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

November 14, 2019

Electronic Devices

Specialist's Factual Report
By Gerald Kawamoto

1. EVENT SUMMARY

Location: Lake Worth, FL
Date: September 9, 2018
Aircraft: Cessna 335
Registration: N2707J
Operator: Private
NTSB Number: ERA18FA244

On September 9, 2018, about 1037 eastern daylight time (EDT), a Cessna 335, N2707J, was destroyed when it impacted terrain in John Prince Park, Lake Worth, Florida. The pilot and passenger were fatally injured. Day visual meteorological conditions prevailed at the time, and no flight plan was filed for the flight that departed Key West International Airport (EYW), Key West, Florida, about 0936. The flight was destined for Palm Beach County Airpark (LNA), Lake Worth, Florida. The airplane was privately owned and operated under the provisions of Title 14 *Code of Federal Regulations* Part 91.

2. GROUP

A group was not convened.

3. DETAILS OF INVESTIGATION

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

Recorder Manufacturer/Model: **JPI EDM-760**
Recorder Serial Number: **04354**

Recorder Manufacturer/Model: **Avidyne PFD**
Recorder Serial Number: **M081703355**

3.1. JPI EDM-760 Description

The J. P. Instruments EDM-760 is a panel mounted gauge that the operator can monitor and record up to 24 parameters related to twin engine operations. Depending on the installation, engine parameters monitored, for both engines, 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, and 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[1] 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.

3.1.1. JPI EDM-760 Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed the device had sustained impact damage as shown in Figure 1. The NVM chips were removed, read out, and converted to engineering units using laboratory tools.

Figure 1. JPI EDM-760 as received.

3.1.2. JPI EDM-760 Data Description

The data extracted included 17 sessions from April 15, 2018, through September 9, 2018. The recorded time is based on the unit's internal clock, which is set and updated by the user. The device begins recording data when power is applied and stops when power is disconnected. Due to the condition of the device, the user set time was unable to be verified and is referred to as JPI Time in this report. The last session recorded on September 9, 2018, is included in this report. The data was recorded at a 6 second-per-sample rate.

3.1.3. JPI EDM-760 Parameters Provided

Table 1 describes data parameters recorded by the device. The engineering units conversions used for the data contained in this report are based on documentation from the manufacturer of the EDM.

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

Table 1: JPI EDM-700 Data Parameters

Parameter Name	Parameter Description
JPI Time	Device time for recorded data point (HH:MM:SS)
Eng1 EGT 1-6 (degF)	Left Engine Exhaust Gas Temperature Cylinder # (degrees Fahrenheit)
Eng1 CHT 1-6 (degF)	Left Engine Cylinder Head Temperature Cylinder # (degrees Fahrenheit)
Eng1 CLD (degF/min)	Left Engine Shock Cooling Rate (degrees Fahrenheit per minute)
Eng1 TIT (degF)	Left Engine Turbine Inlet Temperature (degrees Fahrenheit)
Eng2 EGT 1-6 (degF)	Right Engine Exhaust Gas Temperature Cylinder # (degrees Fahrenheit)
Eng2 CHT 1-6 (degF)	Right Engine Cylinder Head Temperature Cylinder # (degrees Fahrenheit)
Eng2 CLD (degF/min)	Right Engine Shock Cooling Rate (degrees Fahrenheit per minute)
Eng2 TIT (degF)	Right Engine Turbine Inlet Temperature (degrees Fahrenheit)
Voltage (V)	Battery Voltage (Volts)

3.2. Avidyne Primary Flight Display (PFD) Description

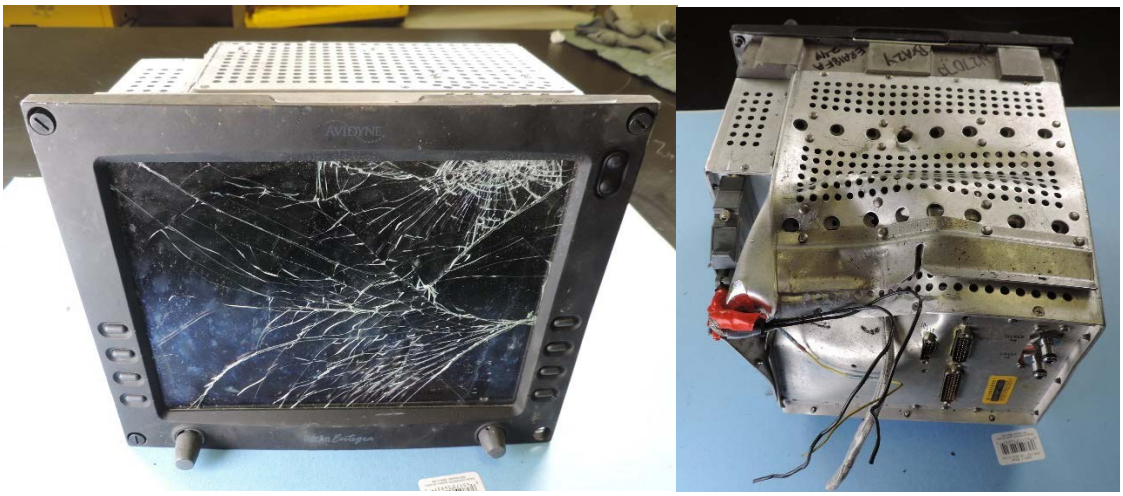
The PFD unit includes a solid-state Air Data and Attitude Heading Reference System (ADAHRS) and displays aircraft parameter data including altitude, airspeed, attitude, vertical speed, and heading. The PFD unit has external pitot/static inputs for altitude, airspeed, and vertical speed information. Each PFD contains two flash memory devices mounted on a riser card. The flash memory stores information the PFD unit uses to generate the various PFD displays. Additionally, the PFD has a data logging function, which is used by the manufacturer for maintenance and diagnostics. Maintenance and diagnostic information recording consists of system information, event data, and flight data.

The PFD samples and stores several data streams in a sequential fashion; when the recording limit of the PFD is reached, the oldest record is dropped and a new record is added. Data from the Attitude/Heading Reference System (AHRS) is recorded at a rate of 5 Hz. Air data information such as pressure altitude, indicated airspeed, and vertical speed are recorded at 1 Hz. Global Positioning System (GPS) as well as navigation display and setting data are recorded at a rate of 0.25 Hz, and information about pilot settings of heading, altitude, and vertical speed references are recorded when changes are made.

3.2.1. Avidyne PFD Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed the device had sustained impact damage as shown in Figure 2. The NVM chips were removed, read out, and converted to engineering units using laboratory tools.

Figure 2. Front and back of the Avidyne PFD as received.



3.2.2. Avidyne PFD Data Description

The PFD recording contained records of 64 power cycles of data. The accident flight was associated with the 59th power cycle[2]. The duration of the 59th power cycle was approximately 1 hour and 17 minutes. Timing of the PFD data is measured in seconds from power-on.

Correlation of the PFD data to Universal Coordinated Time (UTC) was established using the recorded GPS time parameter from the PFD data. Recorded GPS time is updated in 6 second intervals on the PFD[3]. The GPS time is recorded in UTC. The PFD starts recording when power is applied to the unit. The timing begins at 0 seconds for each power cycle and the PFD data is measured in seconds from power-on. An offset is applied to each power cycle plotted to display the data with UTC. Therefore, for the rest of this report, all times are referenced as UTC, not recorded time. The difference between EDT and UTC is 4 hours or 14,400 seconds.

Conversion of the PFD data from the raw recorded information to engineering units is performed using conversions developed by the NTSB. Where applicable, changes to the conversions have been made to ensure the parameters conform to the Safety Board's standard sign convention that climbing right turns are positive (CRT=+).[4]

The PFD records pressure altitude, which is based on a standard altimeter setting of 29.92 inches of mercury (in Hg). The pressure altitude information presented in the plots and in the electronic data has not been corrected for the local altimeter setting at the time of the event.

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[2] During the normal data retrieval process, power is applied to the PFD. Therefore, the accident data is not necessarily the last power cycle recorded.

[3] GPS information is recorded at 4 second (0.25 Hz) intervals; however, it is possible to have the same UTC time recorded in consecutive GPS data records due to the 6 second update rate of the GPS time parameter.

[4] CRT=+ means that for any parameter recorded that indicates a climb or a right turn, the sign for that value is positive. Also, for any parameter recorded that indicates an action or deflection, if it induces a climb or right turn, the value is positive.

3.2.3. Avidyne PFD Parameters Provided

Table 2 describes data parameters recorded by the device.

Table 2: Avidyne Data Parameters

Parameter Name	Parameter Description
Time	Time (UTC) for recorded data point (HH:MM:SS)
Accel Lat (g)	Lateral Acceleration (g)
Accel Long (g)	Longitudinal Acceleration (g)
Accel Vert (g)	Vertical Acceleration (g)
Airspeed Ind (kts)	Indicated Airspeed (knots)
Altitude Press (ft)	Pressure Altitude (feet)
Heading Mag (deg)	Magnetic Heading (degrees)
Pitch (deg)	Pitch Angle (degrees)
Roll (deg)	Roll Angle (degrees)
Temp TAT (degC)	Total Air Temperature (degrees Celsius)

3.3. Plots and Corresponding Tabular Data

Figure 3 is a graphical overlay generated in Google Earth for the entire accident flight. Weather and lighting conditions shown in Google Earth may not be representative of the conditions at the time of the accident flight.

Figure 4 is a graphical overlay generated in Google Earth at the end of the accident flight.

Figure 5 is a plot of Avidyne PFD parameters for the entire accident flight. The time interval displayed is 13:20:00 UTC to 14:40:00 UTC.

Figure 6 is a plot of Avidyne PFD parameters at the end of the accident flight. The time interval displayed is 14:35:40 UTC to 14:37:40 UTC. The recorded data exhibited periodic gaps in the data that lasted 6 seconds. Past sessions revealed this behavior throughout all recorded data.

Figure 7 is a plot of engine 1 parameters of the entire last session recorded on the JPI EDM-760. The time interval displayed is 16:40:00 to 18:00:00 JPI Time.

Figure 8 is a plot of engine 1 parameters at the end of the last session recorded on the JPI EDM-760. The time interval displayed is 17:49:00 to 18:00:00 JPI Time.

Figure 9 is a plot of engine 2 parameters of the entire last session recorded on the JPI EDM-760. The time interval displayed is 16:40:00 to 18:00:00 JPI Time. Values for EGT 3 and CHT 3 stopped trending with the other cylinders approximately 13 minutes after the recording started. Past sessions revealed that these parameters had a history of similar behavior.

Figure 10 is a plot of engine 2 parameters at the end of the last session recorded on the JPI EDM-760. The time interval displayed is 17:49:00 to 18:00:00 JPI Time.

The corresponding tabular data used to create Figures 3 through 6 are provided in electronic (CSV[5]) format as Attachment 1 to this report. The corresponding tabular data used to create Figures 7 through 10 are provided in electronic CSV format as Attachment 2.

[5] Comma Separated Value format.

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

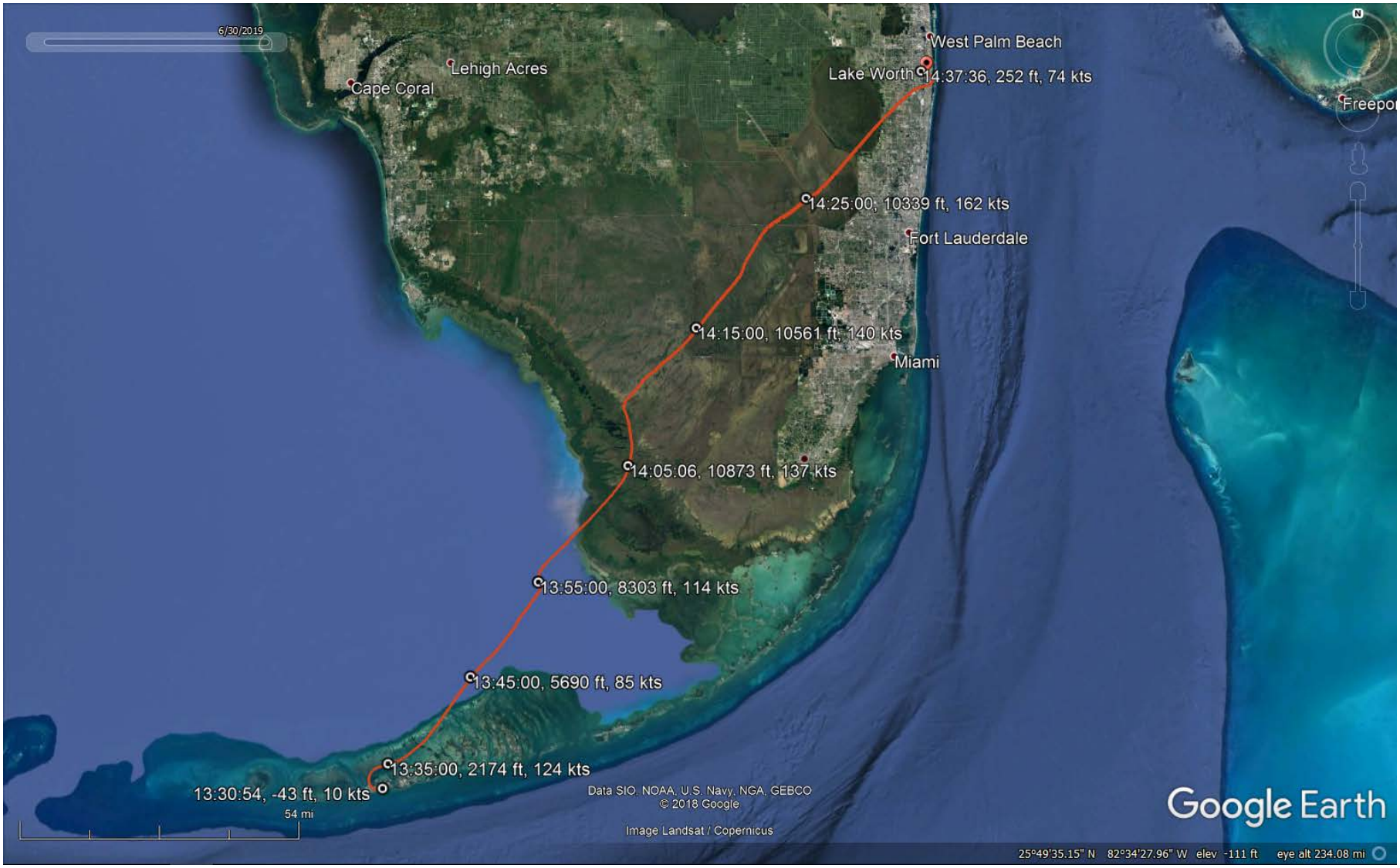

Figure 4. Google Earth overlay at the end of the accident flight.

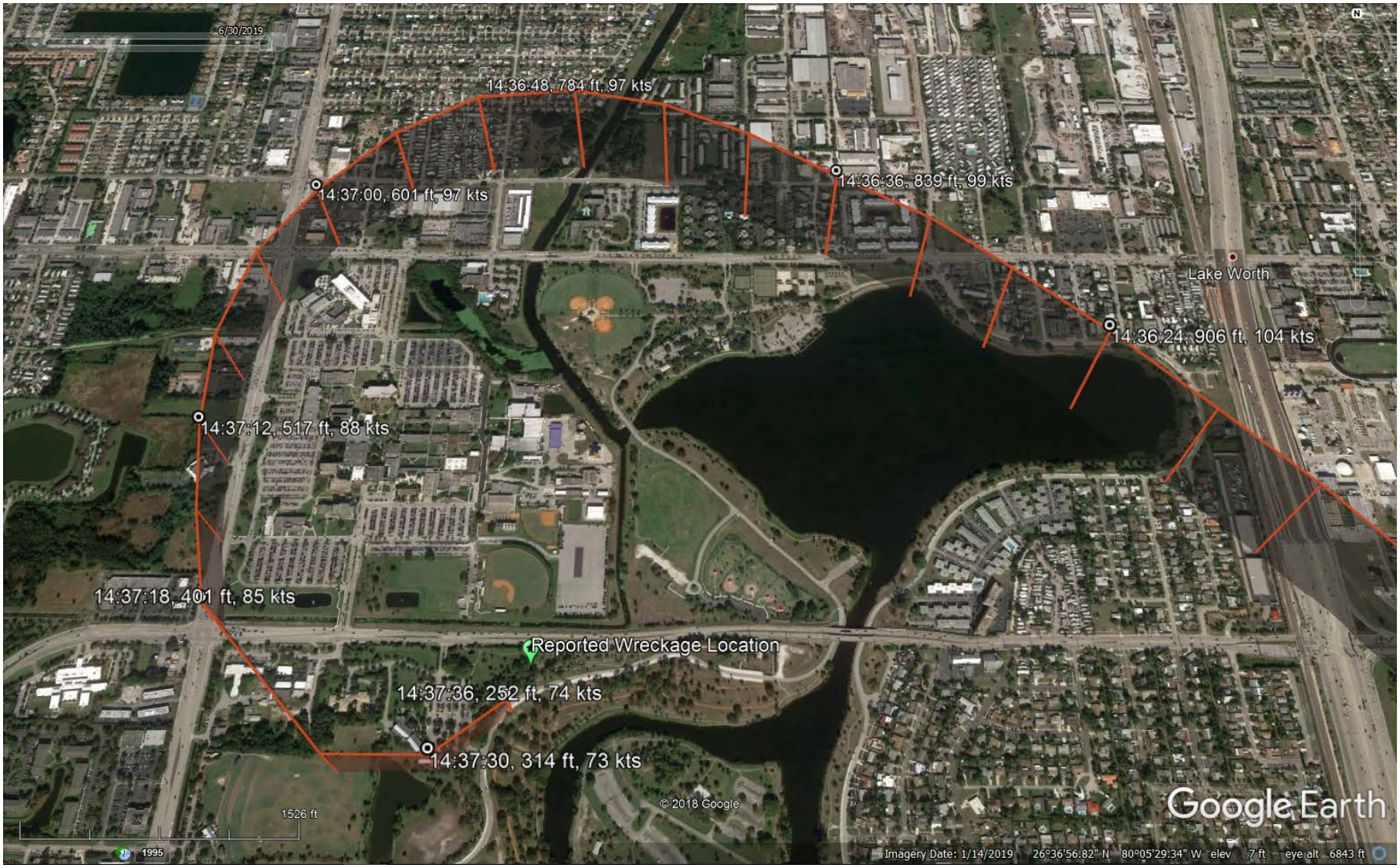

Figure 5. Plot of parameters recorded on the Avidyne PFD for the entire accident flight.

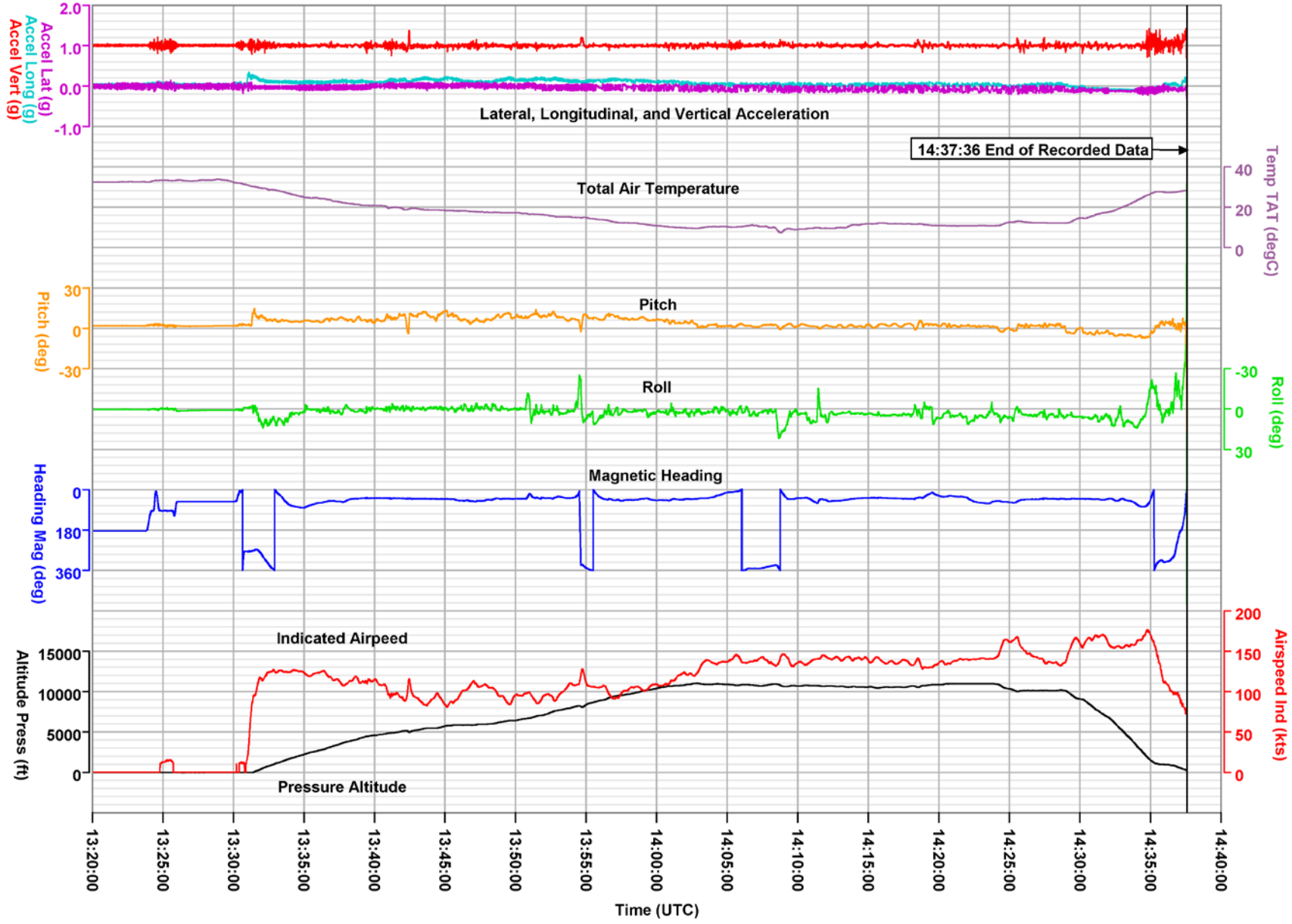

Figure 6. Plot of parameters recorded on the Avidyne PFD at the end of the accident flight.

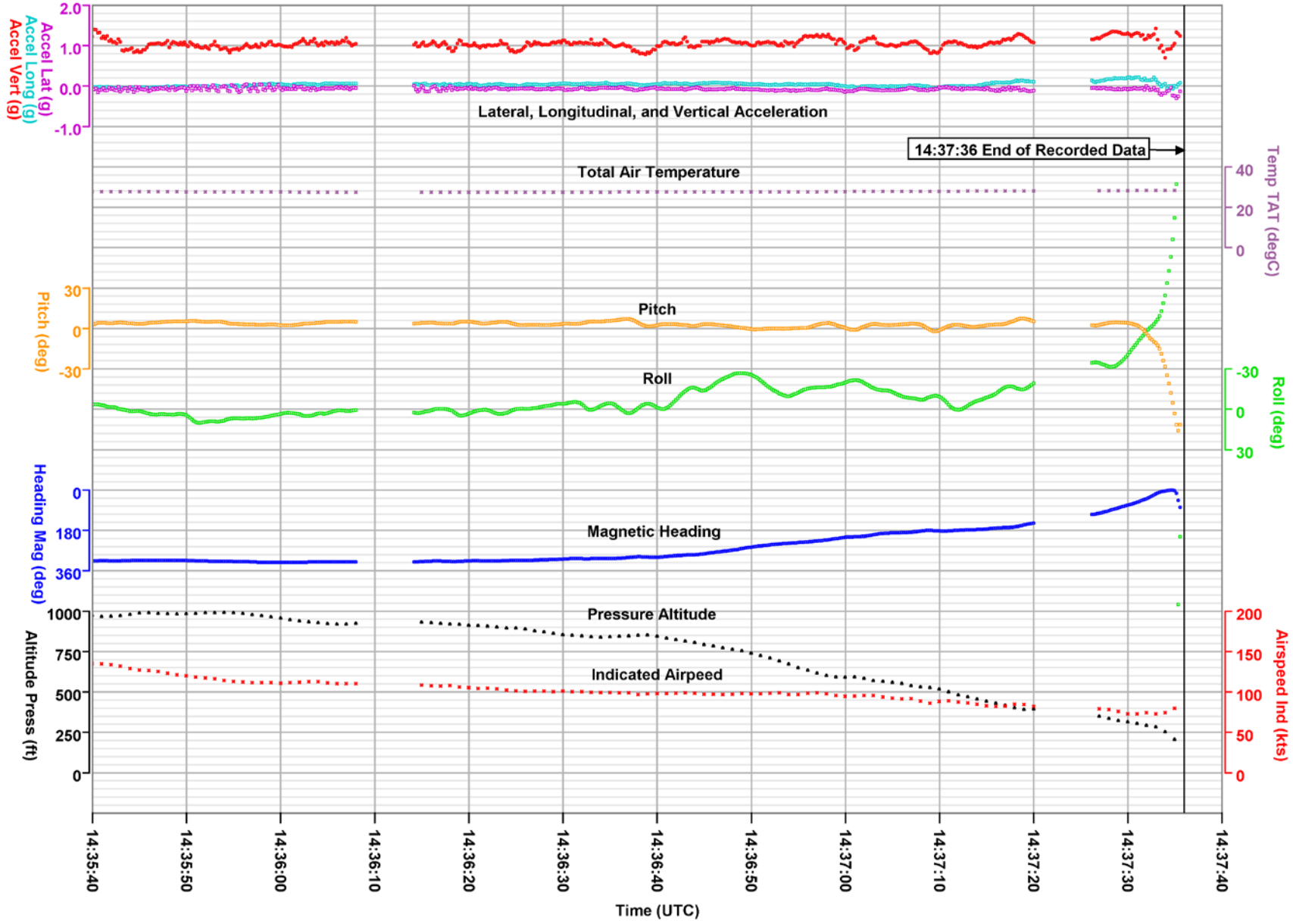

Figure 7. Plot of engine 1 parameters for the entire last session recorded on the JPI EDM-760.

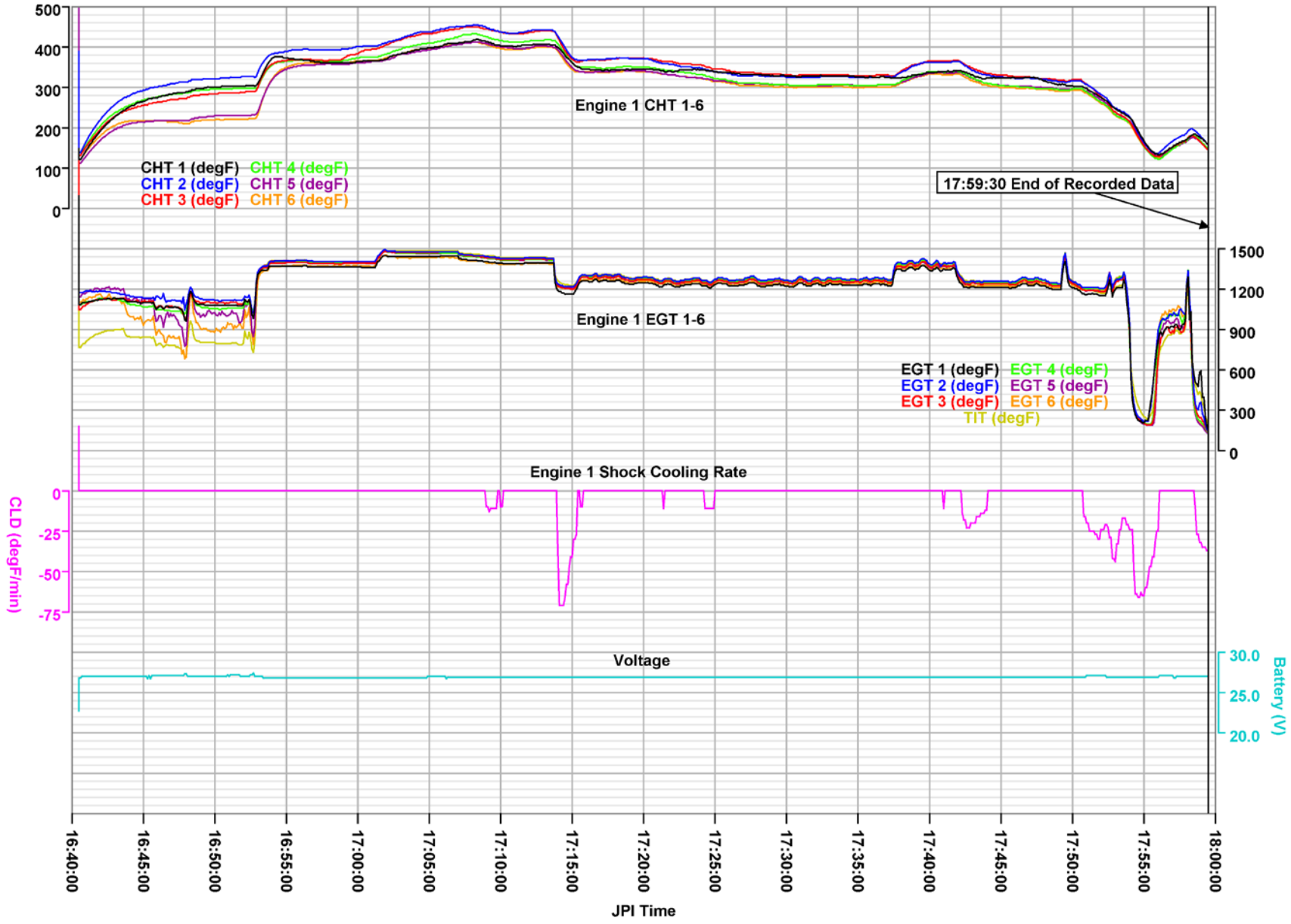

Figure 8. Plot of engine 1 parameters at the end of the last session recorded on the JPI EDM-760.

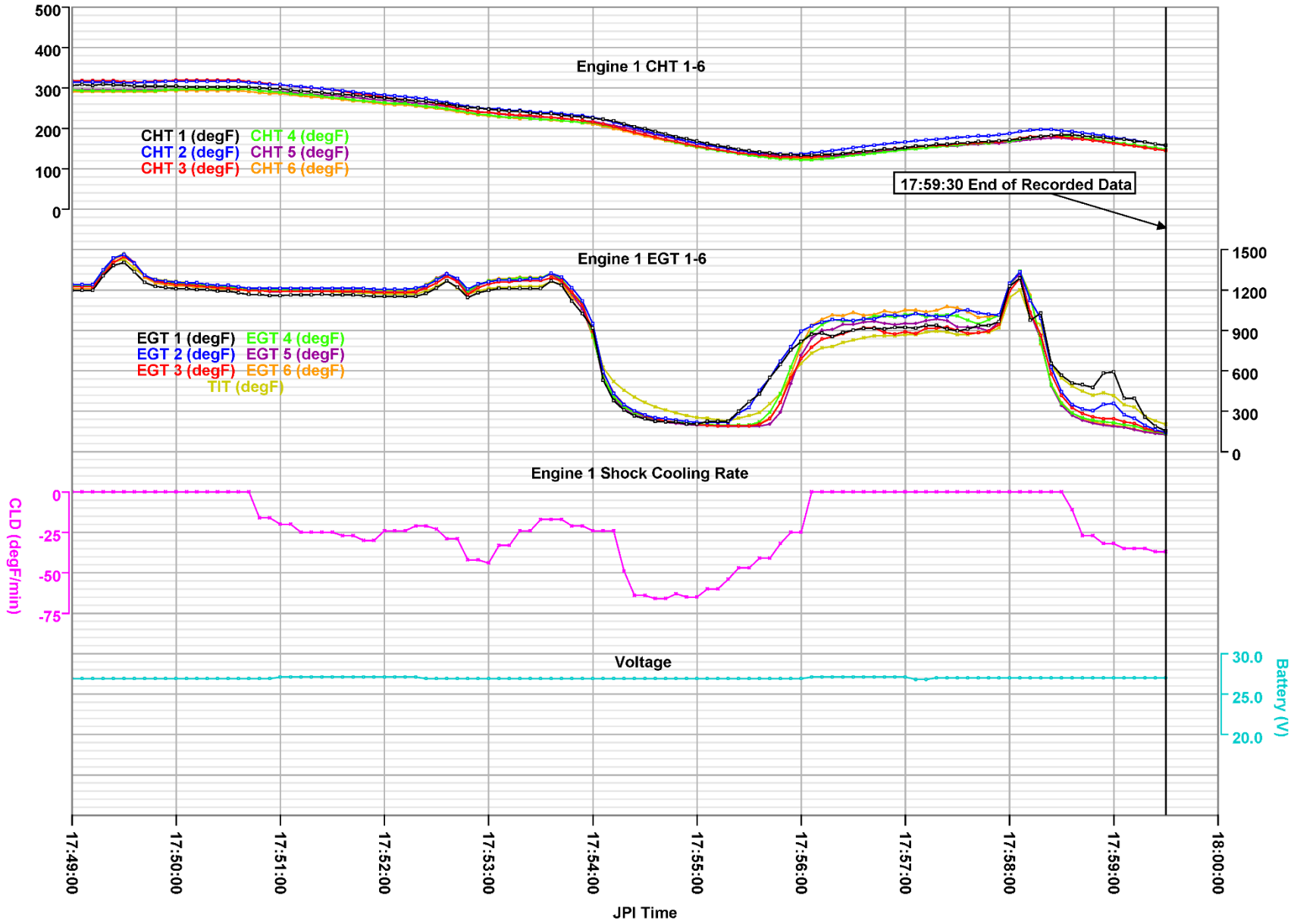

Figure 9. Plot of engine 2 parameters for the entire last session recorded on the JPI EDM-760.

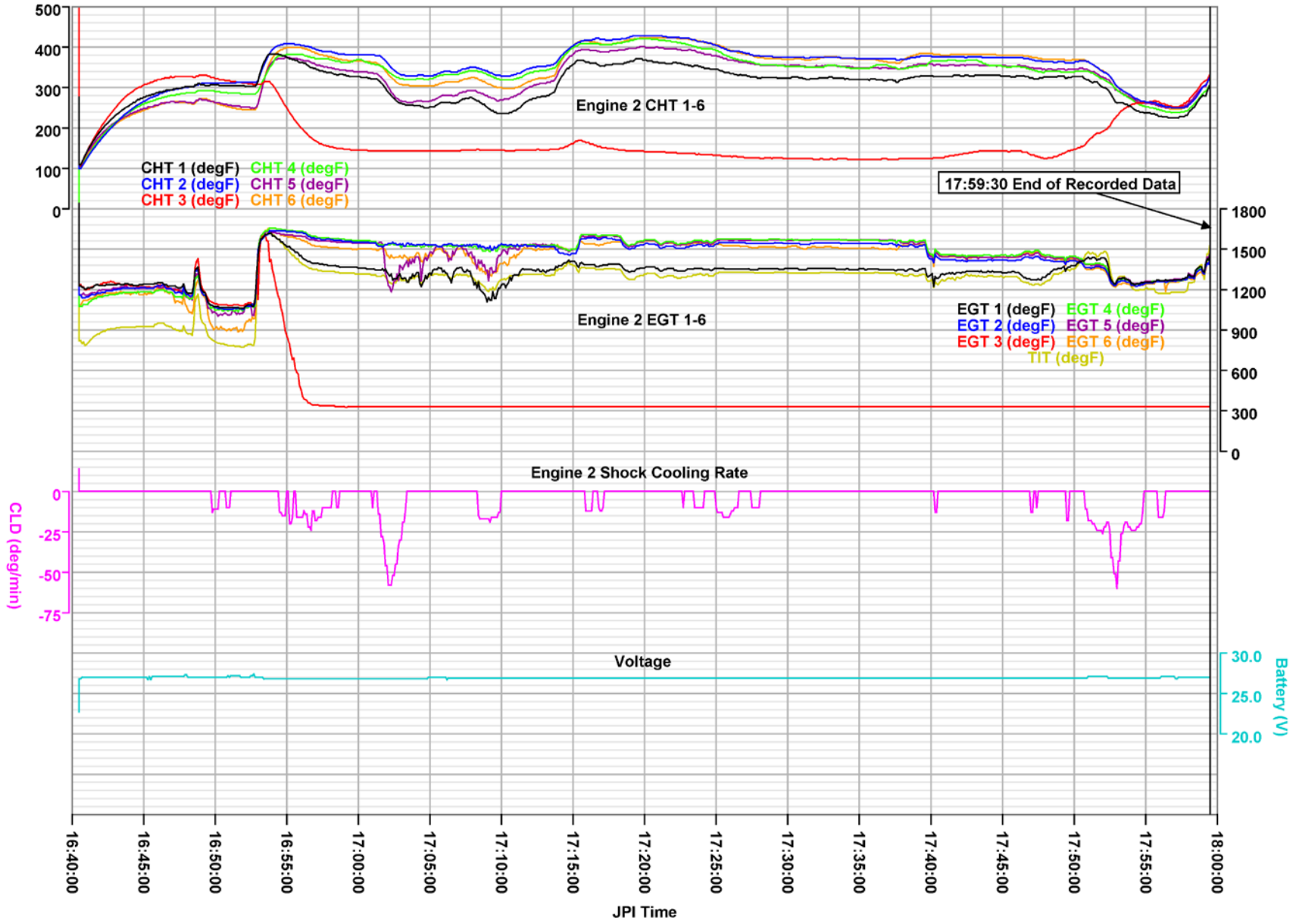

Figure 10. Plot of engine 2 parameters at the end of the last session recorded on the JPI EDM-760.