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

August 20, 2019

Flight Data Monitoring (FDM) Device - Data

Group Chairman's Factual Report
By Sean Payne

1. EVENT SUMMARY

Location:	Zaleski, Ohio
Date:	January 29, 2019
Helicopter:	Bell 407
Registration:	N191SF
Operator:	Viking Aviation, LLC.
NTSB Number:	CEN19FA072

On January 29, 2019, at 0650 Eastern standard time, a single-engine, turbine-powered, Bell 407 helicopter, N191SF, collided with forested, rising terrain about 4 miles northeast of Zaleski, Ohio. The helicopter was registered to and operated by Viking Aviation, LLC, doing business as Survival Flight, Inc., as a visual flight rules helicopter air ambulance flight under the provisions of *14 Code of Federal Regulations* Part 135 when the accident occurred. The certificated commercial pilot, flight nurse, and flight paramedic were fatally injured, and the helicopter was destroyed. Visual meteorological conditions existed at the departure location, and company flight following procedures were in effect. The flight departed Mt. Carmel Hospital, Grove City, Ohio at 0628, destined for Holzer Meigs Hospital, Pomeroy, Ohio, about 69 miles southeast.

2. GROUP

A flight data group was convened on June 12, 2019, at the Vehicle Recorder Division Laboratory at the NTSB headquarters in Washington, DC. The group members who participated are listed below:

Chairman:	Sean Payne Mechanical Engineer National Transportation Safety Board (NTSB)
Member:	Shaun Williams Investigator-In-Charge (IIC) NTSB

Member:	Nicholas Swann Aerospace Engineer NTSB
Member:	Gary Howe Crash Investigator Bell Helicopters

3. DETAILS OF INVESTIGATION

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

Device Manufacturer/Model:	Outerlink IRIS Data Comm Processor
Serial Number:	00254
Device Manufacturer/Model:	Outerlink IRIS Data Comm Dialer
Serial Number:	DCP00251

3.1. Flight Data Monitoring (FDM) Device Carriage Requirements

Per federal regulation 14 CFR 135.607, helicopters in air ambulance operations must be equipped with an approved flight data monitoring system capable of recording flight performance data. The system must receive electrical power from the bus that provides the maximum reliability for operation without jeopardizing service to essential or emergency loads and be operated from the application of electrical power before takeoff until the removal of electrical power after termination of flight.

This rule went into effect on April 23, 2018. The rule does not require helicopter air ambulance operators perform periodic reviews of the flight data to ensure the data is valid, or use the flight data in any kind of flight operations quality assurance (FOQA) program. Additionally, there is no requirement that the FDM devices be certified to any crashworthiness standard.

3.2. Oueterlink IRIS Description

The Outerlink IRIS is a lightweight flight data monitoring, recording and satellite communications device. The system consists of two main components, a control head (known as the dialer unit) that is installed in the helicopter's instrument panel as well as a second processing device (processor) which is installed in the helicopter's avionics bay. The system provides instantaneous two-way communication between the helicopter's flight crew and any equipped ground operator (IP or telephone) via a global satellite network.

In addition to communications features, the device provides flight data monitoring features and the ability to record these functions. The unit contains an internal Attitude Heading Reference System (AHRS) as well as components that facilitate the input of ARINC avionic data streams. A typical configuration will record native AHRS data as well as a variety of ARINC labeled messages that could potentially record engine information.

The system can also record voice and video data. In a typical configuration, the helicopter's intercom system (ICS) is configured to interface with the IRIS device. The pilot's headset hot mic and ear cups are recorded to the IRIS through the ICS system. Additionally, a lipstick style video camera interfaces with the system and is set to record a view over the pilot's shoulder of the helicopter's cockpit, including the pilot's control stick inputs as well as portions of the instrument panel and windscreen.

Data is recorded in three places on the IRIS system, an SD card and two solid-state disks (SSD) in both the dialer and the processor unit. The pedestal mounted control head contains a removable SD card which records only flight data. In an abrupt power loss situation, such as an accident, the SD card is not likely to contain the latest information.

Inside the control head and the processor unit, a solid-state hard drive (SSD) is configured to record flight data, audio and video data. Data recorded by the unit reaches the SSD first and is then dispatched to the SD card (applicable data only). The SSD can be accessed through a hardwire ethernet connection on the back of each device or the unit can be disassembled and the SSD can be read independently. The IRIS system runs on a version of the Linux operating system.

The device is designed to close recorded files every 100 milliseconds, reducing the potential for lost data in abrupt power loss scenario. The manufacturer reports that the device is not crashworthy (as defined by ED155 or ED112), however, the manufacturer has a crash hardened memory that is available for purchase. As of August 2019, the manufacturer reported that the crash hardened memory option has not been purchased by any customer.

3.3. Data Recovery

Figure 1 shows the dialer unit (left) and the processor unit (right) as recovered from the helicopter. Both units were opened and the internal memory was exposed. The internal memory consisted of a commercial off-the-shelf non-volatile (NVM) SSD memory unit. The NVM units from each device was found to be in pristine condition and were removed (figure 2).

Data was recovered by removing the non-volatile memory component of each unit and reading it via a forensic write blocker attached to a PC. Data logs were stored in a Linux file format and information were extracted from the filesystem. Data logs were converted to .CSV[1] using the manufacturer's software and were then input to NTSB plotting software.

Audio data were also recovered from the device and converted using the manufacturer's software. Further details about the audio files are covered in Flight Data Monitoring (FDM) Device – Audio – Group Chairman's Factual Report, which can be found in the public docket for this investigation.

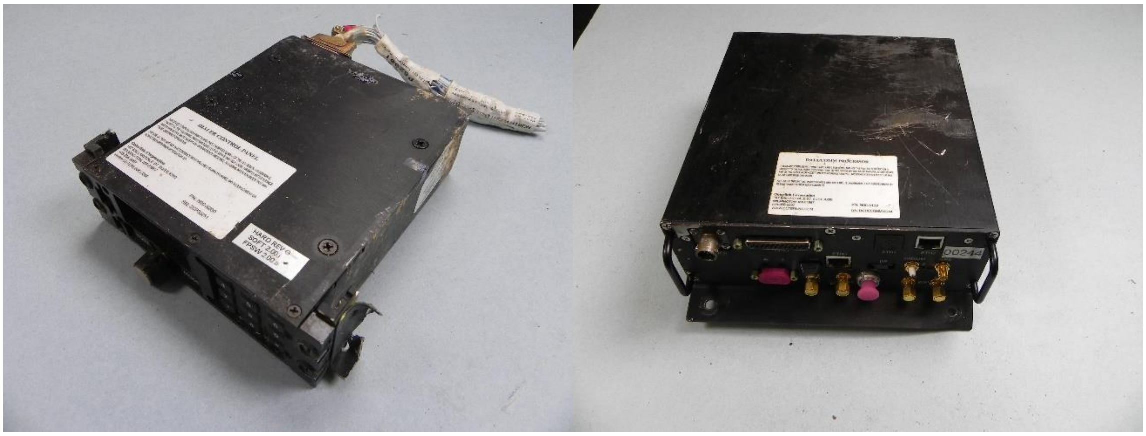

Figure 1. The Dialer (left) and the processor (right).

Figure 2. The NVM unit extracted from the processor unit. The NVM from the processor is shown on the left, the NVM from the dialer is shown on the right.

[1] .CSV – comma separated values.

3.4. Data Description

Video

Although the Outerlink Iris is capable of recording video information, the operator had not configured the unit in the accident helicopter with a camera system. No video data was recorded.

Audio

Audio information from this FDM device is discussed in the report titled, Flight Data Monitoring (FDM) Device – Audio – Group Chairman's Factual Report, which can be found in the public docket for this investigation.

Data

Data logs were available as far back as November 27, 2018. Log files from previous flights were reviewed, but only data from the accident flight is discussed in this report. Data logs were converted from their raw recorded format, to .CSV data using the latest available software from the manufacturer.

The NVM devices included data logs, VZstat logs[2], system logs and audio logs.

A data dropout occurred between approximately 06:47:08.2 and 06:49:08. During this time, both recording units' internal NVM had recording files that contained 0 kilobytes of data. Data returned at approximately 06:49:09. The recording ended at 06:50:08.00.

In a discussion with an engineer and representative of Outerlink, the reason for the interruption of recorded data was attributed to an interruption in an MPIO application which is a software component that functions inside the IRIS unit. The MPIO application collects data and broadcasts it to the recorder. The MPIO application, according to the manufacturer, "watches to make sure all the processes are running, checks each minute, sees the process stopped and restarts it."

3.5. Parameters Provided

Table 1 describes data parameters provided by the FDM device.

[2] VZStat log – log information for the unit's Viasat terminal.

Table 1: FDM Data Parameters

Parameter Name	Parameter Description
Time	Time (EST) for recorded data point (HH:MM:SS)
Voltage (Volts)	Voltage source from alternator power input – 28 volts DC
Lateral Accel. (g)	Acceleration – lateral direction
Vertical Accel. (g)	Acceleration – vertical direction
Engine Oil Pressure (psi)	Engine oil pressure
Transmission Oil Temperature (Deg. C)	Transmission oil temperature
Ambient Pressure (mb)	Ambient pressure
Ambient Temp (Deg. F)	Ambient temperature
Transmission Oil Pressure (psi)	Transmission oil pressure
Gas Generator Turbine Speed (% Ng)	Gas generator turbine speed
MGT (Deg. F)	Measured gas temperature between 2nd and 3rd stage compressor
Torque Raw (%)	Torque
Power Turbine Speed Np (%)	Power turbine speed
Raw Rotor Speed (% Nr)	Main Rotor speed (% Nr)
Fuel Qty. (lbs.)	Fuel quantity
Fuel Flow Actual (pph)	Fuel Flow
Twist Grip Throttle (Deg. PLA)	Twist grip throttle power lever angle
Collective Pitch (%)	Percent collective pitch position
Pitch Angle (Deg.)	Pitch angle
Roll (Deg.)	Roll angle
Magnetic Heading (Deg.)	Magnetic heading
Pressure Altitude (ft)	Pressure altitude
Radio Altitude (ft)	Radio altitude

3.6. OVERLAYS AND TABULAR DATA

Tabular data used to generate figures 3 through 11 are included as Attachment 1. This attachment is provided in electronic comma-delimited (.CSV) format.

All times are given as EST.

Figure 3 is a Google Earth overlay of the entire accident flight tracklog exported from the FDM device. Times are given in 5-minute intervals, with the exception of 06:47:07 and

06:49:09 which was a time interval in which no data was available. The last recorded tracklog point was recorded at 06:50:08.200. The perspective is top-down with the a north-up orientation.

Figure 4 is a Google Earth overlay showing the helicopter's departure from Mt. Carmel Hospital. The perspective is top-down with the a north-up orientation.

Figure 5 is a Google Earth overlay depicting the route of flight around 06:40:00. The perspective is along the route of flight.

Figure 6 is a Google Earth overlay around the end of recorded data. The perspective is top-down with the a north-up orientation. The wreckage location is marked as a yellow pin.

Figure 7 is a Google Earth overlay near the time of data loss at 06:50:08.200. The perspective is top-down with the a north-up orientation. The Wreckage location is shown as a yellow pin.

Figure 8 is Google Earth overlay near the time of data loss at 06:50:08.200. The view is oriented toward the north-west at an oblique angle. The wreckage location is shown as a yellow pin.

Figure 9 is a plot of all validated data parameters for the entire accident flight. The plot begins at 06:23:00 and the plotted time interval ends at 06:51:00. In general, the plot shows that the helicopter departed Mt. Carmel Hospital around 06:28:00 and then entered a cruise portion of flight, climbing to around 3,000 feet pressure altitude around 06:35:00. During the cruise portion of flight, altitude generally varied. Heading was abruptly changed to the left and then right around 06:42:00. A data dropout occurred between approximately 06:47:08.2 and 06:49:09.2. During this time, both recording units' internal NVM had recording files that contained 0 kilobytes of data. Data returned at approximately 06:49:09.2. Shortly thereafter, the helicopter entered a descent and then a brief climb while exhibiting pitch and roll perturbations. Pitch during this time exceed both plus and minus five degrees. Roll at the time of data loss was approximately 30 degrees left (-30). Engine parameters appeared to correlate with the recorded values for Collective Pitch. Rotor speed remained stable around 100% Nr. The recording ended at 06:50:08.00.

Figure 10 is a plot of all validated data parameters for the time period between 06:46:00 and the end of recorded data at 06:50:08.00. The time interval of the data dropout is noted between 06:47:08.2 and 06:49:09.2. The time of the start of an unidentified sound is noted at 06:48:59.939[3]. The time of the end of valid recorded audio is also noted at 06:49:08.939. Data ended at 06:50:08.00.

[3] Audio information from this FDM device is discussed in the report titled, Flight Data Monitoring (FDM) Device – Audio – Group Chairman's Factual Report, which can be found in the public docket for this investigation. More information is also available in the Sound Spectrum Study Report, also found in the docket.

Figure 11 is a plot of all validated data parameters for the time period between 06:49:00 and the end of recorded data at 06:50:08.00. The time of the end of valid recorded audio is also noted at 06:49:08.939. Data ended at 06:50:08.00.

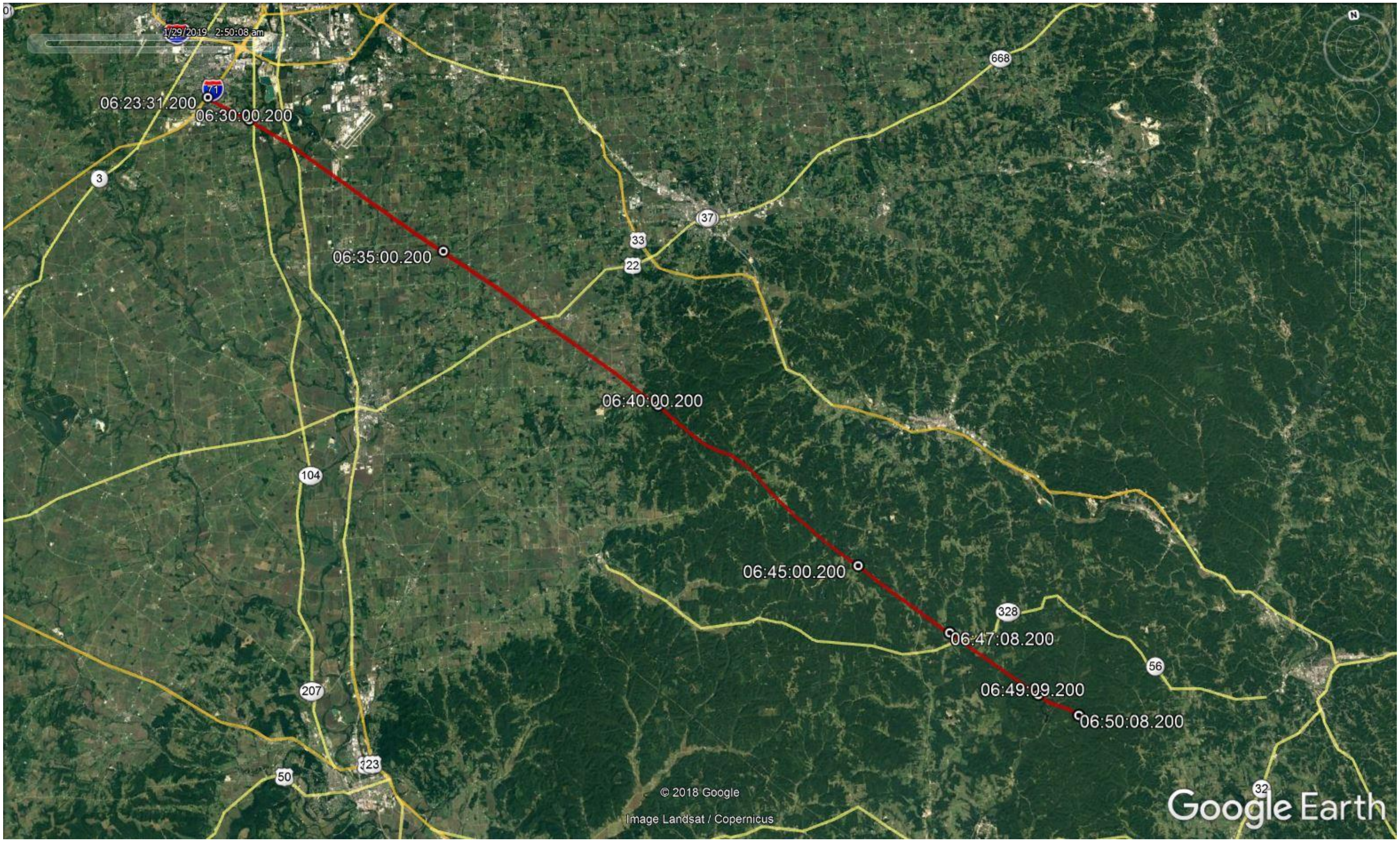

Figure 3. Google Earth overlay showing the entire route of the accident flight.

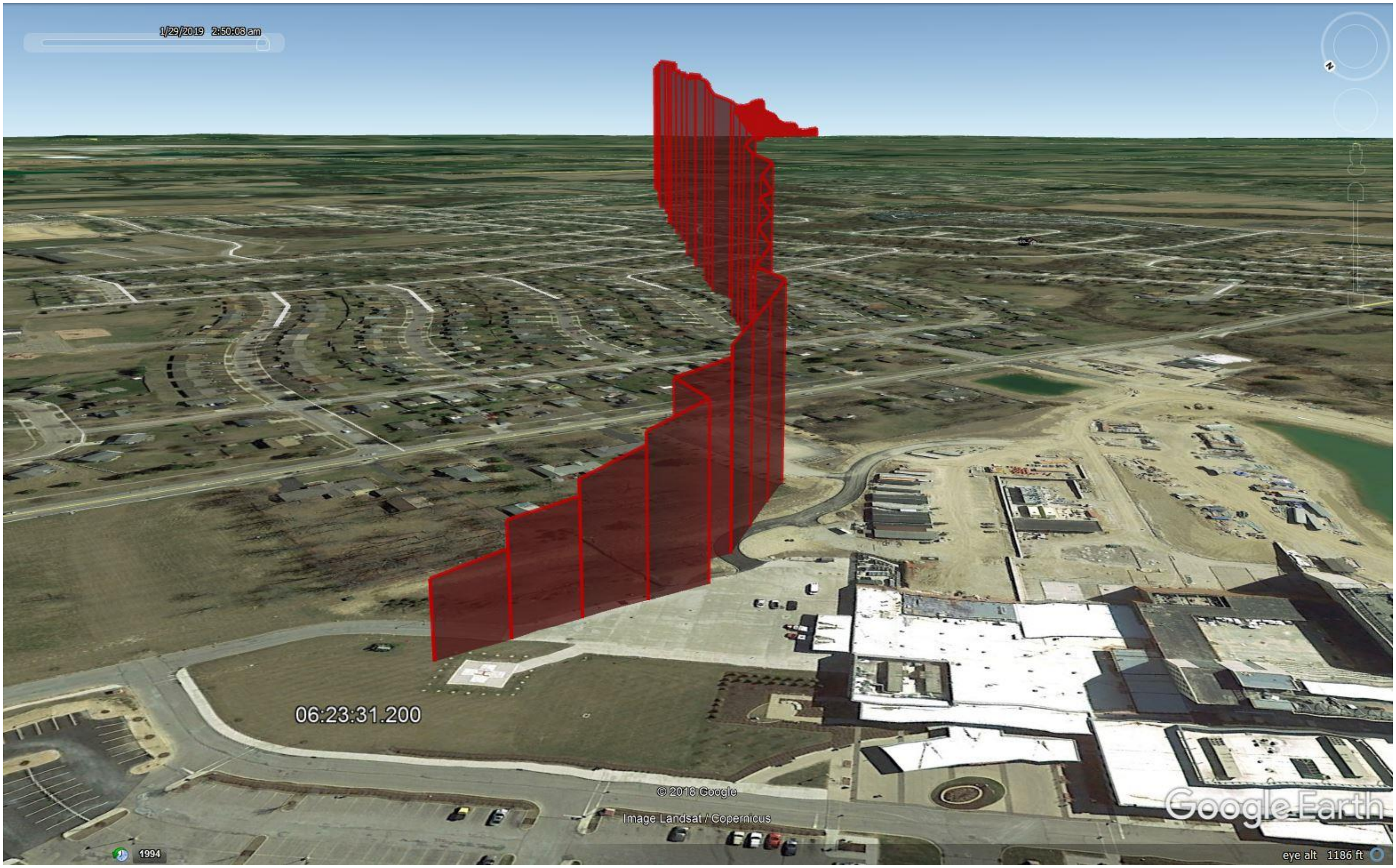

Figure 4. Google Earth overlay showing the departure from Mt. Carmel Hospital.

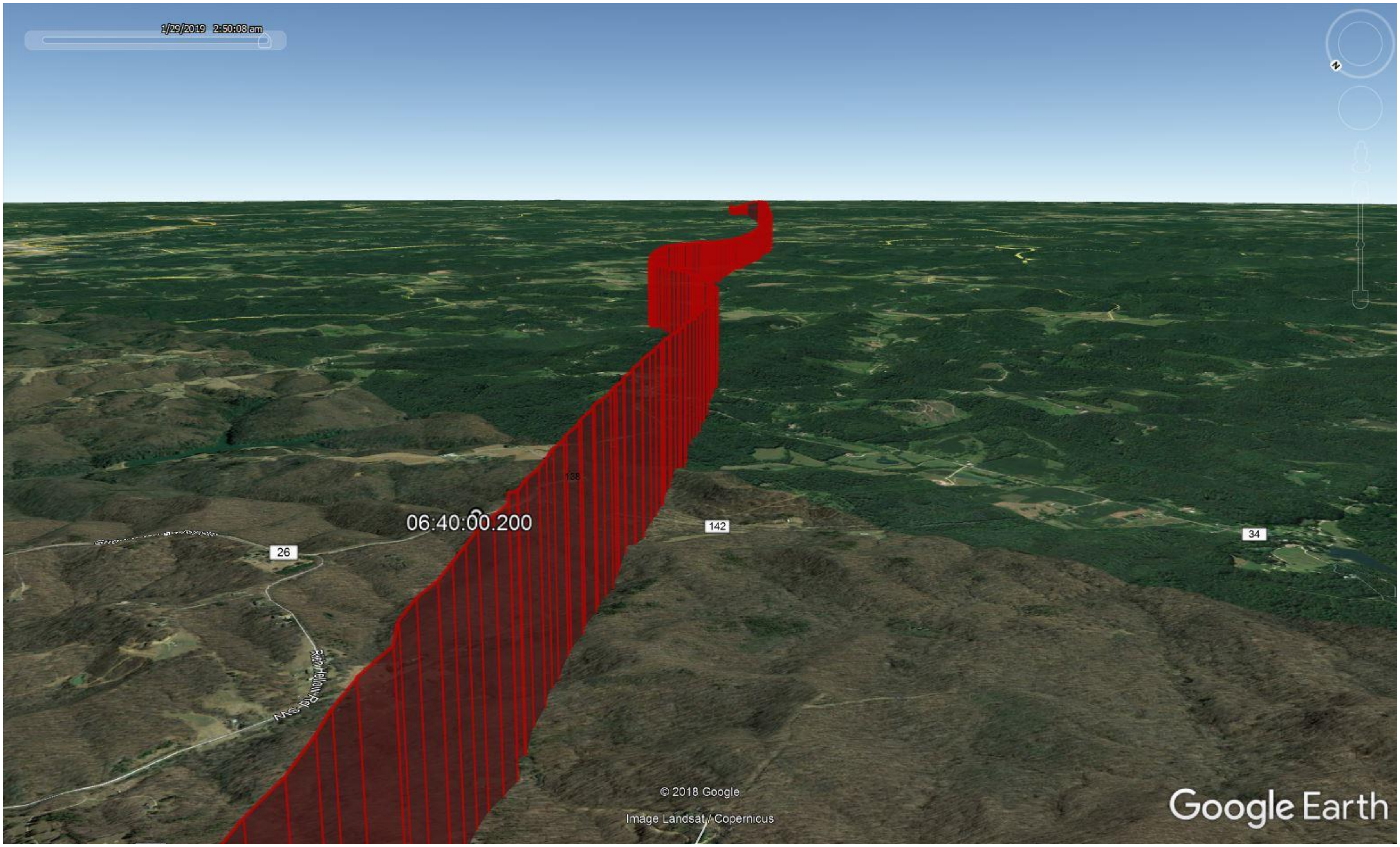

Figure 5. Google Earth overlay depicting the route of flight around 06:40:00.

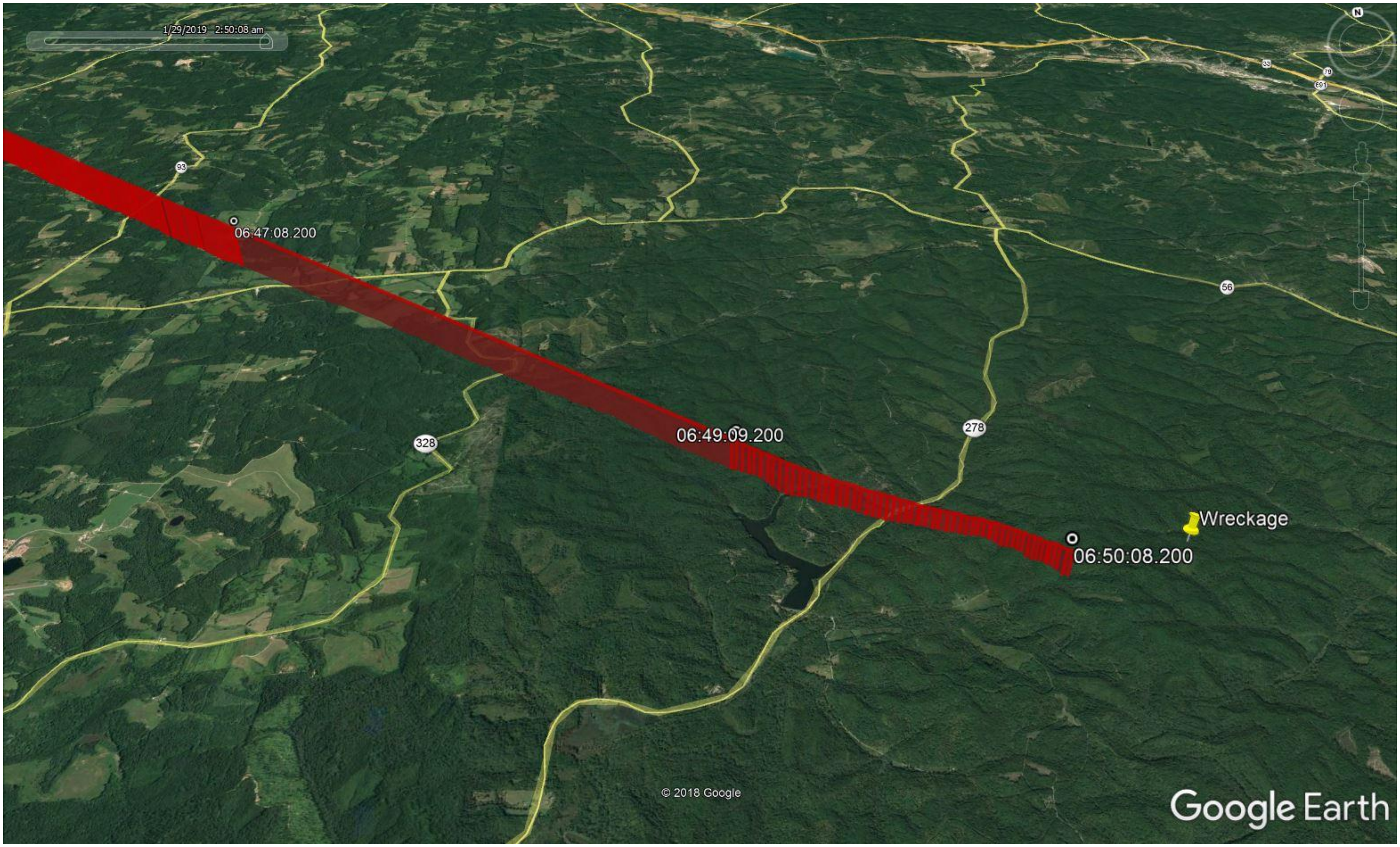

Figure 6. Google Earth overlay around the time of the data dropout.

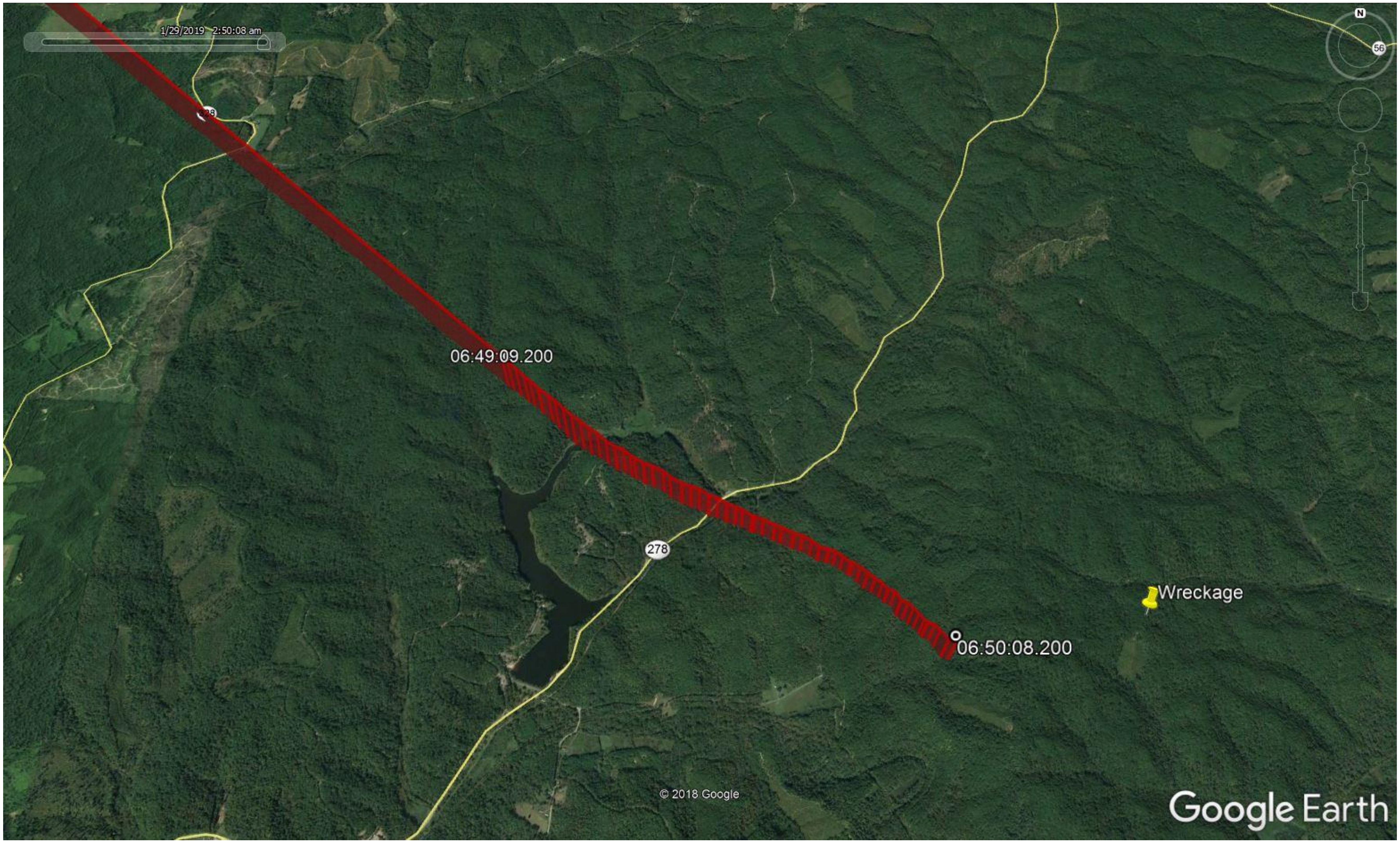

Figure 7. Google Earth overlay near the time of data loss at 06:50:08.200. Wreckage location is shown as a yellow pin.

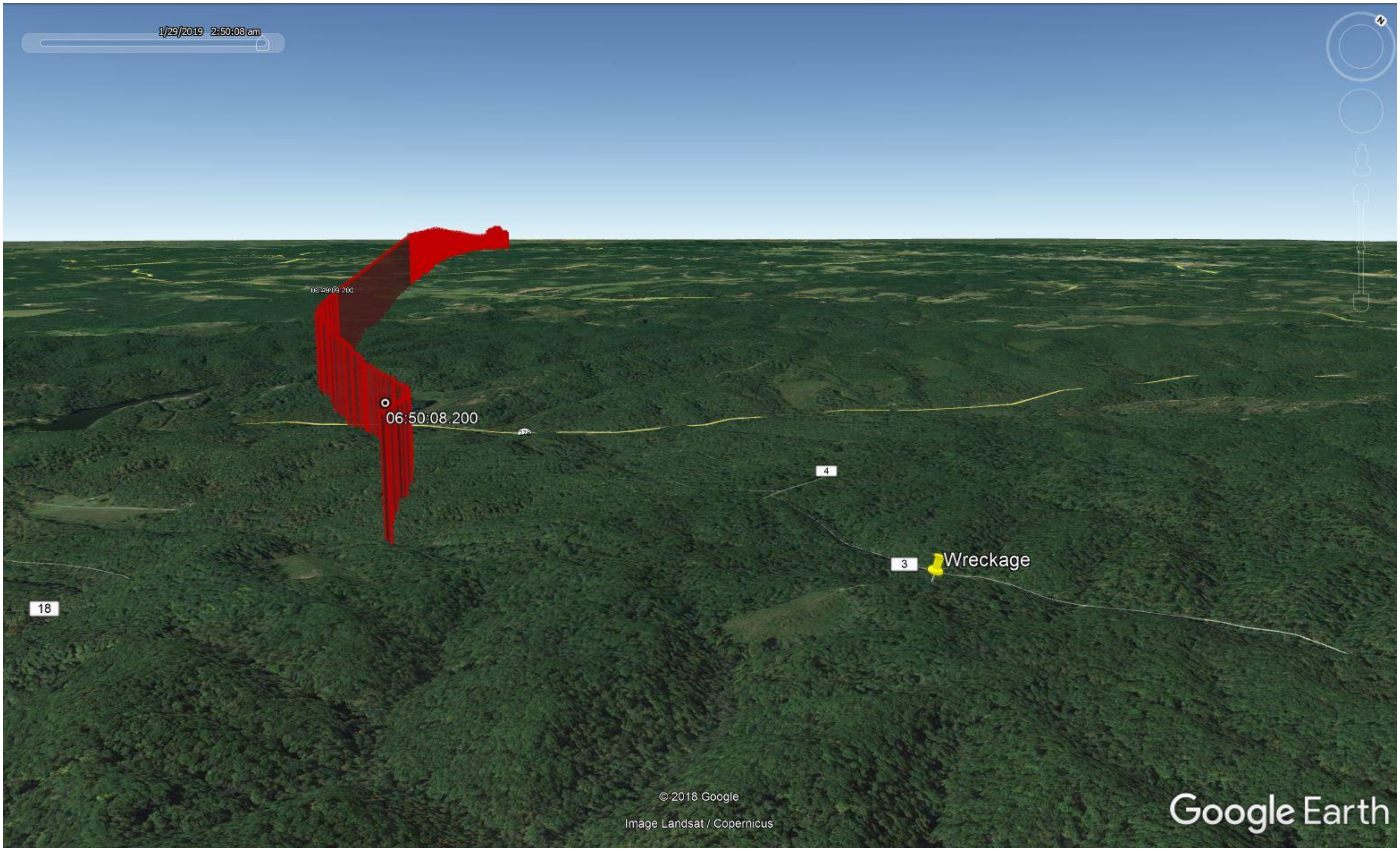

Figure 8. Google Earth overlay near the time of data loss at 06:50:08.200. Wreckage location is shown as a yellow pin.

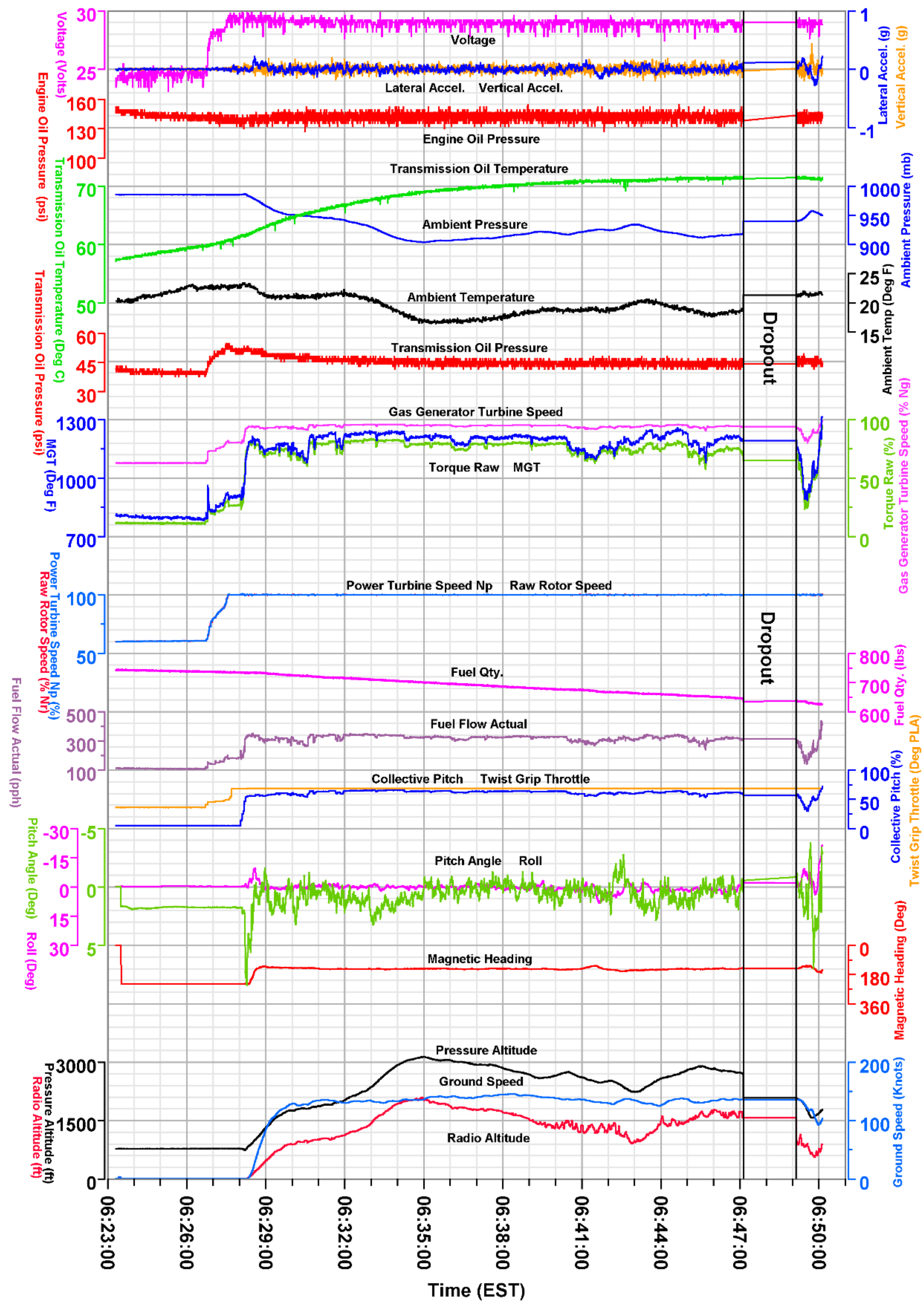

Figure 9. plot data from the entire accident flight.

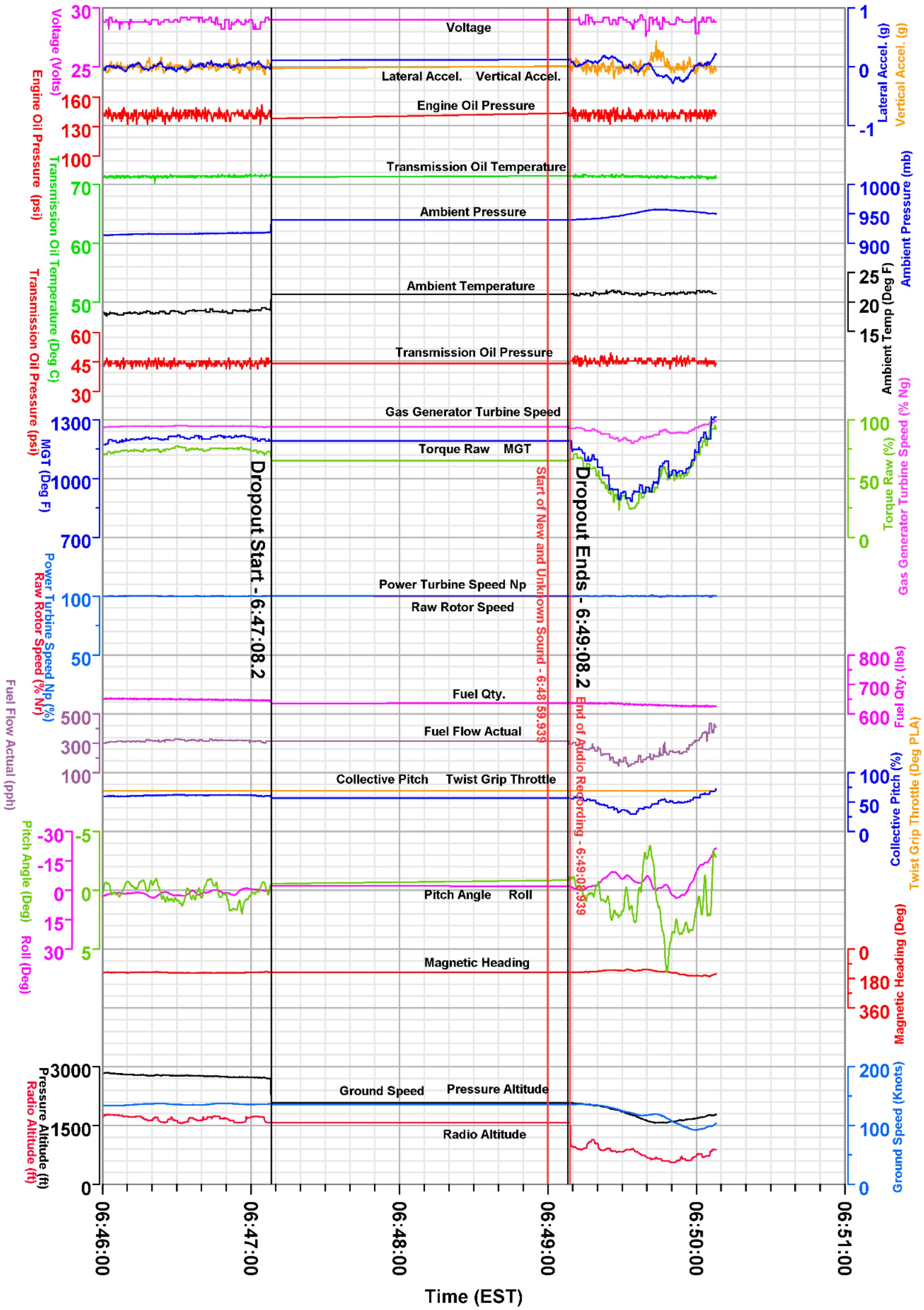

Figure 10. plot data between 06:46:00 and the end of data.

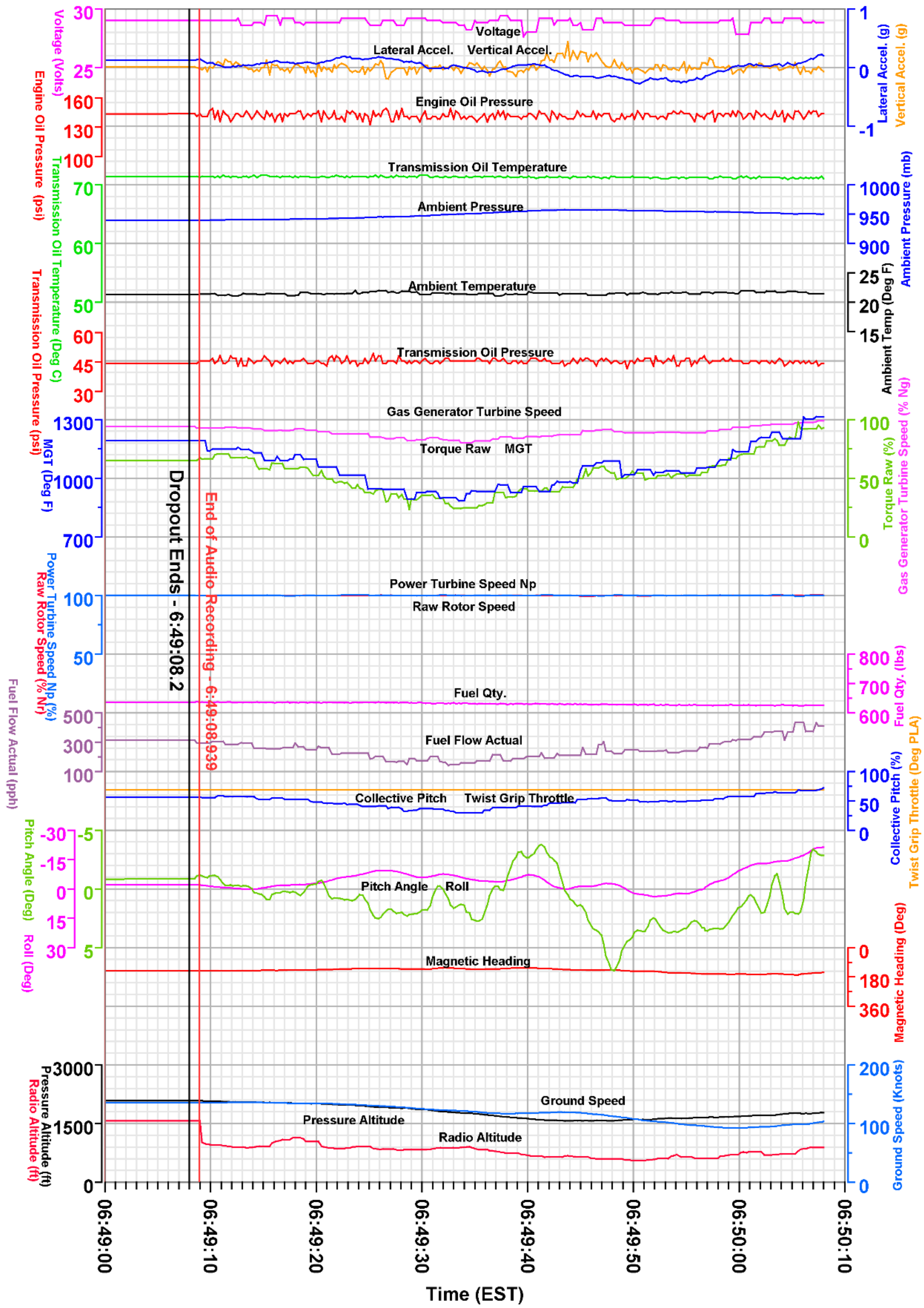

Figure 11. plot data between 06:49:00 and the end of data.