

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



WPR23LA003

ELECTRONIC DEVICES

Specialist's Factual Report

September 13, 2023

TABLE OF CONTENTS

A. ACCIDENT.....	3
B. ELECTRONIC DEVICES SPECIALIST	3
C. DETAILS OF THE INVESTIGATION	3
1.0 EDM-700 DESCRIPTION.....	3
1.1 EDM-700 Data Recovery.....	4
1.2 EDM-700 Recording Description.....	5
2.0 FS 450 DESCRIPTION.....	5
2.1 FS 450 Data Recovery	5
2.2 FS 450 Recording Description	5
3.0 APPAREO STRATUS 3 DESCRIPTION.....	6
3.1 Appareo Stratus 3 Data Recovery.....	6
3.2 Appareo Stratus 3 Recording Description.....	7
D. FIGURES AND TABULAR DATA.....	7
APPENDIX A. VERIFIED AND PROVIDED PARAMETERS JPI EDM-700	14
APPENDIX B. VERIFIED AND PROVIDED PARAMETERS APPAREO STRATUS 3	14

A. ACCIDENT

Location: Boulder City, Nevada
Date: October 2, 2022
Time: 2000 Pacific Daylight Time (PDT)
Airplane: Cessna 182C, private operator, N511W

B. ELECTRONIC DEVICES SPECIALIST

Specialist Matthew Yandrick
Recorder Specialist
National Transportation Safety Board (NTSB)

C. DETAILS OF THE INVESTIGATION

A group was not convened.

The NTSB Vehicle Recorder Division received the following electronic devices:

Recorder Manufacturer/Model: JPI EDM-700
Part Number: EGT-701-6C
Recorder Serial Number: 27200

Recorder Manufacturer/Model: JPI FS 450
Part Number: 450000
Recorder Serial Number: 10598

Recorder Manufacturer/Model: Appareo Stratus 3
Part Number: 153510-000113
Recorder Serial Number: 17868

1.0 EDM-700 Description

The J. P. Instruments EDM-700 is a panel mounted gauge that the operator can 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
- Compressor Discharge Temperature
- Fuel Flow
- Carburetor Temperature
- Battery Voltage

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

The unit contains non-volatile memory (NVM) 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 sample rate. The data can then be downloaded by the operator using the J.P. Instruments software.

1.1 EDM-700 Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed the EDM-700 had sustained water damage as shown in figure 1. The non-volatile memory chips were removed, read out and converted into engineering units using laboratory tools.



Figure 1. Front and side of EDM-700, as received.

1.2 EDM-700 Recording Description

The data extracted included information from January, 27, 2019, through October, 2, 2022.¹ The accident occurred on October 2, 2022. The data rate was found to be set at 500 seconds per sample by the operator. Device time is operator settable and may not be accurate.

2.0 FS 450 Description

The J. P. Instruments Fuel Scan 450 is a panel mounted gauge capable of displaying fuel information to the operator. The fuel status is dependent on the user to properly program the amount of fuel onboard the aircraft prior to each flight. The device stores the last remaining record of fuel used and fuel remaining in gallons.

2.1 FS 450 Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed the FS 450 had sustained water damage as shown in figure 2. The non-volatile memory chip was removed, read out, and a binary image was created using laboratory tools.



Figure 2. Front and side of JPI FS 450, as received.

2.2 FS 450 Recording Description

The binary data was decoded with manufacturer supplied instructions. The following settings were decoded from the binary image:

- Twin/single: "single"

¹ JPI EDM-700 dates and times are referenced to coordinated universal time (UTC).

- Units: "gallons"
- Tanks size: "55"
- Fuel used: unavailable
- Fuel remaining: unavailable

3.0 Appareo Stratus 3 Description

The Appareo Status 3 device is a self-contained battery-powered unit that contains an internal AHRS, GPS/WAAS receiver, and ADS-B receiver in one compact unit.^{2,3,4} 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.

3.1 Appareo Stratus 3 Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed the Stratus 3 had sustained water damage as shown in figure 3. An internal inspection revealed the memory chip appeared undamaged. Subsequently, the chip was removed from the main internal board, and the memory contents of the chip were successfully read, and track log data points were decoded using laboratory equipment.

² 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.

³ 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.

⁴ 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).



Figure 3. Front and back of the Appareo Stratus 3, as received.

3.2 Appareo Stratus 3 Recording Description

The data extracted included 10 sessions from September 25, 2022, through October 3, 2022.⁵ The accident flight was recorded starting at 01:47:54.3 UTC and ending at 02:58:55.9 UTC on October 3, 2022. The difference between UTC and PDT (local time) is 7 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 and bank angle is dependent on the orientation of the device in the aircraft and proper calibration of the device while it's stationary.

D. FIGURES AND TABULAR DATA

Data obtained from the Stratus 3 were used to produce the following overlays and tabular data. Figure 4 and figure 5 are graphical overlays generated using Google Earth. Figure 4 provides an overview of the entire flight, and figure 5 is a zoomed overlay detailing the final segment. The flight originated at Grand Canyon National Park Airport (GCN), Grand Canyon Village, Arizona and the last recorded data point was Lake Mead. The weather and lighting conditions in Google Earth are

⁵ Appareo Stratus 3 dates and times are referenced to coordinated universal time (UTC).

not necessarily the weather and lighting conditions present at the time of the recording.

Figure 6 is a plot of parameters of the entire accident flight recorded on the Stratus 3. The time displayed is 01:47:54.3 UTC to 02:58:55.9 UTC.

Figure 7 is a plot of parameters for approximately the final 6 minutes of the accident flight recorded on the Stratus 3. The time displayed is 02:53:00 UTC to 02:59:00 UTC.

Figure 8 is a plot of parameters of the entire accident flight recorded on the EDM-700. The device time displayed is from 02:25:28 to 03:32:08.

The corresponding tabular data used to create figures 4 to 8 are provided in electronic comma-separated value (CSV) format as attachment 1 (Appareo Stratus 3), and attachment 2 (JPI EDM-700) to this report.

Submitted by:

Matthew Yandrick
Electrical Engineer - Recorder Specialist



Figure 4. Google Earth overlay of track log recorded on Appareo Stratus 3.

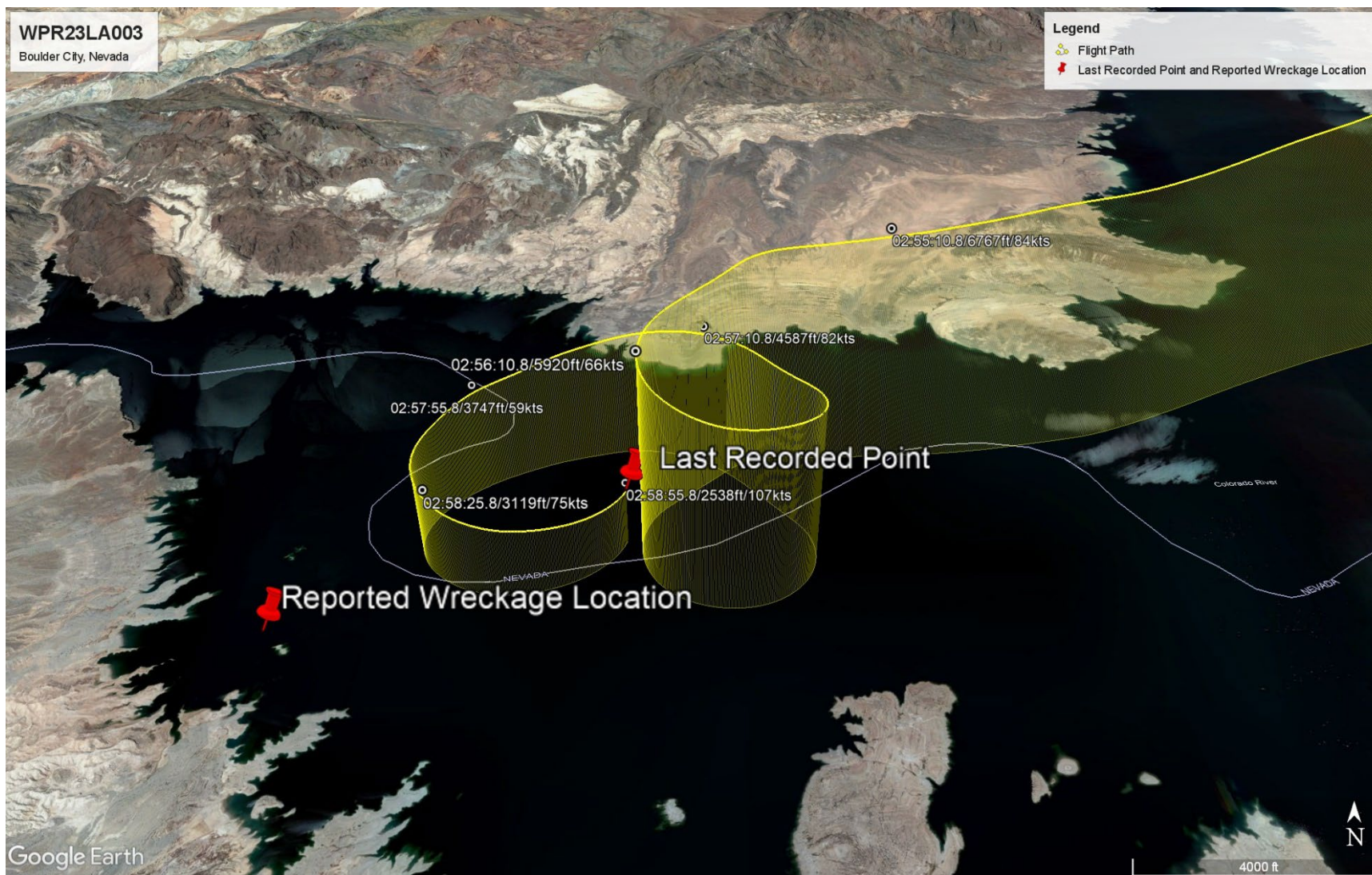


Figure 5. Google Earth overlay of final segment track log recorded on Appareo Stratus 3.

Cessna 182C, N511W

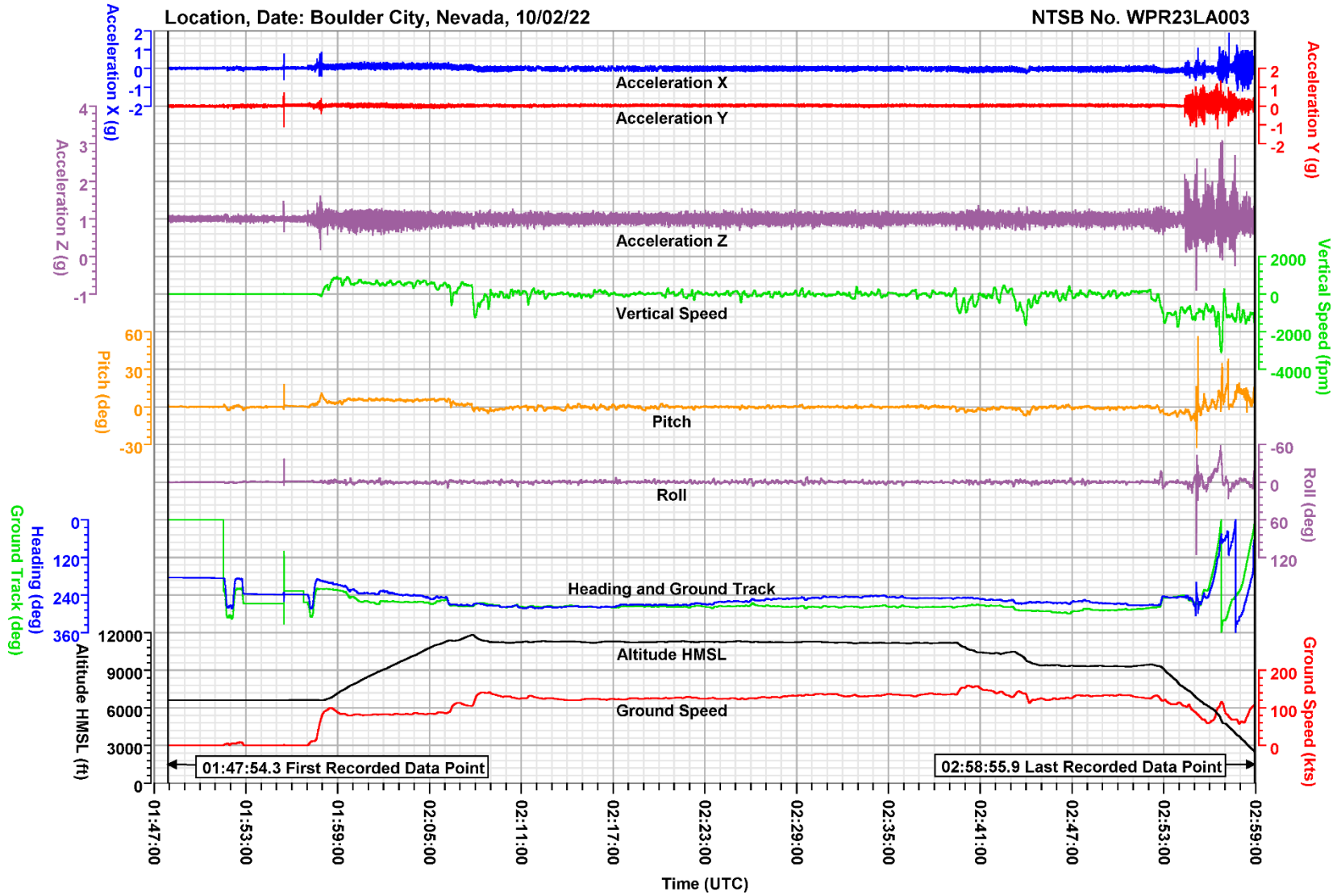


Figure 6. Plot of Appareo Stratus 3 parameters for entire accident flight.

Cessna 182C, N511W

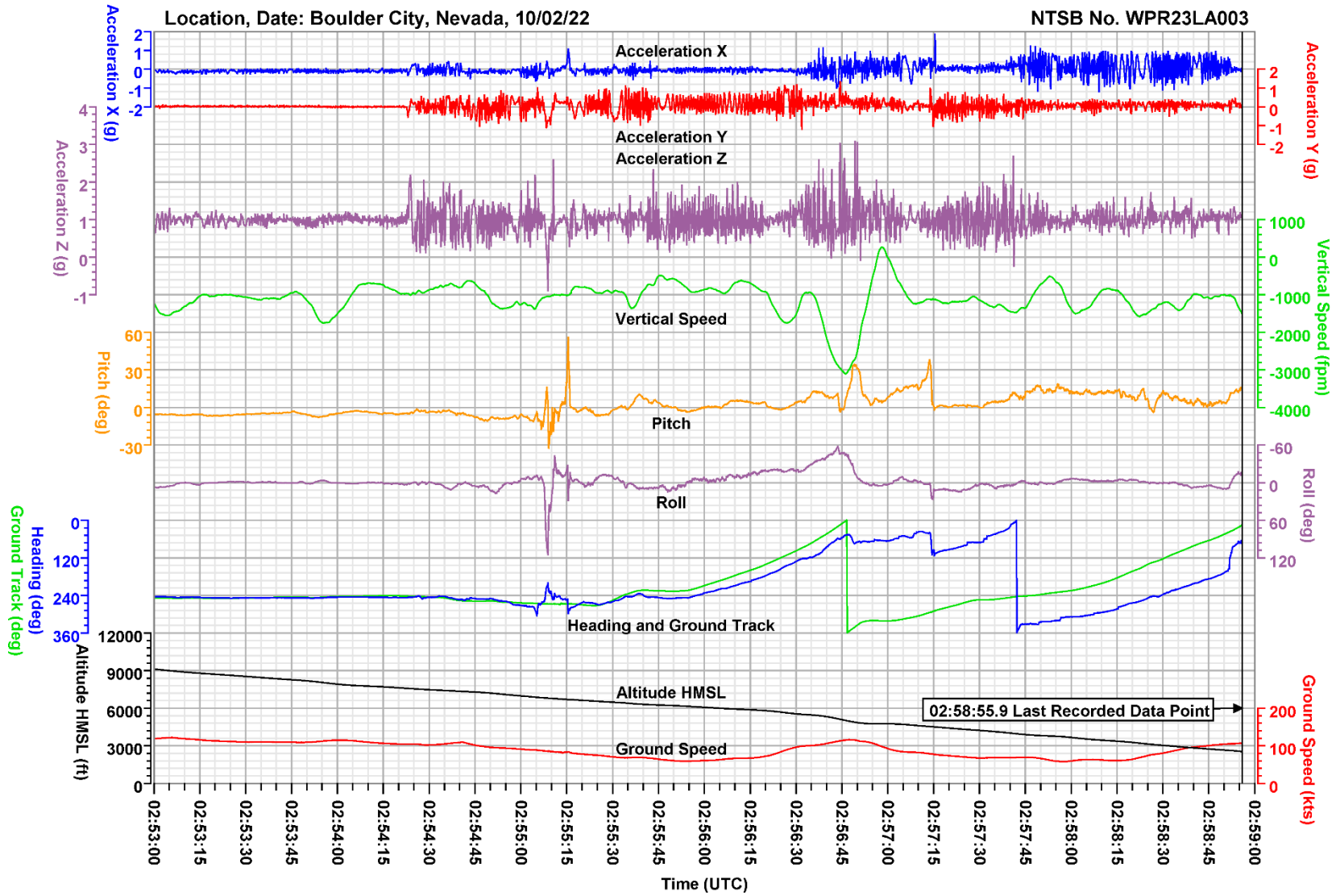


Figure 7. Plot of Appareo Stratus 3 parameters of approximately the final 6 minutes of accident flight.

Cessna 182C, N511W

Location, Date: Boulder City, Nevada, 10/02/22

NTSB No. WPR23LA003

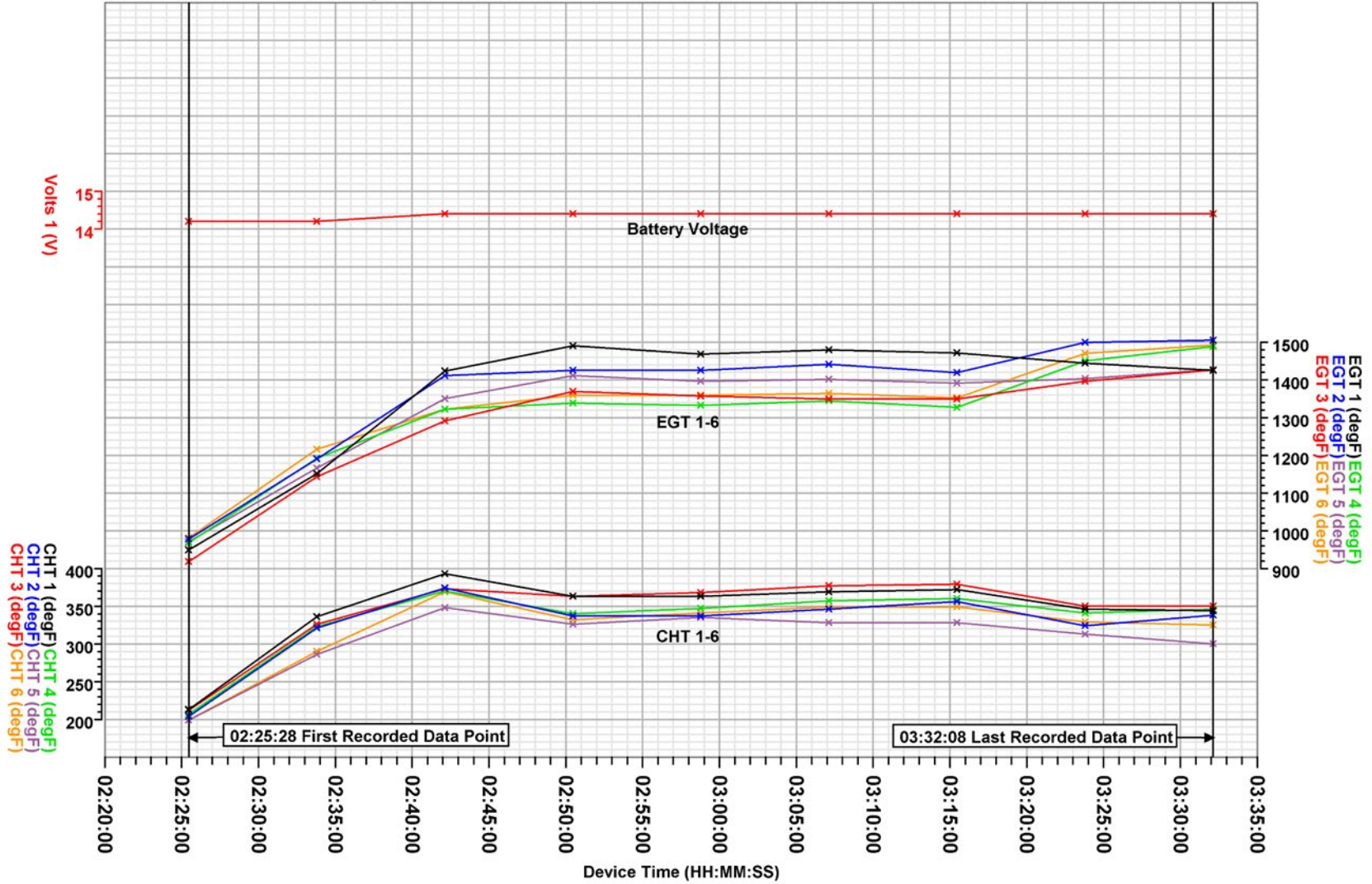


Figure 8. Plot of JPI EDM-700 parameters for entire accident flight.

APPENDIX A. VERIFIED AND PROVIDED PARAMETERS JPI EDM-700

This appendix describes the EDM-700 parameters provided and verified in this report. Table 1 lists the parameters and describes the parameter unit abbreviations used in this report.

Table 1. Verified and provided parameters.

Parameter Name (units)	Parameter Description
Batt-1 (V)	Battery Voltage Input 1 (volts)
Eng1 CHT #1-6 (degF)	Cylinder Head Temperature Cylinder # ⁶ (degrees Fahrenheit)
Eng1 EGT #1-6 (degF)	Exhaust Gas Temperature Cylinder # (degrees Fahrenheit)

APPENDIX B. VERIFIED AND PROVIDED PARAMETERS APPAREO STRATUS 3

This appendix describes the Stratus 3 parameters provided and verified in this report. Table 2 lists the parameters and describes the parameter unit abbreviations used in this report.

Table 2. Verified and provided parameters.

Parameter Name (units)	Parameter Description
Date	Date for recorded data point (MM/DD/YYYY)
Time	Time (UTC) for recorded data point (HH:MM:SS.0)
Latitude (deg)	Recorded Latitude (degrees)
Longitude (deg)	Recorded Longitude (degrees)
Acceleration X (g)	Acceleration in X-Axis (g)
Acceleration Y (g)	Acceleration in Y-Axis (g)
Acceleration Z (g)	Acceleration in Z-Axis (g)
Altitude HMSL (ft)	Recorded GPS Altitude (feet)
Vertical Speed (fps)	Vertical Speed (feet per second)
Ground Speed (kts)	Averaged derived ground speed (knots)
Ground Track (deg)	Ground track (degrees)
Heading (deg)	Magnetic Heading (degrees)
Pitch (deg)	Pitch Angle (degrees)
Roll (deg)	Roll Angle (degrees)

Note: The Stratus 3 records GPS altitude, which is based on a height above the reference ellipsoid.

⁶ Depending on aircraft configuration number of cylinders that are instrumented varies. In the data plots the '#' is replaced with the appropriate cylinder ID.