

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division
Washington, D.C. 20594

September 12, 2016

Flight Data Recorder

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

1. EVENT SUMMARY

Location: Rapid City, South Dakota
Date: July 7, 2016
Aircraft: Airbus A320-200
Registration: N333NW
Operator: Delta Air Lines, Inc.
NTSB Number: DCA16IA200

On July 7, 2016, at 2042 mountain daylight time (MDT), Delta flight 2845, an Airbus 320-200 registration N333NW, landed on runway 13 at Ellsworth Air Force Base (RCA), Rapid City, South Dakota. The flight was a regularly scheduled passenger flight from Minneapolis-St Paul International Airport (MSP), Minneapolis, Minnesota, with the intended destination of Rapid City Regional Airport (RAP), Rapid City, South Dakota. Visual weather conditions prevailed. There was no damage to the airplane, and no injuries to the 6 crew members and 123 passengers. The aircraft was operating under the provisions of Title 14 *Code of Federal Regulations* (CFR) Part 121 on an instrument flight rules flight plan.

2. FLIGHT DATA RECORDER GROUP

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

3. FDR Carriage Requirements

The event aircraft, N333NW, was manufactured in October 1992, and was operating such that it was required to be equipped with an FDR that recorded, at a minimum, 34 parameters, as cited in 14 CFR 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: **Loral/Fairchild F1000**
Recorder Serial Number: **000163692**

4.1. Loral/Fairchild F1000

This model FDR records airplane flight information in a digital format using solid-state flash memory as the recording medium. The F1000 can receive data in the ARINC

573/717/747/542a configurations and can record a minimum of 25 hours of flight data. It is configured to record 128 12-bit words of digital information every second. Each grouping of 128 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 128-word intervals. Each data parameter (e.g. altitude, heading, airspeed) has a specifically assigned word number within the subframe. The F1000 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 58 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 and the subsequent reposition flight from RCA to RAP were the last two flights of the recording, respectively. The event flight duration was approximately 1 hour and 17 minutes and the subsequent reposition flight duration (occurring about 2 hours after the event flight landed) was approximately 12 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 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 and discrete abbreviations used in this report.

4.1.3.1. Non-Computed Data

Certain parameters recorded a non-computed data (NCD) pattern, which is indicative that the raw data was no longer reliable or not available. For example, NCD patterns occur in airspeed when it was below approximately 40 knots and in certain autopilot parameters when the autopilot was off.

4.1.3.2. Intermittent Spikes in Pressure Altitude

Pressure altitude is constructed of two underlying parameters (course altitude and fine altitude) that are sampled at slightly different times. Occasionally the different sampling

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 = +.

times introduce data spikes. These spikes are not representative of a physical reality; rather, they are artifacts of the sampling method.

4.2. Time Correlation

Correlation of the FDR data from SRN to the event local time, MDT, was established by using the recorded Time GMT² Hours, Time GMT Minutes, and Time GMT Seconds and then applying an additional 6 hour offset to change GMT to MDT.

Accordingly, the time offset for the event flight data from SRN to local MDT is the following: MDT = SRN - 129,428.0. For the reposition flight, MDT = SRN – 123,960.0.

Therefore, for the rest of this report, all times are referenced as MDT, not SRN.

4.3. FDR Plots and Corresponding Tabular Data

Figures 1 through 15 contain FDR data recorded during on July 7, 2016. All the parameters listed in table A-1 are plotted except Time GMT Hours, Time GMT Minutes, Time GMT Seconds, and Key VHF; latitude and longitude were interpolated to generate geographic overlays in figures 1, 2, 3, and 14. Figures 2 and 3 include Jeppesen's approach chart overlaid onto Google Earth. The weather and lighting conditions in the geographic overlays are not necessarily representative of the weather and lighting conditions at the time of the flights. Geographic overlays were produced using Google Earth.

Figures 1 through 13 show plots and overlays of the event flight. Collectively, these figures show:

- The aircraft departed MSP at about 19:25 MDT and a climbed to a final cruising altitude³ of flight level 360⁴.
- At about 20:25:28 MDT, the aircraft began a descent when it was about 76 nautical miles (nm) from RAP.
- The aircraft leveled at 10,000 ft from 20:35:52 MDT to 20:36:50 MDT, as its speed slowed below 250 knots indicated airspeed (KIAS). Spoilers were applied during the level-off at 10,000 ft starting at 20:36:31 MDT and were used until about 20:38:58 MDT (with a retraction for about 15 seconds during this time). At 20:36:50 MDT, the aircraft was abeam RCA and about 8.5 nm from RAP and 5.5 nm from RCA.
- The gear was selected down at 20:37:03 MDT, when the aircraft was descending through 9,770 ft and was 5.5 nm abeam from RCA.
- Flaps 1 were selected at 20:37:12 MDT.
- Flaps 2 were selected at 20:37:58 MDT, when the aircraft was about 4.8 nm northeast of RCA and 10 nm northeast of RAP.
- Flaps 3 were selected at 20:38:14 MDT.
- Flaps 4 were selected at 20:39:46 MDT, as the aircraft was in a left turn towards the RAP RNAV 14 final approach course.

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

³ All altitudes are pressure altitude.

⁴ 36,000 feet (ft)

- At 20:40:44 MDT, the autopilot was turned off, as the aircraft was nearly on the RAP RNAV 14 final approach course.
- At 20:41:05 MDT, the flight directors were turned off, as the aircraft deviated left of the RAP RNAV 14 final approach course, was aligned with the runway 13 extended centerline at RCA, and was about 2.8 nm from the approach end of RCA runway 13.
- By 20:42:42 MDT, the aircraft landed at RCA.

Figures 14 and 15 show the reposition flight to RAP. The aircraft departed RCA runway 13 and landed runway 32 at RAP.

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 figures 1 through 15 (and other data as listed in table A-1), are provided in electronic comma separated value (*.csv) format as attachment 1 to this report.

Figure 1. Satellite overlay of entire event flight.



Figure 2. Approach chart overlay (3-D) of event flight approach to RCA.

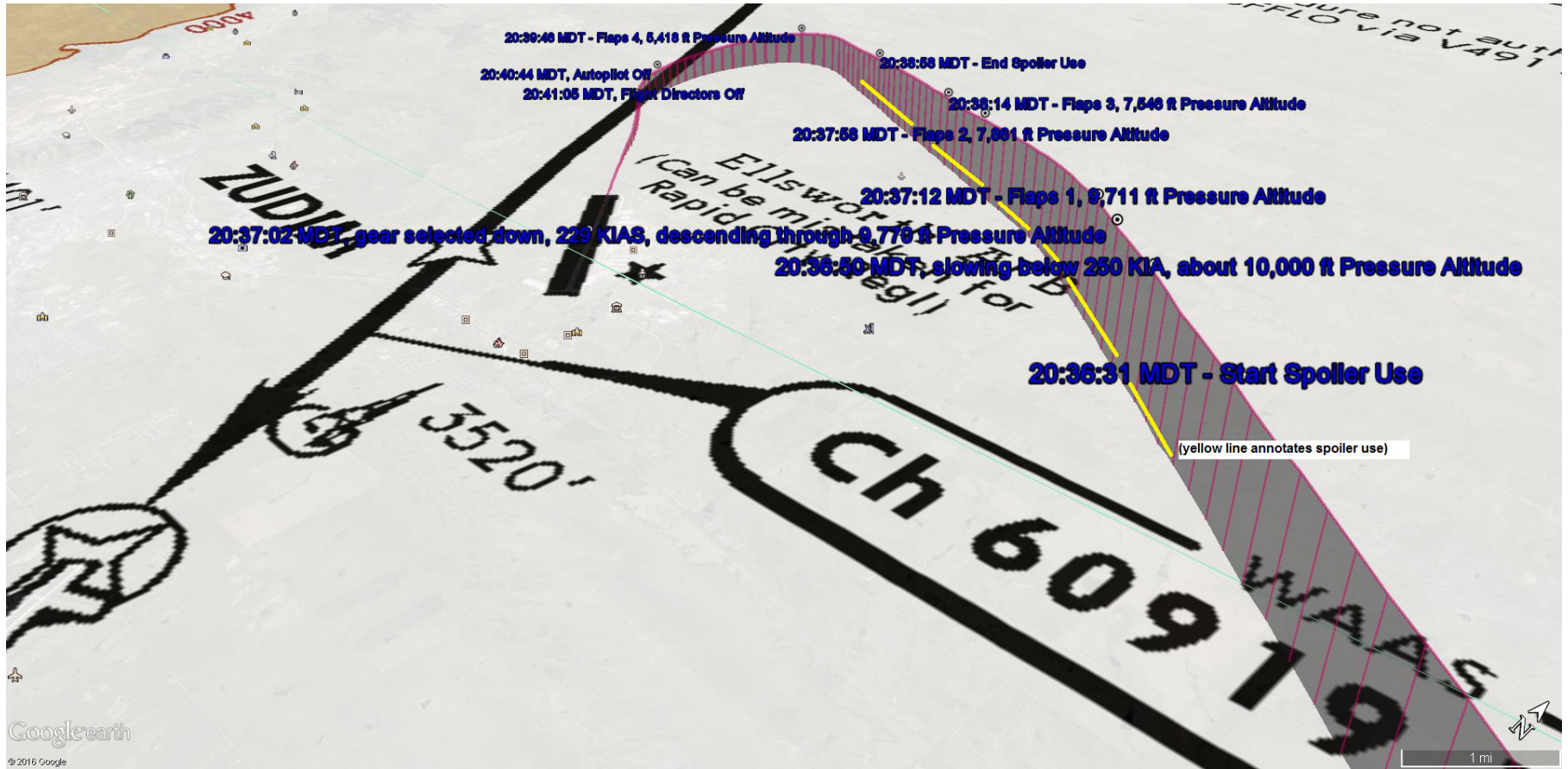


Figure 3. Approach chart overlay (plan view) of event flight approach to RCA.

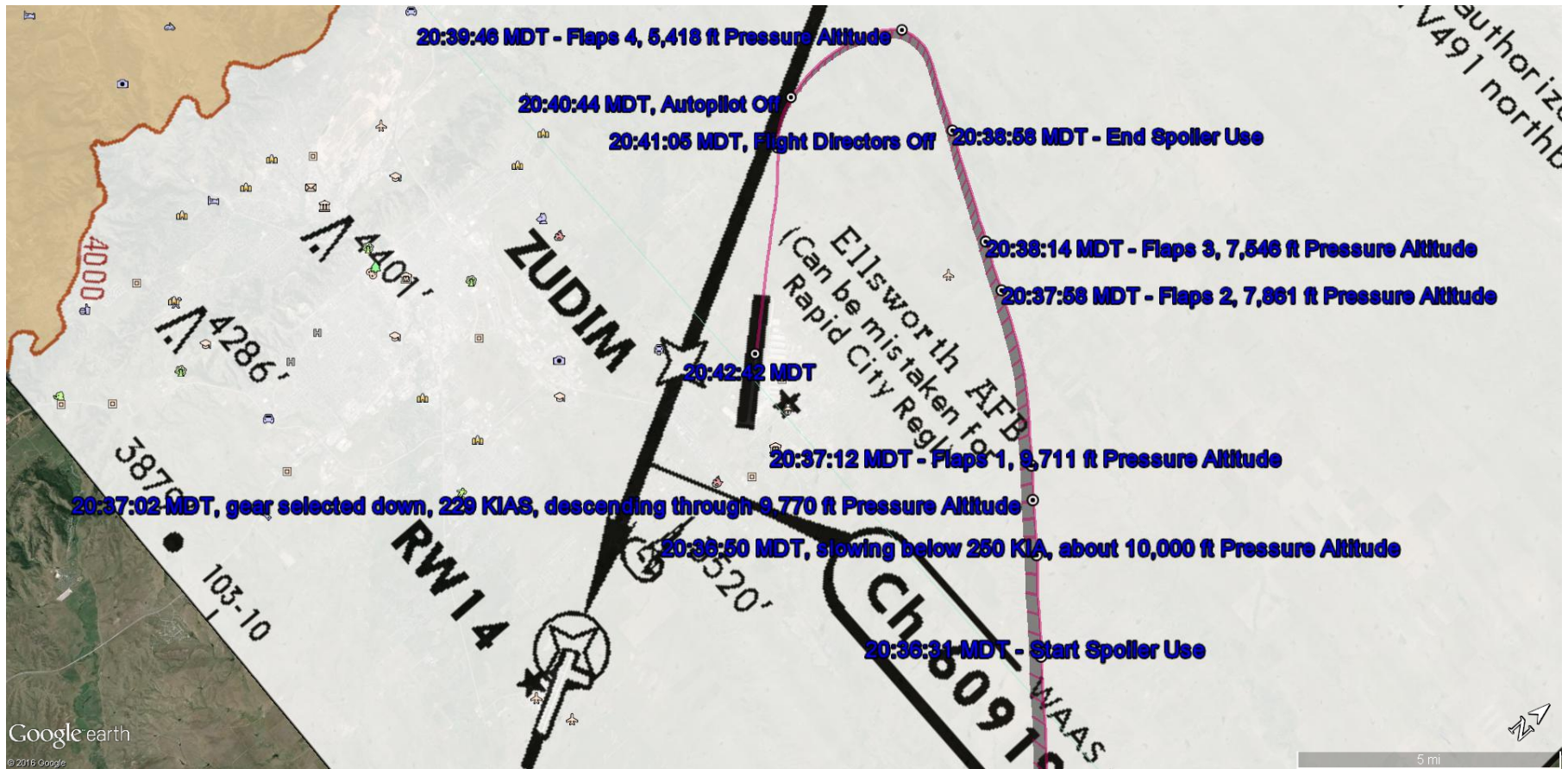
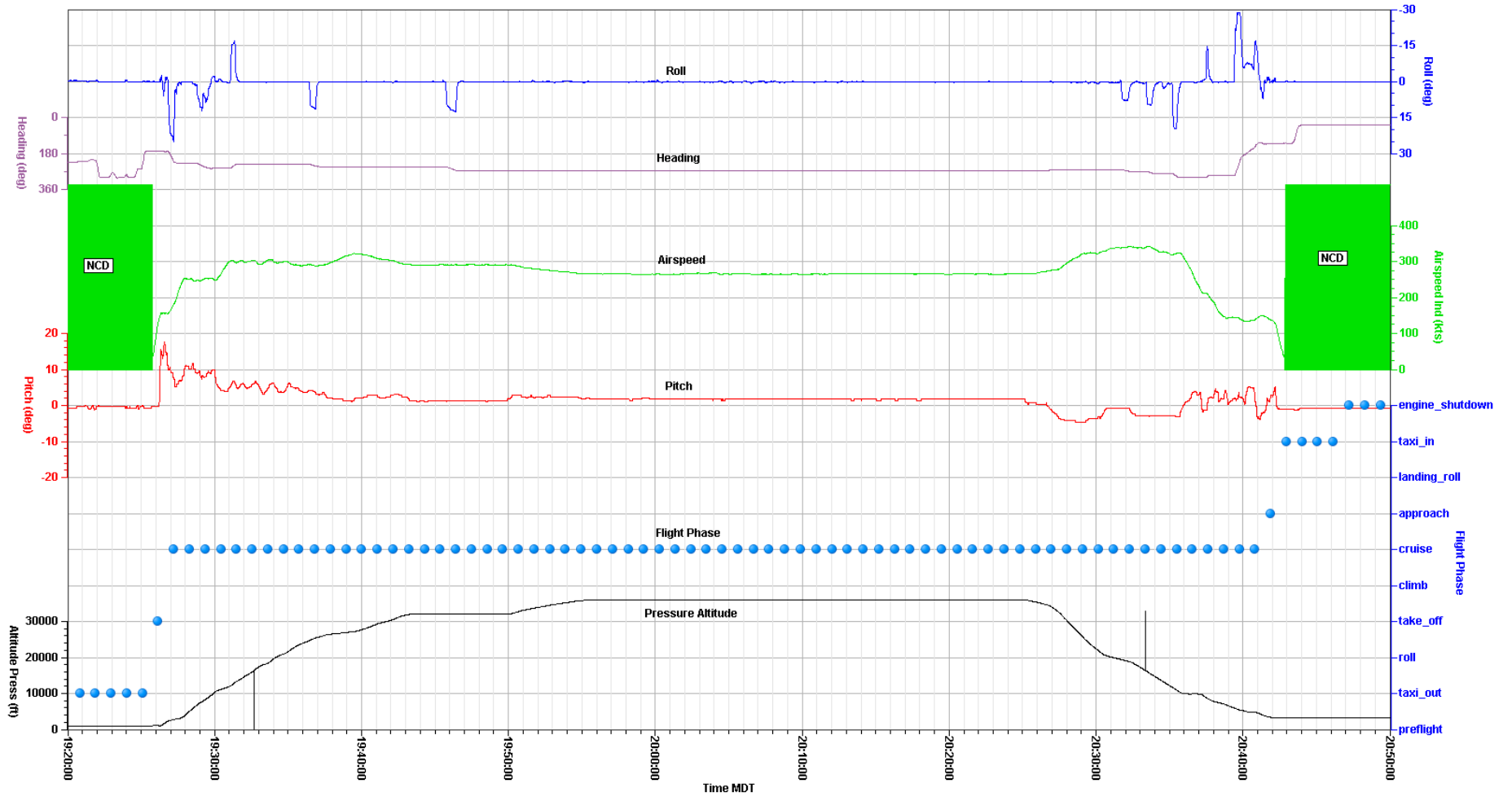


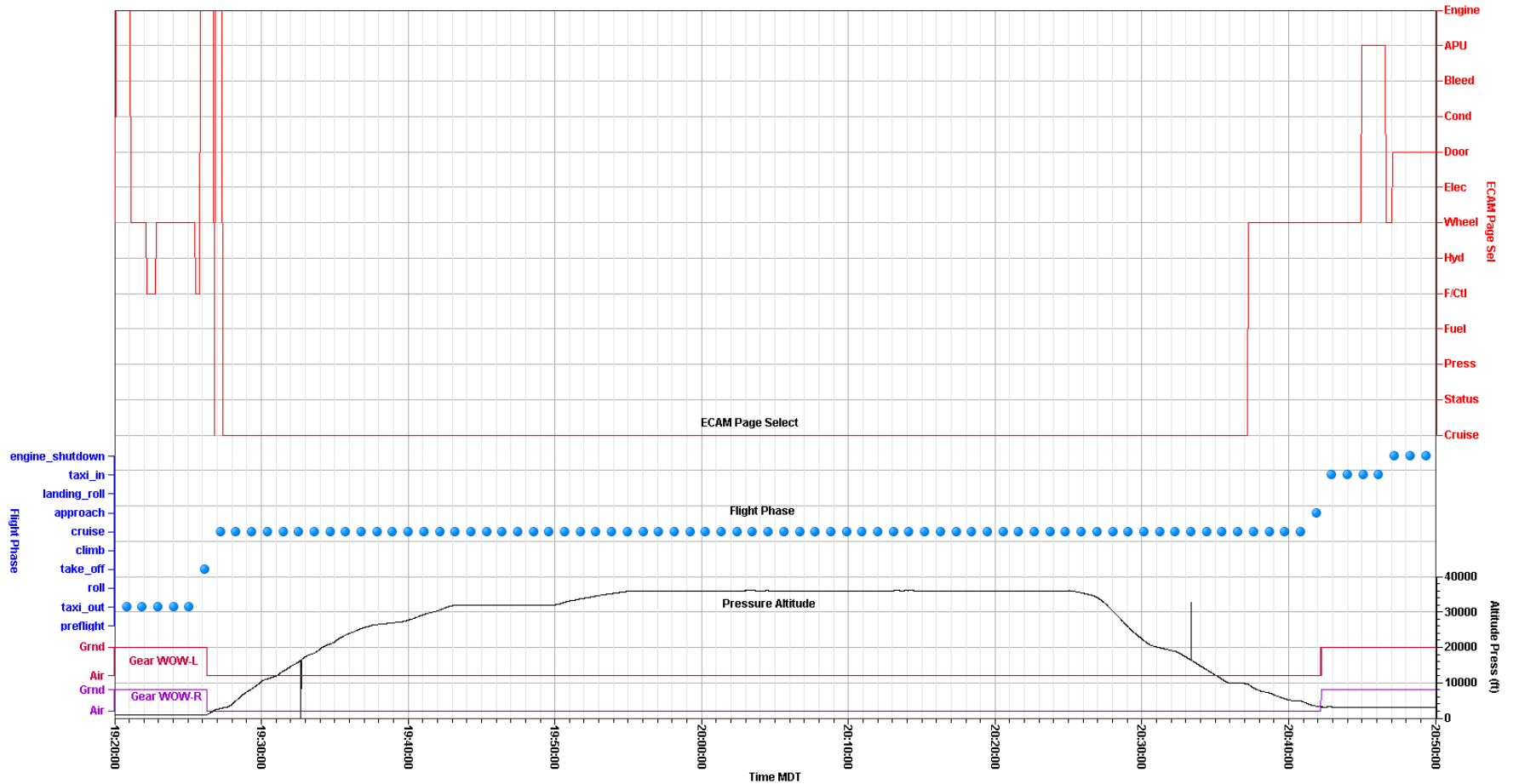
Figure 4. Plot of entire event flight: basic parameters.



Entire Event Flight - Basic Parameters

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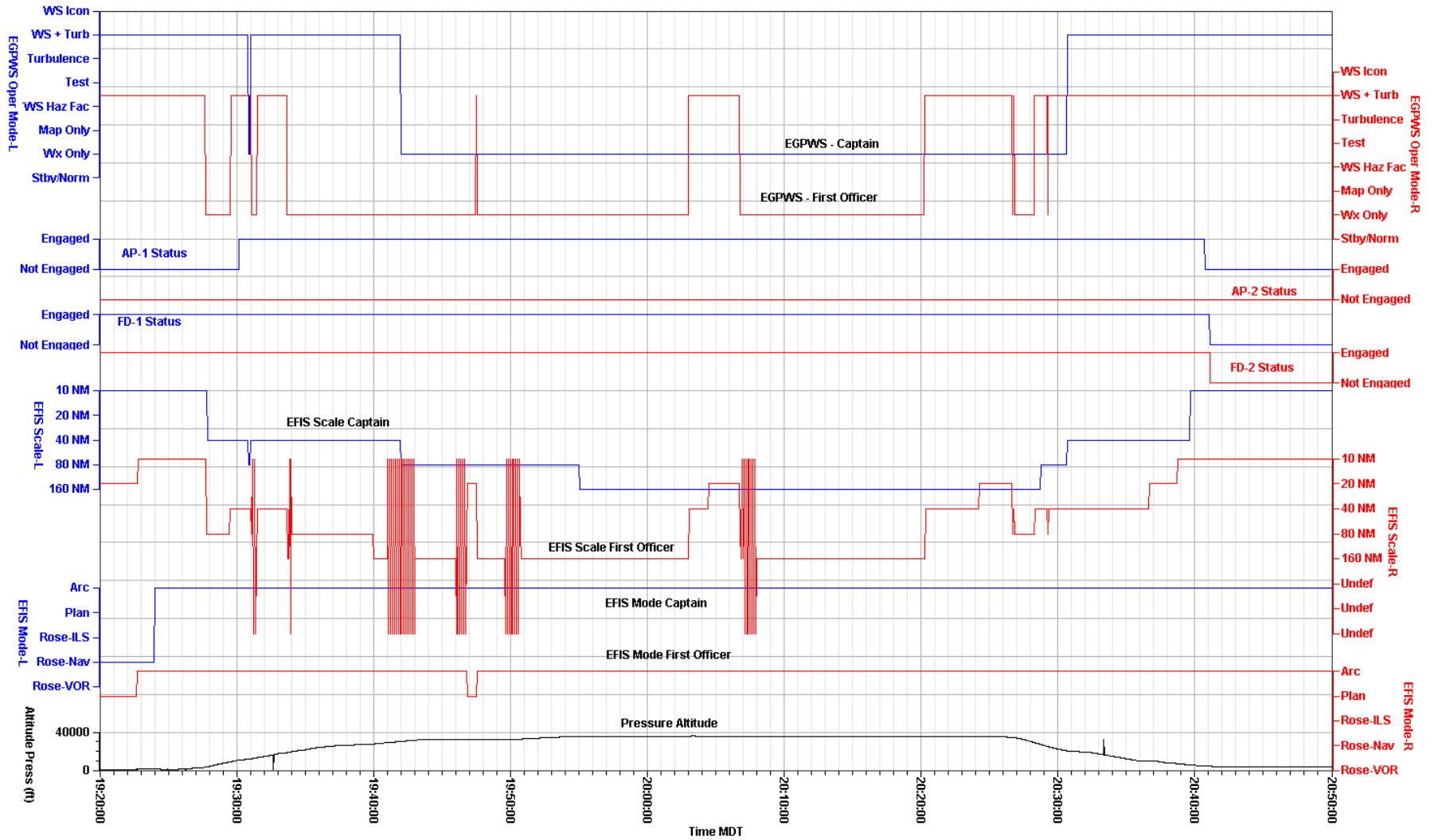
Figure 5. Plot of entire event flight: ECAM pages.



Entire Event Flight - ECAM Pages

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Figure 6. Plot of entire event flight: EGPWS, EFIS modes.

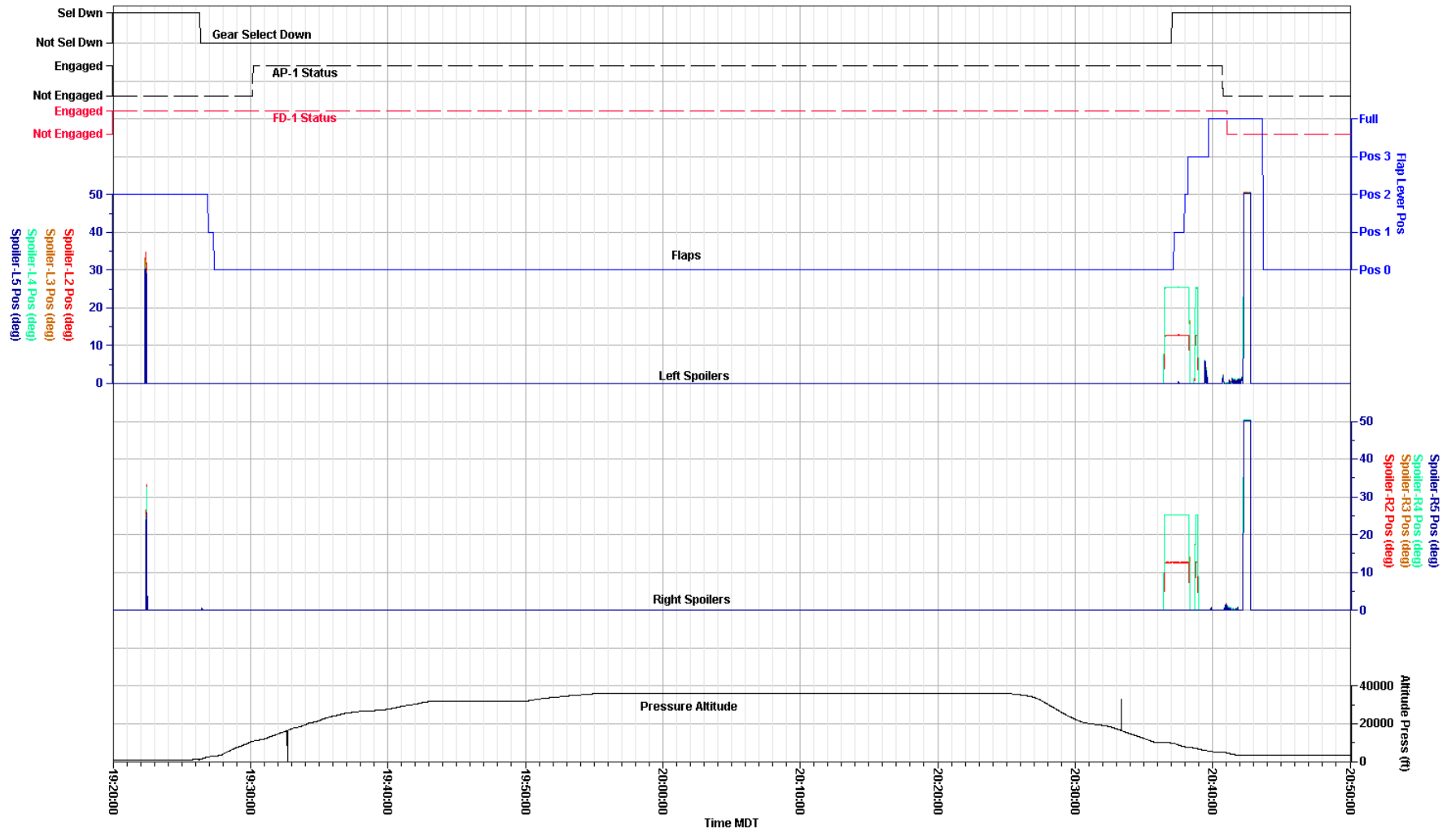


Revised: 16 August 2016

Entire Event Flight - EGPWS, EFIS Modes

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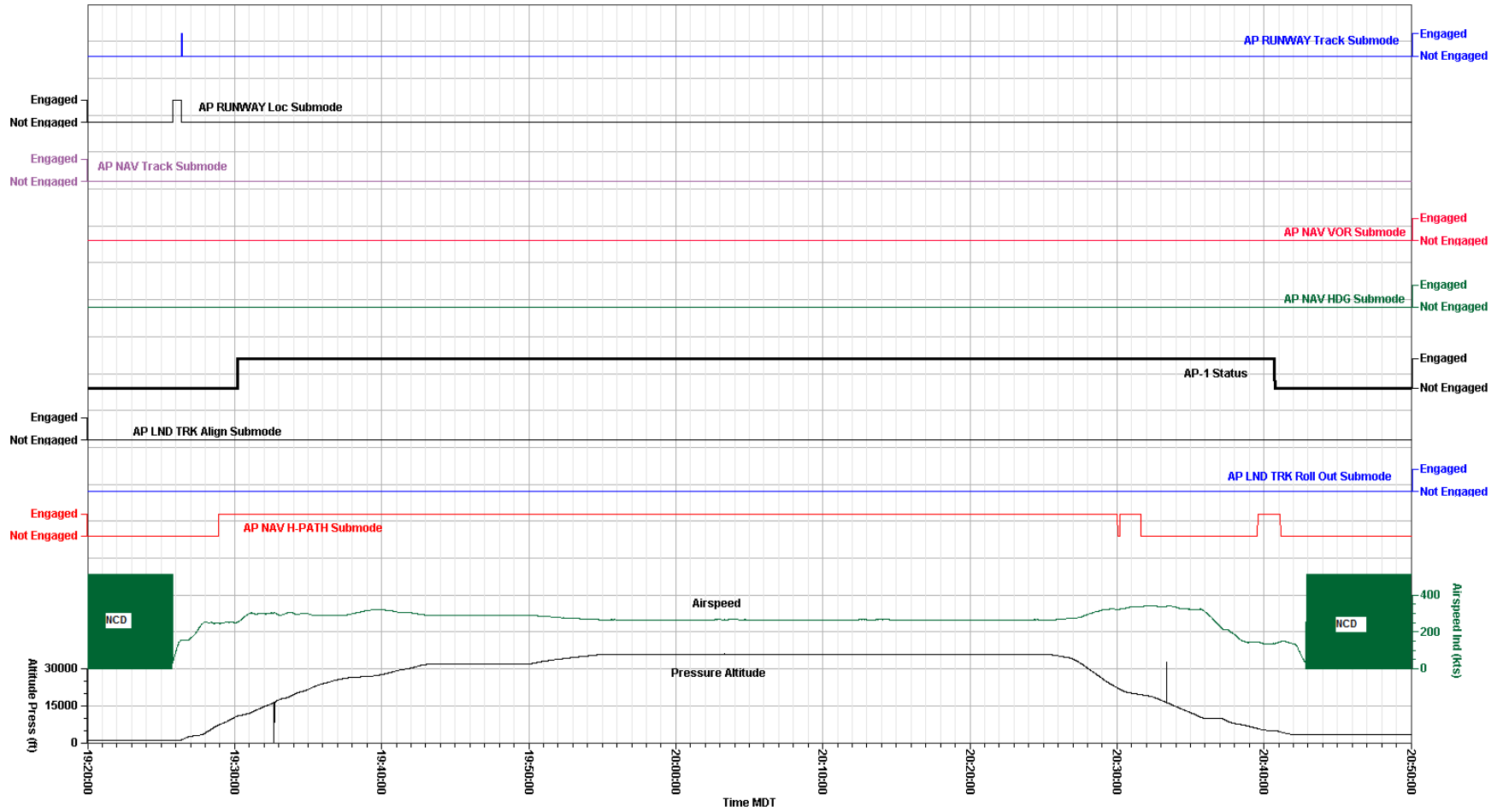
Figure 7. Plot of entire event flight: flaps, spoilers, and gear selection.



Entire Event Flight - Flaps, Gear, Spoilers

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Figure 8. Plot of entire event flight: autopilot submodes.



Entire Event Flight - AP Submodes

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Figure 9. Plot of autopilot lateral and longitudinal modes during event approach.

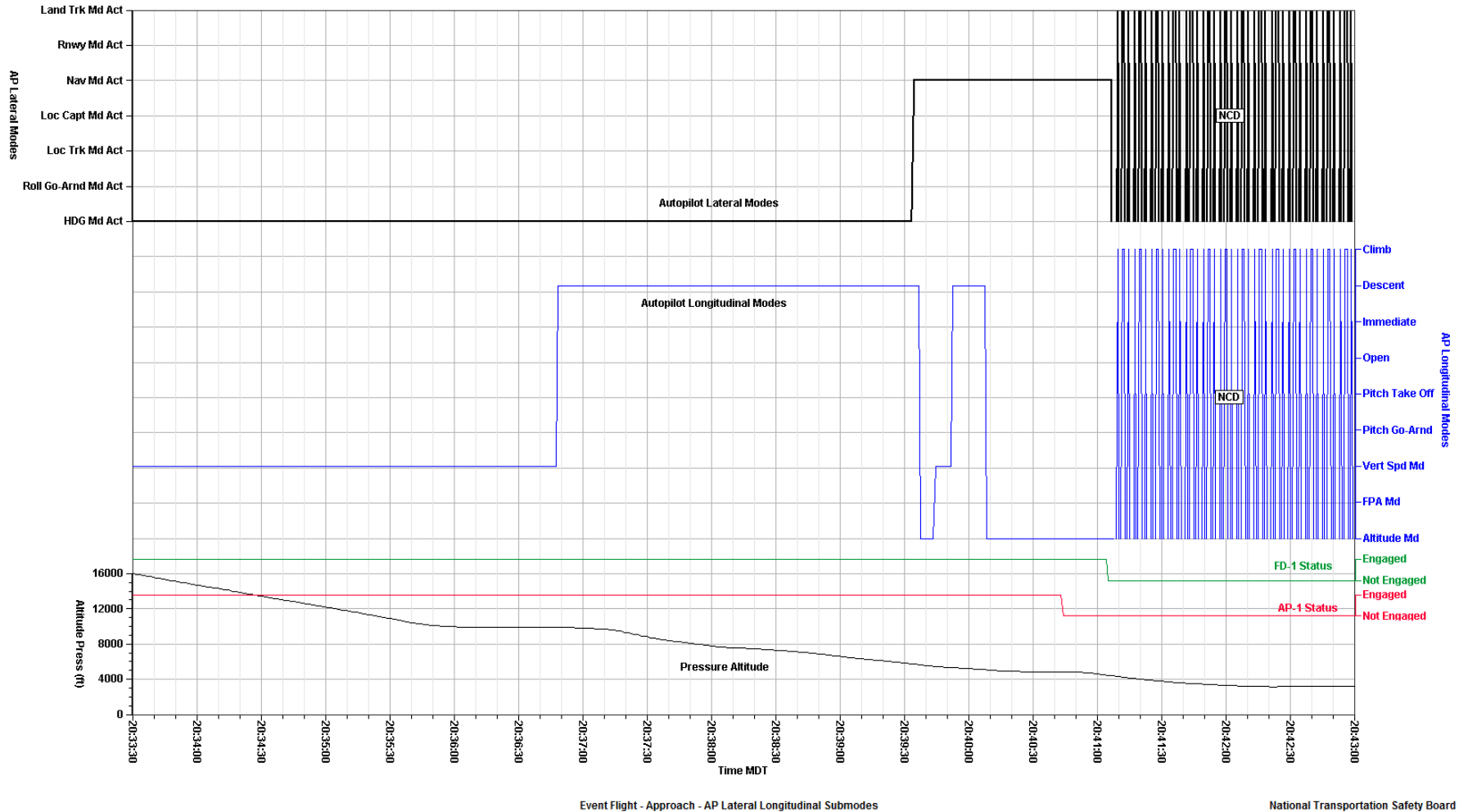
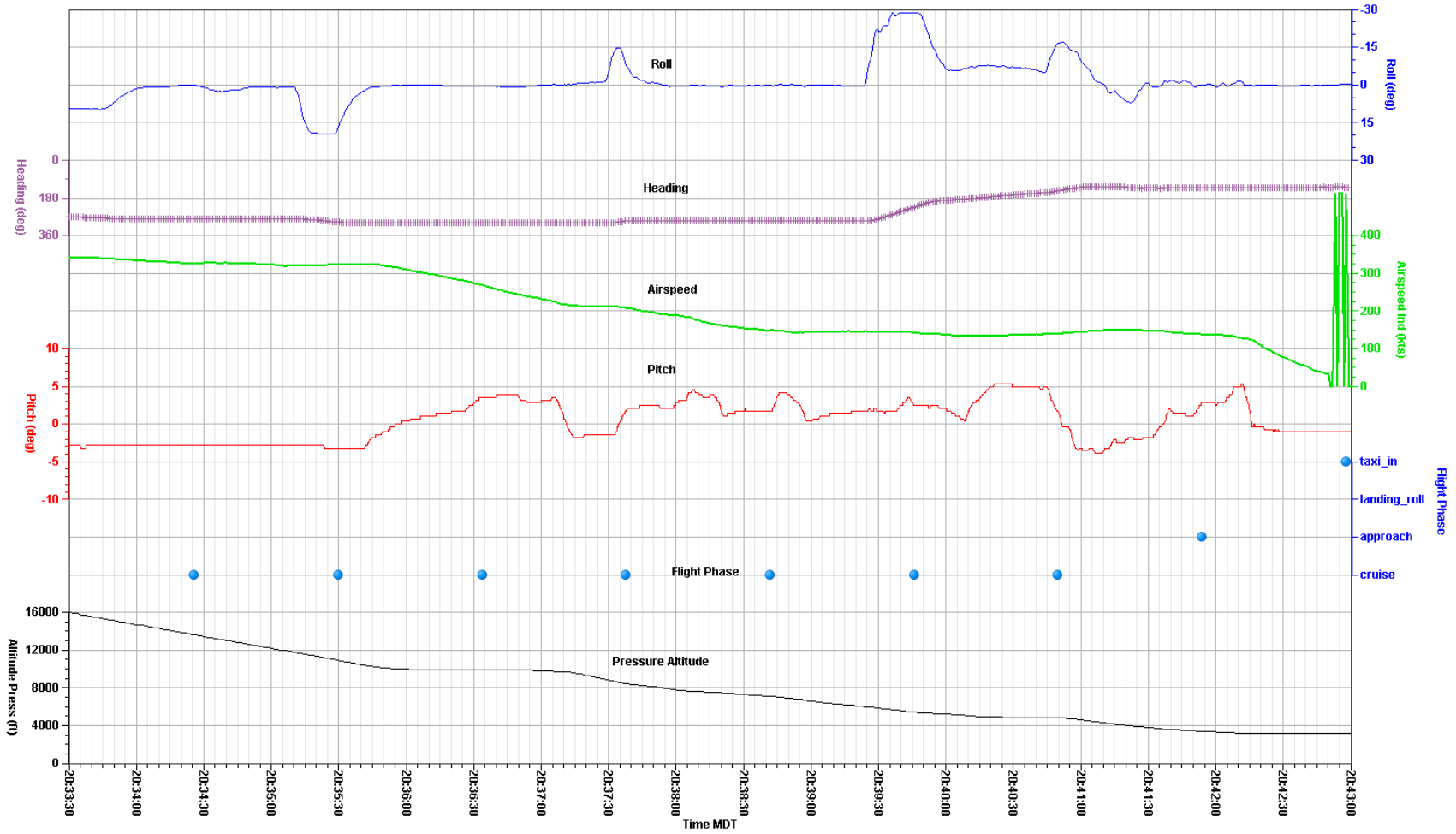


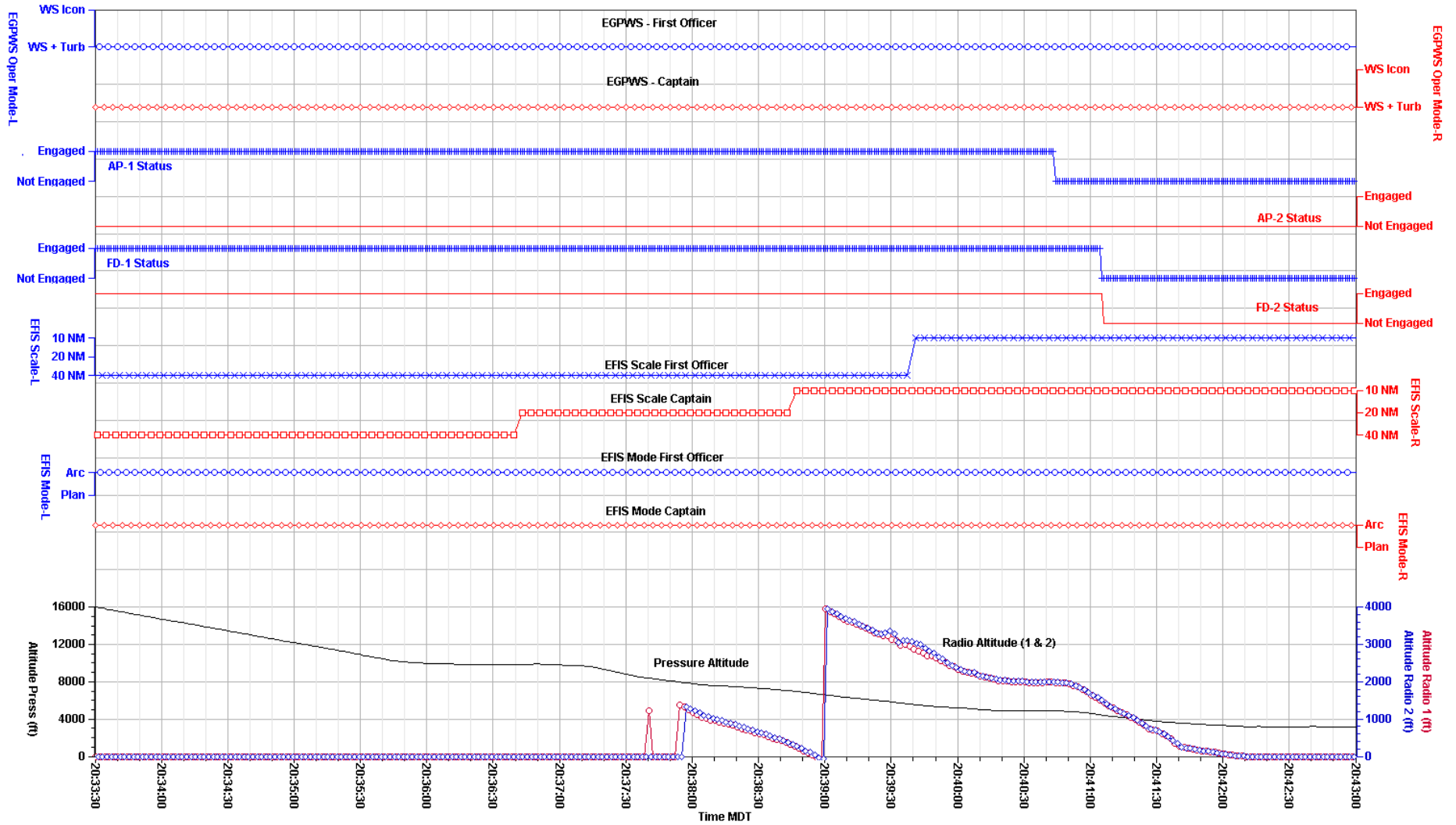
Figure 10. Plot of event flight approach: basic parameters.



Event Flight - Approach - Basic Parameters

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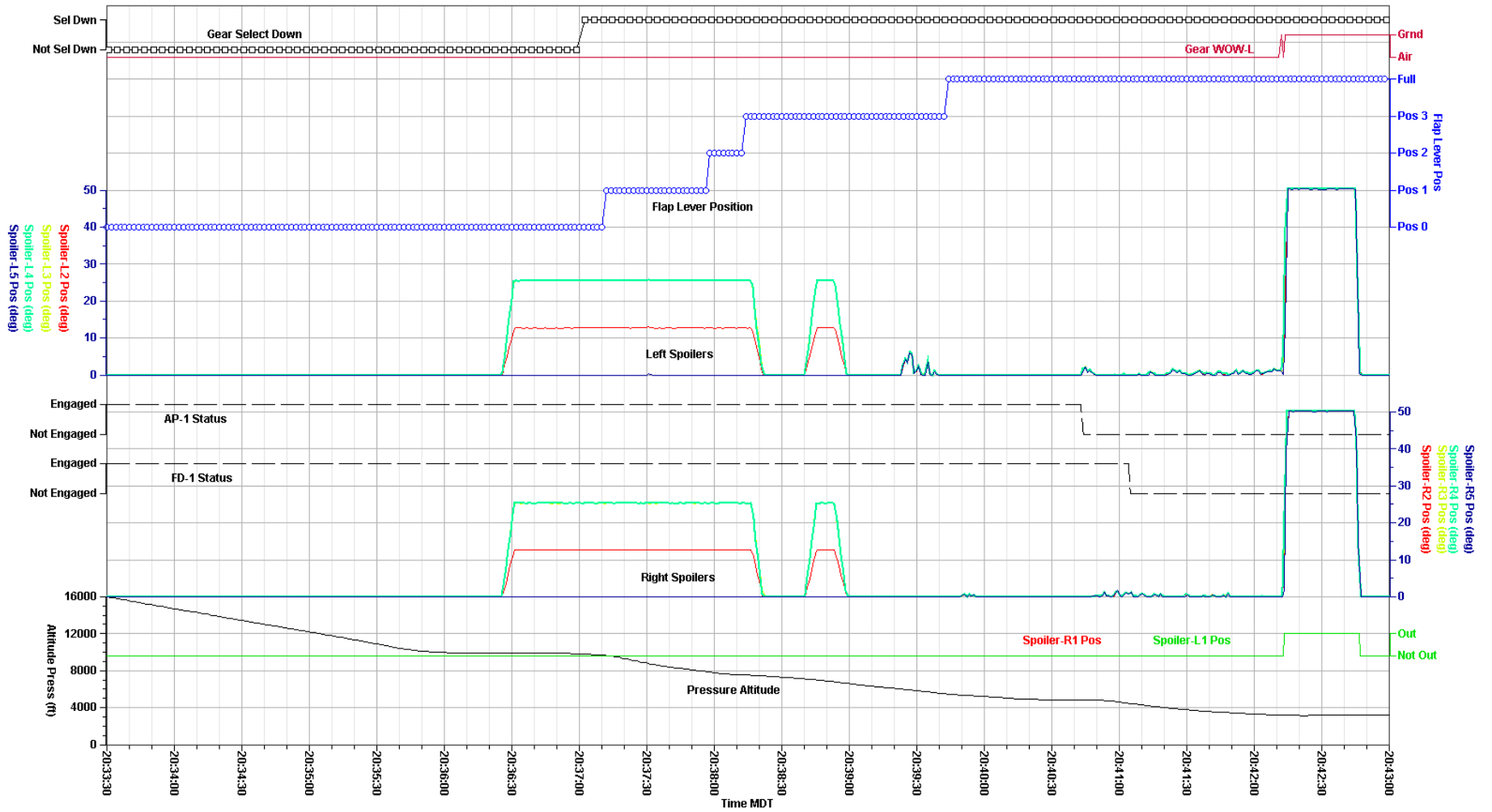
Figure 11. Plot of event flight approach: EGPWS, EFIS modes, and radio altimeter.



Event Flight - Approach - EGPWS, EFIS Modes

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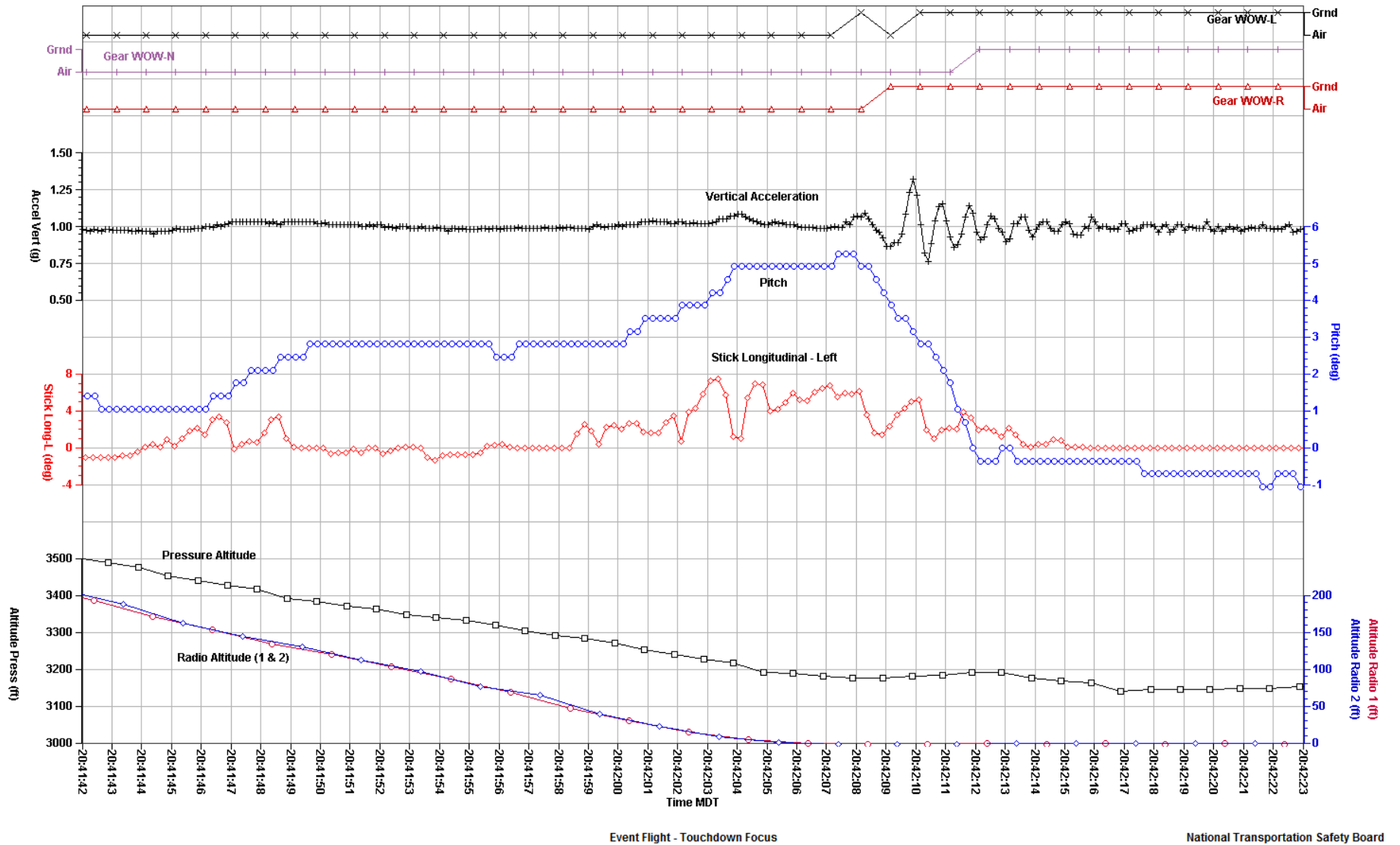
Figure 12. Plot of event flight approach: flaps, spoilers, and gear selection.



Event Flight - Approach - Flaps, Gear, Spoilers

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Figure 13. Plot of event flight touchdown with selected parameters.



Event Flight - Touchdown Focus

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Figure 14. Satellite overlay of reposition flight.

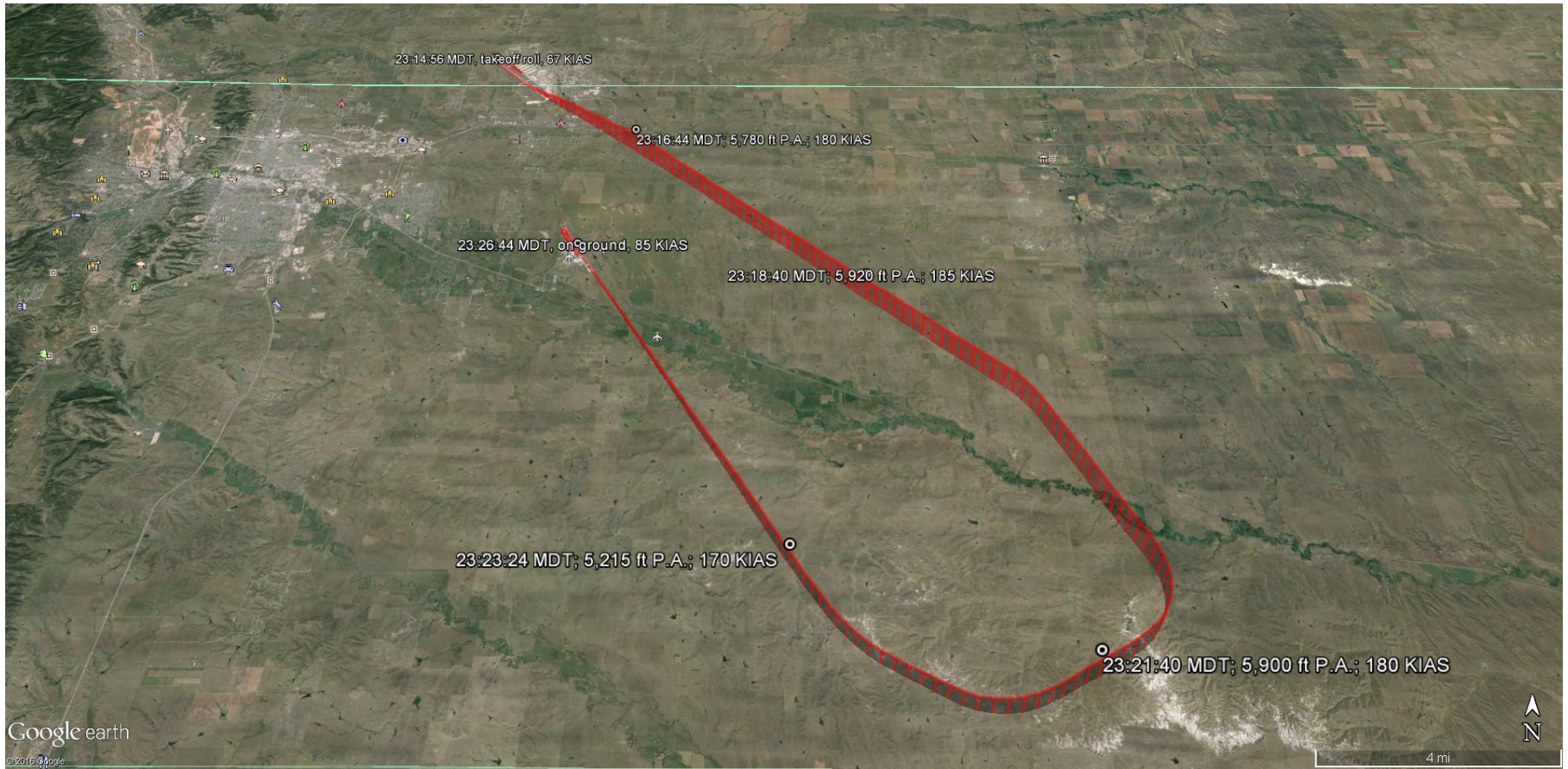
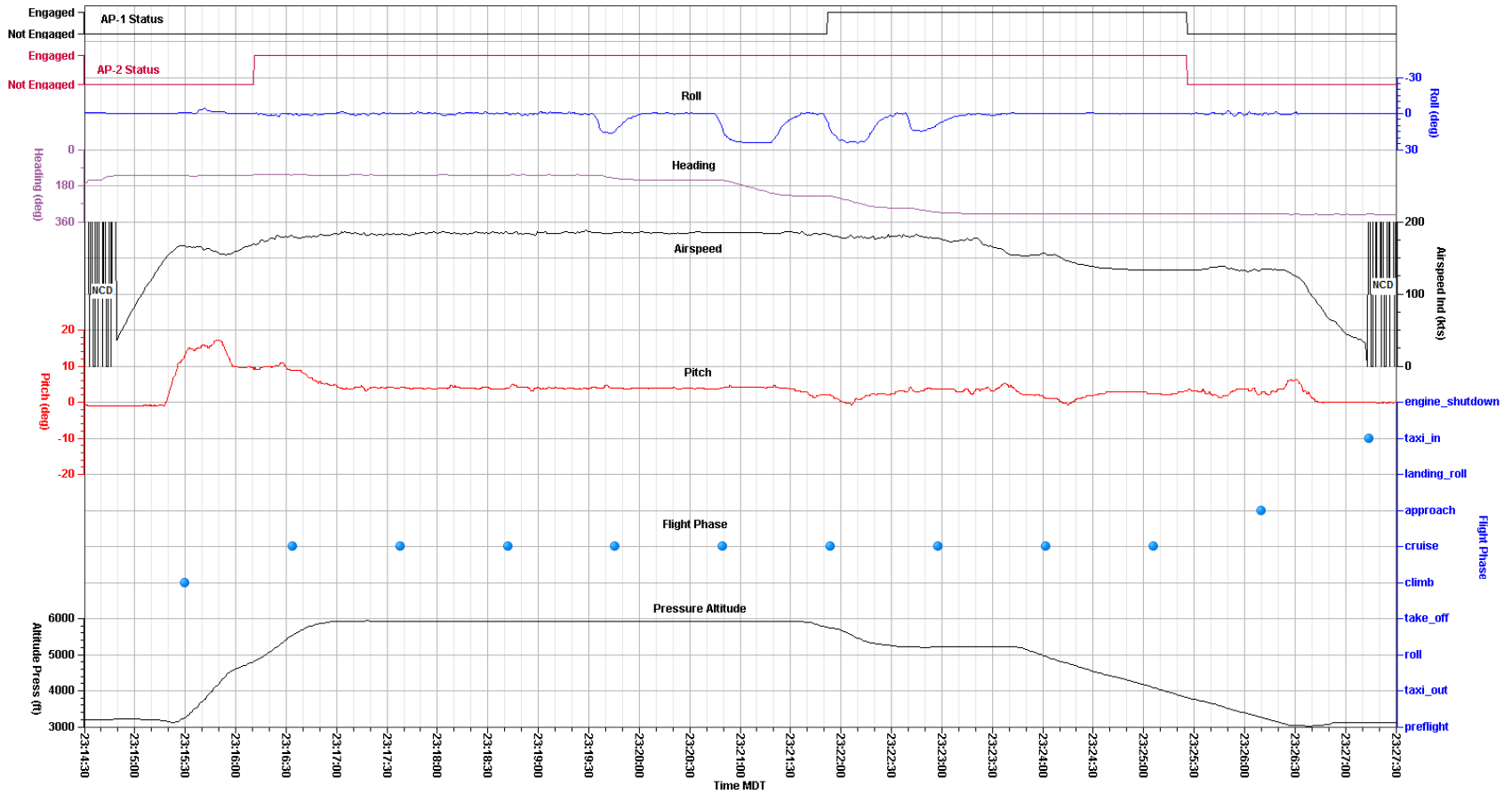


Figure 15. Plot of reposition flight with selected parameters.



Entire Reposition Flight - Basic Parameters

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APPENDIX A

This appendix describes the parameters provided and verified in this report. Table A-1 lists the parameter names, units, and descriptions. Additionally, table A-2 describes the unit and discrete abbreviations used in this report.

Table A-1. Verified and provided FDR parameters.

Parameter Name	Parameter Description
1. Accel Vert (g)	Vertical Acceleration
2. Airspeed Ind (kts)	Indicated Airspeed
3. Altitude Press (ft)	Pressure Altitude
4. Altitude Radio 1 (ft)	Radio Altitude 1
5. Altitude Radio 2 (ft)	Radio Altitude 2
6. AP Lateral Modes (discrete)	Autopilot Lateral Modes
7. AP LND TRK Align Submode (discrete)	Autopilot Land Track Align Submode
8. AP LND TRK Roll Out Submode (discrete)	Autopilot Land Track Roll Out Submode
9. AP Longitudinal Modes (discrete)	Autopilot Longitudinal Modes
10. AP NAV HDG Submode (discrete)	Autopilot Navigation/Heading Submode
11. AP NAV H-PATH Submode (discrete)	Autopilot Navigation/Horizontal-Path Submode
12. AP NAV Track Submode (discrete)	Autopilot Nav/Track Submode
13. AP NAV VOR Submode (discrete)	Autopilot Nav/VOR Submode
14. AP RUNWAY Loc Submode (discrete)	Autopilot Runway Localizer Submode
15. AP RUNWAY Track Submode (discrete)	Autopilot Runway Track Submode
16. AP-1 Status (discrete)	Autopilot 1 Status
17. AP-2 Status (discrete)	Autopilot 2 Status
18. ECAM Page Sel (discrete)	ECAM ⁵ Page Select
19. EFIS Mode-L (discrete)	EFIS ⁶ Mode, Captain
20. EFIS Mode-R (discrete)	EFIS Mode, First Officer
21. EFIS Scale-L (discrete)	EFIS Scale, Captain
22. EFIS Scale-R (discrete)	EFIS Scale, First Officer
23. EGPWS Oper Mode-L (discrete)	EGPWS ⁷ Operating Mode, Captain
24. EGPWS Oper Mode-R (discrete)	EGPWS Operating Mode, First Officer
25. Flap Lever Position (discrete)	Flap Lever Position
26. Flight Phase (discrete)	Flight Phase
27. Gear WOW-L (discrete)	Left Gear Weight-on-Wheels
28. Gear WOW-N (discrete)	Nose Gear Weight-on-Wheels
29. Gear WOW-R (discrete)	Right Gear Weight-on-Wheels
30. Ground Spd (kts)	Ground Speed
31. Heading (deg)	Magnetic Heading
32. Key VHF (discrete)	Microphone VHF Keying
33. Latitude (deg)	Latitude
34. Longitude (deg)	Longitude
35. Pitch (deg)	Pitch Angle

⁵ ECAM means electronic centralized aircraft monitor.

⁶ EFIS means electronic flight instrument system.

⁷ EGPWS means enhanced ground proximity warning system.

Parameter Name	Parameter Description
36. Roll (deg)	Roll Angle
37. Spoiler-L1 Pos (discrete)	Left Spoiler-1 Position
38. Spoiler-L2 Pos (deg)	Left Spoiler-2 Position
39. Spoiler-L3 Pos (deg)	Left Spoiler-3 Position
40. Spoiler-L4 Pos (deg)	Left Spoiler-4 Position
41. Spoiler-L5 Pos (deg)	Left Spoiler-5 Position
42. Spoiler-R1 Pos (discrete)	Right Spoiler-1 Position
43. Spoiler-R2 Pos (deg)	Right Spoiler- 2 Position
44. Spoiler-R3 Pos (deg)	Right Spoiler-3 Position
45. Spoiler-R4 Pos (deg)	Right Spoiler-4 Position
46. Spoiler-R5 Pos (deg)	Right Spoiler-5 Position
47. Stick Long-L (deg)	Captain Longitudinal Stick Position
48. Time GMT Hrs (hr)	Time UTC Hours
49. Time GMT Min (min)	Time UTC Minutes
50. Time UTC Sec (sec)	Time UTC Seconds

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 and discrete abbreviations.

Unit and discrete Abbreviations	Descriptions
Act	active
deg	degrees
discrete	discrete
Dwn	down
Fac	factor
FPA	flight path angle
ft	feet
g	g
Go-Arnd	go around
Haz	hazard
HDG	heading
hrs	hours
ILS	instrument landing system
KIAS	knots indicated airspeed
kts	knots
Md	Mode
min	minutes
Pos	position
sec	seconds
Sel	selected
Stby/Norm	standby/normal
Trk	track
Turb	turbulence
Vert	vertical
VOR	very high-range omnidirectional range
WS	windshear
Wx	weather

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.