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

DCA22MA009

FLIGHT DATA RECORDER

Specialist's Factual Report

December 14, 2022

A. ACCIDENT

Location: Brookshire, Texas
Date: October 19, 2021
Time: 1000 central daylight time (CDT)
Airplane: McDonnell Douglas MD-87, N987AK

B. FLIGHT DATA RECORDER SPECIALIST

Specialist: Michael Portman
Aerospace Engineer – Recorder Specialist
National Transportation Safety Board (NTSB)

C. FEDERAL CARRIAGE REQUIREMENTS

The event aircraft, N987AK, was operating as Title 14 *Code of Federal Regulations* (CFR) Part 91. The event aircraft 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: Allied Signal/Honeywell UFDR
Part Number: Unknown
Recorder Serial Number: 5354

1.0 Allied Signal/Honeywell UFDR Description

The Honeywell Universal Flight Data Recorder (UFDR) records airplane flight information in a binary format, using analog signals, onto eight tracks of 1/4-inch Mylar tape. The UFDR can receive data in the ARINC 573/717/542 configurations and records 64 words of digital information every second, with each word 12 bits in length. Each grouping of 64 words (or 768 bits) is called a subframe. Each subframe has a unique 12-bit synchronization (sync) word identifying it as either subframe 1, 2, 3, or 4. The sync word is the first word in each subframe. Each grouping of consecutive 1, 2, 3 and 4 subframes comprise a frame (i.e., four seconds of data). The data stream is "in sync" when successive sync words appear at the proper 64-word intervals. Each data parameter (e.g. altitude, heading, and airspeed) has a specifically assigned word number within the subframe.

The UFDR records 8 distinct individual tracks, written bi-directionally. Approximately 3 hours of data are written on one track until reaching the end-of-tape sensor, and then the recorder reverses tape direction, switches to the next incremented track, and writes data in the reverse direction on the tape. Using this method, the FDR records even-numbered tracks in one direction, odd-numbered tracks in the opposite direction. A minimum of 25 hours of flight data is recorded by erasing the oldest data and replacing it with the newest.

Additionally, the UFDR is designed to meet the crash and fire protection characteristics of TSO-C51a.

1.1 Recorder Condition

The recorder sustained heat damage as shown in figure 1. The memory module was removed from the recorder and opened, as seen in figure 2. The magnetic tape was removed and found to have had minor damage at the extreme ends of the tape, as shown in figure 3. The cause of the damage is undetermined. The data were transcribed from the tape medium to computer hard drive for analysis using the NTSB's laboratory equipment.

Figure 1. Damaged exterior of flight data recorder.

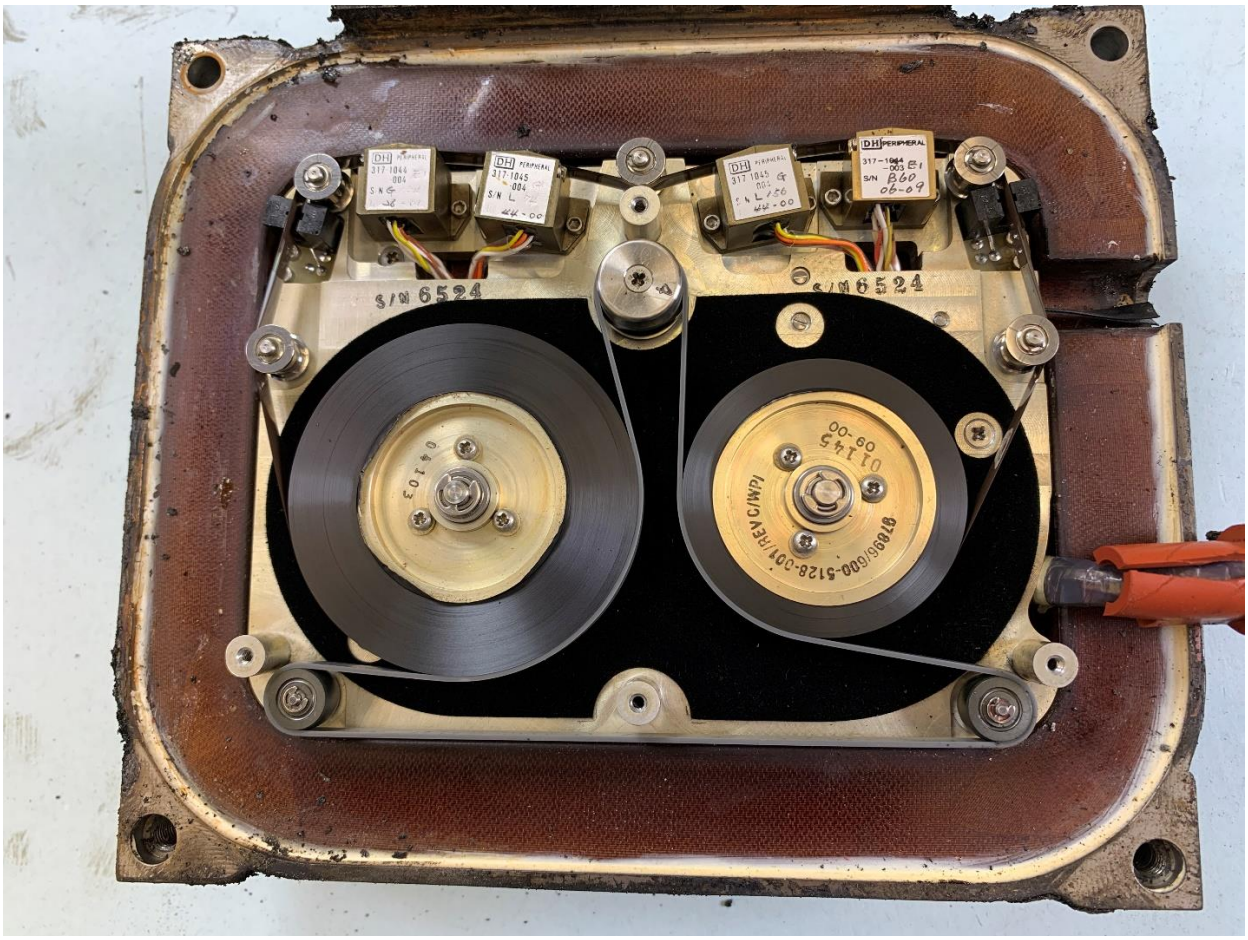

Figure 2. Interior of the Crash Survivable Memory Unit (CSMU) showing the magnetic tape mechanism.

Figure 3. Magnetic tape removed from recording mechanism showing deformed tape wrapped around the center spool.

1.2 Recording Description

The FDR recording contained approximately 25 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 found on track 5 of the FDR tape, and previous flights were found on track 6 of the FDR tape. The event flight was approximately 7 minutes in duration. Due to the nature of the tape-based recorder system and readout equipment, data dropouts (gaps in data) were noted, especially at the end of the accident flight recording.

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]

[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 = +.

In addition to the parameters contained in the documentation, two additional parameters were identified, in consultation with the aircraft manufacturer, that were pertinent to the investigation, control column position and spoiler angle. However, due to a lack of documentation for these parameters from either the NTSB or the aircraft manufacturer, conversion from raw data to engineering units was not possible. Therefore, these two parameters are presented in raw counts.

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

1.3 Time Correlation

Correlation of the FDR data from SRN to the event local time, CDT, was established with an offset provided by the Cockpit Voice Recorder (CVR) Group Chair in the Factual Report, Cockpit Voice Recorder. Accordingly, the time offset for the event flight data from SRN to local CDT is the following: CDT = SRN + 33,056.45. Therefore, for the rest of this report, all times are referenced as CDT, not SRN. However, previous takeoffs are referenced as SRN, not local time.

E. FIGURES AND TABULAR DATA

Figures 4 to 9 contain FDR data recorded during the event on October 19, 2021. Figures 10 to 12 contain FDR data recorded during the previous takeoff from Laredo, Texas, on April 26, 2021. Figures 13 to 15 contain FDR data recorded during a further previous takeoff from Cabo San Lucas, Mexico, on April 26, 2021. All the parameters listed in table 1 are plotted.

Figures 4, 6, and 8 show data for the entire accident recording of general parameters, control parameters, and engine parameters, respectively. Figures 5, 7, and 9 are zoomed plots showing a detailed view of the takeoff sequence of general parameters, control parameters, and engine parameters, respectively.

Figures 10, 11, and 12 show flight data for the preceding takeoff from Laredo, Texas, of general parameters, control parameters, and engine parameters, respectively. Figures 13, 14, and 15 show flight data for the preceding takeoff from Cabo San Lucas, Mexico, of general parameters, control parameters, and engine parameters, 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.

In summary, for the accident flight, the aircraft taxied to the runway and began the takeoff roll at approximately 09:59:24 CDT. During the taxi out, control surface deflections consistent with a controls check were noted. Of note, both elevator

surfaces were recorded consistently around 20 degrees nose down, beyond the documented valid parameter range of 15 degrees nose down to 25 degrees nose up. As the aircraft reached rotation speed, movements of the control wheel were noted, and the elevators appeared to move to a maximum deflection of 5 degrees nose down. As the aircraft failed to rotate significantly, thrust was reduced, and brakes, spoilers, and thrust reversers were applied, consistent with a rejected takeoff. The aircraft reached a maximum recorded airspeed of 158 knots at 09:59:56. Valid recorded data ended at approximately 10:00:03.

As part of the investigation, previous flights data were examined to evaluate the behavior of the elevator control surfaces. Generally, the elevators are free floating and will record deflections with changes in the wind. As the aircraft accelerates down the runway, the elevator deflections will gradually converge around or slightly below 0 degrees, until rotation, at which point the elevators will deflect in a nose-up, or positive, direction. This pattern was noted in the flight data of both previous takeoffs, but not in the accident takeoff.

The corresponding tabular data used to create figures 4 to 9, figures 10 to 12, and figures 13 to 15 are provided in electronic comma separated value (CSV) format as attachments 1, 2, and 3 to this report, respectively.

Submitted by:

Michael Portman
Aerospace Engineer – Recorder Specialist

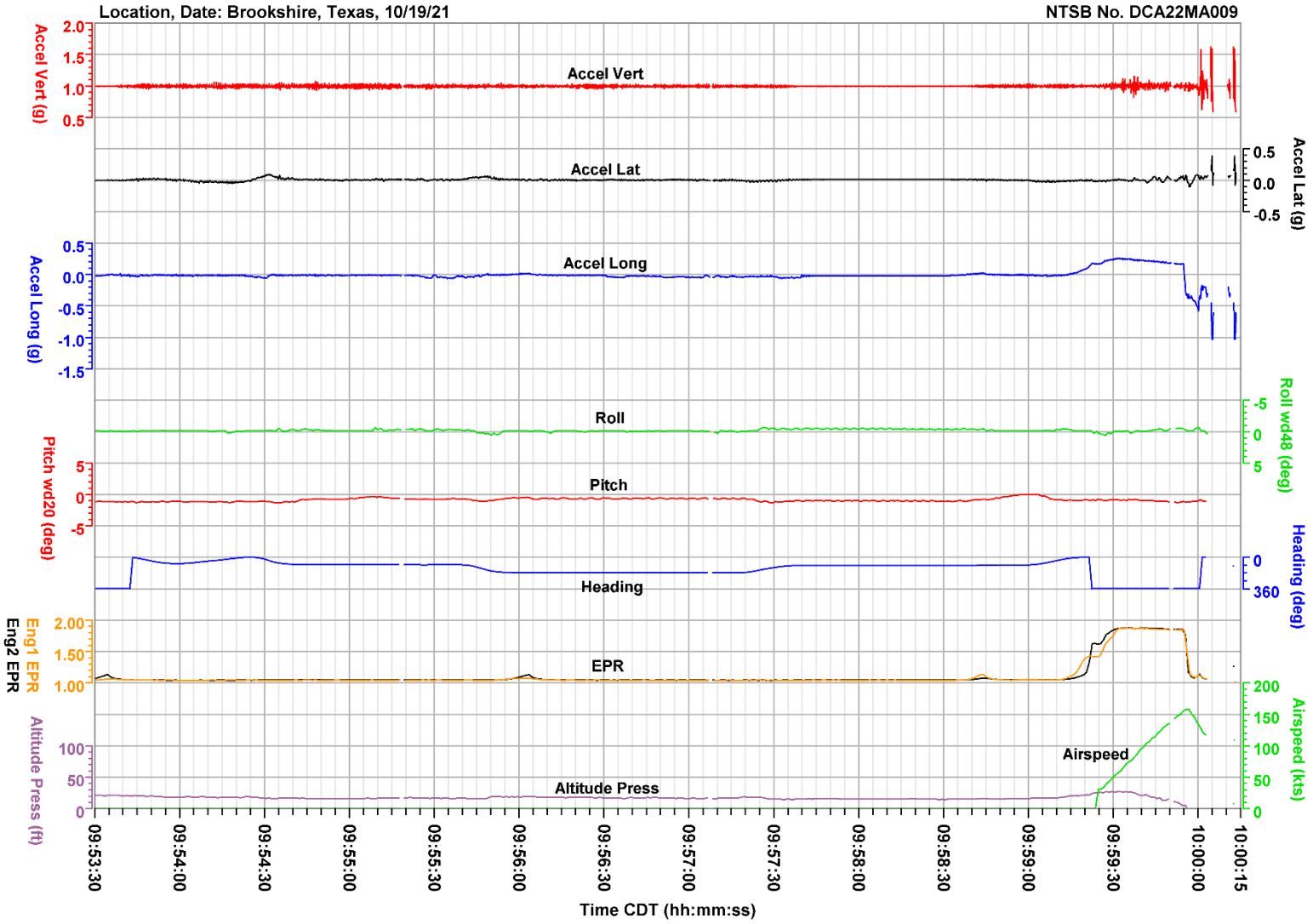

Figure 4. Plot of basic parameters for the entire accident recording.

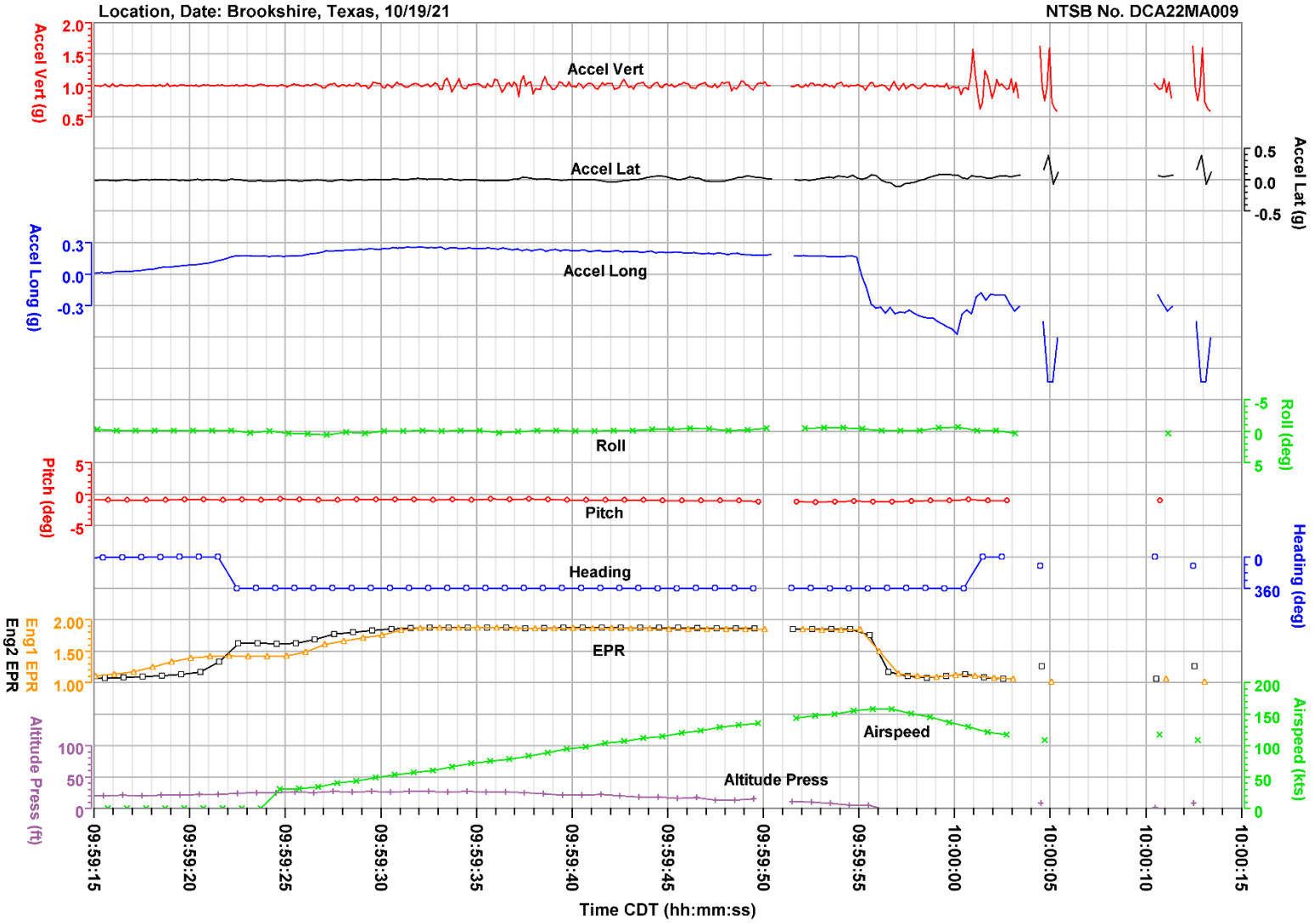

Figure 5. Plot of basic parameters for the accident takeoff.

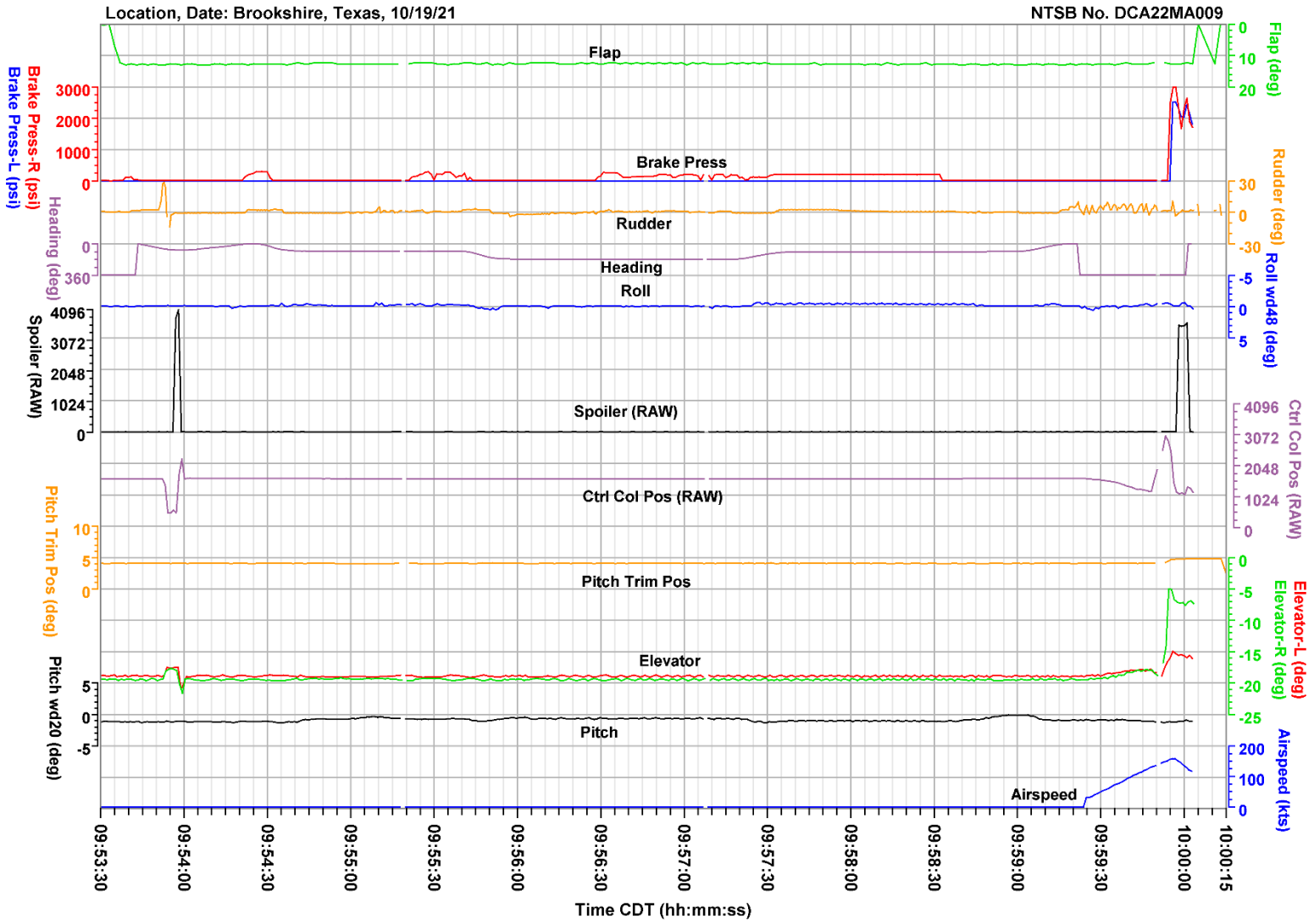

Figure 6. Plot of control parameters for the entire accident recording.

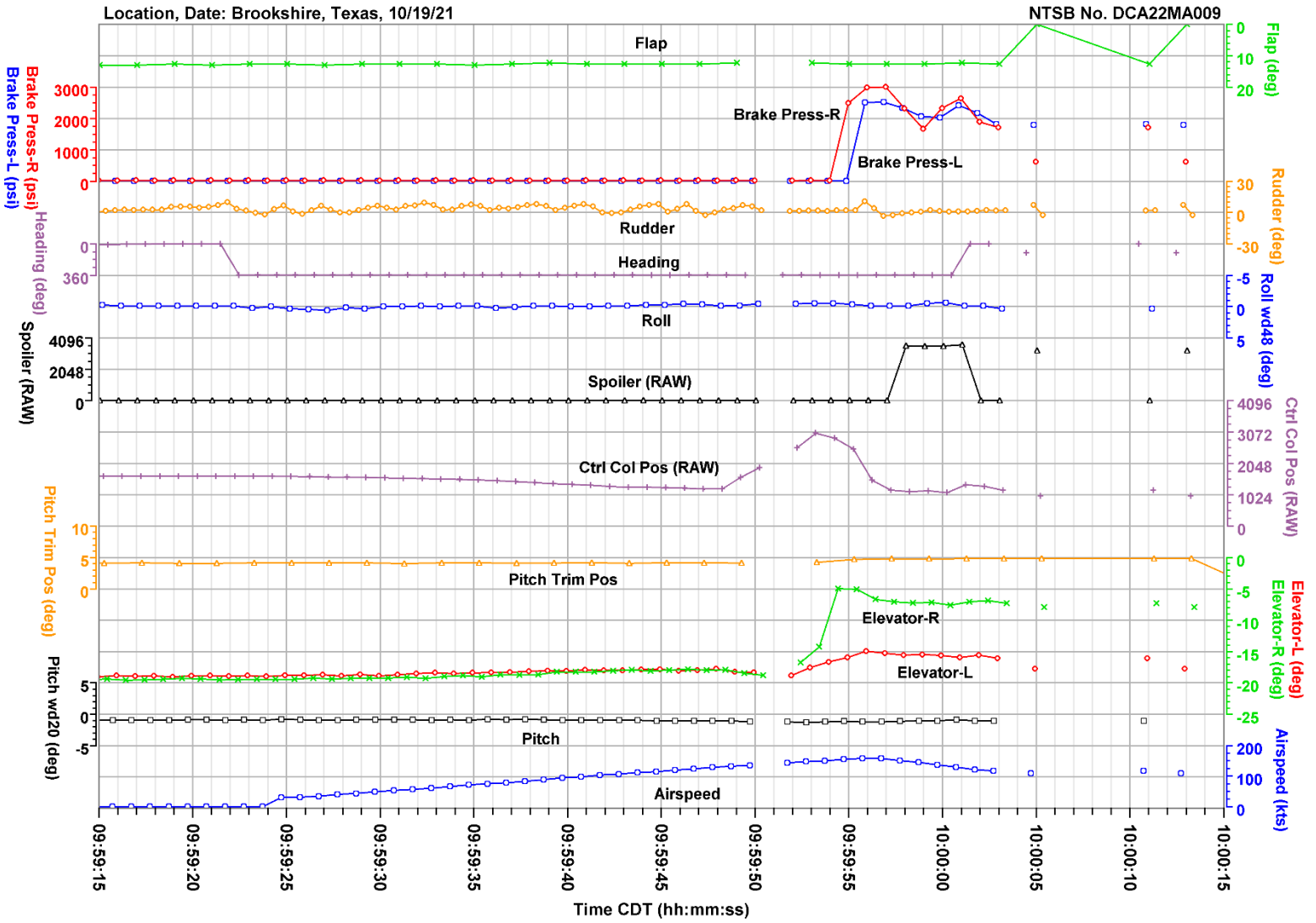

Figure 7. Plot of control parameters for the accident takeoff.

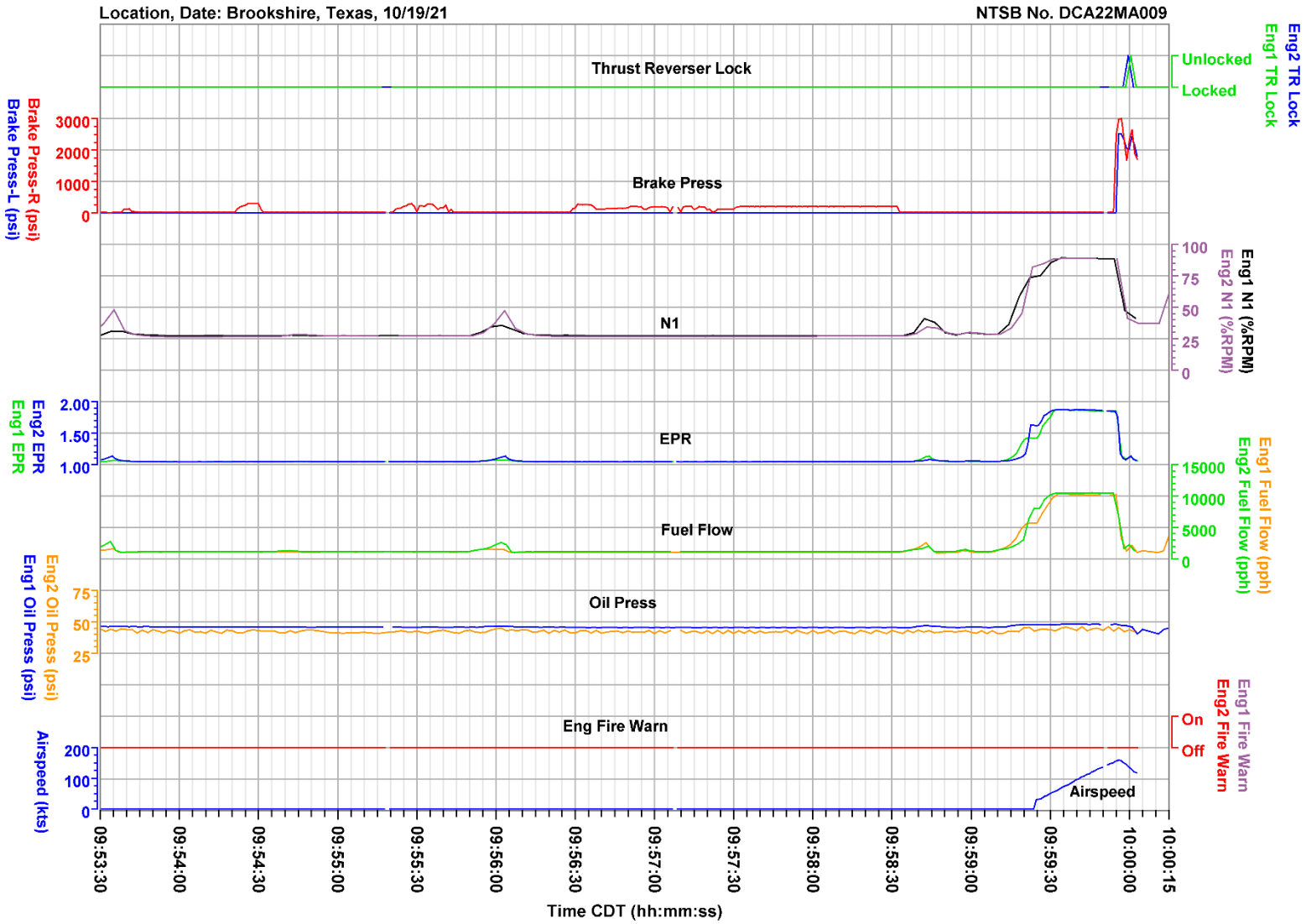

Figure 8. Plot of engine parameters for the entire accident recording.

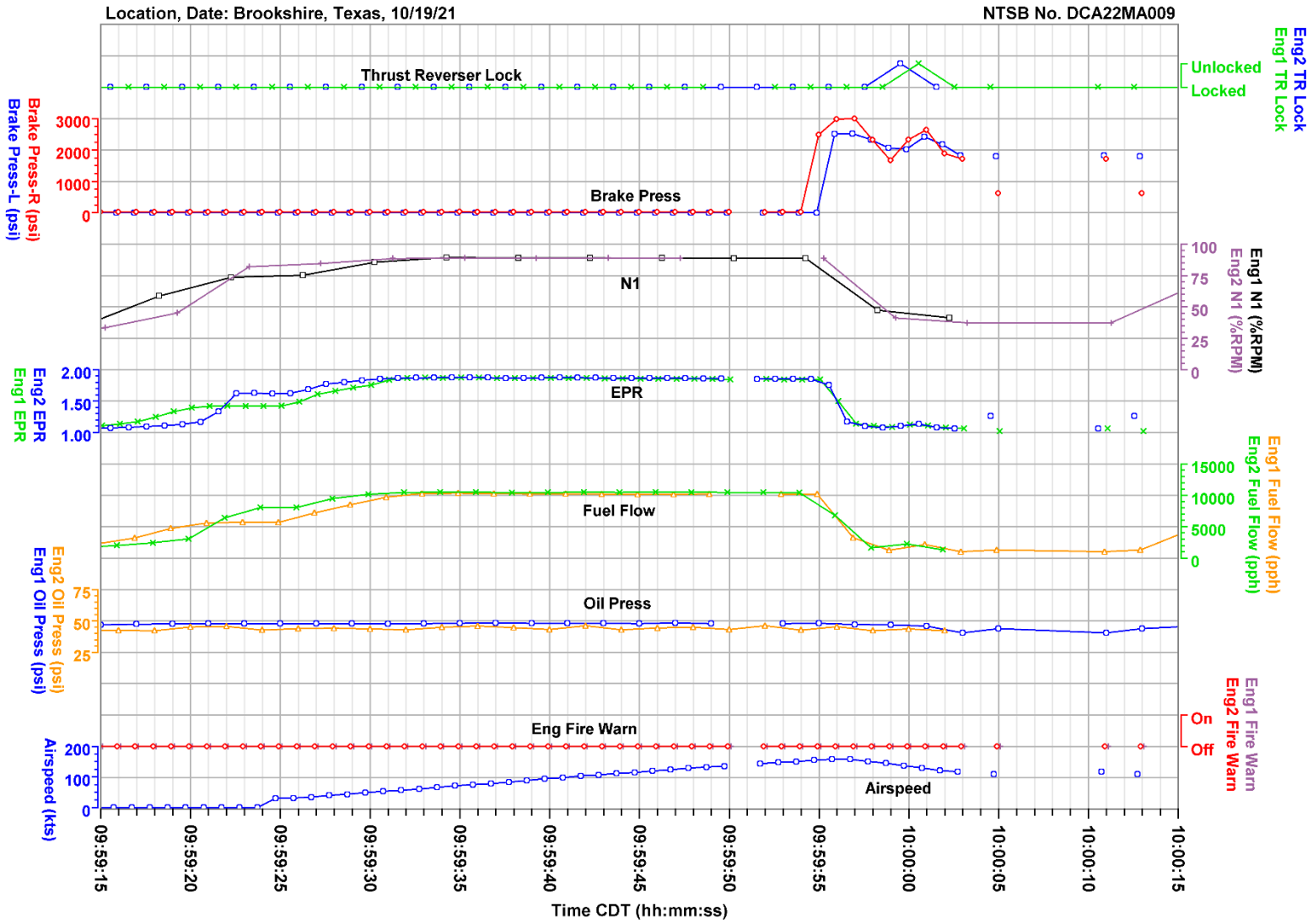

Figure 9. Plot of engine parameters for the accident takeoff.

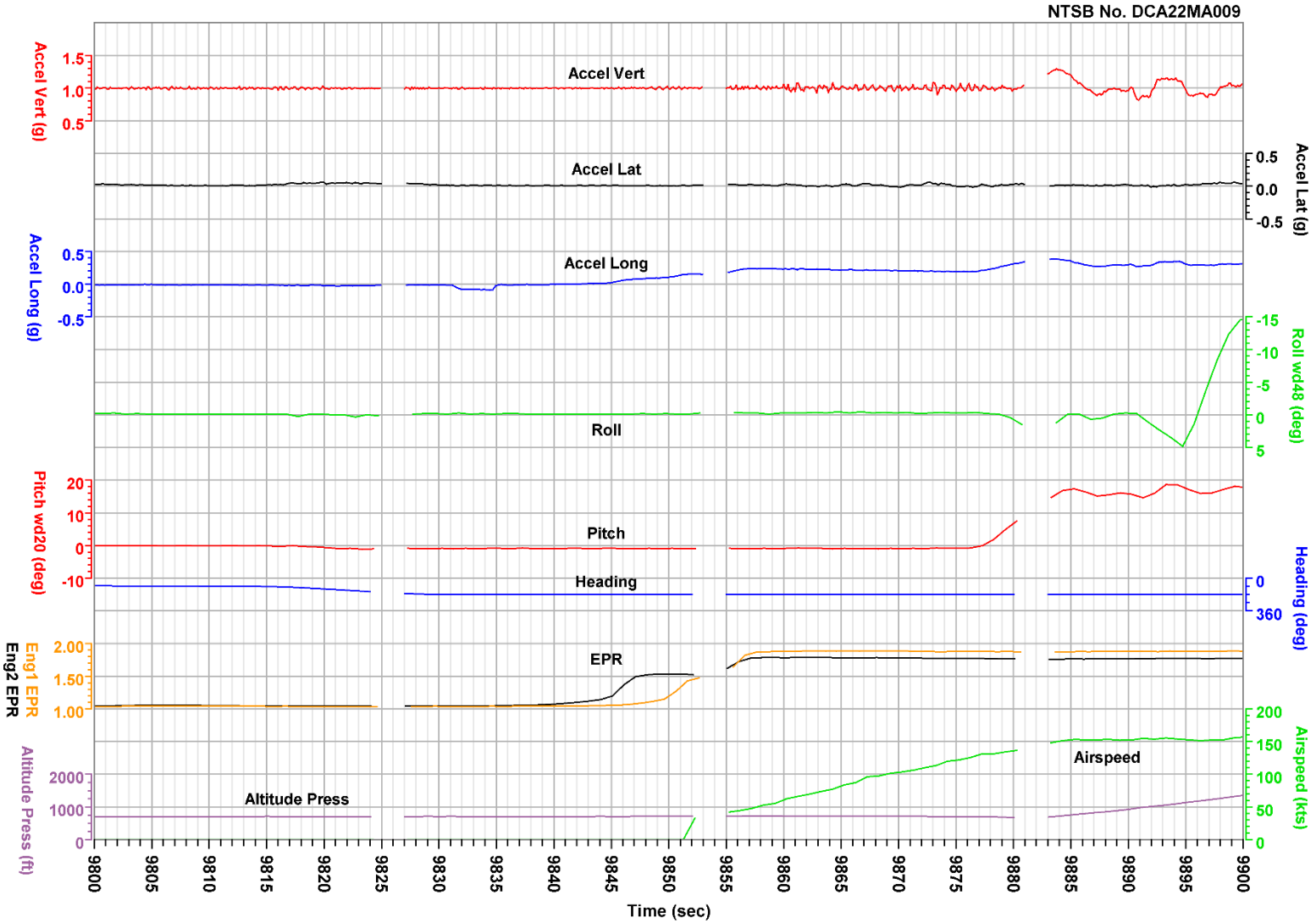

Figure 10. Plot of basic parameters for the previous takeoff from Laredo, Texas.

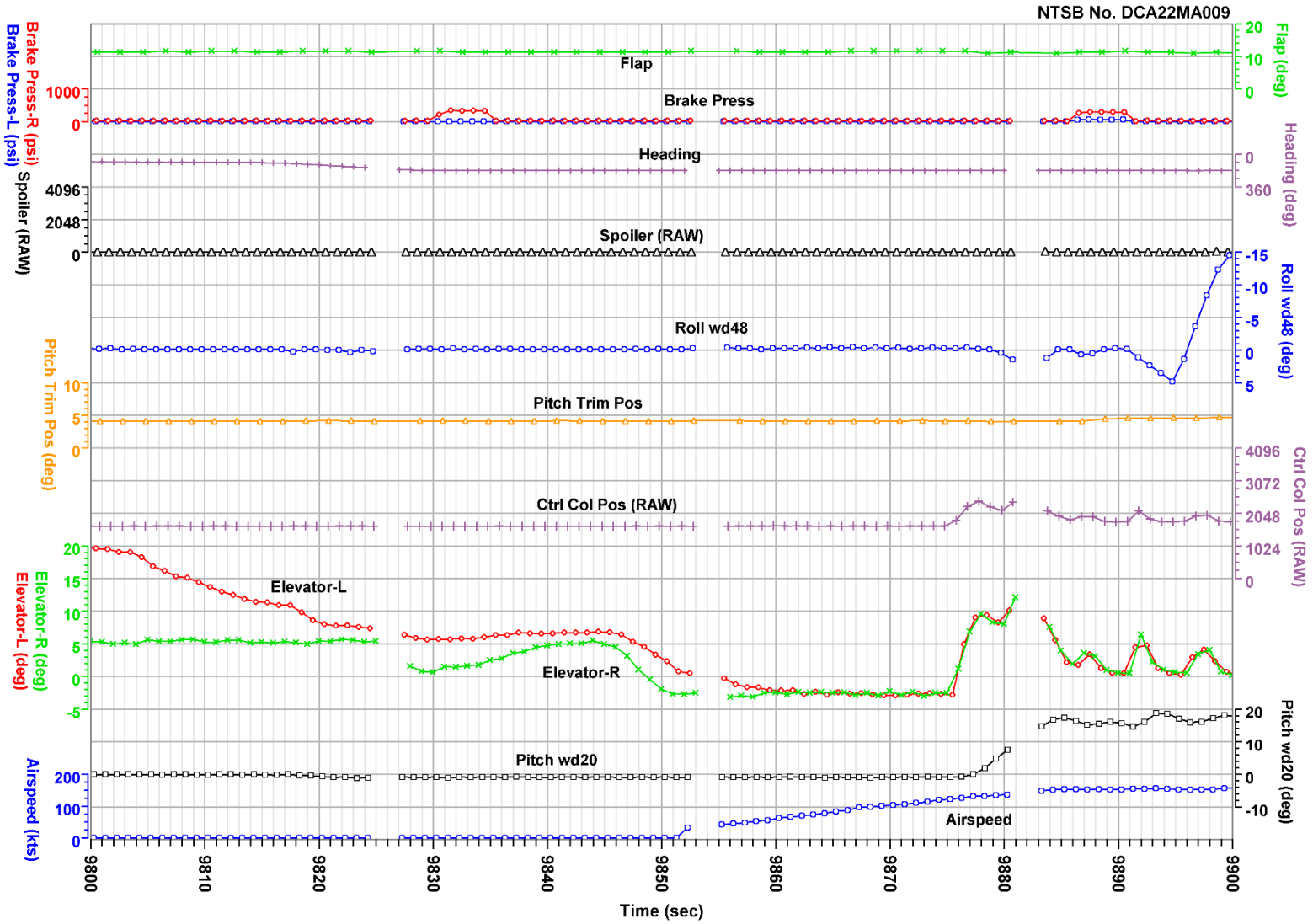

Figure 11. Plot of control parameters for the previous takeoff from Laredo, Texas.

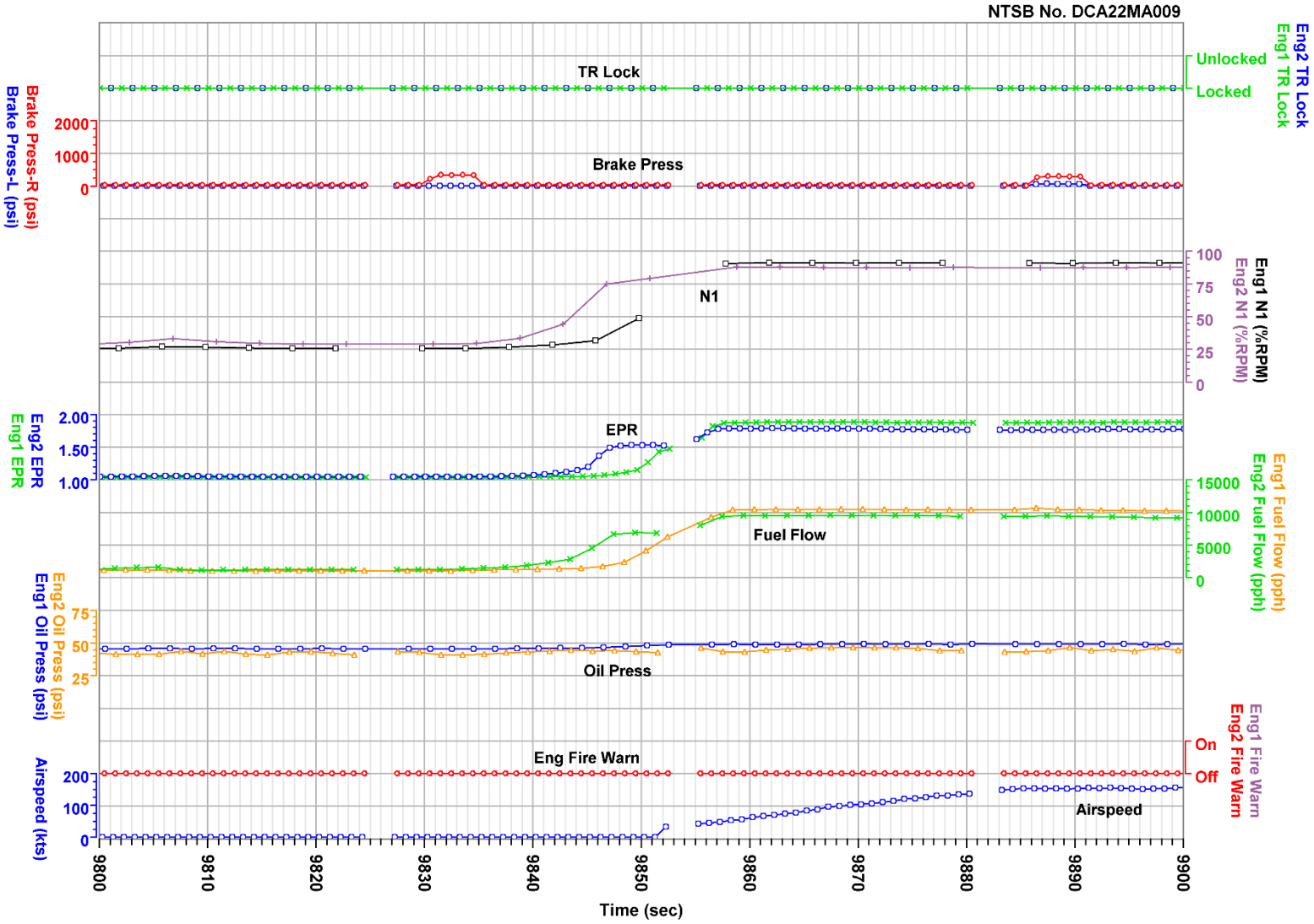

Figure 12. Plot of engine parameters for the previous takeoff from Laredo, Texas.

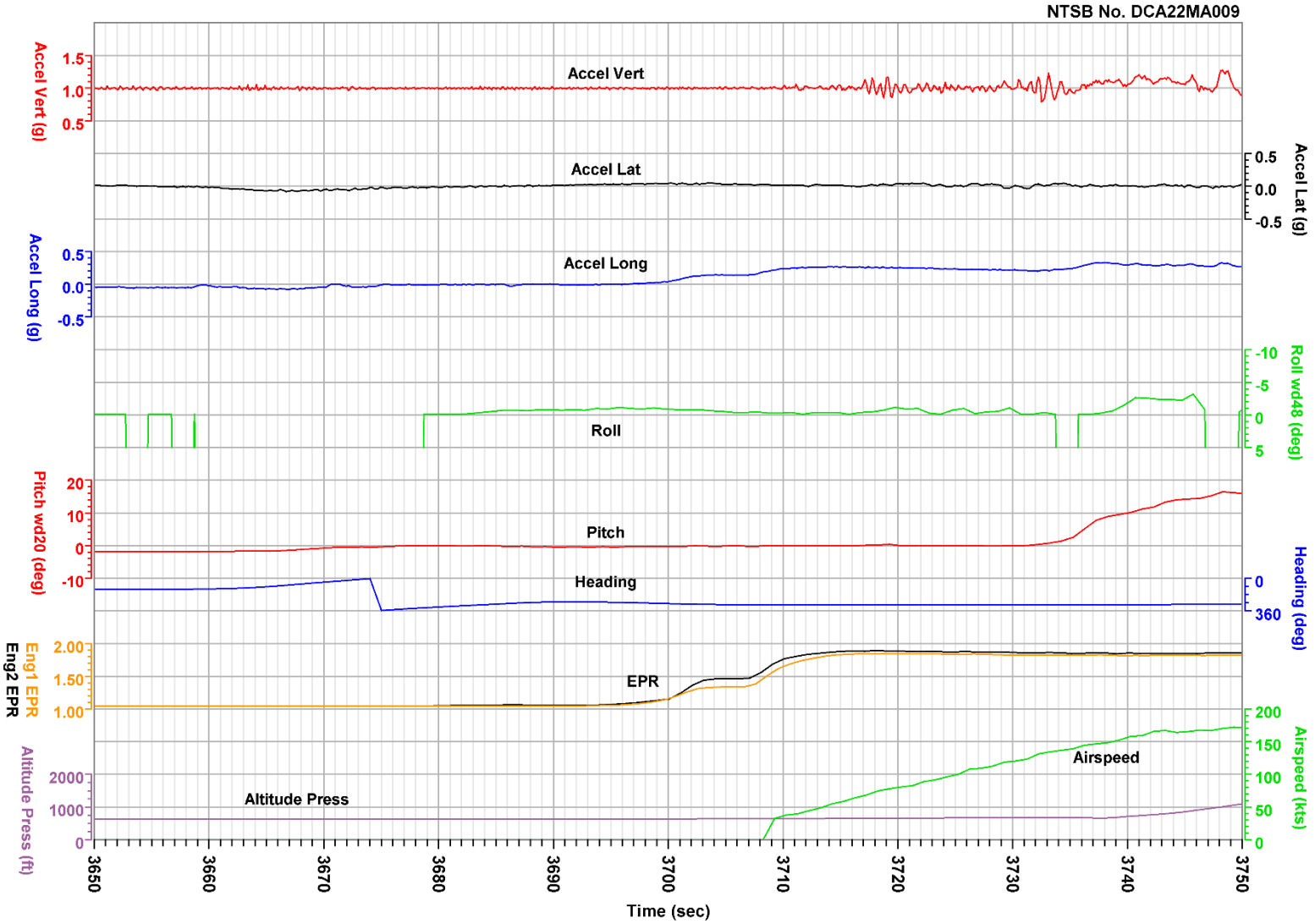

Figure 13. Plot of basic parameters for the previous takeoff from Cabo San Lucas, Mexico.

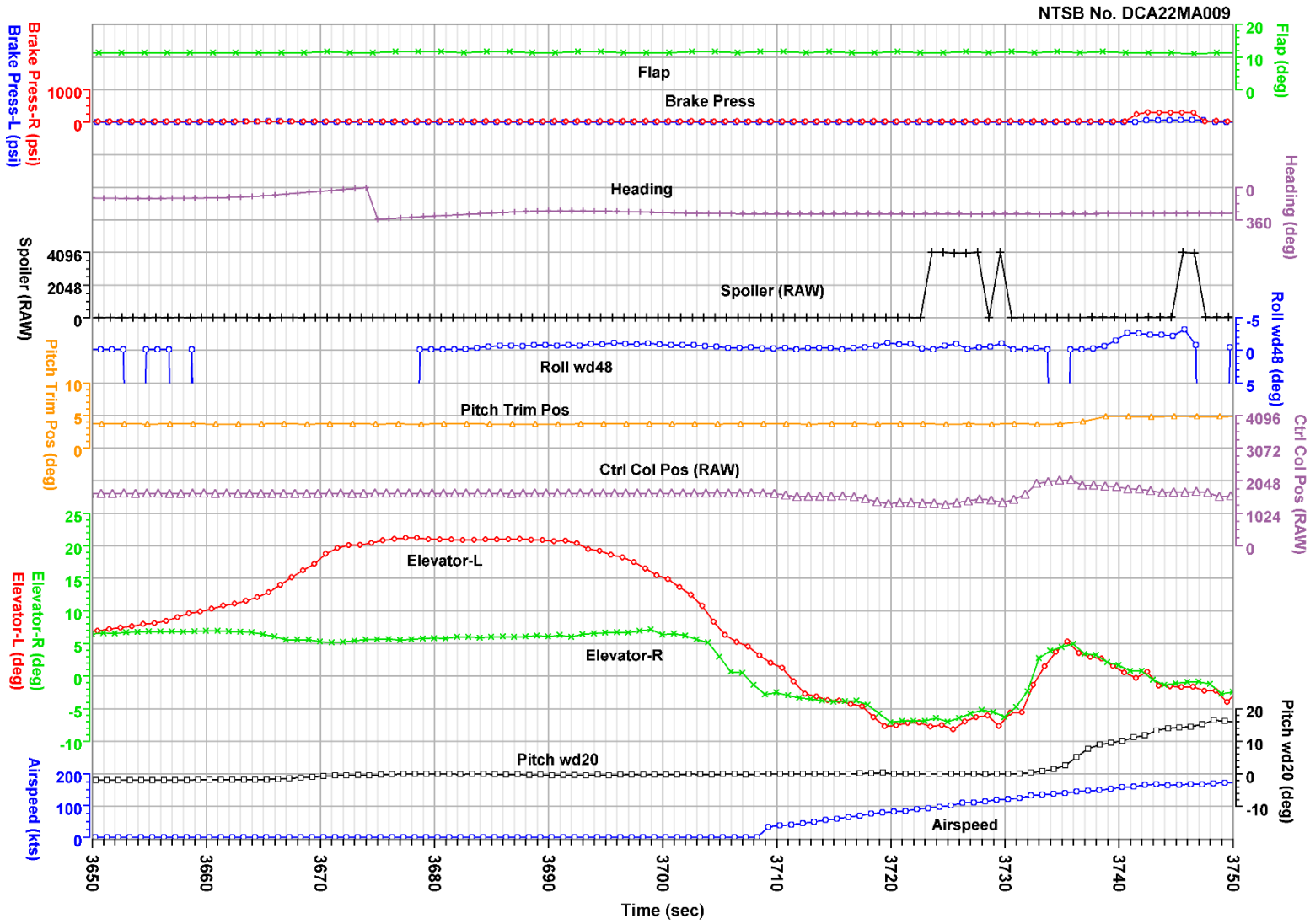

Figure 14. Plot of control parameters for the previous takeoff from Cabo San Lucas, Mexico.

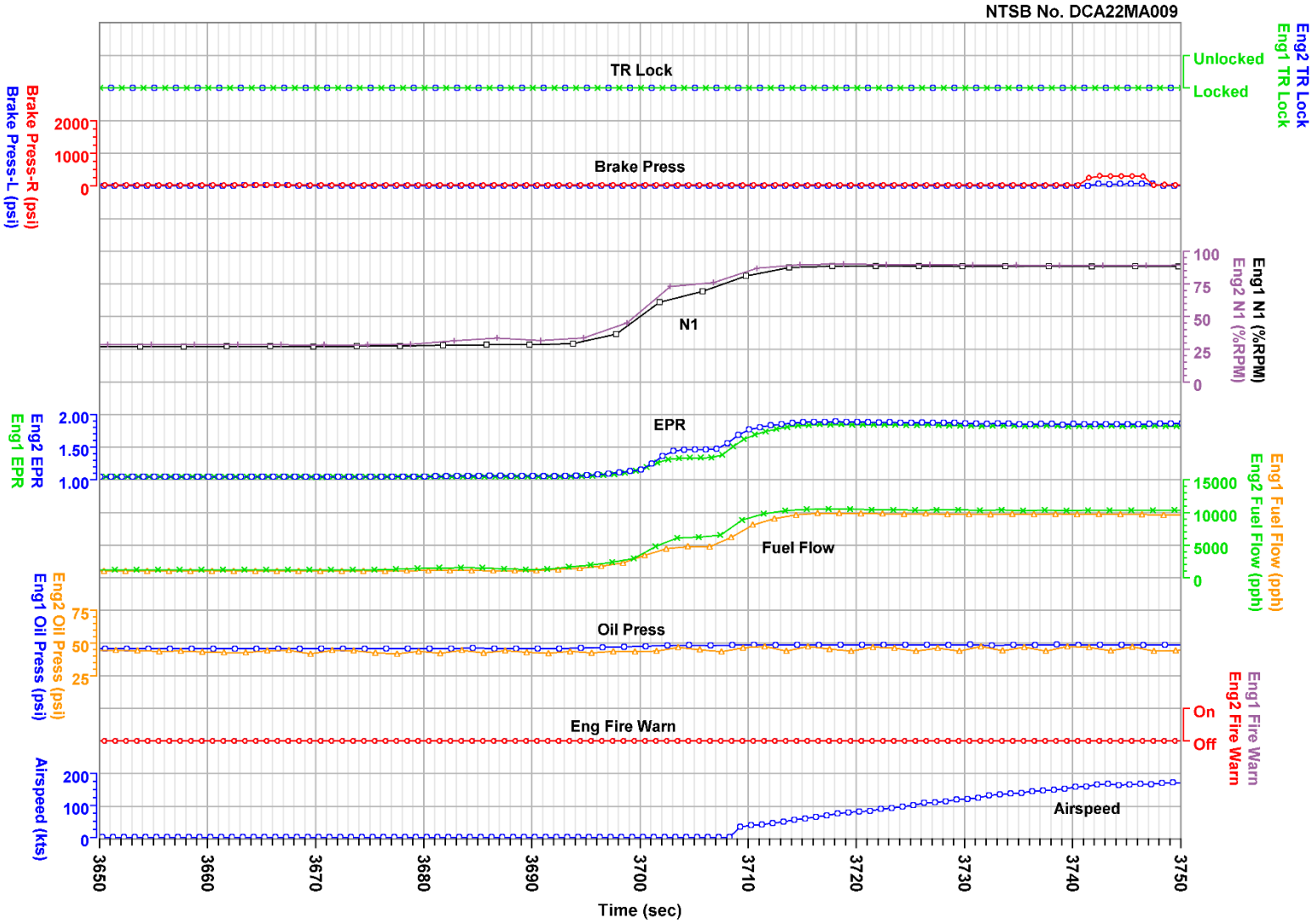

Figure 15. Plot of engine parameters for the previous takeoff from Cabo San Lucas, Mexico.

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
Accel Lat	Lateral Load Factor	g
Accel Long	Longitudinal Load Factor	g
Accel Vert	Vertical Load Factor	g
Airspeed	Airspeed	kts
Altitude Press	Pressure Altitude	ft
Brake Press-L	Left Brake Pressure	psi
Brake Press-R	Right Brake Pressure	psi
Ctrl Col Pos	Control Column Position	RAW
Elevator-L	Left Elevator Position	deg
Elevator-R	Right Elevator Position	deg
Eng1 EPR	Engine 1 Engine Pressure Ratio	ratio
Eng1 Fire Warn	Engine 1 Fire Warning	
Eng1 Fuel Flow	Engine 1 Fuel Flow	pph
Eng1 N1	Engine 1 Fan Speed	%rpm
Eng1 Oil Press	Engine 1 Oil Pressure	psi
Eng1 TR Lock	Engine 1 Thrust Reverser Locked	
Eng2 EPR	Engine 2 Engine Pressure Ratio	ratio
Eng2 Fire Warn	Engine 2 Fire Warning	
Eng2 Fuel Flow	Engine 2 Fuel Flow	pph
Eng2 N1	Engine 2 Fan Speed	%rpm
Eng2 Oil Press	Engine 2 Oil Pressure	psi
Eng2 TR Lock	Engine 2 Thrust Reverser Locked	
Flap	Flap Surface Position	deg
Heading	Heading	deg
Pitch	Pitch Angle	deg
Pitch Trim Pos	Pitch Trim Surface (Horizontal Stabilizer) Position	deg
Roll	Roll Angle	deg
Rudder	Rudder Position	deg
Spoiler Surface	Spoiler Surface Position	RAW

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
ft	feet
g	unit of gravitation acceleration
kts	knots
pph	pounds per hour
psi	pounds per square inch
RAW	unconverted raw counts