

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division
Washington, D.C. 20594

May 25, 2016

Flight Data Recorder

Specialist's Factual Report By George Haralampopoulos

1. EVENT SUMMARY

Location: Nashville, Tennessee
Date: December 15, 2015
Aircraft: Boeing 737-300
Registration: N649SW
Operator: Southwest Airlines
NTSB Number: DCA16LA032

On Tuesday, December 15, 2015 at 1725 central standard time, Southwest Airlines flight 31, a Boeing 737-300, N649SW, departed taxiway T4 and came to rest in a ditch at the Nashville International Airport, (BNA), Nashville, Tennessee. The passengers evacuated via the emergency slides. The aircraft was substantially damaged and nine passengers sustained minor injuries. The flight was a regularly scheduled passenger flight from the William P Hobby Airport (HOU), Houston, Texas. Night visual meteorological conditions prevailed at the time of the accident.

2. FLIGHT DATA RECORDER GROUP

A flight data recorder (FDR) group was not convened.

3. FDR Carriage Requirements

The event aircraft, N649SW, was manufactured in May 1997, and was operating such that it was required to be equipped with an FDR that recorded, at a minimum, 34 parameters, as cited in Title 14 *Code of Federal Regulations* Part 121.344(d).

4. DETAILS OF FDR INVESTIGATION

The National Transportation Safety Board (NTSB) Vehicle Recorder Division received the following FDR:

Recorder Manufacturer/Model: **Honeywell SSFDR Model 980-4700**
Recorder Serial Number: **1366**

4.1. Honeywell 4700 64 wps Description

The Honeywell solid state flight data recorder (SSFDR) records airplane flight information in a digital format using solid-state flash memory as the recording medium. The SSFDR 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 64 12-bit words of digital information every second. Each grouping of 64 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 64-word intervals. Each data parameter (for example, altitude, heading, and airspeed) has a specifically assigned word number within the subframe. The SSFDR is designed to meet the crash-survivability requirements of TSO-C124.

4.1.1. Recorder Condition

The recorder was in good condition and the data were extracted normally from the recorder.

4.1.2. Recording Description

The FDR recording contained approximately 27 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 1 hours and 35 minutes.

4.1.3. Engineering Units Conversions

The engineering units 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 A-1 lists the FDR parameters verified and provided in this report. Additionally, table A-2 describes the unit abbreviations used in this report.

4.2. Time Correlation

Correlation of the FDR data from SRN to the event local time, central standard time (CST), was established by using the recorded Time GMT² hours, Time GMT Minutes, and Time GMT Seconds and then applying an additional 6 hours offset to change GMT to CST.

Accordingly, the time offset for the event flight data from SRN to local CST is the following: CDT = SRN – 35332. For the rest of this report, all times are referenced as CST, not SRN.

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 = +, Pitch Up = +, Elevator Trailing Edge Up = +, Right Rudder = +.

² GMT is Greenwich Mean Time which is also known as Coordinated Universal Time (UTC).

4.3. FDR Plots and Corresponding Tabular Data

The following four figures contain FDR data recorded during the December 15, 2015 event.

Figure 1 is an overview of the entire recorded event flight that captures all phases of flight from 15:49:30 to 17:23:41 CST.

Figure 2 is a seven and a half minute segment of Figure 1, highlighting the peak in accelerations and intermittent weight-on-wheel (WOW) reading around 17:23:30 CST.

Figure 3 is a plot of engine and landing gear parameters during the landing segment of the flight.

Figure 4 is a seven and a half minute segment plot of engine and landing gear parameters highlighting the peak in accelerations and intermittent weight-on-wheel (WOW) reading around 17:23:30 CST.

In brief, the flight was uneventful until the aircraft began its landing rollout around 17:20:33 CST, when the WOW parameter transitioned to ground. At this time, the groundspeed was 137 knots with a heading of 200 degrees. Concurrently, the throttle lever angle's (TLA) moved to a position consistent with thrust reverser deployment and the aircraft's groundspeed continued to decrease until 30 knots at which the TLAs were moved to a setting consistent with idle.

At 17:20:57 CST, the heading began a left turn to 150 degrees. During the turn, the aircraft's groundspeed decreased to around 15 knots and maintained this groundspeed until about 17:23:30 CST. During this time, the heading continued to change consistent with an aircraft taxiing. The taxiing continued for a duration of 2 minutes and 18 seconds. At 17:23:14 CST, the heading showed a turn to the left from 90 to 64 degrees and at 17:23:22 CST, the heading showed a right turn back to 90 degrees. Following the left turn, the vertical acceleration began to increase at 17:23:31 CST, when the pitch and roll indicated 10 degrees nose down and 14 degrees right wing down. Concurrently, the nose WOW and gear down and lock parameters indicated not on ground and not down and locked, 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 corresponding tabular data used to create these four figures are provided in electronic comma separated value (*.csv) format as attachment 1 to this report.

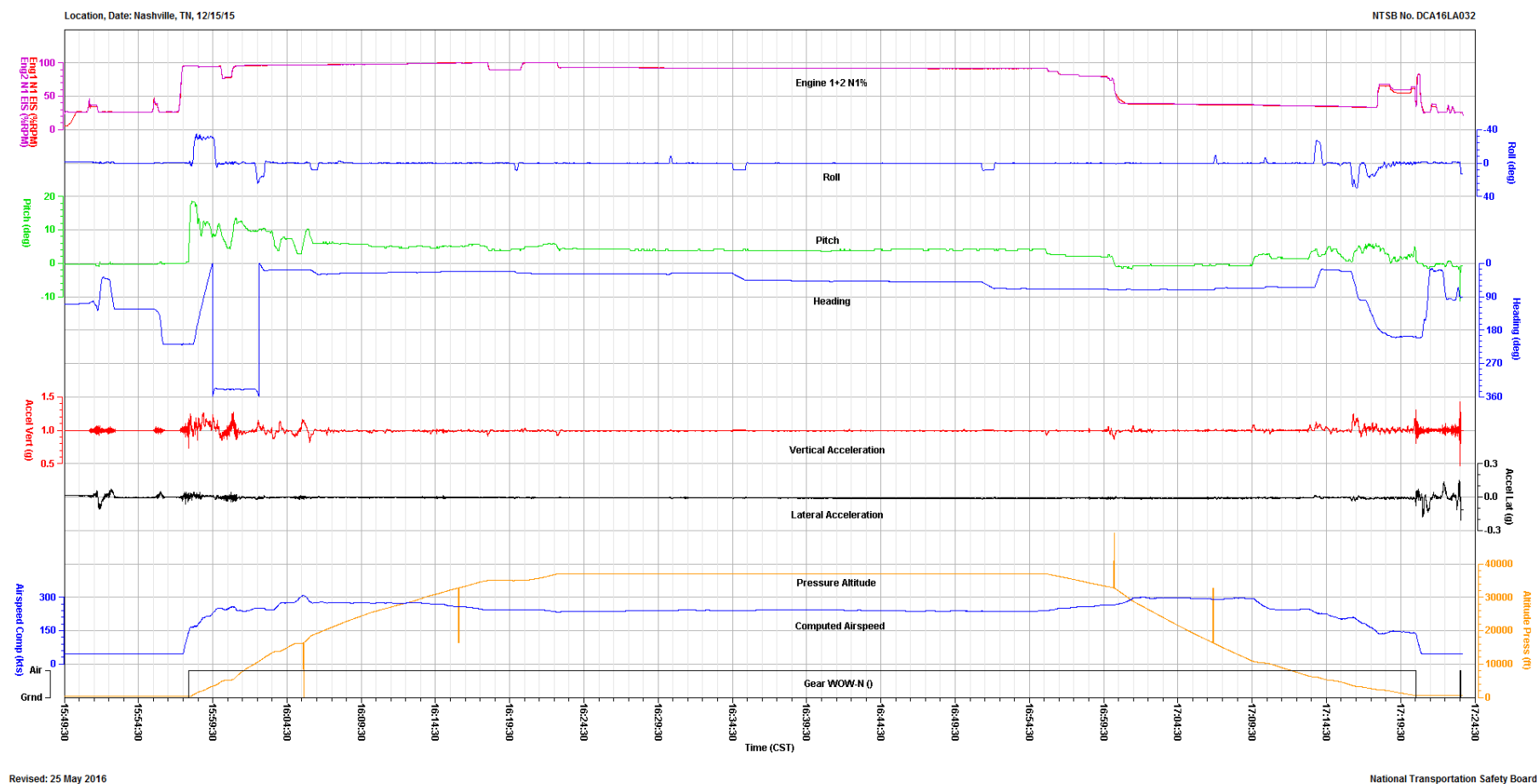
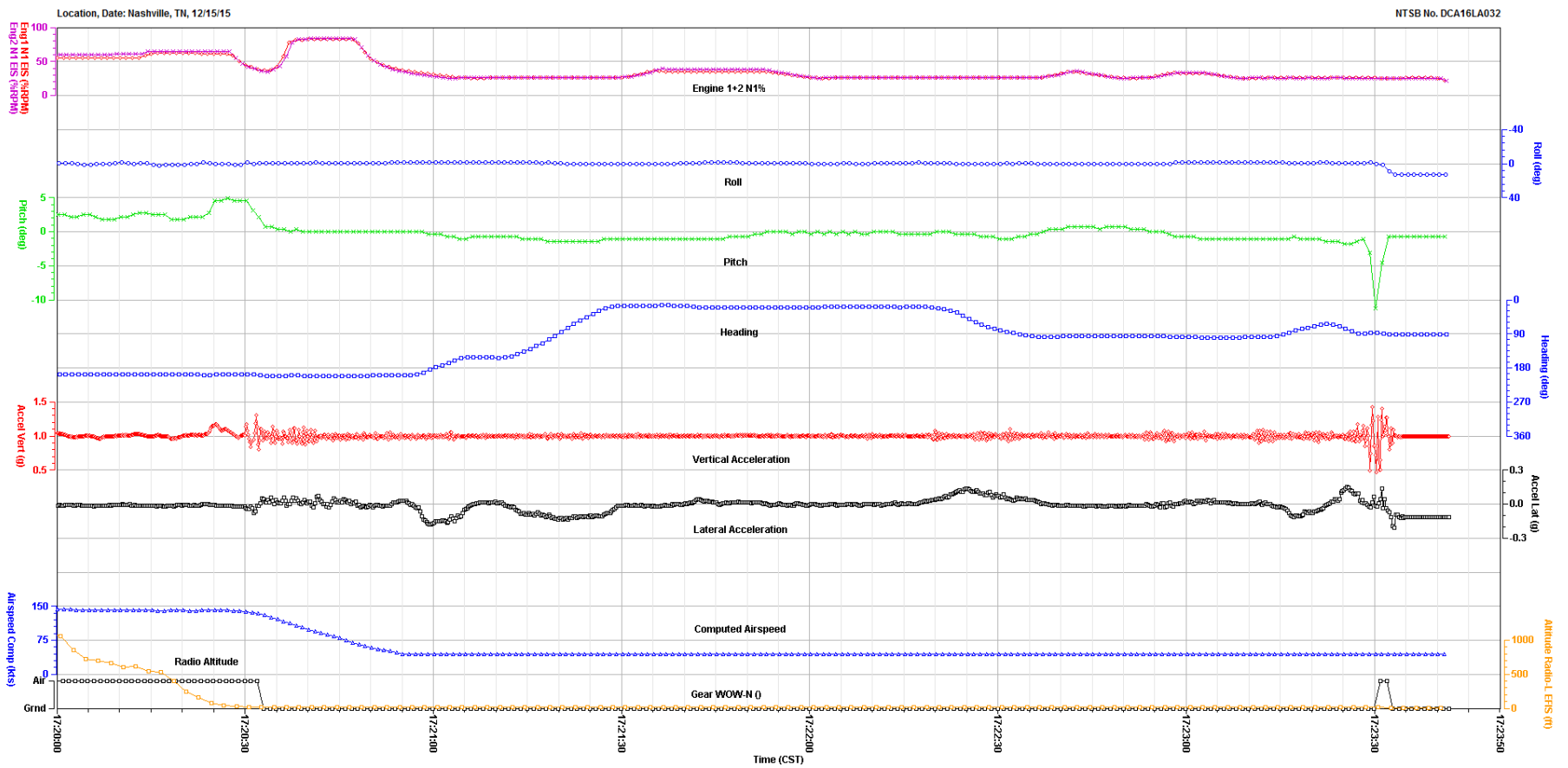


Figure 1. Plot of basic parameters capturing all phases of flight.



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Figure 2. Plot of basic parameters during last recorded data points.

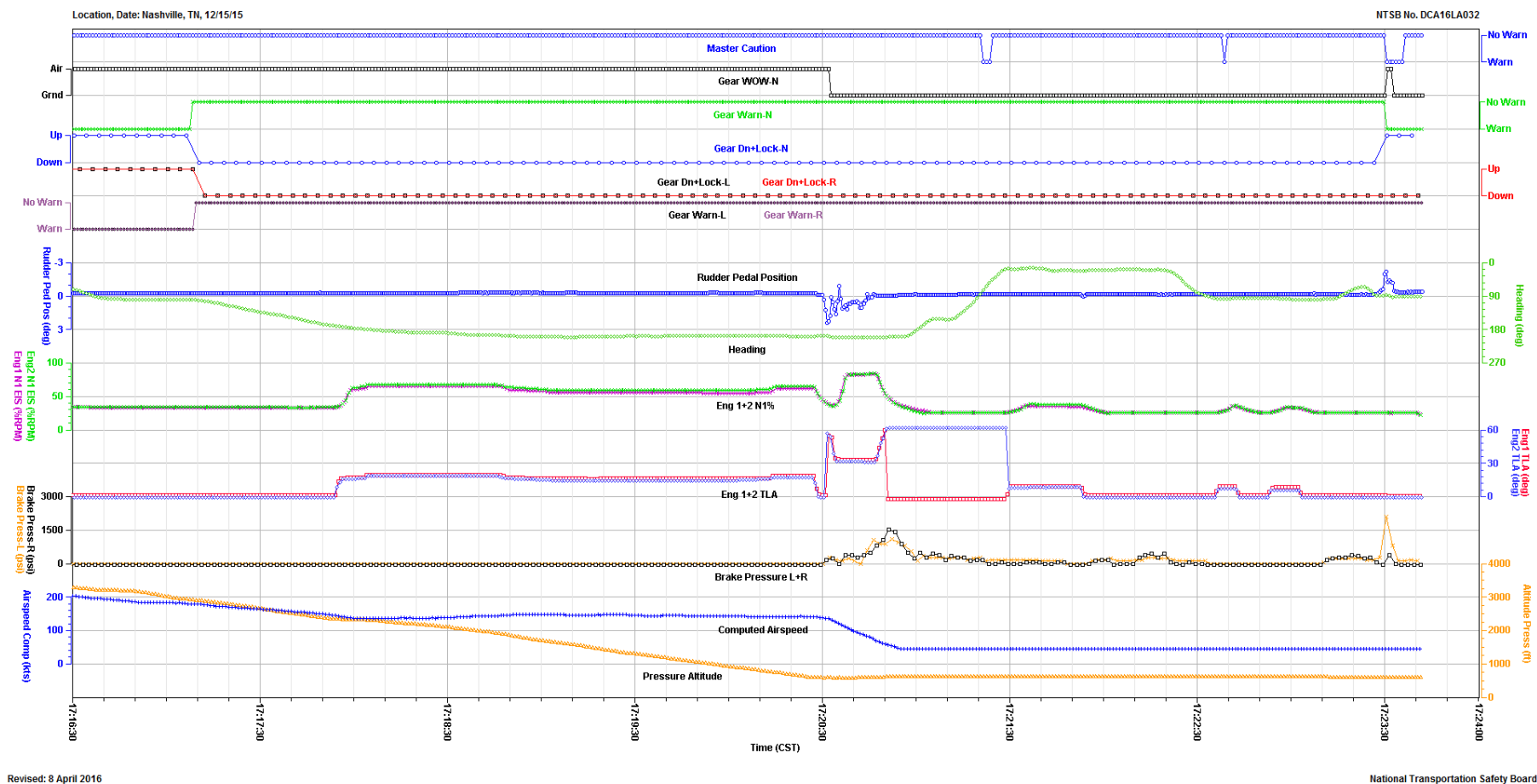


Figure 3. Plot of engine and landing gear parameters during landing segment.

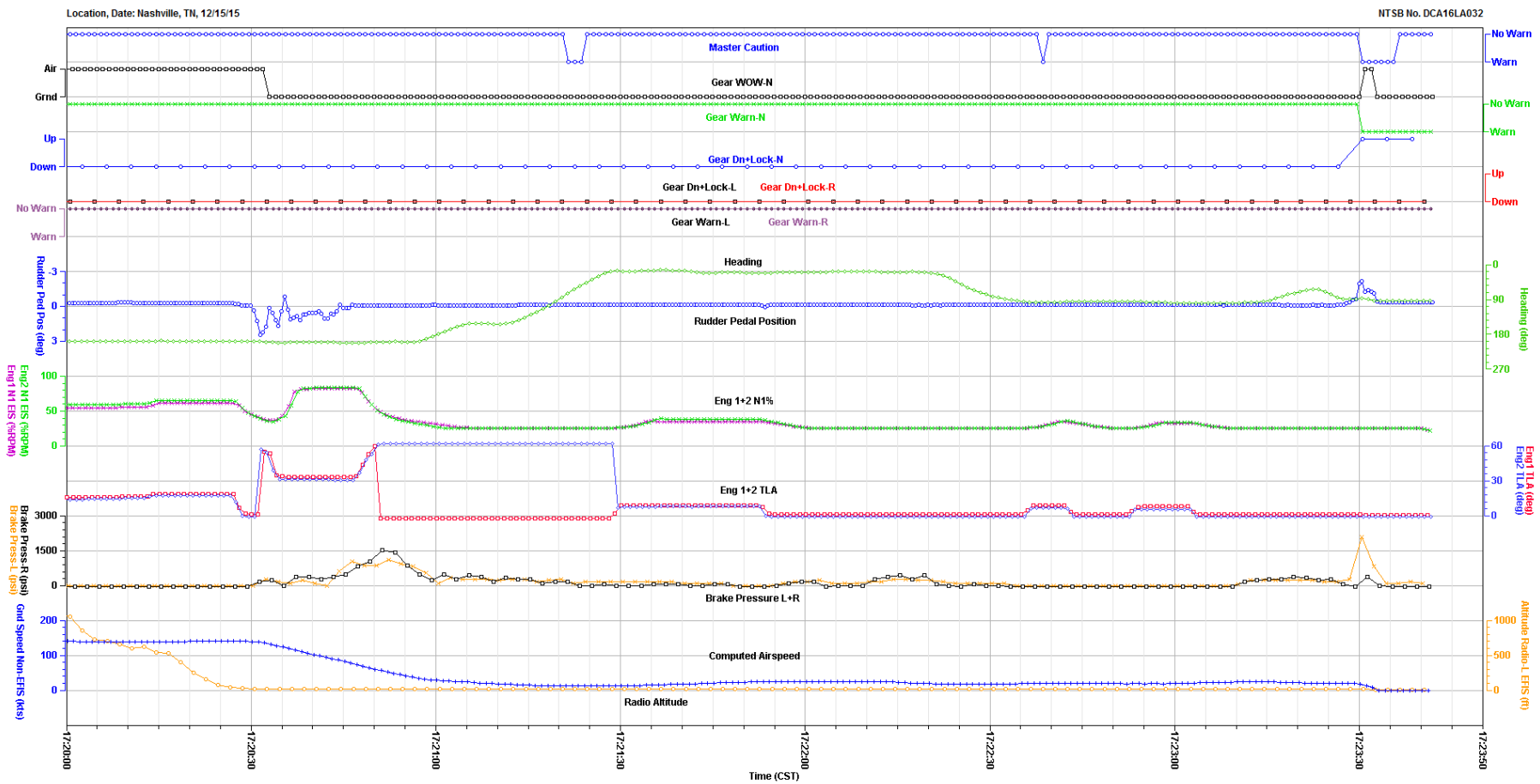


Figure 4. Plot of engine and landing gear parameters during taxi to gate.

APPENDIX A

This appendix describes the parameters provided and verified in this report. Table A-1 lists the parameters and table A-2 describes the unit abbreviations used in this report.

Table A-1. Verified and provided FDR parameters.

Parameter Name	Parameter Description
1. Accel Lat (g)	Lateral Acceleration
2. Accel Long ^a (g)	Longitudinal Acceleration
3. Accel Vert (g)	Vertical Acceleration
4. Airspeed Comp (kts)	Indicated Airspeed
5. Altitude Press (ft)	Pressure Altitude
6. Altitude Radio-L EFIS(ft)	Radio Altitude Left Source
7. Brake Press-L (psi)	Brake Pressure Left Wheel
8. Brake Press-R (psi)	Brake Pressure Right Wheel
9. Eng1 N1 (%RPM)	Engine-1 N1
10. Eng1 TLA (deg)	Engine-1 Throttle Lever Angle
11. Eng2 N1 (%RPM)	Engine-2 N1
12. Eng2 TLA (deg)	Engine-2 Throttle Lever Angle
13. Flap TE-L ^a (deg)	Left Trailing Edge Flap Position
14. Gear Dn + Lock –L (discrete)	Left Gear Down and Locked
15. Gear Dn + Lock –N (discrete)	Nose Gear Down and Locked
16. Gear Dn + Lock –R (discrete)	Right Gear Down and Locked
17. Gear Warn-L (discrete)	Left Main Gear Warning
18. Gear Warn-N (discrete)	Nose Gear Warning
19. Gear Warn-R (discrete)	Right Main Gear Warning
20. Gear WOW-N(discrete)	Nose Gear Weight On Wheels
21. Ground Spd (kts)	Ground Speed
22. Heading (deg)	Magnetic Heading
23. Key VHF-C ^a (discrete)	Cockpit Microphone Keying Center
24. Key VHF-L ^a (discrete)	Cockpit Microphone Keying Left
25. Key VHF-R ^a (discrete)	Cockpit Microphone Keying Right
26. Latitude ^a (deg)	Latitude
27. Longitude ^a (deg)	Longitude
28. Master Caution (discrete)	Master Caution
29. Pitch (deg)	Pitch Angle
30. Roll (deg)	Roll Angle
31. Rudder Ped Pos (deg)	Rudder Pedal Position
32. Time GMT Hrs (hrs)	Hours in GMT
33. Time GMT Min (min)	Minutes in GMT
34. Time GMT Sec (sec)	Seconds in GMT

NOTE: parameters marked with an ^(a) are not plotted but included in the tabular data.

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.

Table A-2. Unit abbreviations.

Units Abbreviation	Description
%rpm	percent revolutions per minute
deg	degrees
discrete	discrete
ft	feet
g	g
hrs	hours
kts	knots
min	minutes
psi	pounds per square inch
sec	seconds

NOTE: For parameters with a unit description of discrete, 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.