

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



ERA21FA346

FLIGHT DATA RECORDER

Specialist's Factual Report

February 8, 2023

TABLE OF CONTENTS

A. ACCIDENT.....	3
B. FLIGHT DATA RECORDER SPECIALIST	3
C. FEDERAL CARRIAGE REQUIREMENTS.....	3
D. DETAILS OF THE INVESTIGATION	3
1.0 L3 FA2100 DESCRIPTION.....	3
1.1 Recorder Condition	4
1.2 Recording Description	6
1.2.1 Engineering Unit Conversions	6
1.3 Time Correlation	6
E. FIGURES AND TABULAR DATA.....	6
APPENDIX A. VERIFIED AND PROVIDED PARAMETERS	19

A. ACCIDENT

Location: Farmington, CT
Date: September 2, 2021
Time: 09:51 am EDT
Airplane: Cessna 560XL, Registration N560AR

B. FLIGHT DATA RECORDER SPECIALIST

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

C. FEDERAL CARRIAGE REQUIREMENTS

The event aircraft, N560AR, was operating as Title 14 *Code of Federal Regulations* (CFR) Part 91. The event aircraft was manufactured in 2009 and was operating such that it was not required to be equipped with 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: L3 FA2100
Part Number: 2100-2043-00
Recorder Serial Number: 000574343

1.0 L3 FA2100 Description

This model FDR records airplane flight information in a digital format using solid-state flash memory as the recording medium. The FA2100 can receive data in the ARINC 573/717/747 configurations and can record a minimum of 25 hours of flight data. It is configured to record 256 12-bit words of digital information every second. Each grouping of 256 words (each second) is called a subframe. Each subframe has a unique 12-bit synchronization (sync) word identifying it as subframe 1, 2, 3, or 4. The sync word is the first word in each subframe. The data stream is "in sync" when successive sync words appear at proper 256-word intervals. Each data parameter (e.g. altitude, heading, airspeed) has a specifically assigned word number within the subframe. The FA2100 is designed to meet the crash-survivability requirements of TSO-C124a.

1.1 Recorder Condition

The recorder was covered with dirt and carbon soot and combustion particles as shown in figure 1. The memory module was removed from the recorder (see figure 2). The memory module, ribbon cable, and connector showed no signs of heat stress. The temperature dot indicated the memory module was not compromised by heat exposure. The memory module was downloaded using NTSB's equipment and the recorder manufacturer's software.

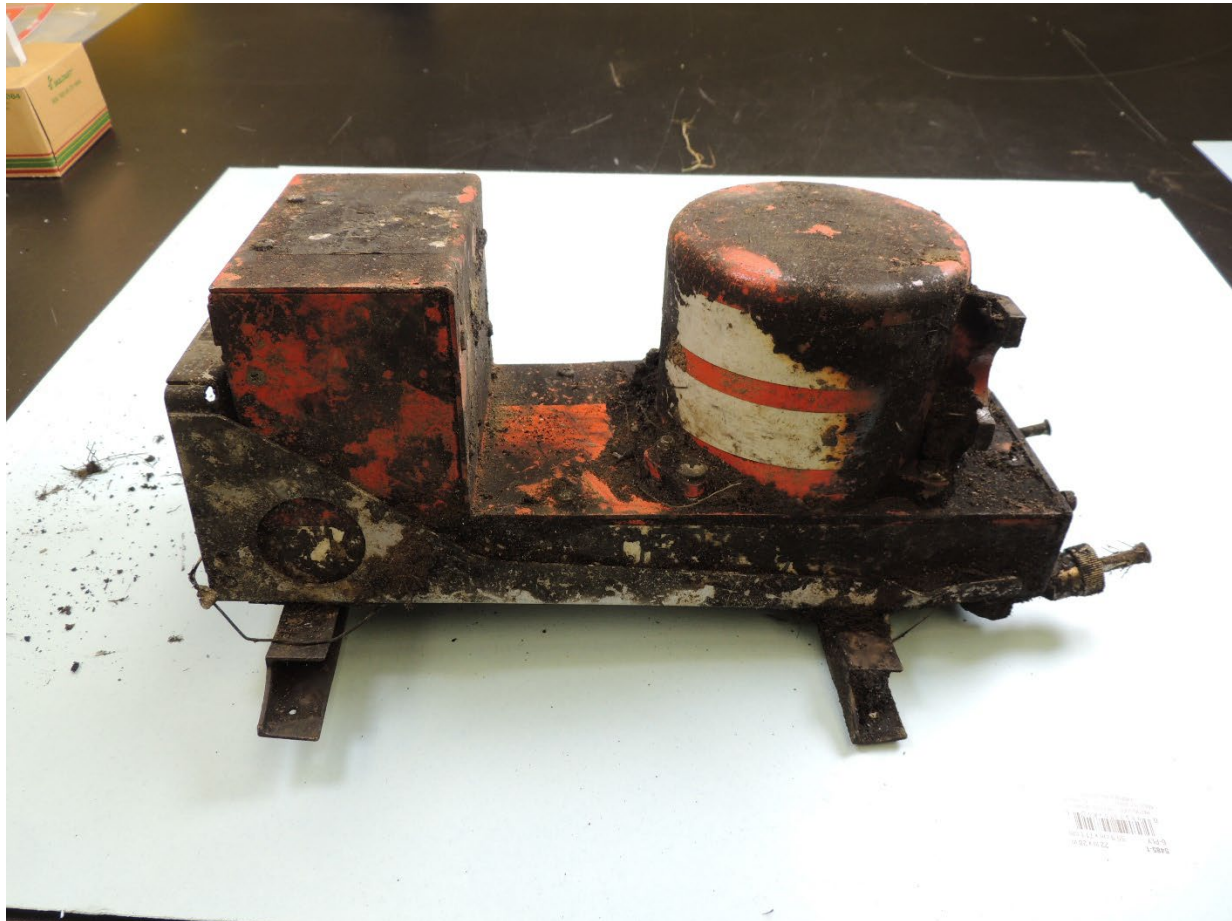


Figure 1. Damaged exterior of flight data recorder.

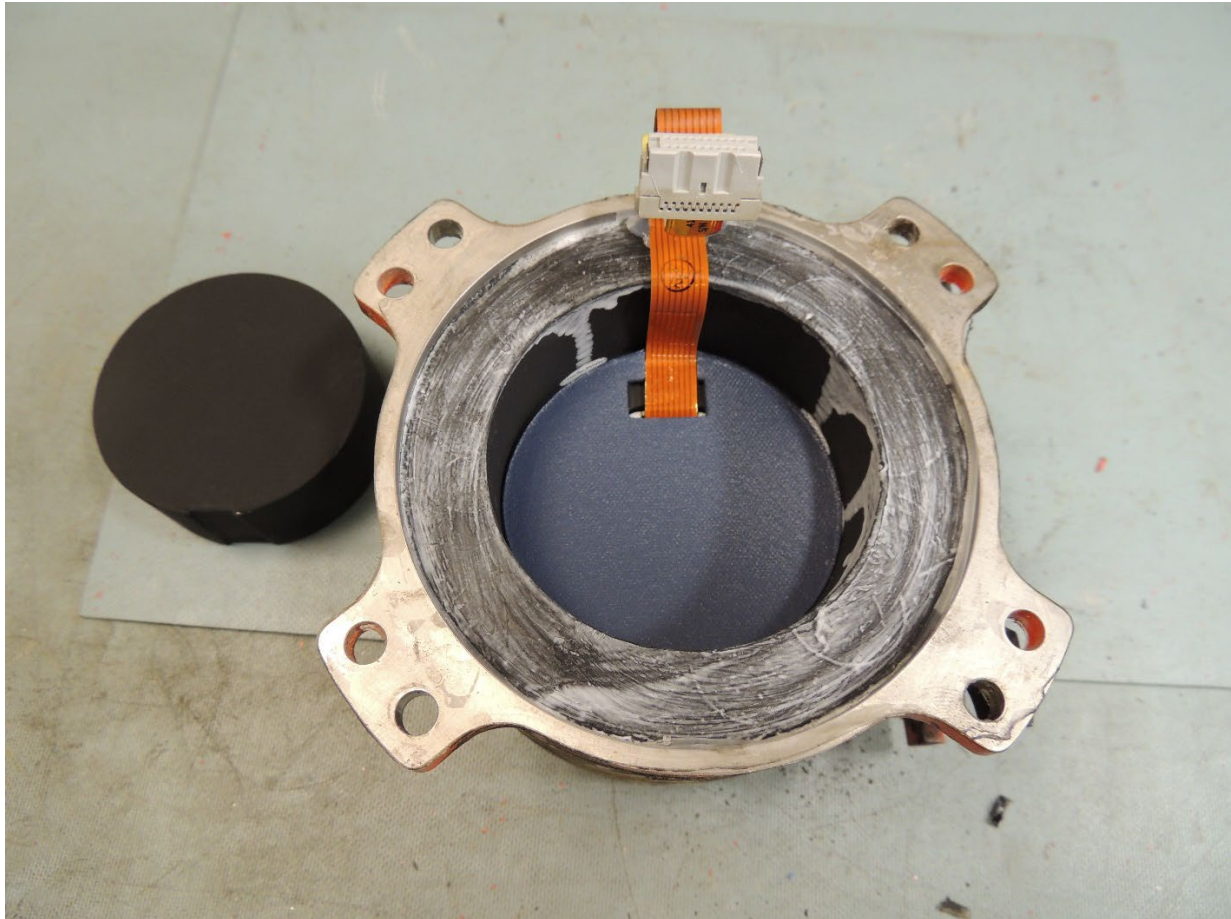


Figure 2. Memory module being removed from the recorder.

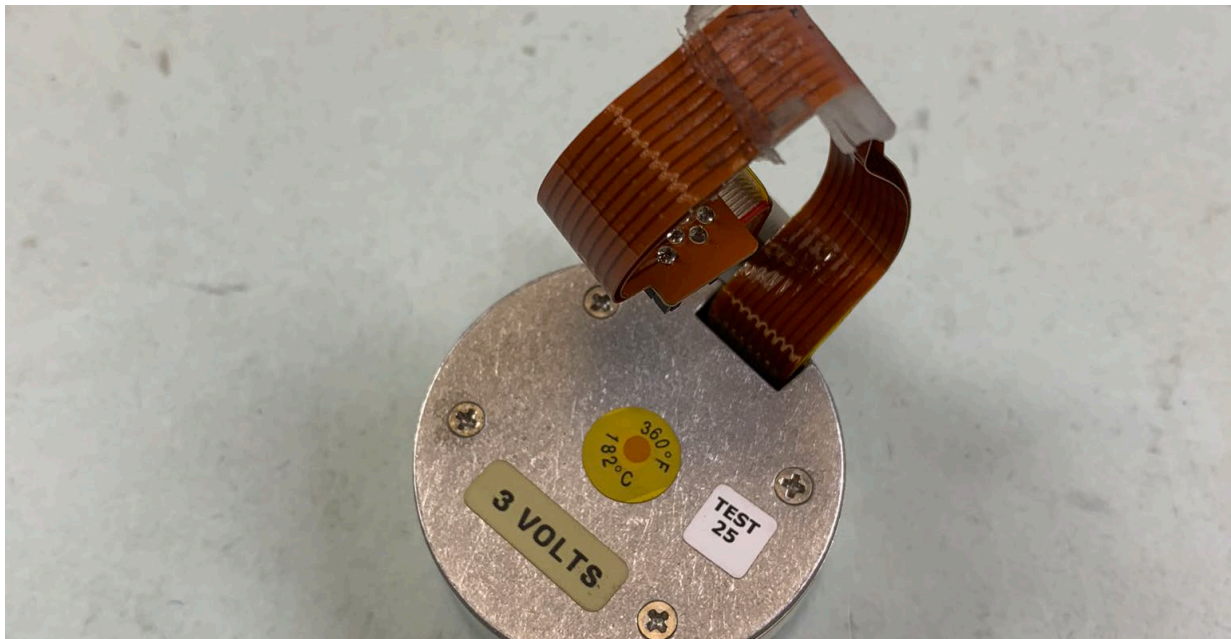


Figure 3. Memory module removed from recorder with temperature dot exposed.

1.2 Recording Description

The FDR recording contained approximately 197 hours 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 6 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, eastern daylight time (EDT), was established by using the recorded coordinated universal time (UTC) Hours, UTC Minutes, and UTC Seconds and then applying an additional 4 hours offset to change UTC to EDT.

Accordingly, the time offset for the event flight data from SRN to local EDT is the following: $EDT = SRN - 674,321.316$. Therefore, for the rest of this report, all times are referenced as EDT, not SRN. However, two previous takeoffs provided for comparison are referenced as SRN, not local time.

E. FIGURES AND TABULAR DATA

Figures 4 to 11 contain FDR data recorded during the event on September 2, 2021. Figure 12 contains FDR data recorded during the previous takeoff to the accident, and figure 13 contains FDR data recorded during the second previous takeoff to the accident. All the parameters listed in table 1 are plotted except UTC Hours, UTC Minutes, and UTC Seconds.

Figures 4 to 7 cover the range of 9:50 to 9:51, a time span from one minute prior to the end of the recording until the end of the recording. Figures 8 to 10 are map overlays from Google Earth showing an overview of the accident and two views

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 = +.

of the departure end of the runway. Figure 11 covers the range of 9:45 to 9:51, a time span of six minutes from the beginning of the accident recording until the end of the recording. Figures 12 and 13 cover a time span of one minute around the previous and second previous takeoffs, 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 FDR began recording the accident flight at 9:45:10 with engine 1 in its start sequence, capturing idle at 9:45:23. The flaps were moved from 0 to 15 degrees at about 9:45:28. The engine 2 fuel switch was moved from the cutoff position at 9:45:32 and the engine captured idle at 9:46:02. The stabilizer was moved into the Down position at 9:45:44. No flight control movements consistent with a control check were observed during the accident flight recording.

The aircraft began to taxi at about 9:46:10 and taxied continuously until it stopped aligned on the runway heading at 9:50:05. At about 9:50:14 the engine TLA advanced from 7 deg (consistent with idle power setting) to 27 deg, and the engines advanced in power and stabilized at 45% N1 with the aircraft still stopped. At 9:50:22 engine TLA began to increase again, and the aircraft started its takeoff roll. In total the aircraft stopped at the end of the runway for about 12 seconds before beginning the takeoff roll.

The engines stabilized at their thrust targets of about 91% N1. Peak longitudinal acceleration of 0.2657g was recorded at 9:50:27 and the aircraft accelerated at a steady rate, reaching 80 knots at about 9:50:40. As the aircraft accelerated past 100 knots at 9:50:43 the elevator position deflected up and aircraft pitch increased about 1.5 deg, from -0.5 deg to 1.0 deg. The aircraft continued to accelerate to 120 knots however it did not rotate past this point with continuous elevator upward deflection.

At 9:50:53 accelerations were recorded consistent with the aircraft departing the runway. The gear weight on wheels signal transitioned from ground to air and the aircraft rotated to ~22.3 deg in less than two seconds. The stick shaker also became active during this time, and the elevator position returned to neutral.

At 9:50:55, the gear position and weight on wheels signals became invalid, consistent with damage to the landing gear. Also at this time, the right engine began an uncommanded rollback in power consistent with damage to the engine. Changes in aircraft accelerations at this time were consistent with the aircraft striking an object and the aircraft began a roll to the right, becoming inverted in about 3.5 seconds.

In previous takeoff 1 and previous takeoff 2, longitudinal acceleration during the takeoff roll was approximately 0.4g. In both of those cases the elevator deflected

at similar speeds to the accident takeoff attempt and the aircraft rotated to about 10 deg over about 4 seconds. The aircraft took off from the runway in both cases as it rotated.

The corresponding tabular data used to create figures 4 to 11, including UTC Hours, UTC Minutes, UTC Seconds, Latitude, and Longitude, are provided in electronic comma separated value (CSV) format as attachment 1 to this report. The corresponding tabular data used to create figure 12 is provided in CSV format as attachment 2 to this report. The corresponding tabular data used to create figure 13 is provided in CSV format as attachment 3 to this report. Additionally, although elevator and aileron trim position engineering units conversions were determined to be invalid, they are included in the tabular data to show that there was consistency in the values recorded at takeoff between the accident and previously recorded data.

Submitted by:

Charles Cates
Mechanical Engineer/Recorder Specialist

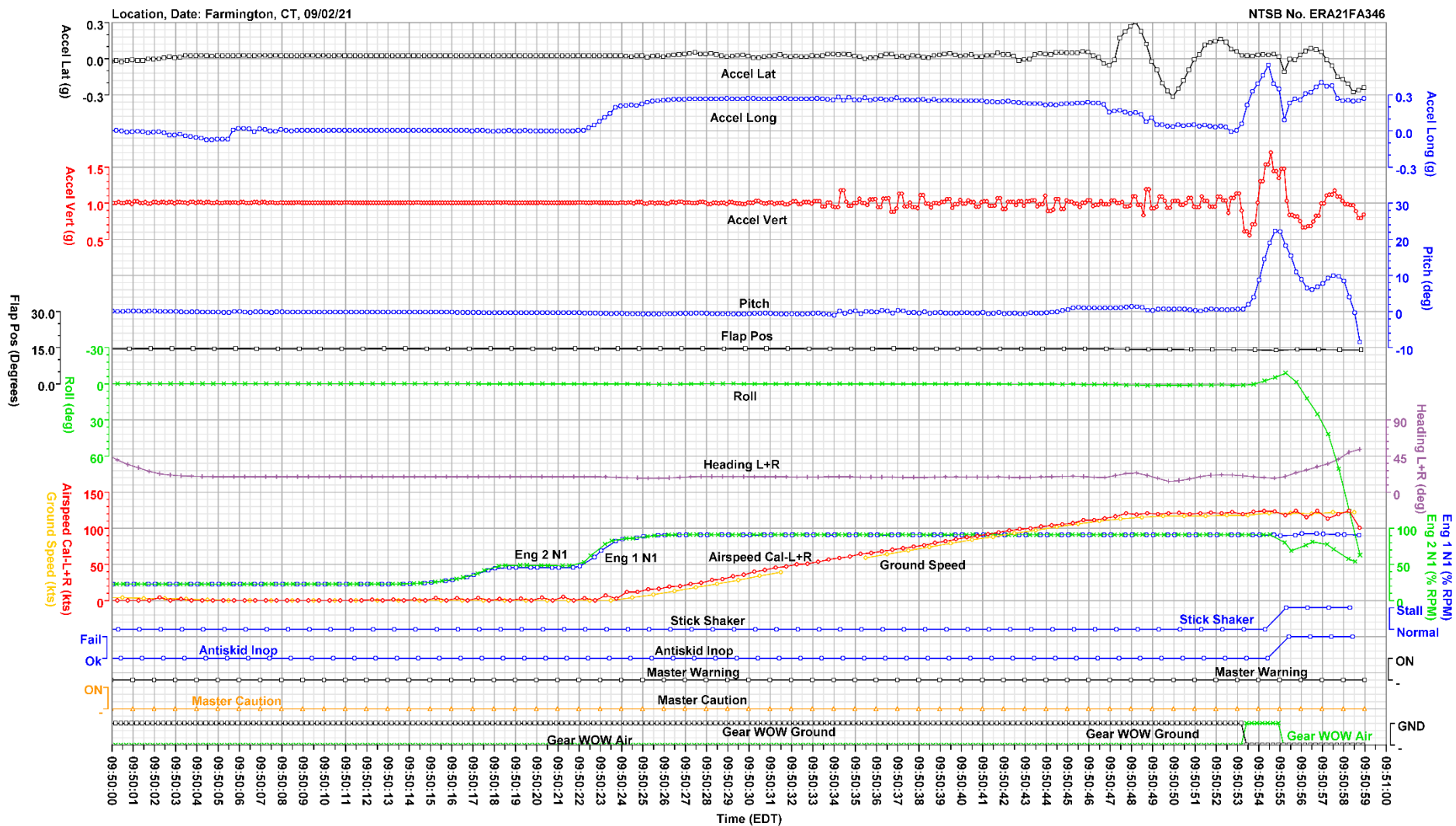


Figure 4. Plot of basic parameters.

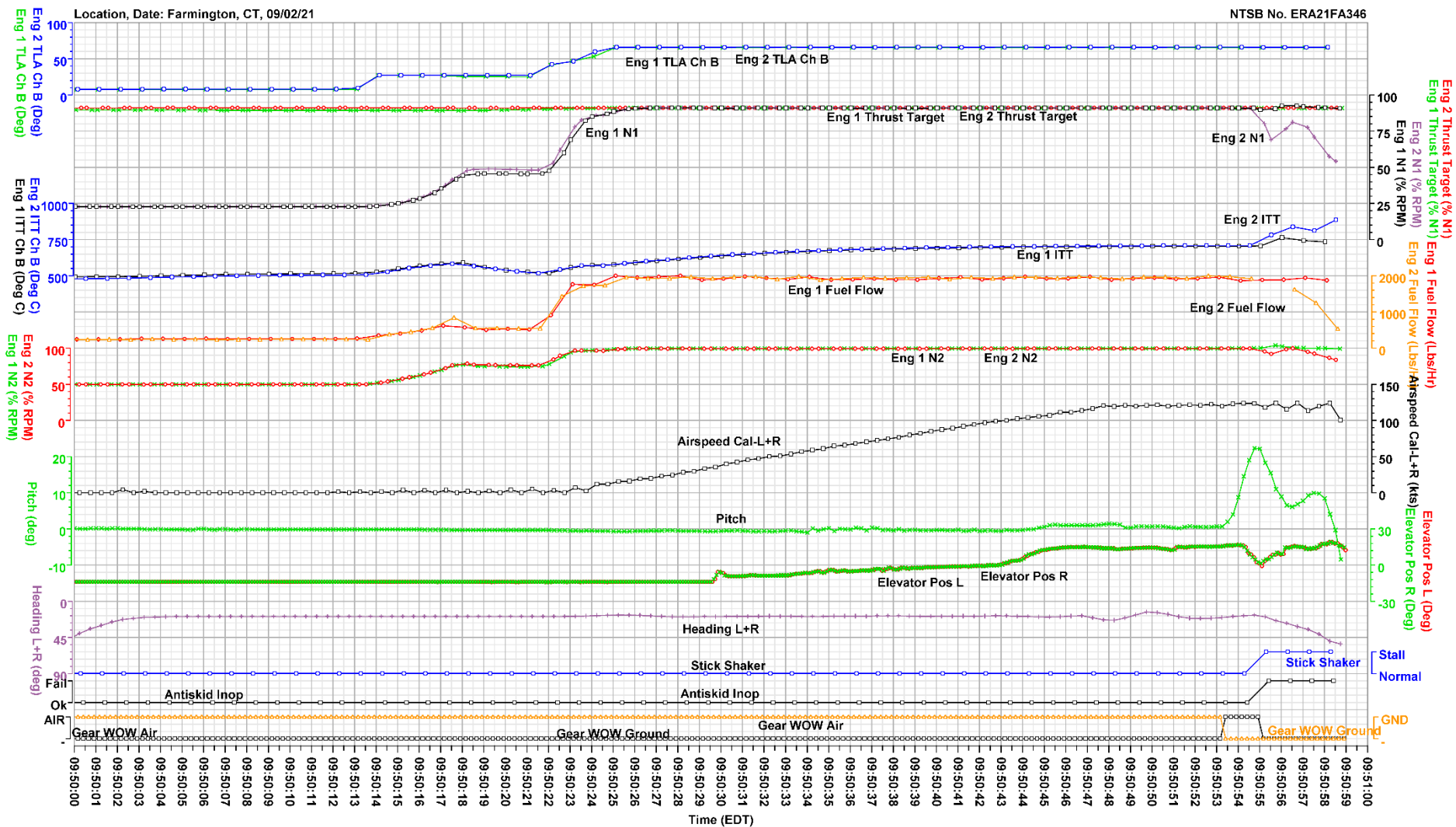


Figure 5. Plot of recorded engine parameters.

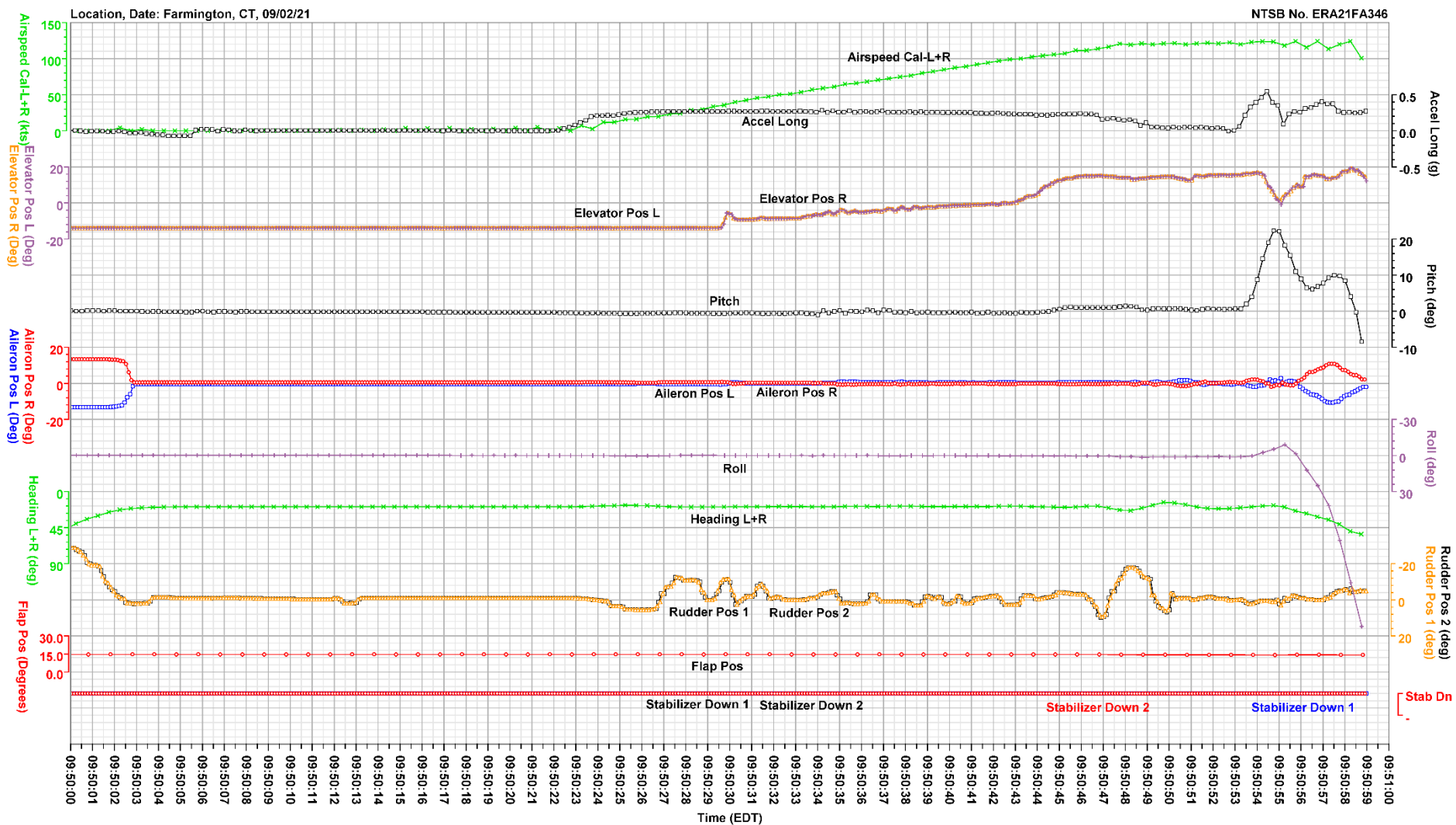


Figure 6. Plot showing recorded flight control positions.

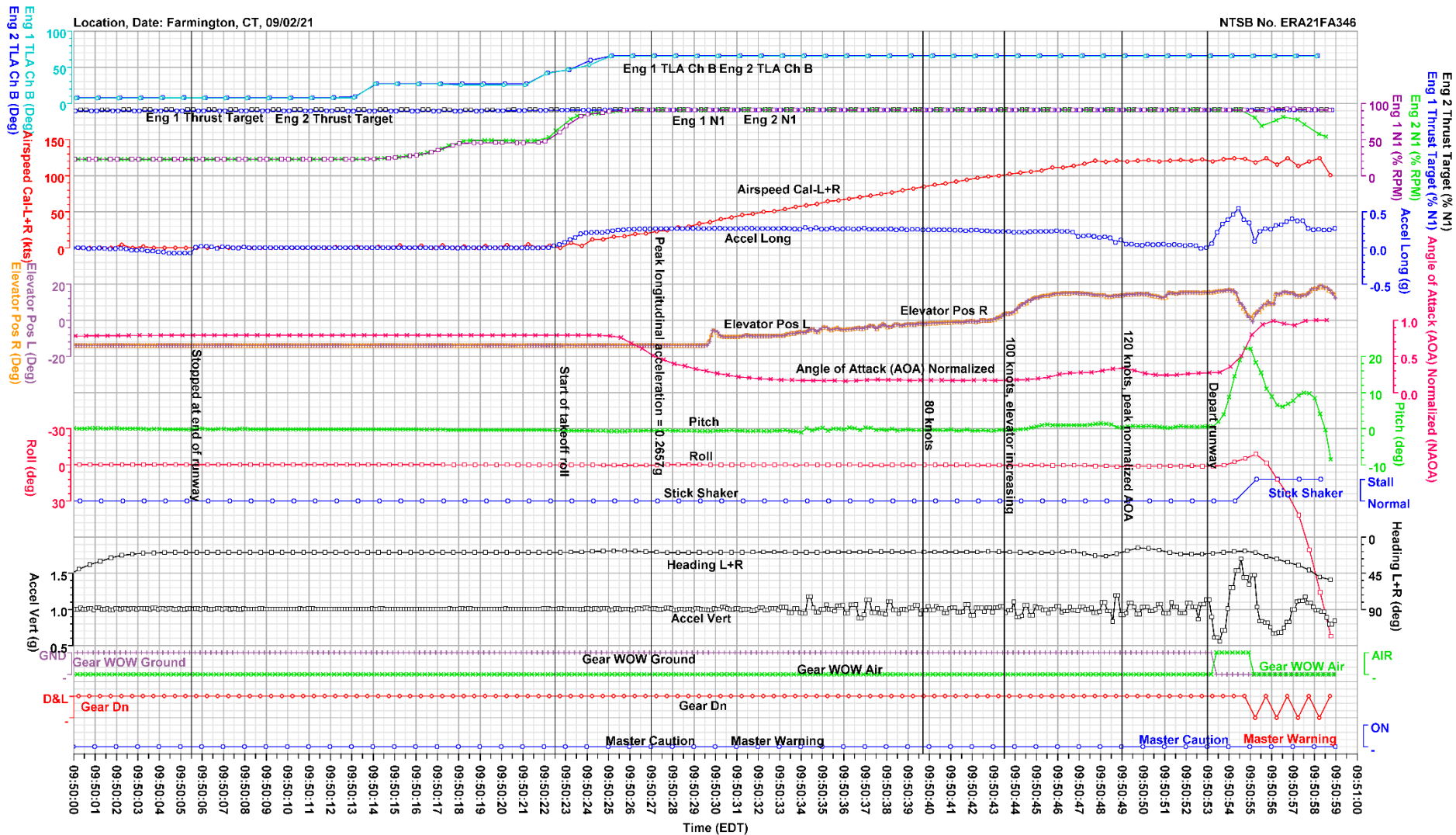


Figure 7. Plot with key events overlaid.

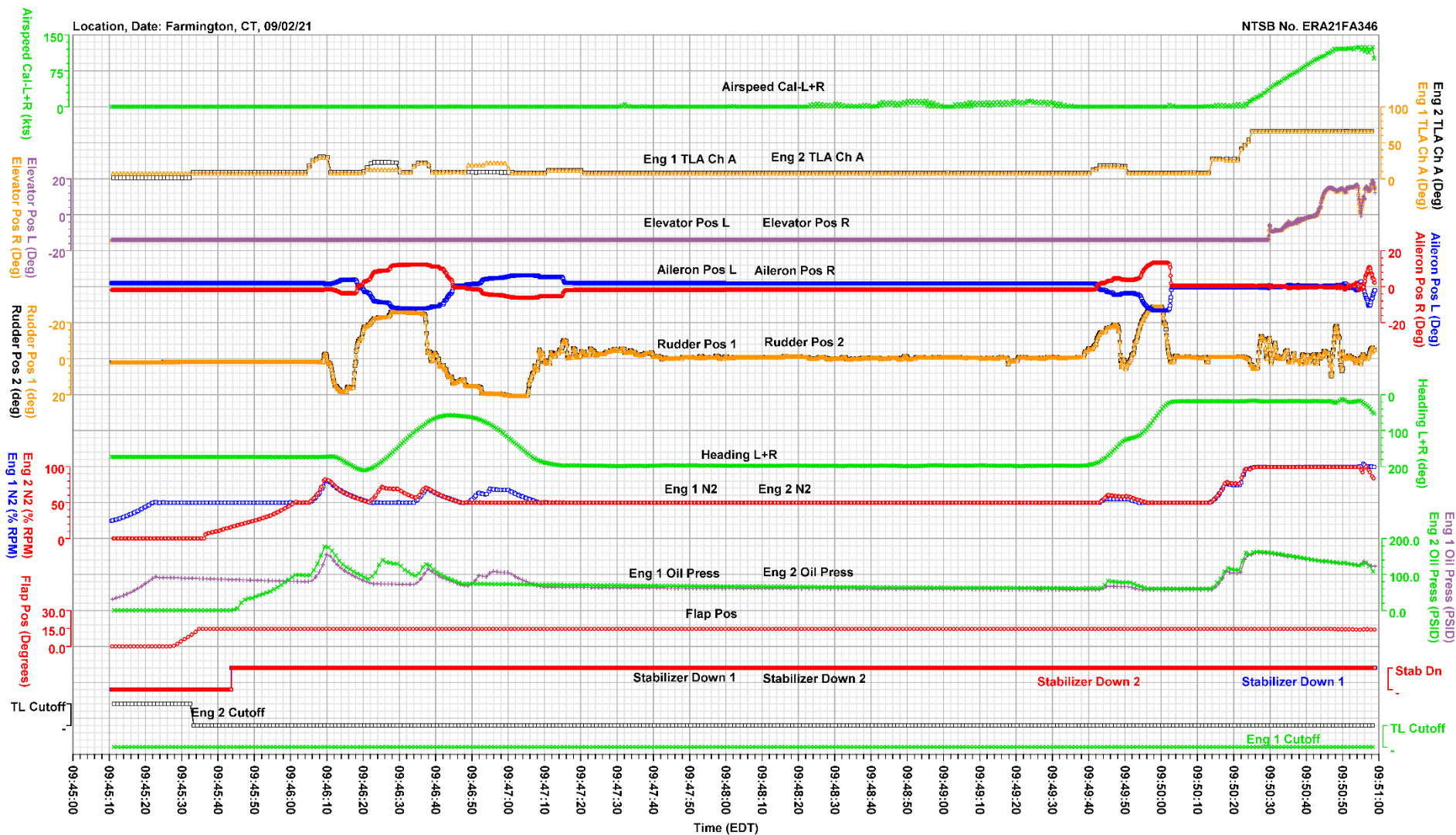


Figure 8. Plot of full accident recording.



Figure 9. Map overlay of takeoff to end of recording.



Figure 10. Map overlay of runway departure end from northeast.



Figure 11. Map overlay of runway departure end from northwest.

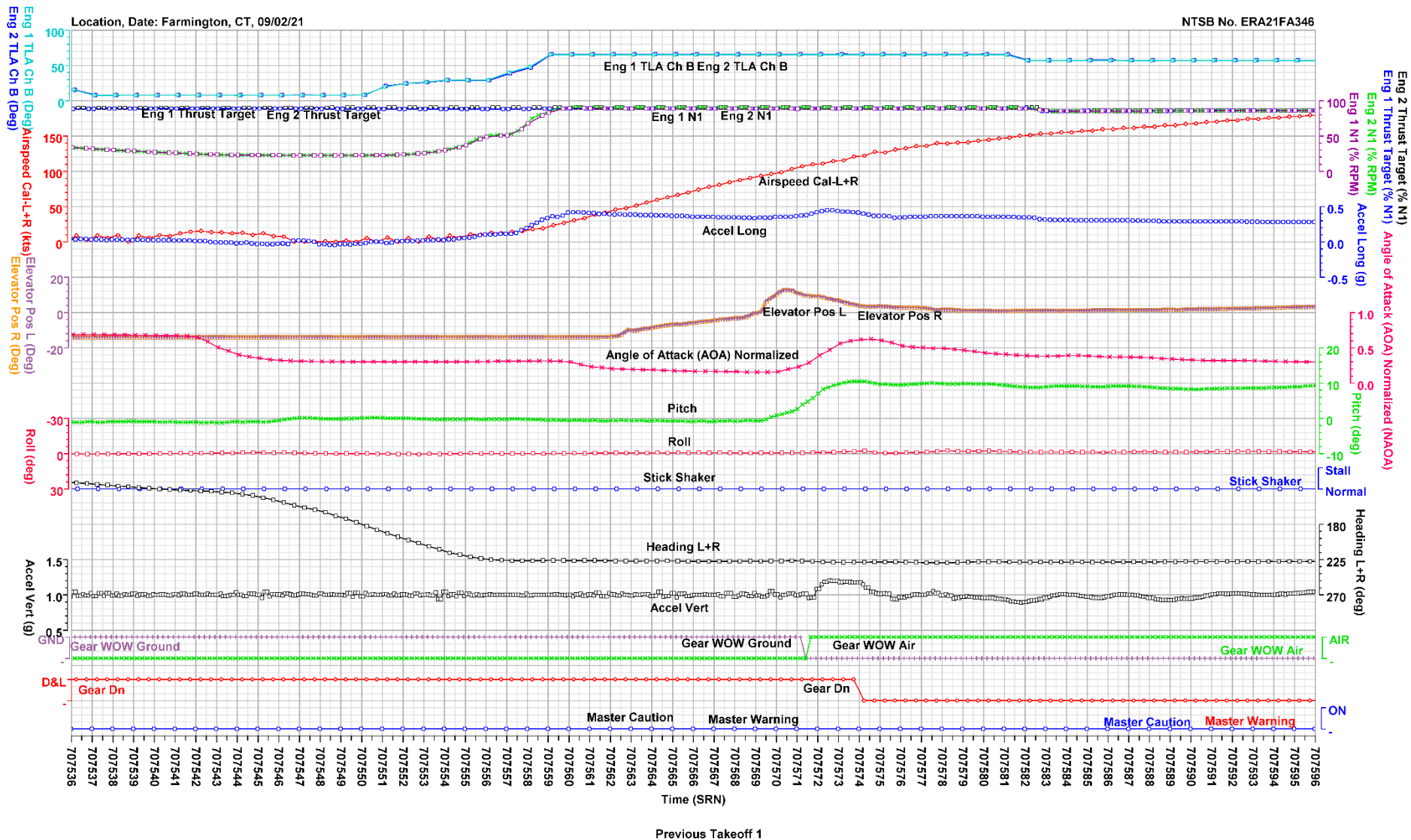


Figure 12. Plot of previous takeoff.

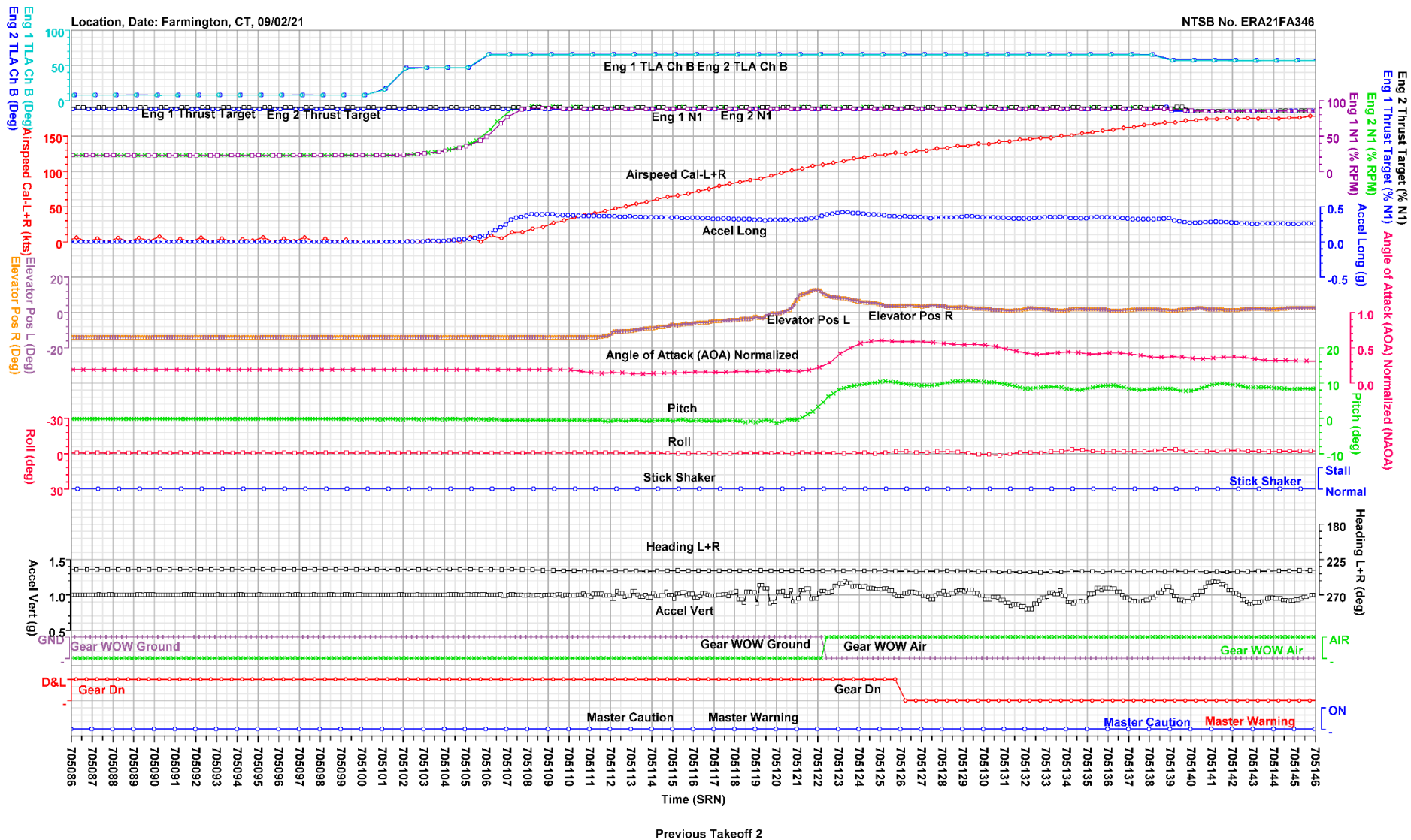


Figure 13. Plot of second previous takeoff.

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 abbreviations used in this report.

Table 1. Verified and provided FDR parameters

Plot/Table Labels	Parameter Names	Units
1. Accel Lat	Lateral Acceleration	g
2. Accel Long	Longitudinal Acceleration	g
3. Accel Vert	Vertical Acceleration	g
4. Aileron Pos L	Left Aileron Position	deg
5. Aileron Pos R	Right Aileron Position	deg
6. Aileron Trim Tab Pos	Aileron Trim Tab Position	deg
7. Airspeed Cal-L+R	Calibrated Airspeed from both ADCs	kts
8. Angle of Attack (AOA) Normalized	Normalized Angle of Attack	
9. Antiskid Inop	Antiskid System Inoperative	
10. Elevator Pos L	Left Elevator Position	deg
11. Elevator Pos R	Right Elevator Position	deg
12. Eng 1 Cutoff	Engine 1 Cutoff Switch Position	
13. Eng 1 Fuel Flow	Engine 1 Fuel Flow	pph
14. Eng 1 ITT Ch B	Engine 1 Interturbine Temperature	deg C
15. Eng 1 N1	Engine 1 Fan Speed	% rpm
16. Eng 1 N2	Engine 1 Core Speed	% rpm
17. Eng 1 Oil Press	Engine 1 Oil Pressure	psi
18. Eng 1 Thrust Target	Engine 1 Thrust Target	% rpm
19. Eng 1 TLA Ch A	Engine 1 Throttle Lever Angle	deg
20. Eng 1 TLA Ch B	Engine 1 Throttle Lever Angle	deg
21. Eng 2 Cutoff	Engine 2 Cutoff Switch Position	
22. Eng 2 Fuel Flow	Engine 2 Fuel Flow	pph
23. Eng 2 ITT Ch B	Engine 2 Interturbine Temperature	deg C
24. Eng 2 N1	Engine 2 Fan Speed	% rpm
25. Eng 2 N2	Engine 2 Core Speed	% rpm
26. Eng 2 Oil Press	Engine 2 Oil Pressure	psi
27. Eng 2 Thrust Target	Engine 2 Thrust Target	% rpm
28. Eng 2 TLA Ch A	Engine 2 Throttle Lever Angle	deg
29. Eng 2 TLA Ch B	Engine 2 Throttle Lever Angle	deg
30. Flap Pos	Flap Position	deg
31. Fuel Qty L	Left Tank Fuel Quantity	lb
32. Fuel Qty R	Right Tank Fuel Quantity	lb

Plot/Table Labels	Parameter Names	Units
33. Gear Dn	Gear Down	
34. Gear Hdl Pos	Gear Handle Position	
35. Gear WOW Air	Gear Detected In Air	
36. Gear WOW Ground	Gear Detected On Ground	
37. Ground Speed	Ground Speed	kts
38. Heading L+R	Magnetic Heading from both ADCs	deg
39. Latitude	Latitude	deg
40. Longitude	Longtiude	deg
41. Master Caution	Master Caution Active	
42. Master Warning	Master Warning Active	
43. Pitch	Pitch Angle	deg
44. Pitch Trim Surf Pos Trm Cmbd #1	Elevator Trim Position, Sensor 1	deg
45. Pitch Trim Surf Pos Trm Cmbd #2	Elevator Trim Position, Sensor 2	deg
46. Roll	Roll Angle	deg
47. Rudder Pos 1	Rudder Position, Sensor 1	deg
48. Rudder Pos 2	Rudder Position, Sensor 2	deg
49. Stabilizer Down 1	Stabilizer in Down Position	
50. Stabilizer Down 2	Stabilizer in Down Position	
51. Stick Shaker	Stick Shaker Active	
52. Time Hours	UTC Hours	hr
53. Time Minutes	UTC Minutes	min
54. Time Seconds	UTC Seconds	sec
55. Wind Direction	Wind Direction	deg
56. Wind Speed	Wind Speed	kts

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 abbreviations

Unit Abbreviations	Descriptions
% rpm	percent revolutions per minute
deg	degrees
deg C	degrees Celsius
g	gravitational acceleration
hr	hour
kts	knots
lb	pounds
min	minute
pph	pounds per hour
psi	pounds per square inch
sec	second