

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

December 1, 2020

Engine Data Monitor (EDM)

Specialist's Factual Report
By Sean Payne

1. EVENT SUMMARY

Location: Dunnellon, FL
Date: October 25, 2020
Aircraft: Cessna 172H
Registration: N724BC
Operator: Private
NTSB Number: ERA21FA029

On October 25, 2020, at 1052 eastern daylight time (EDT), a Cessna 172H, N724BC, was substantially damaged when it was involved in an accident near Dunnellon, Florida. The pilot was fatally injured. The airplane was operated as a Title 14 *Code of Federal Regulations* (CFR) Part 91 personal flight.

2. ENGINE DATA MONITOR GROUP

An engine data monitor (EDM) group was not convened.

3. DETAILS OF INVESTIGATION

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

Recorder Manufacturer/Model: **JPI EDM-730/830**
Recorder Serial Number: **36768**

3.1. EDM 730/830 Description

The J. P. Instruments EDM-730/830 is a panel-mounted LCD 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

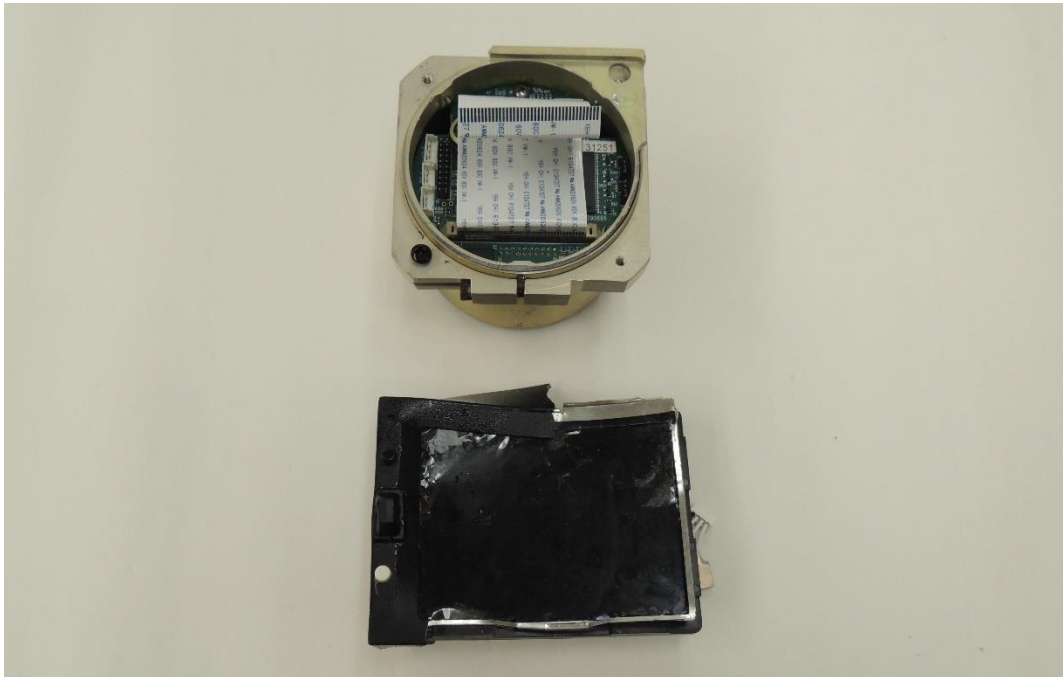
The unit can also calculate, in real-time, horsepower, fuel used, shock cooling rate, and EGT differentials between the highest and lowest cylinder temperatures. The calculations are also based on the aircraft installation.

The unit contains non-volatile memory for storage of the recorded and calculated parameters. The rate at which the data is stored is selectable by the operator and ranges from 2 to 500 seconds between samples. The memory can store up to 20 hours of data at a 6-second sample rate. For a non-damaged unit, the data can be downloaded by the operator using a USB flash drive and following the instructions on the unit.

3.1.1. Data Recovery

The recorder was damaged in the event. The extent of the damage is shown in figure 1. The screen was displaced from the unit, but the unit was otherwise in good condition. The unit was disassembled, inspected for internal damage, and was repaired with a surrogate screen. The unit was powered on and the device's data was extracted using the manufacturer's recommended procedure and software.

Figure 1. Damaged exterior of EDM.



3.1.2. Data Description

The EDM recording contained a multitude of engine data over several power cycles. Only the last few power cycles of data were evaluated. The event flight was the last flight of the recording and its duration was approximately 19 minutes and 48 seconds.

3.1.3. Engineering Units Conversions

The engineering units conversions used for the data contained in this report are based on documentation from the manufacturer of the EDM.

Appendix A lists the EDM parameters verified and provided in this report.

3.2. Time Correlation

The EDM records time with the first data sample based on the unit's internal clock. This clock is set and updated by the operator.

Correlation of the EDM data to the event local time, EDT, was established by using the recorded time and then offsetting the end of the data (last data point) to correlate with the documented accident time of 10:52 EDT. This was done by applying an additional -12,869 second offset. Therefore, for the rest of this report, all times are referenced as EDT, not recorded time.

3.3. Plots and Corresponding Tabular Data

The following three figures contain EDM data recorded during from the EDM between October 8, 2020 and the accident date which was on October 25, 2020.

In a session of recorded data on October 8, 2020, which had a duration of 3 hours 41 minutes and 11 seconds, the value for fuel used at the start of the session was recorded as 2.3 gallons. Operation of the JPI allows the pilot to set the fuel state upon the unit being powered, including zeroing the value for fuel used. This value was not zeroed in the recording and by the end of the session the unit indicated that 31.3 gallons had been used.

Section 4 of the JP Instruments Pilot's Guide for the EDM-730/830 describes the unit's fuel flow option's operation. Selected relevant passages are copied from the manual below:

Section 4 - Fuel Flow Option Operation Fuel Management

Without a means of measuring accurate fuel flow, you must rely on the aircraft fuel gauges or total time of flight. Aircraft fuel gauges are notoriously inaccurate (they are only required by the FAA to read accurately when displaying empty). Determining fuel consumption by multiplying time of flight by estimated flow rate is, at best, an approximation, and assumes a constant fuel flow rate for each phase of flight. However, the EDM Fuel Flow Option uses a small, turbine transducer that measures the fuel flowing into the engine. Higher fuel flow causes the transducer turbine to rotate faster which generates a faster pulse rate. Because the transducer turbine generates thousands of pulses per gallon of fuel, it can measure with high resolution the amount of fuel that flows into the engine. Prior to engine start you inform the EDM Fuel Flow Option of the known quantity of fuel onboard, it subsequently tracks all fuel delivered to the engine.

IMPORTANT: For EDM fuel calculations to be accurate, it is mandatory that you inform the EDM of the correct amount of usable fuel onboard the aircraft

and confirm proper operation of the fuel flow transducer prior to and during flight. Do not rely on fuel flow instruments to determine fuel levels in tanks. Refer to original fuel flow instrumentation for primary fuel management information.

Start Up Fuel

On power-up, you will be prompted to enter any fuel you might have added to the aircraft (this process updates the REMaining and USED values). The EDM will display FUEL for one second, and then flash FILL? N. If you didn't add any fuel, simply tap STEP to exit, otherwise tap LF and pick one of the three choices below:

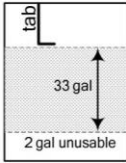
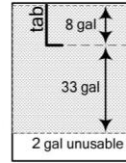
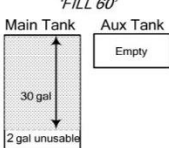
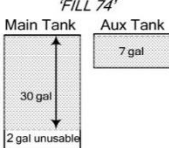
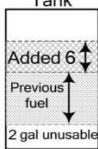
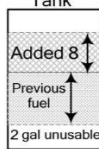
Choice 1) FILL 66 : This shortcut sets REMaining to the MAIN tank value (you preset MAIN in Factory Limits setup).

Choice 2) FILL 86 : This shortcut sets REMaining to the sum of MAIN and AUX (you preset AUX in Factory Limits setup).

Choice 3) FILL + : This allows you to adjust your REMaining either up or down by holding or tapping LF. Use when adding a partial amount of fuel. Once you've selected your choice, tap STEP to accept it

NOTE: If you forgot to update your EDM fuel REMaining before starting the engine, you can still perform the FILL procedure. The EDM will automatically subtract any burned fuel from the FILL value you choose (not applicable to the 'FILL +' feature).

The three examples, shown below, depict different aircraft tank configurations and how you can update your EDM after refueling your aircraft. These are meant to be general guidelines. You are responsible for insuring that your usage of the FILL feature results in the EDM showing the correct amount of usable fuel REMaining onboard the aircraft.

Example A: Aircraft has two fuel tanks with internal tabs. You've preset: 'MAIN = 66' (33 + 33 usable) 'AUX = 16' (8 + 8 usable) When you refuel: 'FILL 66': use this shortcut when filling to the internal tank tabs. 'FILL 82': use this shortcut when filling to the caps. (only one tank is shown in each of the two scenarios) 'FILL 66'  'FILL 82' 	Example B: Aircraft has two MAIN and two AUX tanks. You've preset: 'MAIN = 60' (30 + 30 usable) 'AUX = 14' (7 + 7 usable) When you refuel: 'FILL 60': use this shortcut when filling only MAIN tanks (! AUX tanks must be empty). 'FILL 74': use this shortcut when filling MAIN and AUX tanks. (only one wing shown in each of the two scenarios) 'FILL 60'  'FILL 74' 	Example C: Aircraft has two MAIN tanks. When you partially refuel, use: 'FILL +': use this to add the amount of fuel you pumped into the aircraft (it doesn't matter which tanks you added to - the EDM totalizes ALL onboard usable fuel). In this example you will add '14.0 GAL', the same as your fuel slip reads. This will be added to the totalizer REM value. Left Main Tank  Right Main Tank 
---	---	---

Resetting 'USED'

Every time you inform the EDM that the aircraft is refueled, the amount of fuel USED is automatically set to zero (unless the instrument is programmed to ACCUM? Y). To manually zero the amount of fuel USED at any time, manually STEP to display USED and then hold both buttons until the display shows '0USED'(this normally takes about five seconds).

Figure 2 is a plot of data from the flight previous to the accident flight. Records show this flight occurred on October 9, 2020, and was approximately 4 hours in duration. Except for a large temperature differential between cylinder #1 and cylinder #4 EGTs around 10:10 EDT, the EGT differential averaged around 100 degrees Fahrenheit for the entire recording.

On this flight previous to the accident flight, data showed the initial fuel status was reported by the unit as 31 gallons. Within the next two data samples, this value had been zeroed. By the end of the flight the recorded data showed that 34 gallons of fuel had been used. During this previous flight to the accident flight, the data showed the aircraft averaged between 8 and 9 gallons per hour (gph).

Figure 3 is a plot of data from the entire accident flight. Like the previous flight, there was a large temperature differential between cylinder #1 and cylinder #4 EGTs recorded in the early portion of the data around 10:35 EDT. The inflight portion of the recording was unremarkable until 10:51:42 EDT when fuel flow and EGT values for all cylinders dropped rapidly. The end of data occurred three samples later (18 seconds) at 10:52 EDT. The end of the data does not necessarily represent the moment of impact. It could not be determined if the unit stopped recording upon impact, or continued to record these three samples 18 seconds after impact.

On the accident flight, data showed the initial fuel status was reported by the unit as approximately 34 gallons. Within the next six samples, data showed the value for fuel used was set to zero. By the end of the recording, the value for fuel used showed 2.8 gallons. During the accident flight, the data showed the aircraft averaged around 9 gph during the accident flight.

Figure 4 is an expanded time range plot of the final moments of the accident flight. Tick marks have been added to each parameter's plotted line to indicate exactly when the samples were taken by the unit.

The corresponding tabular data used to create these three plots are provided in electronic (*.csv¹) format. Attachment 1 is all recorded data from the flight previous to the accident flight. Attachment 2 is all recorded data from the accident flight.

¹ Comma Separated Value format.

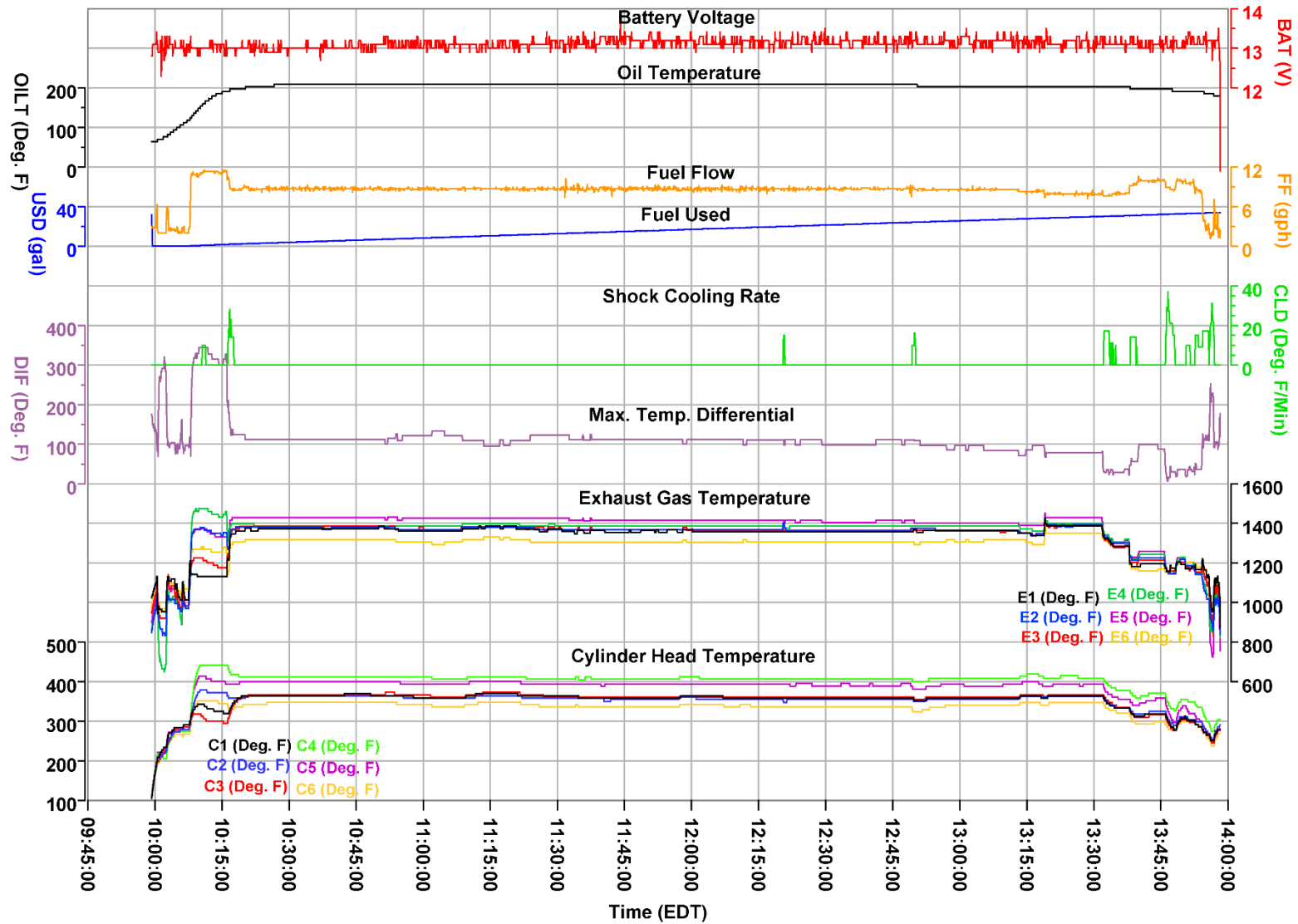


Figure 2. Plot of entire previous flight.

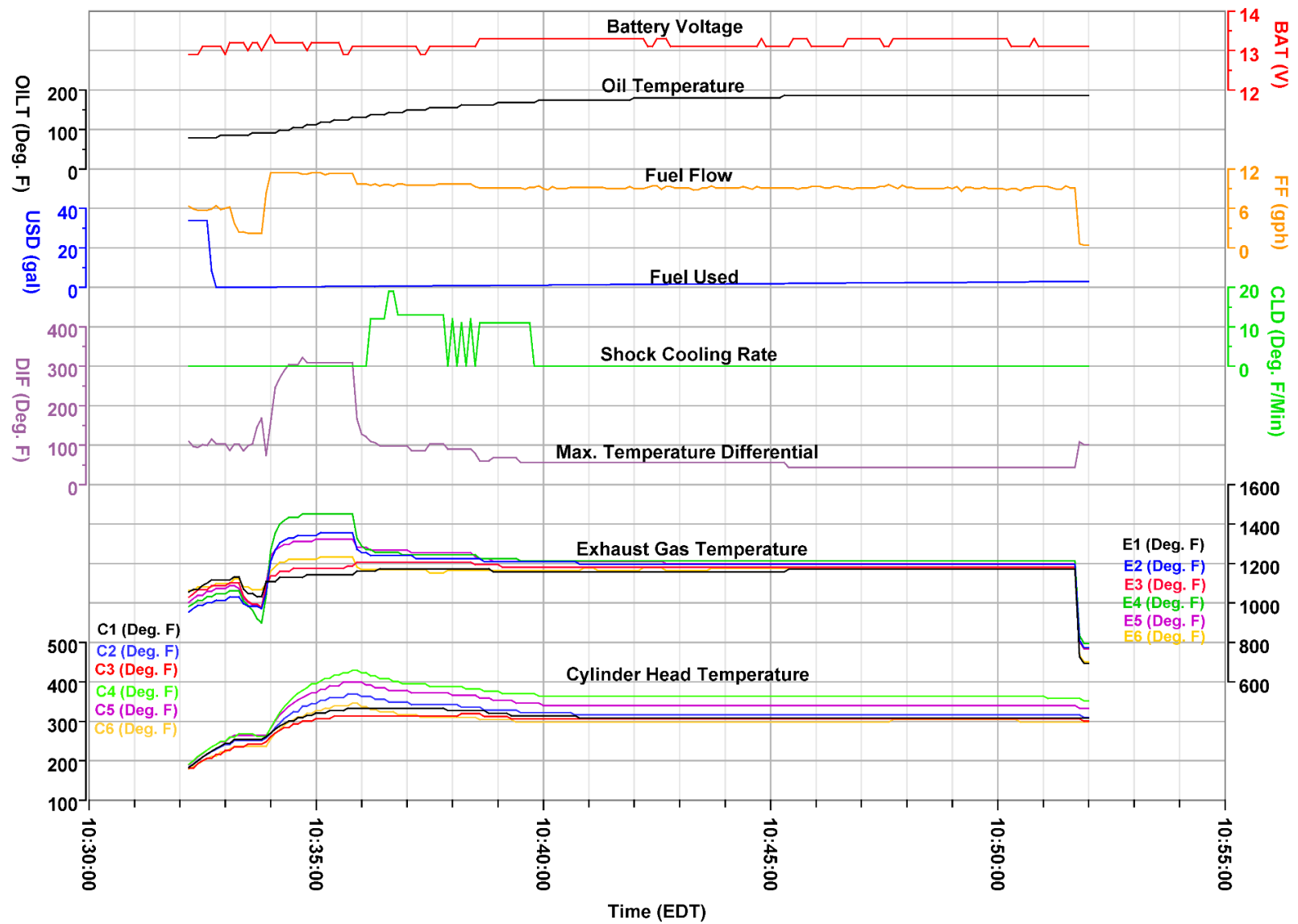


Figure 3. Plot of entire accident flight.

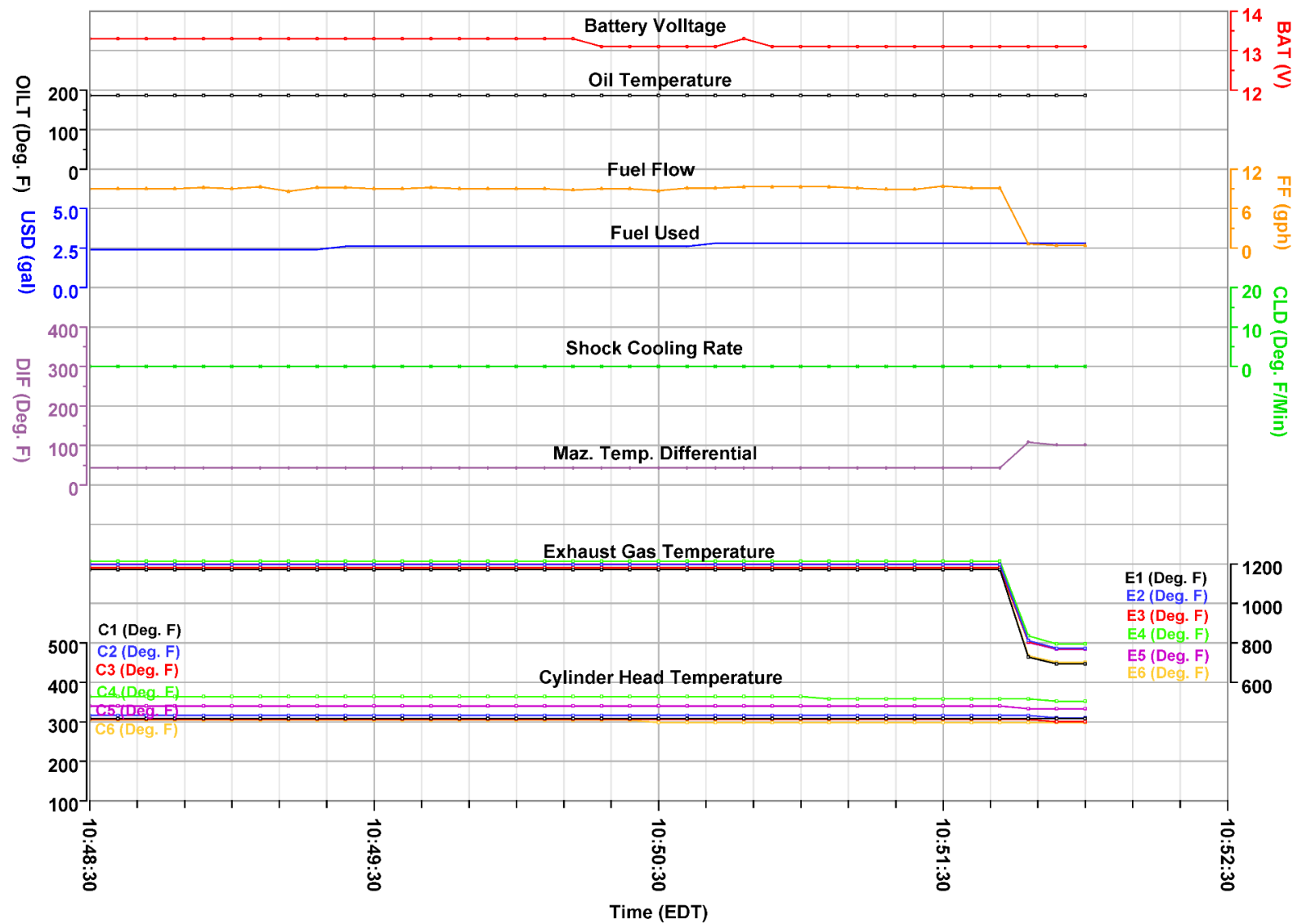


Figure 4. Plot of end of accident flight.

APPENDIX A

This appendix describes the parameters provided and verified in this report. Table A-1 lists the parameters and table A-2 describes the unit abbreviations used in this report.

Table A-1. Verified and provided parameters.

Parameter Name and Units	Parameter Description
1. BAT (V)	Battery Voltage Input 1
2. DIF (Deg. F)	Maximum Temperature Differential – Exhaust Gas Manifolds
3. CHT-# (Deg. F)	Cylinder Head Temperature Cylinder # ²
4. EGT-# (Deg. F)	Exhaust Gas Temperature Cylinder #
5. FF (gph)	Engine Fuel Flow
6. USD (gal)	Engine Fuel Used
7. OilT (Deg. F)	Engine Oil Temperature
8. CLD (Deg. F/min)	Engine Shock Cooling Rate

Table A-2. Unit abbreviations.

Units Abbreviation	Description
Deg. F/Min	degrees Fahrenheit per minute
Deg. F	degrees Fahrenheit
gal	gallons
gph	gallons per hour
V	Volts DC

² Depending on aircraft configuration number of cylinders that are instrumented varies. In the data plots the '#' is replaced with the appropriate cylinder ID.