

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



ERA22LA089

COCKPIT DISPLAYS - RECORDED FLIGHT DATA

Specialist's Factual Report

March 21, 2023

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A. ACCIDENT

Location: Knoxville, Tennessee
Date: December 16, 2021
Time: 1454 Coordinated Universal Time (UTC)
Airplane: Cirrus SR22, private operator, N162AM

B. COCKPIT DISPLAYS - RECORDED FLIGHT DATA SPECIALIST

Specialist: Gerald Kawamoto
Recorder Specialist
National Transportation Safety Board (NTSB)

C. DETAILS OF THE INVESTIGATION

A recorded flight data group was not convened.

The NTSB Vehicle Recorder Division received the following:

Recorder Manufacturer/Model: Avidyne PFD
Part Number: Unknown
Recorder Serial Number: Unknown

Recorder Manufacturer/Model: Avidyne MFD CF Card
Part Number: N/A
Recorder Serial Number: N/A

Recorder Manufacturer/Model: Avidyne Digital Flight Control
Part Number: 700-00170-000
Recorder Serial Number: M104523889

1.0 Avidyne Primary Flight Display Description

The Avidyne primary flight display (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.

1.1 Avidyne PFD Data Recovery

The Avidyne PFD exhibited signs of fire and impact damage, as shown in Figure 1, rendering it inoperable. The internal non-volatile memory chips were removed, read-out, and converted to engineering units using laboratory tools.



Figure 1. Avidyne PFD as received.

1.2 Avidyne PFD Recording Description

The PFD recording contained records of 18 power cycles and the accident flight was associated with the last power cycle.¹ The duration of the final power cycle was approximately 33 minutes. Timing of the PFD data is measured in seconds from power-on.

1.2.1 Avidyne PFD Engineering Unit 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.

1.3 Avidyne PFD Time Correlation

Correlation of the PFD data to 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 universal coordinated time (UTC). 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 desired time zone. Therefore, for the rest of this report, all times are referenced as UTC, 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

2.0 Avidyne Multi-Function Display Description

The Avidyne multi-function flight display (MFD) unit is able to display the pilot checklist, terrain/map information, approach chart information and other

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

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 = +, Right Rudder = +.

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.

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.

2.1 Avidyne MFD Data Recovery

The Avidyne MFD card exhibited signs of fire damage to its exterior as shown in figure 2. The internal components of the CF card were examined and data were extracted normally using a functioning laboratory surrogate.



Figure 2. Front and Back of MFD CF card as received.

2.2 Avidyne MFD Recording Description

The MFD CF card contained 106 data files. One data file was identified as recorded during the accident flight. The data file was approximately 34 minutes in duration.

2.2.1 Avidyne MFD Engineering Unit Conversions

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

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

2.3 Avidyne MFD Time Correlation

Correlation of the MFD data to UTC was established using the recorded GPS time parameter from the PFD data. Recorded GPS time is updated in 6 second intervals on the MFD.⁴ The GPS time is recorded in UTC.

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.

3.0 Avidyne Digital Flight Control Description

The Avidyne DFC-90 is a multi-axis flight control autopilot. During normal operation the device is capable of controlling the aircraft's attitude (both pitch and roll) and maintaining a selected altitude. Additionally, the autopilot is capable of maintaining a controlled rate of climb and descent, has a navigation capability and will maintain a pre-programed flight track profile, and is capable of flying both precision and non-precision approaches. The Avidyne DFC-90 also records flight/navigation data, in addition to operational/fault data, associated with the operation of the autopilot system. The data is stored on a microSD card that is mounted on the main processor board of the autopilot.

3.1 Avidyne Digital Flight Control Data Recovery

The Avidyne DFC-90 exhibited signs of fire damage to its exterior as shown in figure 3. The internally mounted microSD card was in good condition and data were extracted from the card using the manufacturers procedures. The manufacturer converted the data to engineering units and provided data plots to the investigation team.

⁴ 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.

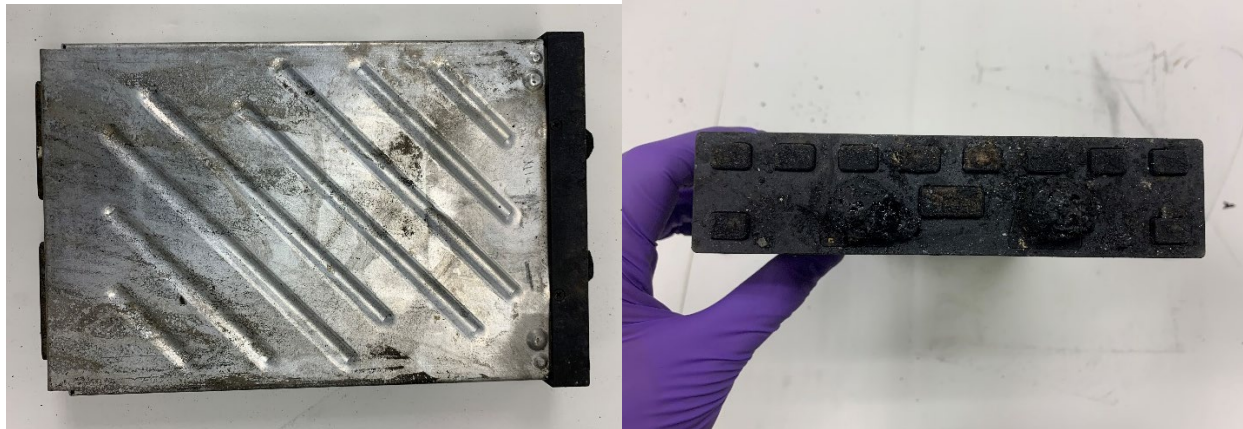


Figure 3. DFC 90 as received.

3.2 Avidyne Digital Flight Control Data Description

The manufacturer indicated the autopilot was off. Plots of provided parameters were redundant with the plotted PFD parameters, therefore, all DFC specific plots are not included in this report.

D. FIGURES AND TABULAR DATA

Figures 4 through 7 are graphical overlays generated using Google Earth showing the accident flight. PFD data were used to generate the overlays in Google Earth. Weather and lighting conditions in Google Earth are not necessarily the weather and lighting conditions present at the time of the recording.

Figure 4 is an overview of the entire flight.

Figure 5 shows approximately the final four minutes of the flight. The final data point is at 14:55:12 UTC.

Figure 6 shows the end of the flight with the terrain feature enabled in Google Earth. Some data points do not appear on the graphical overlay because the Google Earth terrain model elevation may be greater in value than the recorded pressure altitude value.

Figure 7 shows the end of the flight with the terrain feature disabled in Google Earth.

Figure 8 is a plot of PFD parameters for the entire accident flight. The time interval shown is 14:21:00 to 14:55:15 UTC.

Figure 9 is a plot of PFD parameters for approximately the final 4 minutes of recorded data. The time interval shown is 14:51:00 to 14:55:15 UTC.

Figure 10 is a plot of PFD parameters from 14:54:15 to 14:54:45 UTC.

Figure 11 is a plot of MFD parameters for the entire accident flight. The time interval shown is 14:21:00 to 14:55:00 UTC.

Figure 12 is a plot of MFD parameters for approximately the final 4 minutes of recorded data. The time interval shown is 14:51:00 to 14:54:30 UTC.

The corresponding tabular data used to create figures 4 to 12 are provided in electronic comma separated value (CSV) format as attachment 1 for PFD parameters and as attachment 2 for MFD parameters to this report.

Submitted by:

Gerald Kawamoto
Recorder Specialist



Figure 4. Google Earth overlay of the accident flight.



Figure 5. Google Earth overlay of approximately the final 4 minutes of the accident flight.



Figure 6. Google Earth overlay of the end of the accident flight with the terrain feature enabled in Google Earth.

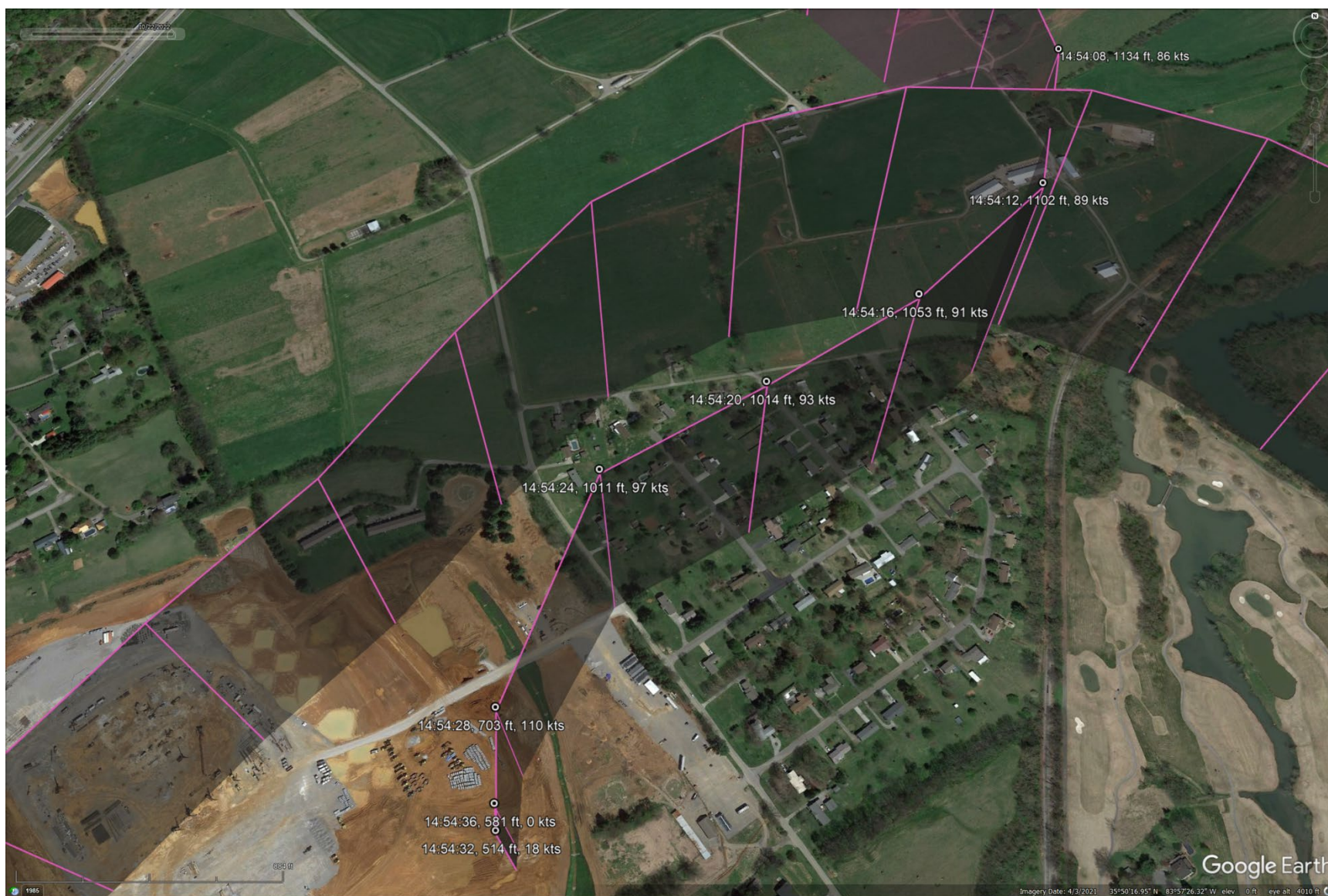


Figure 7. Google Earth overlay of the end of the accident flight with the terrain feature disabled in Google Earth.

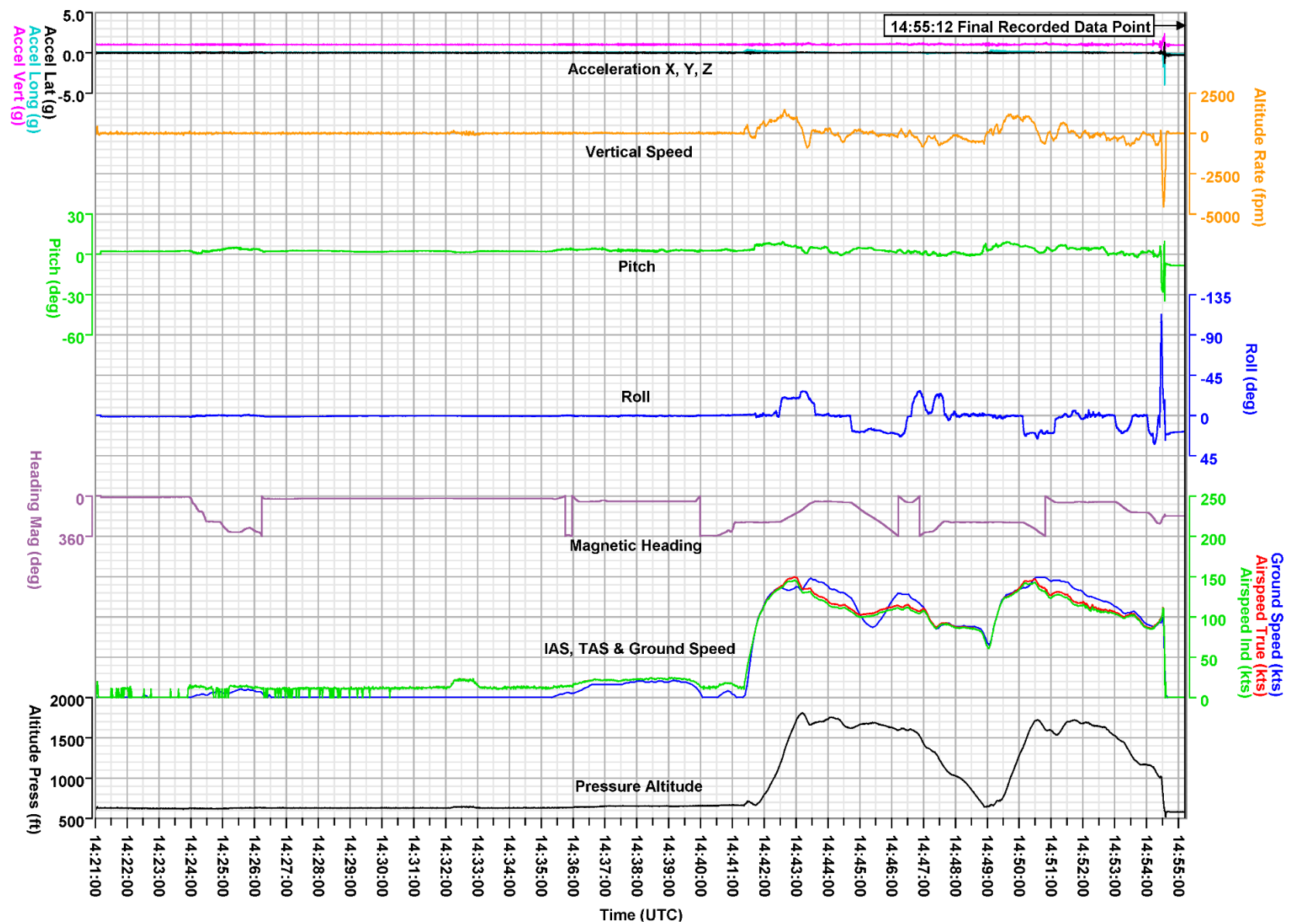


Figure 8. Plot of PFD parameters of the entire accident flight.

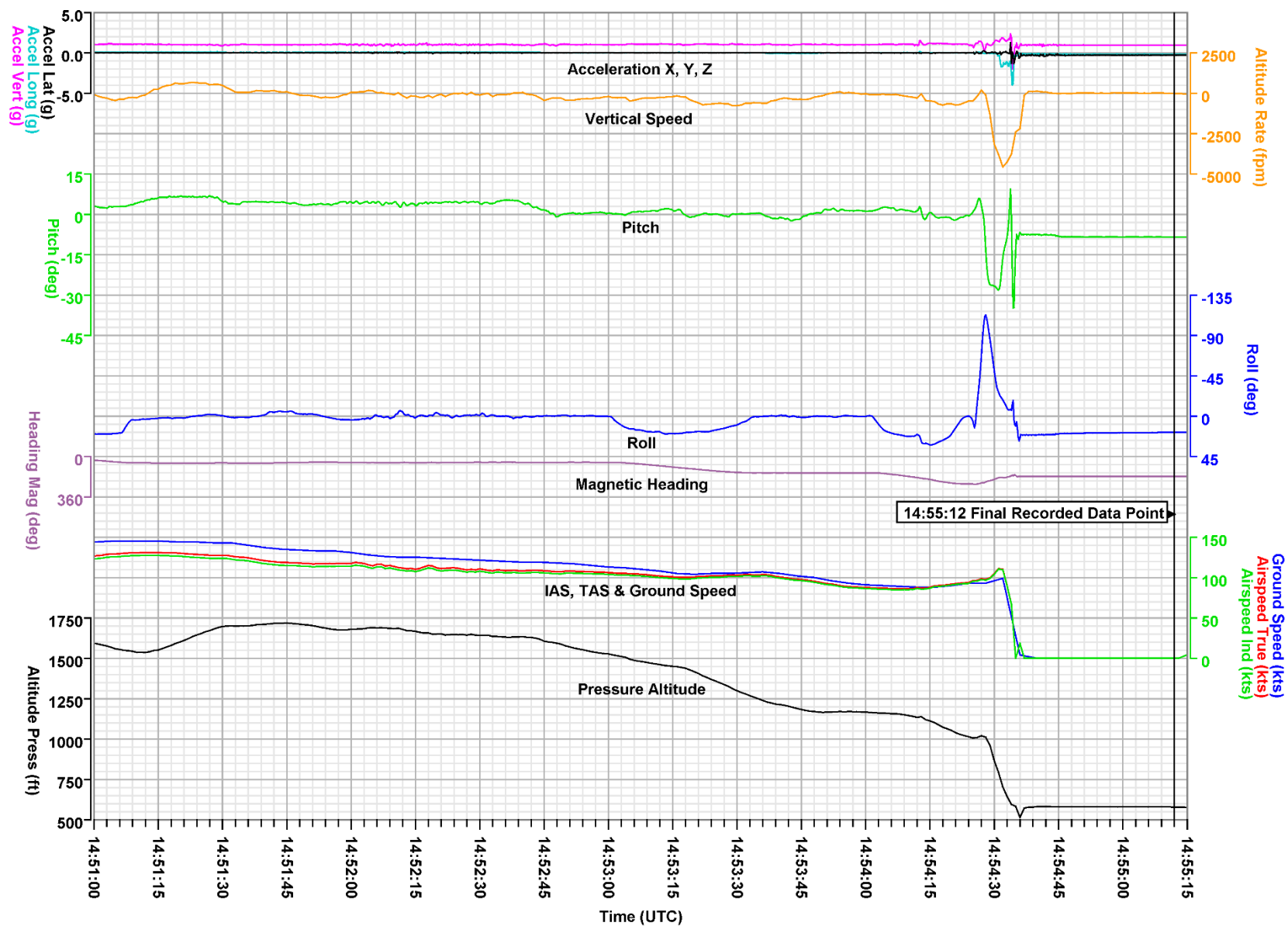


Figure 9. Plot of PFD parameters of approximately the final 4 minutes of the accident flight.

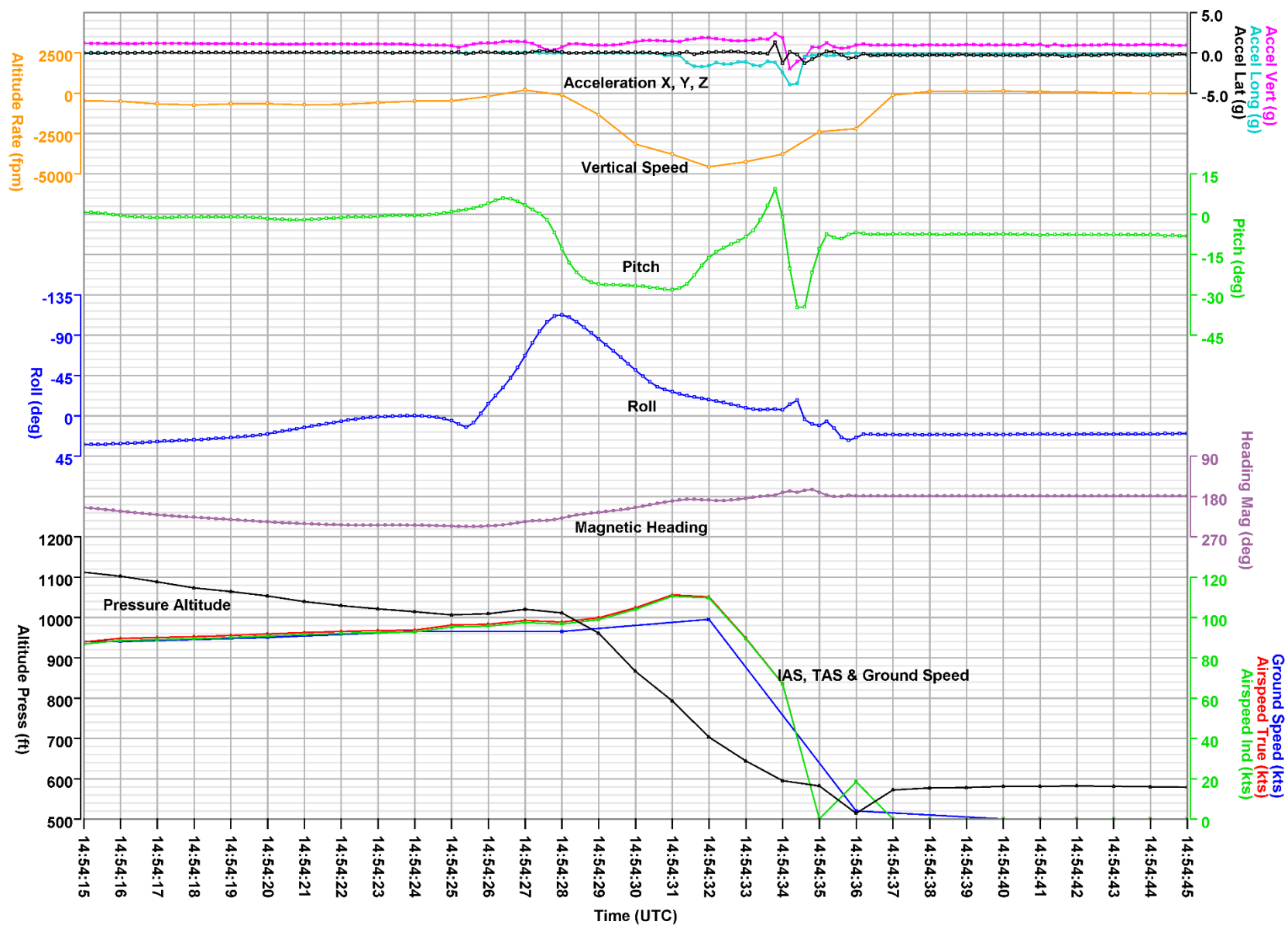


Figure 10. Plot of PFD parameters of the end of the accident flight.

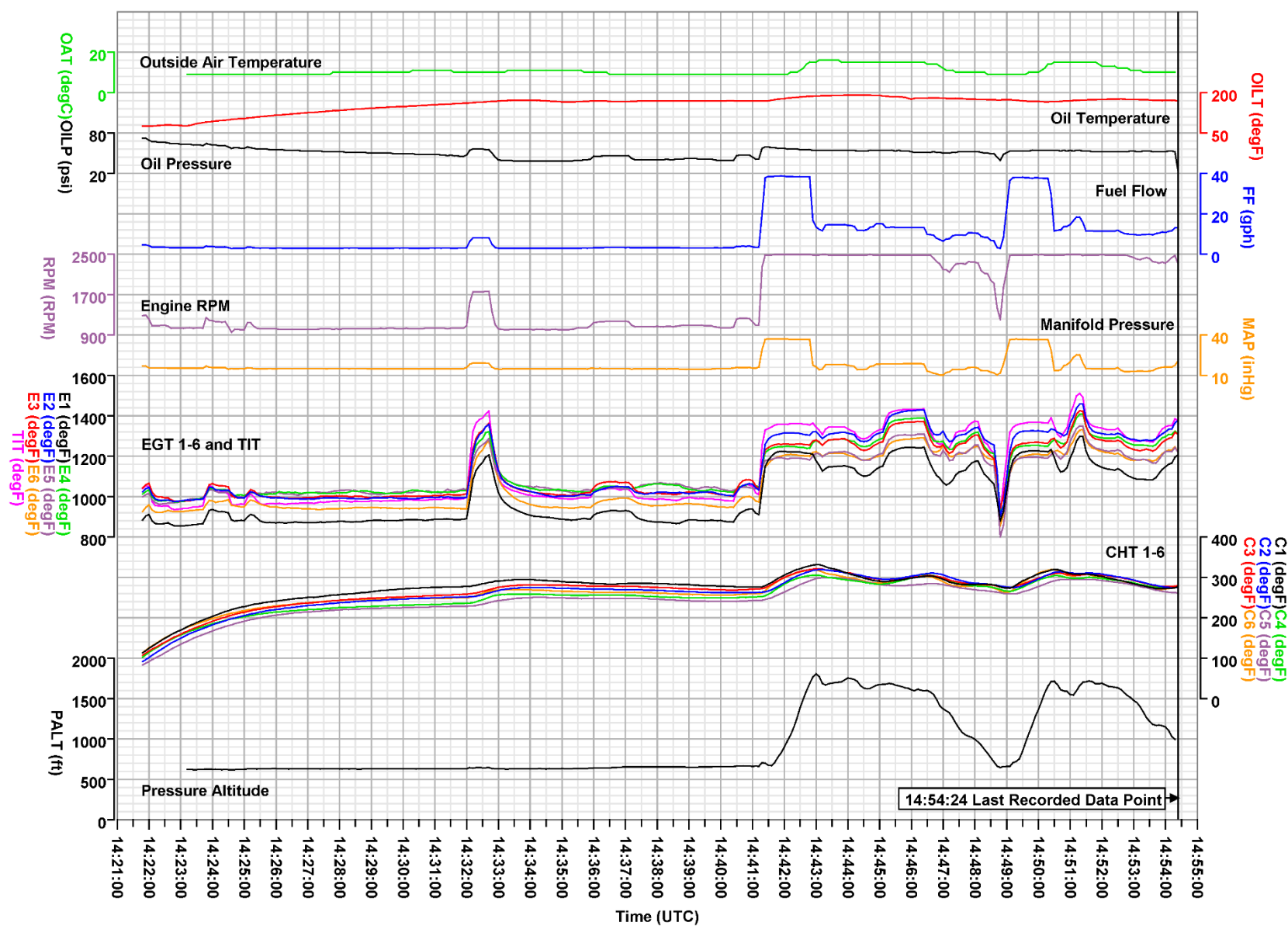


Figure 11. Plot of MFD parameters of the entire accident flight

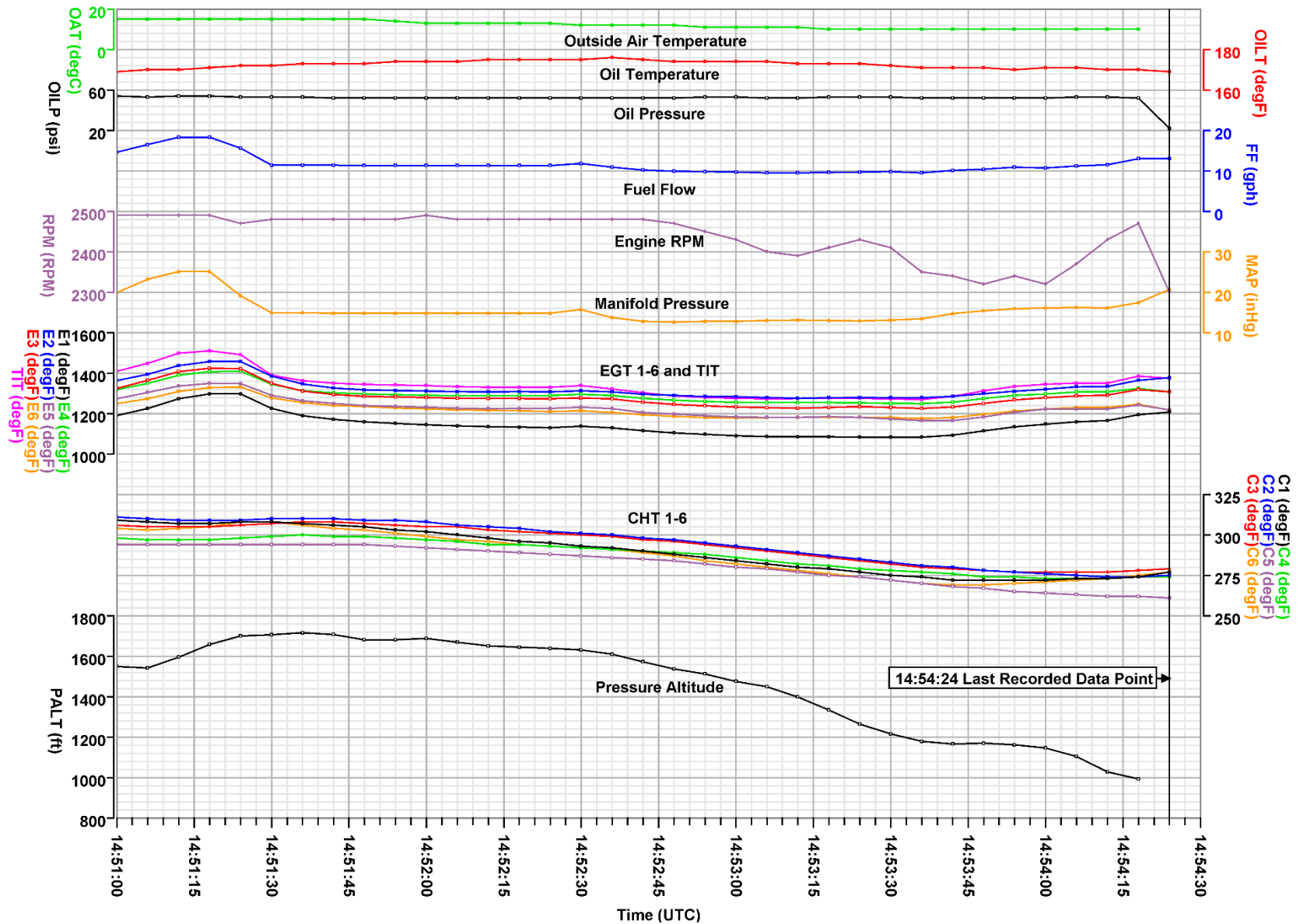


Figure 12. Plot of MFD parameters of approximately the final 4 minutes of the accident flight.

APPENDIX A. VERIFIED AND PROVIDED PARAMETERS AVIDYNE PFD & MFD

This appendix describes the parameters provided and verified in this report.

Table 1. Verified and provided parameters

Parameter Name (units)	Parameter Description (units)	Source
Accel Lat (g)	Lateral Acceleration	PFD
Accel Long (g)	Longitudinal Acceleration	PFD
Accel Vert (g)	Vertical Acceleration	PFD
Airspeed Ind (kts)	Indicated Airspeed (knots)	PFD
Airspeed True (kts)	True Airspeed (knots)	PFD
Altitude Press (ft)	Pressure Altitude (feet)	PFD
Altitude Rate (fpm)	Vertical Speed (feet per minute)	PFD
Ground Speed (kts)	Ground Speed (knots)	PFD
Heading Mag (deg)	Magnetic Heading (degrees)	PFD
Latitude (deg)	Latitude (degrees)	PFD
Longitude (deg)	Longitude (degrees)	PFD
Pitch (deg)	Pitch (degrees)	PFD
Roll (deg)	Roll (degrees)	PFD
Time - Day (day)	Time - Day	PFD
Time - Month (month)	Time - Month	PFD
Time - Year (year)	Time - Year	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
C# (degF)	Cylinder Head Temperature Cylinder # ⁵ (degrees Fahrenheit)	MFD
E# (degF)	Exhaust Gas Temperature Cylinder # (degrees Fahrenheit)	MFD
FF (gph)	Fuel Flow (gallons per hour)	MFD
Eng1 Fuel Used (gal)	Engine 1 Fuel Used	MFD
MAP (inHg)	Manifold Pressure (inches of Mercury)	MFD
OILP (psi)	Oil Pressure (pounds per square inch)	MFD
OILT (degF)	Oil Temperature (degrees Fahrenheit)	MFD
RPM (rpm)	Revolutions Per Minute	MFD
OAT (degC)	Outside Air Temperature (degrees Celsius)	MFD

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.