

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division
Washington, D.C. 20594

October 3, 2017

Flight Data Recorder

Specialist's Factual Report

By Cassandra Johnson, assisted by Michael Johnson

1. EVENT SUMMARY

Location: Port Arthur, Texas
Date: March 14, 2016
Aircraft: Boeing 737-700
Registration: N23708
Operator: United Airlines
Event: Turbulence
NTSB Number: DCA16CA181

2. FLIGHT DATA RECORDER GROUP

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

3. FDR Carriage Requirements

The event aircraft, N23708, was manufactured in 1998 and was operating such that it was required to be equipped with an FDR that recorded, at a minimum, 34 parameters as cited 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 an electronic file containing the FDR data from the N23708 aircraft.

4.1. FDR Data File Description

The FDR data in the electronic file was configured such that 256 12-bit words of digital information were recorded 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 (for example, pressure altitude, pitch angle, roll angle, and magnetic heading) has a specifically assigned word number within the subframe.

4.1.1. Recording Description

The FDR recording contained approximately 49 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 40 minutes. The parameters evaluated for the purpose of this report appeared to be in accordance with federal FDR carriage requirements.

4.1.2. Engineering Units 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 A-1 lists the FDR parameters verified and provided in this report and provides the plot/table labels, parameter names, and units. 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, CDT, was established by using the recorded Time GMT² Hours, Time GMT Minutes, and Time GMT Seconds and then subtracting an additional 5 hours to change GMT to CDT.

Accordingly, the time offset for the event flight data from SRN to CDT is the following: CDT = SRN – 93,889. Therefore, for the rest of this report, all times are referenced as CDT, not SRN.

4.3. FDR Plots and Corresponding Tabular Data

Figures 1 to 6 contain FDR data recorded during the event on March 14, 2016. All the parameters listed in table A-1 are plotted except Time GMT Hours, Time GMT Minutes, and Time GMT Seconds.

Figures 1 and 2 are an overlay of the aircraft's position using Google Earth. Figure 1 shows the entire flight and figure 2 shows the aircraft's position near the turbulence encounter starting at 21:50:00 CDT while at a pressure altitude of 26,987 feet (ft) to 22:02:10 CDT while at a pressure altitude of 24,000 ft. The weather and lighting conditions in Google Earth are not necessarily the weather and lighting conditions present at the time of the recording.

Figures 3 and 4 cover the entire flight from 21:35:00 CDT to 22:20:00 CDT. Figures 5 and 6 have an expanded scale from 21:55:00 CDT to 22:01:00 CDT focusing on the large vertical acceleration excursion.

Figures 3 and 5 contain the basic parameters (vertical acceleration, lateral acceleration, longitudinal acceleration, pressure altitude, pitch angle, roll angle, magnetic heading, computed airspeed), wind speed, wind direction true³, total air temperature and engine N1. Figures 4 and 6 contain select flight control parameters (control column position, control wheel position, aileron position, elevator position, rudder pedal position, rudder position), autopilot command A, and autopilot command B.

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).

³ Wind direction true and wind speed are most likely inaccurate during the upset because wind algorithms assume steady-state conditions.

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 data indicated at 21:56:45 CDT⁴ (about 19 minutes after takeoff) until 21:56:55 CDT, while leveled at a pressure altitude of approximately 27,000 feet (ft) and autopilot command B not selected, there were vertical acceleration variations ranging between 1.58 g's and -0.52 g's before settling to about 1 g. During this time, the roll angle increased to 11.6 degrees right wing down then rapidly reversed to 2.81 degrees left wing down before returning to level. At 21:57:14 CDT, approximately 29 seconds after the start of the vertical acceleration variations, the aircraft began its descent from 27,000 ft and at 21:58:55 CDT leveled at 24,000 ft. During the descent to 24,000 ft, the autopilot command B was selected for 22 seconds then not selected for 20 seconds and back to selected once the aircraft leveled at 24,000 ft. Approximately 19 minutes later at 22:18:06 CDT, the aircraft landed.

The corresponding tabular data used to create figures 1 to 6, including Time GMT Hours, Time GMT Minutes, and Time GMT Seconds, are provided in electronic comma separated value (*.csv) format as attachment 1 to this report.

⁴ At 21:56:45 CDT, the latitude and longitude position was 29° 58' 31.84" North and 92° 44' 32.86" West.

Figure 1. Google Earth overlay showing aircraft's position for entire flight.

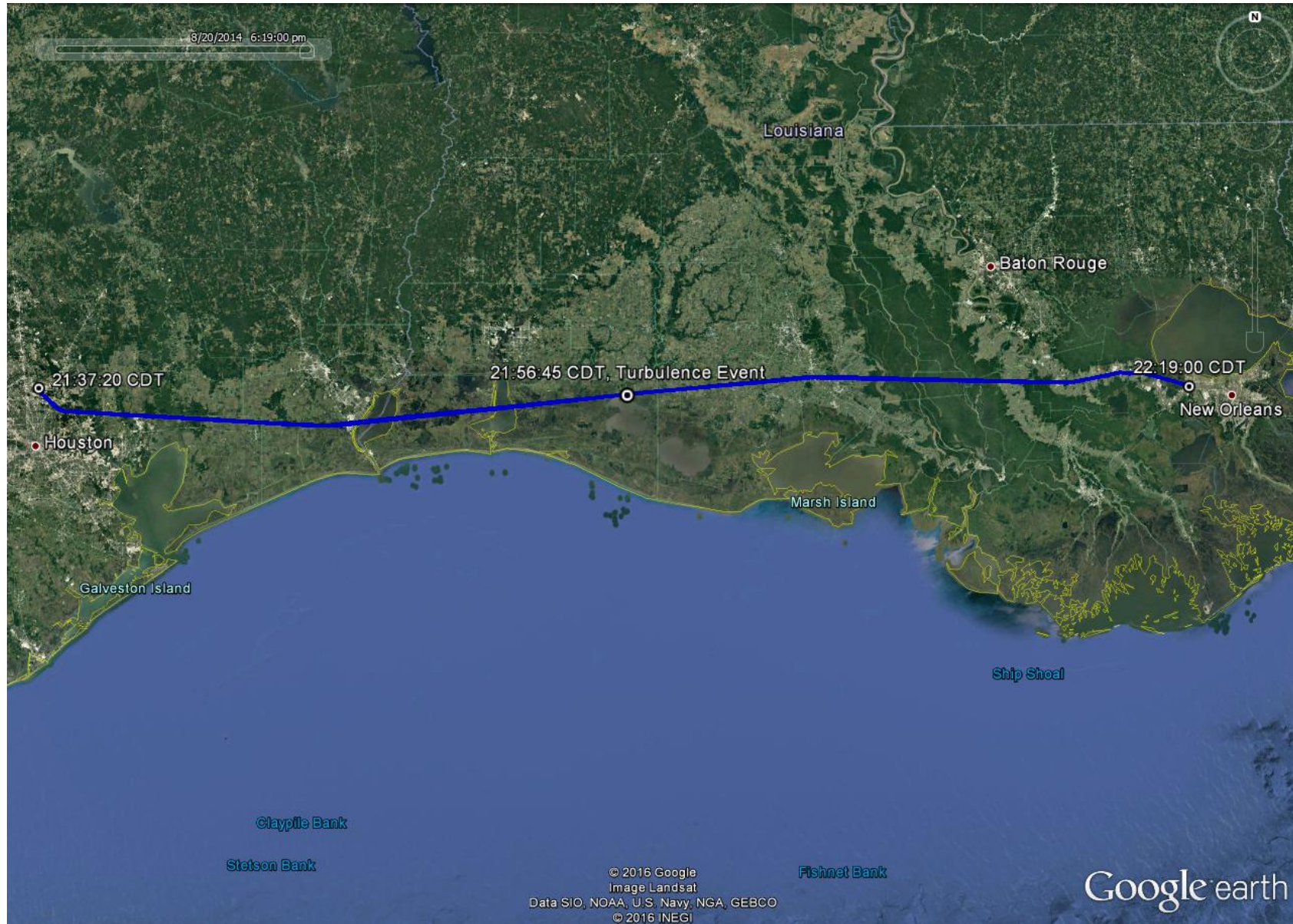


Figure 2. Google Earth overlay showing aircraft's position near the turbulence event.



Figure 3. Plot of basic parameters during entire flight.

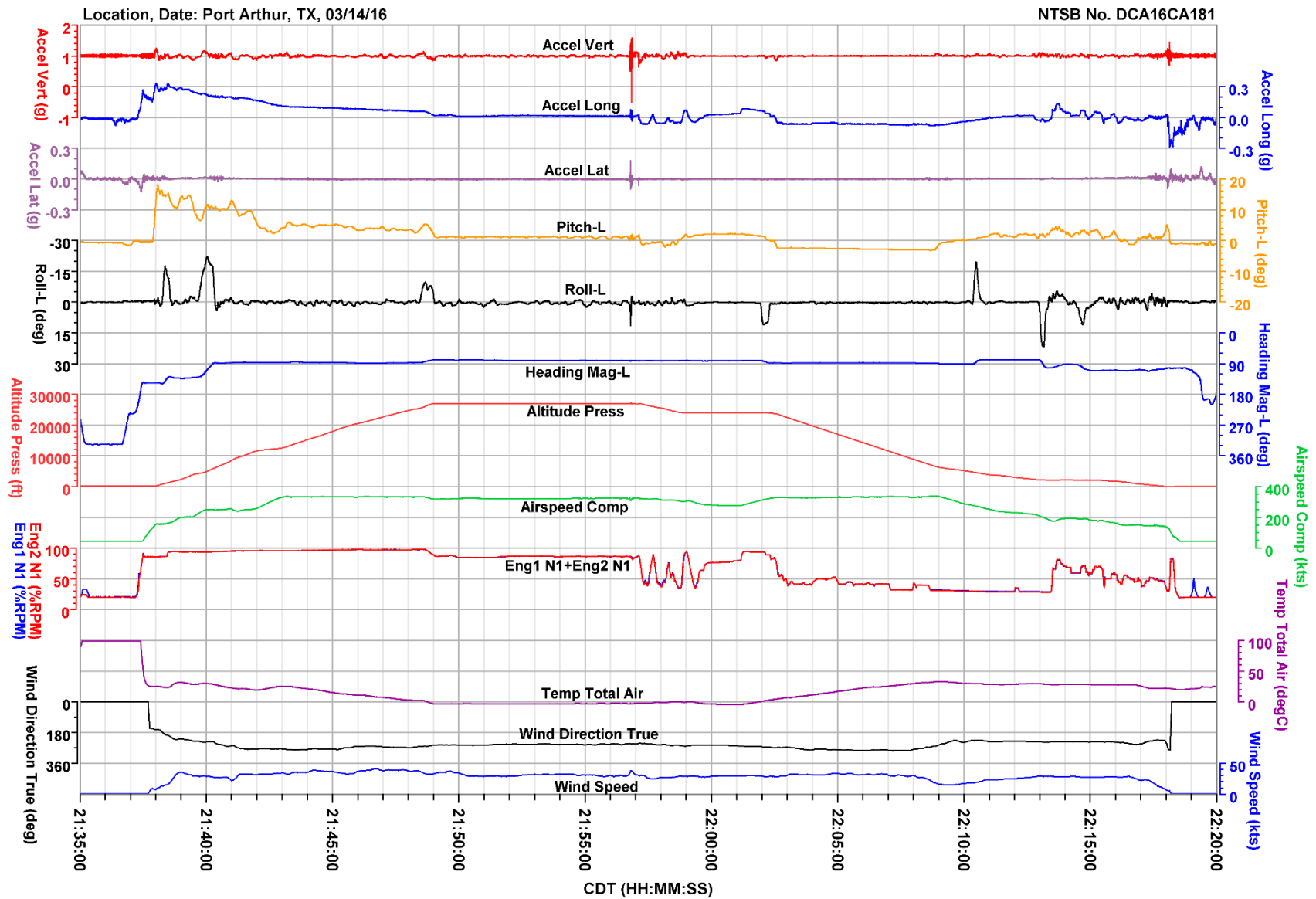


Figure 4. Plot of select flight control parameters during entire flight.

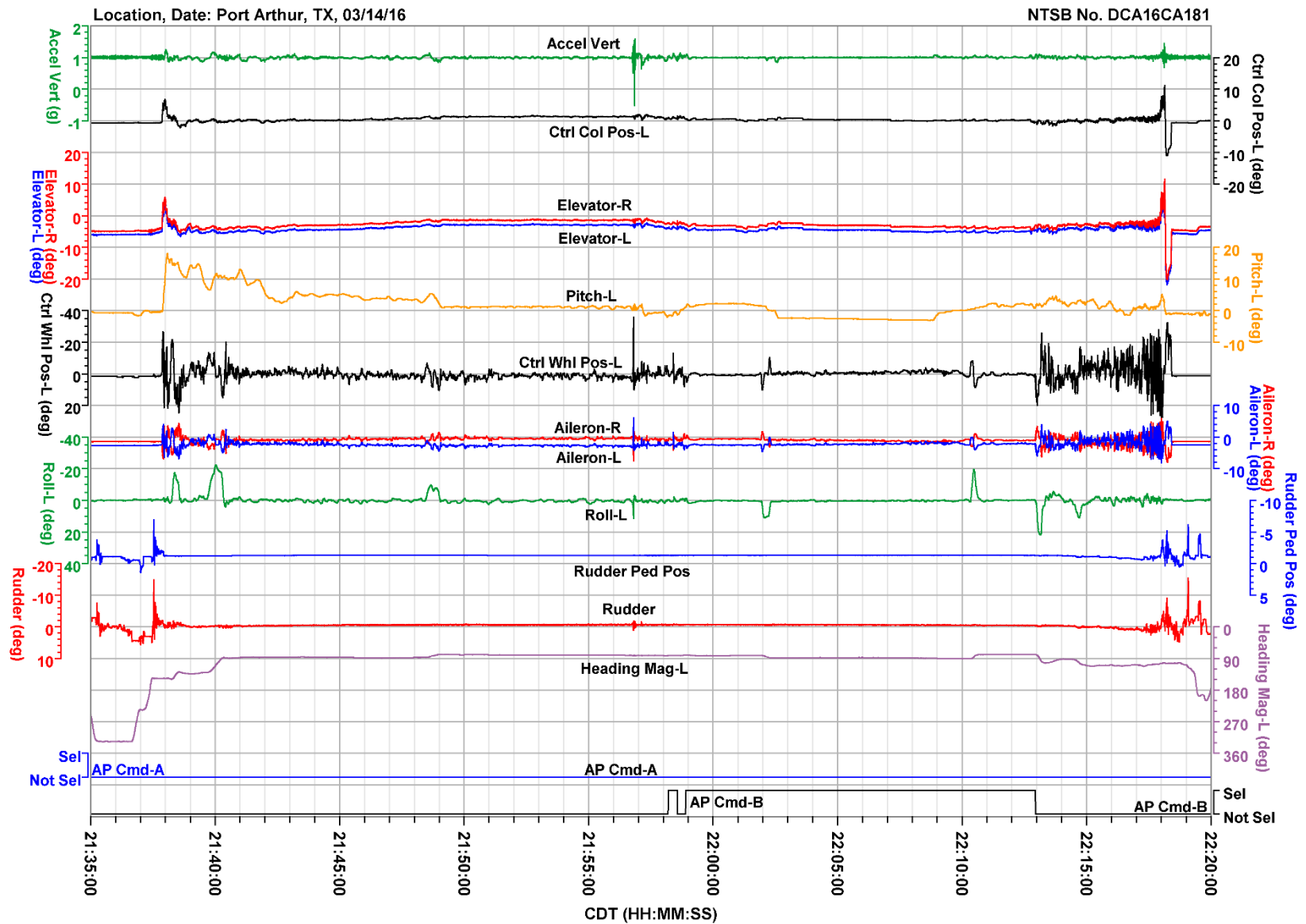


Figure 5. Plot of basic parameters with expanded scale at event.

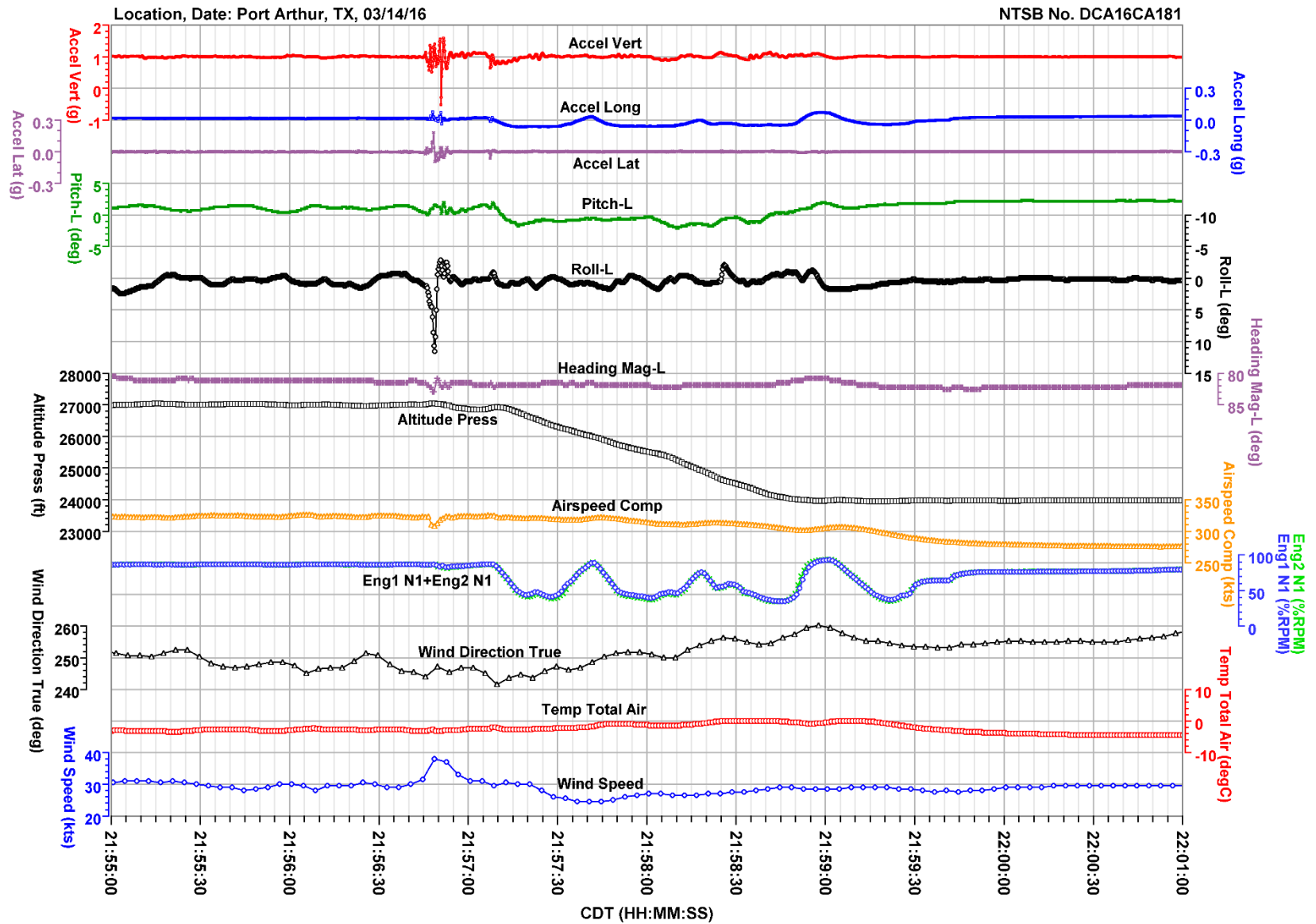
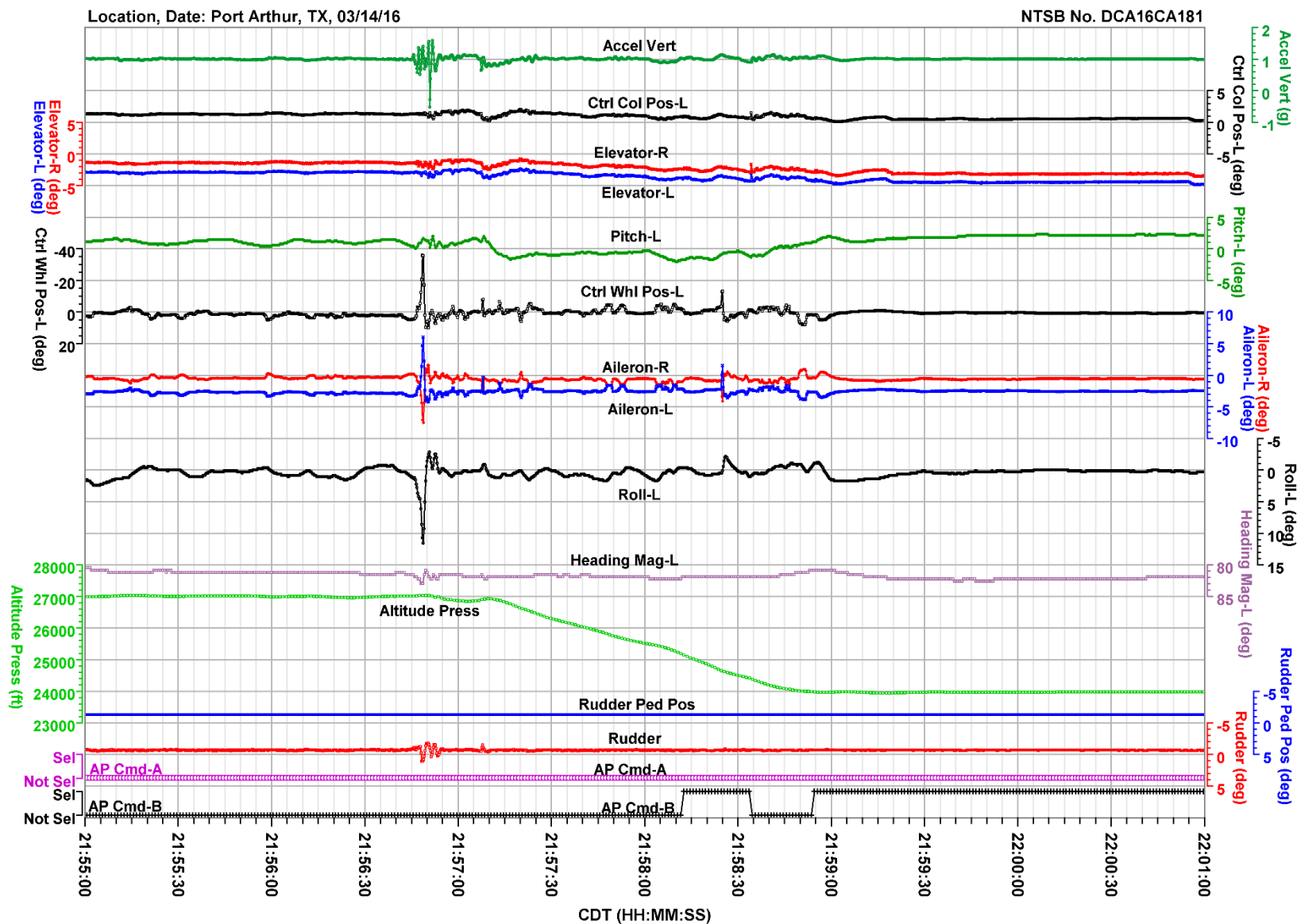


Figure 6. Plot of select flight control parameters expanded scale at event.



APPENDIX A

This appendix describes the parameters provided and verified in this report. Table A-1 lists the plot/table labels, parameter names, and units. Table A-2 contains the unit abbreviations for the parameters.

Table A-1. Verified and provided FDR parameters.

Plot/Table Labels	Parameter Names	Units
Accel Lat	Lateral Acceleration	g
Accel Long	Longitudinal Acceleration	g
Accel Vert	Vertical Acceleration	g
Aileron-L	Left Aileron	deg
Aileron-R	Right Aileron	deg
Airspeed Comp	Computed Airspeed	kts
Altitude Press	Pressure Altitude	ft
AP Cmd-A	Autopilot Command A	
AP Cmd-B	Autopilot Command B	
Ctrl Col Pos-L	Left Control Column Position	deg
Ctrl Whl Pos-L	Left Control Wheel Position	deg
Elevator-L	Left Elevator Position	deg
Elevator-R	Right Elevator Position	deg
Eng1 N1	Engine 1 Fan Speed	%RPM
Eng2 N1	Engine 2 Fan Speed	%RPM
Heading Mag-L	Left Magnetic Heading	deg
Pitch-L	Left Pitch Angle	deg
Roll-L	Left Roll Angle	deg
Rudder	Rudder Position	deg
Rudder Ped Pos	Rudder Pedal Position	deg
Temp Total Air	Total Air Temperature	degC
Time GMT Hrs	Greenwich Mean Time Hours	hrs
Time GMT Min	Greenwich Mean Time Minutes	min
Time GMT Sec	Greenwich Mean Time Seconds	sec
Wind Direction True	Wind Direction True	deg
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 A-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 A-2. Unit abbreviations.

Unit Abbreviations	Descriptions
%RPM	Percentage of Revolutions per Minute
deg	degrees
degC	degrees Celsius
ft	feet
g	g
hrs	hours
kts	knots
min	minutes
sec	seconds