

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division
Washington, D.C. 20594

March 3, 2021

Electronic Devices

**Specialist's Factual Report
by Gerald Kawamoto**

1. EVENT

Location: Bartow, Florida
Date: February 13, 2020
Aircraft: Mooney M20J
Registration: N1149T
Operator: Private
NTSB Number: ERA20FA101

On February 13, 2020, at 1126 eastern standard time (EST), a Mooney M20J, N1149T, was substantially damaged when it impacted terrain while on approach to Bartow Executive Airport (BOW), Bartow, Florida. The private pilot and a passenger were fatally injured. The airplane was registered to and operated by OR & WIL LLC under the provisions of Title 14 *Code of Federal Regulations* Part 91 as a personal flight. Day visual meteorological conditions prevailed at the time and no flight plan was filed for the cross country 4-airplane formation flight that originated at 1045 from Spruce Creek Airport (7FL6), Daytona Beach, Florida.

2. DETAILS OF INVESTIGATION

The National Transportation Safety Board (NTSB) Vehicle Recorder Division received the following devices:

Device 1:	JPI EDM-800
Device 1 Serial Number:	36944
Device 2:	Appareo Stratus 2S
Device 2 Serial Number:	017335
Device 3:	Apple iPad Mini 5
Device 3 Serial Number:	DMPZ63LQLM94
Device 4:	Apple iPad Mini 2
Device 4 Serial Number:	F9FNWG5FECM6

2.1. JPI EDM-800 Device Description

The JPI EDM-800 is a panel-mounted gauge that allows the operator to monitor and record up to 24 parameters related to engine operations. Depending on the installation, engine parameters monitored can include: Exhaust Gas Temperature (EGT), Cylinder Head Temperature (CHT), Oil Pressure and Temperature, Manifold Pressure, Outside Air Temperature, Turbine Inlet Temperature, Engine Revolutions Per Minute (RPM), Compressor Discharge Temperature, Fuel Flow, Carburetor Temperature, and Battery Voltage.

The unit can also calculate in real time, percent of maximum horsepower, fuel used, shock cooling rate, and EGT differentials between highest and lowest cylinder temperatures. The calculations are also based on the aircraft installation.

The unit contains non-volatile memory¹ for data storage of the parameters recorded and calculated. The rate at which the data is stored is selectable by the operator from 2 to 500 seconds per sample. The memory can store up to 20 hours of data at a 6 second-per-sample rate. The data can then be downloaded by the operator using the J.P. Instruments software.

2.1.1. JPI EDM-800 Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed the unit had sustained impact damage, as shown in Figure 1. An internal examination showed the electronic components were in good condition with exception of the display. A functioning surrogate display was connected to the device and it powered on normally. Data was extracted normally using the manufacturer's software.



Figure 1. Front and back of the JPI EDM-800 as received.

2.1.2. JPI EDM-800 Data Description

The data extracted included 27 sessions from December 28, 2019, through February 13, 2020.² The accident flight was the last session recorded and started at 15:38:26 UTC and ended at 16:26:08 UTC on February 13, 2020. The recorded time is based on the unit's

¹ Non-volatile memory (NVM) is semiconductor memory that does not require external power for data retention.

² All dates and times are referenced to Coordinated Universal Time (UTC). The difference between UTC and EST is 5 hours.

internal clock, which is manually adjusted by the operator. The dates recorded for sessions on the device corresponded to dates for sessions extracted from the Stratus 2S device. Data was correlated to UTC by aligning the application of takeoff power to position data extracted from the Stratus 2S. An offset of 28 minutes and 12 seconds was applied to the EDM plots in this report. The data was recorded at a 6 second-per-sample rate.

2.1.3. JPI EDM-800 Parameters Provided

Table 1 describes data parameters recorded by the device.

Table 1: JPI EDM-800 Data Parameters

Parameter Name	Parameter Description
Date	Date for recorded data point (MM/DD/YYYY)
Time	Time for recorded data point (HH:MM:SS)
EGT 1-4 (degF)	Exhaust Gas Temperature Cylinder # (degrees Fahrenheit)
CHT 1-4 (degF)	Cylinder Head Temperature Cylinder # (degrees Fahrenheit)
CLD (degF/min)	Shock Cooling Rate (degrees Fahrenheit per minute)
FF (gph)	Fuel Flow (gallons per hour)
HP (%)	Horsepower (percent)
MAP (inHg)	Manifold Pressure (inches of Mercury)
OAT (degF)	Outside Air Temperature (degrees Fahrenheit)
Oil Temp (degF)	Oil Temperature (degrees Fahrenheit)
RPM	Engine Revolutions Per Minute
USD (gal)	Fuel Used (gallons)
Voltage (V)	Battery Voltage (Volts)

2.2. Appareo Stratus 2S Device Description

The Appareo Status 2S device is a self-contained battery powered unit that contains an internal AHRS,³ GPS/WAAS receiver,⁴ and ADS-B⁵ receiver in one compact unit. The unit communicates wirelessly with compatible devices to display all the acquired information. In addition to communicating with compatible devices, the Stratus device records GPS position and AHRS information internally on a non-volatile flash memory chip. Internal memory has the space to store over 13 hours of flight data that is sampled at approximately 5 data records per second (5 Hz).

³ 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.

⁴ 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.

⁵ 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).

2.2.1. Appareo Stratus 2S Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed the unit had sustained impact damage, as shown in Figure 2, rendering the device inoperable. The non-volatile memory chip was removed, read out, and converted to engineering units using laboratory tools.



Figure 2. Appareo Stratus 2S as received.

2.2.2. Appareo Stratus 2S Data Description

The data extracted included sessions from January 9, 2020, through February 13, 2020.⁶ The last session recorded on the device was determined to be related to the accident event and was parsed out. The recording started at 15:42:44.4 UTC and ended at 16:26:00.6 UTC on February 13, 2020.

2.2.3. Appareo Stratus 2S Parameters Provided

Table 2 describes data parameters recorded and derived by the device. Gyroscopic parameters such as pitch angle and bank angle were recorded, however, are not included in this report due to the parameters being found inaccurate.⁷ The accuracy of these parameters is dependent on proper mounting and orientation prior to powering on the device. The device is automatically calibrated after being powered on and can be recalibrated, as necessary, with a connected iOS device using the ForeFlight⁸ Mobile application. The orientation and calibration of the device in the aircraft could not be confirmed.

⁶ GPS Time. ADS-B data was recorded for the accident aircraft for the first 35 seconds of the flight. The coordinates and timestamps from the ADS-B data and the Stratus were compared and showed that the Stratus data was approximately 18 seconds ahead of the UTC timestamps, indicating that the device was recording GPS time for the accident session. The offset has been applied to the Appareo data plots. GPS Time is depicted in the Appareo data in the Google Earth overlays to illustrate the time correlation to ADS-B data.

⁷ For additional information, refer to the Vehicle Performance Report in the public docket. The parameters are included in the tabular data as Attachment 1 to the Electronic Devices Report.

⁸ iOS Device application capable of displaying the aircraft's altitude, navigation, weather, and traffic information. The application can be used for flight planning, charts, airport information, document management, and flight logging.

Table 2: Appareo Stratus 2S Parameters

Parameter Name	Parameter Description
Date	Date for recorded data point (MM/DD/YYYY)
Time	Time for recorded data point (HH:MM:SS.0)
Latitude (deg)	Recorded Latitude (degrees)
Longitude (deg)	Recorded Longitude (degrees)
MSL Altitude (ft)	Recorded MSL Altitude (feet)
Ground Speed (kts)	Averaged derived ground speed (knots)
Vertical Speed (fpm)	Vertical Speed (feet per minute)

2.3. Personal Electronic Device (PED) Description

PEDs are a category of devices comprised primarily of portable computing devices and mobile phones. Portable computing devices are typically capable of internet access, email, messaging services, and can run user-installed applications to perform specific tasks. PED user and system data is typically stored on non-volatile memory and can be accessed through manufacturer-provided interfaces.

2.3.1. Apple iPad Mini 5 and iPad Mini 2 Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed both iPads had sustained impact damage as shown in Figure 3, rendering the devices inoperable. The logic boards were removed and examined. The extent of the damage precluded normal recovery procedures and additional attempts were unsuccessful in yielding usable data, thus no data were recovered.



Figure 3. Apple iPad Mini 5 (left) and iPad Mini 2 (right).

3. Plots and Corresponding Tabular Data

Figures 4 through 7 are graphical overlays generated using Google Earth. The weather and lighting conditions in Google Earth are not necessarily the weather and lighting conditions present at the time of the recording. Data from the Appareo Stratus 2S were used to create the flight track. GPS Time is depicted.

Figure 4 shows the entire accident flight.

Figure 5 shows the timestamps associated with the ADS-B data from the accident aircraft (green) and the Stratus data (white). ADS-B data from the accident aircraft was only recorded for 35 seconds at the beginning of the flight. The timestamps from the Appareo are 18 seconds ahead of the timestamps from the ADS-B data for corresponding data points (same latitude and longitude). The blue timestamps are ADS-B data from the lead aircraft of the 4-airplane formation.

Figure 6 shows the last 4 minutes of the accident flight.

Figure 7 shows the end of the recordings for ADS-B data from the lead aircraft (#1) and Stratus data from the accident aircraft (#4).

Figure 8 is a plot of parameters from the JPI EDM-800 for the entire accident flight. The time interval displayed is 15:35:00 to 16:27:00 UTC.

Figure 9 is a plot of parameters from the JPI EDM-800 for the last 4 minutes of the accident flight. The time interval displayed is 16:22:30 to 16:26:30 UTC.

Figure 10 is a plot of parameters from the JPI EDM-800 for all sessions recorded. The x-axis depicts time elapsed in seconds starting with the first session recorded to the device's NVM. For all sessions: values for EGT 4 are offset from EGT values for the other cylinders and values for CHT 2 are offset from CHT values for the other cylinders.

Figure 11 is a plot of parameters from the JPI EDM-800 for sessions recorded from February 2, 2020, through February 13, 2020.

Figures 12 and 13 are plots of parameters from the Appareo Stratus 2S. An 18 second offset has been applied to display the data in UTC.

Figure 12 is a plot of the entire accident flight. The time interval displayed is 15:42:00 to 16:27:00 UTC.

Figure 13 is a plot of the last 4 minutes of the accident flight. The time interval displayed is 16:22:00 to 16:26:05 UTC.

The corresponding tabular data from the Stratus are provided in electronic comma separated value (.CSV) format as Attachment 1 to this report. The corresponding tabular data from the JPI are provided in electronic .CSV format as Attachment 2 to this report.

Figure 4. Google Earth overlay of the entire accident flight. GPS Time is depicted.

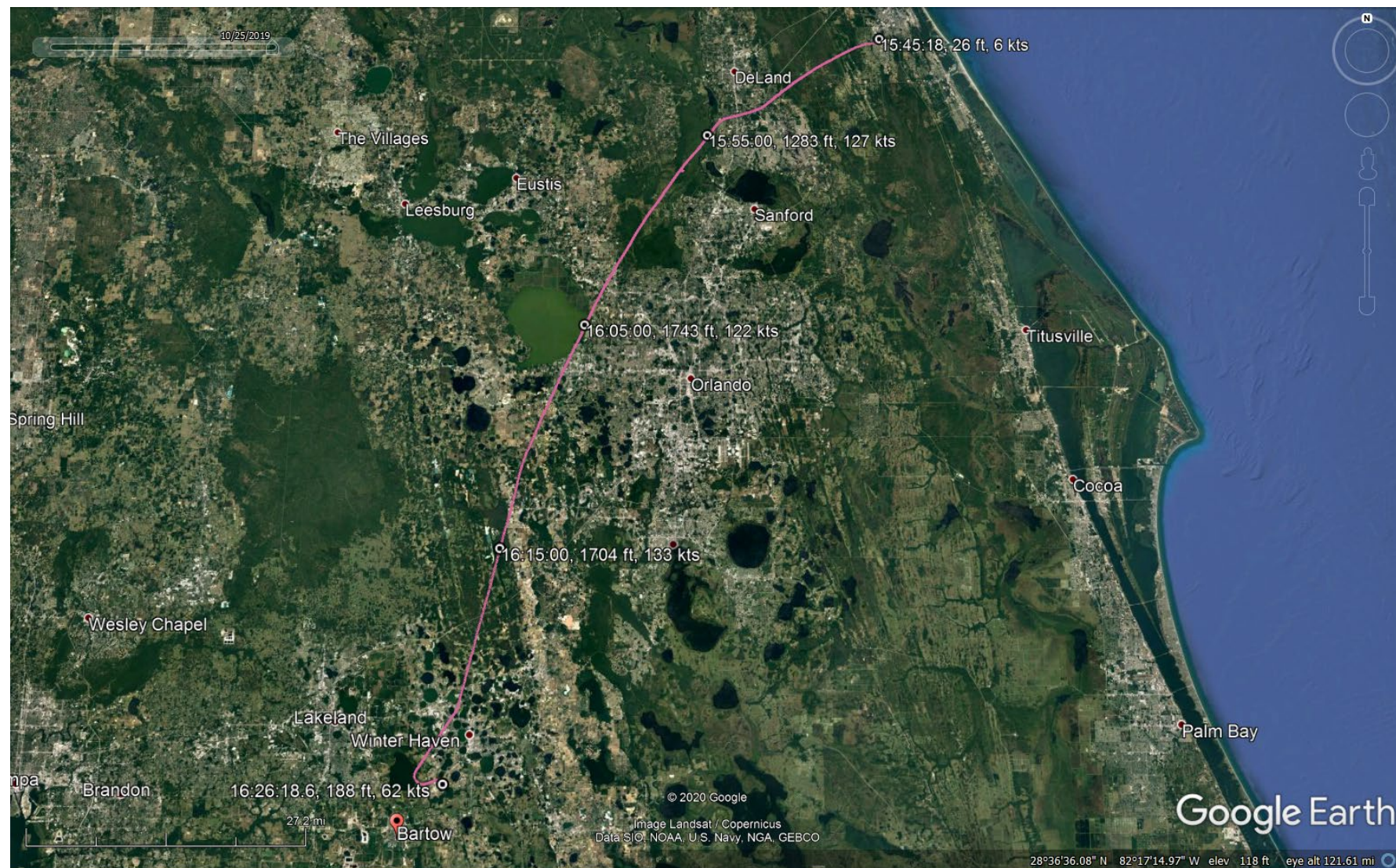


Figure 5. Google Earth overlay showing the time correlation between ADS-B and Stratus data.

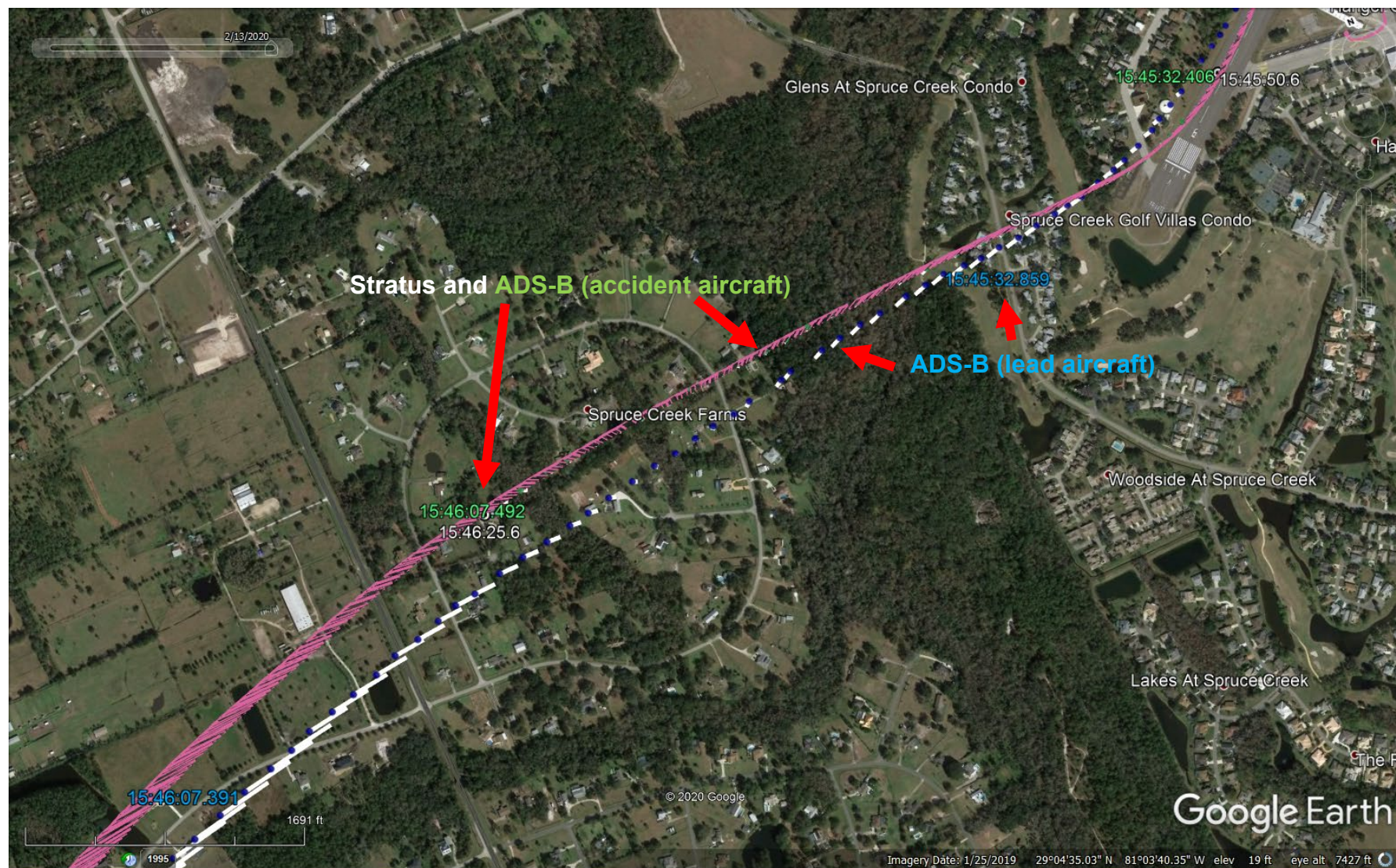


Figure 6. Google Earth overlay showing the last 4 minutes of the accident flight.

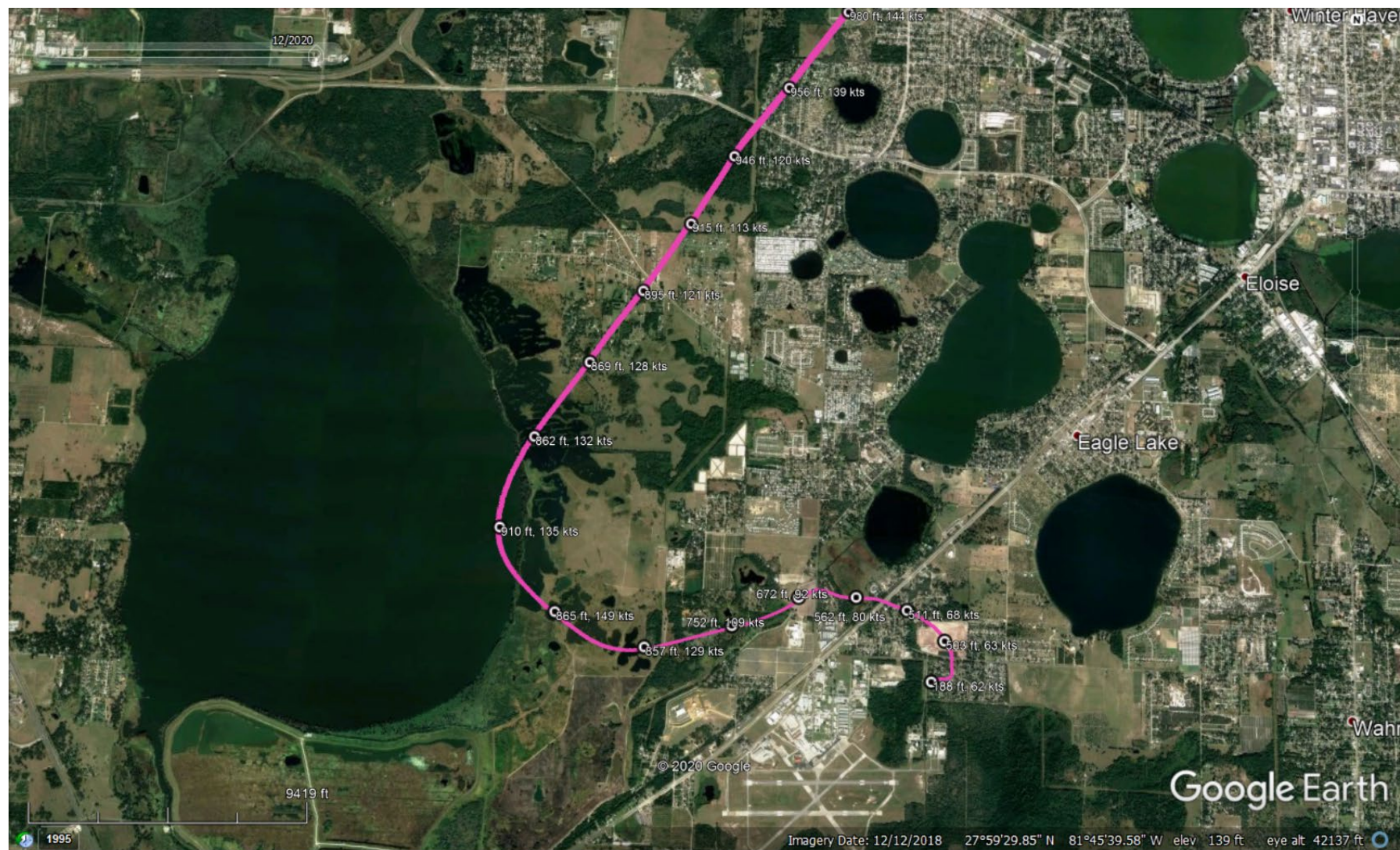


Figure 7. Google Earth overlay showing the end of the recordings of the lead (#1) aircraft and the accident (#4) aircraft.



Figure 8. Plot of parameters from the JPI EDM-800 for the entire accident flight.

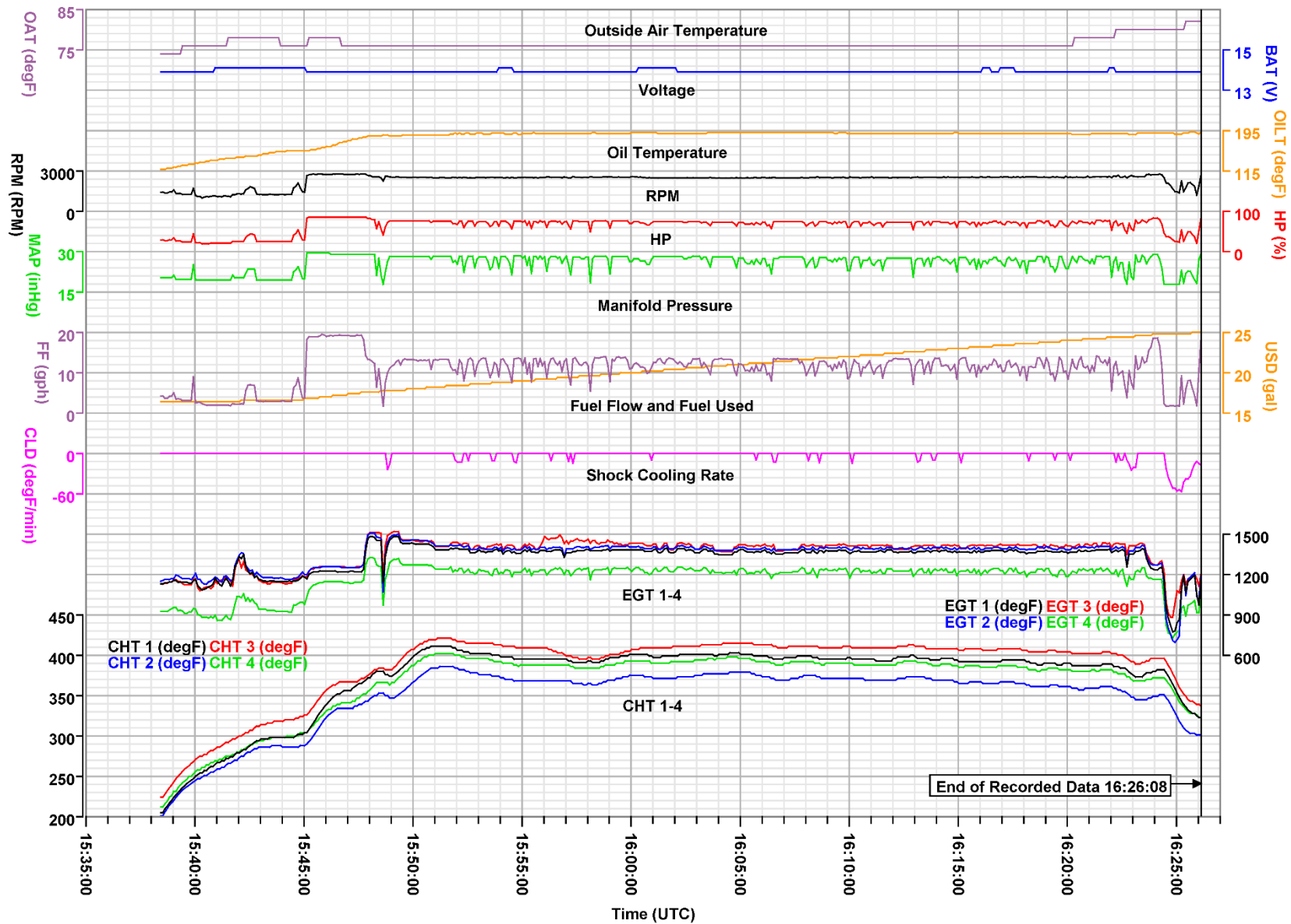


Figure 9. Plot of parameters from the JPI EDM-800 for the last 4 minutes of the accident flight.

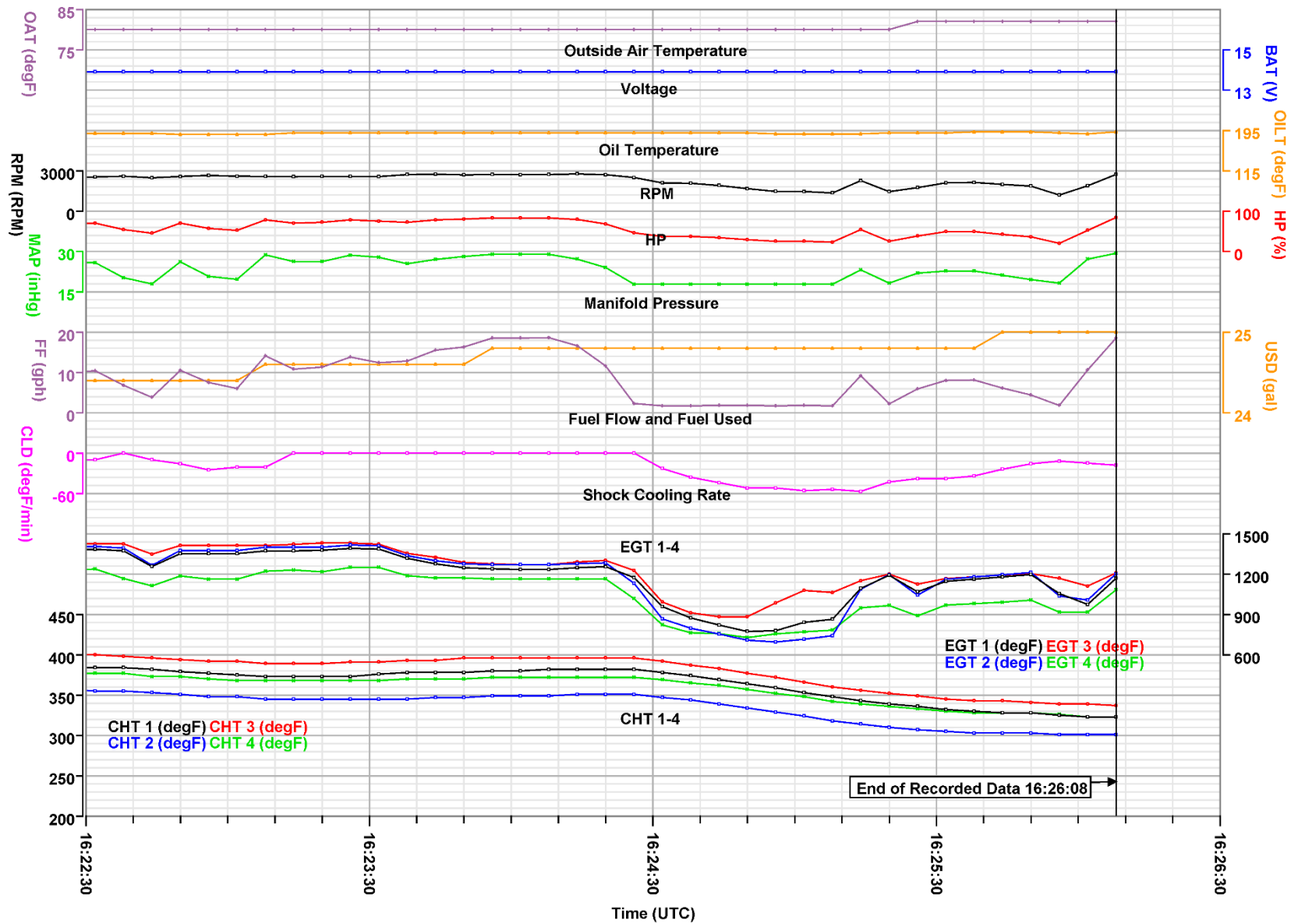


Figure 10. Plot of parameters from the JPI EDM-800 for all sessions recorded.

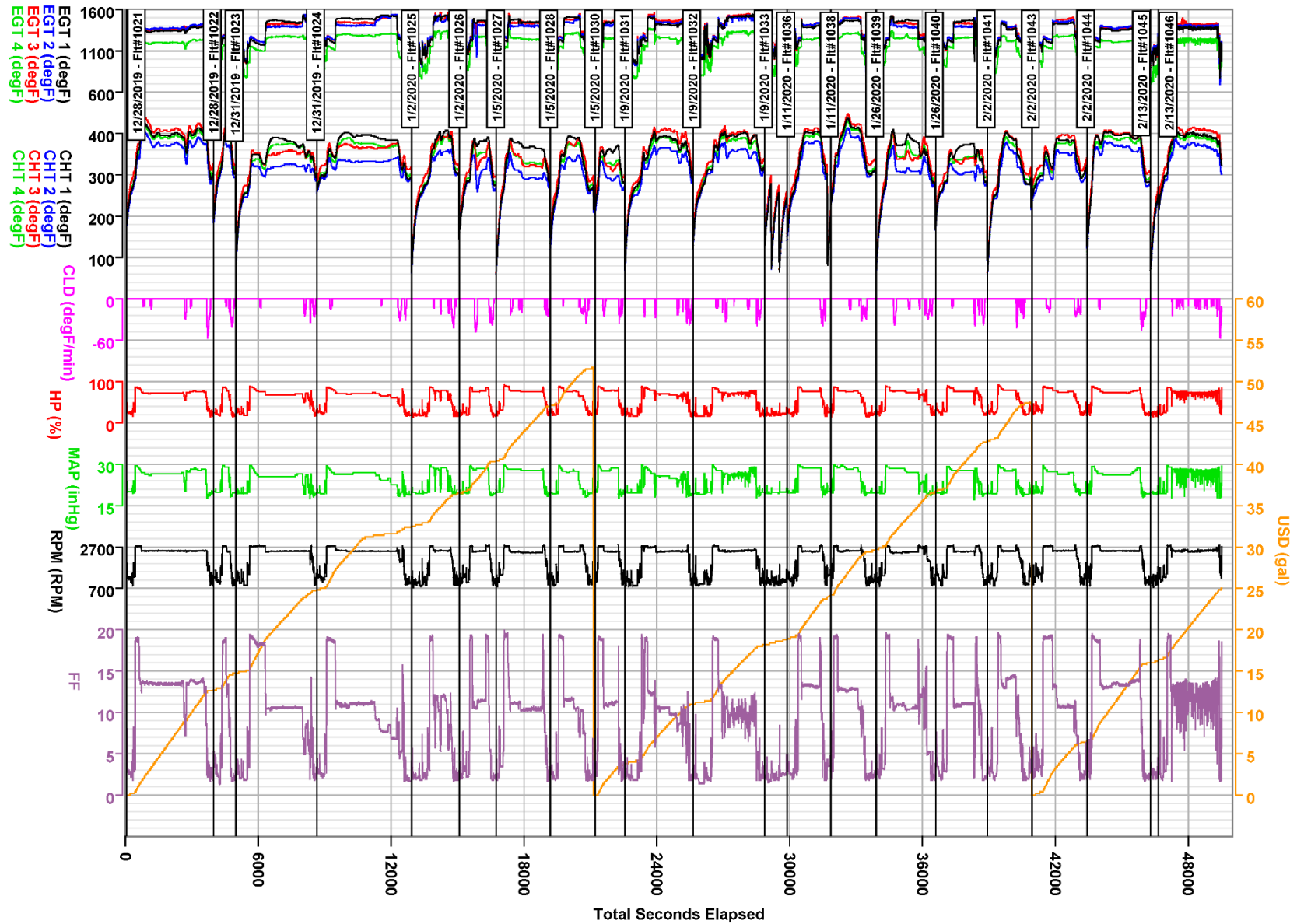
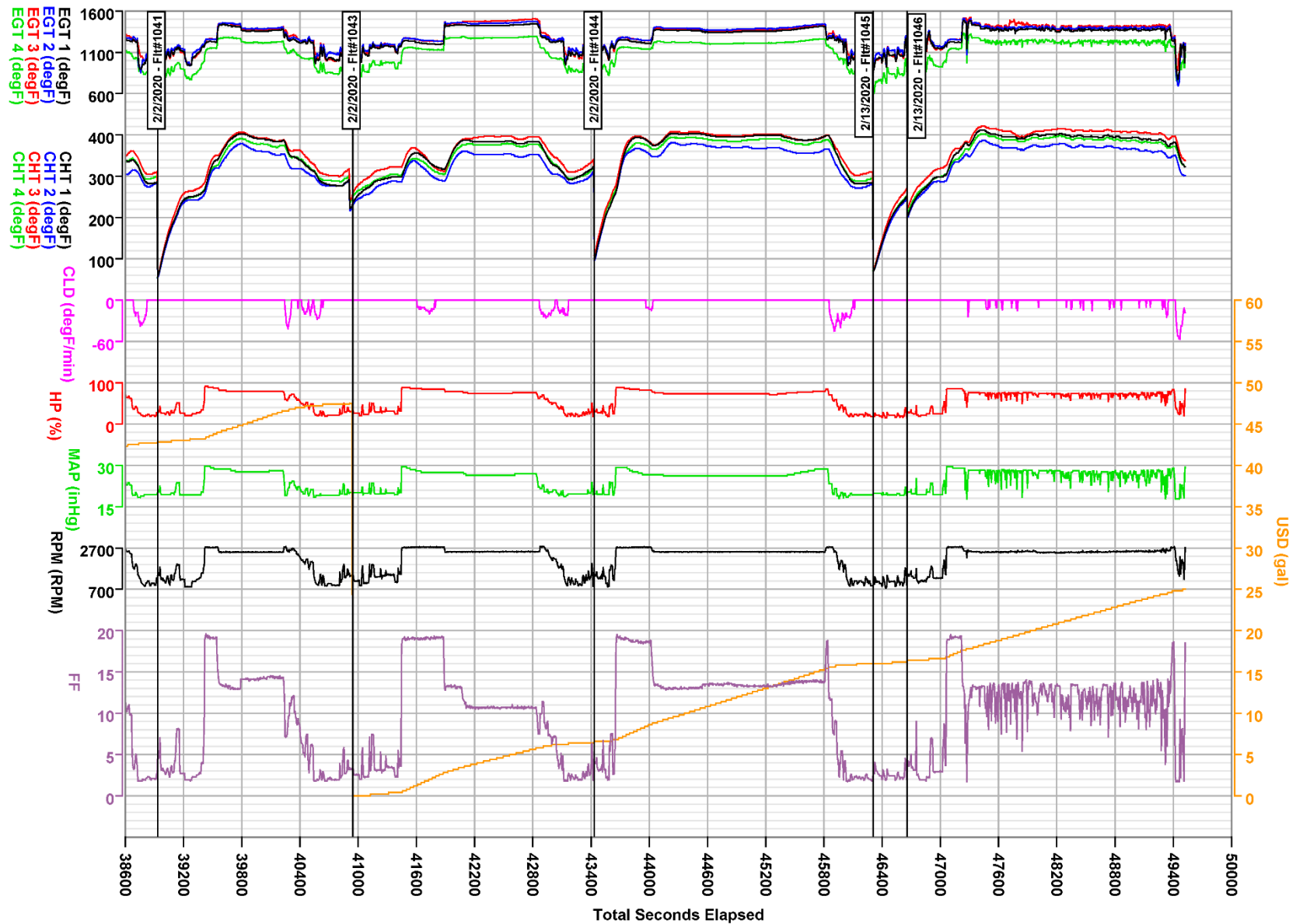


Figure 11. Plot of parameters from the JPI EDM-800 for sessions recorded on February 2, 2020 and February 13, 2020.



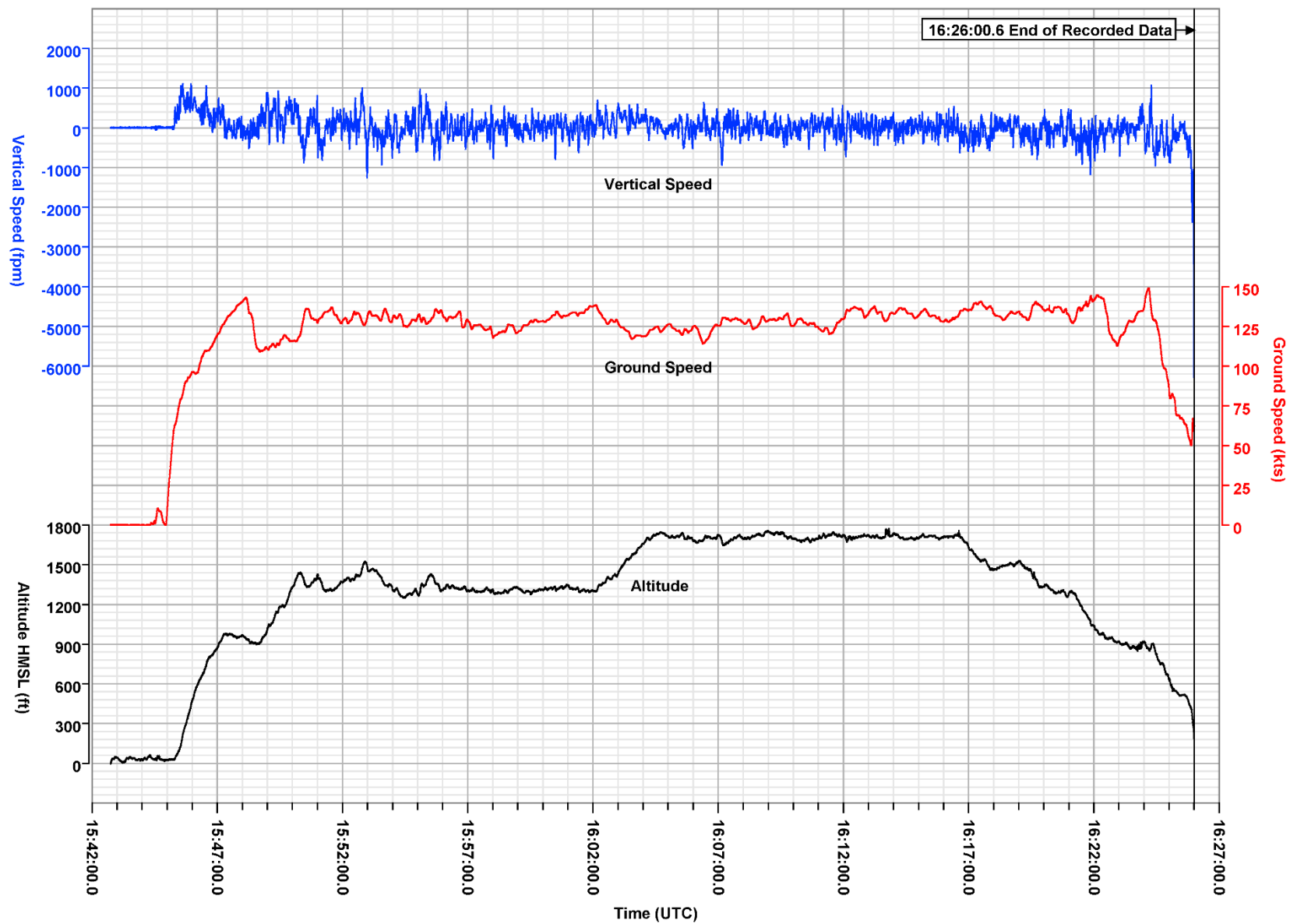


Figure 12. Plot of parameters from the Appareo Stratus 2S for the entire accident flight.

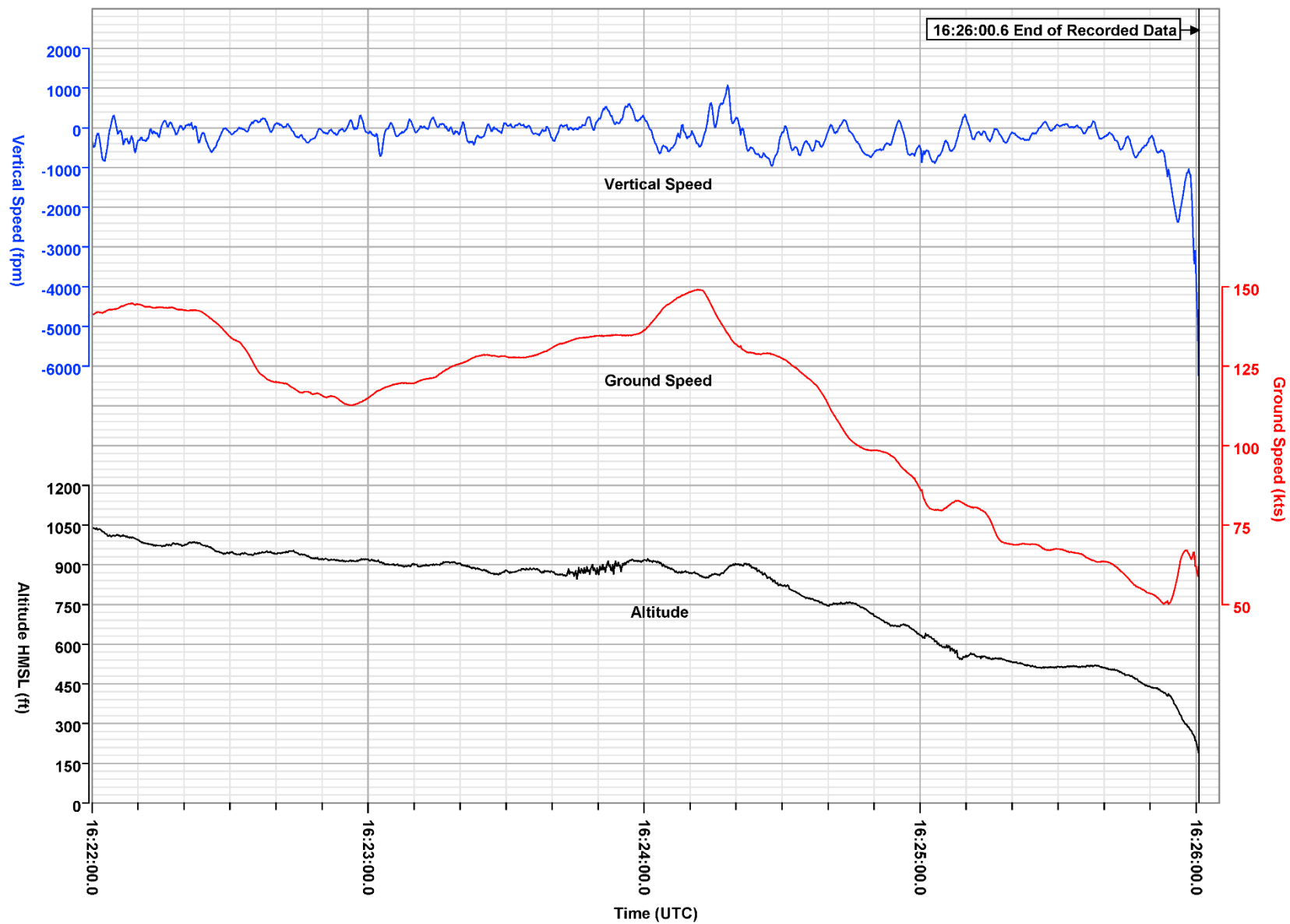


Figure 13. Plot of parameters from the Appareo Stratus 2S for the last 4 minutes of the accident flight.