National Transportation Safety Board
Office of Research and Engineering
Washington, DC 20594

ERA22LA120

FLIGHT DATA RECORDER

Specialist's Factual Report

December 5, 2022

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A. ACCIDENT

Location: Beaufort, North Carolina
Date: February 13, 2022
Time: 14:02 eastern standard time (EST)
Airplane: Pilatus Aircraft PC-12/47E, N79NX

B. FLIGHT DATA RECORDER SPECIALIST

Specialist Charles Cates
Mechanical Engineer/Recorder Specialist
National Transportation Safety Board (NTSB)

C. FEDERAL CARRIAGE REQUIREMENTS

The event aircraft, N79NX, was operating as Title 14 *Code of Federal Regulations* Part 91 and was not required by regulations to carry a flight data recorder (FDR).

D. DETAILS OF THE INVESTIGATION

An FDR group was not convened. The NTSB Vehicle Recorder Division received the following FDR:

Recorder Manufacturer/Model: L-3 Lightweight Data Recorder (LDR)
Part Number: 1000-1000-00
Recorder Serial Number: 001202214

1.0 L-3 Lightweight Data Recorder Description

The L-3 Lightweight Data Recorder (LDR) is a crash-protected multi-function recorder providing both FDR and cockpit voice recorder (CVR) functions along with provisions for GPS data and video capture. Information is stored in a digital format using solid-state flash memory in an embedded USB drive as the recording medium. The LDR is specifically designed for use on General Aviation (GA) fixed wing aircraft and is not intended for installations required by regulations.

The FDR portion can receive data in the ARINC 717 or ARINC 429 formats and can record a minimum of 25 hours of flight data. This installation was configured to record 256 12-bit words of digital information every second in ARINC 717 format. The LDR is designed to be compliant with ED-155 and is certified to FAA TSO-C197.

1.1 Recorder Condition

The wreckage was located 3 miles offshore in about 60 feet (ft) of water. The recorder was recovered from the wreckage by dive crews 5 days after the accident. The recorder was rinsed with fresh water and packed in a container of fresh water for shipment to the NTSB's vehicle recorder laboratory.

Figure 1. Condition of recorder after removal from water upon arrival at lab.

Upon arrival, the recorder was disassembled, and the solid-state memory module was cleaned and dried using the NTSB's standard process for handling of electronics submerged in sea water. During disassembly, it was found that due to mechanical impact damage, the backup power source had been electrically shorted to the crash survivable case of the memory module. Inspecting the memory module showed that many of the solder connections from the memory chips to the circuit board had been corroded away. This was likely due to an oxidizing reaction between the solder and the sea water which was catalyzed by current flow from the backup power source.

Figure 2. LDR internals exposed showing backup power supply shorted to crash-survivable case.

ED-155 presents a minimum performance specification for lightweight recorders like the LDR. The specification includes minimum performance expectations when the recorder is subjected to crash forces like impact and thermal damage. However, the specification does not include requirements for resistance to damage due to deep sea pressure or the corrosive effect of sea water immersion. In this case, sea water immersion led to severe corrosion within the memory module that would not allow it to be downloaded without additional rework of the connections between the memory chips and the circuit board. In the microscope image below (figure 3), the bottom right pin on one of the memory chips is easily seen to be compromised by lack of solder. This is due to the oxidation of the solder in the sea water.

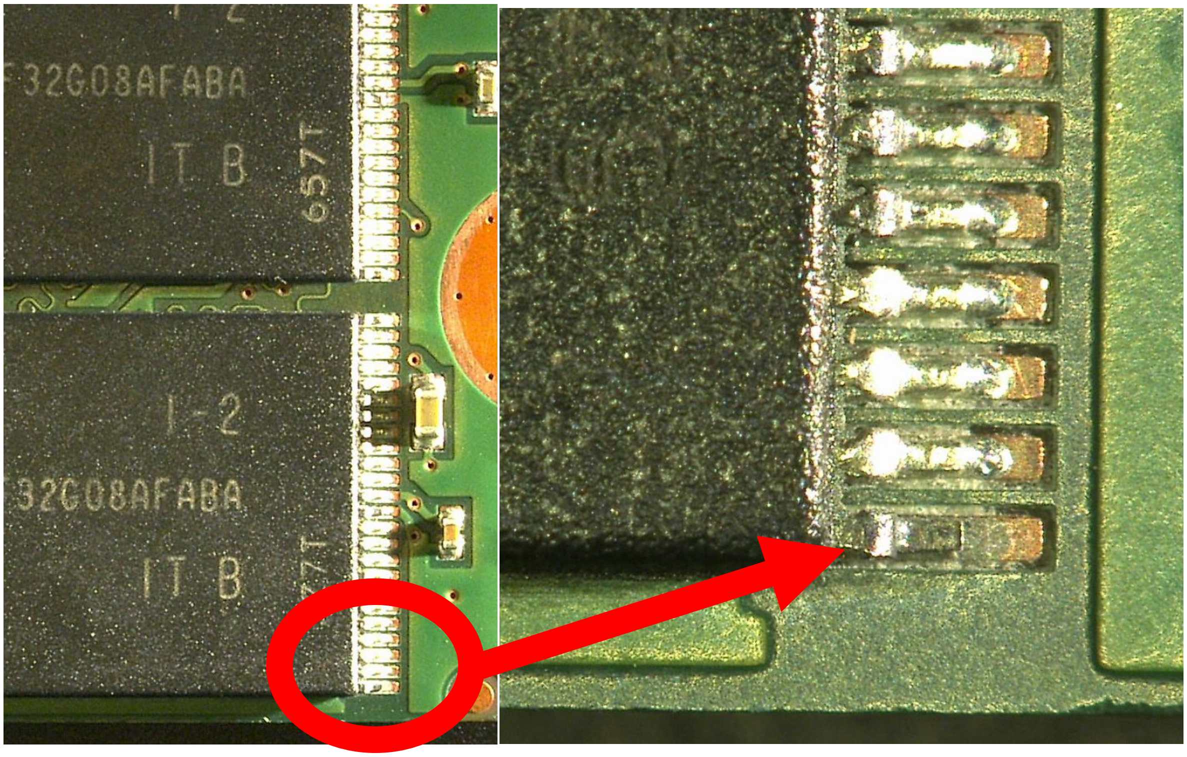

Figure 3. Microscopic view of circuit board with evidence of oxidized solder attachment.

Rework to the memory module included cleaning of the solder pads on the board and the leads on the memory chips and re-soldering individual leads that were no longer making connections to the board. Following the rework, the device was connected through its USB interface and the memory module was downloaded using NTSB's equipment.

1.2 Recording Description

The FDR recording contained 36 flights worth of data. Timing of the FDR data is measured in subframe reference number (SRN), where each SRN equals one elapsed second. The event flight was the last flight of the recording, and its duration was approximately 37 minutes.

1.2.1 Engineering Unit Conversions

The engineering unit conversions used for the data contained in this report are based on documentation from the aircraft manufacturer. Where applicable, the conversions have been changed to ensure that the parameters conform to the NTSB's standard sign convention that climbing right turns are positive (CRT=+).[1]

Table 1 lists the FDR parameters verified and provided in this report. Additionally, table 2 describes the unit and discrete state abbreviations used in this report.

1.3 Time Correlation

Correlation of the FDR data from SRN to the event local time, EST, was established by using the recorded GPS Hours, GPS Minutes, and GPS Seconds and then applying an additional -5 hours offset to change from UTC to EST.[2]

Accordingly, the time offset for the event flight data from SRN to local EST is the following: EST = SRN + 48235.2375. Therefore, for the rest of this report, all times are referenced as EST, not SRN.

E. FIGURES AND TABULAR DATA

Figures 4 to 8 contain FDR data recorded during the event on February 13, 2022. All the parameters listed in table 1 are plotted except GPS Hours, GPS Minutes, GPS Seconds, Latitude, Longitude, and Left and Right VHF Keying.

All figures cover the time from when the engine was started until the time of the accident, a span from 1329:00 EST to 1401:35 EST. Figure 4 is a plot of aircraft basic parameters providing an overview of the accident flight. Figure 5 is a plot of parameters related to aircraft automation. Figure 6 is a plot of flight control parameters. Note that control surface positions are sourced from the Actuator Input/Output Processor (AIOP) module and are only correctly reported when the autopilot is active. Figure 7 is a plot of engine parameters. Figure 8 is a map overlay in Google Earth of the flight path of the accident flight. Note that the atmospheric and lighting conditions in Google Earth are not representative of those at the time of the accident.

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 that the engine was started prior to the accident flight at 1329 EST. The aircraft taxied and the engine was advanced for takeoff at about 1334. The

[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 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 = +.
[2] GPS time is the Global Positioning System broadcast time in universal coordinated time (UTC).

autopilot was engaged shortly after takeoff and the aircraft climbed and leveled at the selected target altitude of 3,500 ft. Airspeed stabilized at about 220 knots (kts).

At 1342:55 the selected altitude reduced to 3,000 ft and pitch control mode changed from altitude hold to vertical speed. The aircraft began to descend, and airspeed accelerated to 240 kts at 1343:42. Upon reaching 240 kts an overspeed warning was recorded. Engine torque was reduced, and the aircraft leveled at 3,000 ft. Torque remained unchanged for about the next 12 minutes. With the reduced torque setting, airspeed stabilized at about 147 kts at 3,000 ft.

At 1356:14 vertical speed mode was engaged again, and the aircraft descended to a new selected altitude of 1,800 ft, capturing it at 1357:33. During the descent, engine torque was reduced slightly. After capturing the altitude, airspeed began to decrease at a rate of about 1 knot per second and pitch began a gradual increase of about 0.1 degrees per second (deg/s). Torque was reduced again during this slow decay of speed and increase of pitch and angle of attack.

At 1358:56 the barometer setting was changed from 29.98 inches of mercury (inHg) to 29.96 inHg. At that time, pitch had increased to 10 degrees (deg) and airspeed decayed to 109 kts. At 1359:12 the stick shaker activated, and the autopilot disconnected. Airspeed reached a low of 93 kts. The autopilot remained disconnected for the rest of the recording. Following the stick shaker activation, the engine torque increased, and the aircraft began a series of oscillations in pitch and roll. Airspeed decayed to 83 kts and pitch increased to 31.7 deg when both the stick shaker and stick pusher activated. The aircraft went through one more series of pitch and roll oscillations before rolling over 90 degrees to the right and pitching over 50 degrees nose down. The recording ended at 1401:26.

The corresponding tabular data used to create figures 4 to 8, including GPS Hours, GPS Minutes, GPS Seconds, Latitude, Longitude, and Left and Right VHF Keying, are provided in electronic comma separated value (CSV) format as attachment 1 to this report.

Submitted by:

Charles Cates
Mechanical Engineer/Recorder Specialist

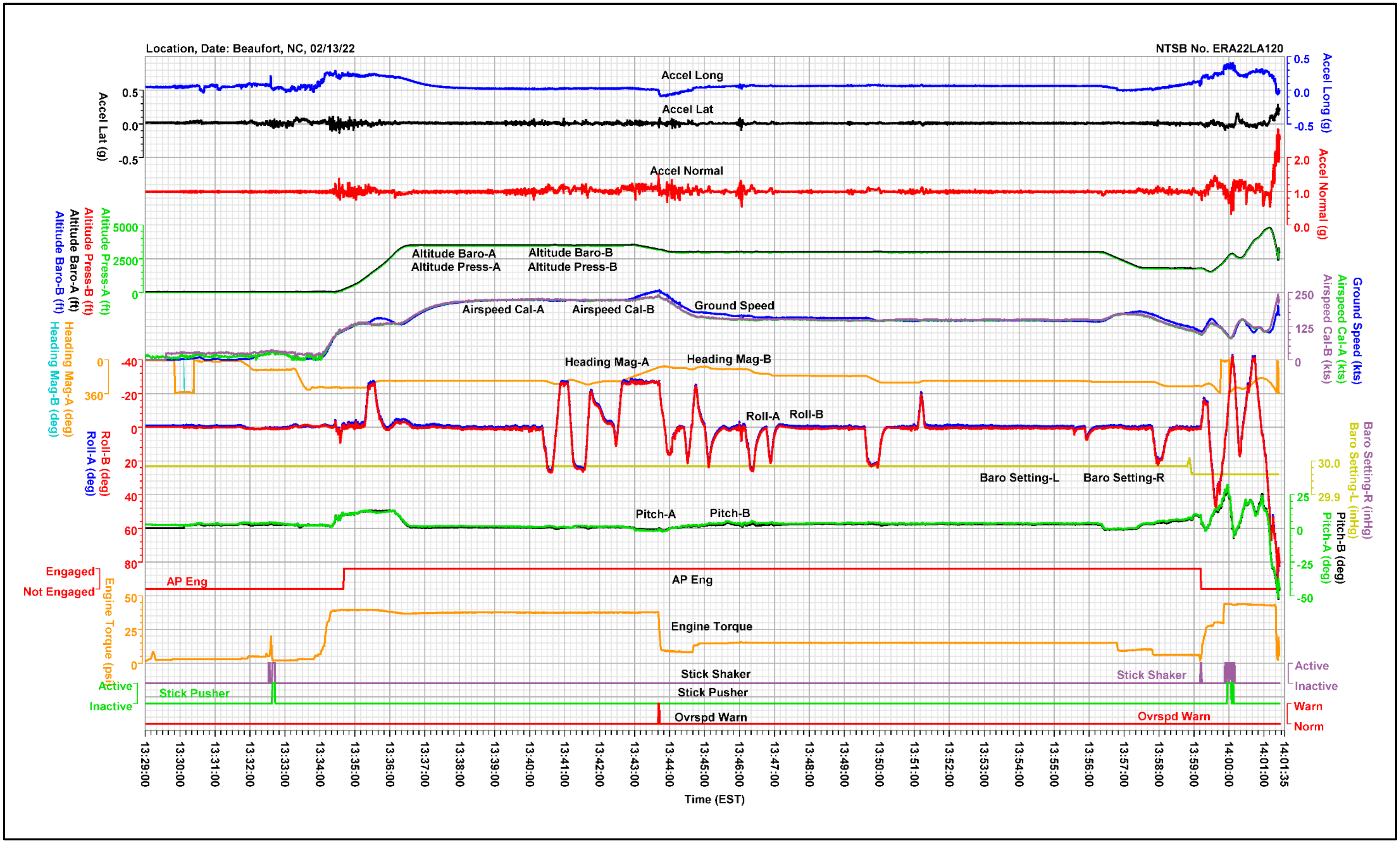

Figure 4. Plot of aircraft basic parameters pertaining to accident.

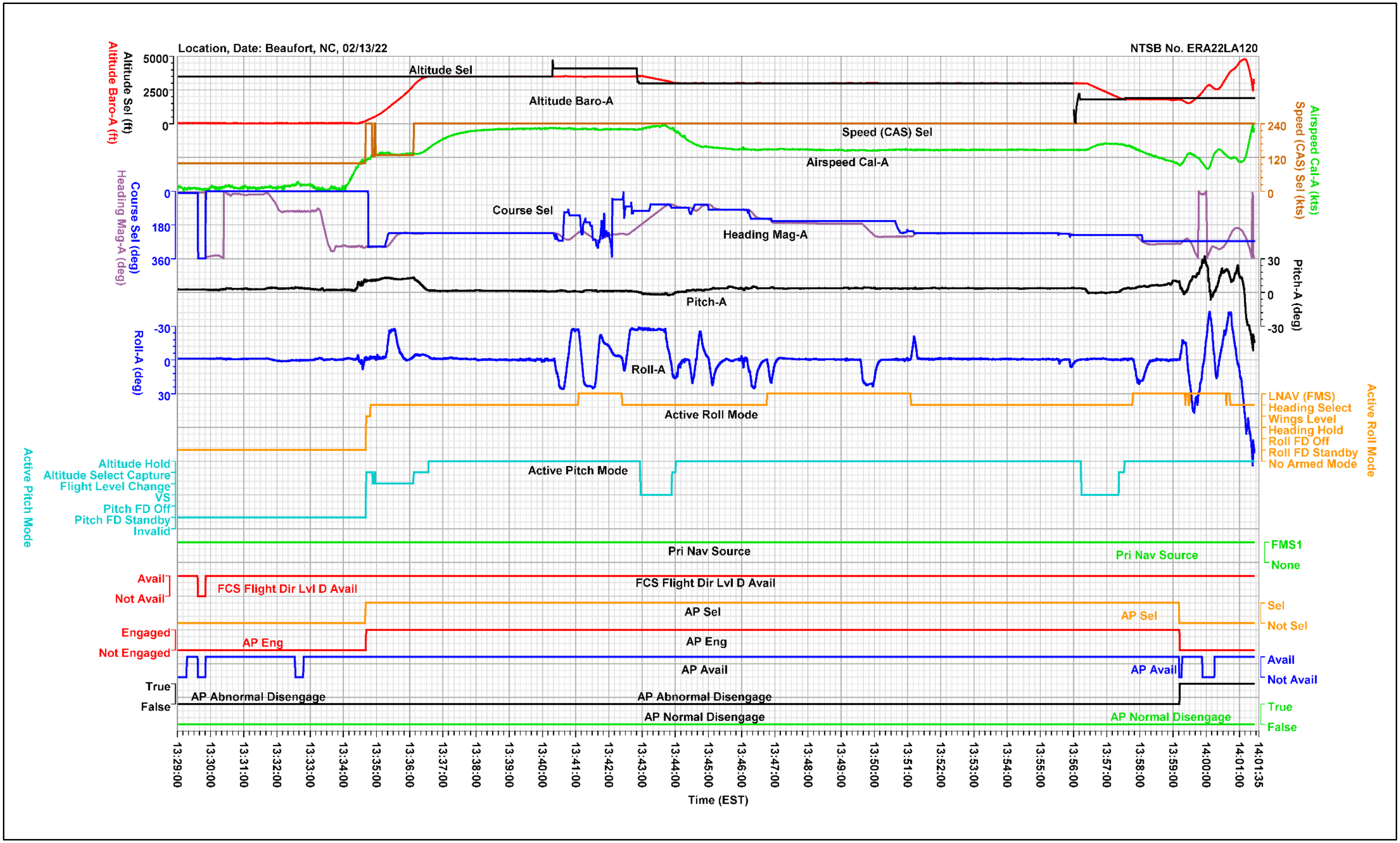

Figure 5. Plot of aircraft automation related parameters.

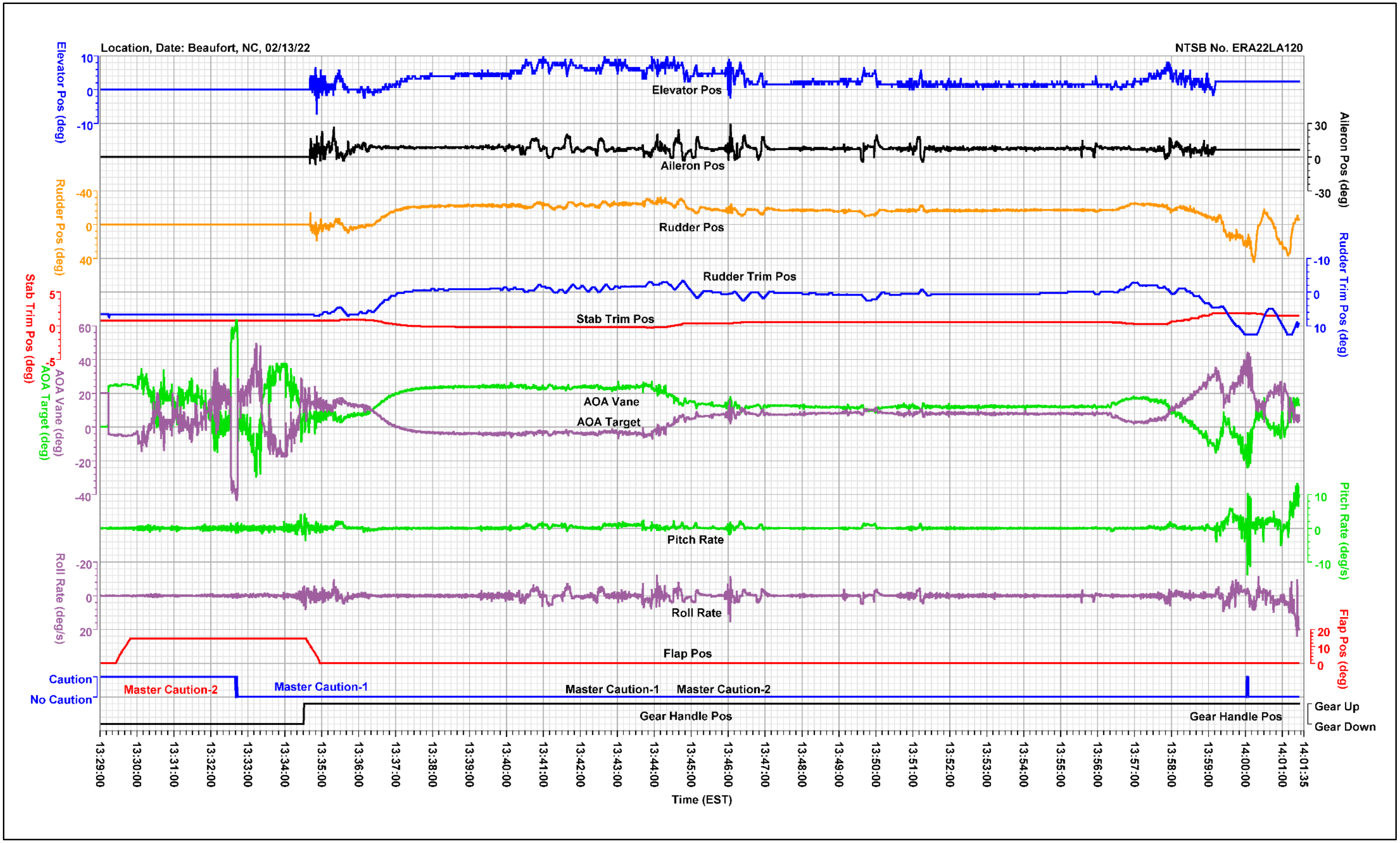

Figure 6. Plot of flight controls parameters.

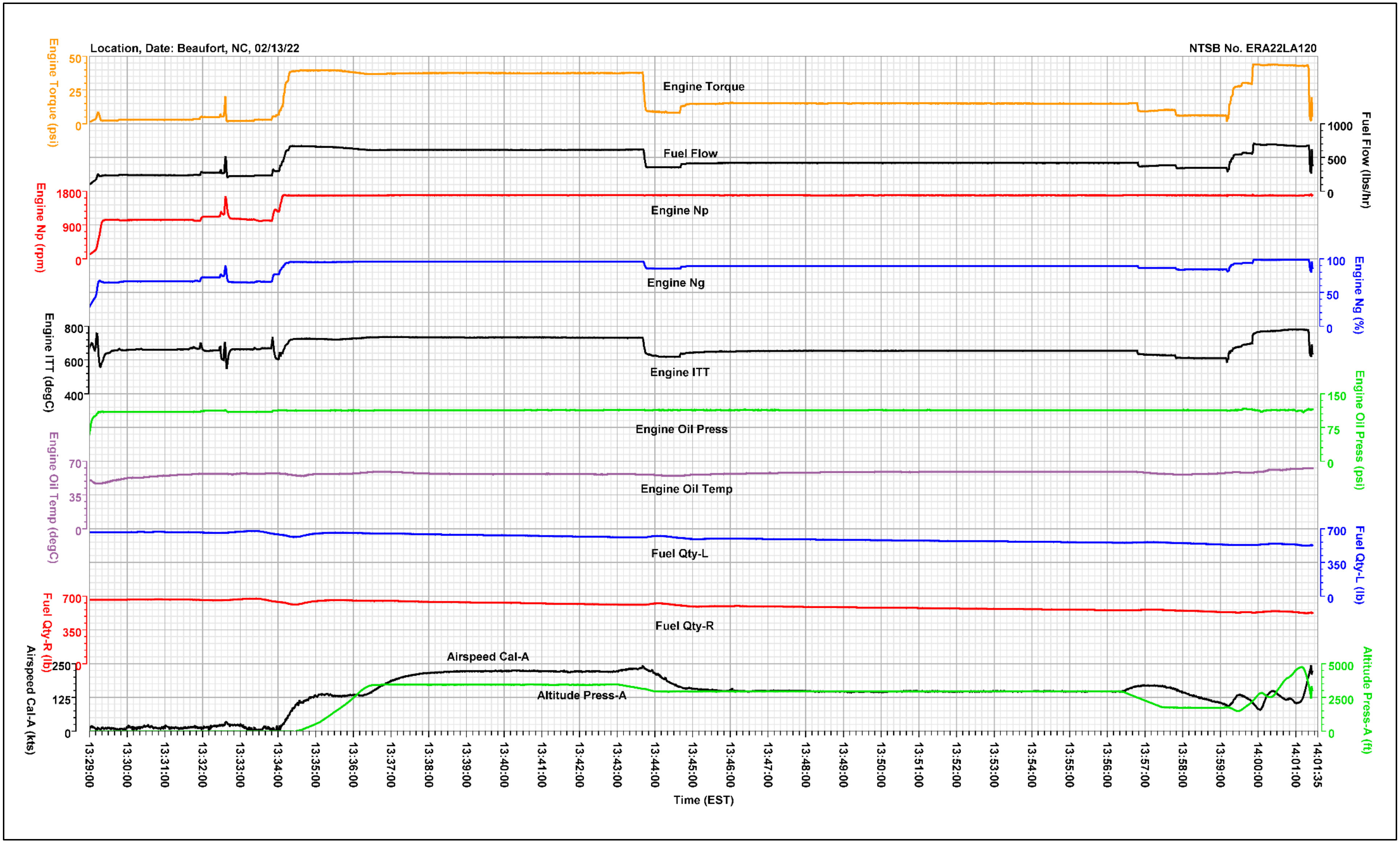

Figure 7. Plot of engine parameters.

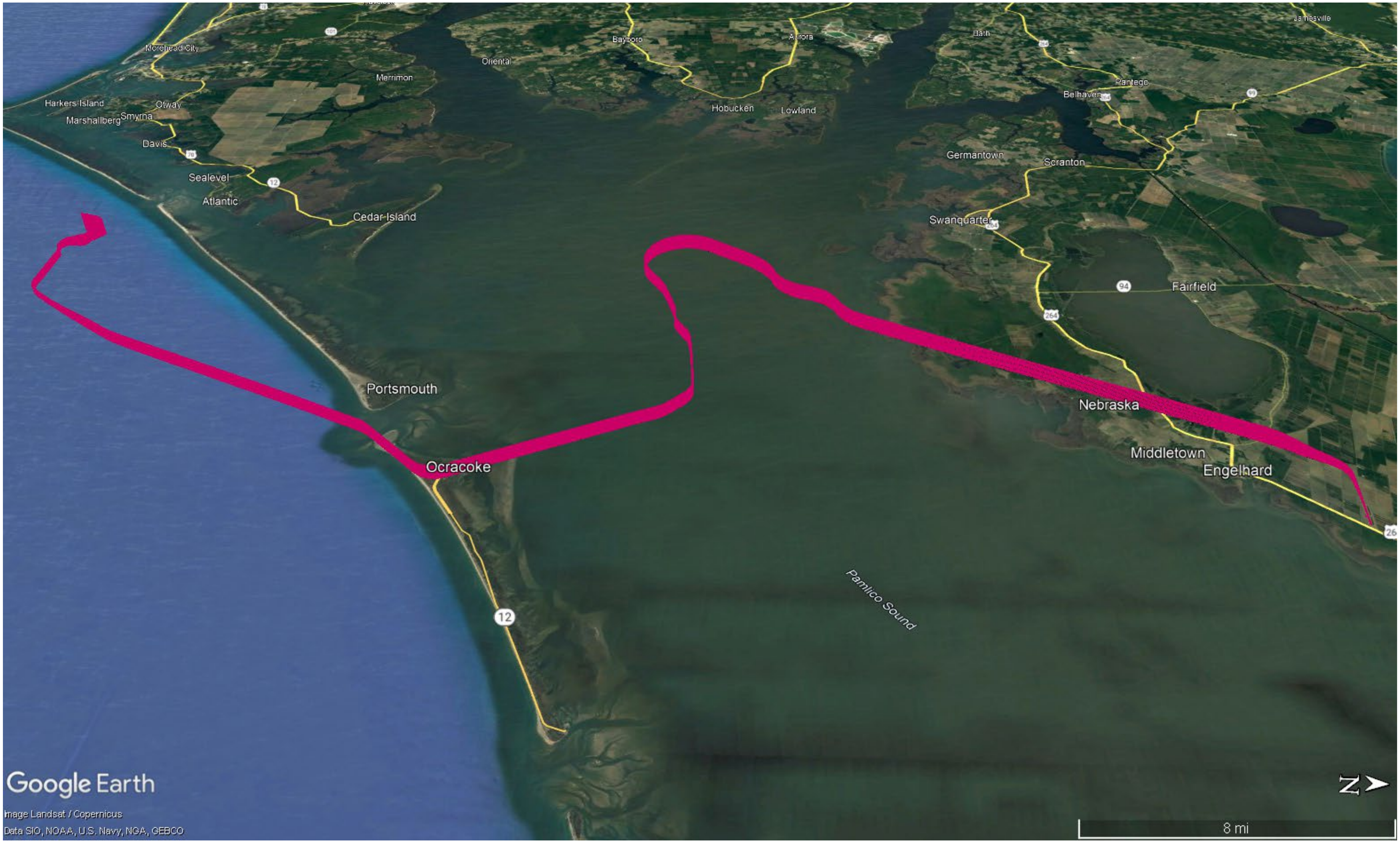

Figure 8. Map overlay of flight track of accident flight.

APPENDIX A. VERIFIED AND PROVIDED PARAMETERS

This appendix describes the parameters provided and verified in this report. Table 1 lists the plot/table labels, parameter names, and units. Additionally, table 2 describes the unit and discrete state abbreviations used in this report.

Table 1. Verified and provided FDR parameters

Plot/Table Names	Parameter Description	Units
1. Accel Lat	Lateral Acceleration	g
2. Accel Long	Longitudinal Acceleration	g
3. Accel Normal	Normal Acceleration	g
4. Active Pitch Mode	Autopilot Active Pitch Mode	
5. Active Roll Mode	Autopilot Active Roll Mode	
6. Aileron Pos	Aileron Surface Position	
7. Airspeed Cal-A	Calibrated Airspeed-A	kts
8. Airspeed Cal-B	Calibrated Airspeed-B	kts
9. Altitude Baro-A	Barometric-Adjusted Altitude-A	ft
10. Altitude Baro-B	Barometric-Adjusted Altitude-B	ft
11. Altitude Press-A	Pressure Altitude-A	ft
12. Altitude Press-B	Pressure Altitude-B	ft
13. Altitude Sel	Selected Altitude	ft
14. AOA Target	Target Angle of Attack	deg
15. AOA Vane	Angle of Attack Vane Angle	deg
16. AP Abnormal Disengage	Autopilot Abnormal Disengagement	
17. AP Avail	Autopilot Available	
18. AP Eng	Autopilot Engaged	
19. AP Normal Disengage	Autopilot Normal Disengagement	
20. AP Sel	Autopilot Selected	
21. Baro Setting-L	Left Barometric Setting	inHg
22. Baro Setting-R	Right Barometric Setting	inHg
23. Course Sel	Course Selected	deg
24. Elevator Pos	Elevator Surface Position	deg
25. Engine ITT	Engine Interturbine Temperature	degC
26. Engine Ng	Engine Gas Generator Speed	%
27. Engine Np	Engine Propeller Speed	rpm
28. Engine Oil Press	Engine Oil Pressure	psi
29. Engine Oil Temp	Engine Oil Temperature	degC
30. Engine Torque	Engine Torque Output	psi
31. FCS Flight Dir Lvl D Avail	Flight Director Available	
32. Flap Pos	Flap Surface Position	deg

Plot/Table Names	Parameter Description	Units
33. Fuel Flow	Engine Fuel Flow	lbs/hr
34. Fuel Qty-L	Left Fuel Quantity	lb
35. Fuel Qty-R	Right Fuel Quantity	lb
36. Gear Handle Pos	Landing Gear Handle Position	
37. Ground Speed	Ground Speed	kts
38. Heading Mag-A	Magnetic Heading-A	deg
39. Heading Mag-B	Magnetic Heading-B	deg
40. Key VHF-L	Left VHF Keying	
41. Key VHF-R	Right VHF Keying	
42. Latitude-FMS1	Latitude	deg
43. Longitude-FMS1	Longitude	deg
44. Master Caution-1	Master Caution-1	
45. Master Caution-2	Master Caution-2	
46. Master Warn-1	Master Warning-1	
47. Master Warn-2	Master Warning-2	
48. On Ground-Global	Weight on Wheels	
49. Ovrspd Warn	Overspeed Warning	
50. Pitch Rate	Body Pitch Rate	deg/s
51. Pitch-A	Pitch Angle-A	deg
52. Pitch-B	Pitch Angle-B	deg
53. Pri Nav Source	Primary Navigation Source	
54. Roll Rate	Body Roll Rate	deg/s
55. Roll-A	Roll Angle-A	deg
56. Roll-B	Roll Angle-B	deg
57. Rudder Pos	Rudder Surface Position	deg
58. Rudder Trim Pos	Rudder Trim Position	deg
59. Speed (CAS) Sel	Calibrated Airspeed Selected	kts
60. Stab Trim Pos	Stabilizer Trim Position	deg
61. Stick Pusher	Stick Pusher Active	
62. Stick Shaker	Stick Shaker Active	

Note: This FDR 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 FDR plots and in the electronic data has not been corrected for the local altimeter setting at the time of the event.

Note: Parameters with a blank unit description in table 1 are discretes. A discrete is typically a 1-bit parameter that is either a 0 state or a 1 state where each state is uniquely defined for each parameter.

Table 2. Unit and discrete state abbreviations

Unit and Discrete State Abbreviations	Description
Avail	Available
deg	degrees
deg/s	degrees per second
degC	degrees Celsius
FCS	Flight Controls System
FD	Flight Director
FMS	Flight Management System
ft	feet
g	gravitational acceleration
inHg	inches of Mercury
kts	knots
lb	pounds
lbs/hr	pounds per hour
LNAV	Lateral Navigation
Lvl	Level
Norm	Normal
psi	pounds per square inch
rpm	revolutions per minute
Sel	Selected
V/S	Vertical Speed