NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, DC 20594

August 26, 2014

Flight Data Recorder

Specialist's Factual Report
By Christopher Babcock

1. EVENT

Location:	Bedford, Massachusetts
Date:	May 31, 2014, 2140 Eastern Daylight Time (EDT)[1]
Aircraft:	Gulfstream GIV, N121JM
Operator:	Arizin Ventures, LLC
NTSB Number:	ERA14MA271

2. GROUP

A group was not convened.

3. SUMMARY

On May 31, 2014, about 2140 eastern daylight time, a Gulfstream Aerospace Corporation GIV, N121JM, operated by Arizin Ventures, LLC, crashed after a rejected takeoff and runway excursion at Laurence G. Hanscom Field (BED), Bedford, Massachusetts. The two pilots, a flight attendant, and four passengers were fatally injured. The airplane was destroyed by impact forces and a postcrash fire. The personal flight, which was destined for Atlantic City International Airport (ACY), Atlantic City, New Jersey, was conducted under the provisions of 14 Code of Federal Regulations Part 91. An instrument flight rules flight plan was filed. Night visual conditions prevailed at the time of the accident.

4. DETAILS OF INVESTIGATION

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

Recorder Manufacturer/Model: Loral/Fairchild F1000 FDR
Serial Number: unknown

Recorder Manufacturer/Model: L-3 Micro QAR
Serial Number: unknown

[1] All times refer to the local EDT of the incident

The flight data recorder (FDR) was damaged by heat (Figures 1 & 2). The crash survivable memory unit was removed from the housing and disassembled (Figure 3). A new ribbon cable was attached to the memory unit (Figure 4) and the FDR was downloaded normally.

The quick access recorder (QAR) was damaged by heat as well (Figure 5). The compact flash card was extracted from the QAR, disassembled, and inspected (Figures 6-8). The surface of the compact flash circuit card did not exhibit any visible damage. The card was placed in a surrogate QAR and downloaded normally.

Figure 1. FDR side view.

Figure 2. FDR front view.

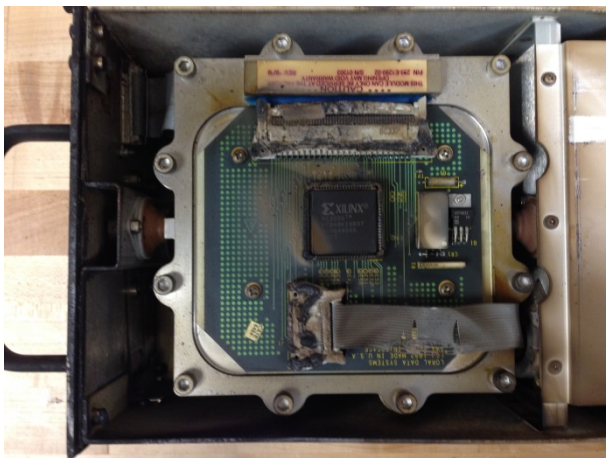

Figure 3. Crash survivable memory unit.

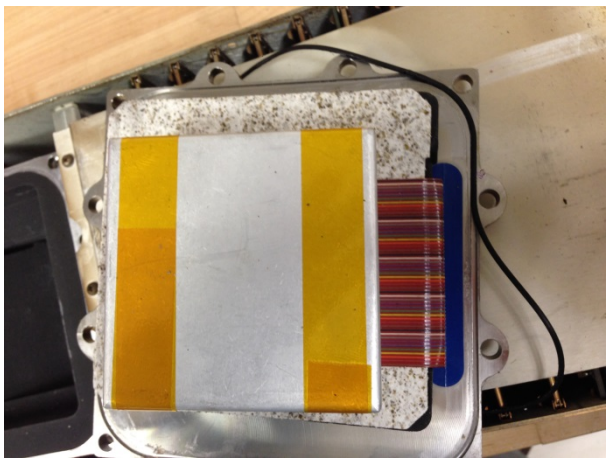

Figure 4. Memory unit and ribbon cable.

Figure 5. Damaged QAR.

Figure 6. Extracted CF card.

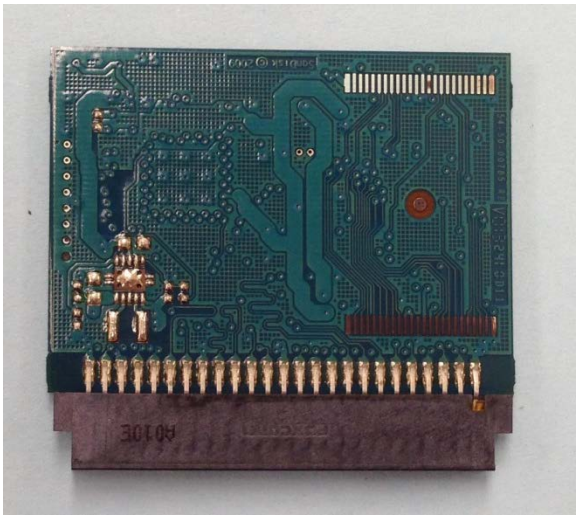

Figure 7. CF obverse side (case removed).

Figure 8. CF reverse side (case removed).

4.1. Recorder Descriptions

4.1.1. Loral/Fairchild F1000 FDR

The Loral/Fairchild F1000 FDR records airplane 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 configurations and records 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 is called a subframe. Each subframe has a unique 12-bit synchronization word identifying it as either subframe 1, 2, 3 or 4. The synchronization 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 (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-C124a.

On the GIV, the FDR will normally power on and begin recording when sufficient engine oil pressure is reached during the start of either engine. This occurs when the engine reaches approximately 40% N2.

4.1.2. L-3 Micro QAR

The L-3 Micro QAR is designed to record a copy of the data provided to the FDR. The data is stored to a removable compact flash card that can be downloaded and used with third-party flight data monitoring tools. The QAR is not designed to any crash-survivability standard, nor is it required to be.

4.2. FDR Carriage Requirements

Federal regulations regarding the carriage requirements of FDRs on transport category aircraft operated under Part 91 can be found in 14 CFR Part 91.609. The accident aircraft, N121JM, was manufactured in 2000 and was required to be equipped with an FDR that recorded, at a minimum, the 18 parameters found in Appendix E to 14 CFR Part 91.

4.3. Recording Description

4.3.1. Loral/Fairchild F1000 FDR

The FDR recording contained approximately 41 hours of data. Timing of the FDR data is measured in subframe reference number (SRN), where each SRN equals one elapsed second. The accident flight was the last flight on the recording and its duration was approximately 9 minutes from FDR power on until the FDR stopped recording.

4.3.2. L-3 Micro QAR

The QAR recording contained approximately 303 hours of data. The parameters recorded on the QAR are the same parameters recorded on the FDR. The QAR stopped recording approximately 6 seconds prior to the end of the FDR. According to the manufacturer of the QAR, the buffer can take up to 5.4 seconds to write data to the internal compact flash card.

4.4. Time Correlation

The accident flight data was offset from SRN to local EDT using the recorded GMT parameter on the FDR and then adjusted for EDT. For the accident flight, the offset from SRN to EDT was accomplished by subtracting 70,003 seconds.

4.5. 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, changes to the conversions have been made to ensure the parameters conform to the Safety Board's standard sign convention that climbing right turns are positive (CRT=+).[2]

[2] CRT=+ means that for any recorded parameter that indicates a climb or right turn, the sign is positive. Also, for any parameter recorded that indicates an action or deflection, if it induces a climb or right turn, the sign is positive. Examples: right roll=+, aileron trailing edge up=+, elevator trailing edge up=+.

4.5.1. Parameters Provided and Verified

Appendix A lists the FDR parameters provided and verified in this report, including the associated plot label.

4.5.2. Engine Power Level Angle

The left and right engine power lever angle parameters measure the throttle angle resolver at the engine. According to the GIV Maintenance Manual, the normal operating range is -22° (maximum reverse thrust) to 39.5° (maximum forward thrust). Forward idle is less than 1.5° and reverse idle (thrust reversers deployed with no engine rpm increase) is -5°.

4.5.3. Elevator Pitch Trim

The elevator pitch trim parameter was recorded; however, it was offset an unknown amount, outside the recording range of the parameter. Therefore, elevator pitch trim position could not be determined.

4.5.4. Aileron Position

Using the Gulfstream provided FDR documentation, one of the aileron position sensors appeared to be providing a reversed polarity (positive/negative) signal to the FDR. Evaluation of the converted magnetic heading, left and right flight spoiler position, and left and right aileron position over previous flights indicated that the polarity of the left aileron position sensor was reversed. For plotting purposes, the conversion of the left aileron position was corrected and is reflected in all data plots that follow.

4.5.5. Warn Inhibit Switch

If the “Warn Inhibit” switch is selected on, as is called for in the taxi/before takeoff checklist, the FDR will not record any amber caution messages. When the inhibit switch is selected, the crew advisory system will display the message, but caution capsule will not illuminate and the single (blue) or dual (amber) chimes will not sound.

4.6. QAR Review

A review of the QAR was performed to determine if pre-takeoff control checks were performed. The QAR contained 176 takeoff events including the accident takeoff. A control check was defined as stop-to-stop motion of the elevator, ailerons, and rudder at some point between the beginning of the FDR power cycle and takeoff. Out of the 176 takeoff events, two complete and 16 partial control checks were identified. The accident took place on takeoff number 176. Table 1 shows the complete and partial control checks present on the QAR. Each takeoff event was also reviewed to note the airspeed at the time the elevator began to move during the takeoff roll. In each case, except for the accident takeoff, the elevator began to move at approximately 60-80 knots calibrated airspeed.

Table 1. Control checks present on QAR.

Takeoff Number	Control Check
1	Elevator & Aileron
2	Elevator & Aileron
3	Full Control Check
4	Elevator & Aileron
8	Rudder
9	Elevator & Aileron
10	Elevator & Aileron
14	Full Control Check
21	Rudder
31	Elevator & Aileron
36	Rudder
47	Elevator & Aileron
74	Elevator & Aileron
108	Elevator & Aileron
112	Elevator & Aileron
121	Elevator & Aileron
146	Aileron
164	Elevator & Aileron

4.7. FDR Plot Description

Figures 9-11 show basic flight, engine, and flight control parameters for the accident takeoff roll. Figures 12-14 show basic flight, engine, and flight control parameters for the accident power cycle. Figures 15-17 show basic flight, engine, and flight control parameters for the previous power cycle. Figure 18 shows flight control data zoomed in on the previous takeoff roll. Timing on all data prior to the accident power cycle is in SRN on the FDR. The corresponding tabular data used to create these figures are provided in electronic (.csv) format as an attachment to this report.

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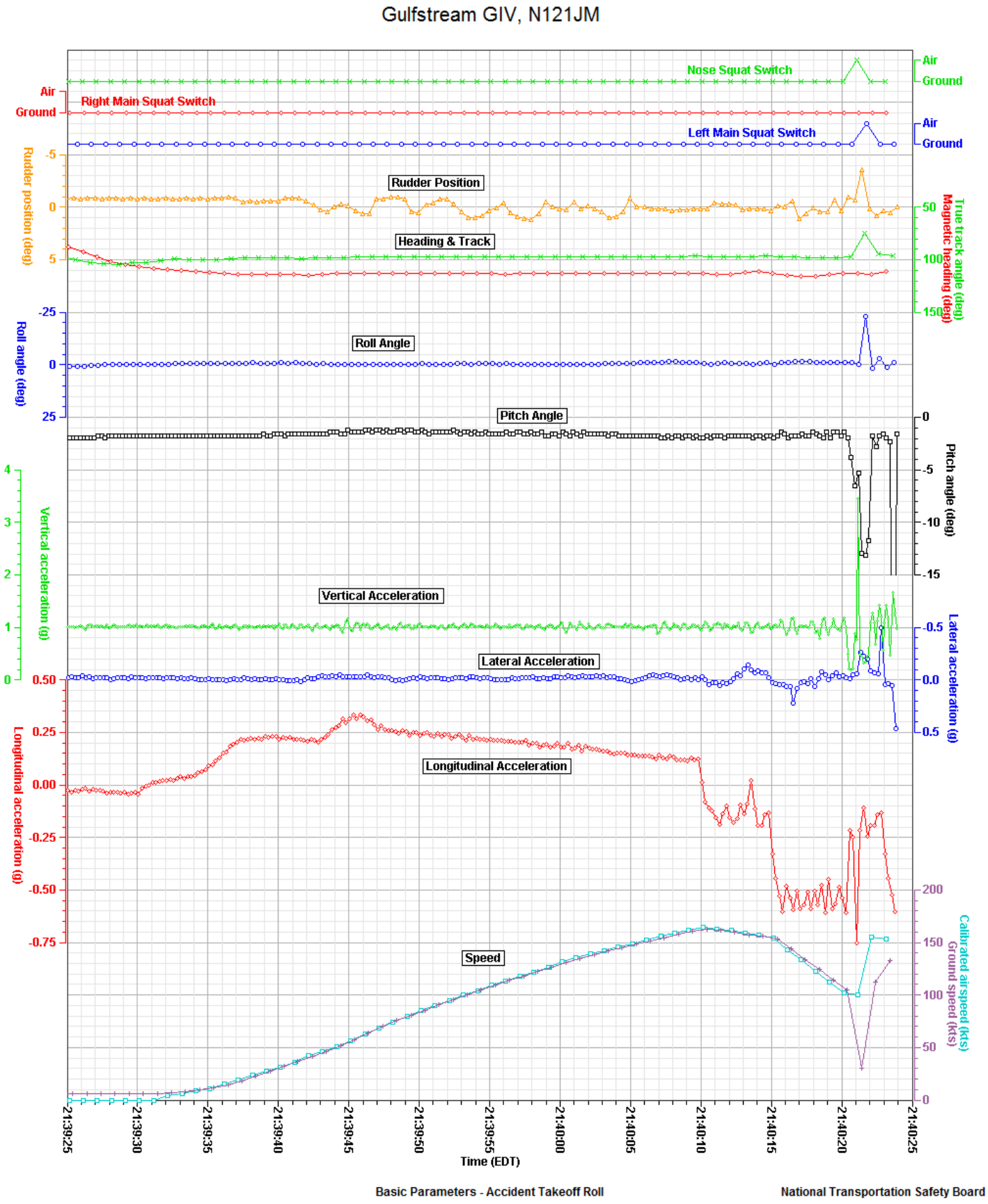

Figure 9. Basic flight data for accident takeoff.

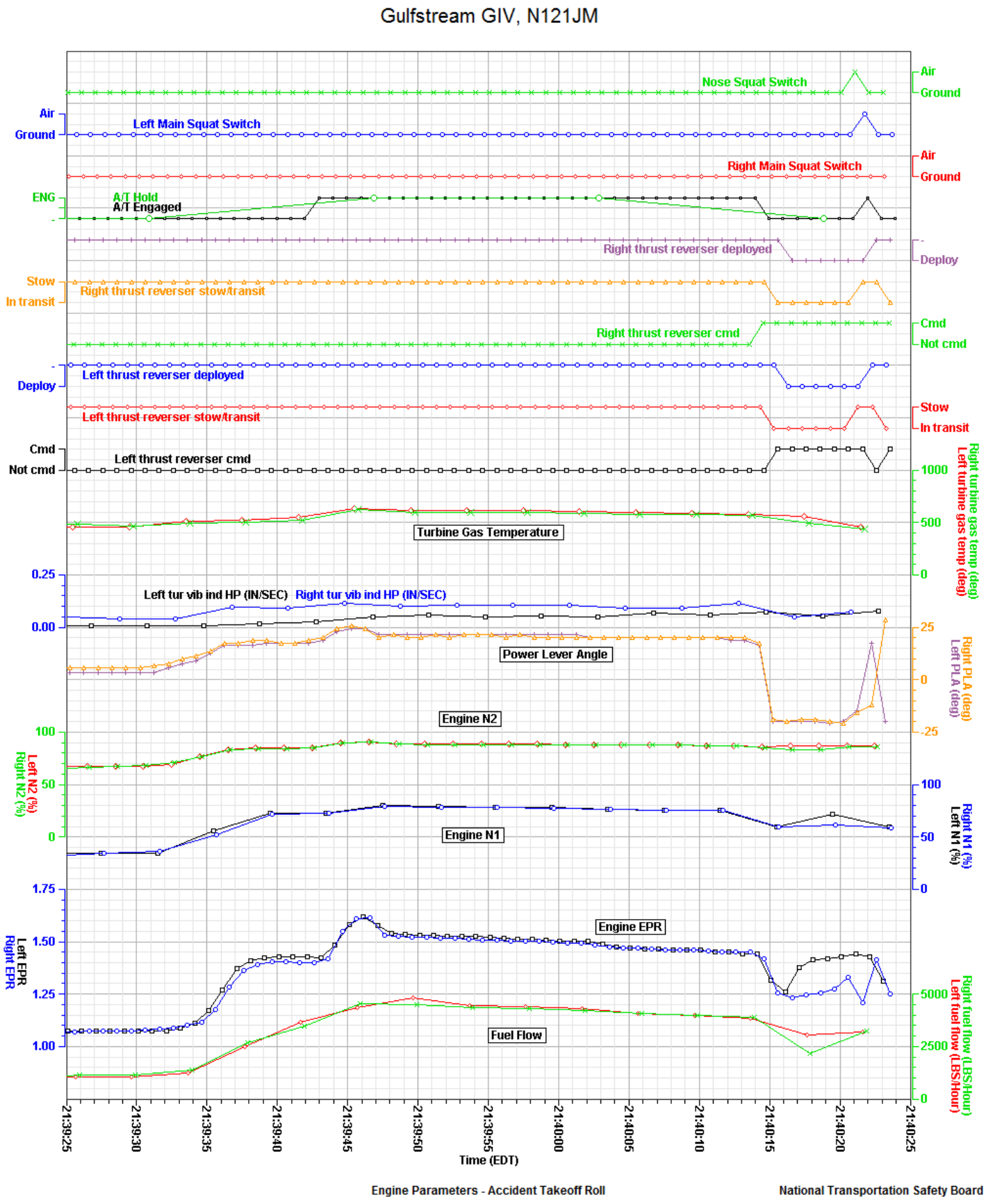

Figure 10. Engine data for accident takeoff.

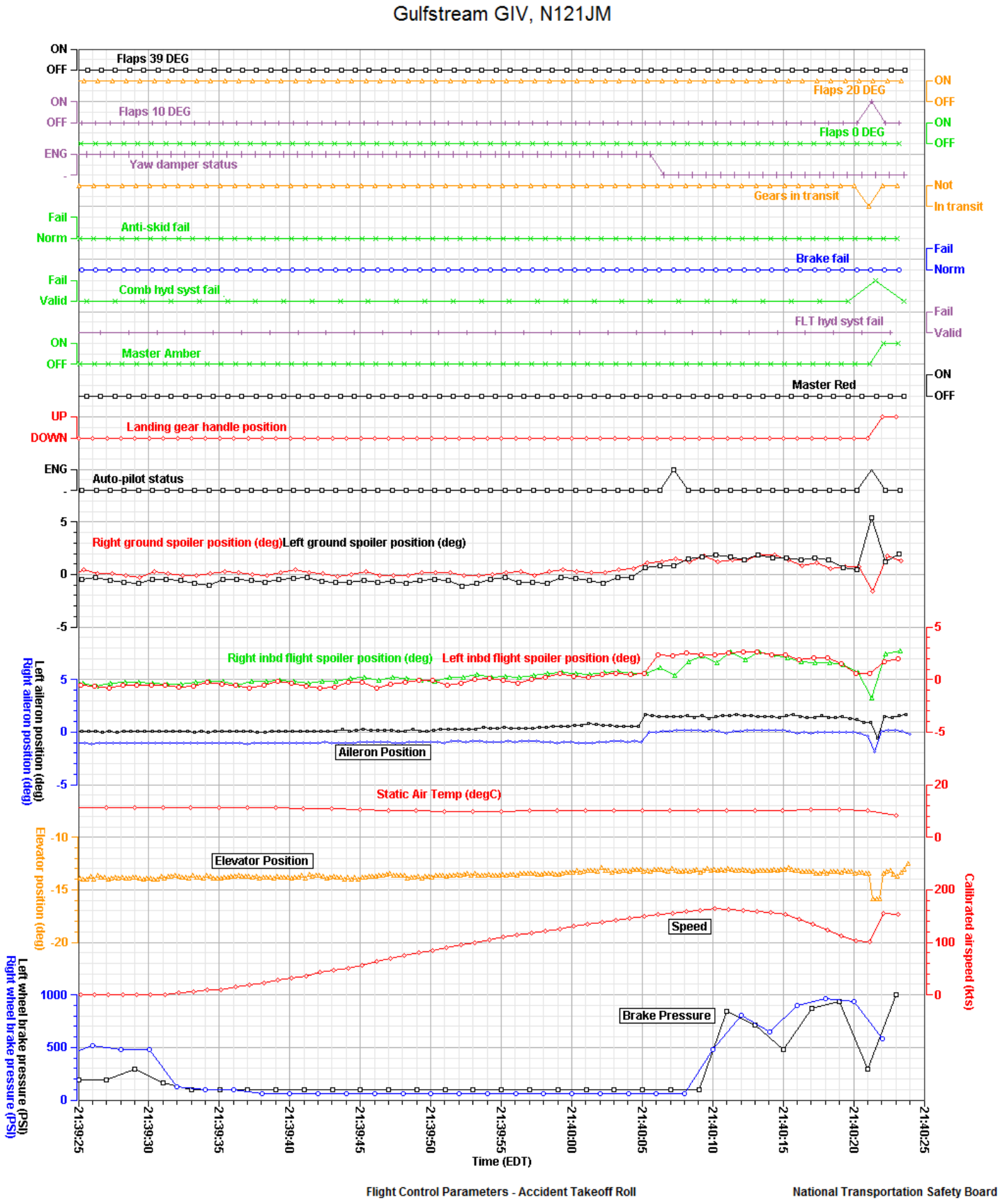

Figure 11. Flight control data for accident takeoff.

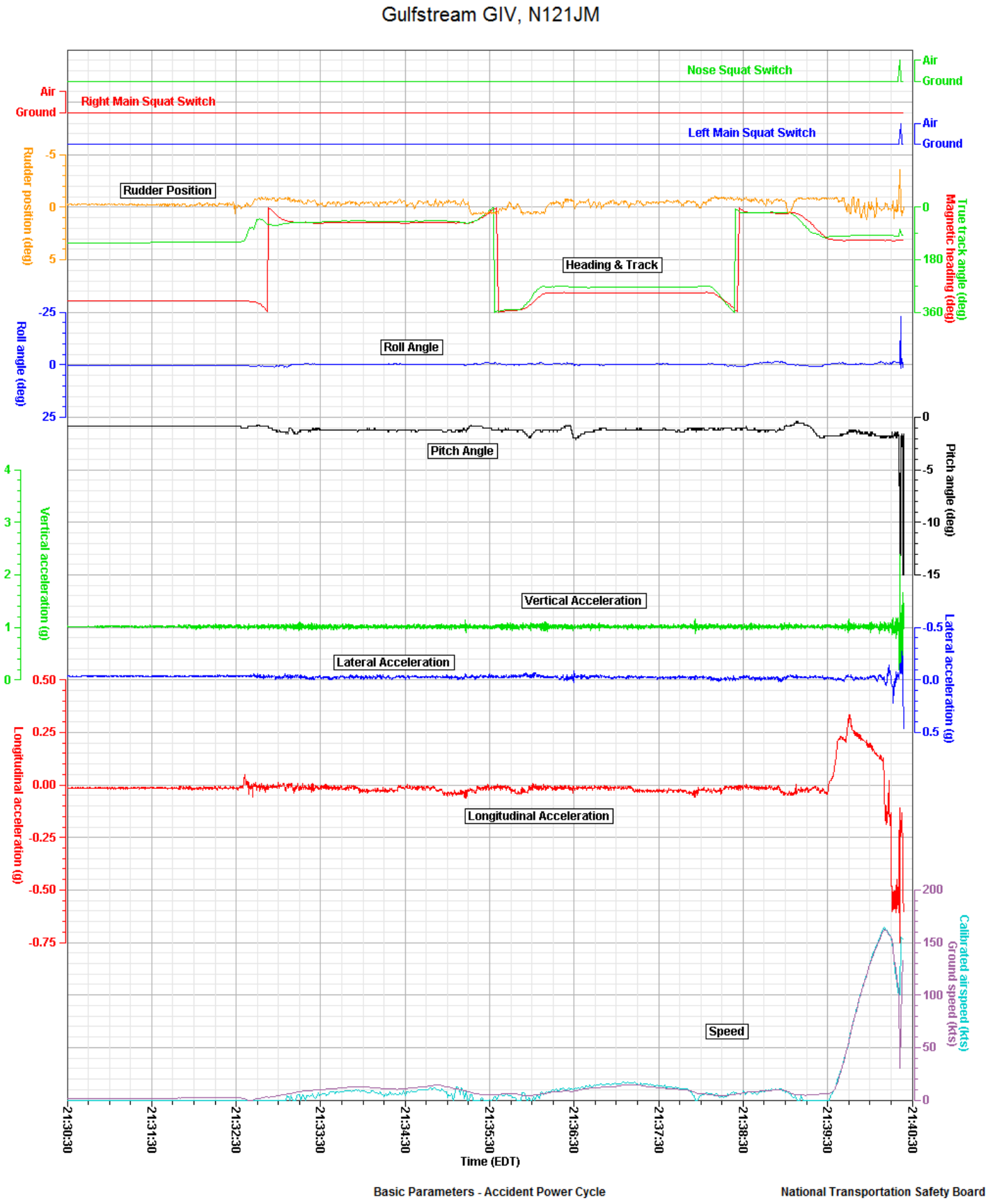

Figure 12. Basic flight data for accident power cycle.

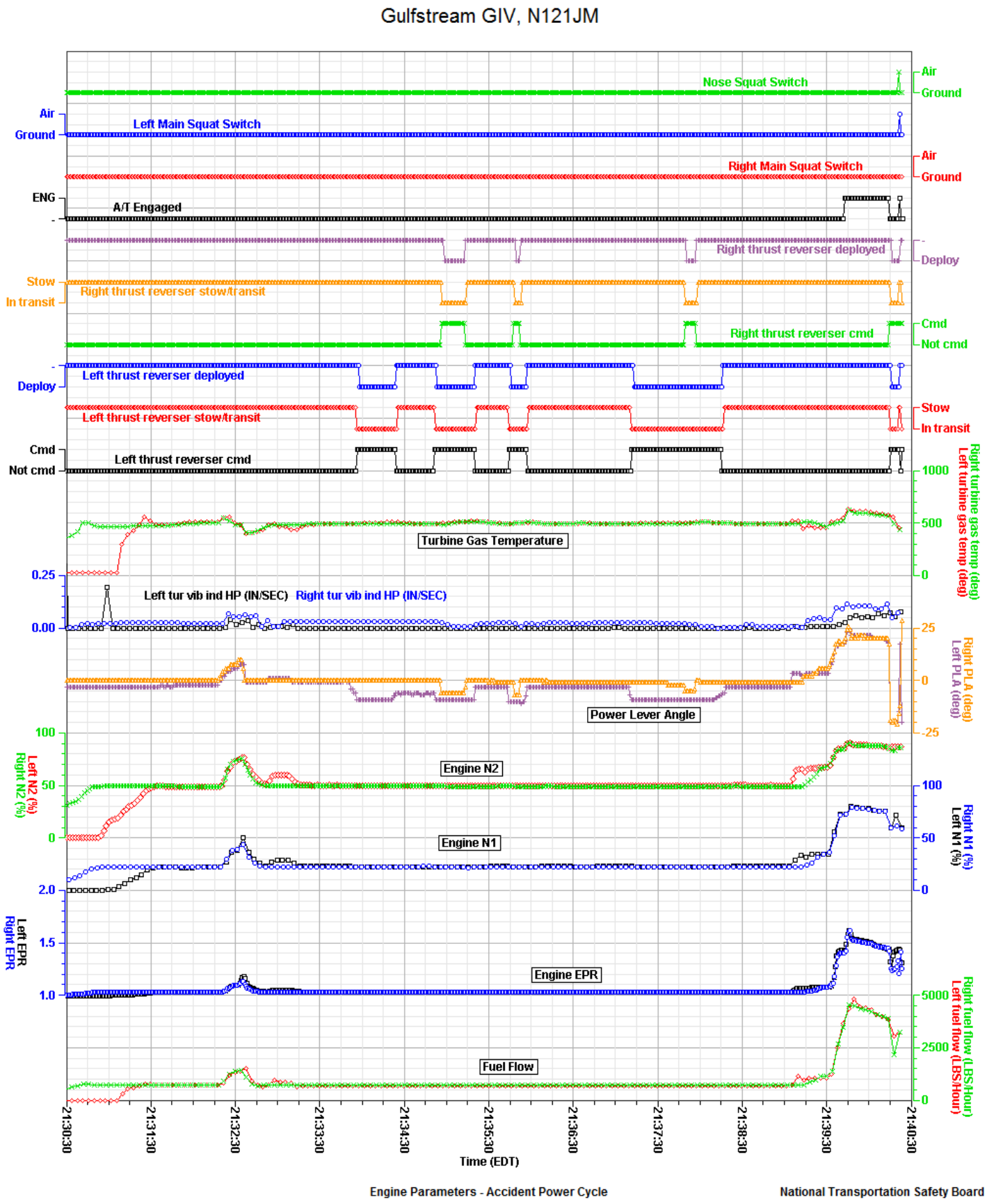

Figure 13. Engine data for accident power cycle.

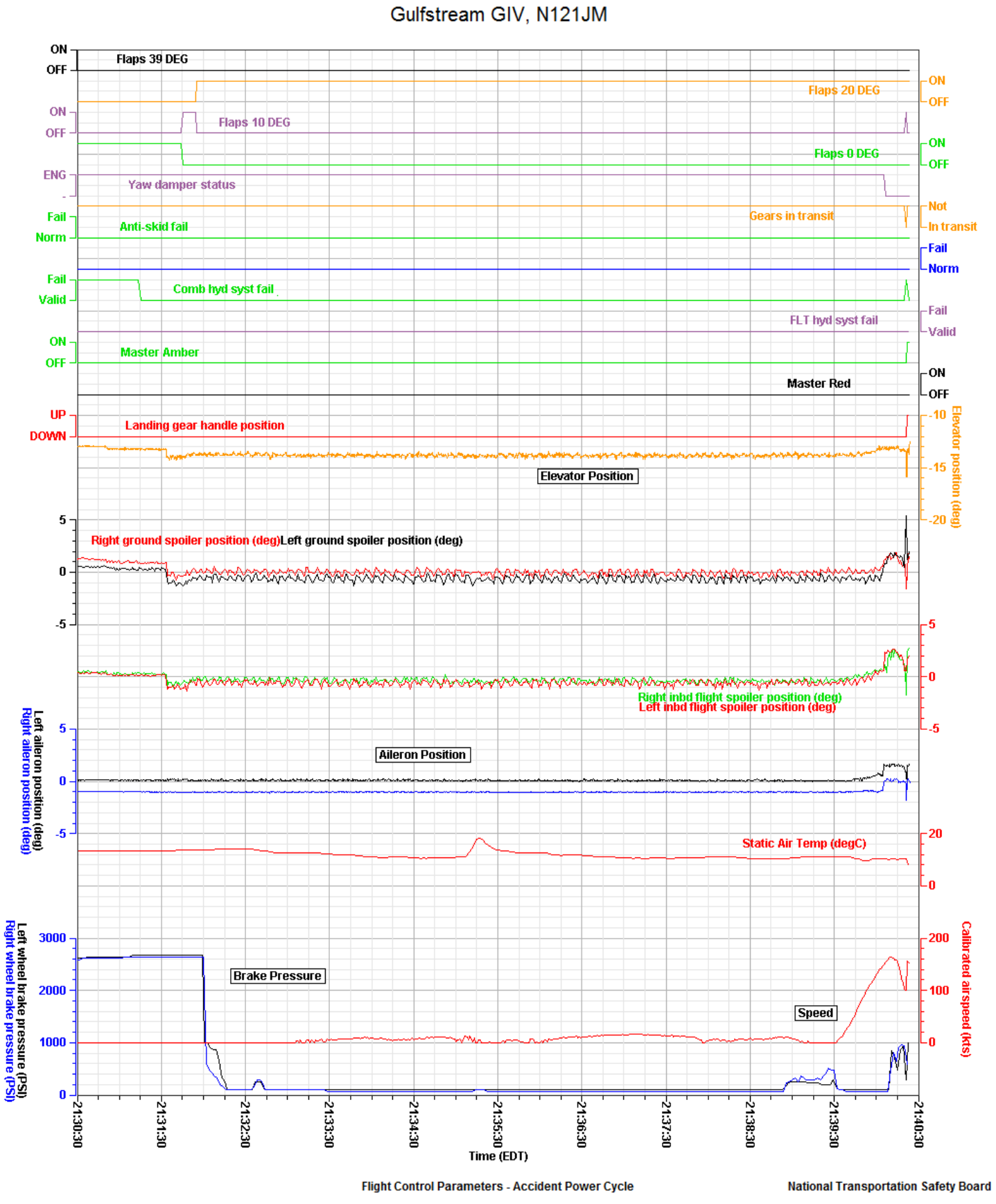

Figure 14. Flight control data for accident power cycle.

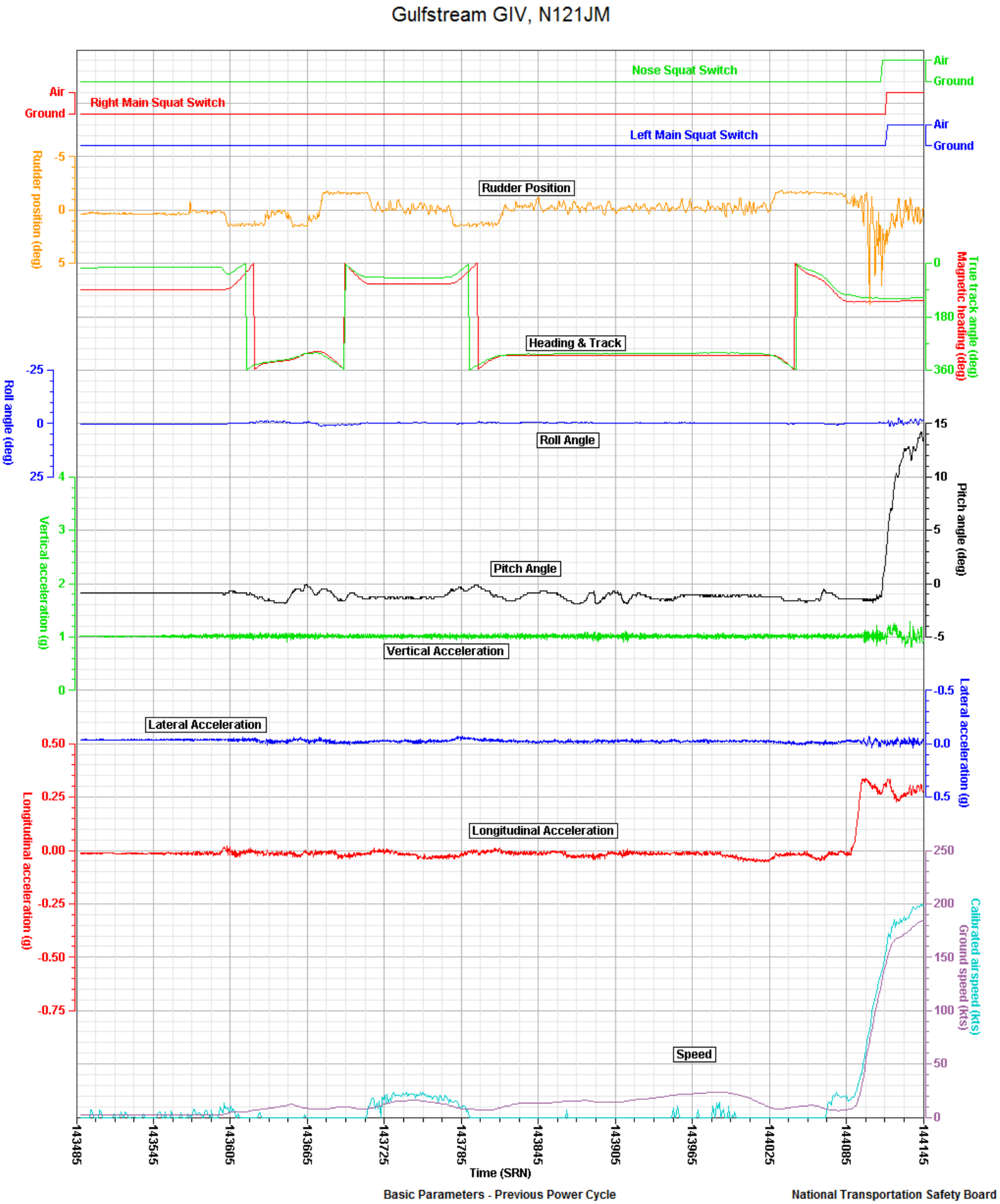

Figure 15. Basic flight data for previous power cycle.

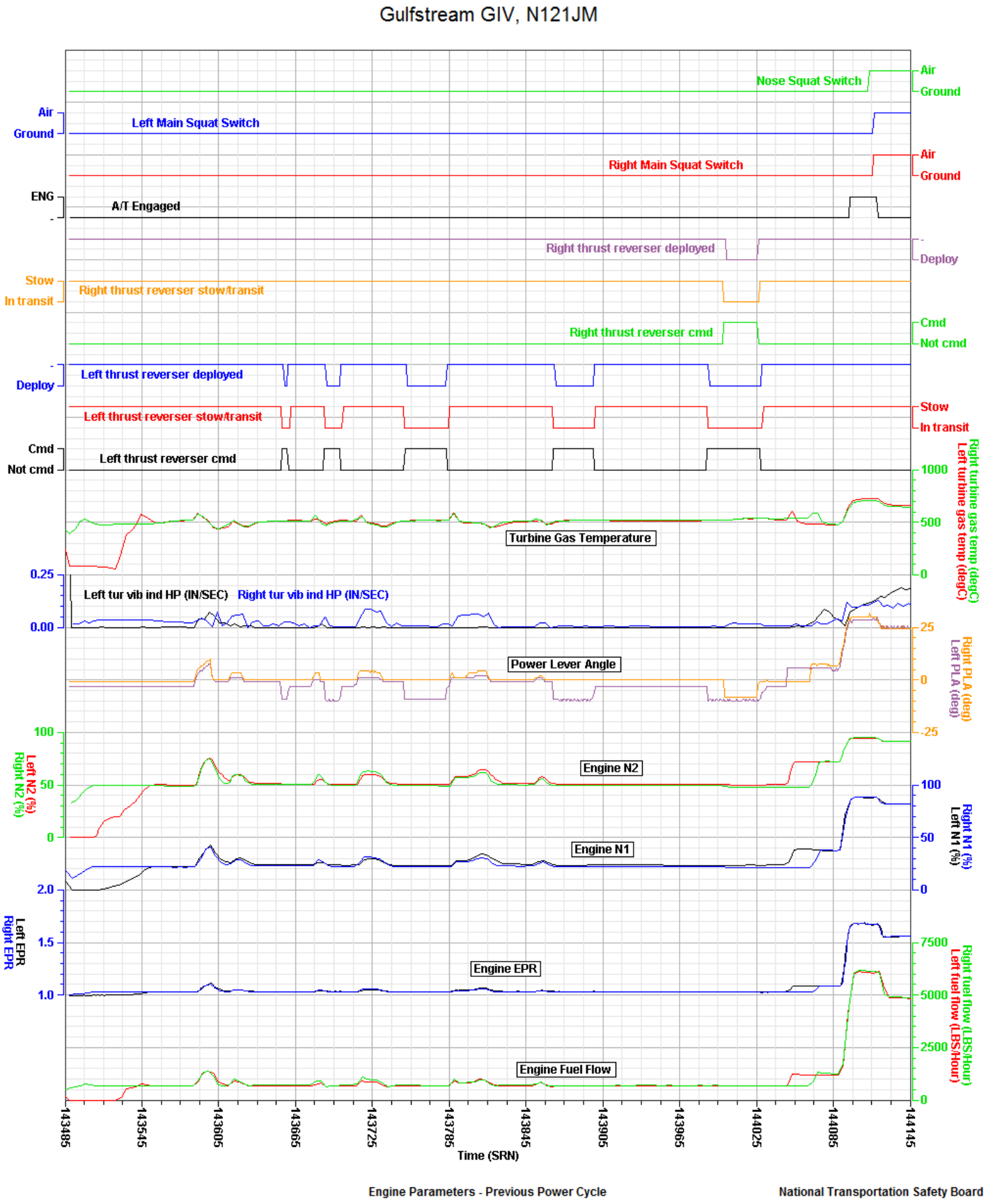

Figure 16. Engine data for previous power cycle.

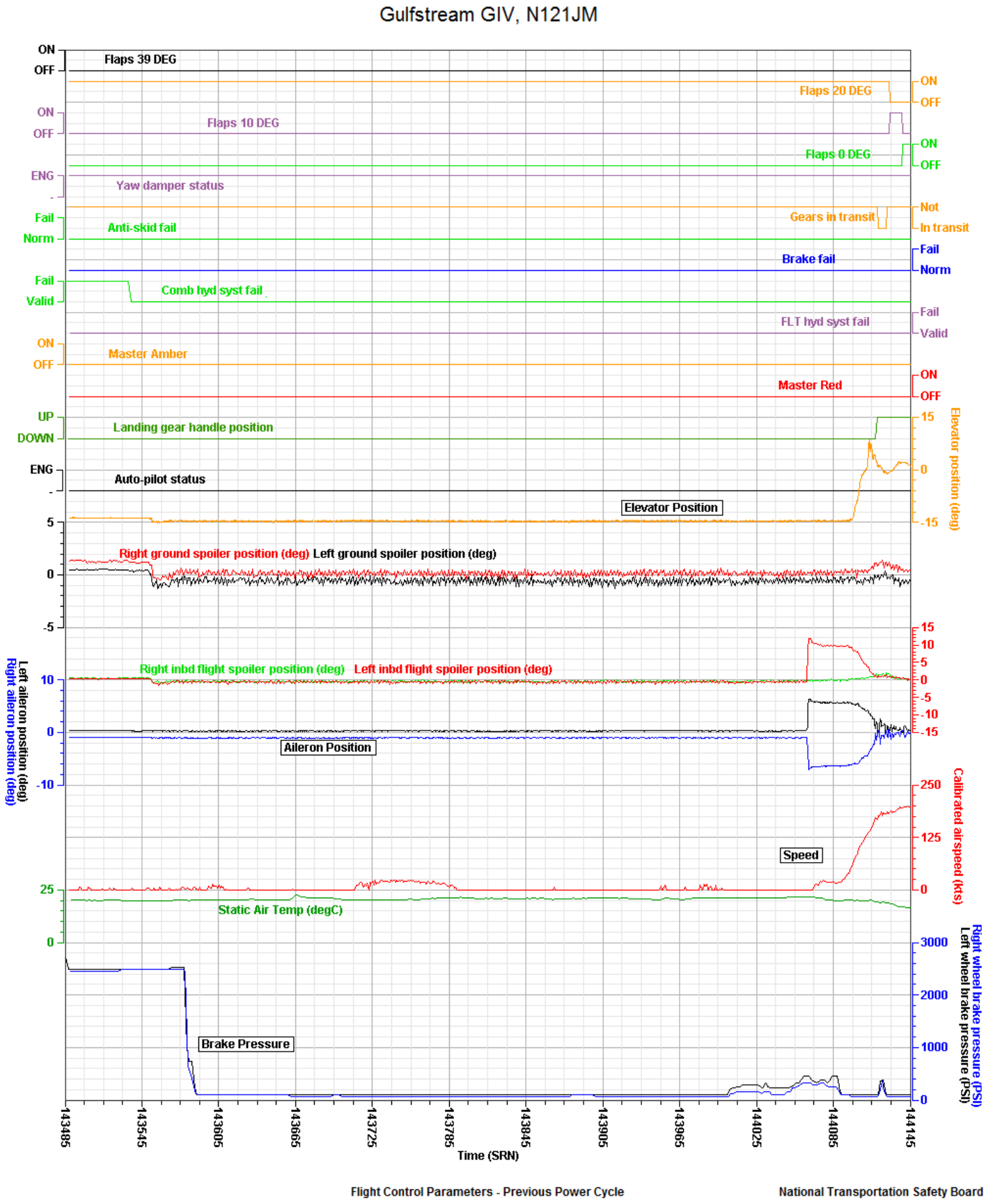

Figure 17. Flight control data for previous power cycle.

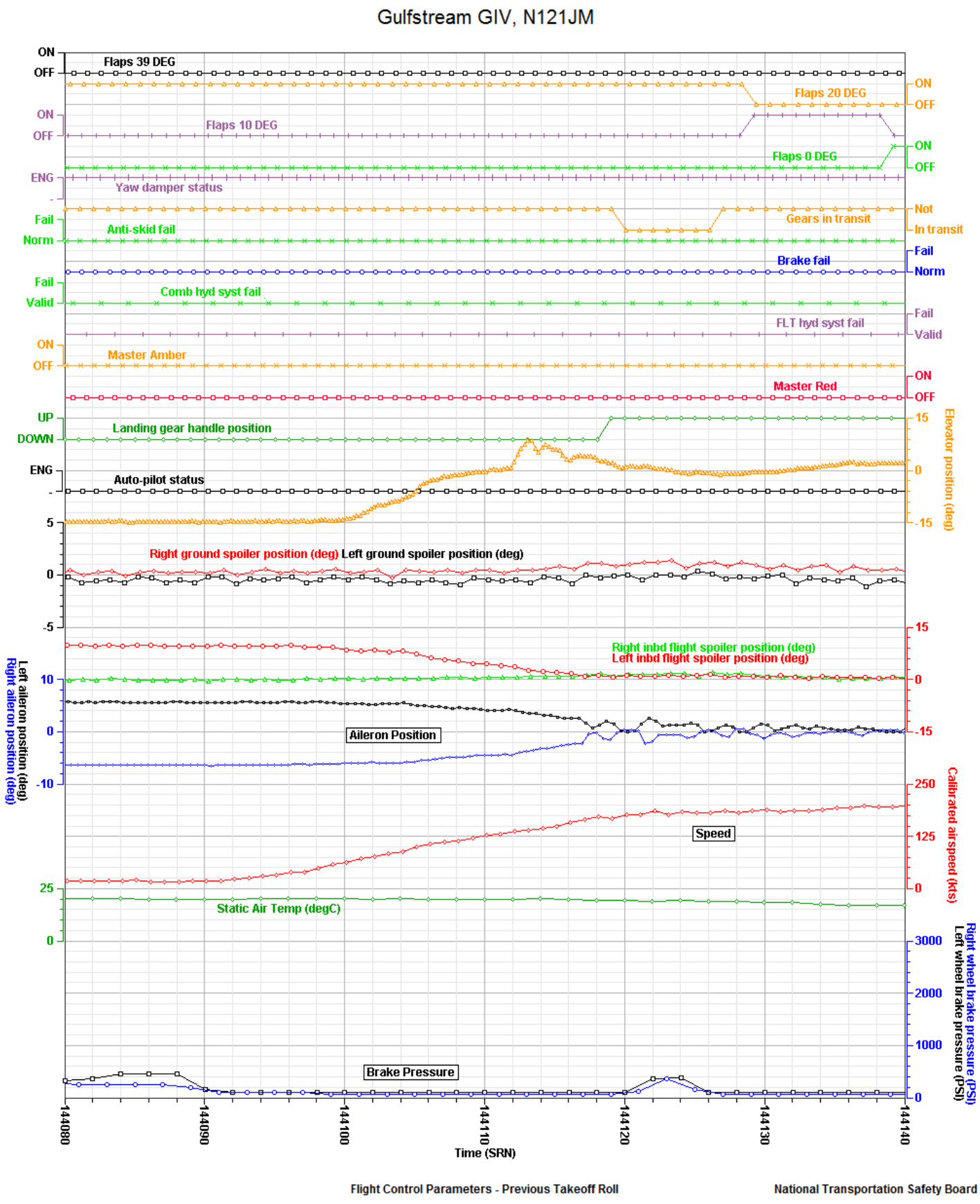

Figure 18. Flight control data for previous takeoff roll.

Appendix A

Table A-1. Provided and verified parameters.

Plot Label	Parameter Description	Sample Rate (Hz)
Anti-skid fail	Anti-Skid System Failure Discrete	1
A/T Engaged	Autothrottle Engaged Discrete	1
A/T Hold	Autothrottle Hold Mode Discrete	1/16
Auto-pilot status	Autopilot Engaged Status Discrete	1
Brake fail	Brake System Failed Discrete	1
Calibrated airspeed (kts)	Calibrated Airspeed	1
Comb hyd sys fail	Combined Hydraulic System Failure Discrete	1/2
Elevator position (deg)	Elevator Deflection	4
Flaps 0 DEG (deg)	Flap Handle Position 0 Degree Discrete	1
Flaps 10 DEG (deg)	Flap Handle Position 10 Degree Discrete	1
Flaps 20 DEG (deg)	Flap Handle Position 20 Degree Discrete	1
Flaps 39 DEG (deg)	Flap Handle Position 39 Degree Discrete	1
FLT hyd syst fail	Flight Hydraulic System Failed Discrete	1/2
Gears in transit	Landing Gear In Transit Discrete	1
Ground speed (kts)	Ground Speed	1
Landing gear handle position	Landing Gear Handle Status Discrete	1
Lateral acceleration (g)	Lateral Acceleration	4
Left aileron position (deg)	Left Aileron Deflection	2
Left EPR	Left Engine Pressure Ratio	1
Left fuel flow (lbs/hr)	Left Engine Fuel Flow	1/4
Left ground spoiler position (deg)	Left Ground Spoiler Position	1
Left inbd flight spoiler position (deg)	Left Inboard Flight Spoiler Deflection	1
Left Main Squat Switch	Left Gear Weight on Wheel Switch Discrete	1
Left N1 (%)	Left Engine N1 Speed	1/4
Left N2 (%)	Left Engine N2 Speed	1/2
Left PLA (deg)	Left Engine Power Lever Angle	1
Left thrust reverser cmd	Left Thrust Reverser Command Discrete	1
Left thrust reverser deployed	Left Thrust Reverser Deployed Discrete	1
Left thrust reverser stow/transit	Left Thrust Reverser In Transit Discrete	1
Left turbine gas temp (degC)	Left Engine Turbine Gas Temperature	1/4
Left tur vib ind HP (in/sec)	Left Engine High Pressure Turbine Shaft Vibration	1/4
Left wheel brake pressure (psi)	Left Gear Brake Pressure	1/2
Longitudinal Acceleration (g)	Longitudinal Acceleration	4
Magnetic heading (deg)	Magnetic Heading	1
Master amber	Master Caution Discrete	1
Master red	Master Warning Discrete	1
Nose Squat Switch	Nose Gear Weight on Wheel Switch Discrete	1
Pitch angle (deg)	Pitch	4
Right aileron position (deg)	Right Aileron Deflection	2
Right EPR	Right Engine Pressure Ratio	1
Right fuel flow (lbs/hr)	Right Engine Fuel Flow	1/4
Right ground spoiler position (deg)	Right Ground Spoiler Position	1
Right inbd flight spoiler position (deg)	Right Inboard Flight Spoiler Deflection	1
Right Main Squat Switch	Right Gear Weight on Wheel Switch Discrete	1
Right N1 (%)	Right Engine N1 Speed	1/4
Right N2 (%)	Right Engine N2 Speed	1/2
Right PLA (deg)	Right Engine Power Lever Angle	1
Right thrust reverser cmd	Right Thrust Reverser Command Discrete	1
Right thrust reverser deployed	Right Thrust Reverser Deployed Discrete	1

Plot Label	Parameter Description	Sample Rate (Hz)
Right thrust reverser stow/transit	Right Thrust Reverser In Transit Discrete	1
Right turbine gas temp (degC)	Right Engine Turbine Gas Temperature	1/4
Right tur vib ind HP (in/sec)	Right Engine High Pressure Turbine Shaft Vibration	1/4
Right wheel brake pressure (psi)	Right Gear Brake Pressure	1/2
Roll angle(deg)	Roll	2
Rudder position (deg)	Rudder Deflection	2
Static Air Temp (degC)	Static Air Temperature	1/2
True track angle (deg)	True Course Over Ground	1
Vertical Acceleration (g)	Vertical Acceleration	8
VHF1 keying[a]	VHF #1 Microphone Keyed Discrete	1
VHF2 keying[a]	VHF #2 Microphone Keyed Discrete	1
VHF3 keying[a]	VHF #3 Microphone Keyed Discrete	1
Yaw damper status	Yaw Damper Status Discrete	1

[a] Only available in .csv format

Table A-2. Unit abbreviations.

Units Abbreviation	Description
deg	degrees
kts	knots
g	units of gravity
discrete	discrete
ft	feet
in	inches
sec	second
hr	hour
psi	pounds per square inch

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.