

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division
Washington, D.C. 20594

September 22, 2016

Flight Data Recorder

Specialist's Factual Report
By Bill Tuccio, Ph.D.

1. EVENT SUMMARY

Location: Wood, South Dakota
Date: August 11, 2016
Aircraft: Airbus A320-232
Registration: N632JB
Operator: JetBlue Airways, Flight Number 429
NTSB Number: DCA16IA215

On August 11, 2016, about 2009 central daylight time, an Airbus A320-232, N632JB, registered to and operated by JetBlue Airways Corporation, as flight 429, a Title 14 *Code of Federal Regulations* (CFR) Part 121 domestic passenger flight from Boston, Massachusetts, to Sacramento, California, encountered turbulence while maneuvering in cruise flight at FL320, to avoid convective weather. The crew declared an emergency and the flight diverted to and landed in Rapid City, South Dakota. The airplane received minor damage. The airline transport-rated pilot, first officer, and 122 passengers were not injured. Three flight attendants and 24 passengers received minor injuries.

2. FLIGHT DATA RECORDER GROUP

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

3. FDR Carriage Requirements

The event aircraft, N632JB, was manufactured in 2006 and was operating such that it was required to be equipped with an FDR that recorded, at a minimum, 88 parameters, as cited in 14 CFR Part 121.344.

4. DETAILS OF FDR INVESTIGATION

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

Recorder Manufacturer/Model: **Honeywell 4700**
Recorder Serial Number: **SSFDR-11773**

4.1. Honeywell 4700 256 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 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 (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 spanning six flights. 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 3 hours and 40 minutes. The parameters evaluated for the purpose of this report appeared to be in accordance with federal FDR carriage requirements.

4.1.3. Engineering Units Conversions

The engineering units conversions used for the data contained in this report are based on documentation from the operator.¹ 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=+).²

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, CDT, was established by using the recorded Time GMT³ hours, Time GMT Minutes, and Time GMT Seconds and then applying an additional 5 hours offset to change GMT to CDT.

Accordingly, the time offset for the event flight data from SRN to local CDT is the following: CDT = SRN - 13611.0. Therefore, for the rest of this report, all times are referenced as CDT, not SRN.

¹ Conversions were based upon a 256 wps dataframe defined by the aircraft having IAE V2527-A5 engines, a SAGEM Flight Data Interface Management Unit (part number ED48A100, software part number 360-04027-050), Airbus revision number 17 dated August 1, 2013 for an Airbus A320-200 series aircraft.

² 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 = +.

³ GMT is Greenwich Mean Time which is also known as Coordinated Universal Time (UTC).

4.3. FDR Plots and Corresponding Tabular Data

Figures in this report contain FDR data recorded during the event on August 11, 2016. Geographic overlays were created using Google Earth. Weather and lighting conditions in the overlays are not necessarily representative of conditions that existed at the time of the event. A review of FDR data indicated significant changes in acceleration parameters began at 2009:54 CDT, at a position over Wood, South Dakota. For the purpose of this report, this time is considered the start of the upset event.

Figures 1 through 6 show an overlay of position over a World Aeronautical Chart. The aircraft was in cruise flight at flight level 320. In the 10 minutes prior to the event, the aircraft had turned from southwest towards the northwest. Just prior to the event, the aircraft had started a left turn in the vicinity of Wood, SD.

Figures 7 and 8 show a plot of basic parameters. The aircraft departed about 1700 CDT and climbed to flight level 320. Autopilot one was engaged during the initial climb and remained on until the upset.

By 2009:40 CDT, the computed airspeed began to increase from a nominal value of about 275 knots to 285 knots at 2009:54 CDT. At 2009:54 CDT, as the aircraft was in a bank to the left, acceleration parameters began to change. Notably, the vertical acceleration increased to +1.7 g by 2009:55 CDT (1 second after the upset began). After fluctuating at positive values, at 2010:00 CDT (6 seconds after the upset began), the vertical acceleration began to reduce, reaching a maximum negative value of -0.75 g at 2010:00 CDT. As the vertical acceleration began to increase towards 1 g, the autopilot disconnected. By 2010:17 CDT, accelerations had fluctuated back to nominal values observed before the upset event. During the upset event, the aircraft climbed from flight level 320 to flight level 330.

Figure 9 shows the descent after the upset event. At about 2017:10 CDT (about 7 minutes after the upset began), the aircraft started a descent with both autopilots still disengaged, through about flight level 310, reaching a maximum rate of descent of about 5,300 feet per minute. Thereafter, autopilot one was engaged, and the aircraft continued to descend at a lesser rate of descent, until about flight level 200, when the autopilots were once again disengaged and the descent continued. The autopilot was used again during the descent as shown in figure 9.

Figures 10 and 11 show confirmatory plots of pilot control inputs and responding control surface positions. These plots are helpful to understand control inputs during the upset event.

Figures 12 and 13 show control inputs and control surface positions during the upset event. No inputs were made by the first officer during the upset event. Figure 12 shows aft (nose-up) pitch inputs by the captain during the upset, 1 second prior to autopilot disconnect; during this period, the elevator began commanding a nose-down pitch command and pitch increase subsided. As the autopilot disconnected, the captain's pitch input was nearly level and then began to be nose-up and the elevator responded with a nose-up deflection and the pitch angle began to increase. During the entire flight, pitch and roll remained in normal law.

Figure 13 shows lateral inputs. Immediately after the upset event, and after the autopilot was disconnected, the captain sidestick inputs reduced the roll angle. No rudder inputs were made on the rudder pedals, though the rudder control deflected left and right during the upset event.

Figure 14 and 15 show Enhanced Ground Proximity Warning System (EGPWS) and radar related settings for the flight and upset event, respectively. Captain and first officer EGPWS operating modes were set to Windshear/Turbulence for the entire flight and both operated their navigational displays (NDs) in arc mode for the entire flight (shortly after takeoff). After reaching cruise flight, the captain's ND range remained at 320 nm; the first officer's ND range changed between 320 nm, then reduced to 40 nm closer to the event upset, then back to 160 nm just before the event upset.

Figures 16 and 17 show lateral and longitudinal flight mode annunciator states for the entire flight and the period surrounding the upset event.

Figure 18 shows engine related parameters surrounding the event. The thrust lever angle did not change, and the auto thrust system remained engaged throughout the event.

Figures 19 and 20 show flight director states as well as cautions and warnings. Both flight directors remained engaged for the entire flight. The autopilot disconnect during the upset event was consistent with an involuntary disconnect. There were master caution and warnings 1 second and 3 seconds into the upset event, respectively.

Figures 21 and 22 show atmospheric parameters. The large spikes in total air temperature, wind speed, and wind direction are likely due to the manner in which the aircraft computes these values and the underlying computational model expecting steady-state conditions, rather than discrete changes in state (for example, large accelerations and change of altitude and airspeed).

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 figures are provided in electronic comma separated value (*.csv) format as attachment 1 to this report.

Figure 1. Overlay of last one hour of flight.

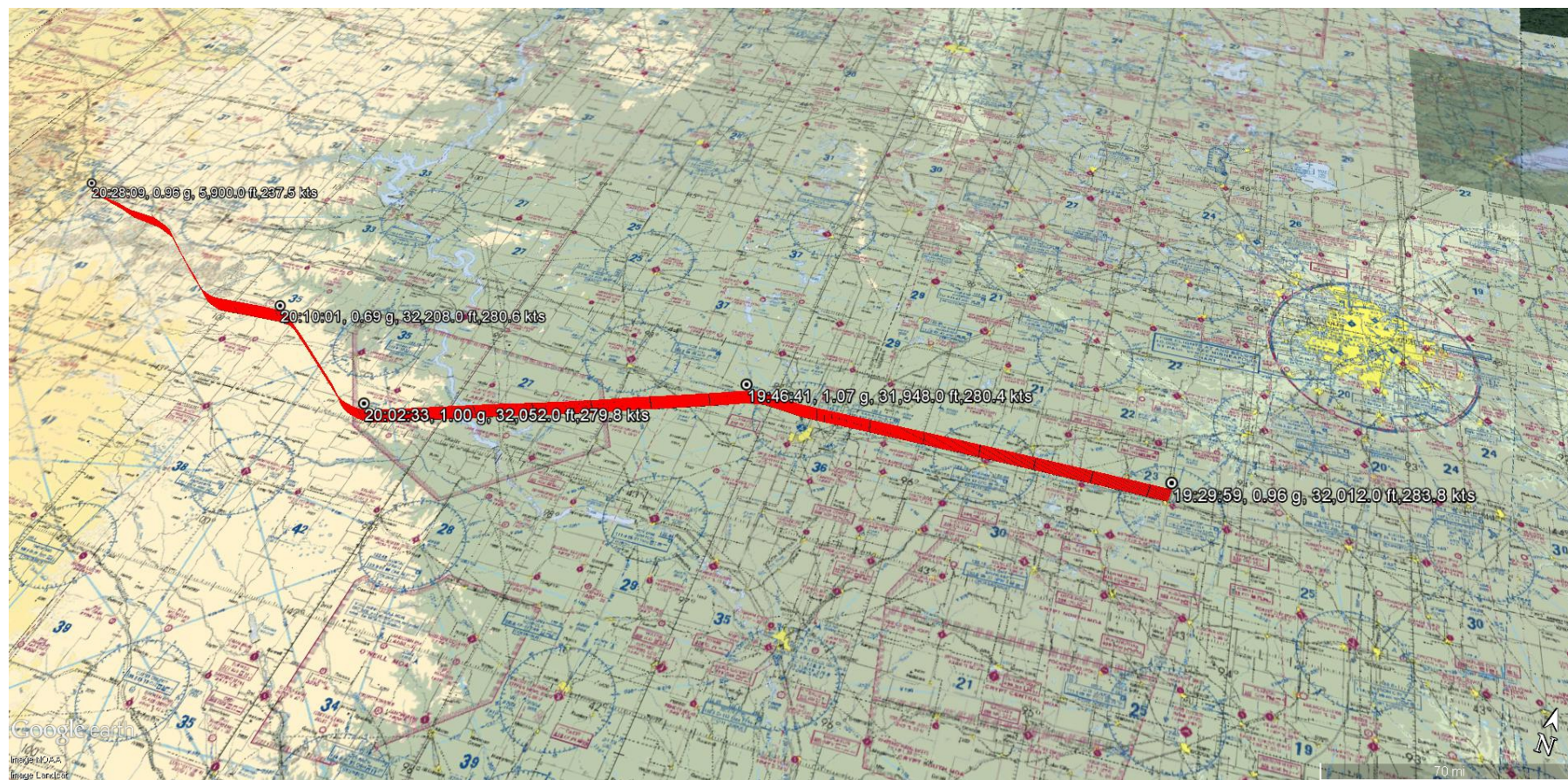


Figure 2. Overlay 19:30 to 19:46 CDT.

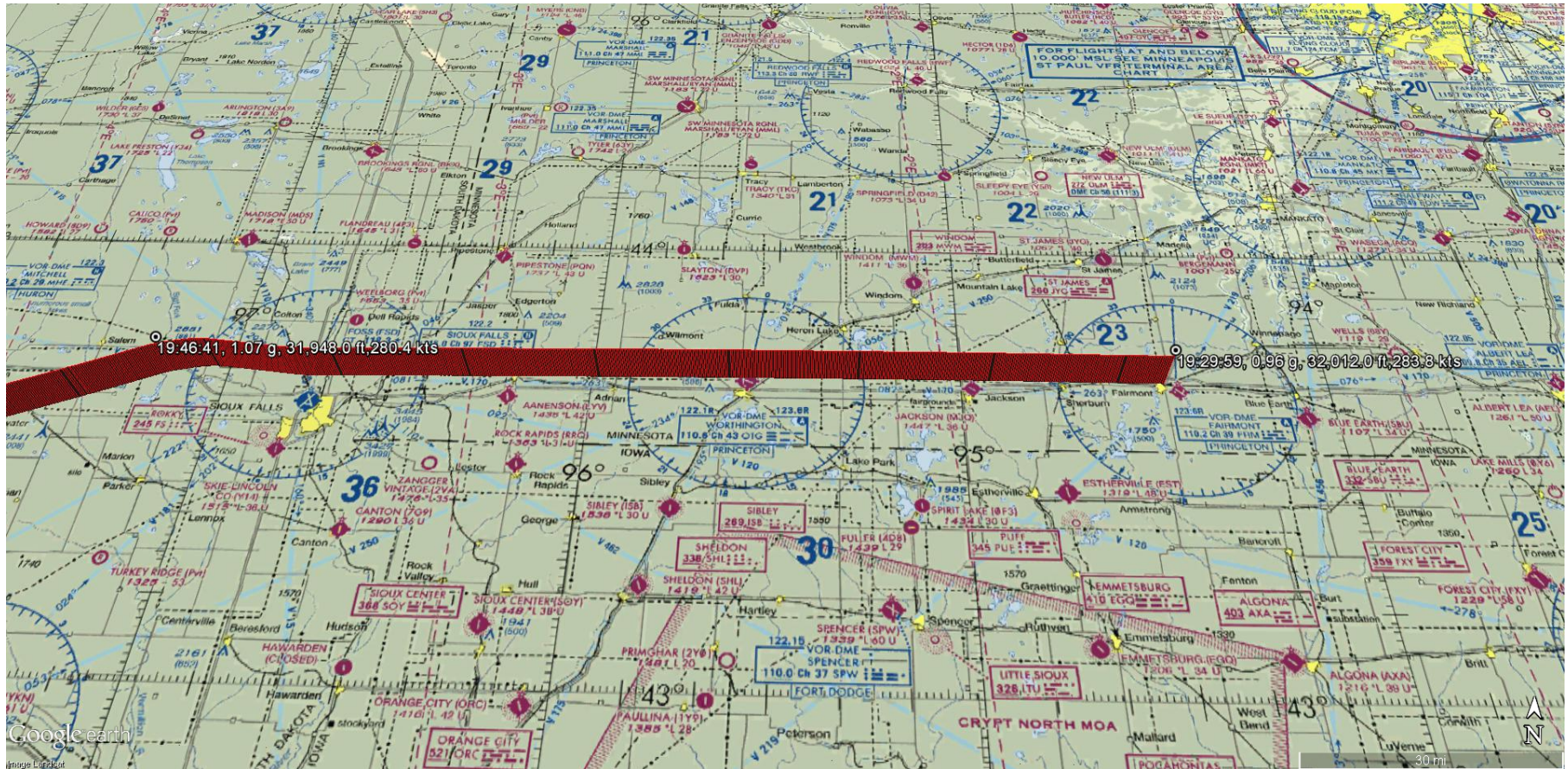


Figure 3. Overlay 19:46 to 20:10 CDT.



Figure 4. Overlay 20:02 through event at about 20:10 CDT.



Figure 5. Overlay event closeup (20:10 CDT).

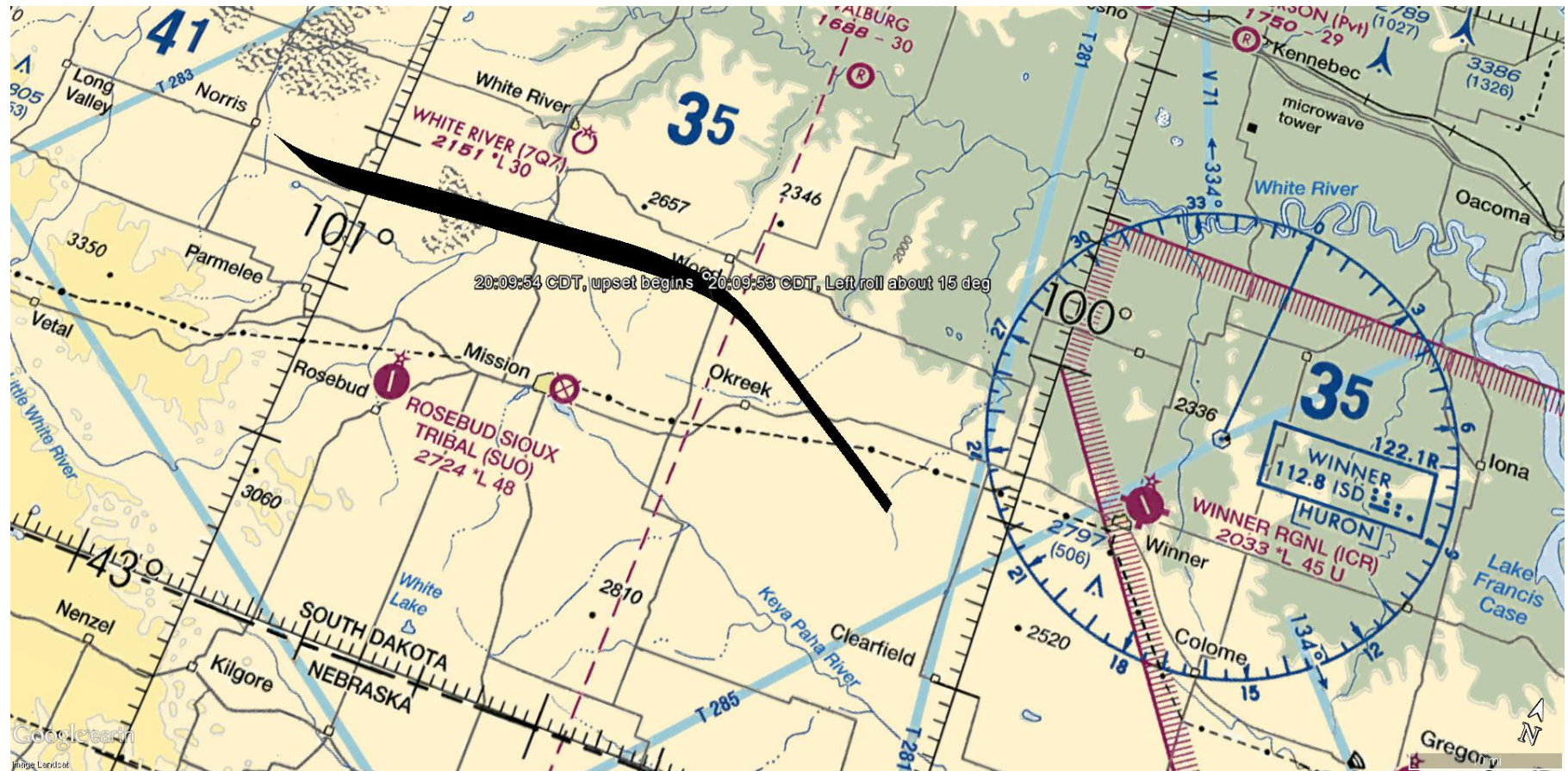


Figure 6. Overlay event to landing approach.



Figure 7. Plot of basic parameters for entire flight.

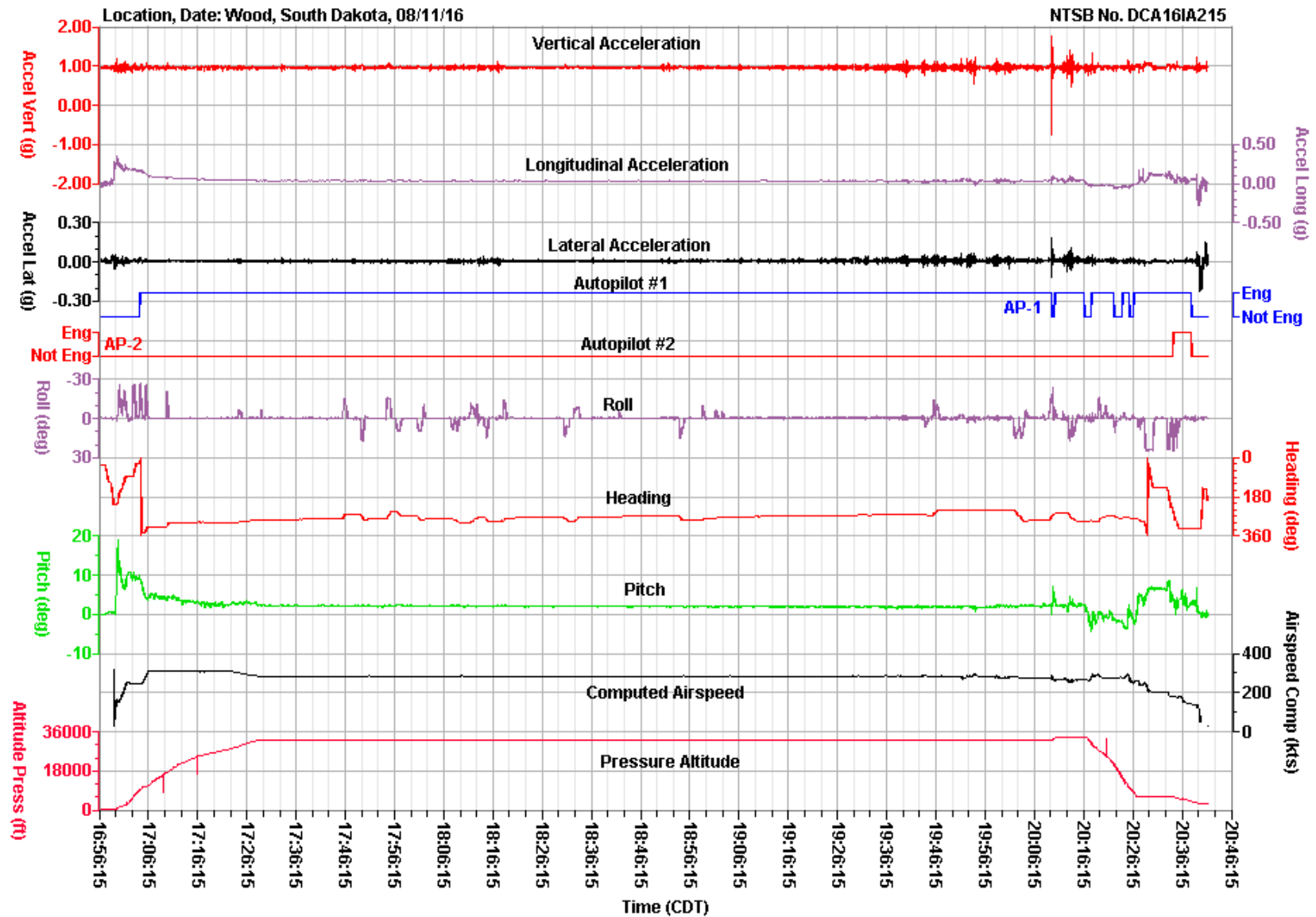


Figure 8. Plot of basic parameters during upset.

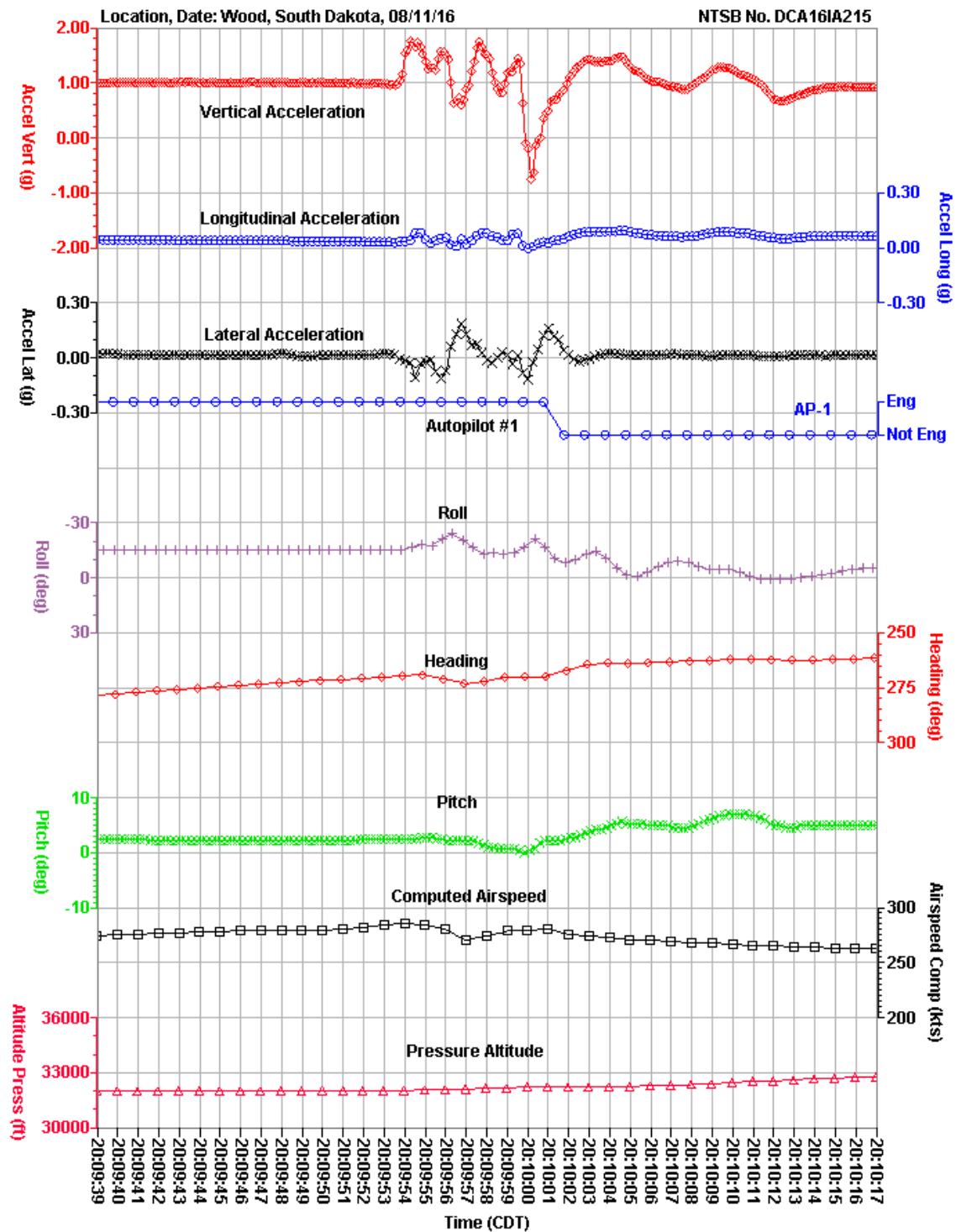


Figure 9. Plot of basic parameters for descent after upset.

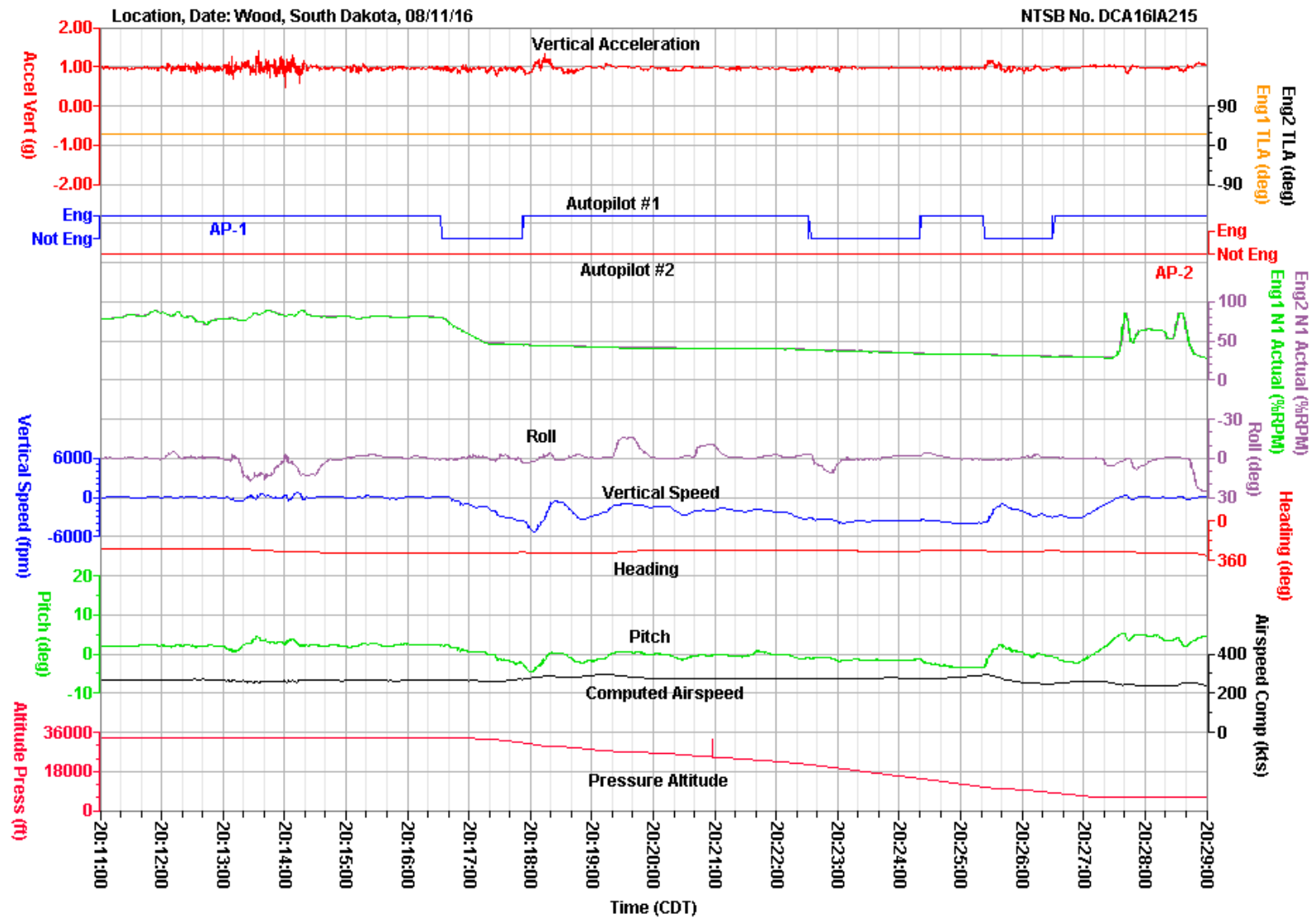


Figure 10. Plot of flight control directionality during takeoff (pitch).

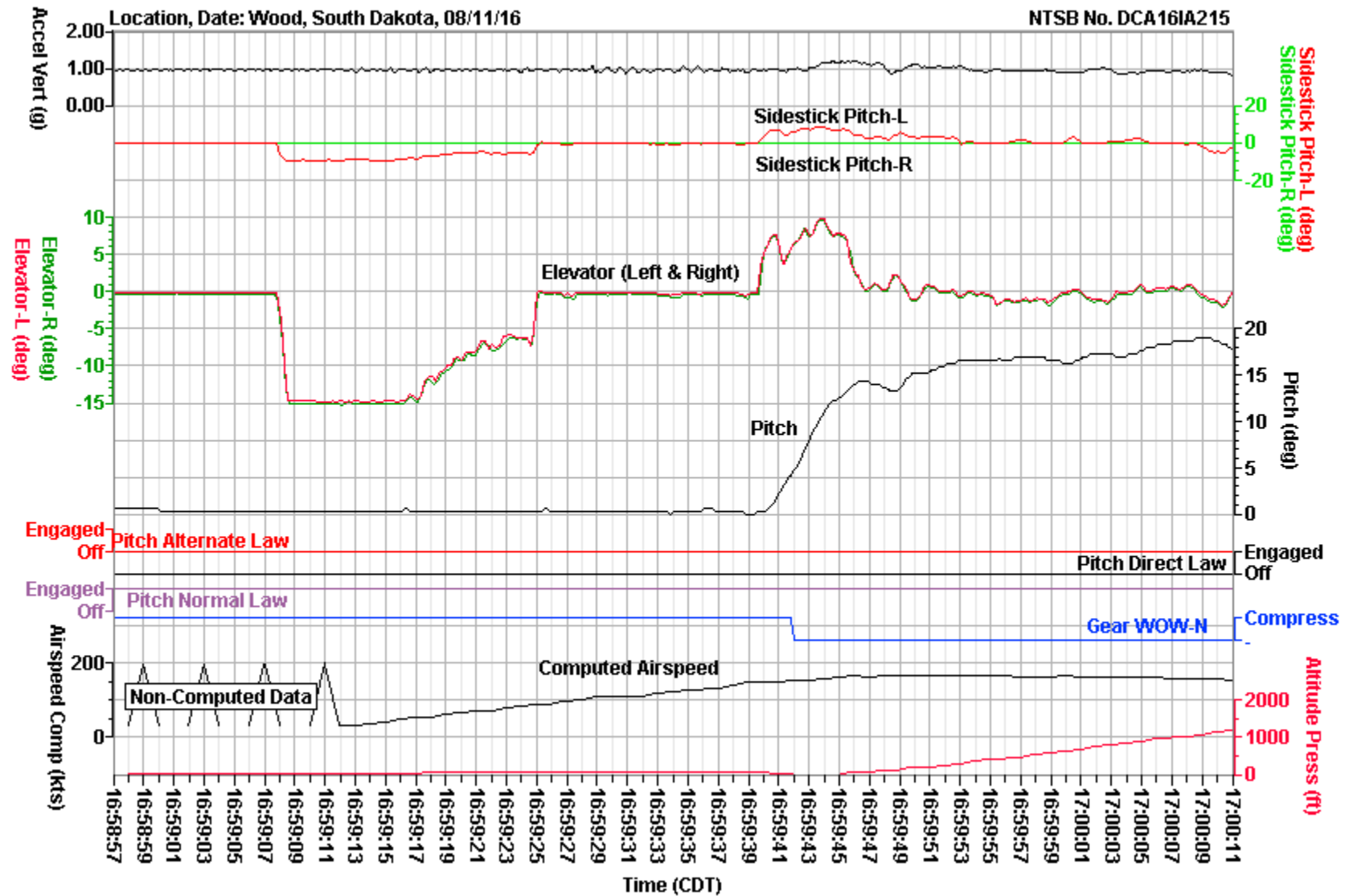


Figure 11. Plot of flight control directionality during takeoff (roll).

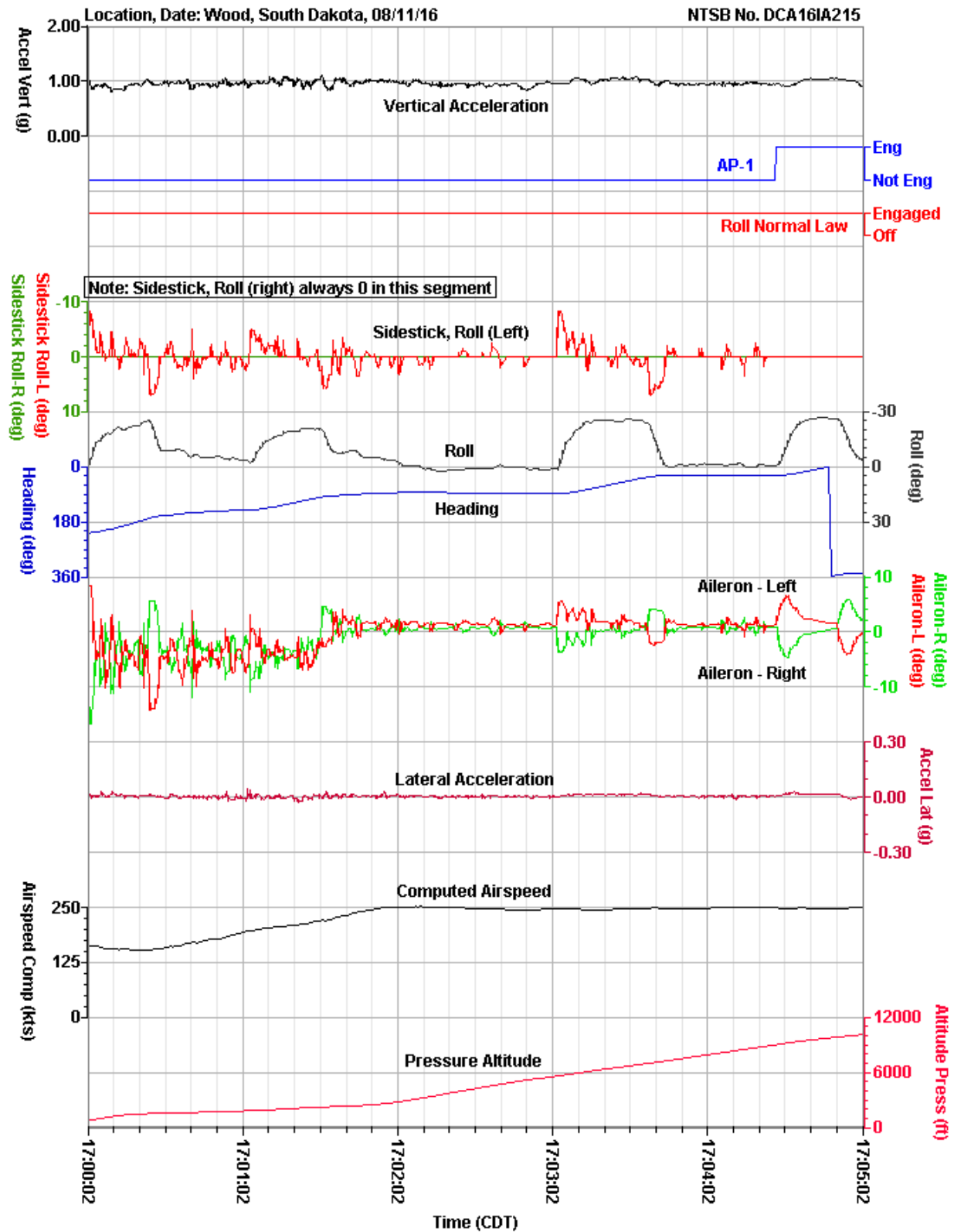


Figure 12. Plot of flight control positions during upset (pitch).

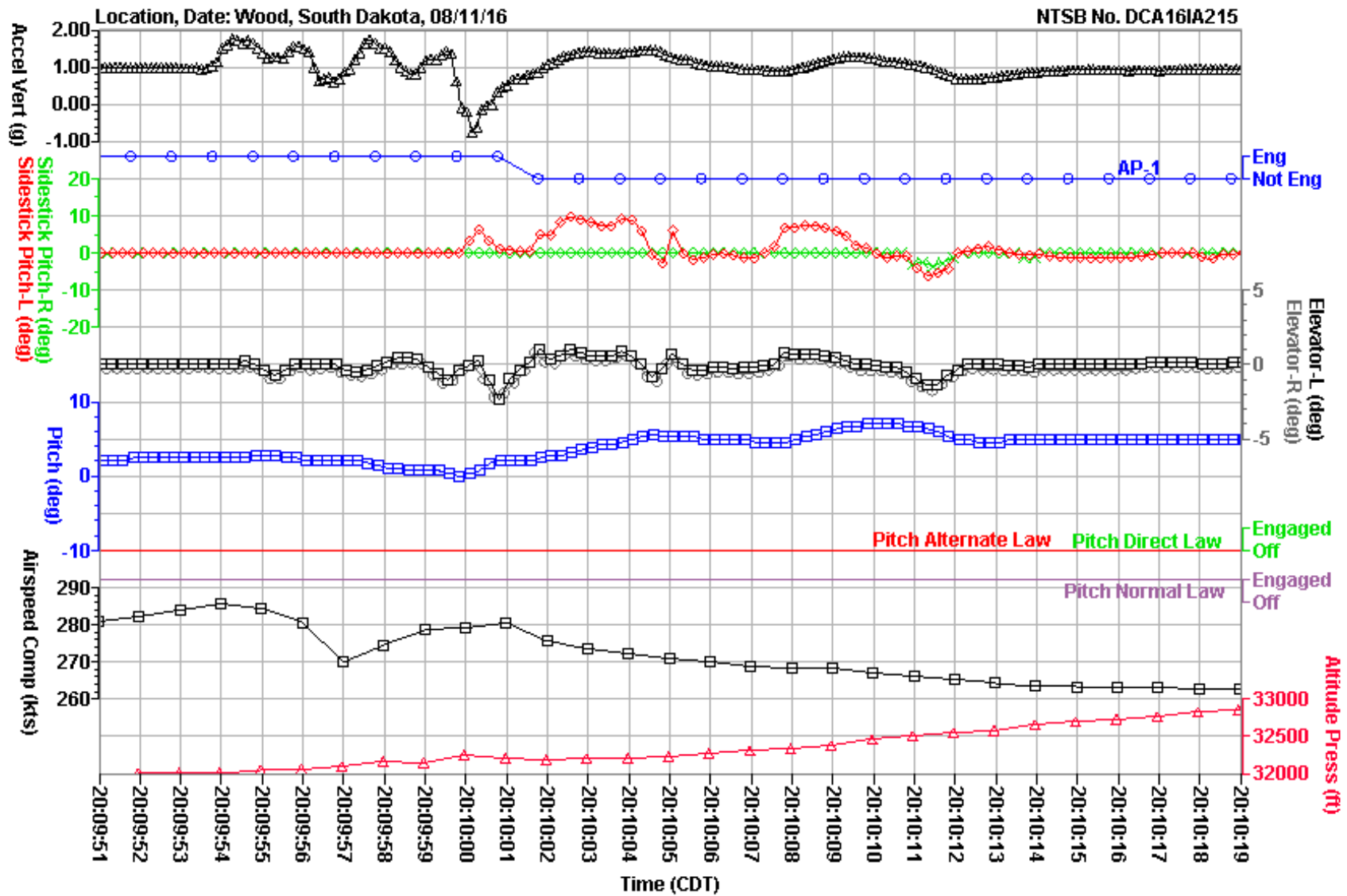


Figure 13. Plot of flight control positions during upset (roll).

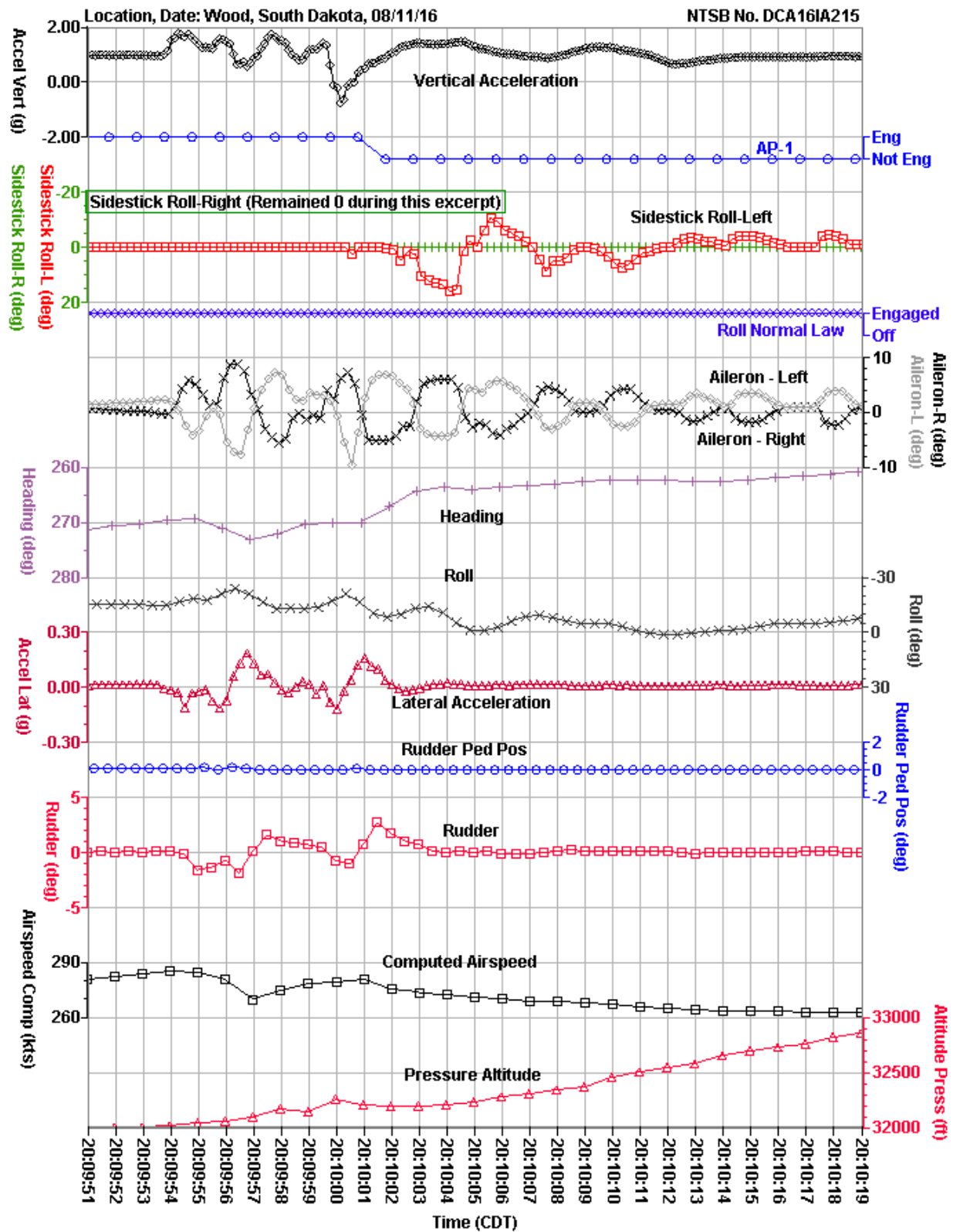


Figure 14. Plot of EGPWS and radar systems for entire flight.

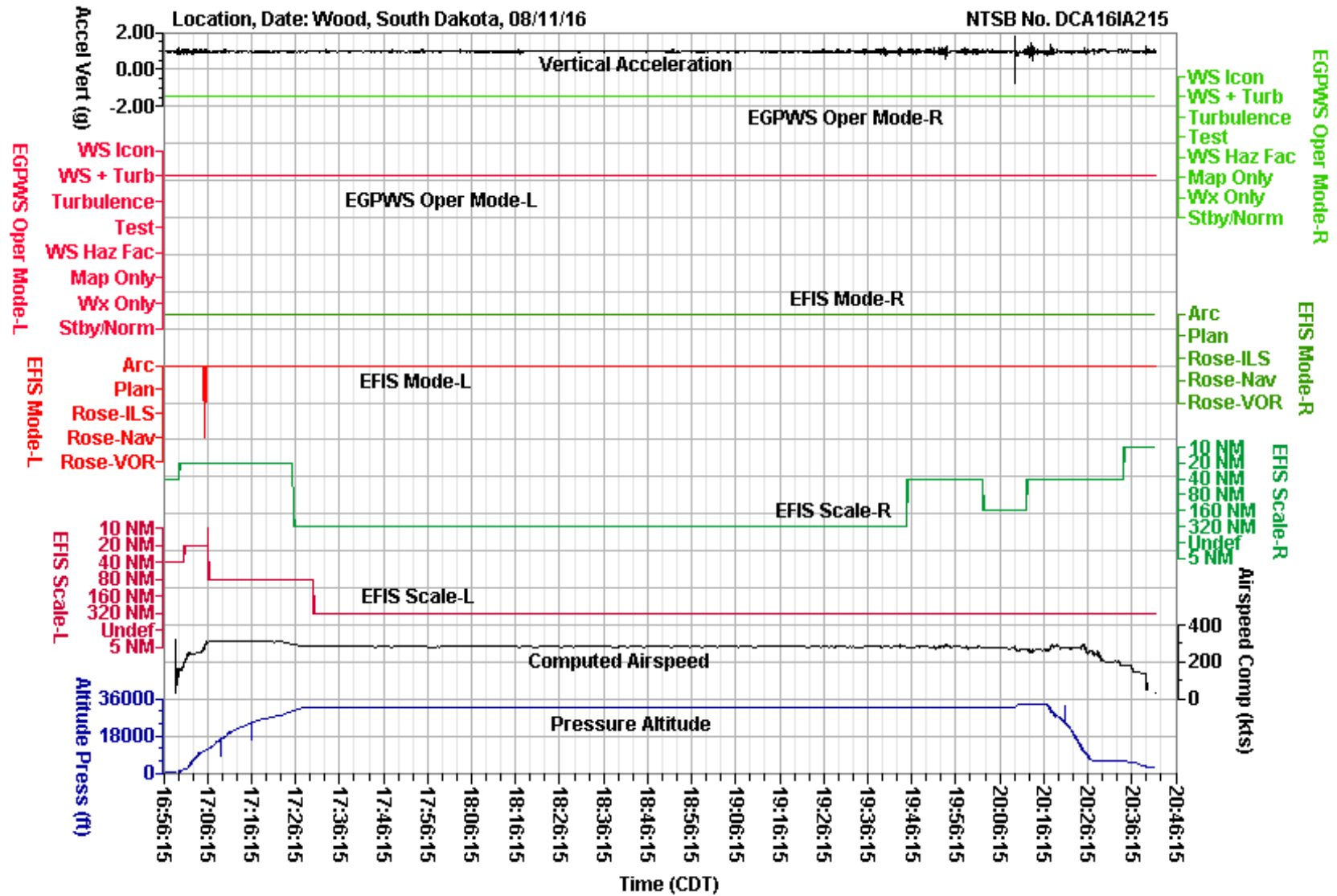


Figure 15. Plot of EGPWS and radar systems around upset time period.

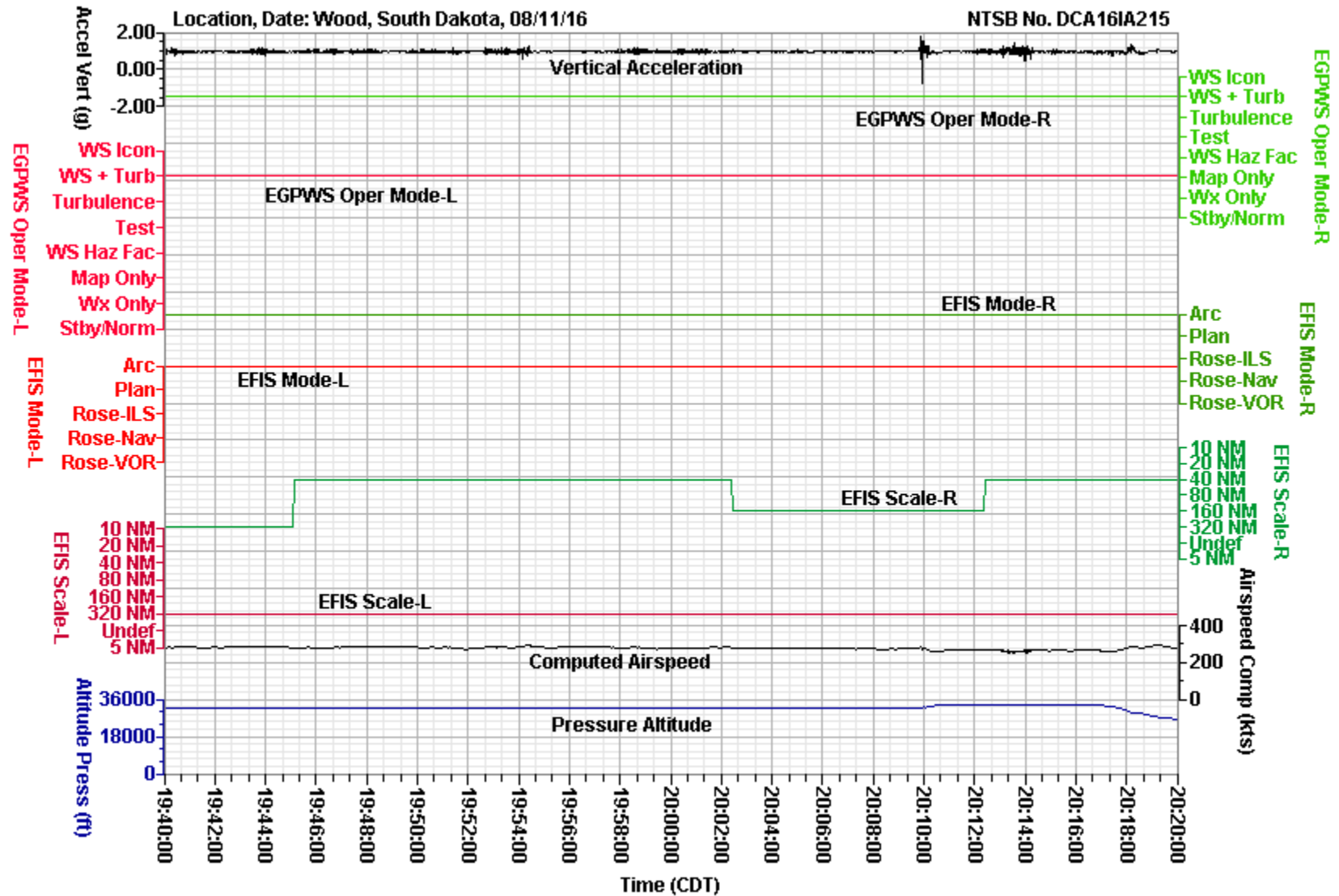


Figure 16. Plot of Flight Mode Annunciator (FMA) modes for entire flight.

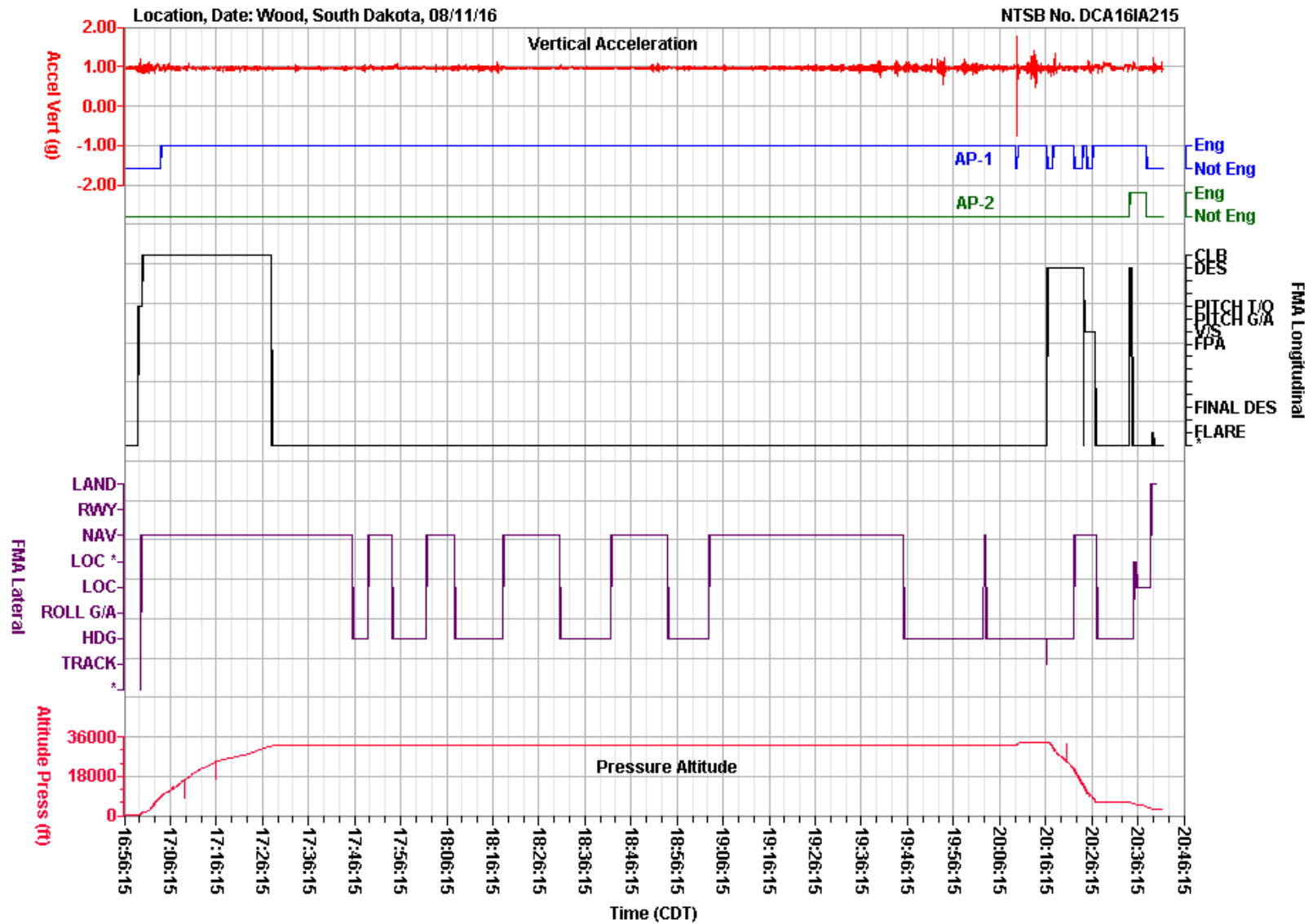


Figure 17. Plot of FMA modes surrounding upset period.

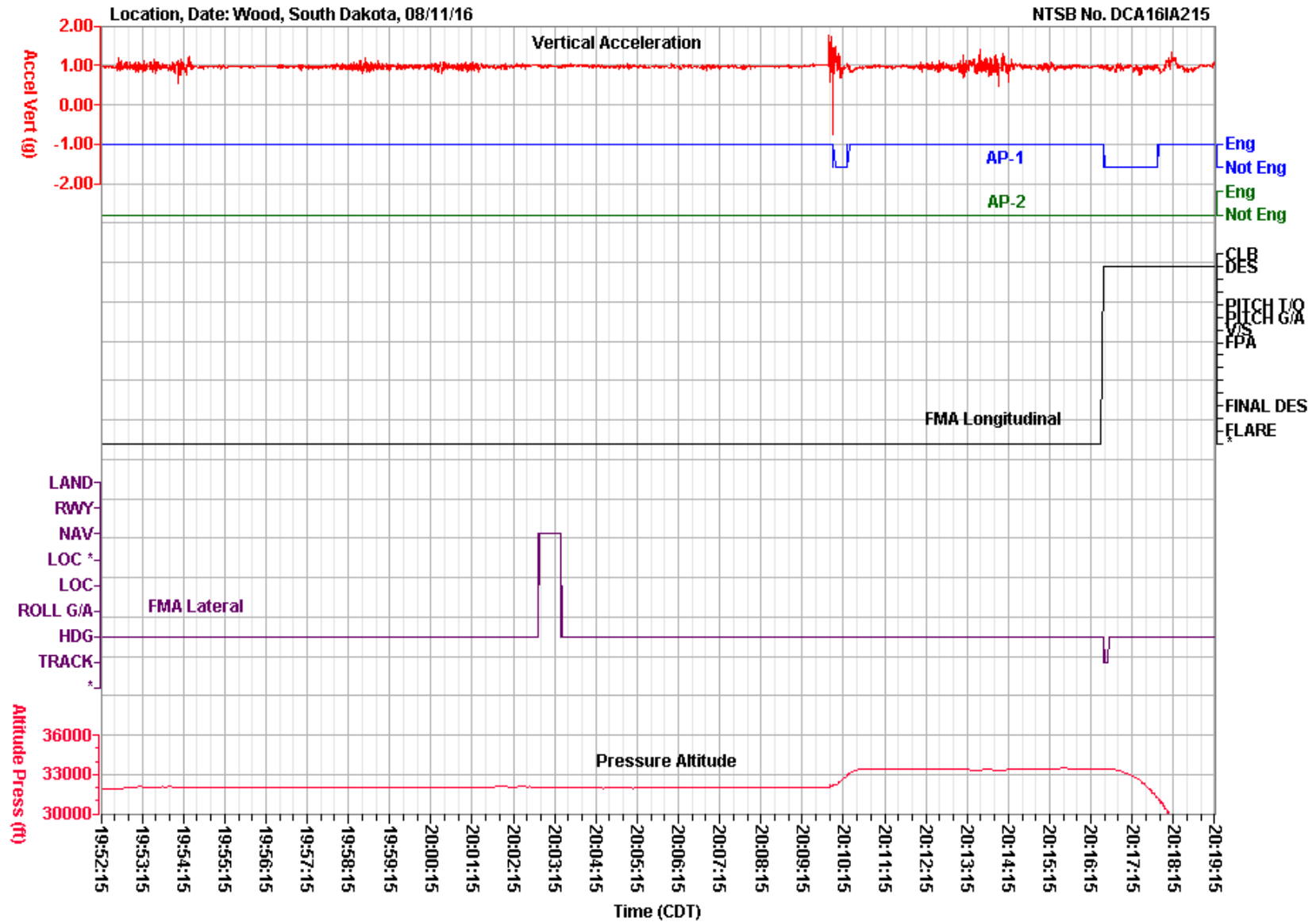


Figure 18. Plot of engine related parameters surrounding upset period.

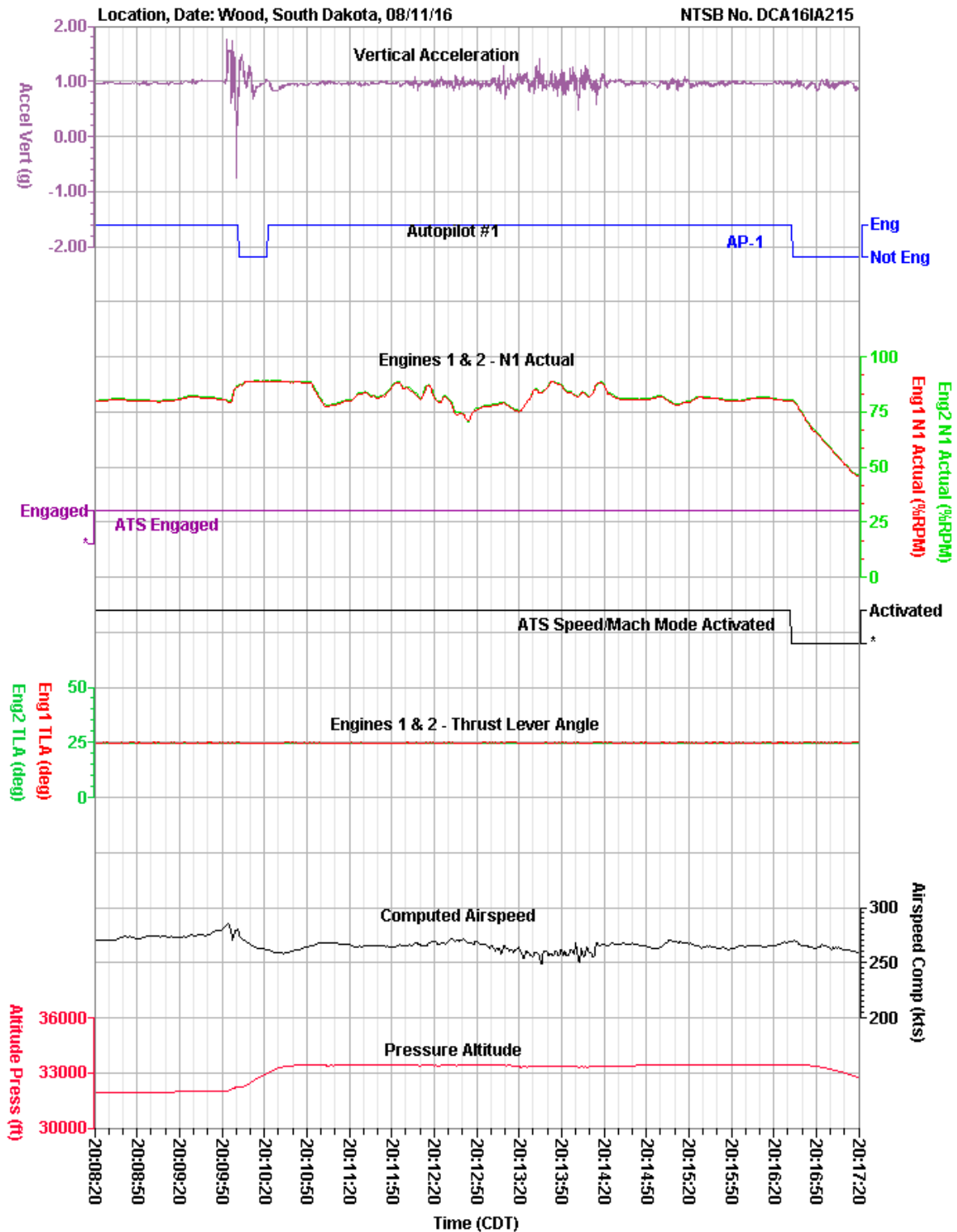


Figure 19. Plot of autopilot, flight director, warnings, and cautions for entire flight.

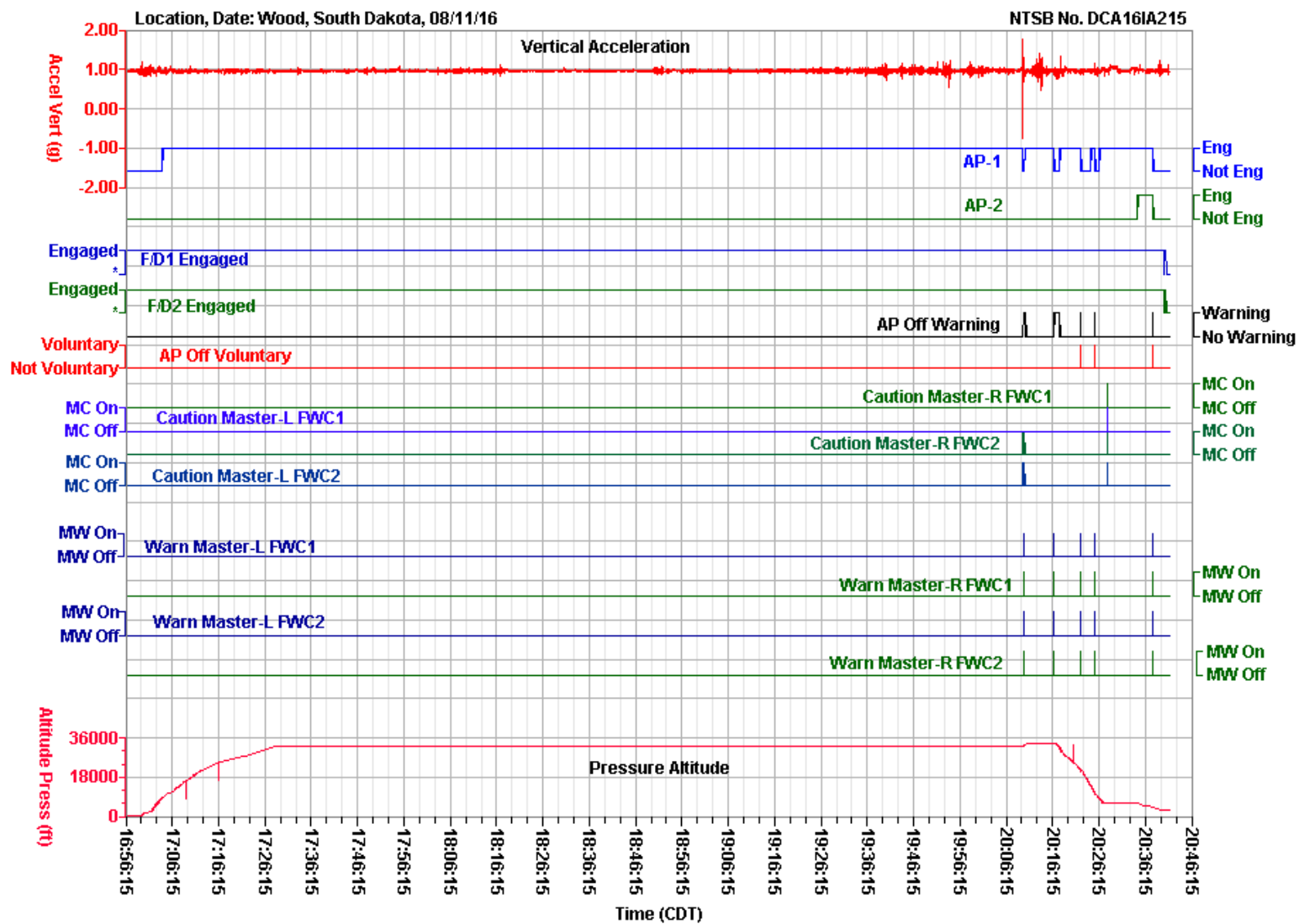


Figure 20. Plot of autopilot, flight director, warnings, and cautions surrounding event period.

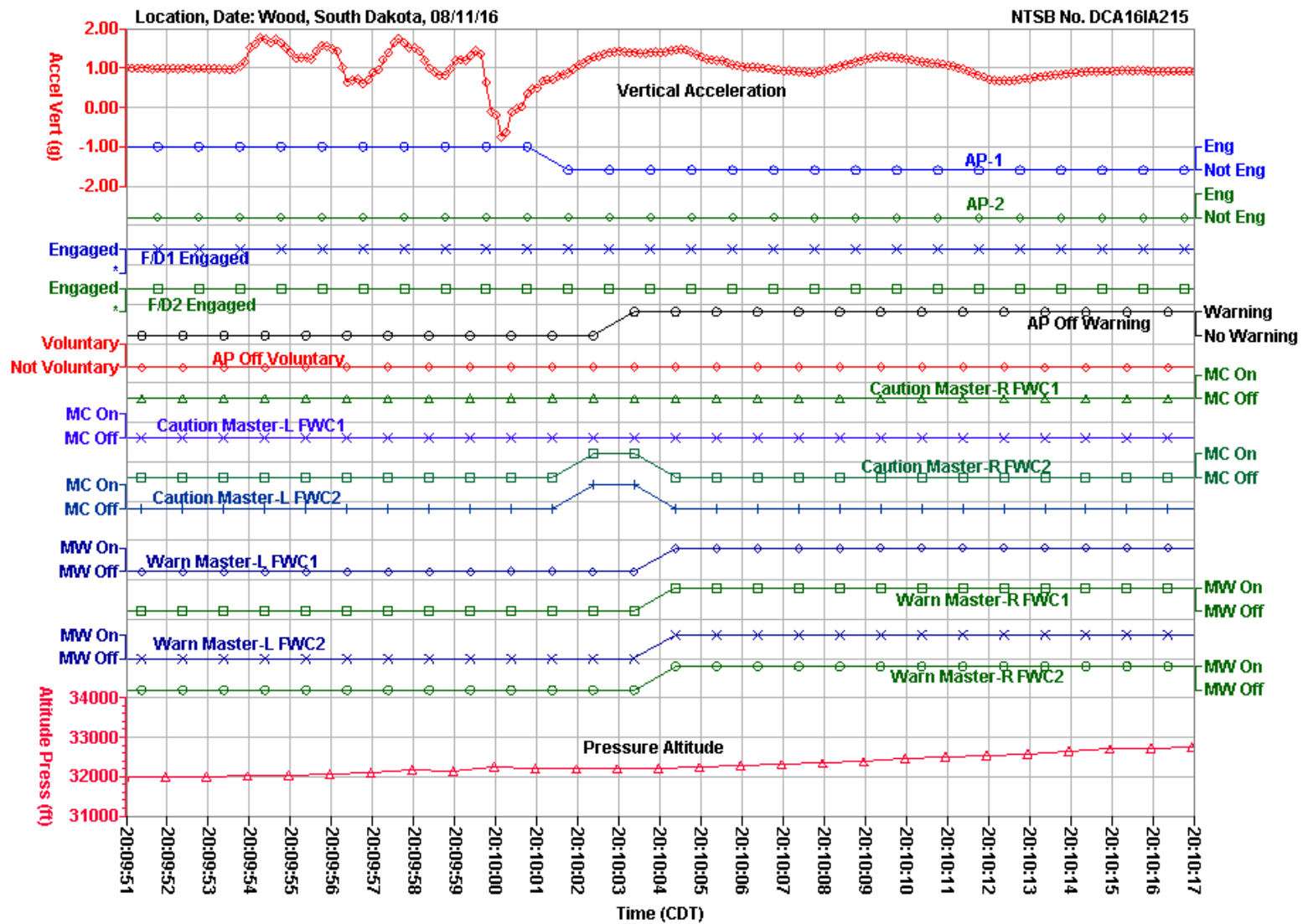


Figure 21. Plot of atmospheric-related parameters for entire flight.

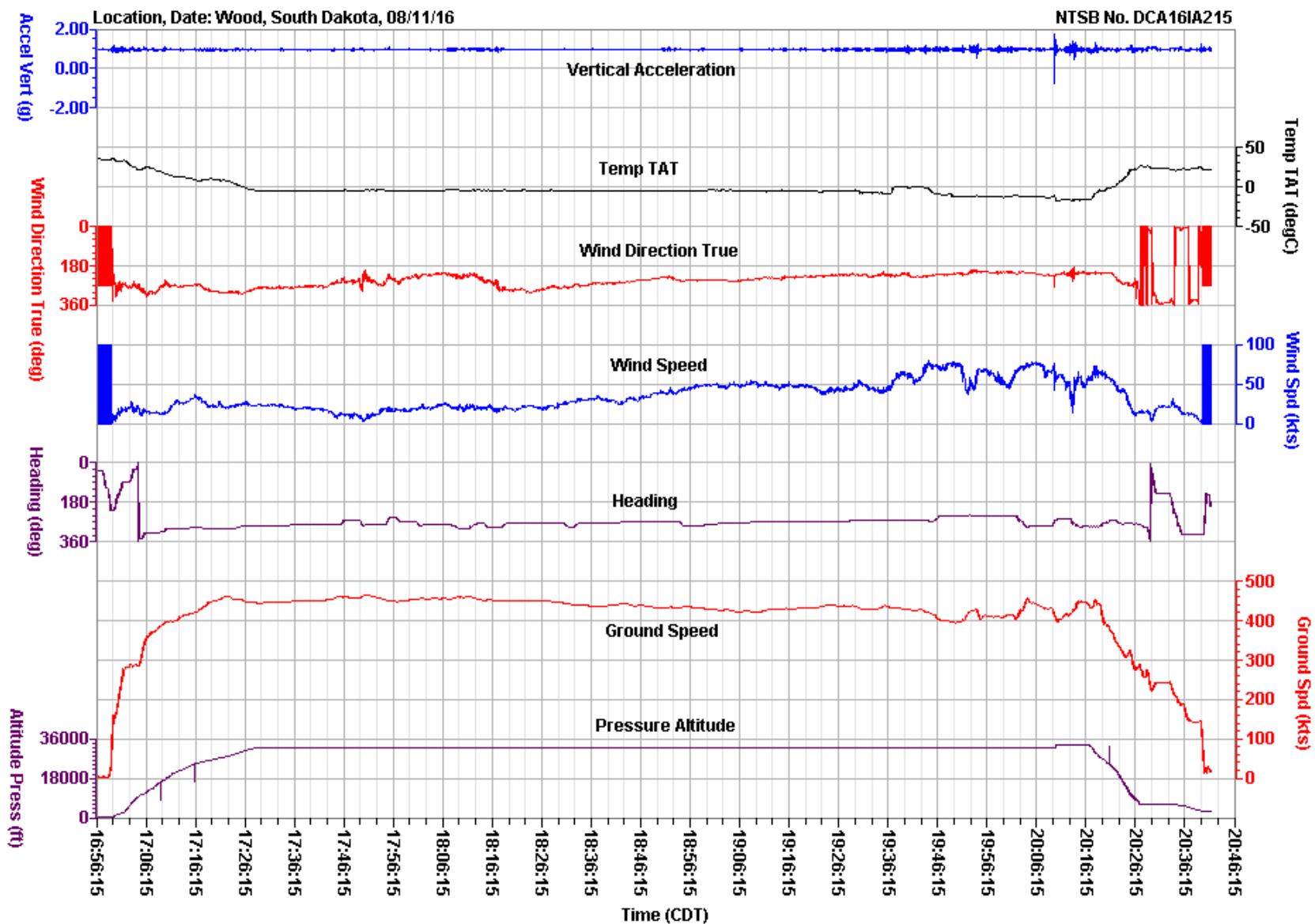
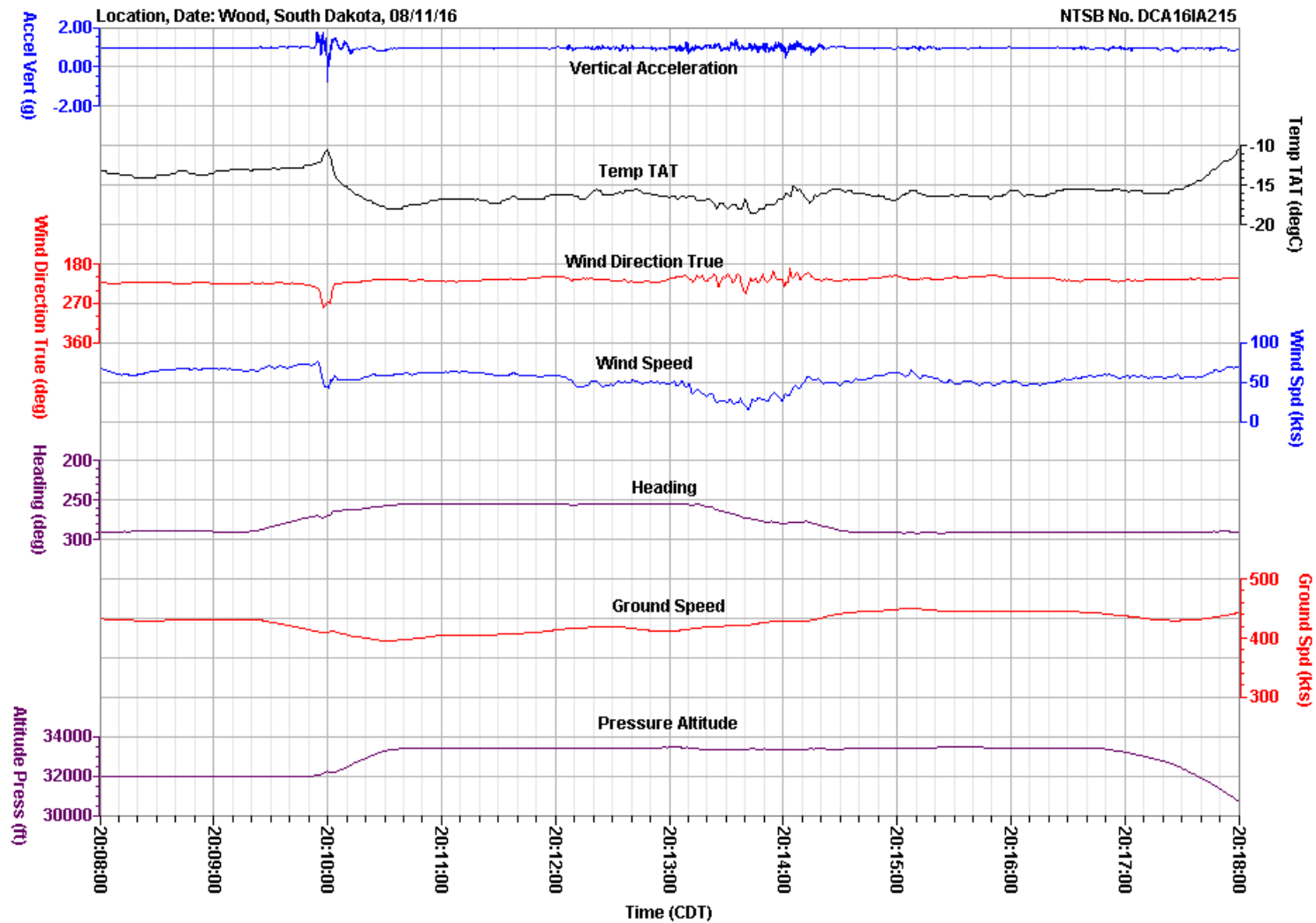


Figure 22. Plot of atmospheric-related parameters surrounding event period.



APPENDIX A

This appendix describes the parameters provided and verified in this report. Table A-1 lists the parameter names, and descriptions. Additionally, 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 (g)	Longitudinal Acceleration
3. Accel Vert (g)	Vertical Acceleration
4. Aileron-L (deg)	Left Aileron Position
5. Aileron-R (deg)	Right Aileron Position
6. Airspeed Comp (kts)	Computed Airspeed
7. Altitude Press (ft)	Pressure Altitude
8. AP ⁴ Off Warning (discrete)	AP Off Warning
9. AP Off Voluntary (discrete)	AP Off Voluntary
10. AP-1 (discrete)	AP-1 Status
11. AP-2 (discrete)	AP-2 Status
12. ATS ⁵ Engaged (discrete)	ATS Engaged
13. ATS Speed/Mach Mode Activated ()	ATS Speed/Mach Mode Activated
14. Caution Master-L FWC1 (discrete)	Left Master Caution Master, FWC ⁶ -1
15. Caution Master-L FWC2 (discrete)	Left Master Caution Master, FWC-2
16. Caution Master-R FWC1 (discrete)	Right Master Caution Master, FWC-1
17. Caution Master-R FWC2 (discrete)	Right Master Caution Master, FWC-2
18. EFIS Mode-L (discrete)	EFIS Mode-L
19. EFIS Mode-R (discrete)	EFIS Mode-R
20. EFIS Scale-L (discrete)	EFIS Scale-L
21. EFIS Scale-R (discrete)	EFIS Scale-R
22. EGPWS ⁷ Oper Mode-L (discrete)	EGPWS Oper Mode-L
23. EGPWS Oper Mode-R (discrete)	EGPWS Oper Mode-R
24. Elevator-L (deg)	Elevator-L
25. Elevator-R (deg)	Elevator-R
26. Eng1 N1 Actual (%RPM)	Eng1 N1 Actual
27. Eng1 TLA ⁸ (deg)	Eng1 TLA
28. Eng2 N1 Actual (%RPM)	Eng2 N1 Actual
29. Eng2 TLA (deg)	Eng2 TLA
30. F/D ⁹ 1 Engaged (discrete)	Left F/D Engaged
31. F/D2 Engaged (discrete)	Right F/D Engaged
32. FMA ¹⁰ Lateral (discrete)	Lateral FMA

⁴ AP means autopilot

⁵ ATS means Auto Thrust System

⁶ FWC means Flight Warning Computer

⁷ EGPWS means Enhanced Ground Proximity Warning System

⁸ TLA means Throttle Lever Angle

⁹ F/D means flight director

¹⁰ FMA means Flight Mode Annunciator

Parameter Name	Parameter Description
33. FMA Longitudinal (discrete)	Longitudinal FMA
34. Gear WOW-N (discrete)	Nose Gear Weight-on-Wheels
35. Key VHF-1 (discrete)	Key VHF-1
36. Key VHF-2 (discrete)	Key VHF-2
37. Key VHF-3 (discrete)	Key VHF-3
38. Latitude-Capt (deg)	Captain Latitude
39. Longitude-Capt (deg)	Captain Longitude
40. Pitch (deg)	Pitch Angle
41. Pitch Alternate Law (discrete)	Pitch Alternate Control Law
42. Pitch Direct Law (discrete)	Pitch Direct Control Law
43. Pitch Normal Law (discrete)	Pitch Normal Control Law
44. Roll (deg)	Roll Angle
45. Roll Normal Law (discrete)	Roll Normal Control Law
46. Rudder (deg)	Rudder Deflection
47. Rudder Ped Pos (deg)	Rudder Ped Pos
48. Sidestick Pitch-L (deg)	Captain Sidestick Pitch
49. Sidestick Pitch-R (deg)	First Officer Sidestick Pitch
50. Sidestick Roll-L (deg)	Captain Sidestick Roll
51. Sidestick Roll-R (deg)	First Officer Sidestick Roll
52. Temp TAT (degC)	Total Air Temperature
53. Time GMT Min (min)	Time GMT Min
54. Time GMT Sec (sec)	Time GMT Sec
55. Time UTC Hrs (spr 00) (hrs)	Time GMT Hrs
56. Vertical Speed (fpm)	Vertical Speed
57. Warn Master-L FWC1 (discrete)	Left Master Warning, FWC-1
58. Warn Master-L FWC2 (discrete)	Left Master Warning, FWC-2
59. Warn Master-R FWC1 (discrete)	Right Master Warning, FWC-1
60. Warn Master-R FWC2 (discrete)	Right Master Warning, FWC-2
61. Wind Direction True (deg)	Wind Direction True (Computed)
62. Wind Spd (kts)	Wind Speed (Computed)

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.

Unit Abbreviations	Descriptions
%rpm	percent revolutions per minute
deg	degrees
degC	degrees Celsius
fpm	feet per minute
ft	feet
g	g
hrs	hours
kts	knots
min	minutes
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.