

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



CEN23LA297

COCKPIT DISPLAY - RECORDED FLIGHT DATA

Specialist's Factual Report

December 11, 2023

A. ACCIDENT

Location: Boelus, Nebraska
Date: July 11, 2023
Time: 2103 central daylight time (CDT)
Airplane: Cirrus SR22, private operator, N151SR

B. COCKPIT DISPLAY - RECORDED FLIGHT DATA SPECIALIST

Specialist: Steven Smith
Mechanical Engineer (Recorder Specialist)
National Transportation Safety Board (NTSB)

C. DETAILS OF THE INVESTIGATION

A group was not convened. The NTSB Vehicle Recorder Division received the following electronic devices:

Recorder Manufacturer/Model: Avidyne PFD
Part Number: 700-00006-000
Recorder Serial Number: 20034486

Recorder Manufacturer/Model: Avidyne MFD Compact Flash
Part Number: 053-00201-110 REV00
Software Number: 530-00201-100 REV01

Recorder Manufacturer/Model: Avidyne DFC 90 MicroSD
Part Number: 056-00002-003 REV 00

1.0 Avidyne Primary Flight Display Description

The Avidyne Entegra 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 was damaged in the event. The front screen was cracked and the connectors in the back were bent. However, the device was able to be connected to and powered up normally. The extent of the damage is shown in figures 1 and 2. The data were downloaded using the manufacturer's procedure and converted to engineering units using laboratory tools.



Figure 1. Front of the Avidyne PFD as received by the Vehicle Recorders Lab.

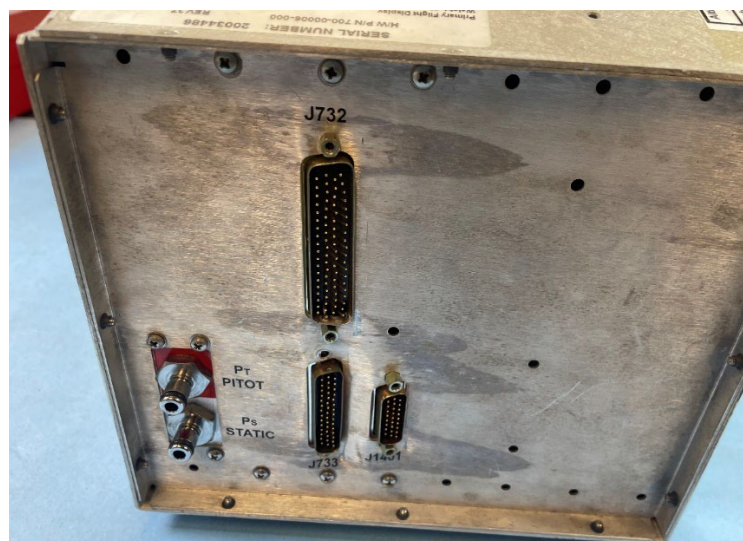


Figure 2. Back of the Avidyne PFD as received by the Vehicle Recorders Lab.

1.2 Avidyne PFD Recording Description

The PFD recording contained records of 15 power cycles and approximately 16.11 hours of data. The accident flight was associated with the last power cycle.¹ The duration of the last power cycle was approximately a half hour. Timing of the PFD data is measured in seconds from power-on.

1.2.1 Avidyne PFD Parameters Provided

Table 1 lists the PFD parameters verified and provided in this report.

Table 1. Avidyne PFD data parameters provided.

Parameter Name (unit)	Parameter Description (unit)
Accel Lat (g)	Lateral Acceleration (gravitational acceleration)
Accel Long (g)	Longitudinal Acceleration (gravitational acceleration)
Accel Vert (g)	Vertical Acceleration (gravitational acceleration)
Airspeed Ind (kts)	Indicated Airspeed (knots)
Altitude Press (ft)	Pressure Altitude (feet)
Ground Speed (kts)	Ground Speed (knots)
Heading Mag (deg)	Magnetic Heading (degrees)
Latitude (deg)	Latitude (degrees)
Longitude (deg)	Longitude (degrees)
Pitch (deg)	Pitch Angle (degrees)
Roll (deg)	Roll Angle (degrees)
Time UTC Hrs (hrs)	Coordinated Universal Time Hours (hours)
Time UTC Min (min)	Coordinated Universal Time Minutes (minutes)
Time UTC Sec (sec)	Coordinated Universal Time Seconds (seconds)

1.3 Avidyne PFD Time Correlation

Correlation of the PFD data to 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 coordinated universal time (UTC). The difference between CDT and UTC is 5 hours, or 18000 seconds. The PFD starts recording when power is applied to the unit. For each power cycle the timing begins at 0 seconds and the PFD data is measured in seconds from power-on. An offset is

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 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.

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 CDT.

Due to the 6 second update rate of the GPS time, the times noted in this report could be up to 6 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 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 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.

2.1 Avidyne MFD Compact Flash Data Recovery

The Avidyne MFD Compact Flash card was in good condition and the data were downloaded using the manufacturer's procedure.

2.2 Avidyne MFD Compact Flash Recording Description

The MFD CF card contained 172 data files. One data file was identified as recording during the accident flight. The data file was approximately 29 minutes and 30 seconds in duration.

2.2.1 Avidyne MFD Compact Flash Parameters Provided

Table 2 lists the MFD parameters verified and provided in this report.

Table 2. Avidyne MFD data parameters provided.

Parameter Name (unit)	Parameter Description (unit)
AMP1 (A)	Alternator 1 Output (amps)
AMP2 (A)	Alternator 2 Output (amps)
AMPB (A)	Battery Output (amps)
C# (degF)	Engine Cylinder Head Temperature # ³ (degrees Fahrenheit)
E# (degF)	Engine Exhaust Gas Temperature # (degrees Fahrenheit)
EBUS (V)	Essential Bus Voltage (V)
FF (gph)	Fuel Flow (gallons per hour)
LAT (deg)	Latitude (degrees)
LON (deg)	Longitude (degrees)
MAP (inHg)	Engine Manifold Pressure (inches of Mercury)
MBUS (V)	Main Bus Voltage (volts)
OIL P (psi)	Oil Pressure (pounds per square inch)
OIL T (degF)	Oil Temperature (degrees Fahrenheit)
PALT (ft)	Pressure Altitude (feet)
RPM (rpm)	Engine Revolutions per Minute (revolutions per minute)
USED (gal)	Fuel Used (gallons)

2.3 Avidyne MFD Compact Flash Time Correlation

Correlation of the MFD data to CDT was established by using the recorded GPS time, pressure altitude, latitude, and longitude parameters from the PFD data. The MFD data contained the same parameters and therefore they were compared at takeoff and landing against the PFD parameters.

To correlate the time between the MFD and the PFD, a 2 second offset was applied to the MFD recorded data time.

3.0 Avidyne Digital Flight Computer Autopilot Description

The Avidyne DFC-90 (digital flight computer) 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

³ This aircraft engine is configured with 6 cylinders. In the data plots, the '#' is replaced with the appropriate cylinder ID.

autopilot is capable of maintaining a controlled rate of climb and descent, has a navigation capability and will maintain a pre-programmed 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 DFC AP Data Recovery

The Avidyne DFC AP was in good condition and the data were downloaded using the manufacturer's procedure.

3.2 Avidyne DFC AP Data Description

The Investigator in Charge (IIC) and the Vehicle Recorder Division discussed the value that the DFC 90 would provide to the investigation. Since all the engine data stored on the DFC 90 is redundant to that of the MFD, it was agreed that there would be no need to process the data and produce plots. Thus, it has been omitted from this factual report.

D. FIGURES AND TABULAR DATA

Figures 3 and 4 contain PFD data and figures 5 and 6 contain MFD data recorded during the event on July 11, 2023. All the parameters listed in tables 1 and 2 for the PFD and MFD, respectively, are plotted except UTC Hours, UTC Minutes, UTC Seconds, Latitude, and Longitude.

Figures 3 and 4 present time history plots of the same parameters from the Avidyne PFD for the entire flight (20:33:30 CDT to 21:03:14 CDT) and the final minute and 44 seconds (21:01:30 CDT to 21:03:14 CDT), respectively.

Figures 5 and 6 present time history plots of the same parameters from the Avidyne MFD for the entire flight (20:33:30 CDT to 21:02:50 CDT) and the final minute and 50 seconds (21:01:00 CDT to 21:02:50 CDT), respectively.

These figures are configured such that right turns are indicated by the trace moving toward the bottom of the page, left turns towards the top of the page, and nose up attitudes towards the top of the page.

The data show the following:

- **20:34:04 CDT:** The approximate time that the takeoff rollout was initiated from Werner Ranch Airfield (NE36) in Grand Island, Nebraska.

- **20:35:00 CDT:** The aircraft reached a magnetic heading of 111 degrees (deg) and continued an east southeastern course. The takeoff and cruise portion up to the accident time were uneventful.
- **21:00:02 CDT:** The aircraft was in cruise flight at 3219 feet (ft) pressure altitude, indicated airspeed was 147 knots (kts), and the magnetic heading was 114 deg. Engine rpm was 2610 rotations per minute (rpm), fuel flow was 15.6 gallons per hour (gph), and the oil pressure was 44 pounds per square inch (psi).
- **21:01:43 CDT:** The aircraft airspeed was 146 kts.
- **21:01:44 CDT:** Fuel flow was 13.4 gph, engine rpm was 2600 rpm and oil pressure was 44 psi. Exhaust gas temperature ranged from 1393 to 1496 degrees Fahrenheit (degF) between hottest and coolest cylinders.
- **21:01:50 CDT:** Fuel flow was 12.7 gph, engine rpm was 2590 rpm and oil pressure was 44 psi. Exhaust gas temperature ranged from 1358 to 1460 degrees Fahrenheit (degF) between hottest and coolest cylinders.
- **21:01:56 CDT:** Fuel flow was 13.7 gph, engine rpm was 2590 rpm and oil pressure was 40 psi. Exhaust gas temperature ranged from 960 to 994 degrees Fahrenheit (degF) between hottest and coolest cylinders.
- **21:01:57 CDT:** The aircraft airspeed was 123 kts.
- **21:02:02 CDT:** Oil pressure was 44 psi. Oil pressure steadily decreased to zero for the remainder of the recording.
- **21:02:50 CDT:** The last recorded MFD data sample.
- **21:03:14 CDT:** The last recorded PFD data sample.

Figures 7 and 8 are graphical overlays derived from the Avidyne PFD data and generated using Google Earth presenting the entire accident flight from NE36 and the final 2 minutes and 14 seconds before the accident, respectively. Weather and lighting conditions in Google Earth are not necessarily the weather and lighting conditions present at the time of the recording.

The corresponding PFD tabular data used to create figures 3 and 4 and figures 7 and 8 are provided in electronic comma separated value (CSV) format as attachment 1 to this report. The corresponding MFD tabular data used to create figures 5 and 6 are provided in electronic comma separated value (CSV) format as attachment 2 to this report.

Submitted by:

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Mechanical Engineer (Recorder Specialist)

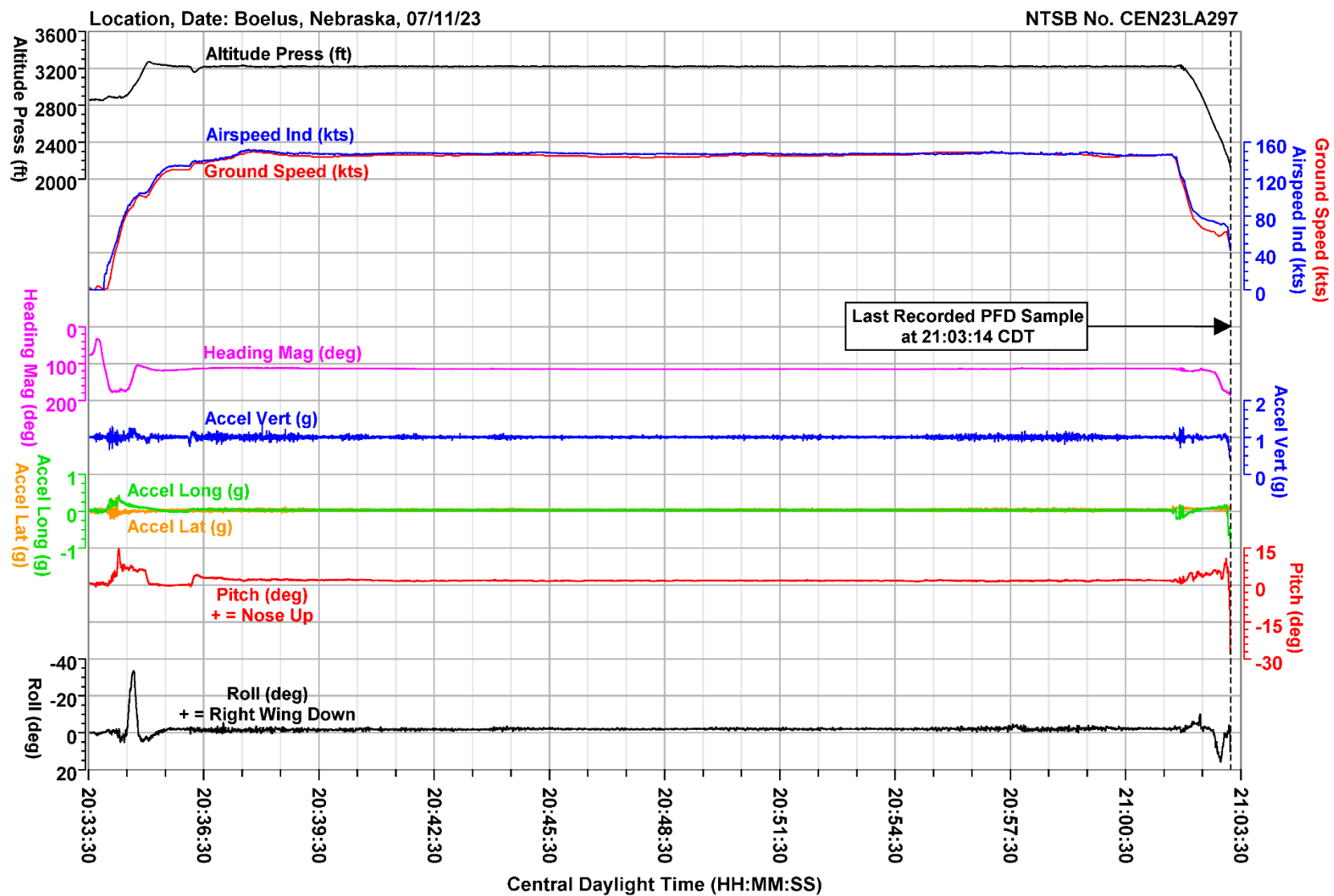


Figure 3. Time history plot for PFD parameters for the entire accident flight.

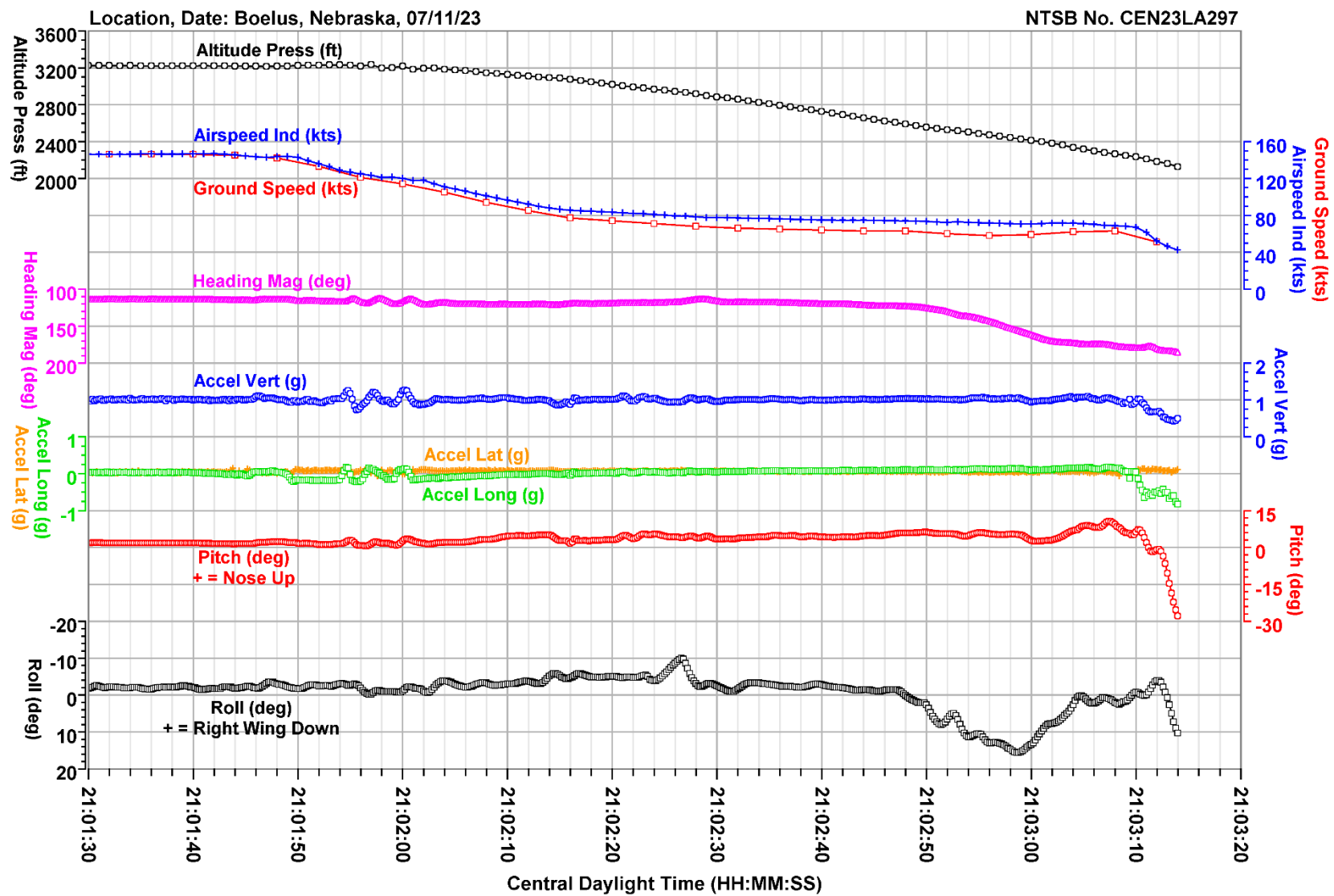


Figure 4. Time history plot for PFD parameters for the final minute and 44 seconds of the accident flight.

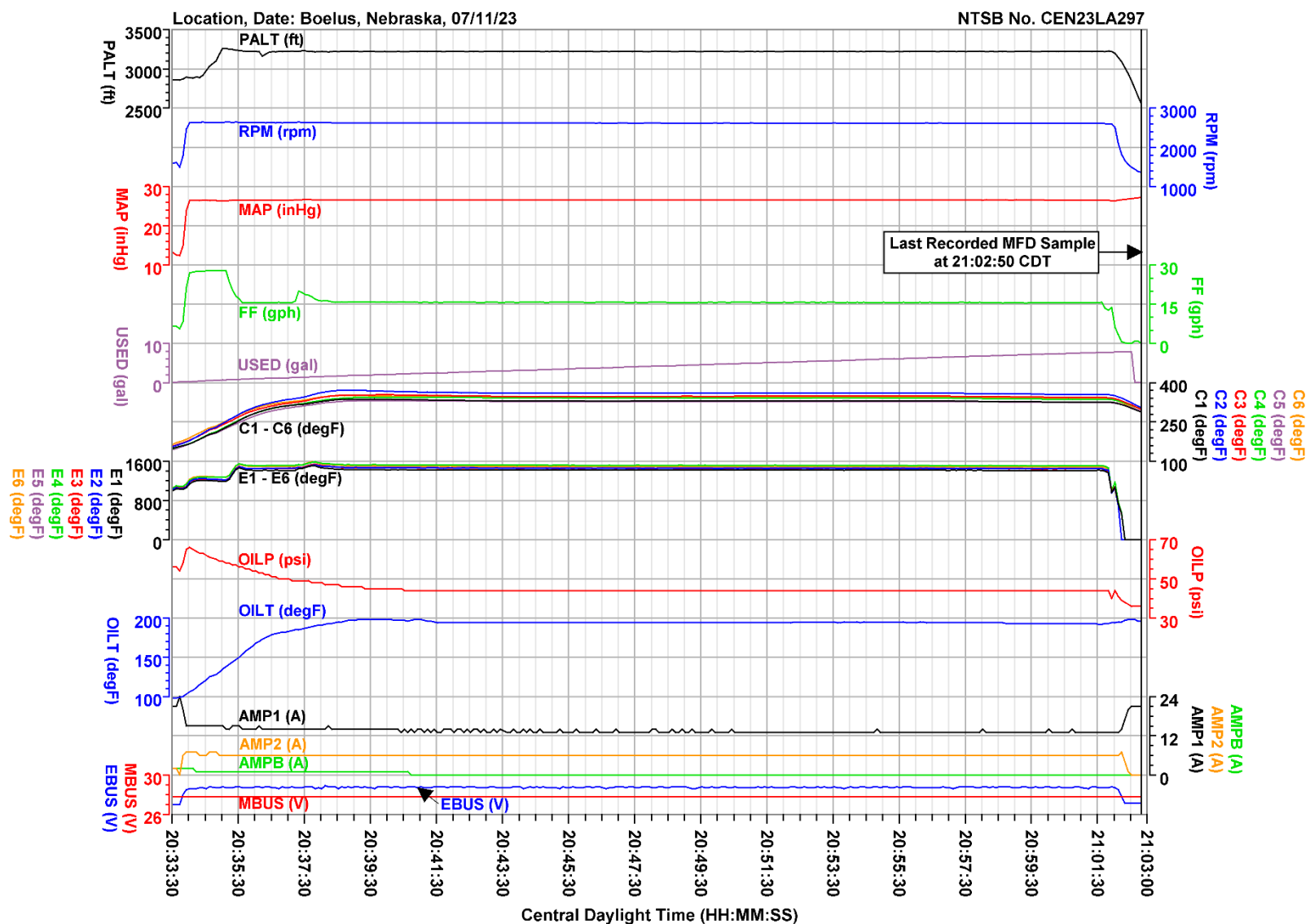


Figure 5. Time history plot of MFD parameters for the entire accident flight.

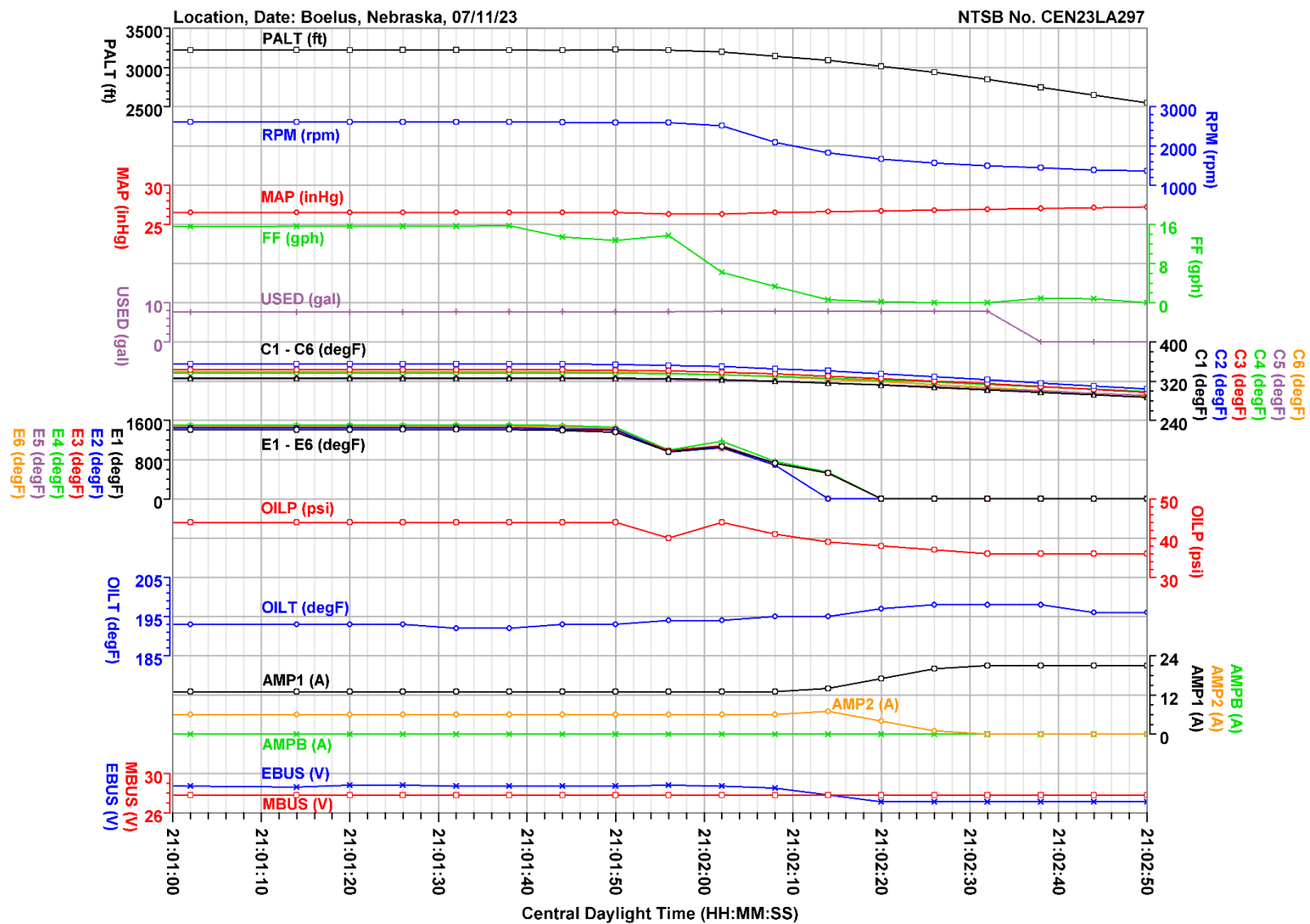


Figure 6. Time history plot of MFD parameters for the final minute and 50 seconds of the accident flight.



Figure 7. Google Earth overlay of the entire accident flight.

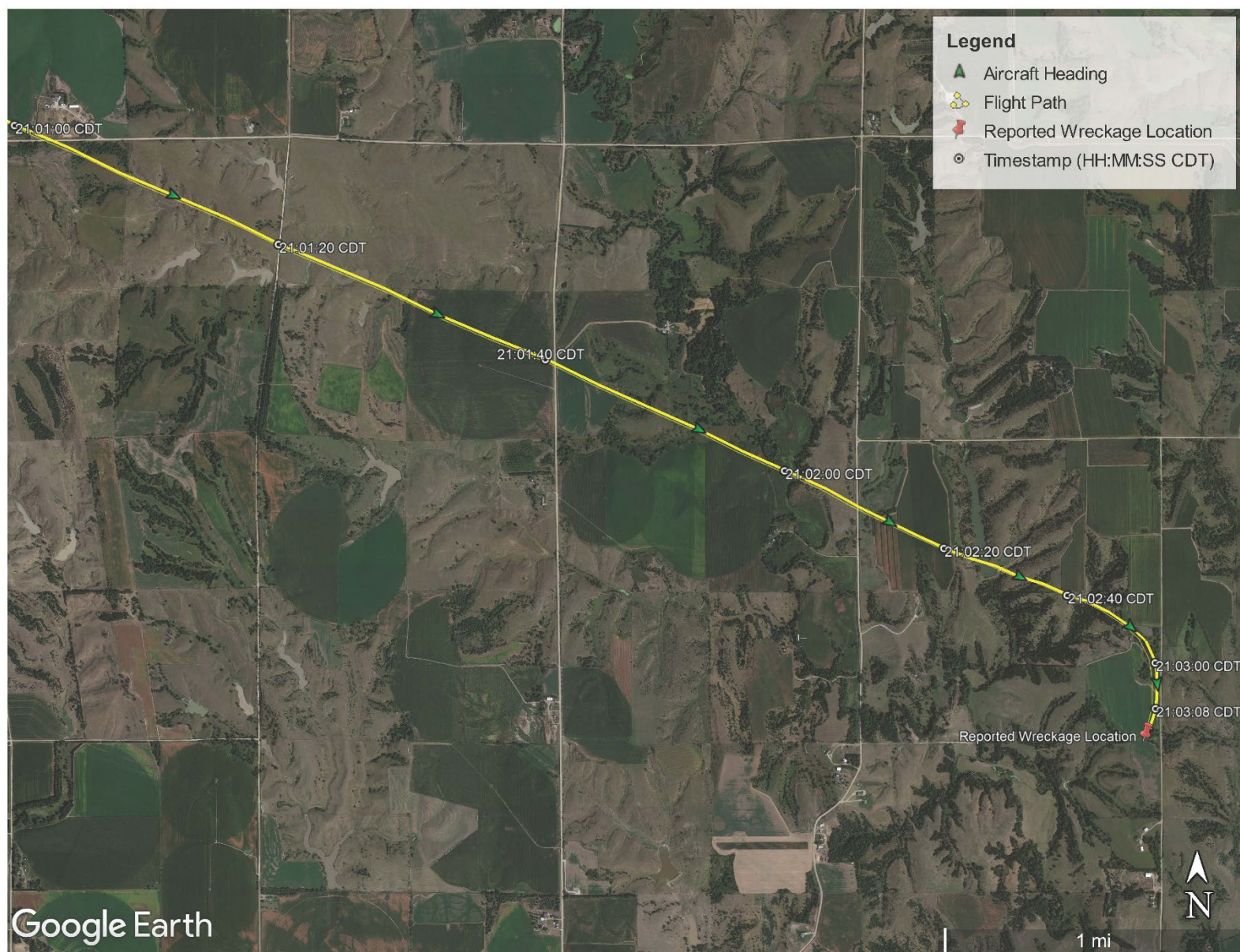


Figure 8. Google Earth overlay of the final 2 minutes and 14 seconds prior to the accident.