

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division
Washington, D.C. 20594

April 11, 2022

Cockpit Displays - Recorded Flight Data

Specialist's Factual Report By Michael Portman

1. EVENT SUMMARY

Location: Conway, Arkansas
Date: June 18, 2021
Aircraft: Cirrus SR20
Registration: N62WR
Operator: Private
NTSB Number: CEN21FA277

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: **20594445**

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

Recorder Manufacturer/Model: **Avidyne DFC-90 Autopilot**
Recorder Serial Number: **M190344723**

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 PFD arrived at the NTSB's recorders lab exhibiting significant impact damage, as seen in figure 1. The identified memory chips are shown in figure 2.



Figure 1. The PFD as received exhibiting impact damage.

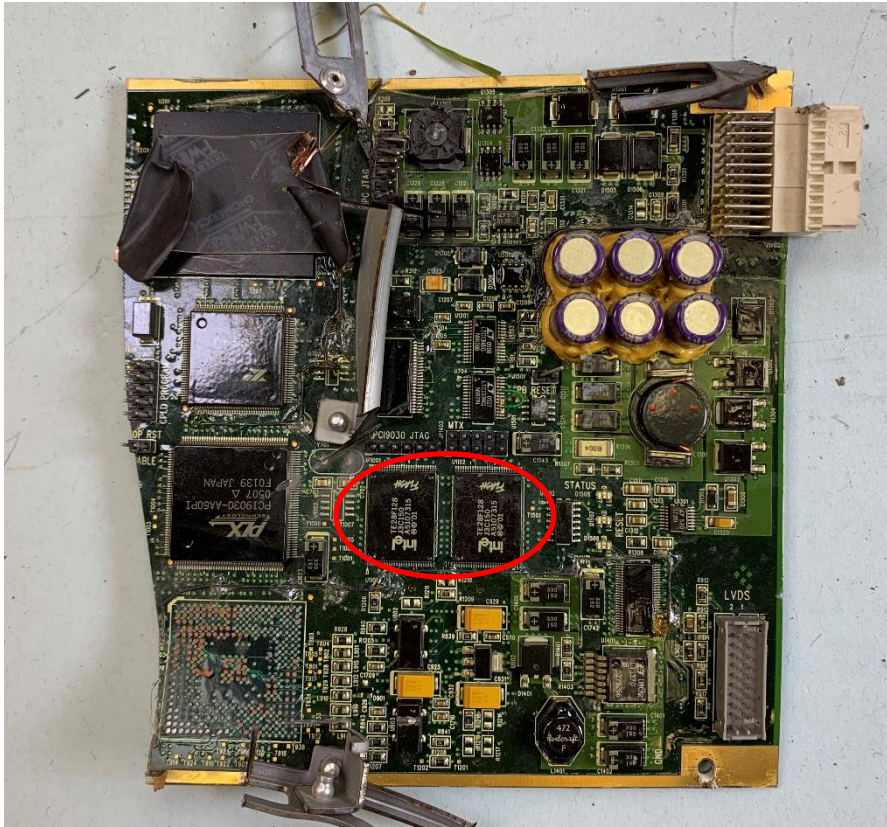


Figure 2. Internal components of the PFD with the two memory chips identified in the red circle.

The two memory chips were removed from the damaged board and read out using laboratory techniques.

3.1.2. PFD Data Description

The PFD recording contained records of approximately 16 hours and 15 minutes of data. The accident flight was the final flight recorded.

3.1.3. PFD Engineering Units Conversions

Conversion of the PFD data from the raw recorded information to engineering units was performed using documentation provided by Avidyne. Acceleration data, as documented by Avidyne, were 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=+).¹ APPENDIX A lists the parameters verified and provided in this report.

¹ 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

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 MFD's CF memory card was in good condition and the data were downloaded using the manufacturer's procedure.

3.2.2. MFD Data Description

The MFD CF card contained 435 data files. One data file was identified as recording during the accident flight. The data file was approximately 14 minutes and 18 seconds in duration.

3.2.3. MFD Engineering Units Conversions

The data files downloaded from the MFD are in engineering units. APPENDIX A lists the parameters verified and provided in this report.

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

The Avidyne DFC-90 is an attitude-based flight control system that contains Envelope Protection and Envelope Alerting. Each DFC-90 contains an SD card in a small orange case that records attitudes, attitude rates, and many flight control system related

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 = +.

parameters. The data on the DFC-90 is stored sequentially in three sampling rate fidelities in the Common Data Format (CDF) convention.

3.3.1. DFC AP Data Recovery

The recorder exhibited signs of minor impact damage. The extent of the damage is shown in figure 3. The extraction of the memory module, which appeared undamaged, is shown in figure 4.



Figure 3. The DFC autopilot module, as recovered.

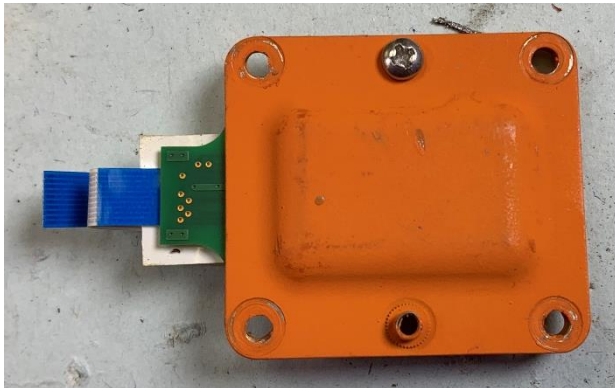


Figure 4. The extracted memory module from within the autopilot unit.

The raw data were extracted using laboratory procedures and sent to Avidyne for decoding and conversion. Upon consultation with the Investigator-In-Charge (IIC), the AP data was determined to be non-pertinent for this investigation and is therefore not included in this report.

3.4. Time Correlation

Correlation of the PFD data to central daylight time (CDT) was established using the recorded GPS time parameter from the PFD data. Recorded GPS time is updated in 6 second intervals on the PFD.² The GPS time is recorded in Universal Coordinated Time (UTC). The difference between CDT and UTC is 5 hours, or 18,000 seconds. MFD data was recorded in Universal Coordinated Time (UTC). The incident flight data has been offset from recorded MFD time to CDT by subtracting 18,000 seconds. Therefore, for the rest of this report, all times are referenced as CDT, not recorded 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.

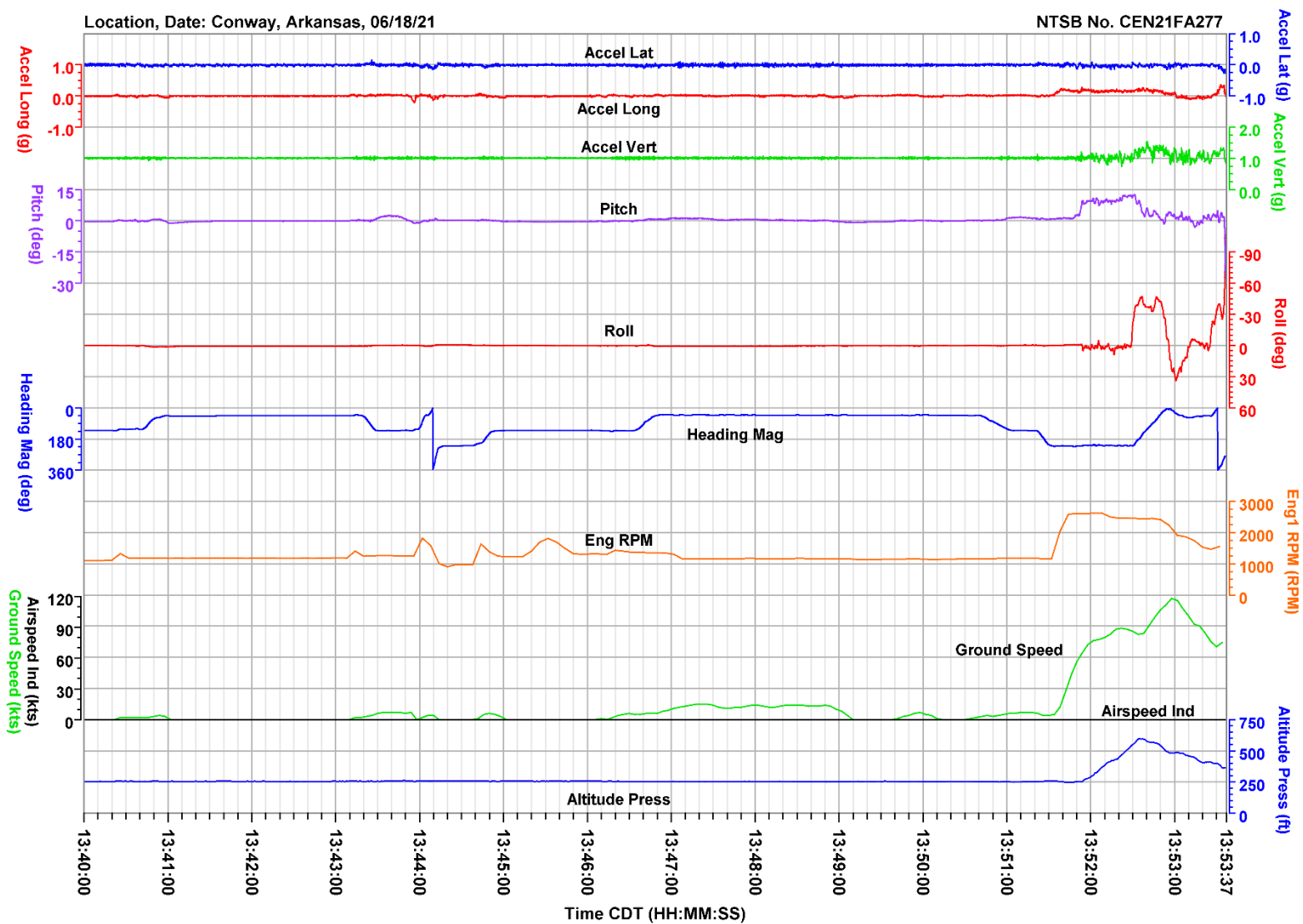
3.5. Plots and Corresponding Tabular Data

The following four figures contain PFD and MFD data recorded during the June 18, 2021, event. Figures 5 and 6 show parameters recovered from the PFD for the entire event recording and the takeoff roll, respectively. Of note, during the takeoff roll, the ground speed was noted as increasing in an expected manner, but the indicated airspeed parameter remained at 0 throughout the event recording. Review of previous flights indicated the airspeed indication functioning normally. Figures 7 and 8 show parameters recovered from the MFD for the entire event recording and the takeoff roll, respectively.

The corresponding tabular data used to create figures 5 and 6 are provided in electronic (*.csv) format as Attachment 1 to this report.³ The corresponding tabular data used to create figures 7 and 8 are provided in electronic (*.csv) format as Attachment 2 to this report.³

² 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.

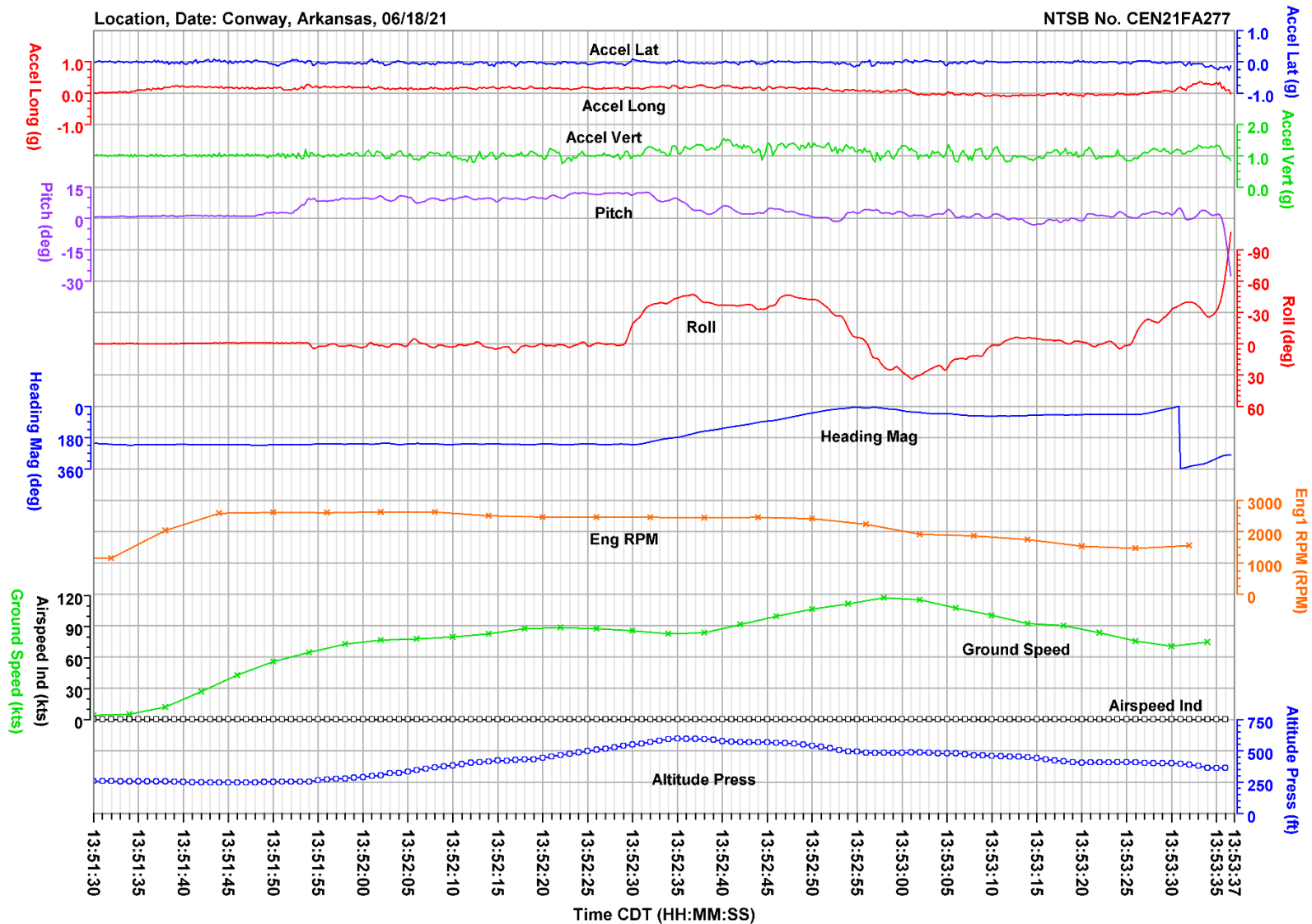
³ Comma Separated Value format.



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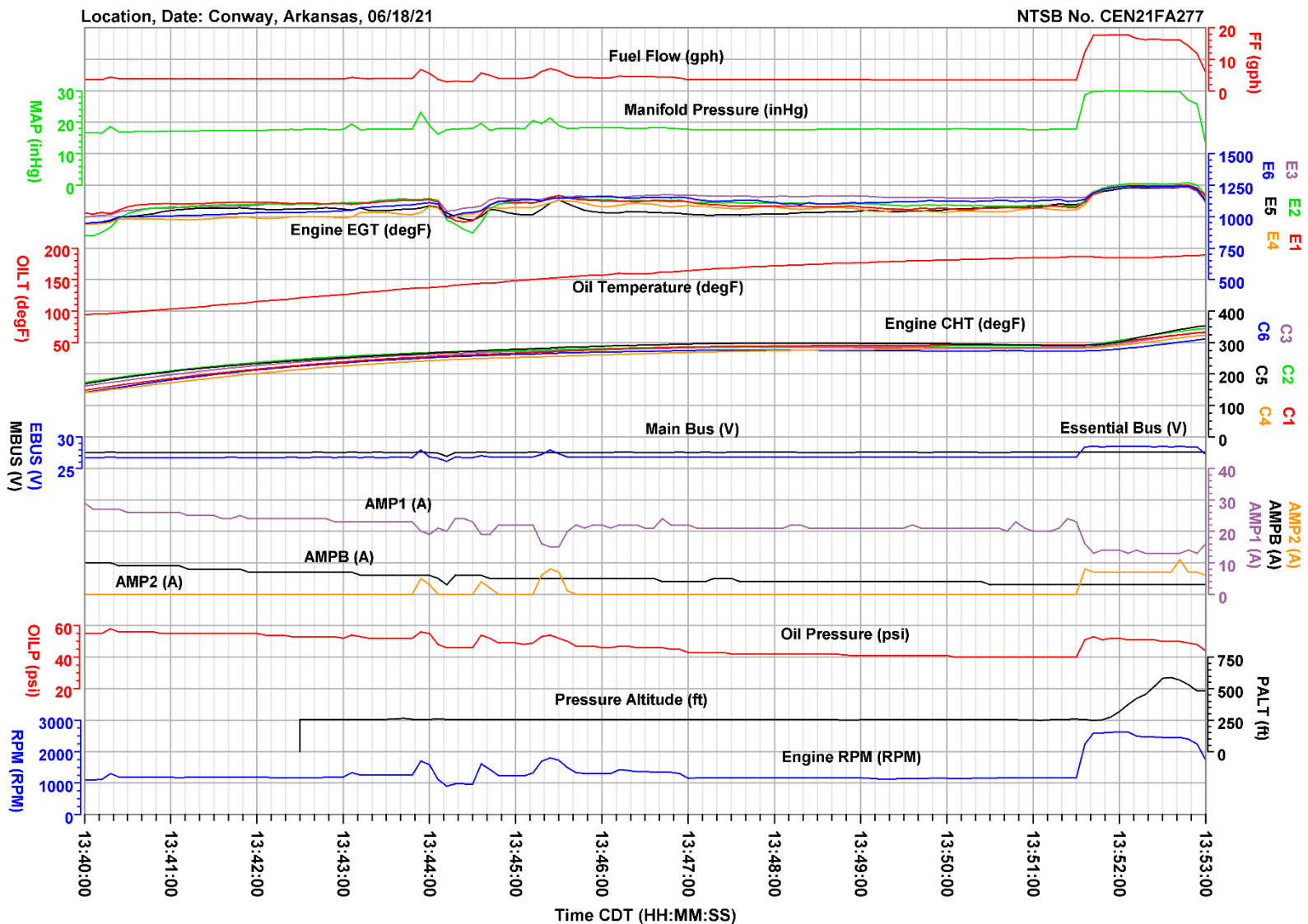
Figure 5. Plot of basic parameters for the entire event recording.



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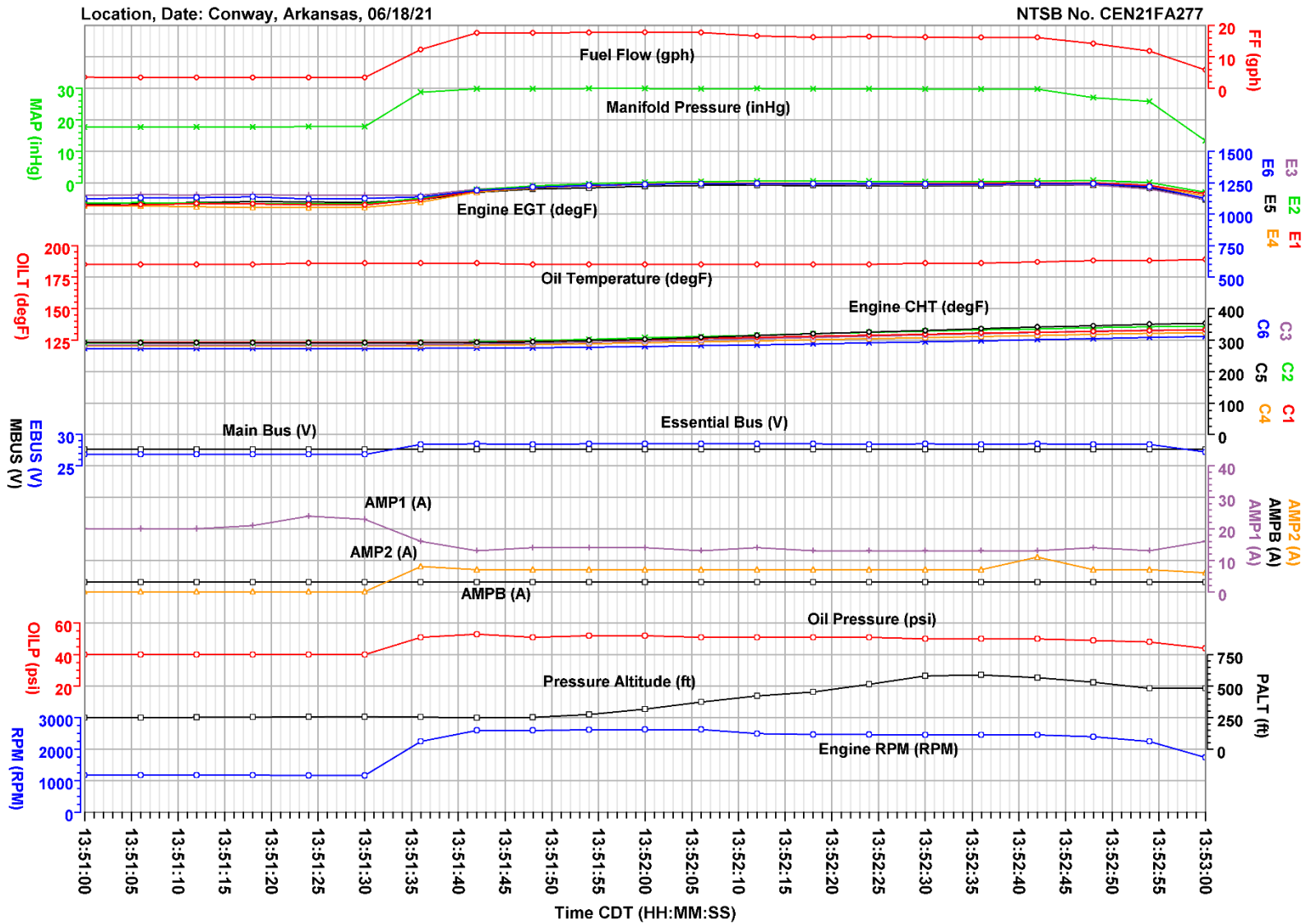
Figure 6. Plot of basic parameters during the takeoff roll.



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Figure 7. Plot of MFD parameters for the entire event recording.



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Figure 8. Plot of MFD parameters during the takeoff roll.

APPENDIX A - Parameters

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	Parameter Description	Source
Accel Lat (g)	Lateral Acceleration	PFD
Accel Long (g)	Longitudinal Acceleration	PFD
Accel Vert (g)	Vertical Acceleration	PFD
Airspeed Ind (kts)	Indicated Airspeed	PFD
AMP1 (A)	Bus 1 Amps	MFD
AMP2 (A)	Bus 2 Amps	MFD
AMPB (A)	Battery Bus Amps	MFD
Altitude Press (ft)	Pressure Altitude	PFD/MFD
CHT Cyl# (degF)	Cylinder Head Temperature Cylinder # ⁴	MFD
EBUS (V)	Essential Bus Voltage	MFD
EGT Cyl# (degF)	Exhaust Gas Temperature Cylinder # ⁴	MFD
Eng RPM (rpm)	Engine RPM	PFD/MFD
FF (gph)	Fuel Flow	MFD
Ground Speed (kts)	Ground Speed	PFD
Heading Mag (deg)	Magnetic Heading	PFD
Latitude (deg)	Latitude	PFD
Longitude (deg)	Longitude	PFD
MAP (inHg)	Manifold Pressure	MFD
MBUS (V)	Main Bus Voltage	MFD
OILP (psi)	Oil Pressure	MFD
OILT (degF)	Oil Temperature	MFD
Pitch (deg)	Pitch	PFD
Roll (deg)	Roll	PFD
Time UTC Hrs (hr)	Time UTC Hrs	PFD
Time UTC Min (min)	Time UTC Min	PFD
Time UTC Sec (sec)	Time UTC Sec	PFD

⁴ 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 displays record 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
rpm	revolutions per minute
A	Amperes
deg	degrees
degF	degrees Fahrenheit
ft	feet
gph	gallons per hour
hrs	hours
inHg	inches of Mercury
kts	knots
psi	pounds per square inch
sec	seconds
V	Volts DC