

National Transportation Safety Board

Office of Research and Engineering

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GLOBAL POSITIONING SYSTEM DEVICE

Specialist's Factual Report

October 5, 2023

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A. ACCIDENT

Location: Falmouth, Massachusetts
Date: December 2, 2022
Time: 2004 coordinated universal time (UTC)
Airplane: Mooney M20J, private operator, N3515H

B. GLOBAL POSITIONING SYSTEM DEVICE SPECIALIST

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C. DETAILS OF THE INVESTIGATION

A global positioning system (GPS) group was not convened. The NTSB Vehicle Recorder Division received the following GPS device:

Recorder Manufacturer/Model: Appareo Stratus PRX V2
Part Number: 150500-000003
Serial Number: 201529

1.0 Appareo Stratus PRX V2 Description

The Appareo Stratus device is a self-contained battery powered unit that contains an internal AHRS, GPS/WAAS receiver, and ADS-B receiver in one compact unit.^{1, 2, 3} The unit communicates wirelessly with the pilot's iPad or iPhone ("iOS Device") to display all of the acquired information. The pilot needs to have a particular software application called ForeFlight installed on their iOS Device to view the Stratus data.⁴ In addition to communicating with the iOS Device, the Stratus

¹ The Attitude Heading Reference System (AHRS) 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 (program) that communicates wirelessly with the Appareo Stratus device to display aircraft's attitude, navigation, weather, and traffic information.

device records GPS position and AHRS information internally on a non-volatile flash memory chip.⁵ Internal memory has the space to store over 13 hours of data.

1.1 Appareo Stratus PRX V2 Data Recovery

The Stratus PRX V2 was in good condition and the data were downloaded normally using the manufacturers' procedure. Figure 1 is a photo of the device as received.



Figure 1. Front and back of the Appareo Stratus PRX V2 as received.

1.2 Appareo Stratus PRX V2 Recording Description

The data extracted included 12 sessions (power cycles) from November 5, 2022, through December 2, 2022.⁶ The accident flight started at 19:16:06.8 UTC and ended at 20:05:24.6 UTC on December 2, 2022. A post-accident recorded session started at 20:05:30.4 UTC and ended at 21:03:20.4 UTC on December 2, 2022. The difference between UTC and EST (local time) is 5 hours. The data rate was found to be 0.2 seconds per sample.

Vertical speed and Acceleration Z were found to be reversed when compared to other data. These parameters were inversed in the plotted information and tabular data provided in this report. Accuracy of gyroscopic parameters such as pitch angle

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

⁶ All dates and times are referenced to coordinated universal time (UTC).

and bank angle is dependent on the orientation of the device in the aircraft and proper calibration of the device while it is stationary.

1.3 Appareo Stratus PRX V2 Parameters Provided

Table 1 describes the Stratus PRX V2 parameters provided and verified in this report. The table also describes the parameter unit abbreviations used in this report.

Table 1. Verified and provided GPS Parameters.

Parameter Name	Parameter Description
Date (MM/DD/YYYY)	Date for recorded data point (Month/Day/Year)
Time (HH:MM:SS.0)	Time (UTC) for recorded data point (Hours:Minutes:Seconds)
Latitude (deg)	Recorded latitude (degrees)
Longitude (deg)	Recorded longitude (degrees)
Acceleration X (g)	Acceleration in longitudinal axis (g)
Acceleration Y (g)	Acceleration in lateral axis (g)
Acceleration Z (g)	Acceleration in vertical axis (g)
Altitude HMSL (ft)	GPS altitude height above mean sea level recorded in meters and converted to feet
Ground Speed (kts)	Average derived ground speed recorded in meters per second and converted to knots
Ground Track (deg)	Ground track (degrees)
Vertical Speed (ft/min)	Vertical speed recorded in meters per second and converted to feet per minute
True Heading (deg)	Magnetic heading (degrees)
Pitch (deg)	Pitch angle (degrees)
Roll (deg)	Roll angle (degrees)

D. OVERLAYS AND TABULAR DATA

Data obtained from the Stratus PRX V2 was used to produce the following overlays, figures, and tabular data. Figures 5 to 7 are configured such that right turns are indicated by the trace moving toward the bottom of the page, left turns towards the top of the page, and nose up attitudes towards the top of the page.

Figures 2 to 4 are graphical overlays generated using Google Earth for the accident flight. Figure 2 is a Google Earth overlay of the entire flight. The flight originated at Westfield-Barnes Regional Airport (BAF), Westfield, Massachusetts. Figure 3 is a Google Earth overlay detailing approximately the last 5 minutes. Figure 4 is a Google Earth overlay detailing approximately the last 2 minutes. The last recorded data point was at Falmouth Airpark (5B6), Falmouth, Massachusetts. The

weather, landscaping, and lighting conditions in Google Earth are not necessarily the weather, landscaping, and lighting conditions present at the time of the recording.

Figure 5 is a plot of parameters of the entire accident flight and post-accident recording on the Stratus PRX V2. The data displayed is from 19:16:06.8 UTC to 21:03:20.4 UTC.

Figure 6 is a plot of parameters of the entire accident flight. The data displayed is from 19:16:06.8 UTC to 20:05:24.6 UTC.

Figure 7 is a plot of parameters during the final segment when ground speed approaches 0 knots. The data displayed is from 20:03:45.0 UTC to 20:04:00.0 UTC.

The corresponding tabular data used to create figures 2 to 7 are provided in electronic comma-separated value (CSV) format as attachment 1 to this report.

Submitted by:

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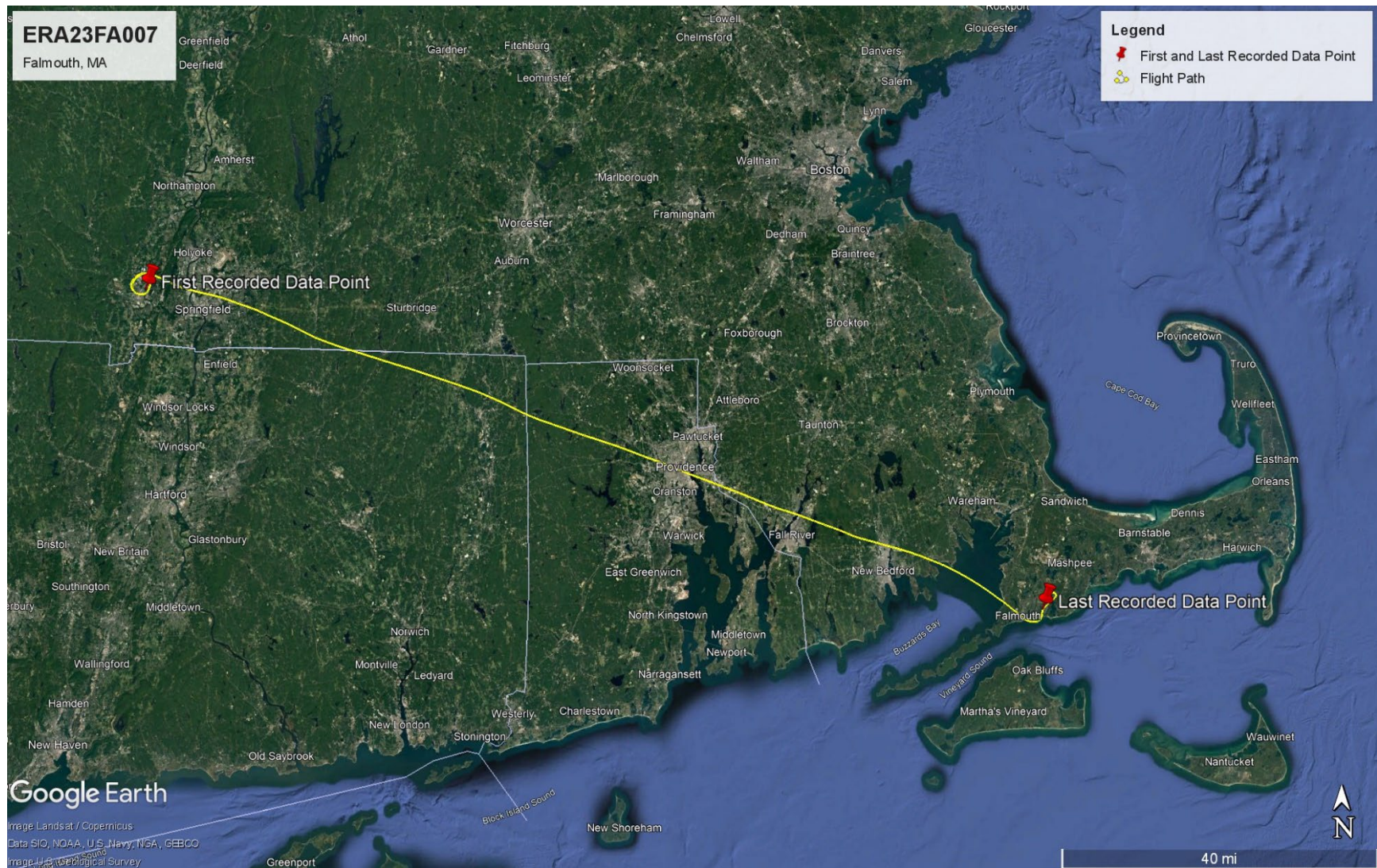


Figure 2. Google Earth overlay showing the entire accident flight.

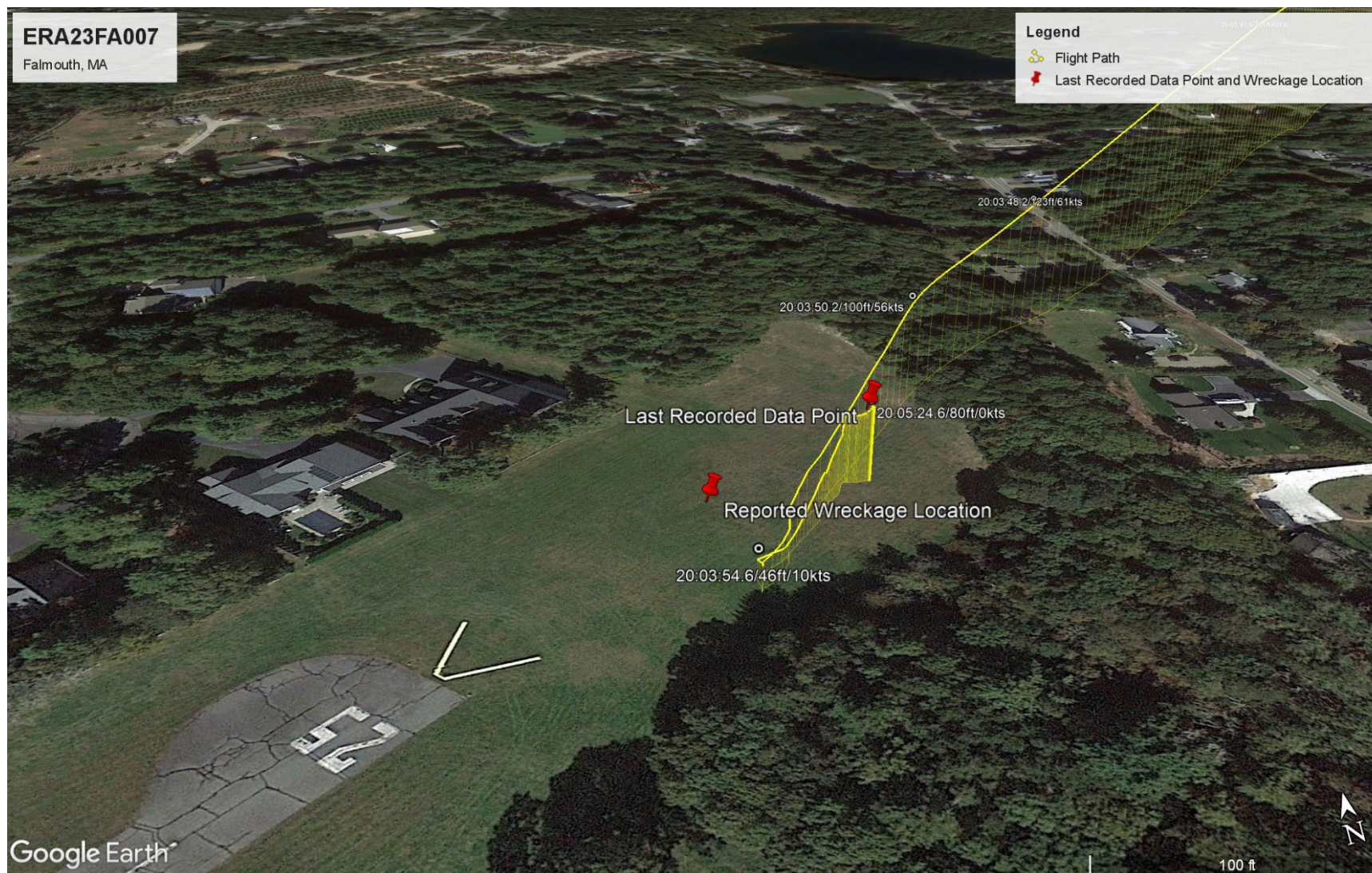


Figure 4. Google Earth overlay showing the accident flight's final segment.

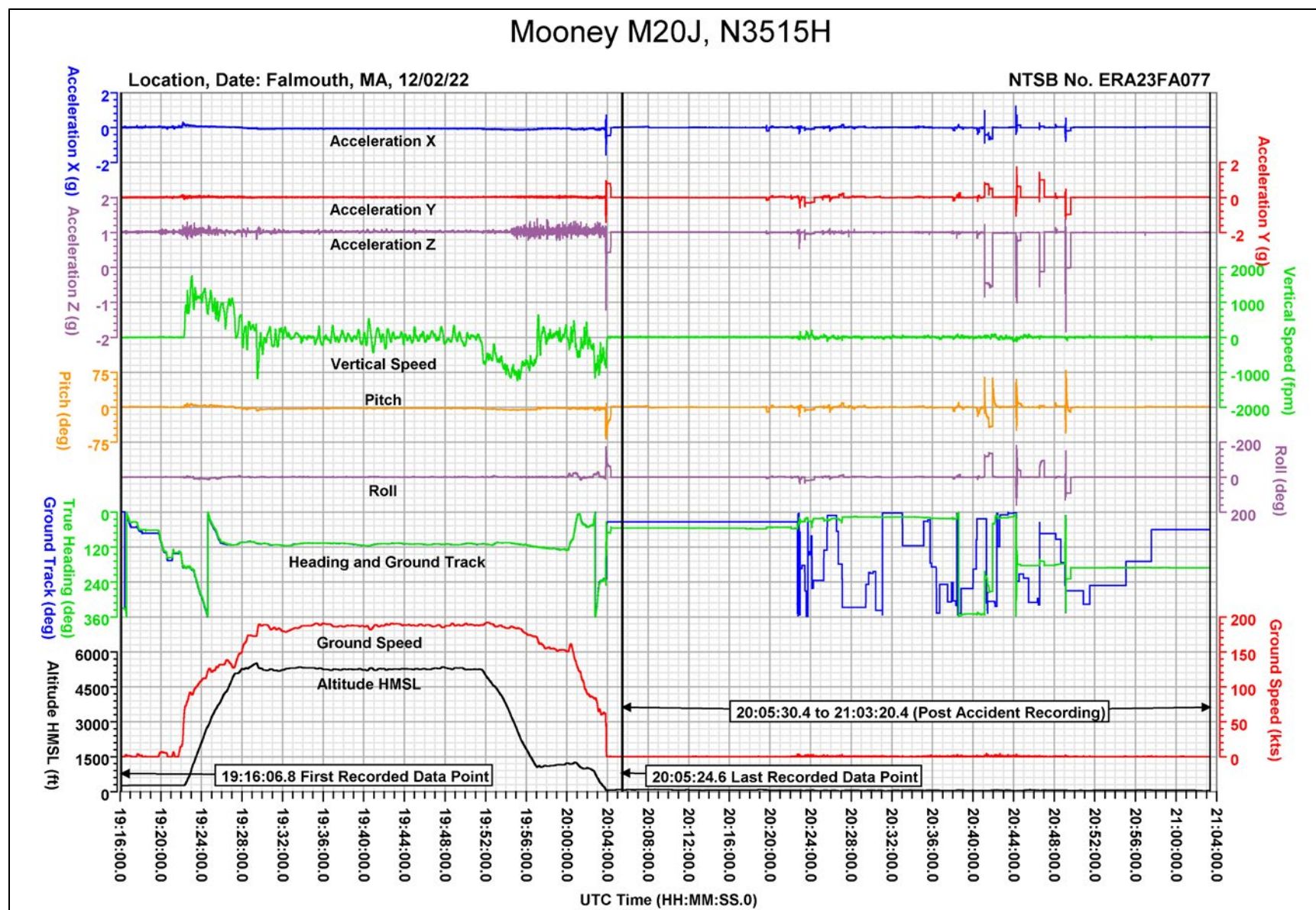


Figure 5. Plot of Appareo Stratus PRX V2 parameters for accident and post-accident flight.

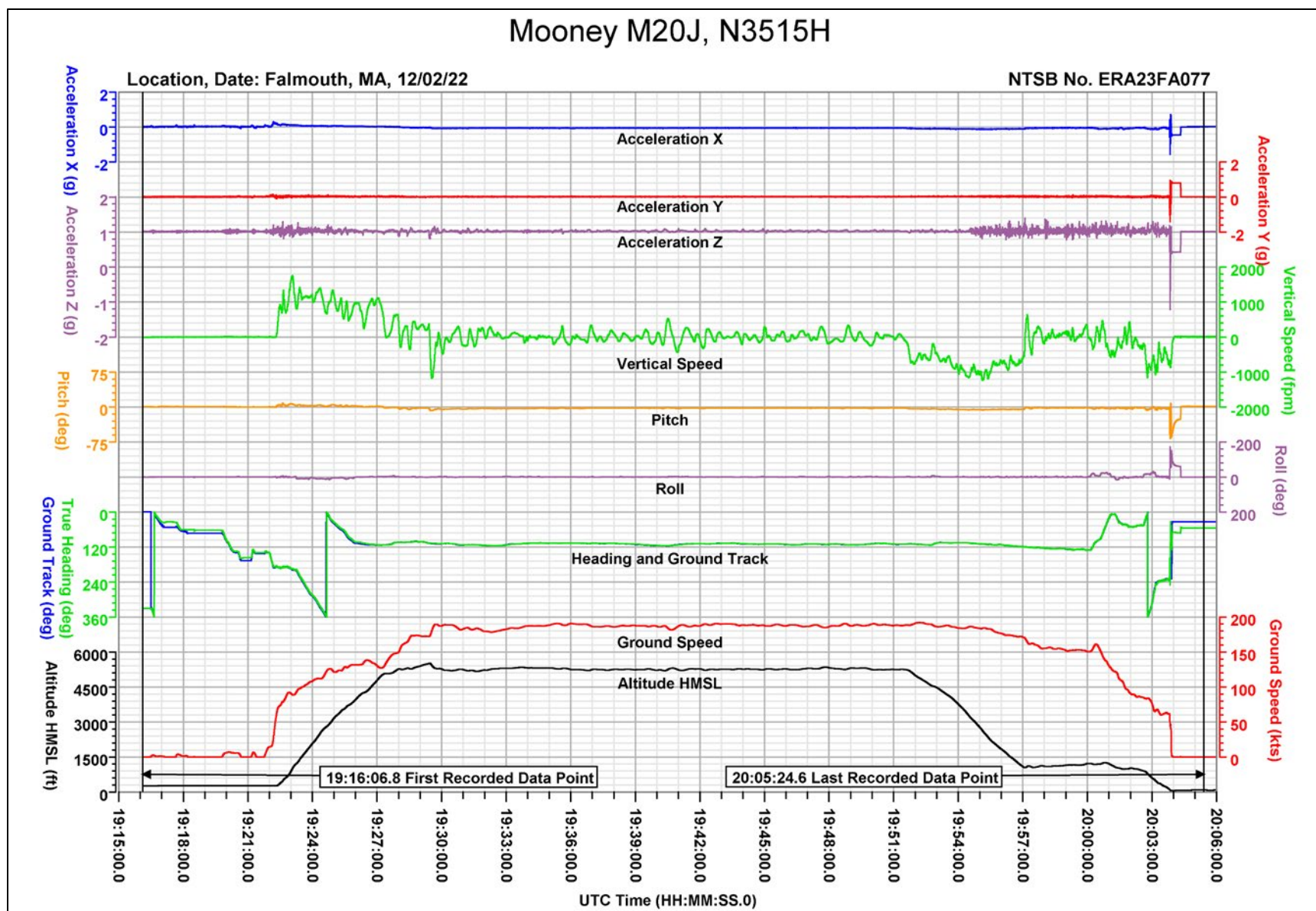


Figure 6. Plot of Appareo Stratus PRX V2 parameters for the accident flight.

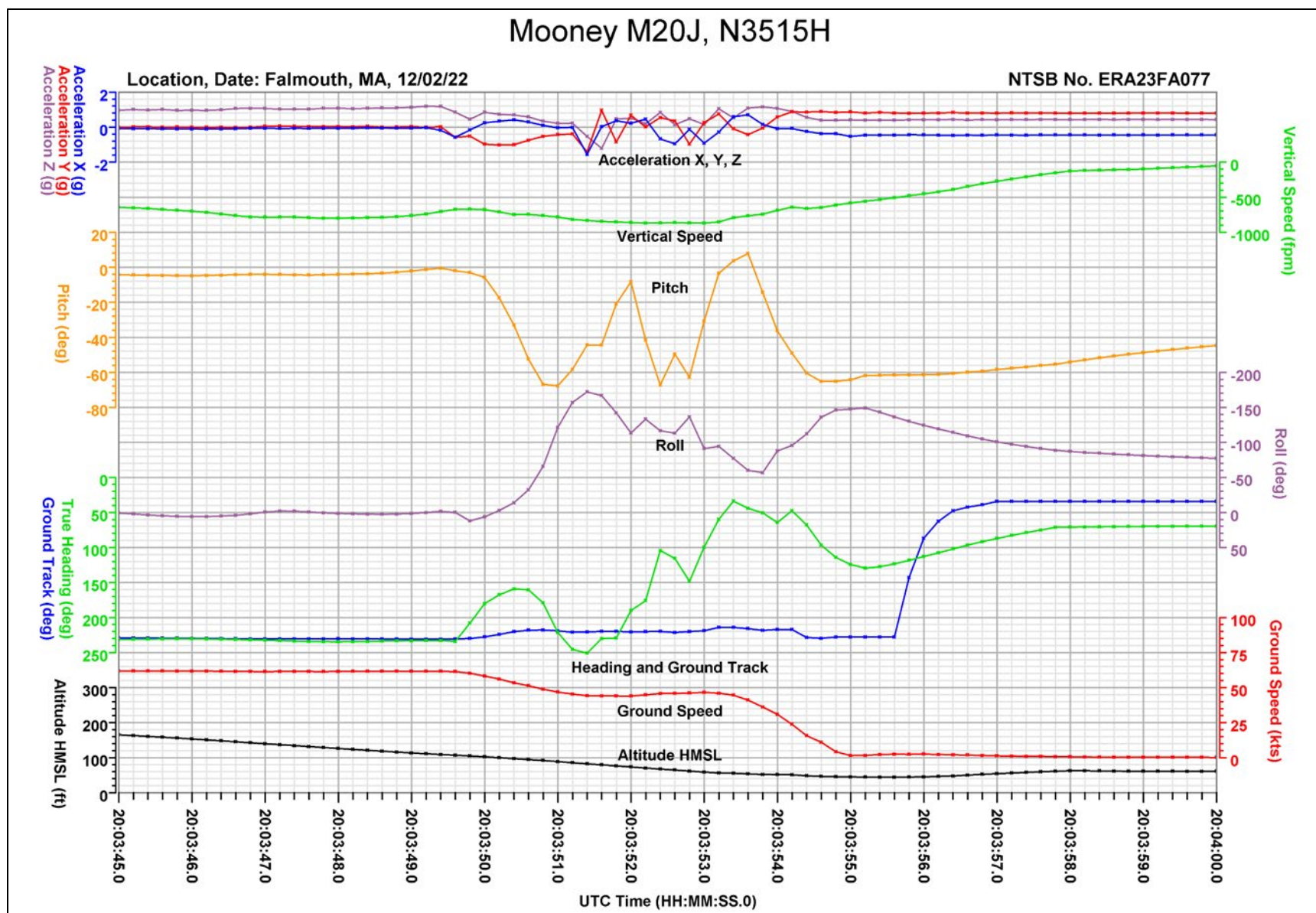


Figure 7. Plot of Appareo Stratus PRX V2 parameters when ground speed approaches 0 kts.