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

April 24, 2018

Cockpit Displays – Recorded Flight Data

Specialist's Factual Report
By Jane Foster

1. EVENT SUMMARY

Location: Alexandria, Louisiana
Date: March 23, 2016
Aircraft: Cirrus SR22
Registration: N927DS
Operator: Private
NTSB Number: CEN16LA143

On March 23, 2016, about 1600 central daylight time (CDT), a Cirrus SR22, N927DS, experienced a partial loss of engine power during descent into Alexandria International Airport (KAEX), Alexandria, Louisiana. The airplane sustained substantial damage following deployment of the ballistic recovery parachute. The private pilot and flight instructor on-board were not injured. The airplane was registered to Rucks Aviation, LLC and operated by the owner under the provisions of 14 *Code of Federal Regulations* Part 91 as a personal flight. Visual meteorological conditions prevailed for the flight, and no instrument flight rules flight plan was filed. The flight originated at Dallas Executive Airport (KRBD), Dallas, Texas.

2. RECORDED FLIGHT DATA GROUP

A recorded flight data 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: **Avidyne PFD**
Recorder Serial Number: **20110456**

Recorder Manufacturer/Model: **Avidyne MFD Card**
Recorder Serial Number: **Unknown**

3.1. 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) and 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.

3.1.1. PFD Data Recovery

The recorder was in good condition and the data were downloaded using the manufacturer's procedure. The device is shown in figures 1 and 2.

Figure 1. Front of device as received.

Figure 2. Back of device as received.

3.1.2. PFD Data Description

The PFD recording contained records of 39 power cycles and approximately 25 hours of data. The accident flight was associated with the 35th power cycle.[1] The duration of the 35th power cycle was approximately 1 hour and 36 minutes. Timing of the PFD data is measured in seconds from power-on.

As stated in section 3.1, the PFD records most data at regular time intervals. The recorded data has shown, at times, to drop data records for up to 6 seconds in duration. The dropout condition has been reported to the manufacturer of the PFD. The condition that causes the dropouts is related to time overruns in the low-priority data logging code, which results in the input buffer overflowing. In later PFD software versions, if a drop-out occurs, an event is recorded in the event log.

3.1.3. PFD Engineering Units Conversions

Conversion of the PFD data from the raw recorded information to engineering units is performed by Avidyne. Acceleration data, as provided by Avidyne, was converted from meters per second-squared (m/s^2) to standard acceleration units (g).

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

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=+).[2]

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

3.2. Avidyne Multi-Function Display (MFD) Description

The MFD unit is able to display the pilot checklist, terrain/map information, approach chart information and other aircraft/operational information depending on the specific configuration and options that are installed. One of the options available is a display of comprehensive engine monitoring and performance data.

Each MFD contains a compact flash (CF) memory card located in a slot on the side of the unit. This memory card contains all of the software that the MFD needs to operate. Additionally, this card contains all of the checklist, approach charts, and map information that the unit uses to generate the various cockpit displays.

During operation, the MFD display receives information from several other units that are installed on the aircraft. Specifically, the MFD receives GPS position, time and track data from the aircraft's GPS receiver. The MFD may also receive information from the aircraft concerning altitude, engine and electrical system parameters, and outside air temperature. This data is also stored on the unit's CF memory card.

The MFD generates new data files for each MFD power-on cycle. The oldest file is dropped and replaced by a new recording once the storage limit has been reached. MFD data are sampled every six seconds, and are recorded to memory once every minute. If an interruption of power occurs during the minute between MFD memory write cycles, data sampled during that portion of a minute are not recorded.

3.2.1. MFD Data Recovery

The recorder was in good condition and the data were downloaded using the manufacturer's procedure. The device is shown in figure 3.

[2] 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. Examples: Right Roll = +, Left Aileron Trailing Edge Down = -, Right Aileron Trailing Edge Up = +, Pitch Up = +, Elevator Trailing Edge Up = +.

Figure 3. Front and back of device as received.

3.2.2. MFD Data Description

The MFD CF card contained 81 data files. One data file was identified as recording during the incident flight. The data file was approximately 1 hour and 36 minutes in duration

3.2.3. MFD Engineering Units Conversions

The data files downloaded from the MFD are in engineering units.

Appendix B lists the MFD parameters verified and provided in this report.

3.3. Time Correlation

Correlation of the PFD data to central daylight time 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 Universal Coordinated Time (UTC). The difference between Central Daylight Time and UTC is five hours, or -18000 seconds. The PFD starts recording when power is applied to the unit. Each power cycle the timing begins at 0 seconds 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 the local time zone. Therefore, for the rest of this report, all times are referenced as Central Daylight Time, not recorded time.

MFD data was recorded in Universal Coordinated Time (UTC). The difference between Central Daylight Time and UTC is five hours, or -18000 seconds. The incident flight data has been offset from recorded MFD time to Central Daylight Time by subtracting -18000 seconds.

Due to the six second update rate of the GPS time, the times noted in this report could be up to six seconds off from actual GPS time

3.4. Plots and Corresponding Tabular Data

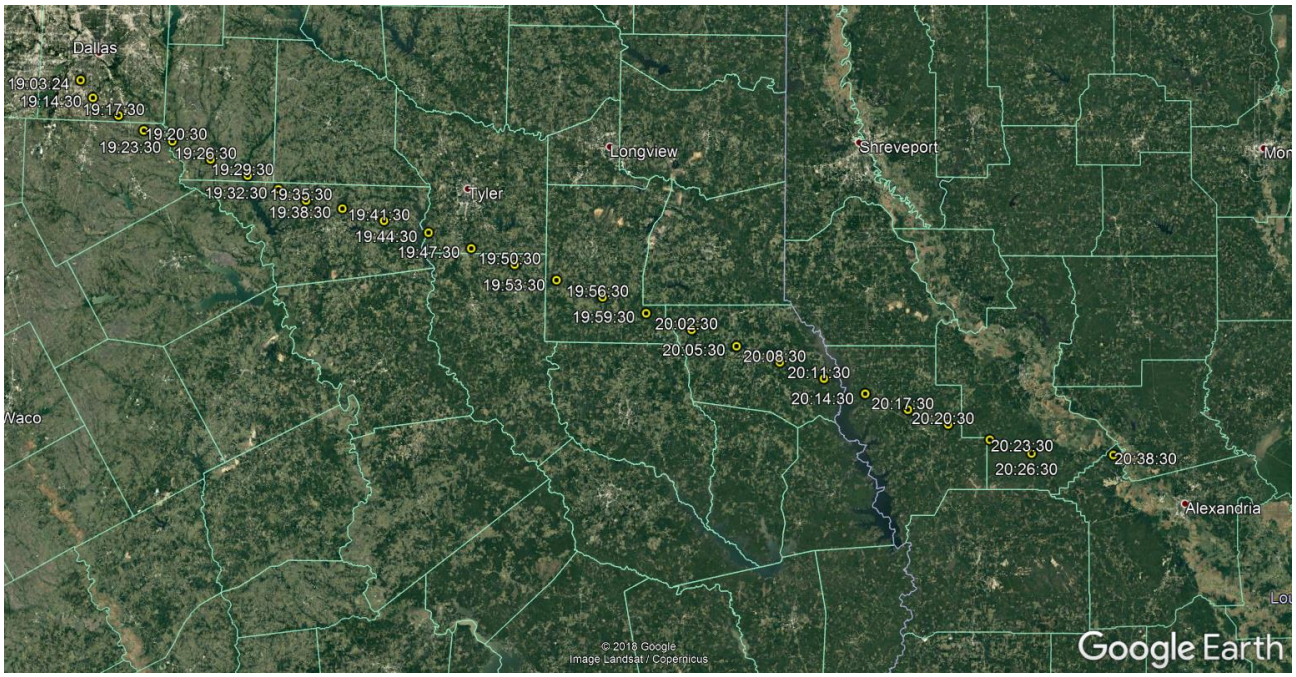
The following four figures contain data recorded during the March 23, 2016 event.

[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.

Some GPS data was recorded by the MFD. Figure 4 is a graphical overlay generated using Google Earth for the accident flight. The weather and lighting conditions in Google Earth are not necessarily the weather and lighting conditions present at the time of the recording.

The corresponding tabular data used to create these four plots are provided in electronic (*.csv[4]) format as Attachment 1 (PFD) and Attachment 2 (MFD) to this report.

Figure 4. Some GPS related data recorded by the MFD showing the accident flight. Time is shown in UTC.



[4] Comma Separated Value format.

Figure 5. Plot of the full flight with data from the PFD.

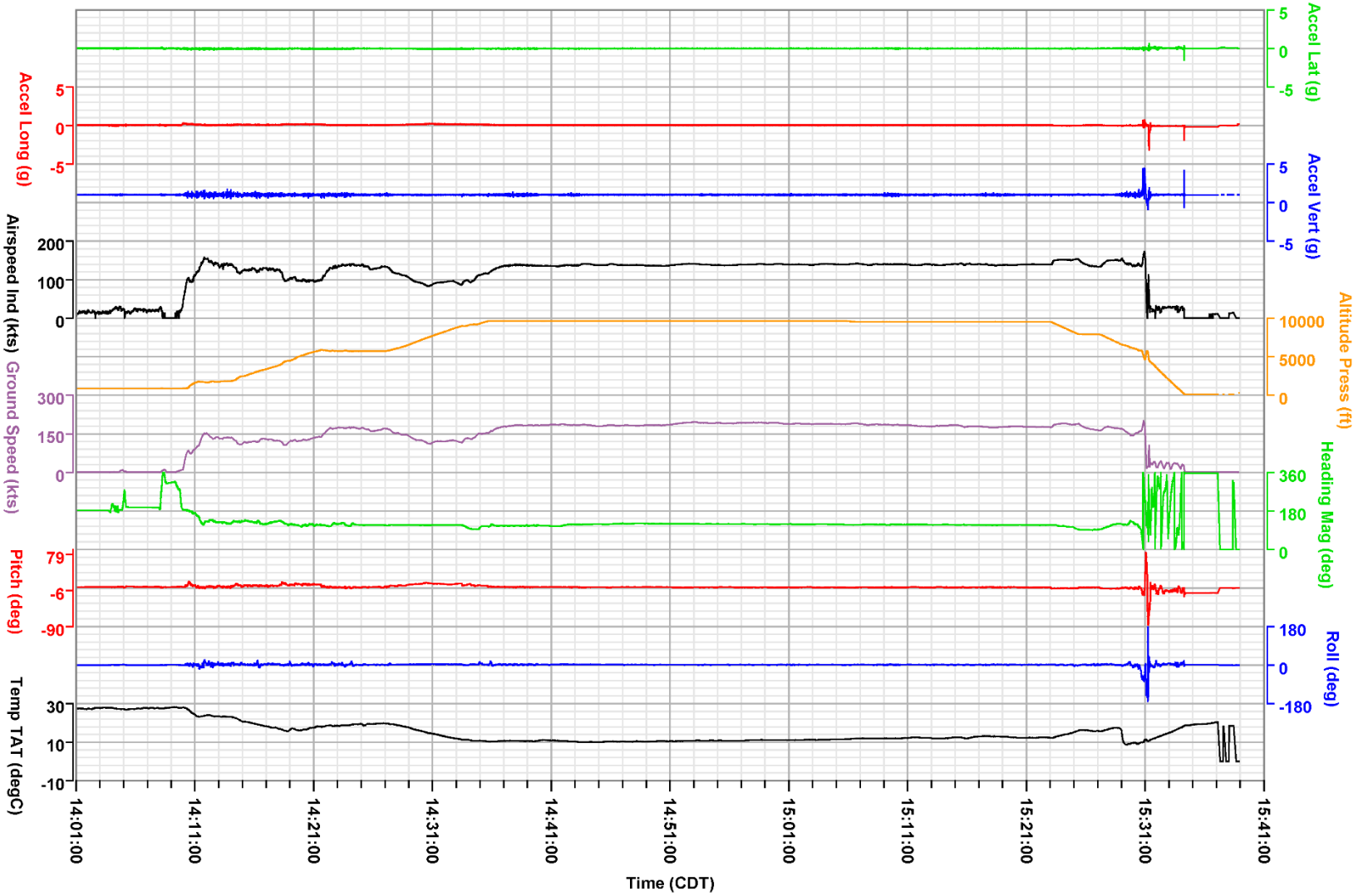


Figure 6. Plot of the full flight with data from the MFD.

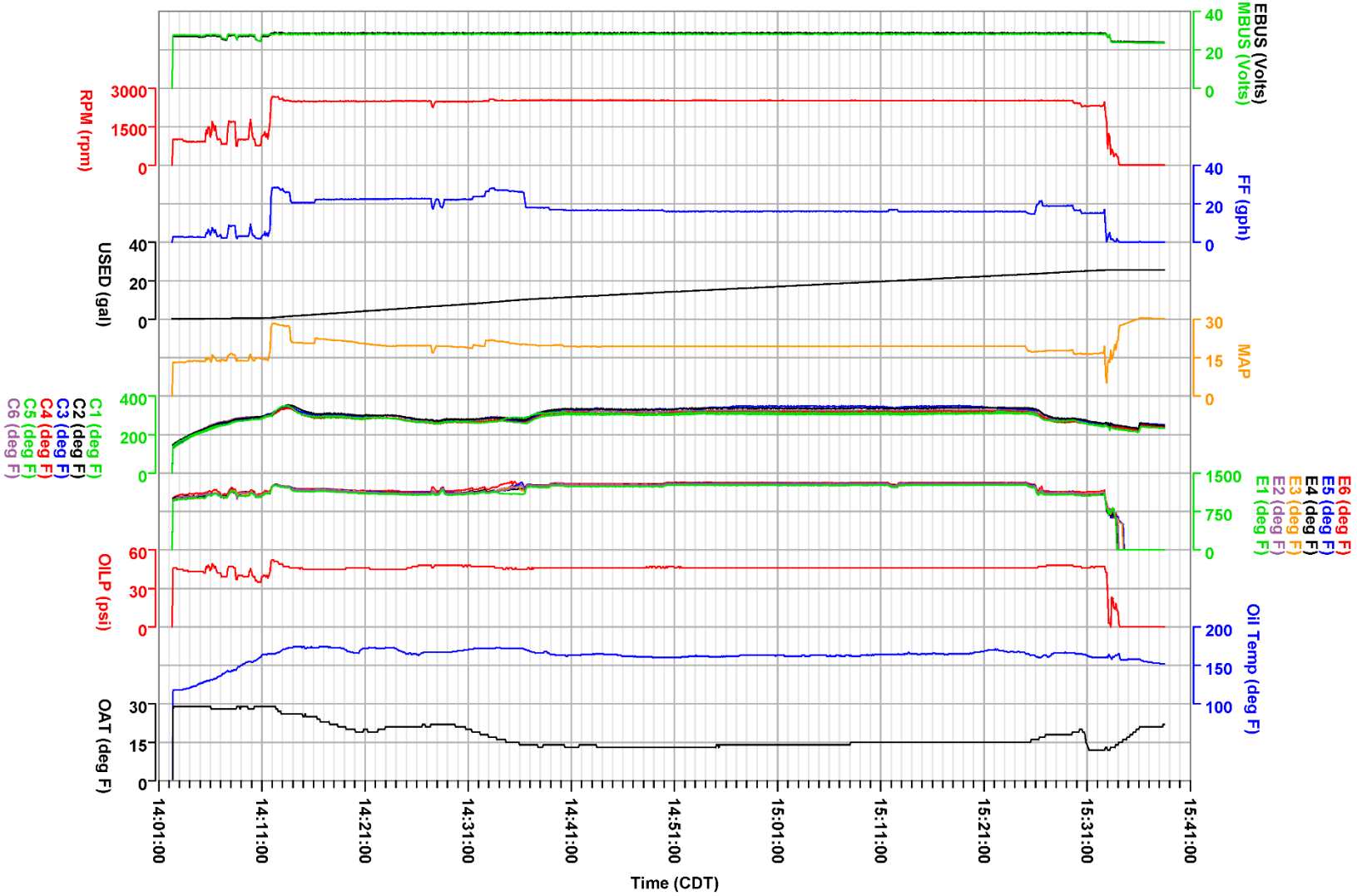
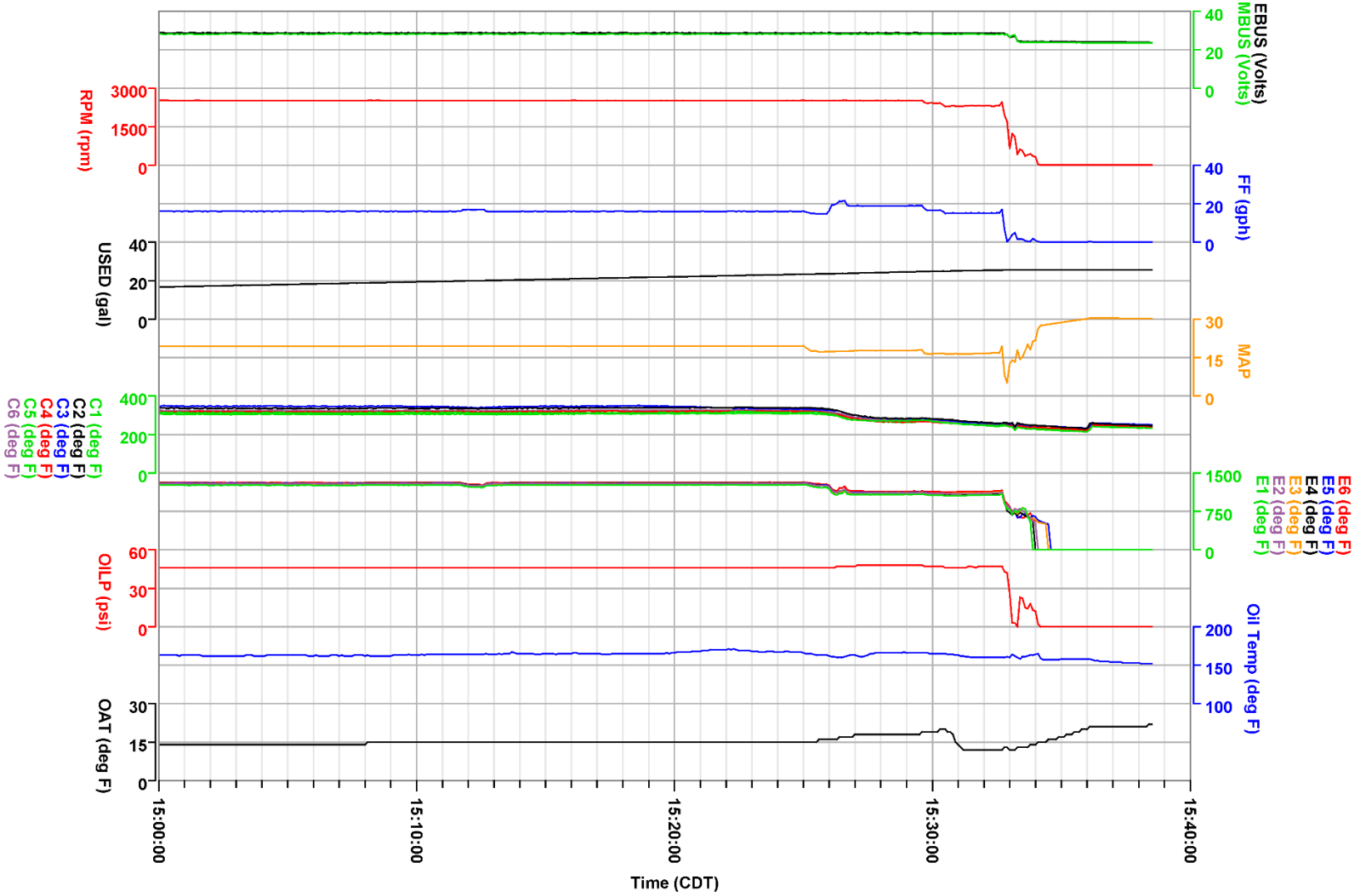


Figure 7. Plot of the end of the flight using data from the MFD.



APPENDIX A - PFD Parameters

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

Table A-1 - Verified and provided parameters.

Parameter Name	Parameter Description
Accel Lat (g)	Lateral Acceleration
Accel Long (g)	Longitudinal Acceleration
Accel Vert (g)	Vertical Acceleration
Airspeed Ind (kts)	Indicated Airspeed
Altitude Press (ft)	Pressure Altitude
Ground Speed (kts)	Ground Speed
Heading (deg)	Heading
Pitch (deg)	Pitch
Roll (deg)	Roll
Temp TAT (deg)	Total Air Temperature

The PFD records pressure altitude, which is based on a standard altimeter setting of 29.92 inches of mercury (in Hg).

Table A-2 - Unit abbreviations.

Units Abbreviation	Description
deg	degrees
degC	degrees Celsius
ft	feet
kts	knots
g	g

APPENDIX B - MFD Parameters

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

Table B-1 - Verified and provided parameters.

Parameter Name	Parameter Description
AMP1	Bus 1 Amps (amps)
AMP2	Bus 2 Amps (amps)
AMPB	Battery Bus Amps (amps)
C#	Engine 1 Cylinder Head Temperature Cylinder #[5] (degrees Fahrenheit)
E#	Engine 1 Exhaust Gas Temperature Cylinder #[5] (degrees Fahrenheit)
FF	Engine 1 Fuel Flow (gallons per hour)
USED	Engine 1 Fuel Used (gallons)
MAP	Engine 1 Manifold Pressure (inches of mercury)
OILP	Engine 1 Oil Pressure (pounds per square inch)
Oil Temp	Engine 1 Oil Temperature (degrees Fahrenheit)
RPM	Engine 1 Revolutions Per Minute (revolutions per minute)
EBUS	Essential Bus Voltage (Volts)
Latitude (deg)	Latitude (degrees)
Longitude (deg)	Longitude (degrees)
MBUS	Main Bus Voltage (Volts)
OAT	Outside Air Temperature (degrees Celsius)

Table B-2 - Unit abbreviations.

Units Abbreviation	Description
rpm	revolutions per minute
A	Amperes
deg	degrees
degF	Degrees Fahrenheit
gal	gallons
gph	gallons per hour
psi	pounds per square inch
V	Volts DC

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