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

November 5, 2015

Cockpit Displays – Recorded Flight Data

Specialist's Factual Report
By Bill Tuccio, Ph.D.

1. EVENT SUMMARY

Location: Houston, Texas
Date: July 7, 2015
Aircraft: Cirrus SR22
Registration: N422PB
Operator: AIRCCS, LLC
NTSB Number: CEN15LA298

On July 7, 2015, about 1137 central daylight time (CDT), a Cirrus SR-22 single-engine airplane, N422PB, descended under the canopy of the cirrus airframe parachute system (CAPS) and landed in a residential neighborhood at Houston, Texas. The pilot and passenger sustained minor injuries, and the airplane was substantially damaged. The airplane was registered to and operated by AIRCCS, LLC; Humble, Texas, as a 14 *Code of Federal Regulations* Part 91 business flight. Day visual meteorological conditions (VMC) prevailed and a flight plan had not been filed. The airplane departed George Bush Intercontinental/Houston Airport (IAH), Houston, Texas, at 1133 and was destined for Austin Bergstrom International Airport (AUS), Austin, 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 Primary Flight Display (PFD)**
Recorder Serial Number: **20027526**

Recorder Manufacturer/Model: **Avidyne Multi-Function Flight Display (MFD)**
Recorder Serial Number: **20168145**

3.1. Avidyne 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 ADAHRS 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 manufacturers' procedure.

3.1.2. PFD Data Description

The PFD recording contained records of 36 power cycles and approximately 20 hours of data. The accident flight was associated with the 32nd power cycle.[1] The duration of the 32nd power cycle was approximately 16 minutes. Timing of the PFD data is measured in seconds from power-on.

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).

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.

[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.

[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 = +.

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 manufacturers' procedure.

3.2.2. MFD Data Description

The MFD CF card contained 103 data files. The last data file was identified as recording during the accident flight. For this report, RPM and pressure altitude were examined for 82 data files starting from March 28, 2015, through the accident flight. For the 16 minute accident flight, additional parameters were examined as described in Appendix B.

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

Flights prior to the accident flight are described in elapsed time since the start of recording. Between each flight, a time interval was inserted to ease identification of the next flight recording.

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. With 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 as UTC. Therefore, for the rest of this report, all times are referenced as UTC, not recorded time.

[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.

MFD data was recorded in UTC. UTC time recorded by the MFD was confirmed to be the same as PFD UTC time.

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 seven figures contain data recorded by the MFD and PFD. Satellite overlays were created with Google Earth; weather and lighting conditions depicted in the overlays are not necessarily representative of the weather and lighting conditions at the time of the accident.

Figure 1 shows a history of propeller RPM values recorded by the MFD from March 28, 2015, through the accident flight. From March 28, 2015, through the day prior to the accident, propeller RPM recorded values never exceeded 2,800 RPM.

Figure 2 shows details of propeller RPM values recorded on the two flights on the day of the accident. During the flight prior to the accident, the RPM values exceeded 2,800 RPM on about 7 samples; during the accident flight, RPM values exceeded 2,800 RPM during climb for about 2 minutes and 42 seconds.

Figures 3 and 4 show the accident flight PFD/GPS recorded data overlaid on satellite imagery. The recording began at 16:22:20 UTC. By 16:27:36 UTC, the aircraft began to taxi, reaching the end of the departure runway by about 16:32:08 UTC. By 16:32:56 UTC, the aircraft started its takeoff roll. After takeoff, the aircraft climbed in a right turn towards the west. By 16:35:56 UTC, the aircraft began to descend. The recording ended at 16:38:36 UTC.

Figure 5 shows a plot of basic parameters from the PFD accident flight recording, and figures 6 and 7 show a plot of engine parameters from the MFD accident flight recording. Collectively, these plots show:

- During the takeoff roll, the RPM increased above 2,800 RPM and remained so until manifold pressure decreased and EGT values began to fluctuate.
- The propeller was operated above 2,800 RPM for about 2 minutes and 42 seconds.
- At about the time EGT values began to fluctuate, altitude, CHT, and fuel flow began to decrease.
- About 1 minute after EGT values began to fluctuate, basic parametric data is consistent with activation of the CAPS.

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

[4] Comma Separated Value format.

Figure 1. RPM values from March 28, 2015, through the accident flight.

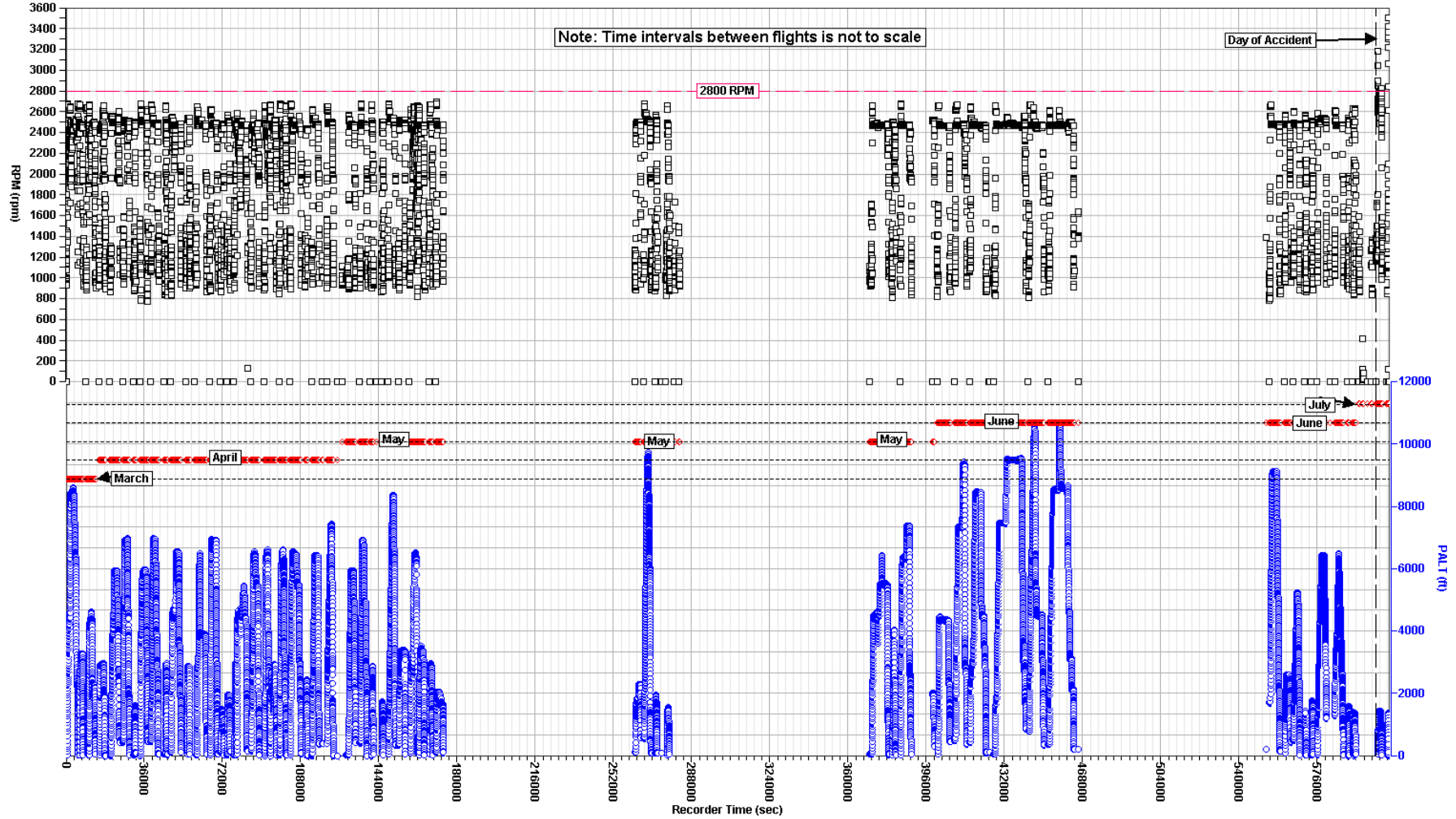


Figure 2. RPM values on day of the accident.

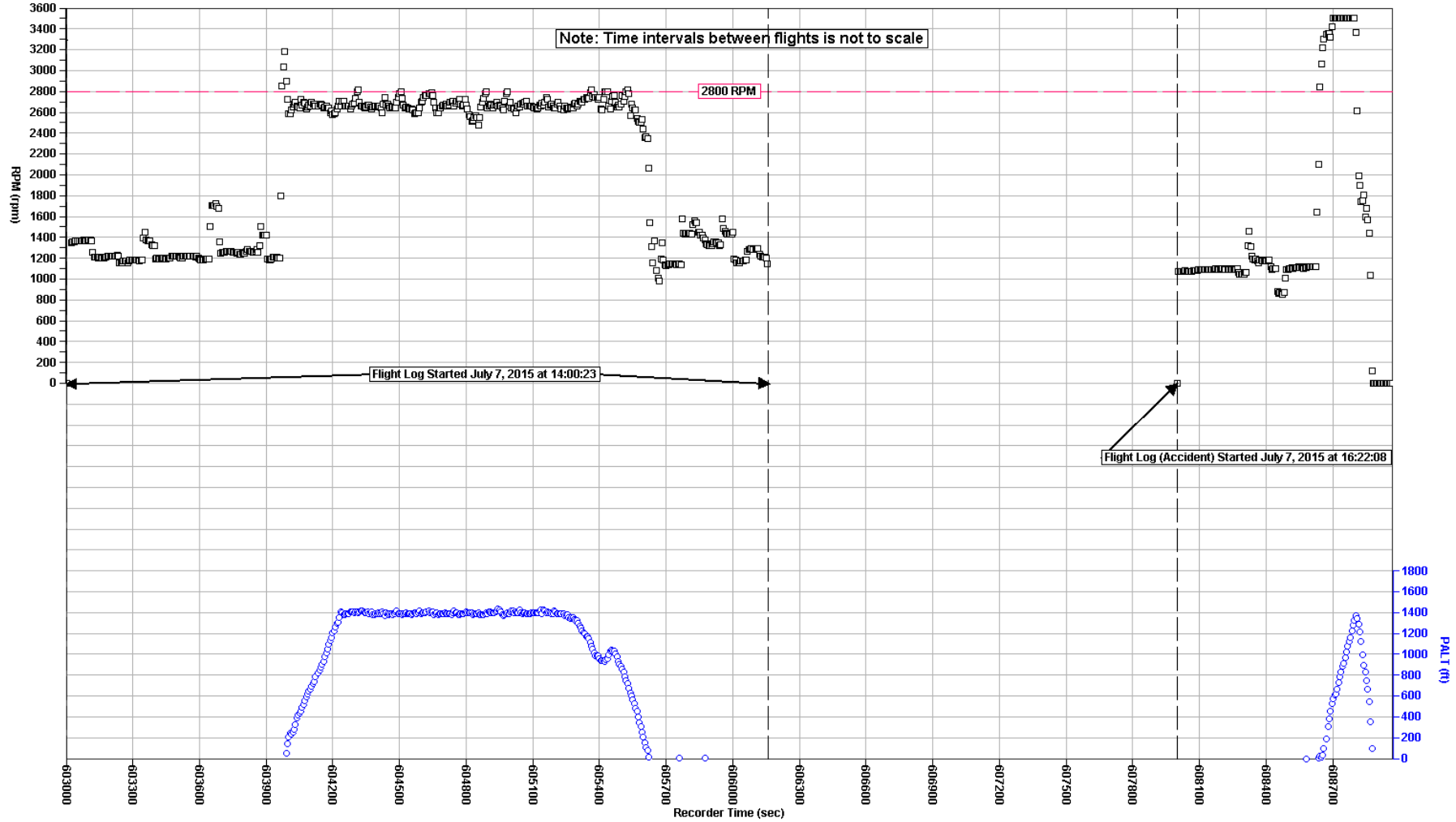


Figure 3. Google Earth overlay of accident flight.

Figure 4. Google Earth overlay of accident flight ground operations.

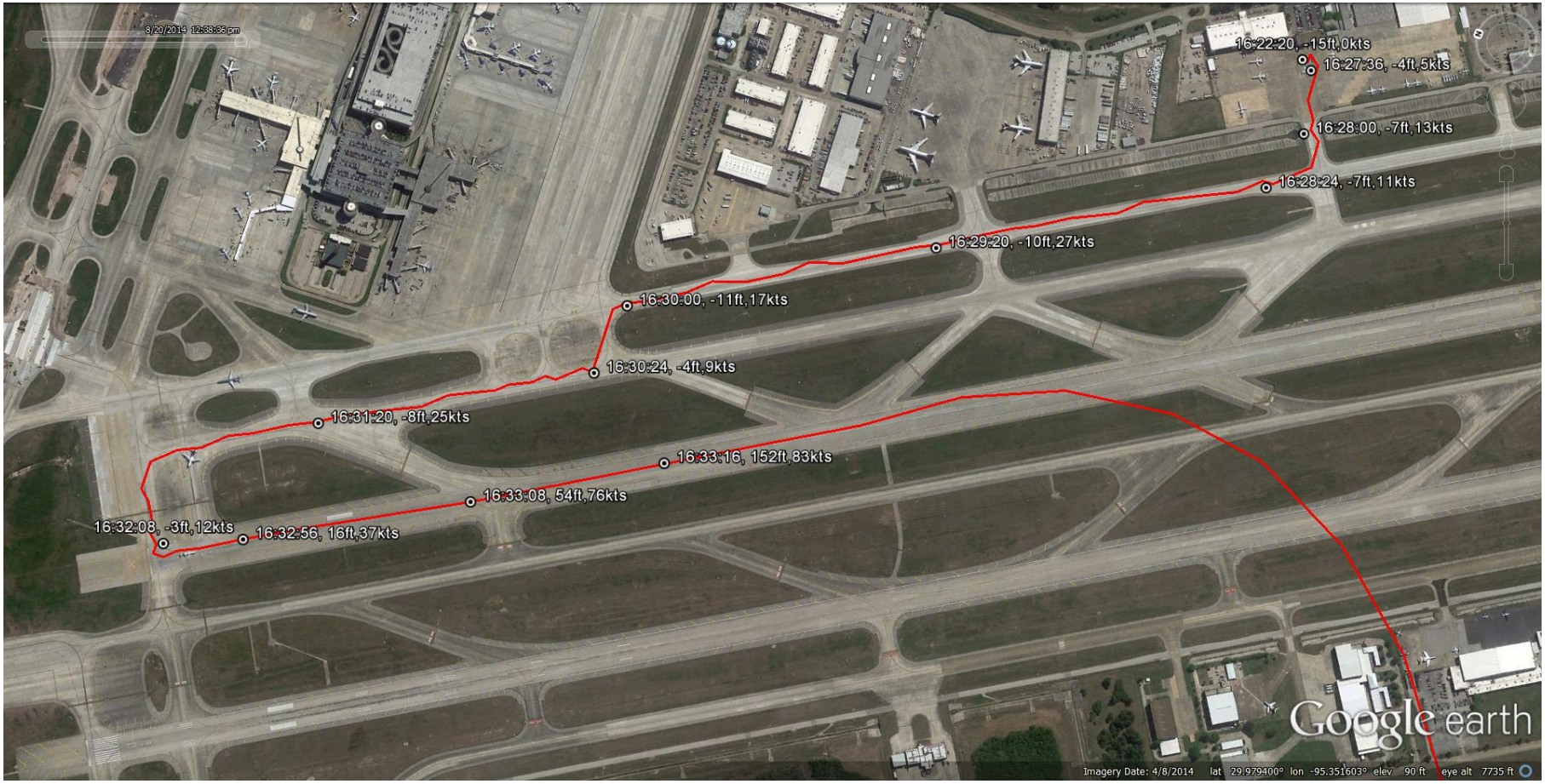
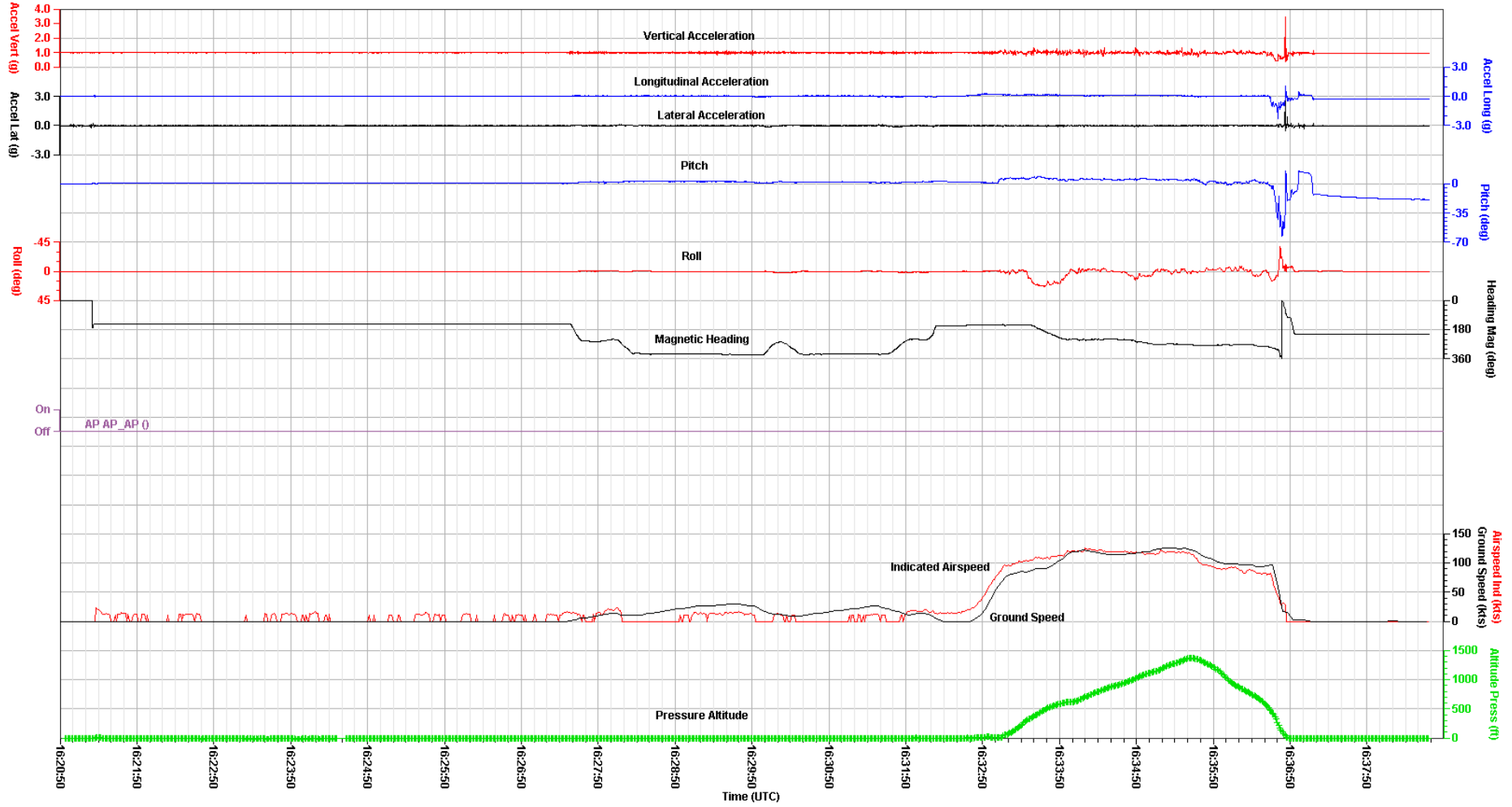


Figure 5. Basic PFD parameters - accident flight.



Revised: 5 November 2015 Main Parameters - Accident Flight Recording National Transportation Safety Board

Figure 6. MFD accident flight recording.

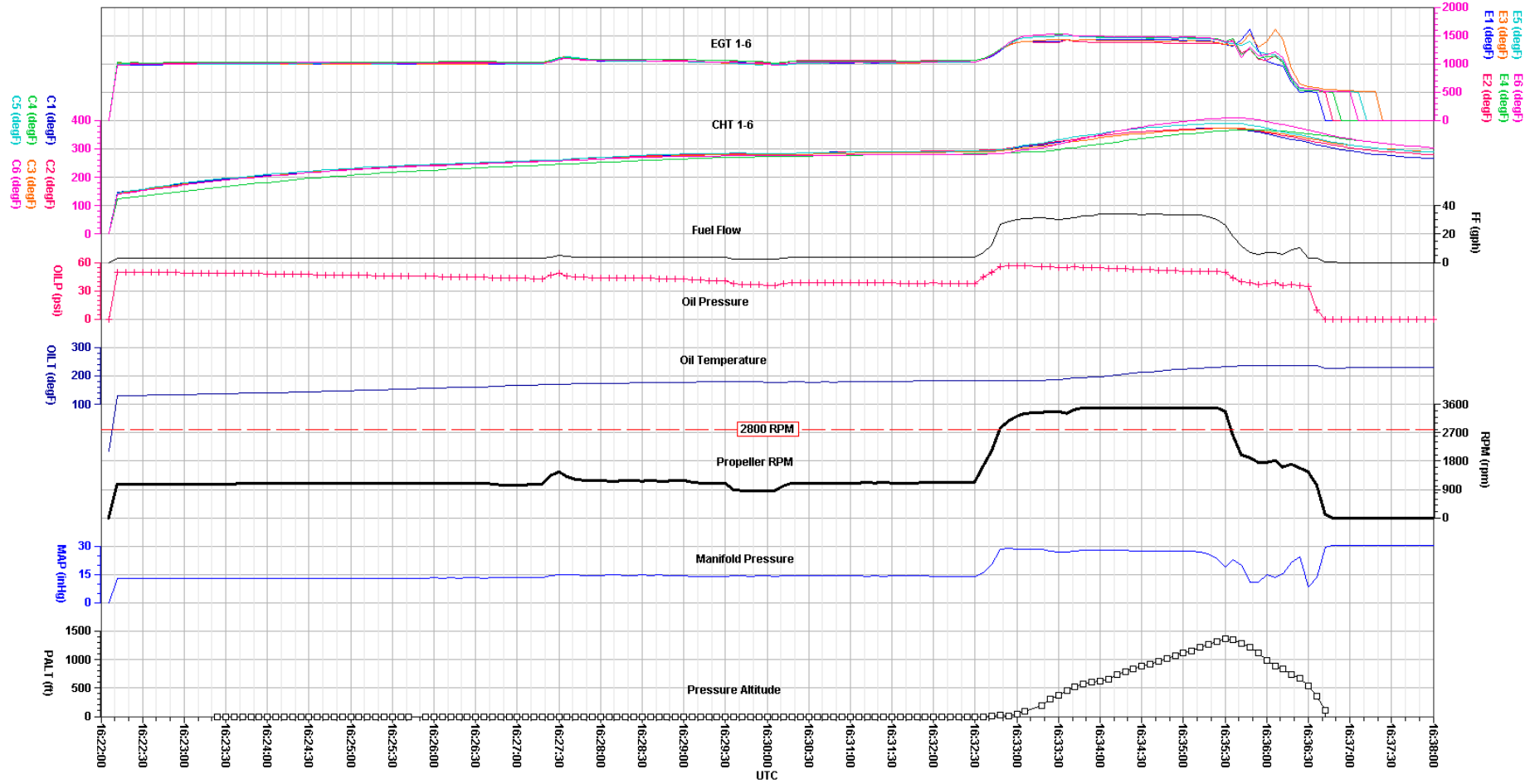
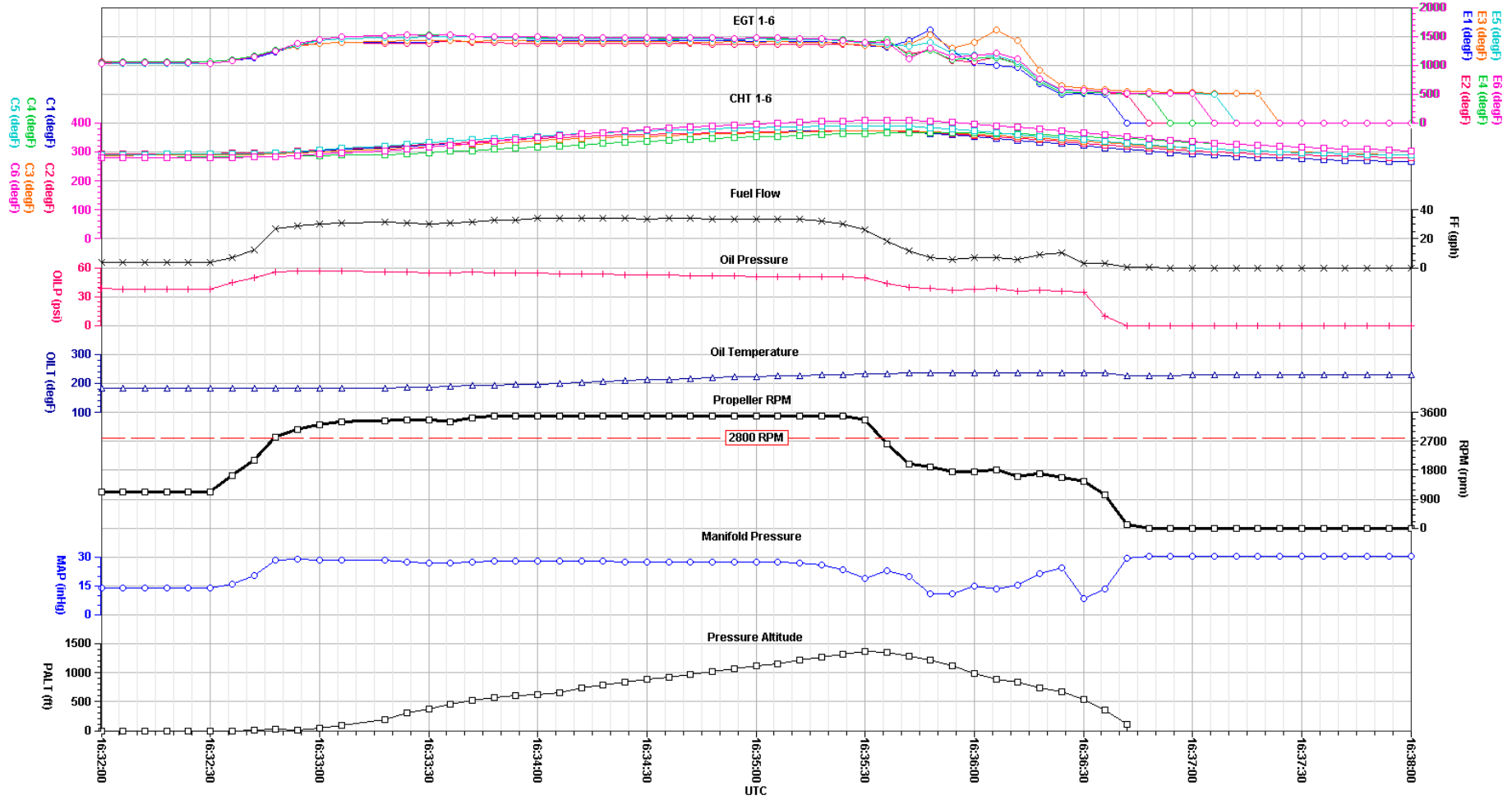


Figure 7. MFD accident flight recording (in-flight portion).



Revised: 22 October 2015 | Accident Flight (in-flight portion) - Engine | National Transportation Safety Board

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
Active Bearing (deg)	Active Bearing
Airspeed Ind (kts)	Indicated Airspeed
Altitude Press (ft)	Pressure Altitude
AP AP_AP (discrete)	Full Autopilot Mode
Ground Speed (kts)	Ground Speed
Heading Mag (deg)	Magnetic Heading
Latitude (deg)	Latitude
Longitude (deg)	Longitude
Pitch (deg)	Pitch
Roll (deg)	Roll
Time UTC Hrs (hrs)	Time UTC Hours
Time UTC Min (min)	Time UTC Minutes
Time UTC Sec (sec)	Time UTC Seconds

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.

Table A-2 - Unit abbreviations.

Units Abbreviation	Description
deg	degrees
discrete	discrete
ft	feet
g	g
hrs	hours
kts	knots
min	minutes
sec	seconds

NOTE: For parameters with a unit description of discrete, a discrete is typically a 1-bit parameter that is either a 0 state or a 1 state where each state is uniquely defined for each parameter.

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. All parameters in table B-1 are provided for the accident flight; for flights prior to the accident flight only RPM, PALT, LogMonth, and UTC time are supplied.

Table B-1 - Verified and provided parameters.

Parameter Name	Parameter Description
C# (degF)	Cylinder Head Temperature Cylinder #[A]
E# (degF)	Exhaust Gas Temperature Cylinder #[A]
FF (gph)	Fuel Flow
LogMonth (mm)	Month Log Began
MAP (inHg)	Manifold Pressure
OILP (psi)	Oil Pressure
OILT (degF)	Oil Temperature
PALT (ft)	Pressure Altitude
RPM (rpm)	Propeller Revolutions Per Minute
UTC Time (hrs:min:sec)	Time of Engine Sample

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

The MFD 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.

Table B-2 - Unit abbreviations.

Units Abbreviation	Description
dd	day
degF	Degrees Fahrenheit
ft	feet
gph	gallons per hour
hrs	hours
inHg	inches of Mercury
min	minutes
mm	month
psi	pounds per square inch
rpm	revolutions per minute
sec	seconds
yyyy	year

NOTE: For parameters with a unit description of discrete, a discrete is typically a 1-bit parameter that is either a 0 state or a 1 state where each state is uniquely defined for each parameter.