

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



DCA23FA428

FLIGHT DATA RECORDER

Specialist's Factual Report

January 19, 2024

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A. ACCIDENT

Location: Atlanta, Georgia
Date: August 29, 2023
Time: 1831 eastern daylight time (EDT)
2231 coordinated universal time (UTC)
Airplane: Airbus A350-941, N576DZ, Delta Air Lines flight 175 (DAL 175)

B. FLIGHT DATA RECORDER SPECIALIST

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

C. FEDERAL CARRIAGE REQUIREMENTS

The event aircraft, N576DZ, was operating as Title 14 *Code of Federal Regulations* (CFR) Part 121. The event aircraft was manufactured in 2019 and was operating such that it was required to be equipped with a flight data recorder (FDR) that recorded, at a minimum, 88 parameters, as cited in 14 CFR Part 121.344.

D. DETAILS OF THE INVESTIGATION

The NTSB Vehicle Recorder Division received an electronic file containing the FDR data from the N576DZ aircraft. An FDR group was not convened.

1.1 Recording Description

The FDR recording was delivered electronically to the Vehicle Recorder Division in compressed .fdr format. The decompressed file contained approximately 87 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 9 hours and 50 minutes. The parameters evaluated for the purpose of this report appeared to be in accordance with federal FDR carriage requirements.

1.1.1 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 2 lists the FDR parameters verified and provided in this report. Additionally, table 3 describes the unit and discrete state abbreviations and other acronyms used in this report.

1.2 Time Correlation

Timing of the FDR data was established by using the recorded coordinated universal time (UTC) Hours, UTC Minutes, and UTC Seconds sourced from the ADIRS GPS Clock.

Accordingly, the time offset for the event flight data from SRN to UTC is the following: UTC = SRN - 226555.6. Therefore, for the rest of this report, all times are referenced as UTC, not SRN.

E. FIGURES AND TABULAR DATA

Figures 1 to 13 contain FDR data recorded during the event on August 29, 2023. Table 1 is a summary of the figures provided in this report. All the parameters listed in table 2 are plotted except UTC Hours, UTC Minutes, and UTC Seconds.

Table 1. Summary of figures.

Figure	Timeframe	Summary of figure
Figure 1	Final 23 minutes of flight	Map overlay in Google Earth ²
Figure 2	Full accident flight	Basic parameters (accelerations, speed, altitude, attitude)
Figure 3		Attitude and altitude rates, FWA Master parameters
Figure 4		Autoflight related parameters
Figure 5		Sidestick position and flight computer command parameters
Figure 6		Control surface position parameters
Figure 7		Weather radar parameters
Figure 8		Atmospheric wind conditions and related aircraft parameters
Figure 9		Basic parameters (accelerations, speed, altitude, attitude)
Figure 10	Final 23 minutes of flight	Attitude and altitude rate, FWA Master parameters
Figure 11		Sidestick position and flight computer command parameters
Figure 12		Control surface position parameters
Figure 13		Atmospheric wind conditions and related aircraft parameters

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 = +.

² Weather and lighting conditions in Google Earth are not necessarily representative of weather and lighting conditions prevalent at the time of the event.

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 data show that the aircraft departed shortly after 1300 UTC. The aircraft climbed to cruise altitude and the cruise portion of the flight lasted approximately 9 hours. Autopilot was engaged shortly after departure and remained on until the final approach.

During the descent at about 2231:15 UTC, as the aircraft passed through a pressure altitude of about 15,100 ft and computed airspeed of 312 kts, the aircraft experienced a period of severe turbulence.³ In less than one second, the aircraft experienced vertical accelerations ranging from +1.69g to -0.97g and recorded vertical speeds from +3,000 fpm to -10,600 fpm. Peak values were likely not captured due to the sampling rate of the data. The aircraft experienced perturbations in pitch, roll, yaw, and airspeed.

Following the turbulence encounter, the aircraft continued its descent and landed at 2248:06 UTC.

The corresponding tabular data used to create figures 1 to 13 are provided in electronic comma-separated value (CSV) format as attachment 1 to this report.

Submitted by:

Charles Cates
Mechanical Engineer/Recorder Specialist

³ The November 2019 Airbus Safety First publication defines severe turbulence as the following: "Severe turbulence causes large abrupt changes in aircraft altitude and attitude with large variations in airspeed."

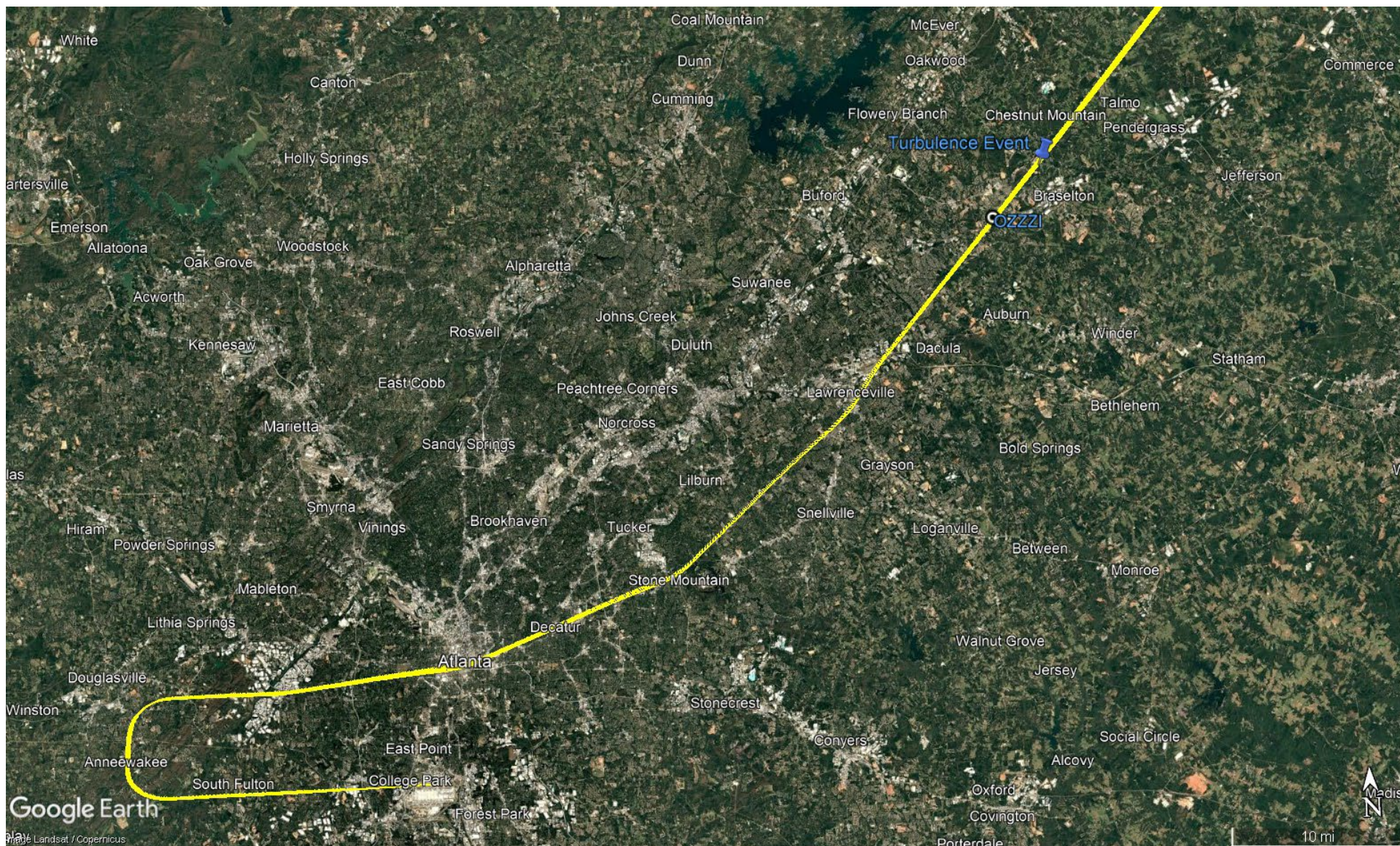


Figure 1. Map overlay of flight path for final 23 minutes of flight, including annotations denoting the locations of the turbulence encounter and the waypoint COZZI.

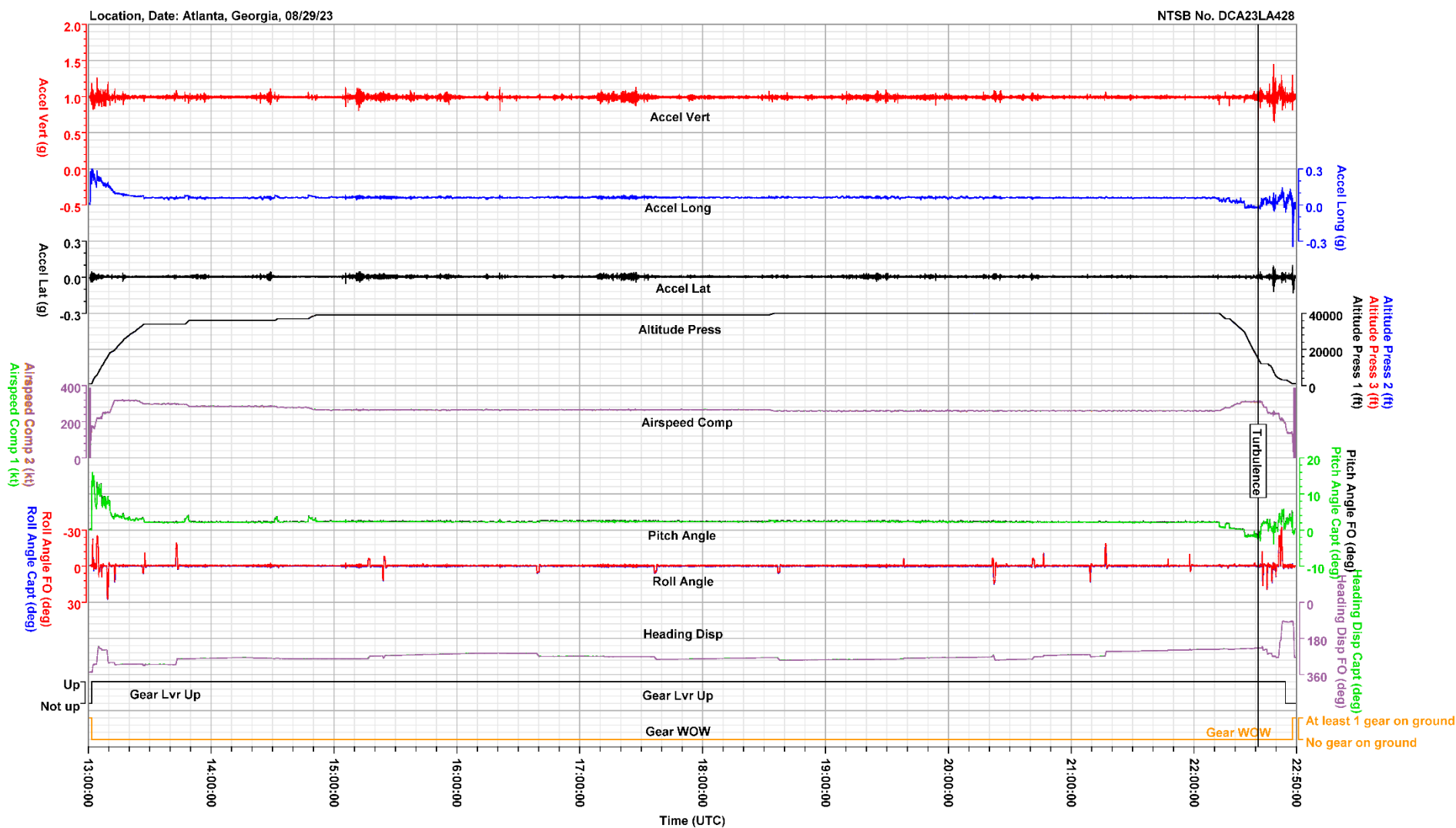


Figure 2. Plot of aircraft basic parameters for the full accident flight.

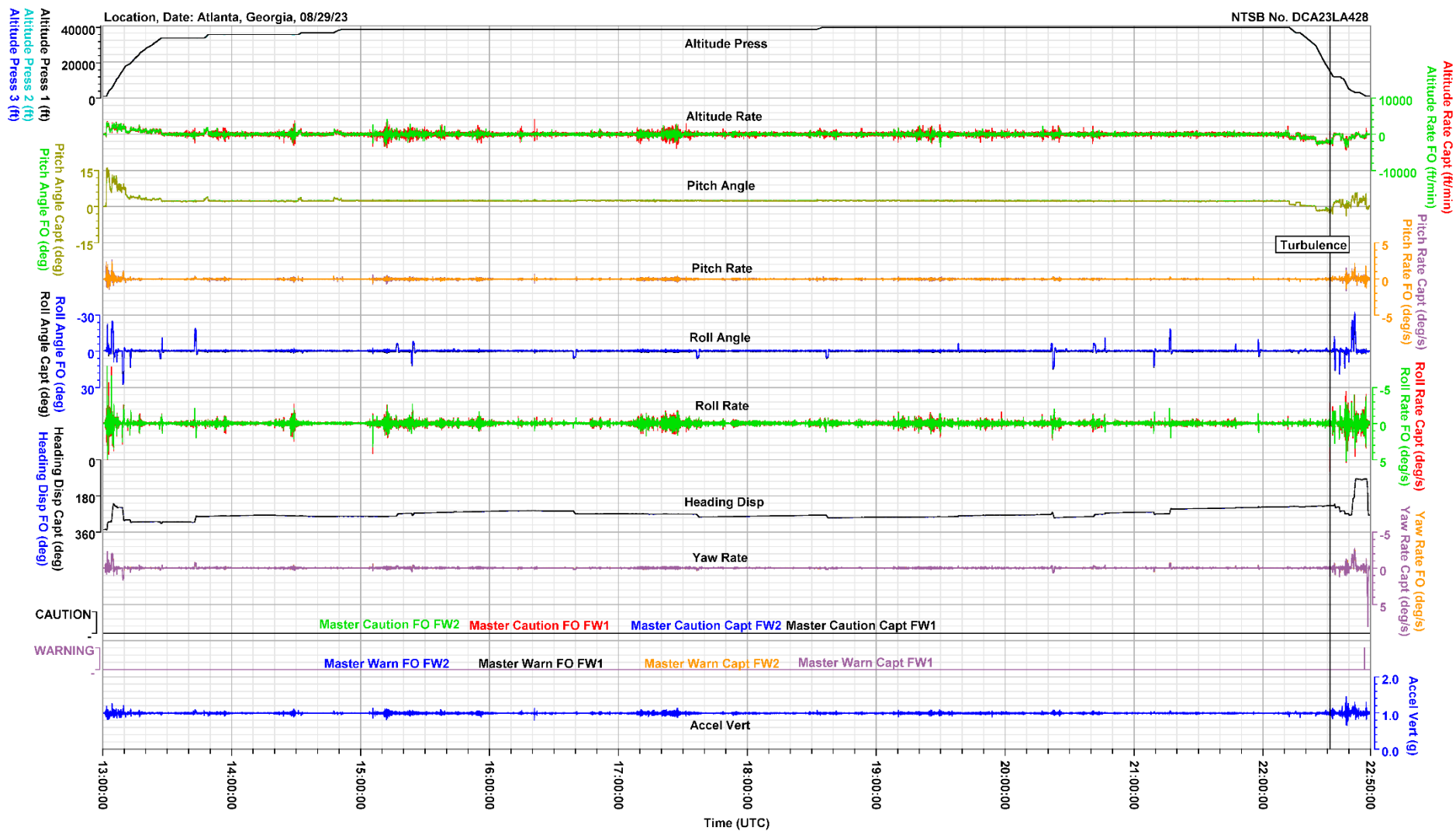


Figure 3. Plot of attitude, attitude rates, and FWA master parameters for the full accident flight.

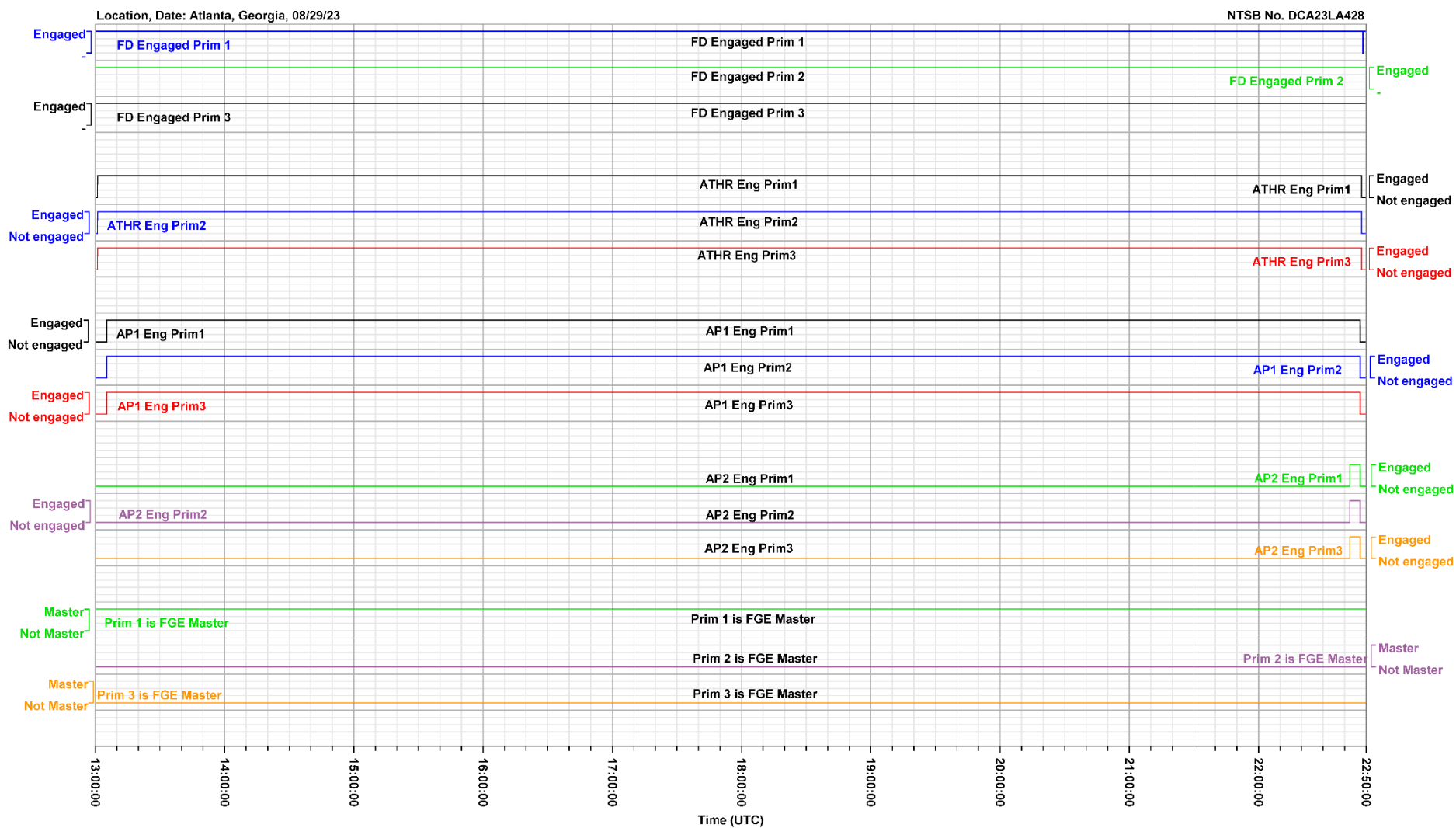


Figure 4. Plot of autoflight-related parameters for the full accident flight.

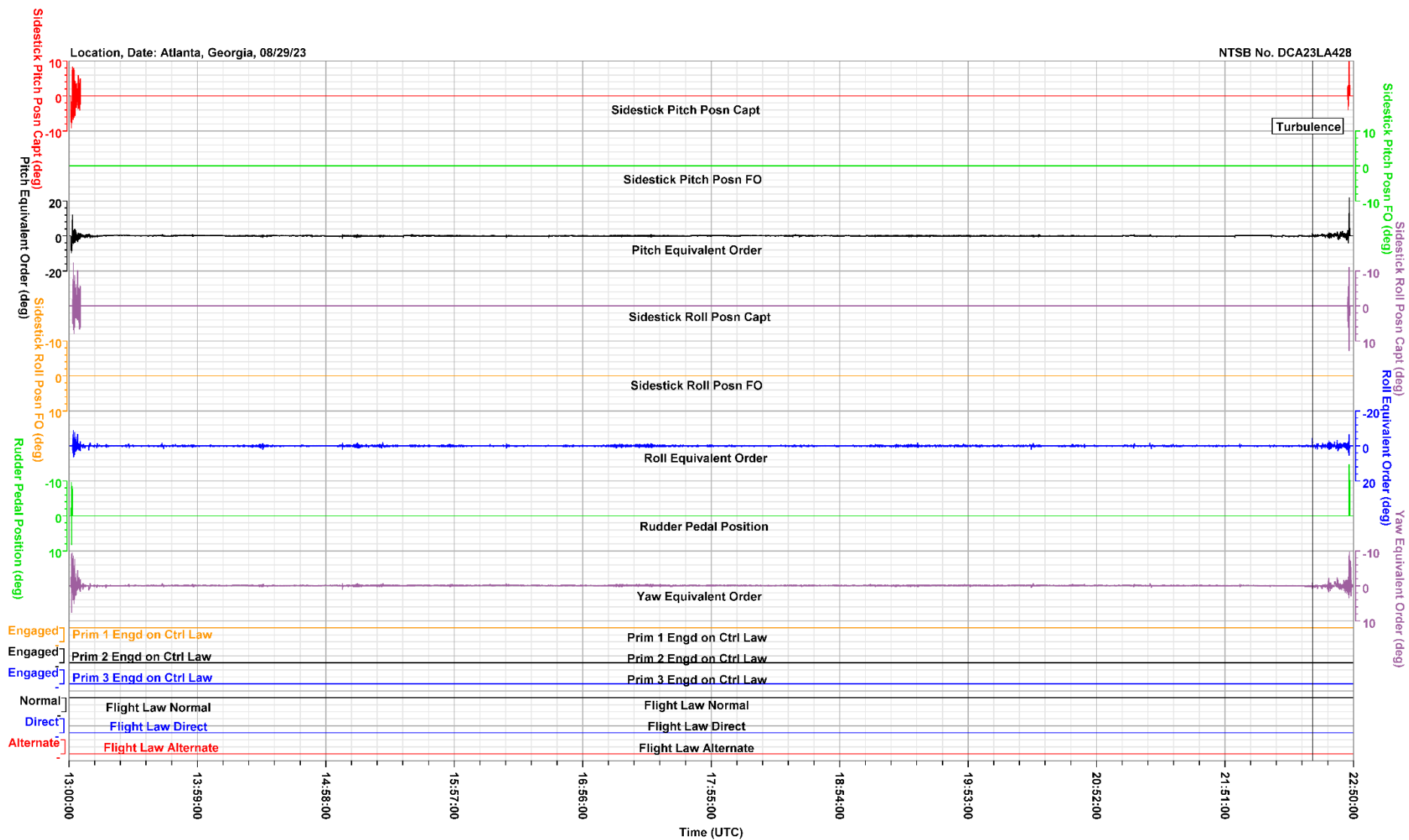


Figure 5. Plot of sidestick positions and flight computer commands for the full accident flight.

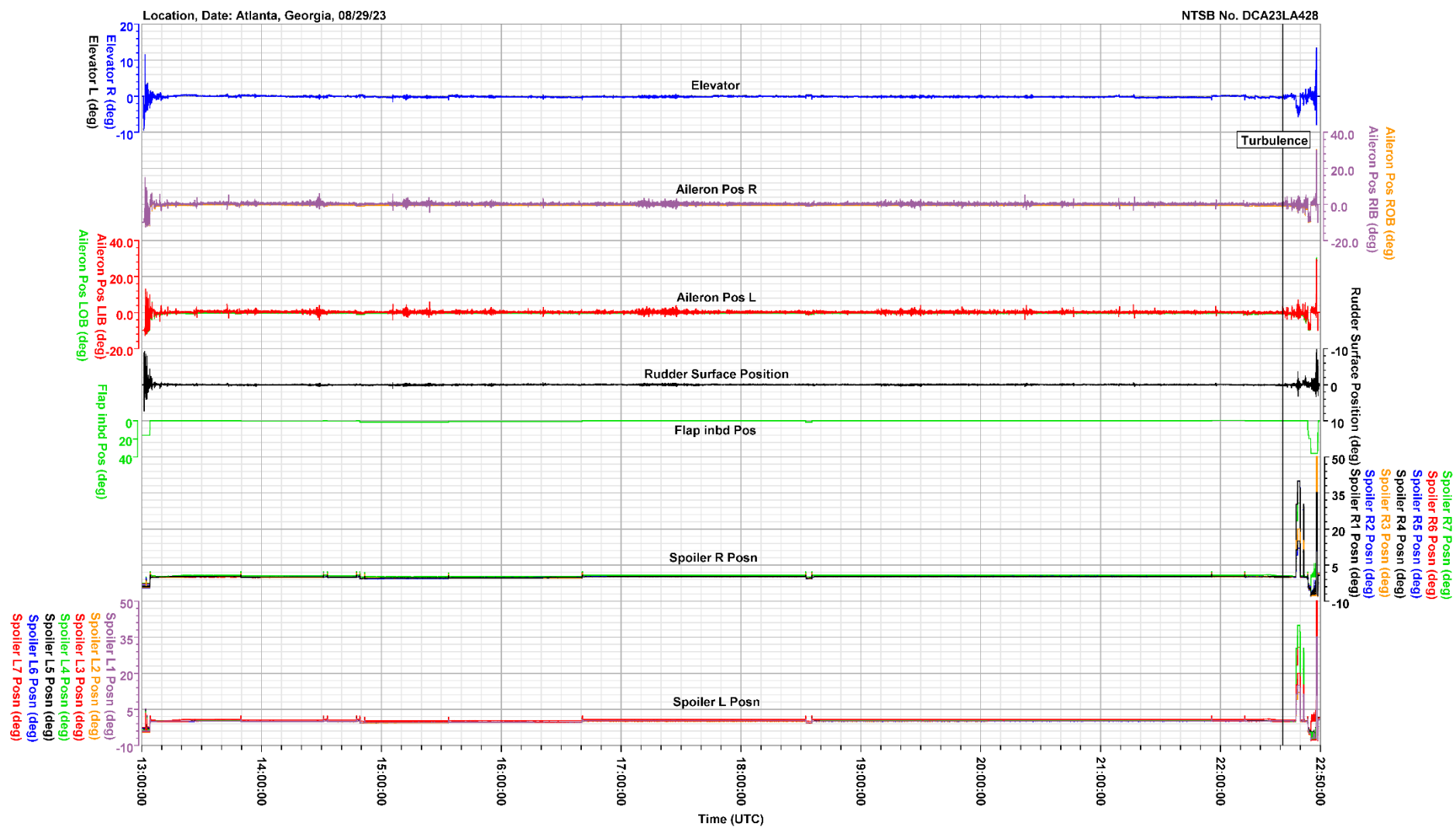


Figure 6. Plot of control surface positions for the full accident flight.

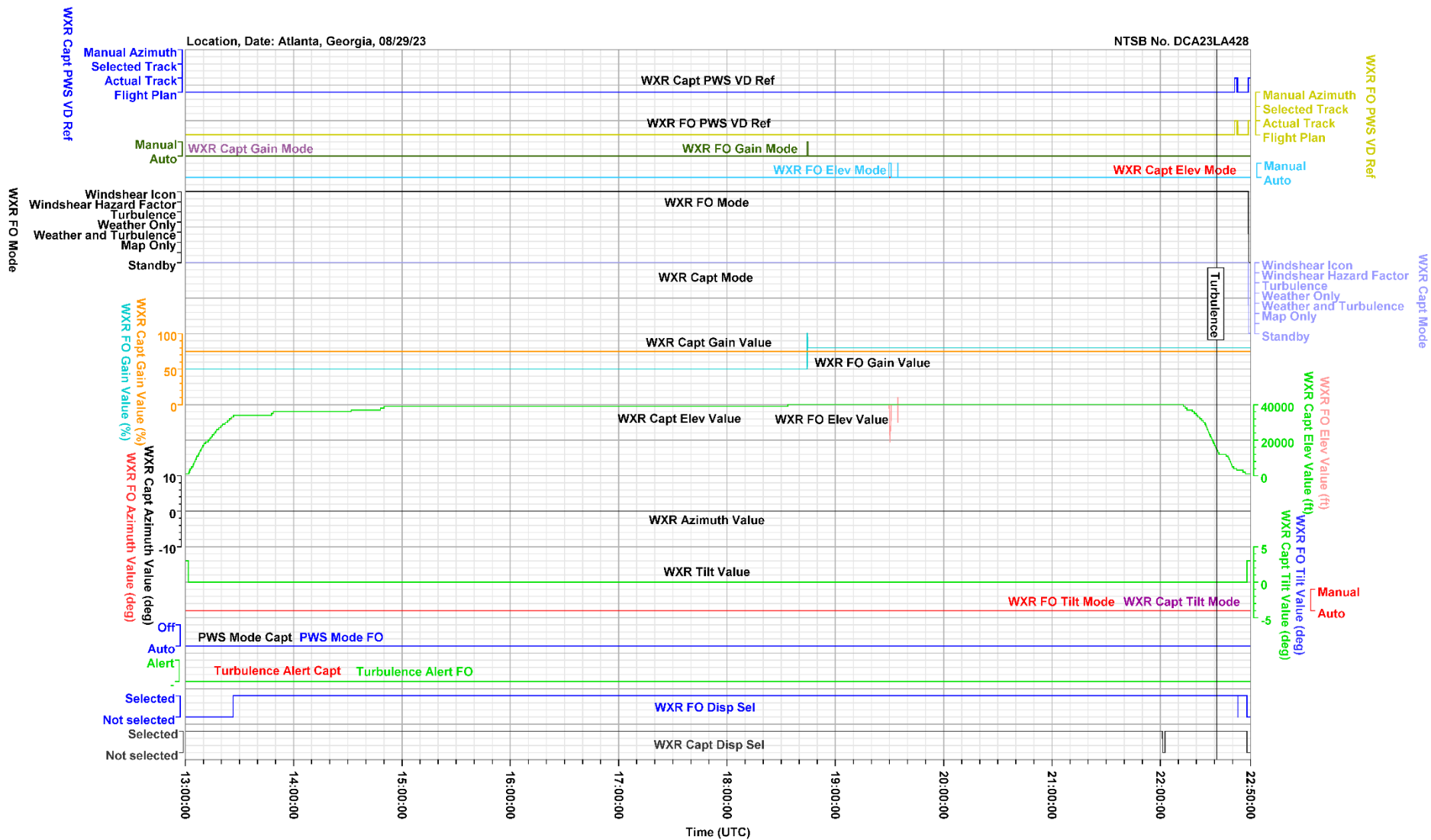


Figure 7. Plot of weather radar parameters for the full accident flight.

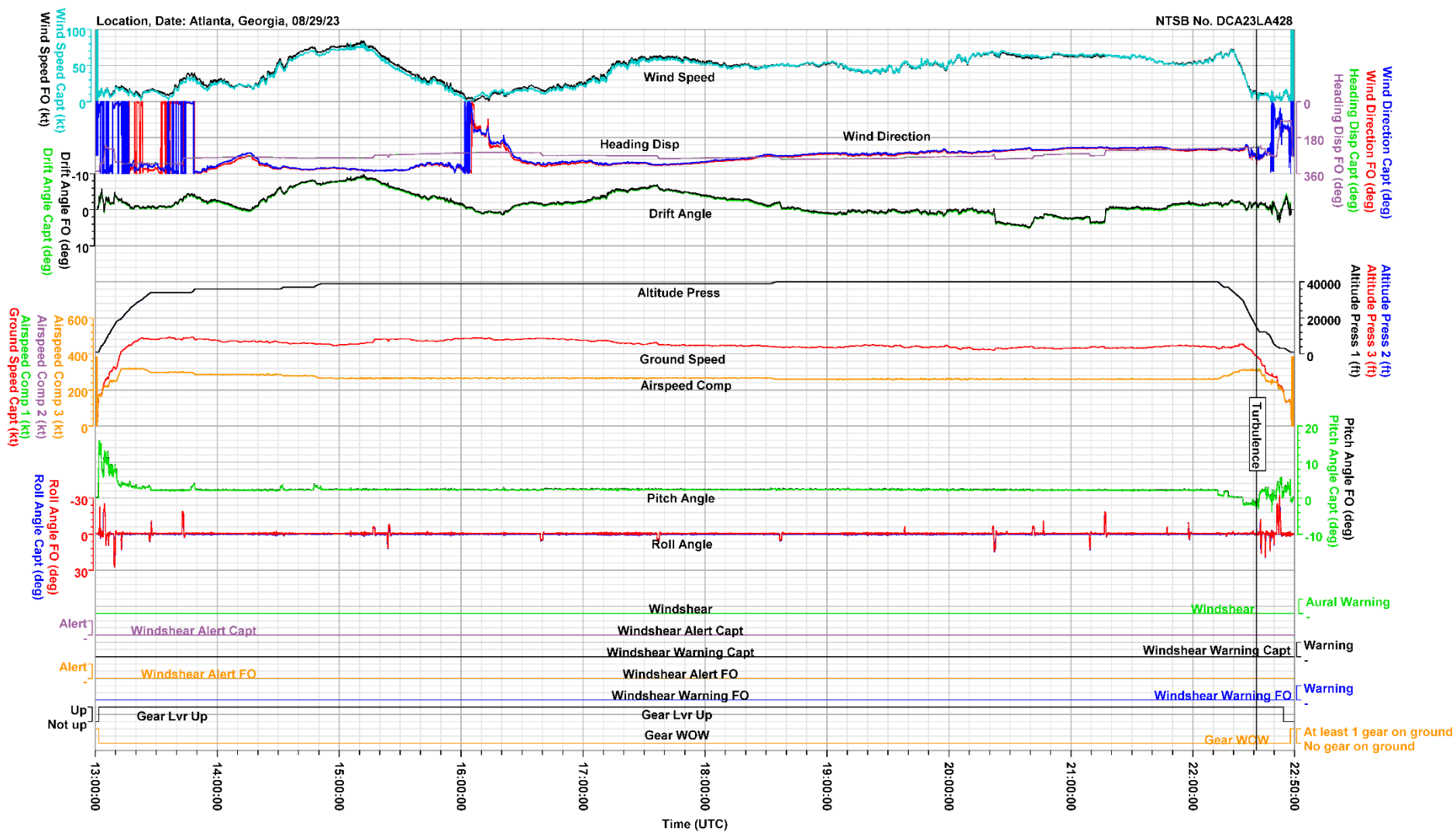


Figure 8. Plot of atmospheric wind conditions and related aircraft effects for the full accident flight.

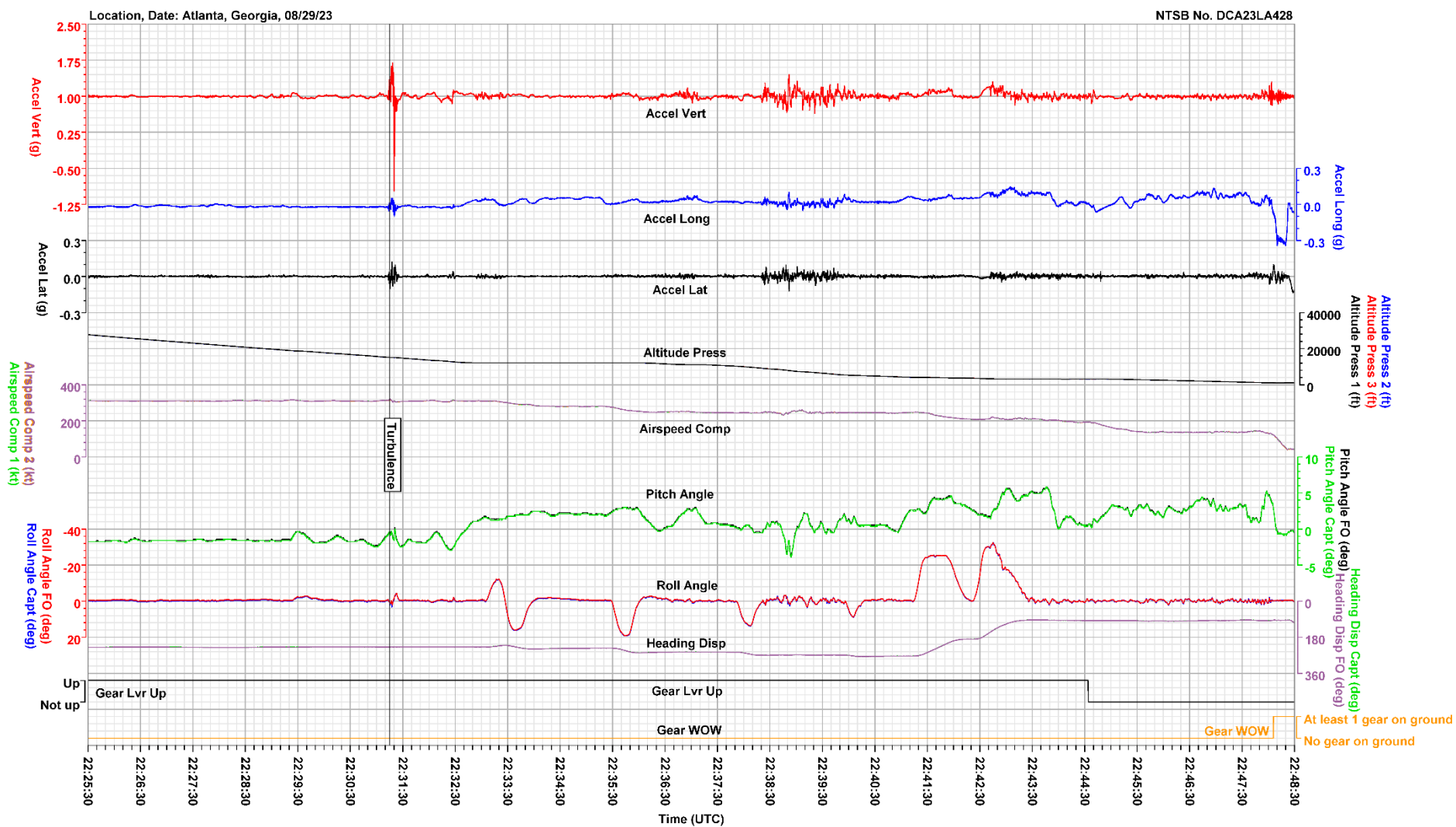


Figure 9. Plot of aircraft basic parameters for final 23 minutes of flight.

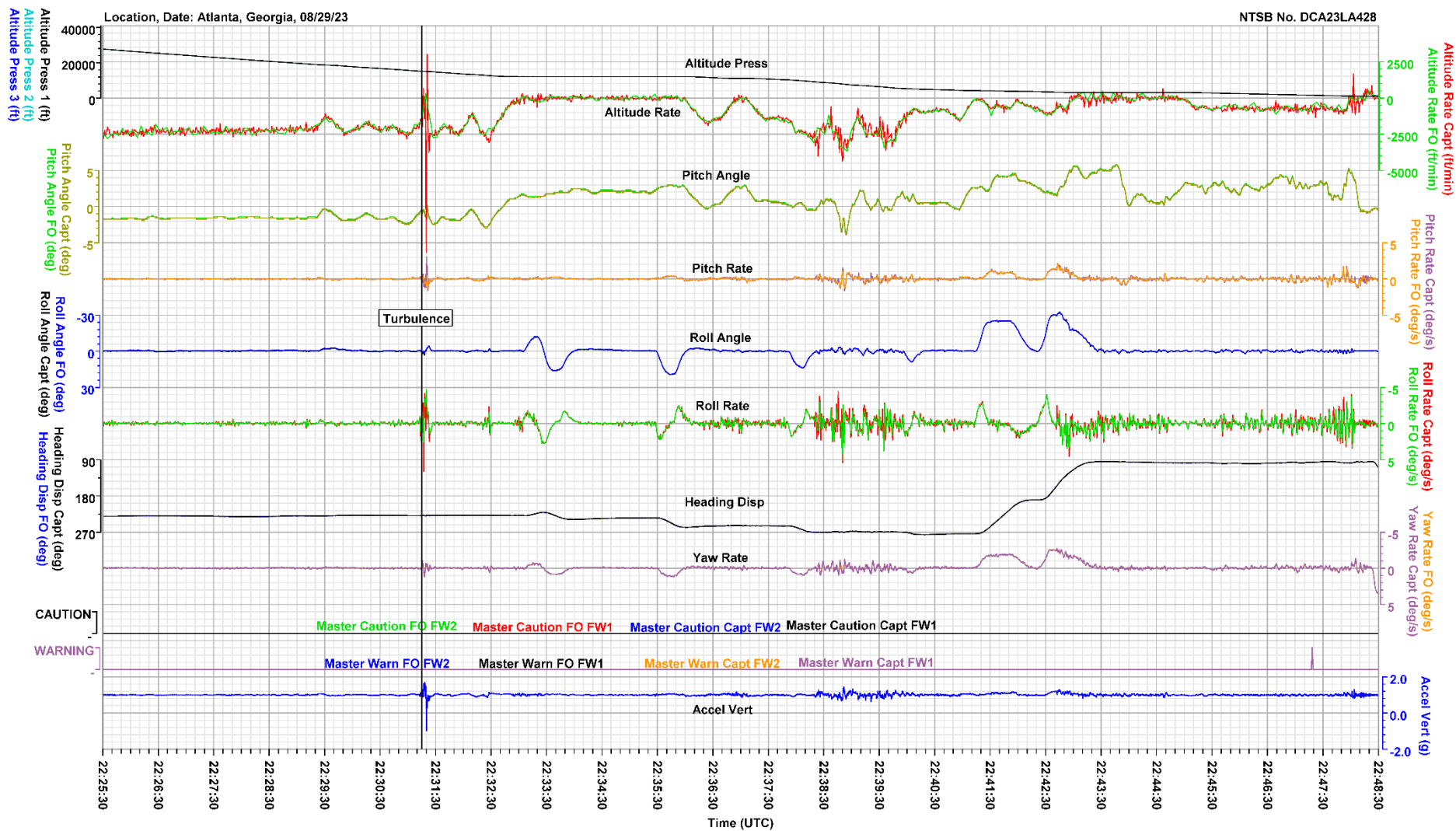


Figure 10. Plot of attitude, attitude rates, and FWA master parameters for final 23 minutes of flight.

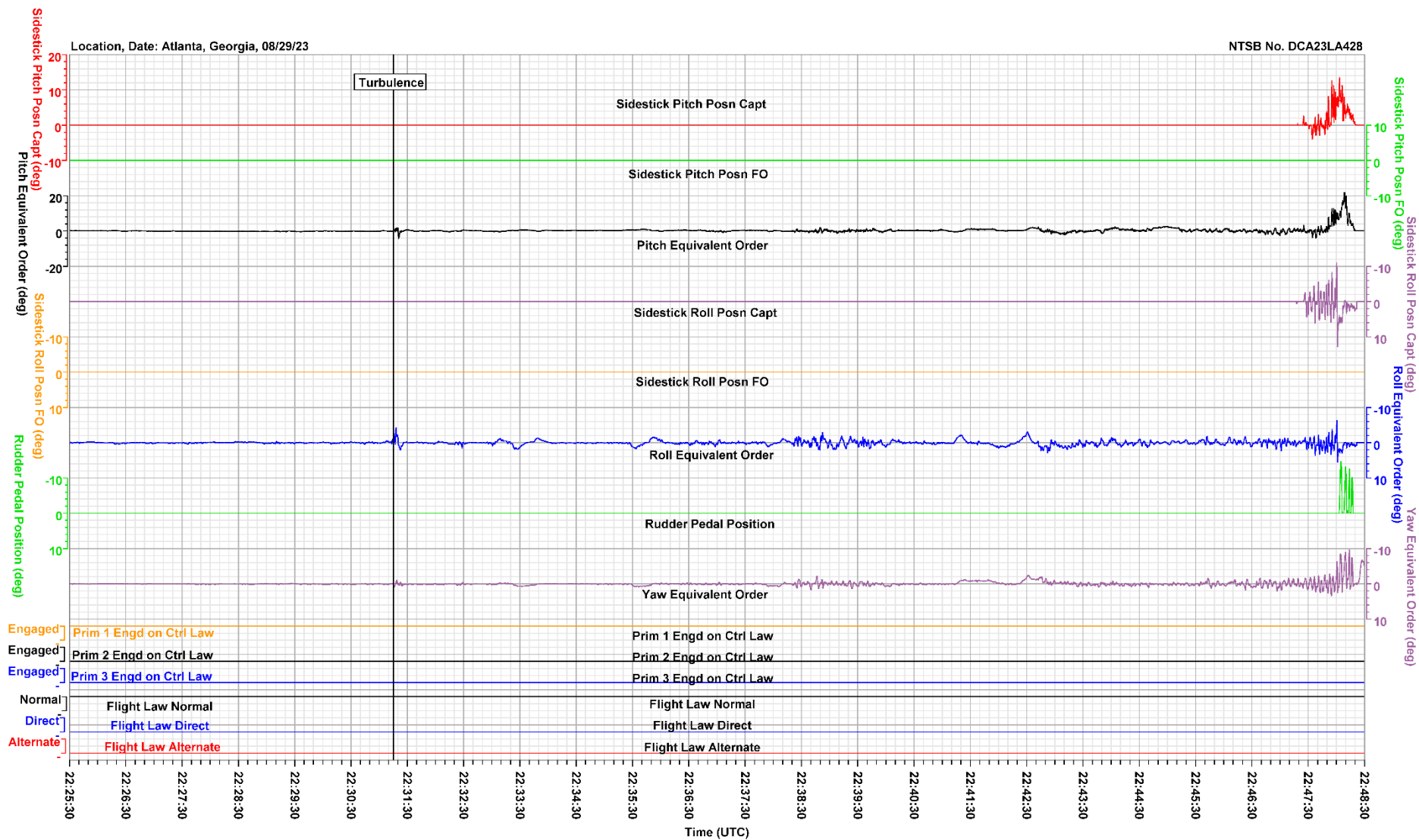


Figure 11. Plot of sidestick positions and flight computer command parameters for final 23 minutes of flight.

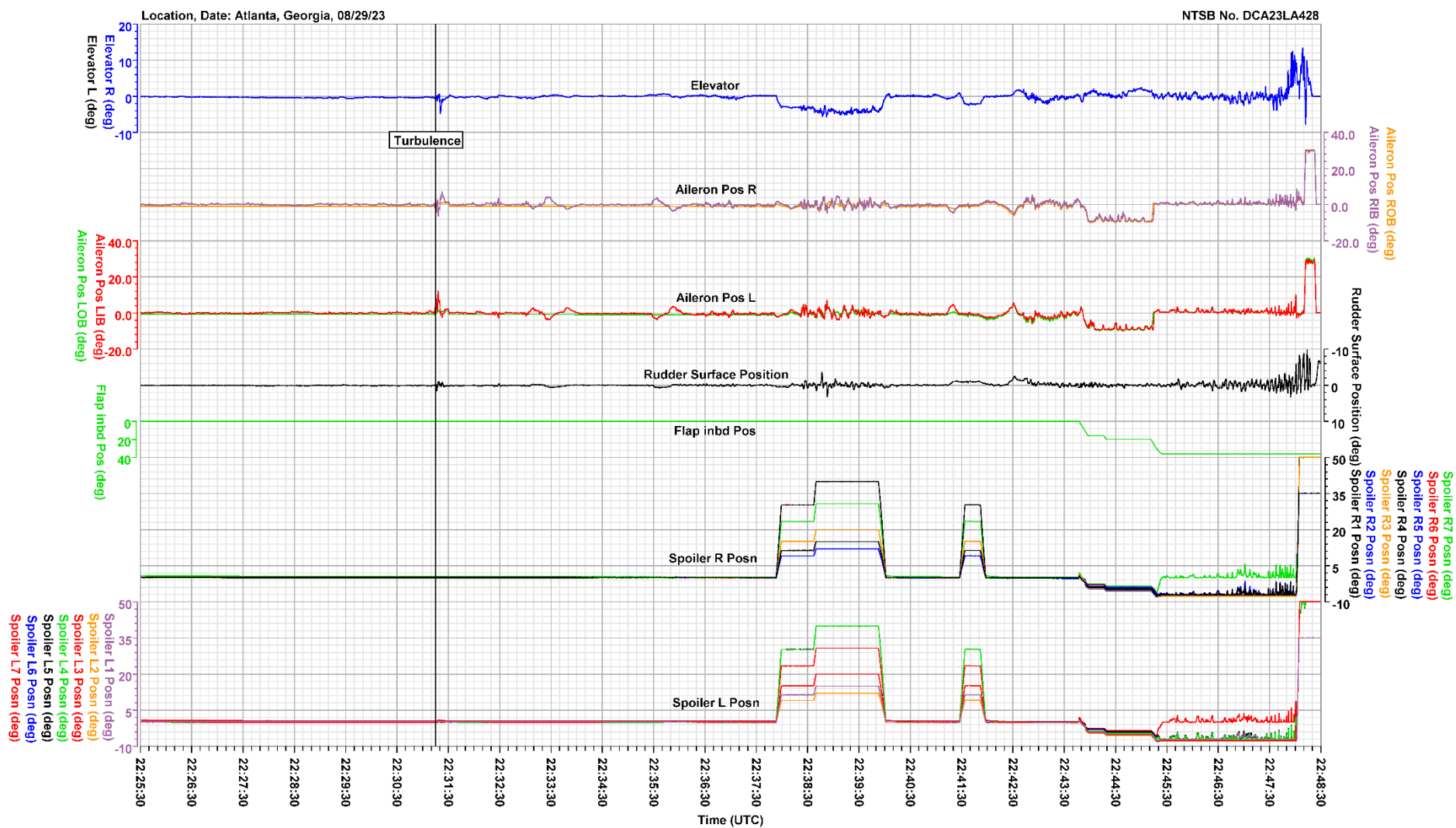


Figure 12. Plot of control surface position parameters for final 23 minutes of flight.

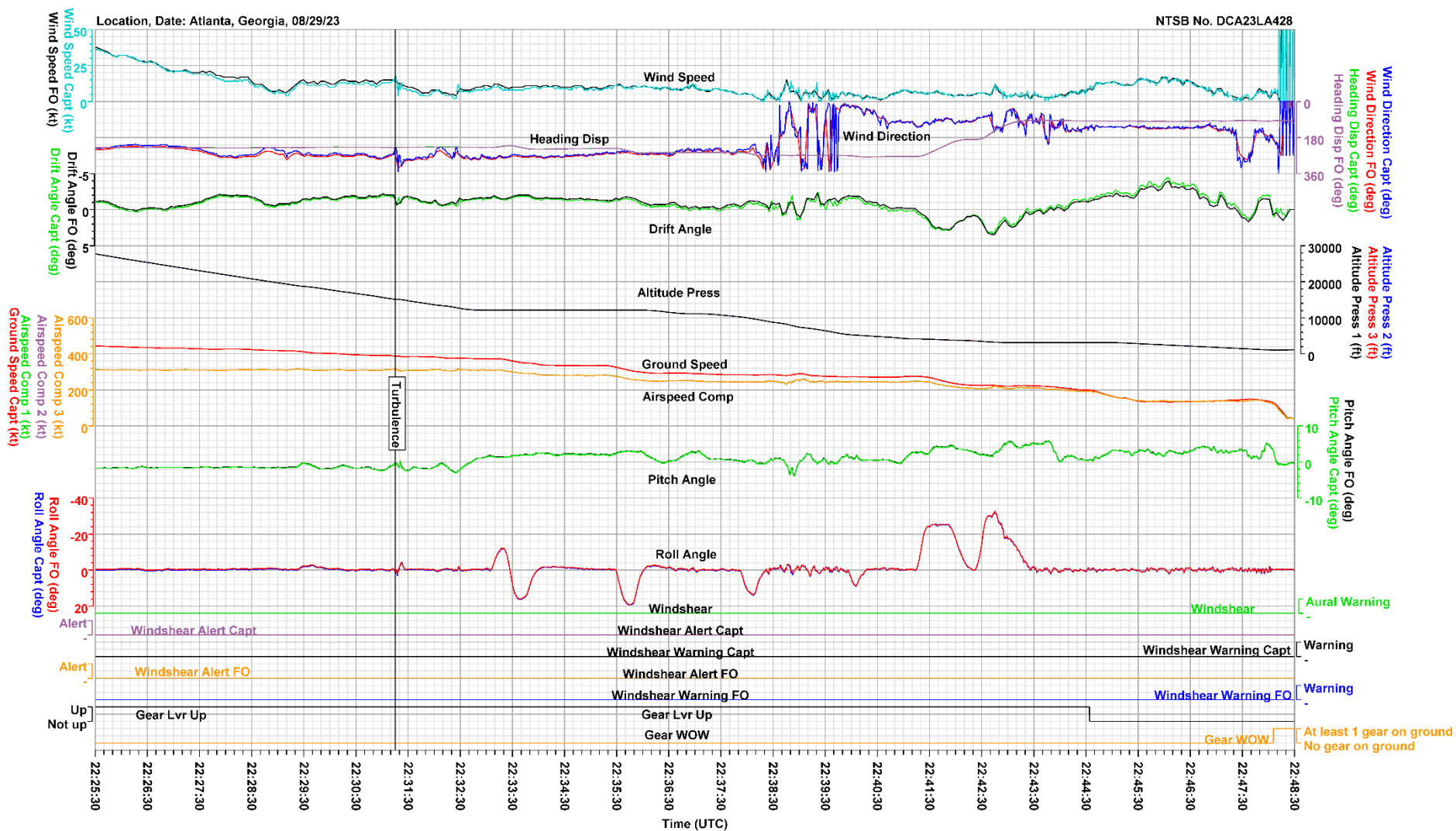


Figure 13. Plot of atmospheric wind conditions and related aircraft effect parameters for final 23 minutes of flight.

APPENDIX A. VERIFIED AND PROVIDED PARAMETERS

This appendix describes the parameters provided and verified in this report. Table 2 lists the plot/table labels, parameter names, and units. Additionally, table 3 describes the unit and discrete state abbreviations used in this report.

Table 2. Verified and provided FDR parameters.

Plot/Table Label	Parameter Name/Description	Units
1. Accel Lat	Body Lateral Acceleration	g
2. Accel Long	Body Longitudinal Acceleration	g
3. Accel Vert	Body Normal Acceleration	g
4. Aileron Pos LIB	Left Inboard Aileron Position	deg
5. Aileron Pos LOB	Left Outboard Aileron Position	deg
6. Aileron Pos RIB	Right Inboard Aileron Position	deg
7. Aileron Pos ROB	Right Outboard Aileron Position	deg
8. Airspeed Comp 1	Computed Air Speed ADR 1	kts
9. Airspeed Comp 2	Computed Air Speed ADR 2	kts
10. Airspeed Comp 3	Computed Air Speed ADR 3	kts
11. Altitude Press 1	Standard Pressure Altitude ADR 1	ft
12. Altitude Press 2	Standard Pressure Altitude ADR 2	ft
13. Altitude Press 3	Standard Pressure Altitude ADR 3	ft
14. Altitude Rate Capt	Altitude Rate - Captain	fpm
15. Altitude Rate FO	Altitude Rate - FO	fpm
16. AP1 Eng Prim1	AP1 Engaged on PRIM1	
17. AP1 Eng Prim2	AP1 Engaged on PRIM2	
18. AP1 Eng Prim3	AP1 Engaged on PRIM3	
19. AP2 Eng Prim1	AP2 Engaged on PRIM1	
20. AP2 Eng Prim2	AP2 Engaged on PRIM2	
21. AP2 Eng Prim3	AP2 Engaged on PRIM3	
22. ATHR Eng Prim1	ATHR Engaged on PRIM 1	
23. ATHR Eng Prim2	ATHR Engaged on PRIM 2	
24. ATHR Eng Prim3	ATHR Engaged on PRIM 3	
25. Drift Angle Capt	Drift Angle - Captain	deg
26. Drift Angle FO	Drift Angle - FO	deg
27. Elevator L	Left Elevator Position	deg
28. Elevator R	Right Elevator Position	deg
29. FD Engaged Prim 1	FD Engaged on PRIM1	
30. FD Engaged Prim 2	FD Engaged on PRIM2	
31. FD Engaged Prim 3	FD Engaged on PRIM3	
32. Flap inbd Pos	Flap Inboard Surface position	deg
33. Flight Law Alternate	Alternate Flight Law	
34. Flight Law Direct	Direct Flight Law	
35. Flight Law Normal	Normal Flight Law	
36. Gear Lvr Up	Landing Gear Lever is Up	
37. Gear WOW	On landing gear on ground	
38. Ground Speed Capt	Ground Speed - Captain	kts
39. Heading Disp Capt	Selected Heading Capt	deg

Plot/Table Label	Parameter Name/Description	Units
40. Heading Disp FO	Selected Heading FO	deg
41. Latitude AC Pres Pos Capt	Present Position Latitude - Captain	deg
42. Latitude GPS Pos Capt	GPS Present Position Latitude - Captain	deg
43. Latitude IRS Capt	IRS Present Position Latitude - Captain	deg
44. Longitude AC Pres Pos Capt	Present Position Longitude - Captain	deg
45. Longitude GPS Pos Capt	GPS Present Position Longitude - Captain	deg
46. Longitude IRS Capt	IRS Present Position Longitude - Captain	deg
47. Master Caution Capt FW1	Master Caution Captain FW 1	
48. Master Caution Capt FW2	Master Caution Captain FW 2	
49. Master Caution FO FW1	Master Caution FO FW 1	
50. Master Caution FO FW2	Master Caution FO FW 2	
51. Master Warn Capt FW1	Master Warning Captain FW1	
52. Master Warn Capt FW2	Master Warning Captain FW2	
53. Master Warn FO FW1	Master Warning FO FW 1	
54. Master Warn FO FW2	Master Warning FO FW 2	
55. Pitch Angle Capt	Pitch Angle - Captain	deg
56. Pitch Angle FO	Pitch Angle - FO	deg
57. Pitch Equivalent Order	Pitch Side Stick order used by control laws	deg
58. Pitch Rate Capt	Body Pitch Rate - Captain	deg/sec
59. Pitch Rate FO	Body Pitch Rate - FO	deg/sec
60. Prim 1 Engd on Ctrl Law	PRIM1 engaged on control law	
61. Prim 1 is FGE Master	PRIM 1 Master for FGE functions	
62. Prim 2 Engd on Ctrl Law	PRIM2 engaged on control law	
63. Prim 2 is FGE Master	PRIM 2 Master for FGE functions	
64. Prim 3 Engd on Ctrl Law	PRIM3 engaged on control law	
65. Prim 3 is FGE Master	PRIM 3 Master for FGE functions	
66. PWS Mode Capt	Capt PWS Mode	
67. PWS Mode FO	FO PWS Mode	
68. Roll Angle Capt	Roll Angle - Captain	deg
69. Roll Angle FO	Roll Angle - FO	deg
70. Roll Equivalent Order	Roll Side Stick Order used by control laws	deg
71. Roll Rate Capt	Body Roll Rate - Captain	deg/sec
72. Roll Rate FO	Body Roll Rate - FO	deg/sec
73. Rudder Pedal Position	Rudder Pedal Position	deg
74. Rudder Surface Position	Rudder Surface Position	deg
75. Sidestick Pitch Posn Capt	Capt Pitch Sidestick Position	deg
76. Sidestick Pitch Posn FO	FO Pitch Sidestick Position	deg
77. Sidestick Roll Posn Capt	Capt Roll Sidestick Position	deg
78. Sidestick Roll Posn FO	FO Roll Sidestick Position	deg
79. Spoiler L1 Posn	Left Spoiler 1 Position	deg
80. Spoiler L2 Posn	Left Spoiler 2 Position	deg
81. Spoiler L3 Posn	Left Spoiler 3 Position	deg
82. Spoiler L4 Posn	Left Spoiler 4 Position	deg
83. Spoiler L5 Posn	Left Spoiler 5 Position	deg
84. Spoiler L6 Posn	Left Spoiler 6 Position	deg
85. Spoiler L7 Posn	Left Spoiler 7 Position	deg
86. Spoiler R1 Posn	Right Spoiler 1 Position	deg

Plot/Table Label	Parameter Name/Description	Units
87. Spoiler R2 Posn	Right Spoiler 2 Position	deg
88. Spoiler R3 Posn	Right Spoiler 3 Position	deg
89. Spoiler R4 Posn	Right Spoiler 4 Position	deg
90. Spoiler R5 Posn	Right Spoiler 5 Position	deg
91. Spoiler R6 Posn	Right Spoiler 6 Position	deg
92. Spoiler R7 Posn	Right Spoiler 7 Position	deg
93. Turbulence Alert Capt	Capt Turbulence Alert	
94. Turbulence Alert FO	FO Turbulence Alert	
95. Wind Direction Capt	Wind Direction - Captain	deg
96. Wind Direction FO	Wind Direction - FO	deg
97. Wind Speed Capt	Wind Speed - Captain	kts
98. Wind Speed FO	Wind Speed - FO	kts
99. Windshear	Windshear	
100. Windshear Alert Capt	Capt Windshear Alert	
101. Windshear Alert FO	FO Windshear Alert	
102. Windshear Warning Capt	Capt Windshear Warning	
103. Windshear Warning FO	FO Windshear Warning	
104. WXR Capt Azimuth Value	WXR Capt Azimuth Value	
105. WXR Capt Disp Sel	Capt WXR Display Selected	
106. WXR Capt Elev Mode	Capt Elevation Mode	
107. WXR Capt Elev Value	WXR Capt Elevation Value	
108. WXR Capt Gain Mode	Capt Gain Mode	
109. WXR Capt Gain Value	WXR Capt Gain Value	
110. WXR Capt Mode	Capt WXR Mode	
111. WXR Capt PWS VD Ref	Capt WXR PWS VD Ref	
112. WXR Capt Tilt Value	WXR Capt Tilt Value	
113. WXR FO Azimuth Value	WXR FO Azimuth Value	
114. WXR FO Disp Sel	FO WXR Display Selected	
115. WXR FO Elev Mode	FO Elevation Mode	
116. WXR FO Elev Value	WXR FO Elevation Value	
117. WXR FO Gain Mode	FO Gain Mode	
118. WXR FO Gain Value	WXR FO Gain Value	
119. WXR FO Mode	FO WXR Mode	
120. WXR FO PWS VD Ref	FO WXR PWS VD Ref	
121. WXR FO Tilt Value	WXR FO Tilt Value	
122. Yaw Equivalent Order	Yaw Equivalent Order used by control laws	deg
123. Yaw Rate Capt	Body Yaw Rate - Captain	deg/sec
124. Yaw Rate FO	Body Yaw Rate - FO	deg/sec

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 3. Unit and discrete state abbreviations and acronyms

Unit/discrete state/abbreviation	Description
ADIRS	Air Data/Inertial Reference System
ADR	Air Data Reference
AP	Autopilot
ATHR	Autothrust
Capt	Captain
deg	degrees
FD	Flight Director
FGE	Flight Guidance and Envelope
FO	First Officer
fpm	feet per minute
ft	feet
FW	Failure Warning
FWA	Flight Warning Application
g	gravitational constant
GPS	Global Positioning System
hr	hours
inbd	Inboard
IRS	Inertial Reference System
kt	knots
L	Left
min	minutes
PRIM	Primary Flight Control Computer
PWS	Predictive Windshear
R	Right
sec	seconds
VD	Vertical Display
WOW	Weight on Wheels
WXR	Weather Radar