

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division
Washington, D.C. 20594

February 14, 2022

Global Positioning System (GPS) & Attitude and Heading Reference System (AHRS)

Specialist's Factual Report
by W. Deven Chen

1. EVENT

Location: Temecula, California
Date: November 23, 2021
Aircraft: Zenith Zodiac CH601XL
Registration: N601KS
Operator: Private
NTSB Number: WPR22FA048

2. DETAILS OF INVESTIGATION

On November 29, 2021, the National Transportation Safety Board (NTSB) Vehicle Recorder Division received the following device:

Device: Appareo Stratus PRX V2
Device Serial Number: 22254

2.1. Device Description

The Appareo Stratus PRX V2 device is a self-contained battery-powered unit that contains an internal AHRS,¹ GPS/WAAS receiver,² and ADS-B³ receiver in one compact unit. The unit communicates wirelessly with the pilot's iPad or iPhone ("iOS Device") to display all the acquired information. The pilot needs to have a particular software application called ForeFlight⁴ installed on their iOS Device to view the Stratus data. In addition to communicating with the iOS Device, the Stratus device records GPS position

¹ The Attitude Heading Reference System consists of a set of 3-axis gyroscope, accelerometers and heading reference sensors that enable the unit to compute pitch, roll, and yaw motions.

² The Wide Area Augmentation System (WAAS) is an air navigation aid to augment the Global Positioning System (GPS), by improving its accuracy, integrity, and availability.

³ Automatic Dependent Surveillance-Broadcast (ADS-B) is a surveillance technology deployed throughout the national airspace system. The ADS-B system is composed of aircraft avionics and a ground infrastructure. Onboard avionics determine the position of the aircraft by using the GPS and transmit its position along with additional information about the aircraft to ground stations for use by air traffic control (ATC) and other ADS-B services. This information is transmitted at a rate of approximately once per second. Operators equipped with ADS-B realize additional benefits from ADS-B broadcast services: Traffic Information Service - Broadcast (TIS-B) (traffic information) and Flight Information Service - Broadcast (FIS-B) (weather information).

⁴ ForeFlight is an iOS Device app that communicates wirelessly with the Appareo Stratus unit to display aircraft's attitude, navigation, weather, and traffic information.

and AHRS information internally on a non-volatile flash⁵ memory chip. Internal memory has the space to store over 13 hours of data at 5 Hz rate.

2.2. Data Recovery

Upon arrival at the Vehicle Recorder Division, an external examination revealed the device had sustained damage, as shown in Figure 1, rendering it inoperable. The non-volatile memory chip was removed, read out, and converted to engineering units using laboratory tools.



Figure 1: Appareo Stratus PRX V2 as received.

2.3. Data Description

The data extracted contained several sessions. The session determined to be relevant to the event was parsed out and started at 18:18:18.2 UTC (Coordinated Universal Time) and ended at 18:33:10.6 UTC on November 23, 2021. All times are expressed as Pacific standard time (PST) for the rest of this report. The difference between UTC and PST is 8 hours.

The Appareo Stratus PRX V2 is an externally mounted device and is not necessarily fixed to the aircraft's instrument panel in a rigid mounted position. As such, the device might be subject to movement under extreme pitch and roll conditions, and the accuracy of gyroscopic parameters on the Stratus is dependent on the device being properly oriented and calibrated.

⁵ Non-volatile memory (NVM) is semiconductor memory that does not require external power for data retention.

2.4. Parameters Provided

Table 1 describes data parameters recorded and derived by the device.

Table 1: Validated Appareo Stratus PRX V2 Parameters

Parameter Name	Parameter Description (units)
Date	Date for recorded data point (MM/DD/YYYY)
Time	Converted Time (PST) for recorded data point (HH:MM:SS.0)
Latitude	Recorded Latitude (degrees)
Longitude	Recorded Longitude (degrees)
Acceleration X	Acceleration in X-Axis (g)
Acceleration Y	Acceleration in Y-Axis (g)
Acceleration Z	Acceleration in Z-Axis (g)
Altitude HAE	Altitude above Ellipsoid (feet)
Altitude HMSL	Altitude above mean sea level (feet)
Ground Speed	Averaged derived ground speed (knots)
Heading	Magnetic Heading (degrees)
Ground Track	Ground Track (degrees)
Pitch	Pitch Angle (degrees)
Roll	Roll Angle (degrees)
Turn Rate	Turn Rate (degrees per second)
Slip	Slip/Skid of the turn (g)
Vertical Speed	Vertical Speed (feet per second)

2.5. Plots and Corresponding Tabular Data

Figure 2 is a graphical overlay generated using Google Earth showing the entire event flight. Weather and lighting conditions in Google Earth are not necessarily the weather and lighting conditions present at the time of the recording.

Figure 3 is a Google Earth overlay showing the take-off of the event aircraft from French Valley Airport (F70) around 10:20:00 PST.

Figure 4 is a Google Earth overlay of the end of the event flight. The reported wreckage location is shown with a red pin.

Figure 5 is a plot of the validated parameters for the entire event flight. The time interval displayed is 10:18:00 to 10:34:00 PST.

Figure 6 is a plot of the validated parameters at the end of the event flight. The time interval displayed is 10:32:40 to 10:33:12 PST.

The corresponding tabular data used to create Figures 2 through 6 are provided in comma-separated value (CSV) format as Attachments 1 and 2 to this report.



Figure 2: Google Earth overlay of the entire event flight.



Figure 3: Google Earth overlay showing the start of the recording and French Valley Airport (F70).

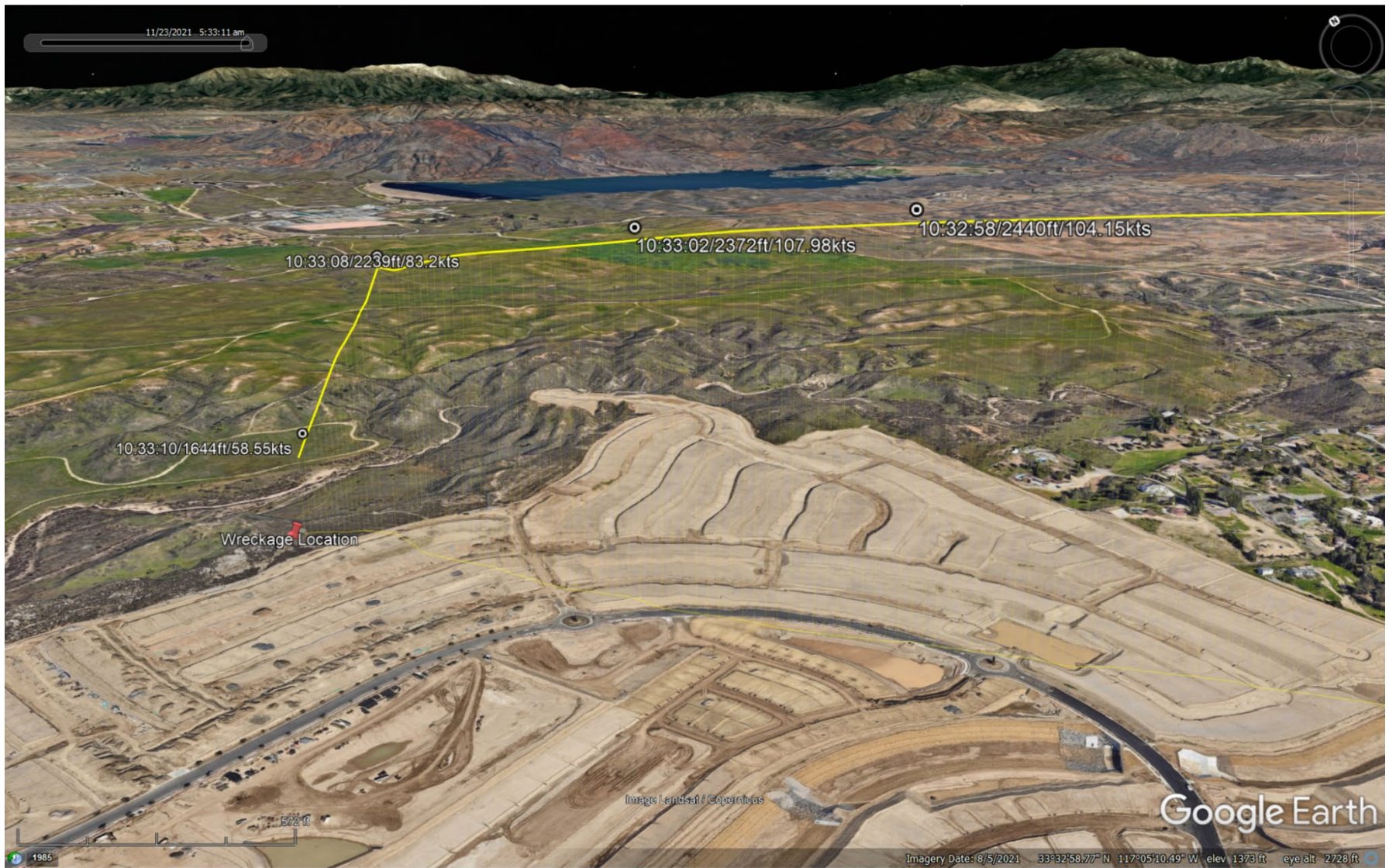


Figure 4: Google Earth overlay showing the end of the event flight.

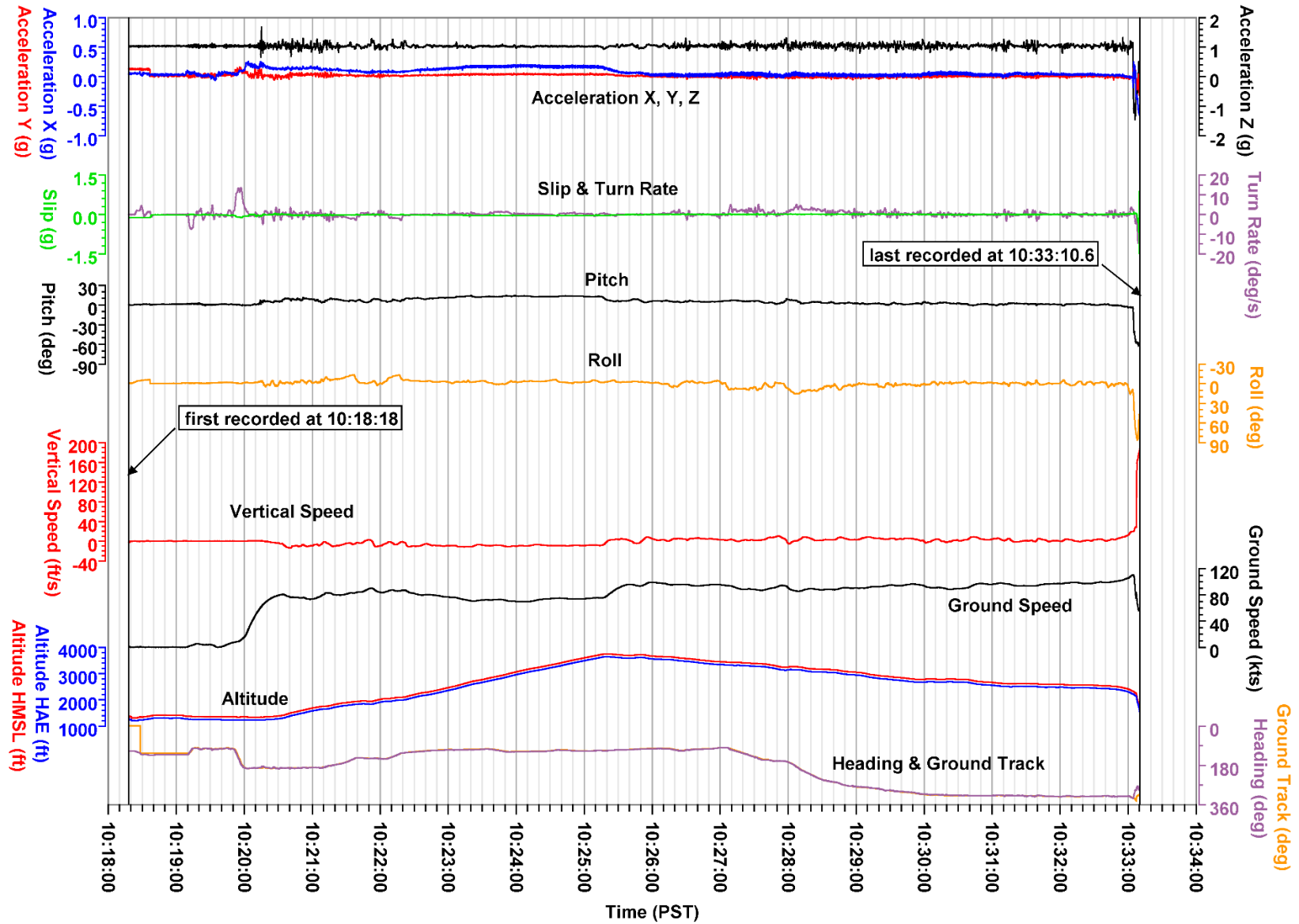


Figure 5: Plot of parameters for the entire event flight.

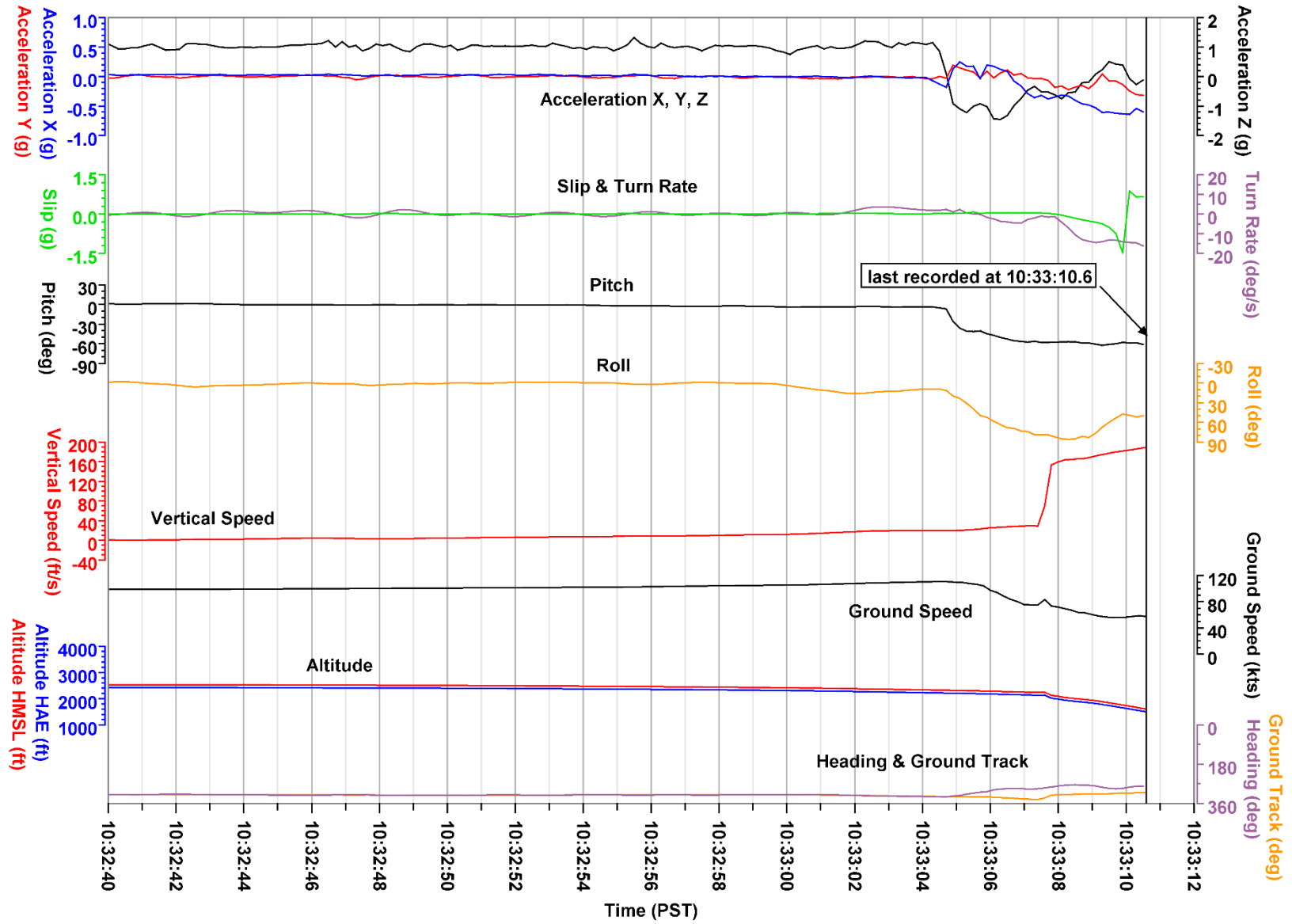


Figure 6: Plot of parameters for the end of the event flight.