeed 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 track log as a function of time or distance moved, depending on how the unit has been configured.[1] Once the current track log memory becomes full, new information either overwrites the oldest information or recording stops, depending on how the unit is configured. The current track log can be saved to long-term memory and 15 saved track logs can be maintained in addition to the current track log. Track log storage may be activated or de-activated at user discretion. All recorded data is stored in *non-volatile*[2] memory. The unit contains hardware and software permitting the download of recorded waypoint, route, and track log information to a PC via a built-in serial port using the NMEA 0183 version 2.0 protocol. 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.

2.1.1. Garmin GPSMAP 296 Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed that the unit had sustained impact damage compromising the LCD screen and outer case (see figure 1). An internal inspection was performed (see figures 2 and 3). Numerous electronic components were found to be irreparably damaged or displaced. This damage was severe enough to render the unit irreparable.

The GPSMAP 296 stores recorded data in *non-volatile* memory (FLASH).[3] This particular model stores recorded data on an AM29SL160CB12VC FLASH memory device mounted to the main printed circuit board (PCB) (not shown in figure 2). The FLASH memory device was removed from the PCB using a hot air re-work station, reballed using an infrared re-work station, and a raw-data binary readout of the chip[4] was obtained using a *Xeltek SP-3000u* EEPROM programmer. Recorded track log data was identified and converted to engineering units using an in-house software program.

[1] A 'resolution' setting is also available which records a new track point only when the direction and speed have changed significantly. In this mode the unit examines current 2-D position, velocity, and ground track once per-second, and calculates a projected position. If the unit's actual position 1-second later differs from the projected position by a set value (25 meters, or 82 feet, by default), or if the ground track changes by more than 5°, a new track point is recorded. This saves memory during non-maneuvering flight.
[2] Non-volatile memory is semiconductor memory that does not require external power for data retention.
[3] FLASH Memory is a form of re-writeable, non-volatile memory that can retain data without external power - provided that the chip is not heated beyond the data retention temperature limit as stated in the datasheet.
[4] Chip: colloquial term for an integrated circuit device.

2.1.2. Garmin GPSMAP 296 Data Description

Track log data dated from September 7, 2012 to May 18, 2013 was recovered from the unit.

3. GPS PARAMETERS PROVIDED

Table 1 describes data parameters provided by the GPS device. Date, Time, Longitude, Latitude, and GPS Altitude are recorded by the device. Groundspeed and Course are derived from the recorded parameters. Data covering the last three recorded flights is provided in tabular format as Attachment 1 to this report.

Table 1: GPS Data Parameters

Parameter Name	Parameter Description
Date	Date for recorded data point (MM/DD/YYYY)
Time	Time (PDT) for recorded data point (HH:MM:SS)
Latitude	Recorded Longitude (degrees)
Longitude	Recorded Latitude (degrees)
GPS Alt	Recorded GPS Altitude (feet, MSL[5])
Groundspeed	Average groundspeed between current and previous data point (knots)
Course	Average true course between current and previous data point (degrees)

4. OVERLAYS AND TABULAR DATA

All graphical overlays in this report were generated using Google Earth.

Recorded data for the last track log starts at 1750:05 PDT with the aircraft at approximately 954 ft GPS altitude and at latitude/longitude coordinates corresponding to the Crazy Creek Glider Port northeast of Middleton, CA. Field elevation at this location according to Google Earth is approximately 977 ft. Recorded data and ends at 1838:55 PDT with the aircraft at 1744 ft GPS altitude and at latitude/longitude coordinates corresponding to the Auburn Municipal Airport north of Auburn, CA. The average groundspeed between the last two recorded GPS track points was computed to be approximately 64 knots.

[5] MSL means altitude above mean sea level

Figure 4 is a graphical overlay of the last recorded track log. The track log begins on the left side of the figure and ends at the right side of the figure. The aircraft entered the area of Auburn Municipal Airport (AUN) from the west-southwest and executed a downwind to a left base for runway 25. Figure 5 is a plot of the same data zoomed in to show the last 5 ½ minutes of the flight. During this time the aircraft descended continuously from approximately 3000 ft to 1744 ft GPS altitude, while slowing continuously from approximately 100 knots to 64 knots groundspeed. Figure 6 depicts a 3-D view of this same data looking to the west.

Figures 7 and 8 depict derived groundspeed, measured GPS altitude, and derived true course during the last 10-minutes of the recorded flight. In figure 6, GPS altitude is given in red and referred to the scale on the left axis, while groundspeed is given in blue and referred to the scale on the right axis. In figure 7, GPS altitude is given in red and referred to the scale on the left axis, while true course is given in blue and referred to the scale on the right axis.

Figure 1. External view of the Garmin 296 (s/n 67009449).

Figure 2. Internal view of the Garmin 296 main Printed Circuit Board (FLASH memory device removed from location circled in red).

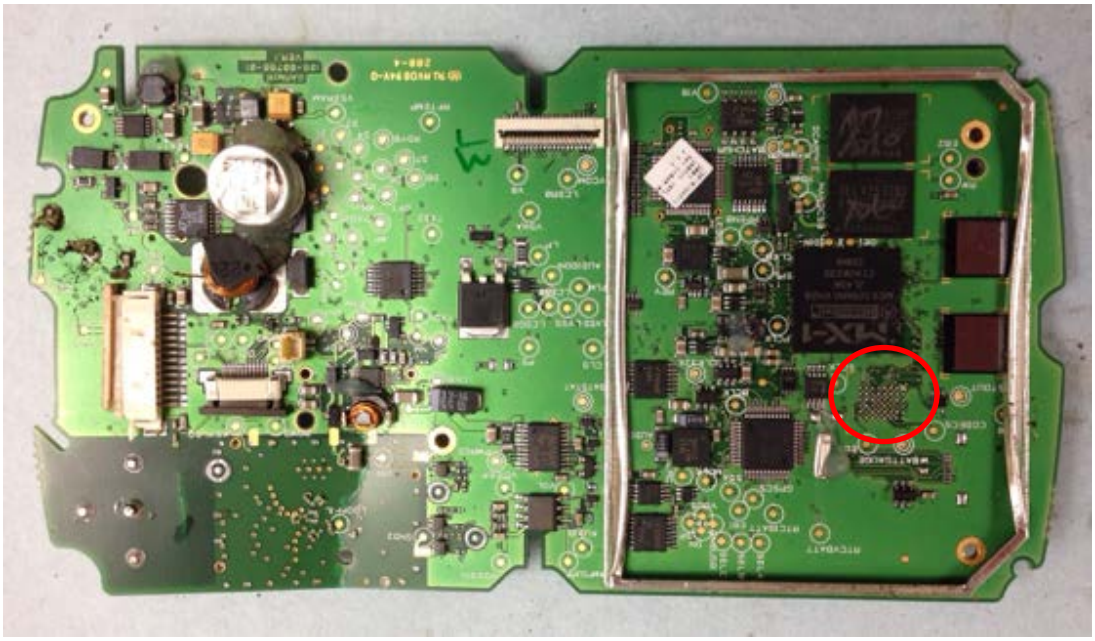

Figure 3. Internal view of the Garmin 296 main Printed Circuit Board (backside).

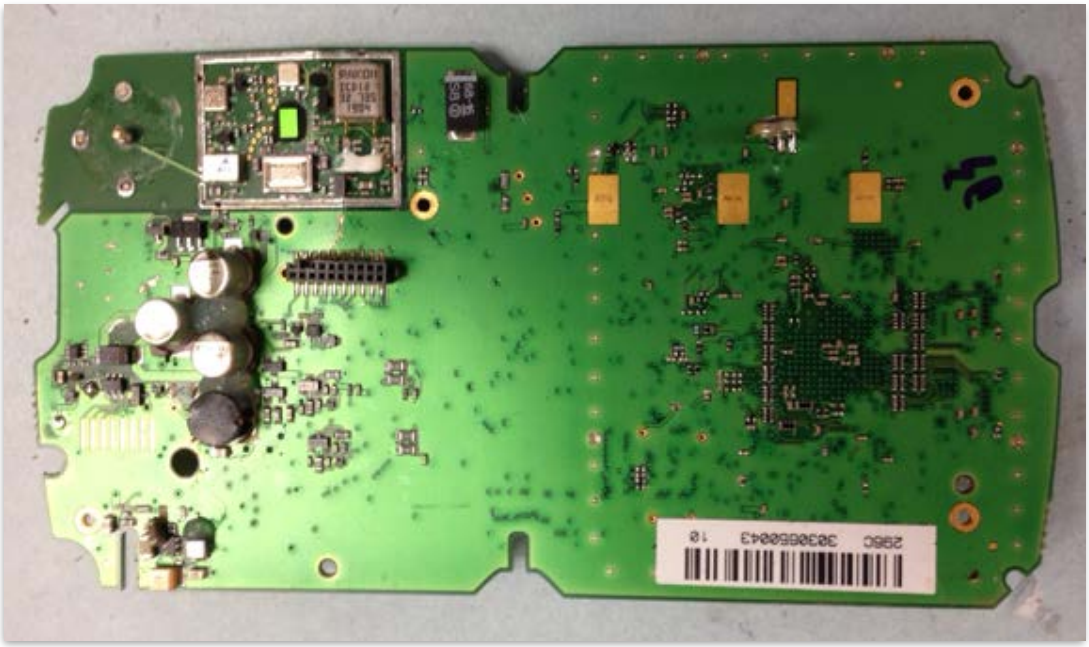

Figure 4. Google Earth 2-D plot showing the last recorded track log from the GPSMAP 296.

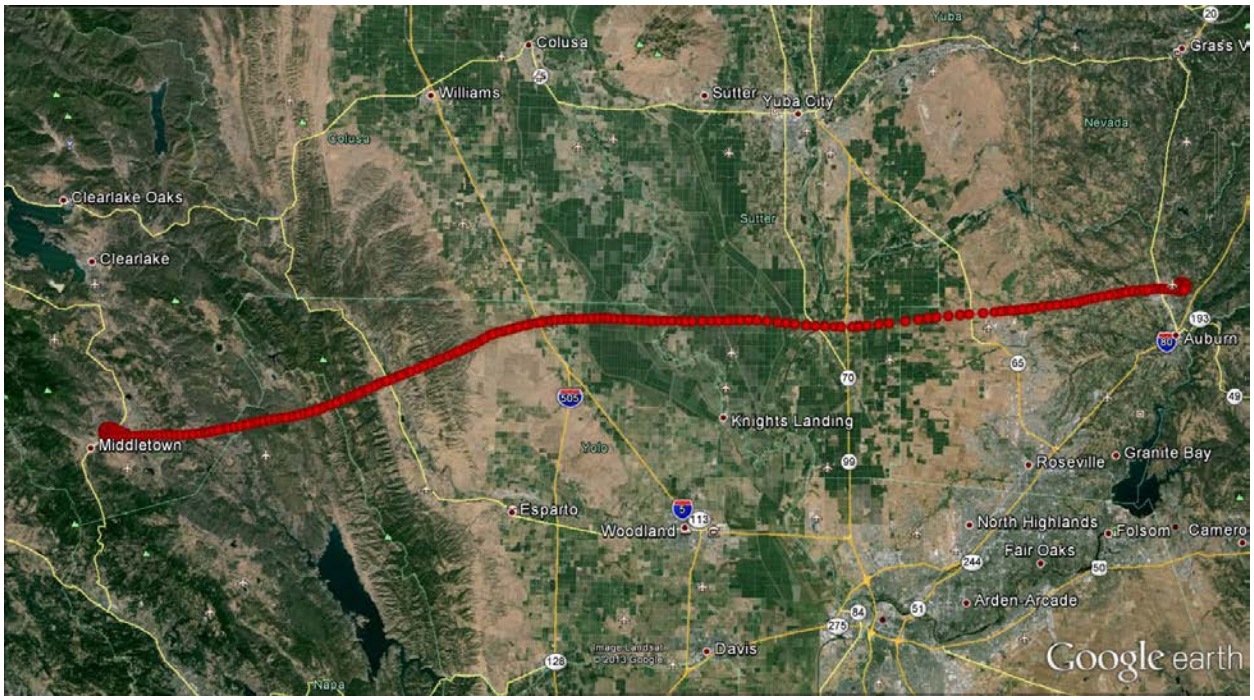

Figure 5. Google Earth 2-D plot showing the final 5 ½ minutes of the last recorded flight.

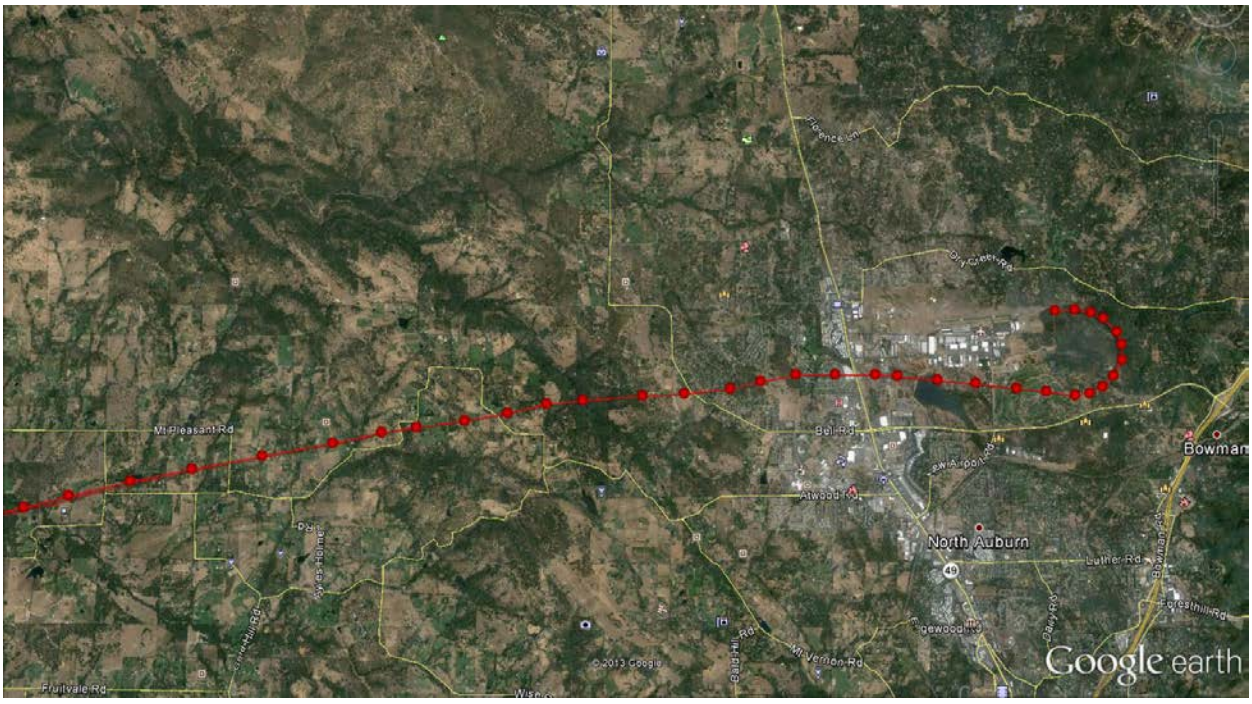

Figure 6. Google Earth 3-D plot showing the arrival and approach phase of the flight.

Figure 7. Graph giving the GPS altitude and groundspeed during the last 10-minutes of the flight.

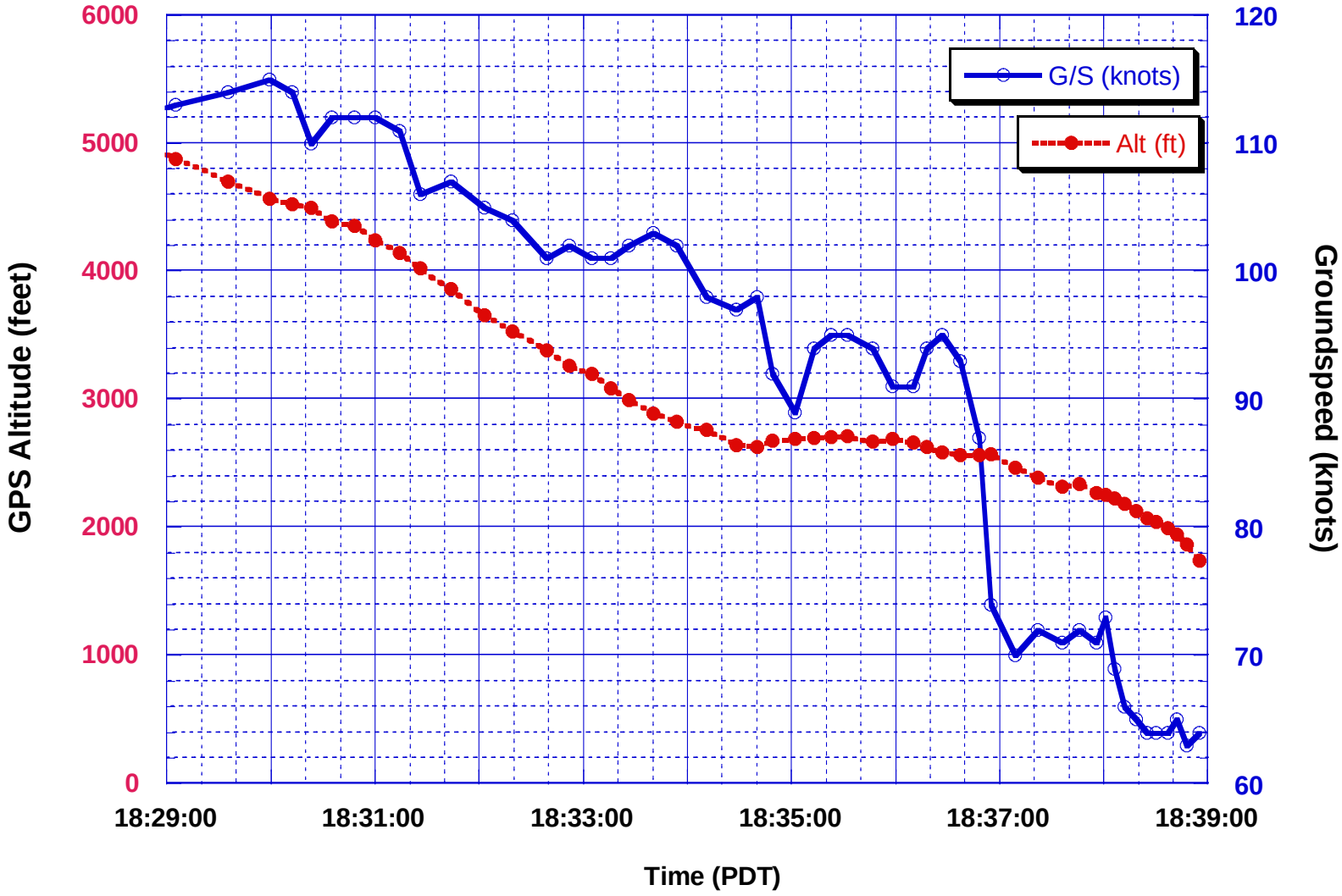

Figure 8. Graph giving the GPS altitude and true course during the last 10-minutes of the flight.