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

April 21, 2017

Cockpit Displays – Recorded Flight Data

Specialist's Factual Report
By James Cash

1. EVENT SUMMARY

Location:	Charleston, West Virginia
Date:	December 16, 2015
Aircraft:	Cirrus SR20
Registration:	N614CD
Operator:	Thunderbolt Aviation
NTSB Number:	ERA16LA070

On December 16, 2015, at 0935 Eastern Standard Time, a Cirrus SR20, N614CD, was substantially damaged during impact with terrain, after deployment of the Cirrus Airplane Parachute System (CAPS), following a loss of control near Charles Town, West Virginia. The flight instructor and student pilot were not injured. Visual meteorological conditions prevailed and no flight plan was filed for the instructional flight that departed Leesburg Executive Airport (JYO), Leesburg, Virginia, about 0915, destined for Winchester Regional Airport (OKV), Winchester, Virginia. The airplane was operated by Atlantic Airways under the provisions of Title 14 Code of Federal Regulations Part 91.

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:	**D1217**
Recorder Manufacturer/Model:	**Avidyne MFD memory card**
Recorder Serial Number:	**N/A**
Recorder Manufacturer/Model:	**Avidyne DFC-90 Autopilot**
Recorder Serial Number:	**M140110374**

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 manufacturers' procedure.

3.1.2. PFD Data Description

The PFD recording contained records of 35 power cycles and approximately 17 hours of data. The accident flight was associated with the 30th power cycle[1]. The duration of the 30th power cycle was approximately 34 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 is 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' procedures.

3.2.2. MFD Data Description

The MFD CF card contained 106 data files. One data file was identified as recording during the incident flight. The data file was approximately 32 minutes in duration

3.2.3. MFD Engineering Units Conversions

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

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

[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 = +.

3.3. Avidyne Digital Flight Computer (DFC-90) Autopilot (AP) Description

The Avidyne DFC-90 autopilot is a multi-axis flight control auto-pilot. During normal operation the device is capable of controlling the aircraft's attitude (both pitch and roll) and maintaining a selected altitude. Additionally the auto-pilot is capable of maintaining a controlled rate of climb and descent. The auto-pilot also had a navigation capability and will maintain a pre-programed flight track profile. In addition the autopilot is capable of flying both precision and non-precision approaches.

The Avidyne DFC-90 autopilot also records flight/navigation, in addition to operational/fault data, associated with the operation of the autopilot system. The data is stored on a crash and fire hardened micro CF card that is mounted on the main processor board of the autopilot. Approximately 280 parameters associated with the autopilot's operation are stored on the memory card.

3.3.1. DFC AP Data Recovery

The recorder was in good condition and the data were downloaded and decoded using the manufacturers' documentation.

3.3.2. DFC AP Data Description

The DFC AP recording contained records of 68 power cycles and approximately 38 hours of data. The accident flight was associated with the 66 rd power cycle[3]. The duration of the 66 rd power cycle was approximately 34 minutes. Timing of the DFC-90 data is measured in seconds from power-on.

3.3.3. DFC AP Engineering Units Conversions

Conversion of the DFC-90 AP data from the raw recorded information to engineering units was performed using information provided by Avidyne.

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]

3.4. Time Correlation

Correlation of the three data sets to EST was established using the recorded GPS time parameter from the PFD and DFC-90 data. The GPS time is recorded in Universal Coordinated Time (UTC). The difference between EST and UTC is -5 hours. 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 EST not recorded time.

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

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

3.5. Plots and Corresponding Tabular Data

The following three figures contain EDM data recorded during the December 16, 2015 event.

Figure 1 depicts data recovered from the pilots PFD display for the entire accident flight. Figure 2 depicts the same PFD data but only for the last 4 minutes of the flight. Figure 3 depicts the PFD data centered on the initial upset of the aircraft.

The corresponding tabular data used to create these three figures are provided in electronic (*.csv[5]) format. .

[5] Comma Separated Value format.

Figure 1. Plot of PFD basic parameters during entire flight.

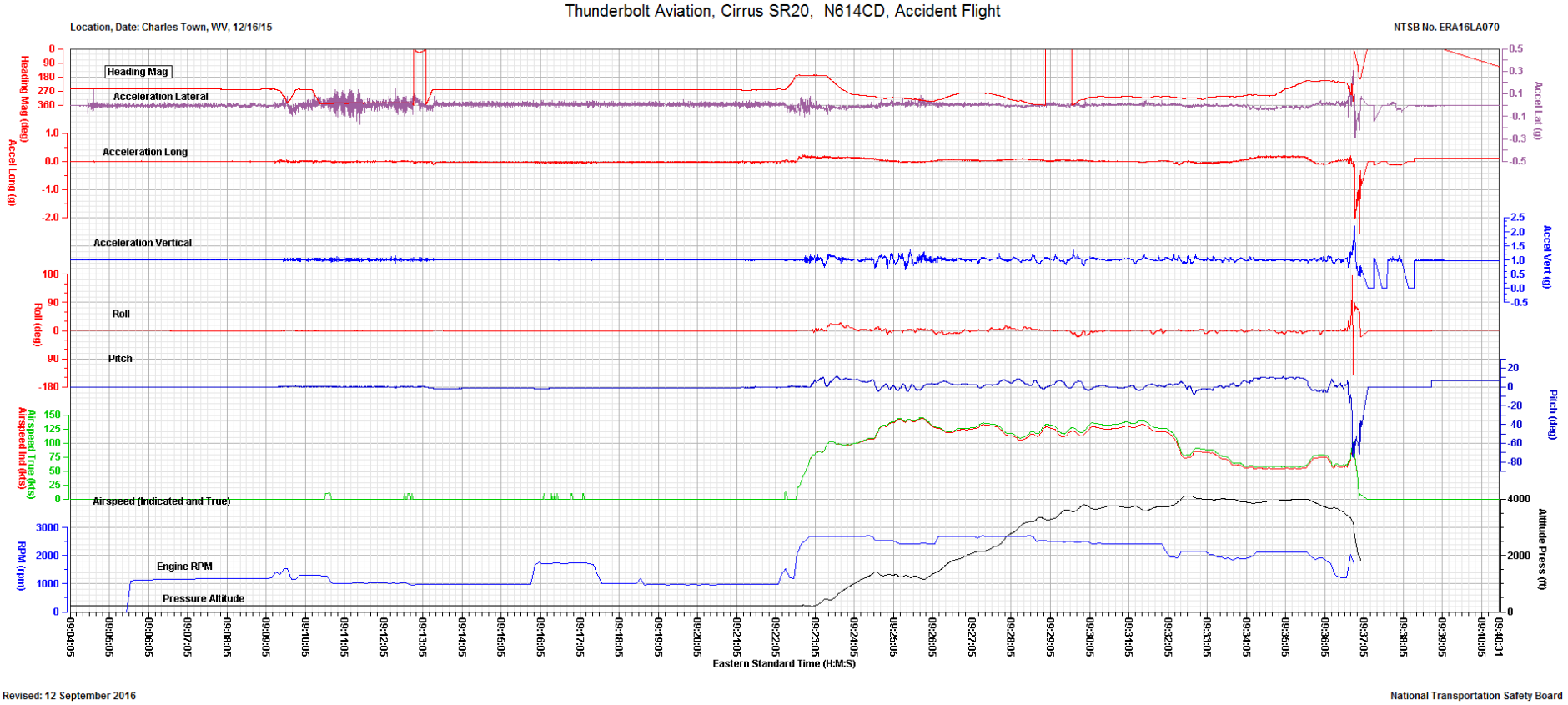


Figure 2. Plot of PFD basic parameters during last 4 minutes of the flight.

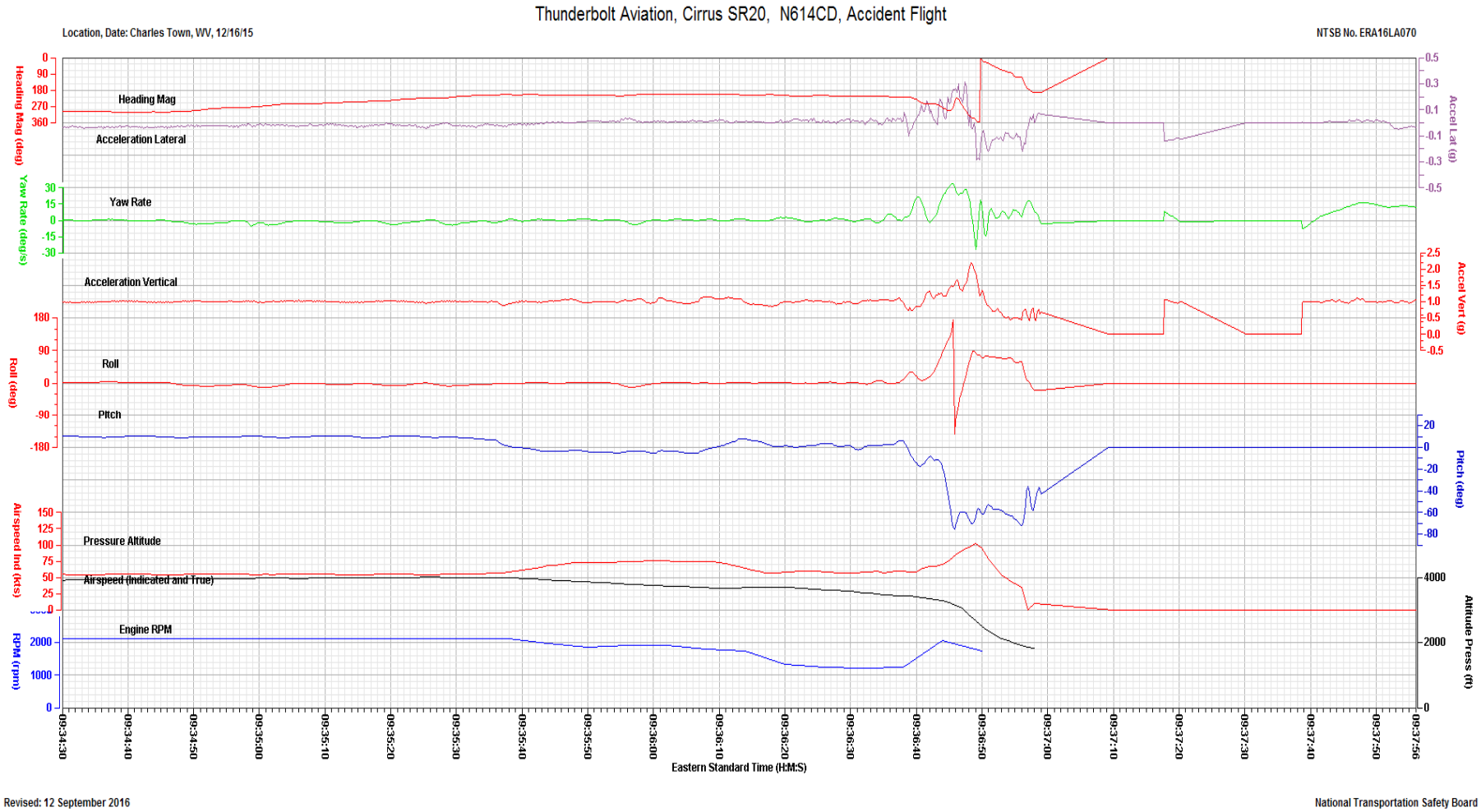
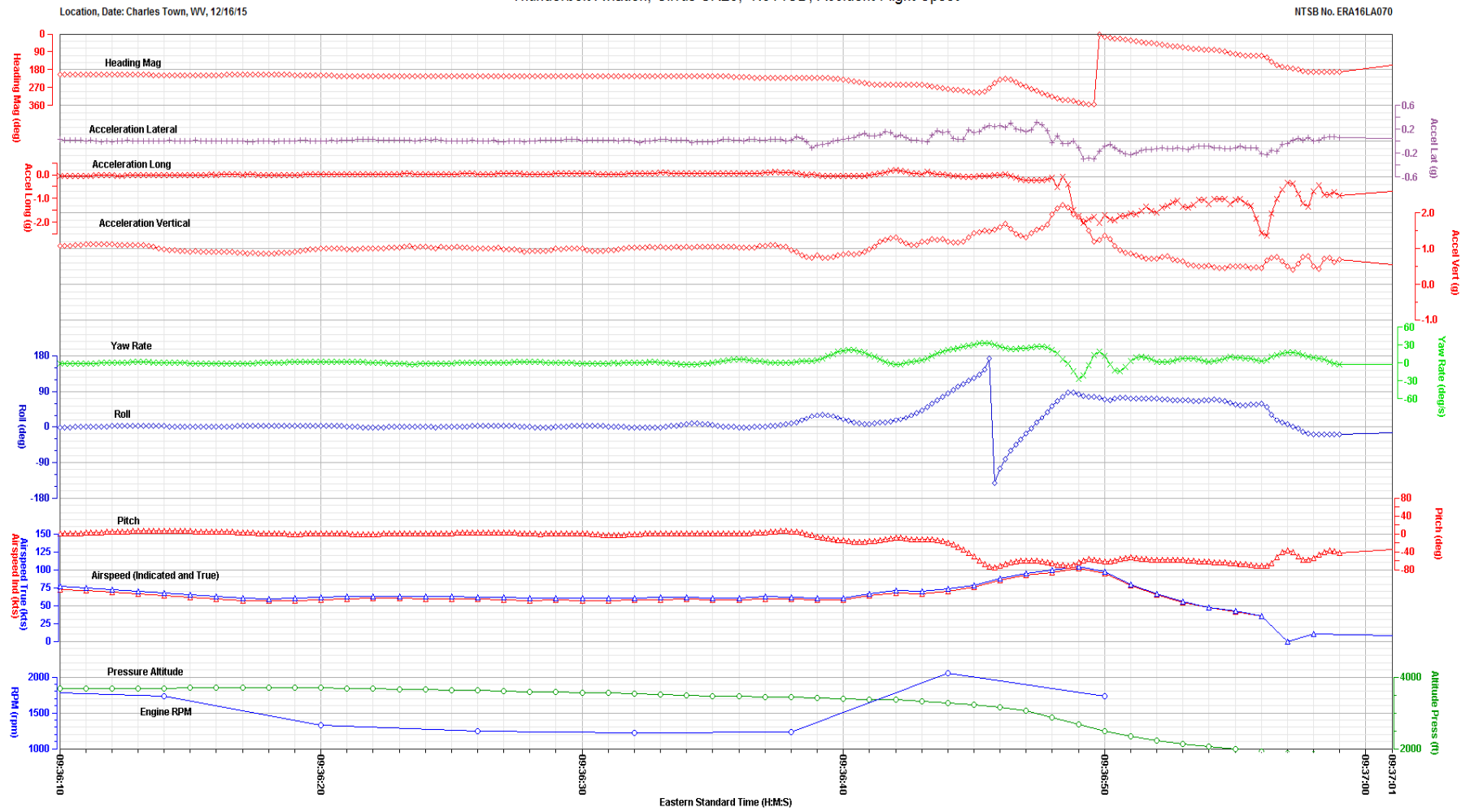


Figure 3. Plot of PFD basic parameters centered on the initial upset

Thunderbolt Aviation, Cirrus SR20, N614CD, Accident Flight Upset



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	Source
Accel Lat (g)	Lateral Acceleration	PFD
Accel Lat-Slip Skid (g)	Lateral Acceleration - Slip Skid Indication	PFD
Accel Long (g)	Longitudinal Acceleration	PFD
Accel Vert (g)	Vertical Acceleration	PFD
Airspeed Ind (kts)	Indicated Airspeed	PFD
Airspeed True (kts)	True Airspeed	PFD
Altitude Press (ft)	Pressure Altitude	
Ground Speed (kts)	Ground Speed	PFD
Heading (deg)	Heading	PFD
Latitude (deg)	Latitude	PFD
Longitude (deg)	Longitude	PFD
Pitch (deg)	Pitch	PFD
Roll (deg)	Roll	PFD
Yaw Rate (deg/sec)	Yaw Rate	PFD

The PFD records pressure altitude, which is based on a standard altimeter setting of 29.92 inches of mercury (in Hg). The barometric correction is also recorded by the PFD. In this report, barometric altitude in feet, Mean Sea Level, is calculated using the pressure altitude and the barometric correction using the following formula:

$$Altitude_{Baro}\ (ft\ MSL) = Altitude_{Pressure}\ (ft) + \big(Baro\ Correction\ (inHg) - 29.92\ (inHg)\big) \times 924.82\ (ft/inHg)$$

Table A-2 - Unit abbreviations.

Units Abbreviation	Description
rpm	revolutions per minute
deg	degrees
deg/sec	degrees per second
ft	feet
kts	knots

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
Eng1 RPM-MFD (rpm)	Engine 1 Revolutions Per Minute (revolutions per minute)
Latitude (deg)	Latitude (degrees)
Longitude (deg)	Longitude (degrees)

Table B-2 - Unit abbreviations.

Units Abbreviation	Description
rpm	revolutions per minute
deg	degrees