

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

March 18, 2021

Multiple Electronic Devices

Specialist's Factual Report By Sean Payne

1. EVENT SUMMARY

Location: Hollywood, FL
Date: November 23, 2020
Aircraft: Lancair Legacy FG
Registration: N3UH
Operator: Private
NTSB Number: ERA21LA052

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: **Garmin GTN-750**
Recorder Serial Number: **1za013415**

Recorder Manufacturer/Model: **Dynon EFIS D-100**
Recorder Serial Number: **3662**

Recorder Manufacturer/Model: **Dynon FlightDEK-D180**
Recorder Serial Number: **002439**

3.1. Garmin GTN-750 Description

The Garmin GTN 750 is a panel-mounted GPS receiver featuring a 6.9-inch color liquid crystal (LCD) display. It has a GPS/SBAS engine and is TSO-C146c certified for primary domestic, oceanic, and remote navigation including en route, terminal, and non-precision approaches, and approaches with vertical guidance, such as LPV and LNA/VNAV. The unit can simultaneously display approach information and weather and traffic data in relation to their position on a large, color moving map display. Its color moving map features a built-in database that shows cities, highways, railroads, rivers, lakes, and coastlines. The unit has a slot on the front for a Jeppesen database containing all airports, VORs, NDBs, intersections, FSSs, approaches, DPs/STARs and SUA information. A flight plan composed of multiple waypoints, including user-defined waypoints, can be programmed in the unit. The GTN 750 also includes a TSO approved airborne VHF communications transceiver and TSO

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approved airborne VOR/Localizer and Glideslope receivers. The unit contains an internal SD card storing flight log data, which can be accessed through the slot in the right side of the unit. If the unit is equipped with a firmware v6.50 or later, the internal SD card will store a limited set of flight data information.

3.1.1. Garmin GTN-750 Data Recovery

The device was damaged in the accident and is shown in figure 1. The internal data card was removed (SD style card). The internal data card was in pristine condition and was read out via PC. A review of the internal data card did not reveal any flight data. According to laboratory notes on the device, this device will only record when a certain version of firmware is installed. It is unclear which version of firmware was installed on this device, however, the internal data card did not contain any flight data. No useful data was recovered from the device. As of the publishing of this report, a representative from Garmin had not responded to an additional request for information about this particular device's flight data logging capabilities.

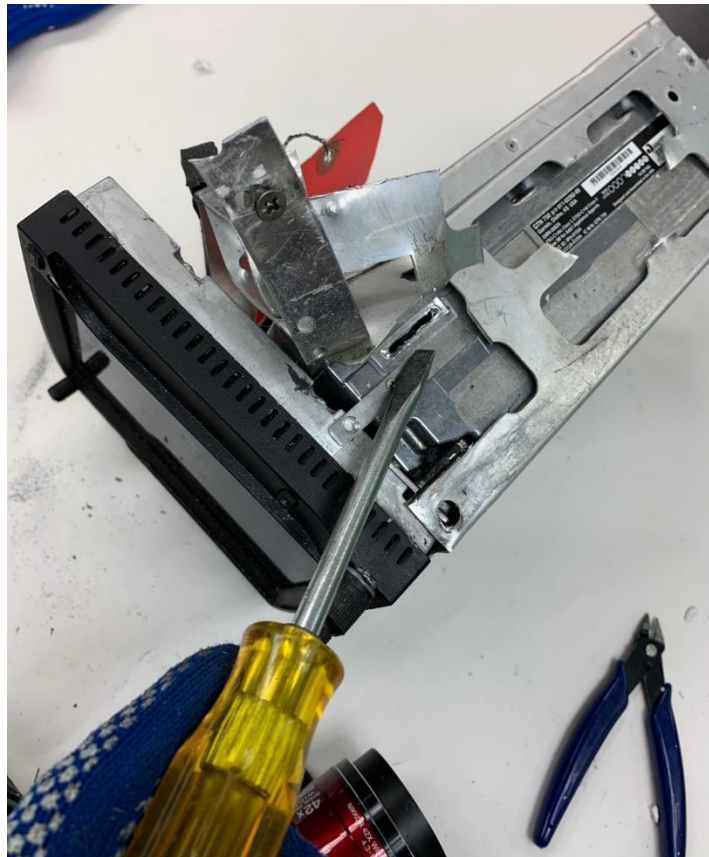


Figure 1. Damaged exterior of Garmin GTN-750. The screwdriver is pointing to the mount location of the internal data card. The seal was broken by the specialist, the card was removed and was in pristine condition.

3.2. Dynon EFIS D-100 Description

The Dynon Electronic Flight Information System (EFIS) D100 is a 7-inch wide screen display mounted in the cockpit of non-type certificated aircraft. The instrument integrates multiple flight instruments including airspeed, altitude, gyro-stabilized magnetic compass, turn rate, slip/skid

ball, bank angle, pitch angle and vertical speed. The unit also has other functions that include a clock/timer, g-meter, voltmeter, and a density altitude/true airspeed calculator. The unit contains an Air Data, Attitude and Heading Reference System (ADAHRS) to provide air data, attitude, and heading information to the display. Depending on the installation in the operator's aircraft certain parameters might not be displayed, for example angle-of-attack.

Depending on the firmware version on the unit, the ability to log data to internal memory exists. According to the manufacturer, firmware versions 5.0 and later contain the ability to log certain EFIS and GPS parameters. The data logging must be configured by the operator to enable logging and set the data log interval. The unit can also be configured to start logging data automatically at boot-up. The data logging interval can be set to store at 1, 3, 5, 10, 30 or 60 second intervals. The internal memory can store at least 2 hours of cumulative data at a 1 second recording interval or at least 120 hours at a 60 second data recording interval. When the recording limit in the internal memory is reached, the oldest record is dropped and a new record is added.

3.2.1. Dynon EFIS D-100 Data Recovery

Depending on the unit's software load, the unit may or may not record data. Depending on the electrical configuration of the aircraft, the device may be networked with the other EFIS display (FlightDEK D-180) installed in the aircraft. Based on previous accident investigations of this device, the FlightDek D-180 would contain nearly the same, or more data than the EFIS D-100.

The device was damaged and non-functional. The damage to the device is shown below in figure 2. The device's screen was replaced with a working surrogate. The device was powered. The device showed that it was equipped with firmware version 5.6.1. According to the manufacturer, units containing firmware 5.0 higher are capable of recording data. The device's navigation menu was explored until the datalog configuration page was discovered. The settings page revealed that data recording was set to "off." Furthermore, the device contained a setting that inhibited recording at start up ("Record at Boot: No"). This setting allows a user to inhibit data recording at the start of each power cycle. Figure 3 is a photo of the unit powered with the datalog configuration page displayed.



Figure 2. Damaged exterior of Dynon EFIS D-100.



Figure 3. The Datalog Configuration page of the Dynon EFIS D-100.

3.3. Dynon FlightDEK-D180 Description

The Dynon FlightDEK-D180 is a 7-inch wide screen display mounted in the cockpit of non-type certificated aircraft. The instrument integrates multiple flight instruments including airspeed, altitude, gyro-stabilized magnetic compass, turn rate, slip/skid ball, bank angle, pitch angle and vertical speed. The unit also has other functions that include a clock/timer, g-meter, voltmeter, and a density altitude/true airspeed calculator. The unit contains an Air

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Data, Attitude and Heading Reference System (ADAHRS) to provide air data, attitude and heading information to the display. Depending on the installation in the operator's aircraft, certain parameters might not be displayed, for example angle-of-attack. The instrument also integrates up to 16 engine related instruments including manifold pressure, temperatures, RPM and fuel system information. Depending on the type of engine installed in the aircraft and pilot preferences, not all display options can be available.

Depending on the firmware version on the unit, the ability to log data to internal memory exists. According to the manufacturer, firmware versions 3.0 and later contain the ability to log certain engine parameters and firmware versions 5.0 and later contain the ability to log certain EFIS and GPS parameters. The data logging must be configured by the operator to enable logging and set the data log interval. The unit can also be configured to start logging data automatically at boot-up. The data logging interval can be set to store at 1, 3, 5, 10, 30 or 60 second intervals. The internal memory can store at least 30 minutes of cumulative data at a 1 second recording interval or at least 30 hours at a 60 second data recording interval. When the recording limit in the internal memory is reached, the oldest record is dropped and a new record is added.

3.3.1. Dynon FlightDEK-D180 Data Recovery

The device was damaged in the event. The extent of the damage is shown in figure 4. The data were extracted by identifying the non-volatile memory (NVM) chip inside the device, removing it via a de-soldering process, and reading the NVM's binary contents in a forensic reader.¹ The binary contents were then converted to engineering units using documentation supplied by the manufacturer with the assistance of NTSB laboratory software.



Figure 4. Damaged exterior of Dynon FlightDEK-D180.

¹ Non-volatile memory (NVM) – semi-conductor memory that does not require power in order to retain data.

3.3.2. Dynon FlightDEK-D180 Data Description

Based on information from the manufacturer, the unit can store data in internal non-volatile memory. The operator had the datalog function enabled and it was set to record information. The recording contained approximately 250 minutes of data. The accident flight recording was approximately 8 minutes long. The data from the unit may have ended prematurely; this condition could have been a result of data buffering prior to being written to the unit's NVM.

3.3.3. Dynon FlightDEK-D180 Engineering Units Conversions

Conversion of the PFD data from the raw recorded information to engineering units is performed by referencing documentation from the manufacturer.

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.

3.4. Time Correlation

Correlation of the Dynon data to local time (EST) was established using the recorded GPS time parameter from the Dynon FlightDEK-D180 data. The GPS time is recorded in Universal Coordinated Time (UTC). The Dynon starts recording when power is applied to the unit. 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.

3.5. Plots and Corresponding Tabular Data

The following seven figures contain data recorded during the accident flight.

Figure 5 is a Google Earth overlay showing the entire recorded tracklog points for the accident flight. The first valid data point, the time of takeoff roll, and the final recorded point are highlighted. Google Earth does not depict weather or lighting conditions at the time of the accident.

Figure 6 is a Google Earth overlay showing the entire recorded tracklog points for the accident flight from a different perspective. The overlay is oriented to show the aircraft's attempted return to the airfield.

Figure 7 is a plot of basic flight parameters for the entire accident recording. Groundspeed begins increasing around 15:22:00, followed by an increasing trend in indicated airspeed. Around 15:22:25, airspeed reaches a maximum of around 92 knots, altitude was increasing at this time. As altitude continued to increase, airspeed and groundspeed began to decrease. Around 15:22:35, as the aircraft began changing heading to the right, altitude

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 = +.

continued to increase until approximately 15:22:40 when the altitude stabilized around 246 feet MSL. It is possible at this time that altitude data was unreliable given the repeated nature of the sampled data at 246 MSL until approximately 15:23:05 when a decreasing altitude trend began. As the altitude data stabilized, indicated airspeed data stabilized while groundspeed increased. The approximate difference between airspeed and groundspeed at this time was around 13 knots. The recorded groundspeed being higher than the recorded indicated airspeed data. By 15:23:05, altitude data began decreasing as recorded angle of attack and pitch values began increasing. The data then showed a roll. Data ended at 15:23:12. Figure 11 further details the accident flight in relation to recorded engine data.

Figure 8 is a plot of basic flight parameters for the end of the accident recording.

Figure 9 is a plot of engine parameters for the entire accident recording.

Figure 10 is a plot of engine parameters for the end of the accident recording.

Figure 11 is a plot of selected air data, AHRS and engine parameters for a portion of the recording relevant to the accident investigation. The data show that takeoff roll began around 15:22:03 as manifold pressure and rpm increased to values consistent with a near max power setting for this make and model of aircraft engine. Cylinder head temperatures and exhaust gas temperatures were nominal for the first portion of the flight immediately following takeoff and through a portion of the aircraft's climb. Around 15:22:40, the aircraft stopped its climb. At this time, the aircraft was already in a right turn, and data showed the aircraft in a right bank. Around 15:23:00, the value for exhaust gas temperature in cylinder 1 showed a marked divergence from the other cylinders. At this time, RPM dropped to around 1600 rpm and manifold pressure to about 12 in/Hg. Data show the aircraft continued a right bank and right heading change in the direction of the airport. Air data show the aircraft was in a descent by 15:23:05. A few seconds later at 15:23:09, manifold pressure increased to around 22 in/Hg and RPM to about 2300 RPM. At this time, the data show the aircraft increased its pitch and angle of attack. The angle of attack value reached 100% (critical angle of attack) at 15:23:10.³ The last two data points showed values for pitch decreasing rapidly and right roll of over 100 degrees developed. Data ended with an indicated pressure altitude of 151 feet recorded.⁴

Figure 12 is a plot of selected air data, AHRS, and engine parameters for the end of the accident recording showing the above-mentioned parameters in greater detail.

The nature of the chip recovery of the FlightDEK D-180 precluded a recovery of available EFIS alerting information. Any alerts or warning issued by the EFIS were unable to be reviewed.

The corresponding tabular data used to create these eight plots are provided in electronic (*.csv⁵) format as Attachment 1 to this report.

³ Critical angle of attack on this instrumentation system is set by the aircraft builder. A value of 100% should indicate the aircraft had reached a critical angle of attack condition.

⁴ Pressure altitude is recorded at 29.92 in/Hg. Barometric setting. The data was not offset for the local barometric pressure setting at the time of the accident.

⁵ Comma Separated Value format.

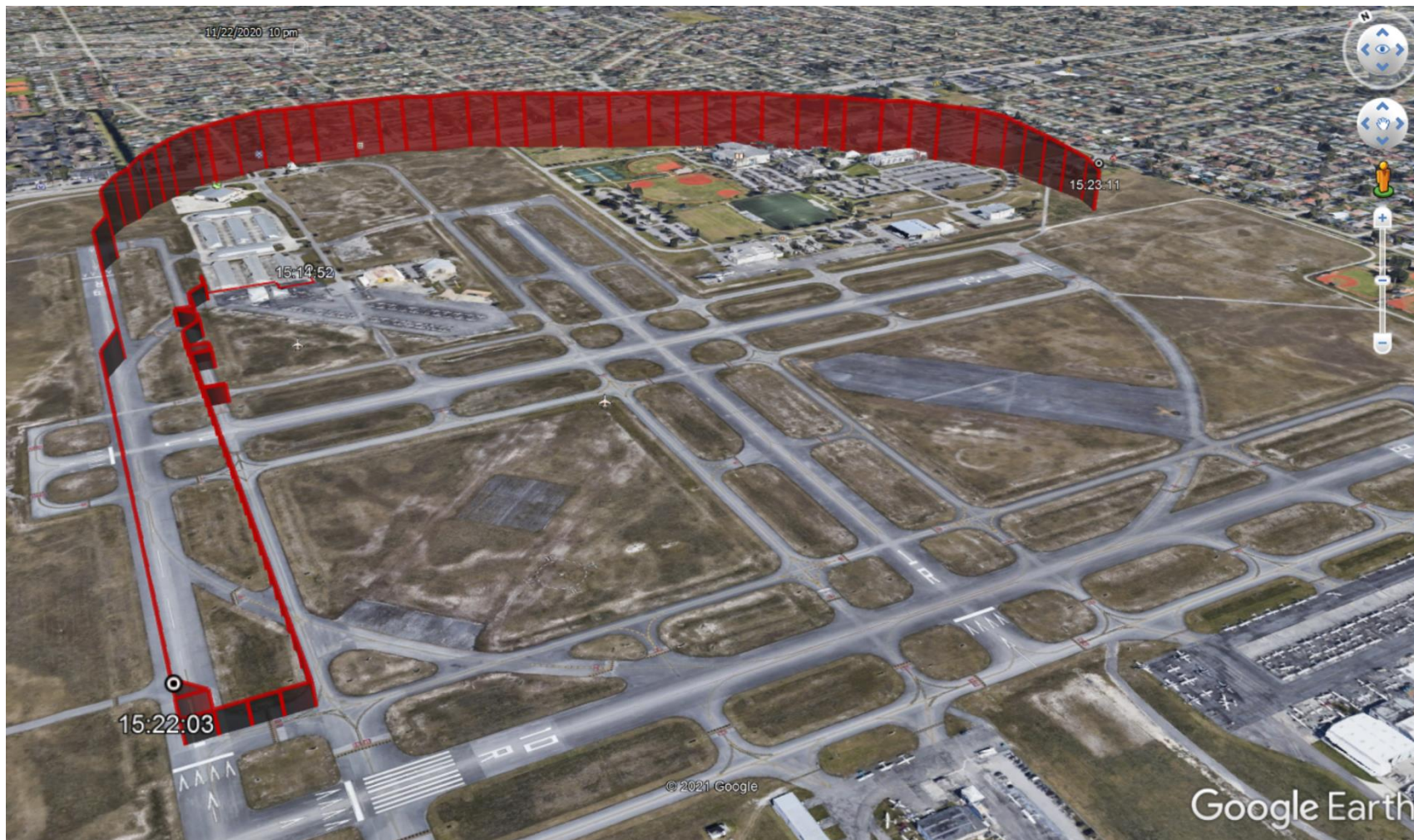


Figure 5. A Google Earth overlay of the entire accident flight.

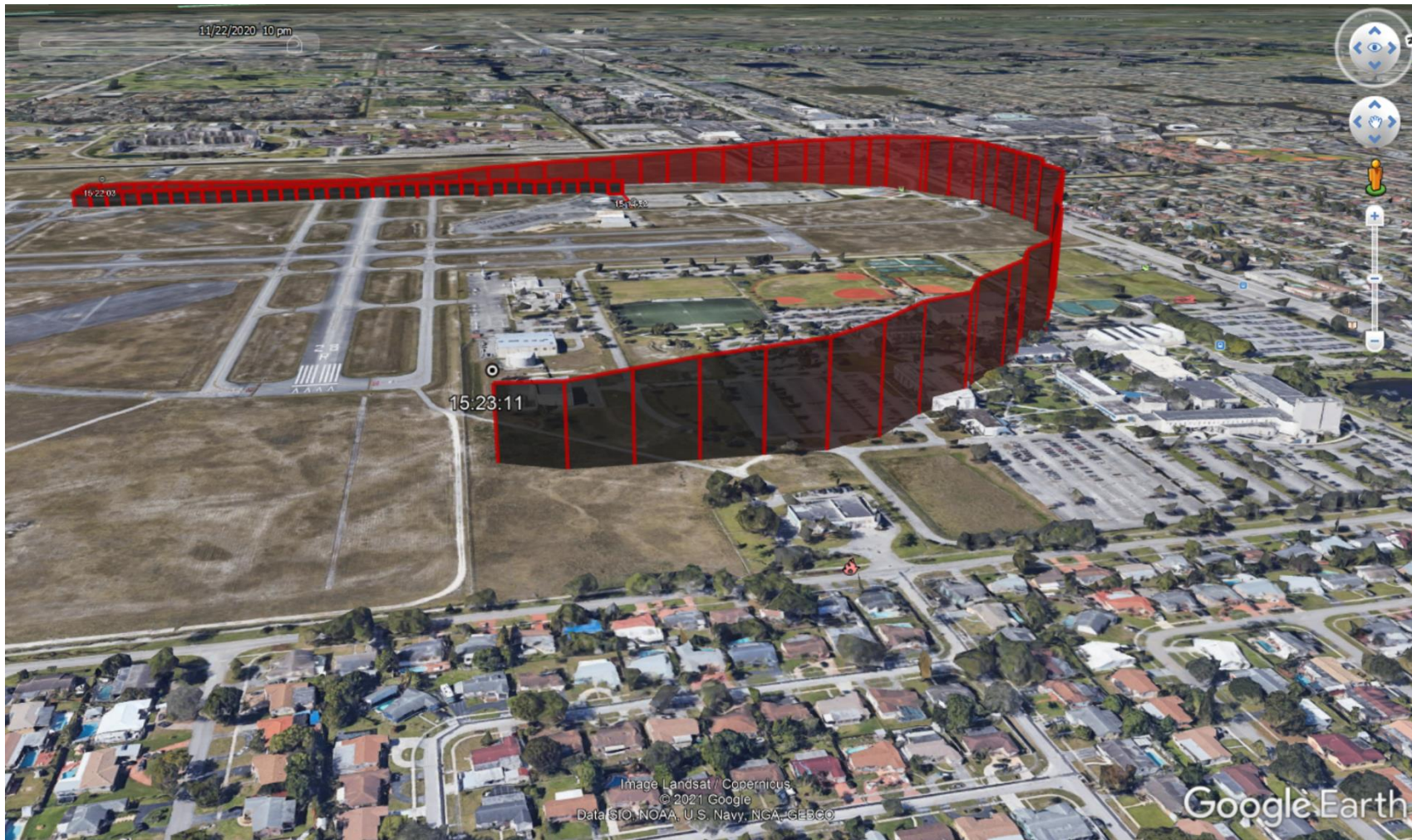


Figure 6. A Google Earth overlay of highlighting the aircraft's attempted return to the airport.

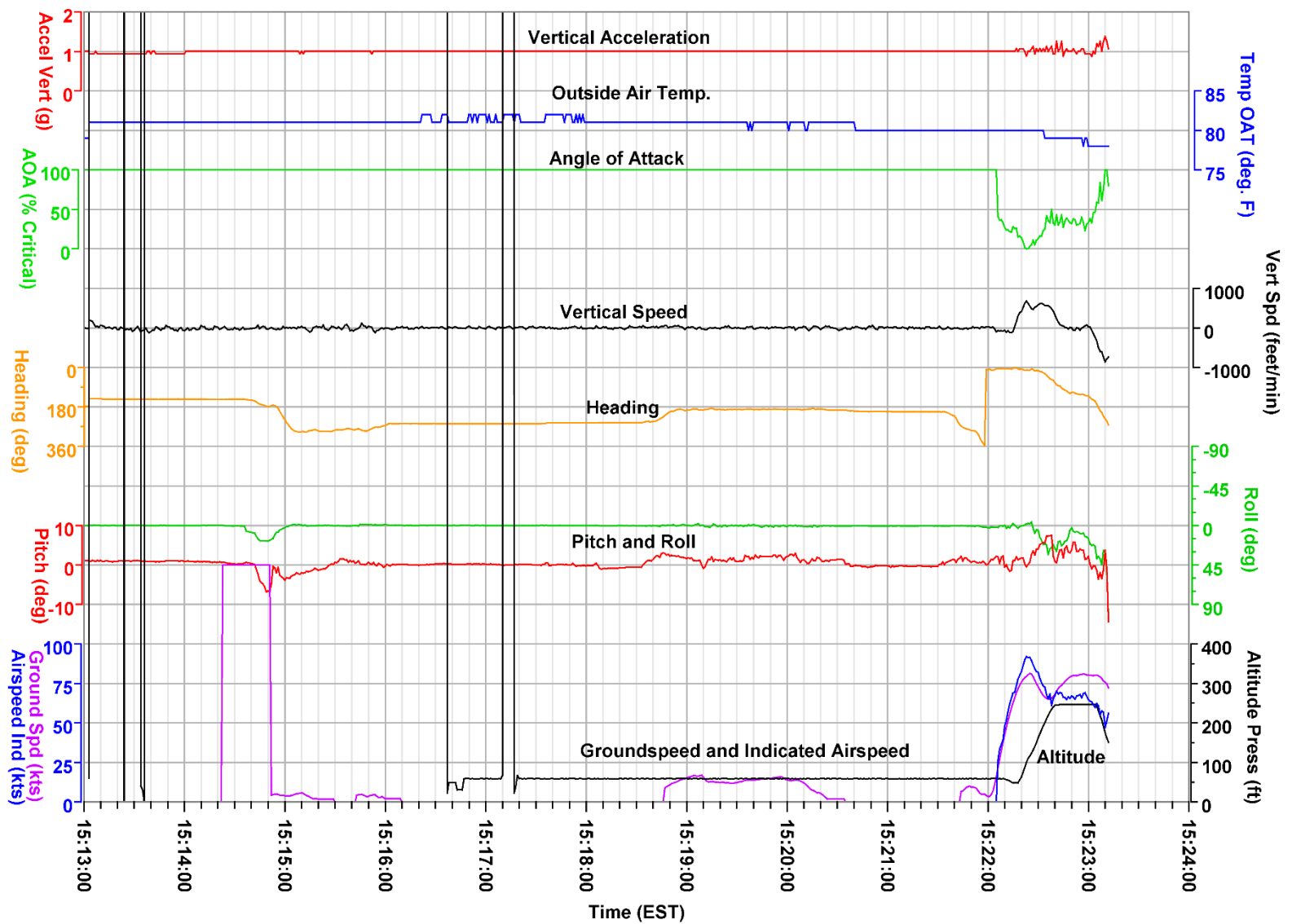


Figure 7. A plot of showing basic flight parameters for the entire accident recording.

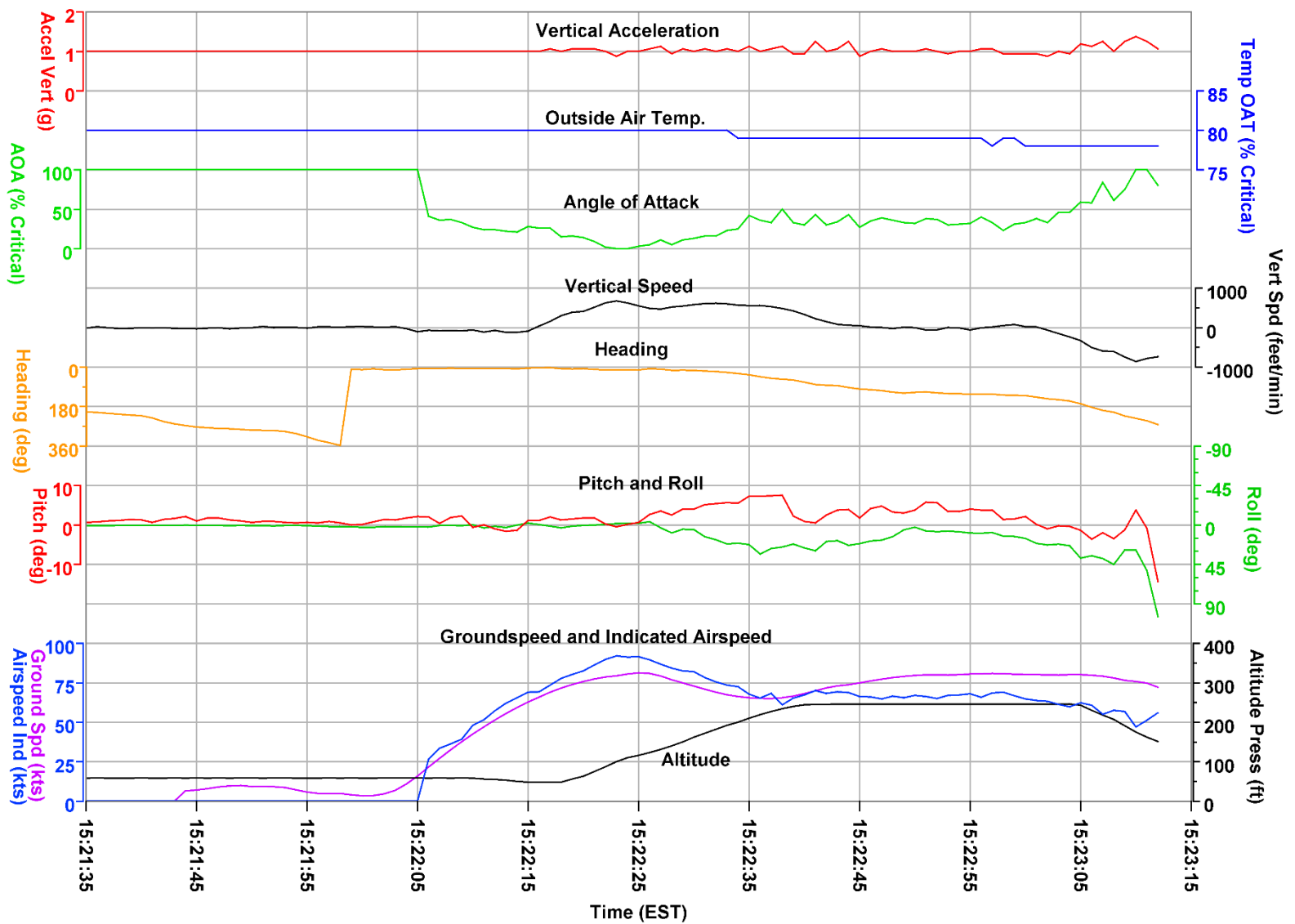


Figure 8. A plot of showing basic flight parameters for the end of the accident recording.

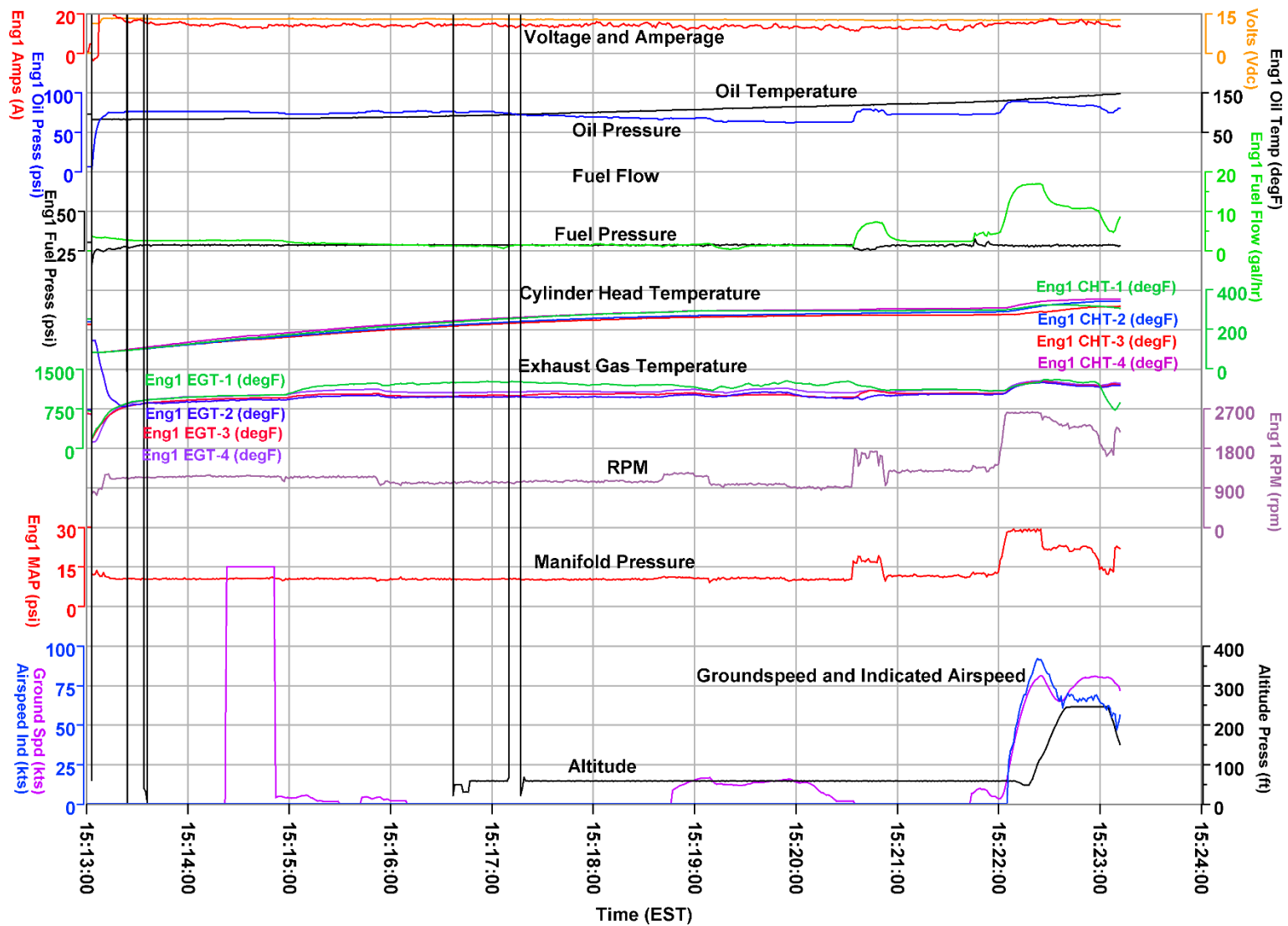


Figure 9. A plot of showing engine parameters for the entire accident recording.

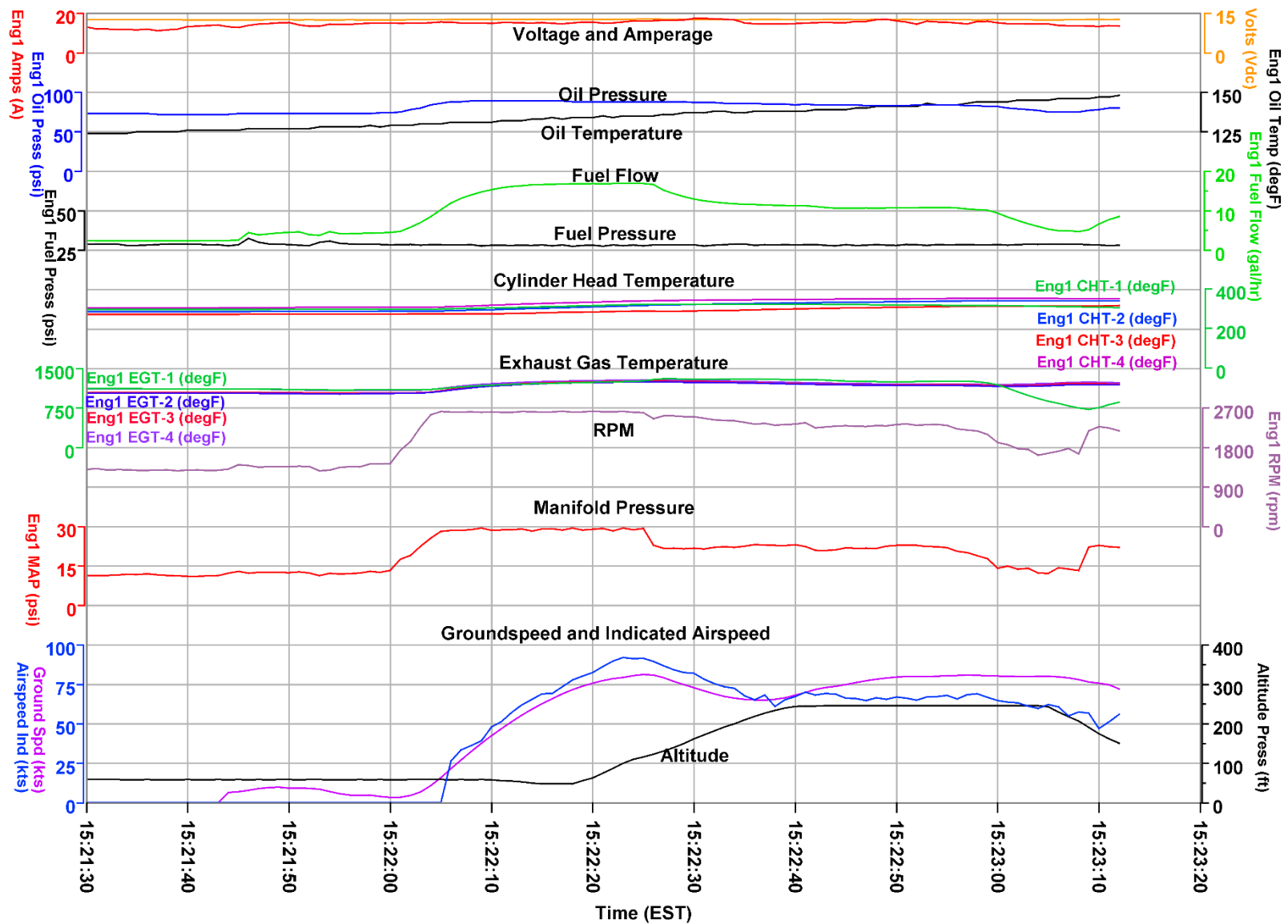


Figure 10. A plot of showing engine parameters for the end of the accident recording.

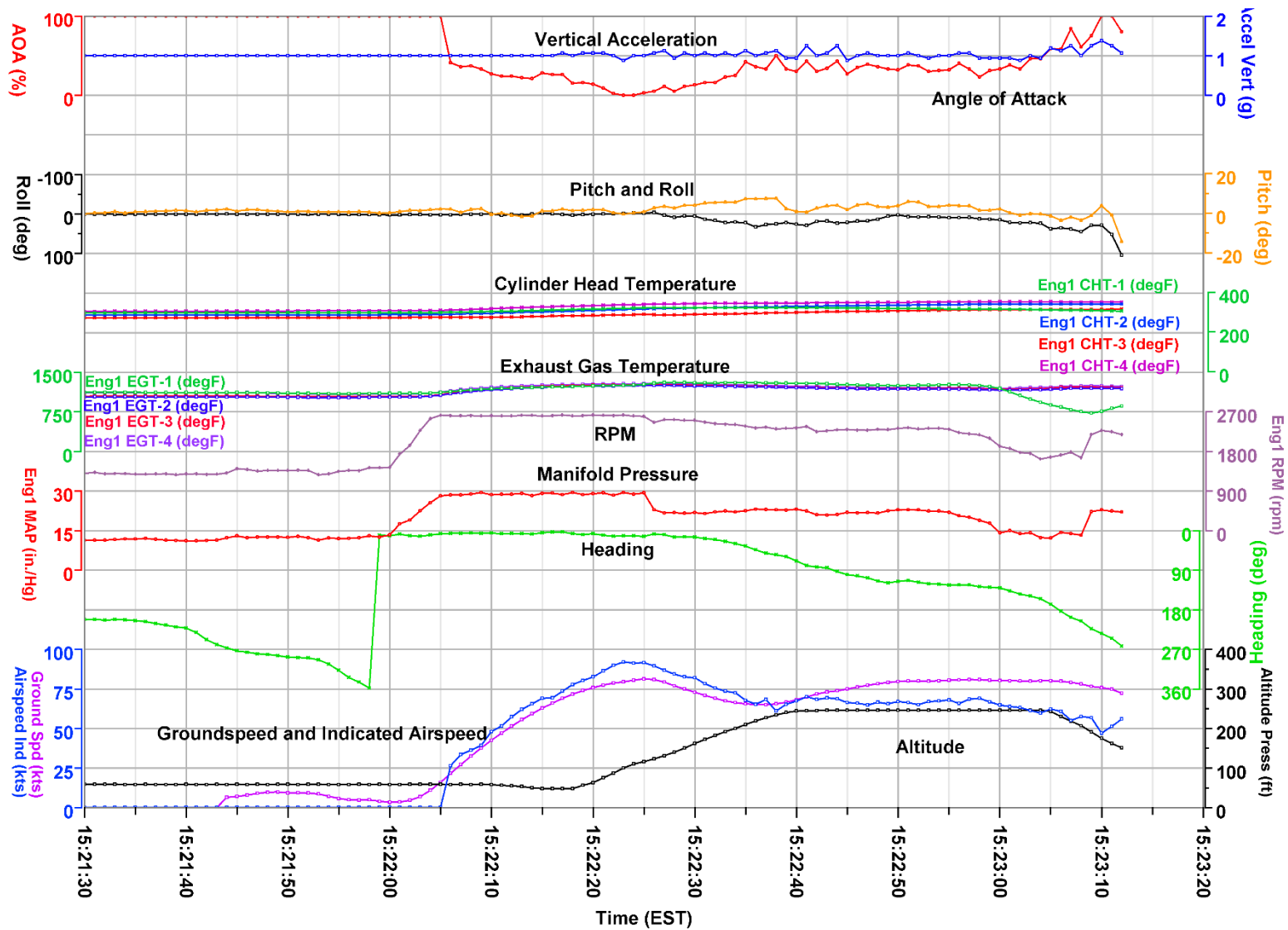


Figure 11. A plot of showing selected air data, AHRS, and engine parameters for a portion of the recording relevant to the accident investigation.

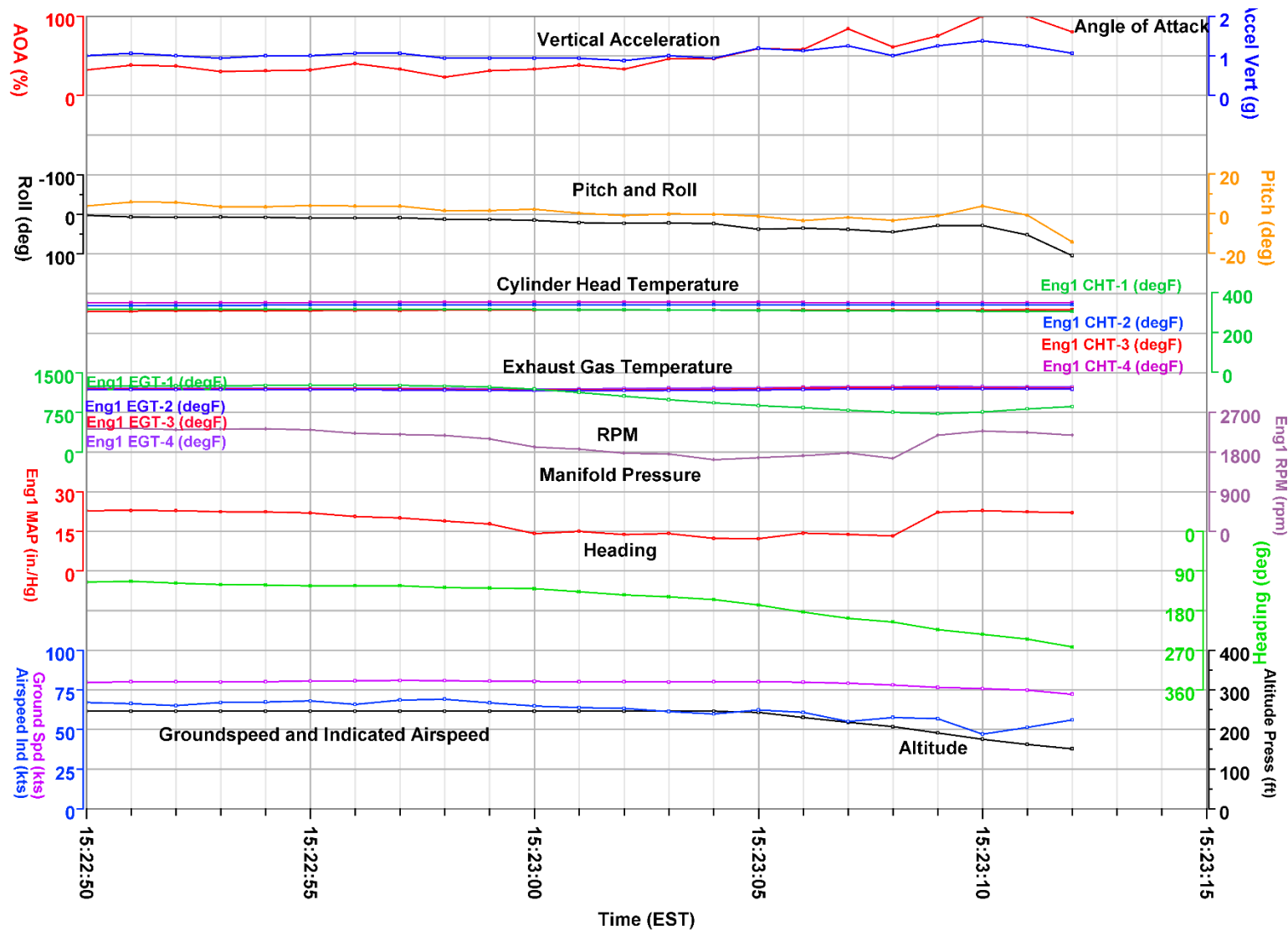


Figure 12. A plot of showing selected air data, AHRS, and engine parameters for the end of the accident recording.

APPENDIX A - Dynon FlightDEK-D180 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 Vert (g)	Vertical Acceleration
Airspeed Ind (kts)	Indicated Airspeed
Altitude Press (ft)	Pressure Altitude
AOA (%)	Percent Critical Angle of Attack
Eng1 Oil Press (psi)	Oil Pressure
Eng1 Oil Temp (degF)	Oil Temperature
Eng1 Amps (A)	Amperage
Eng1 CHT-# (degF)	Cylinder Head Temperature – Cylinder #
Eng1 EGT-# (degF)	Exhaust Gas Temperature - Manifold #
Eng1 Fuel Flow (gal/hr.)	Fuel Flow
Eng1 Fuel Press (psi)	Fuel Pressure
Eng1 MAP (in./Hg)	Manifold Pressure
Eng1 RPM (rpm)	Engine RPM
Eng1 Volts (Vdc)	Voltage
Ground Spd (kts)	Groundspeed
Heading (deg)	Magnetic Heading
Latitude (deg)	Latitude
Longitude (deg)	Longitude
Pitch (deg)	Pitch
Roll (deg)	Roll
Temp OAT (degF)	Outside Air Temperature
Time GMT Hour	Time (GMT Hours)
Time GMT Min	Time (GMT Minutes)
Time GMT Sec	Time (GMT Seconds)
Vert Speed (feet/min)	Vertical Speed

The Dynon FlightDEK-D180 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
A	Amperes
deg	Degrees
degF	Degrees Fahrenheit
Feet/min	Feet per minute
ft	Feet
g	Acceleration
gal/hr.	Gallons per hour
in./Hg	Inches of Mercury
kts	Knots
psi	Pounds per square inch
RPM	Revolutions per minute
Vdc	Volts DC