

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



DCA23LA005

FLIGHT DATA RECORDER

Specialist's Factual Report

August 21, 2023

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A. INCIDENT

Location: Dayton, Ohio
Date: October 5, 2022
Time: 1859 eastern daylight time (EDT)
Airplane: Bombardier CL-600-2B19 (CRJ-200), Air Wisconsin Airlines, N447AW

B. FLIGHT DATA RECORDER SPECIALIST

Specialist: Steven Smith
Mechanical Engineer (Recorder Specialist)
National Transportation Safety Board (NTSB)

C. FEDERAL CARRIAGE REQUIREMENTS

The event aircraft, N447AW, was operating as Title 14 *Code of Federal Regulations* (CFR) Part 121. The event aircraft was manufactured in 2003 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(f).

D. DETAILS OF THE INVESTIGATION

An FDR group was not convened. The NTSB Vehicle Recorder Division received an electronic file containing the FDR data from the N447AW aircraft.

1.0 FDR Data File Description

The FDR data in the electronic file was 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, airspeed) has a specifically assigned word number within the subframe.

1.1 Recording Description

The FDR recording contained approximately 116 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 1 hour and 17 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

1.2 Time Correlation

Correlation of the FDR data from SRN to the event local time, EDT, was established by using the recorded coordinated universal time (UTC) Hours, UTC Minutes, and UTC Seconds and then applying an additional 4 hours offset to change UTC to EDT.

In addition to the event flight, three previous flights on October 5, 2022, were also reviewed as part of this investigation:

- Air Wisconsin Flight (AWI) 3921 from Mississauga, Ontario, Canada, to Dulles, Virginia, United States of America (USA)
- AWI 3836 from Dulles Virginia, USA, to Mississauga, Ontario, Canada
- AWI 3778 from Pittsburgh, Pennsylvania, USA, to Dulles, Virginia, USA

Table 1 lists the conversions for the FDR from SRN to EDT.

Table 1. FDR time correlation for incident and previous flights.

Flight Number	Departure	Arrival	FDR Offset
AWI 3818 ²	Dulles, Virginia, USA (KIAD)	Dayton, Ohio, USA (KDAY)	EDT = SRN - 345,385
AWI 3921	Mississauga, Ontario, Canada (CYYZ)	Dulles, Virginia, USA (KIAD)	EDT = SRN - 349,980
AWI 3836	Dulles, Virginia, USA (KIAD)	Mississauga, Ontario, Canada (CYYZ)	EDT = SRN - 349,947
AWI 3778	Pittsburgh, Pennsylvania, USA (KPIT)	Dulles, Virginia, USA (KIAD)	EDT = SRN - 354,046

1.3 Verified and Provided FDR Parameters

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

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 Denotes the incident flight on October 5, 2022.

E. FIGURES AND TABULAR DATA

Figures 1 to 10 contain FDR data recorded during the event on October 5, 2022. All the parameters listed in table 1 are plotted except UTC Hours, UTC Minutes, UTC Seconds, Latitude, and Longitude.

Figures 1 and 2 are time history plots presenting the braking, gear, and pedal parameters for the approach and landing, and the landing sequence only, respectively.

Figures 3 and 4 are time history plots presenting pilot inputs for the approach and landing, and the landing sequence only, respectively.

Figures 5 and 6 are time history plots presenting flight control surface parameters for the approach and landing, and the landing sequence only, respectively.

Figures 7 and 8 are time history plots presenting engine parameters for the approach and landing, and the landing sequence only, respectively.

Figures 9 and 10 are time history plots presenting braking and hydraulic parameters for the approach and landing, and the landing sequence only, respectively.

Figure 11 is a time history plot presenting FDR warning and caution parameters for the approach and landing.

Figure 12 is a time history plot displaying the instrument approach and landing.

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.

Figure 13 and 14 are graphical overlays generated using Google Earth presenting the entire flight from Dulles, Virginia, to Dayton, Ohio, and the landing rollout, respectively. Weather and lighting conditions in Google Earth are not necessarily the weather and lighting conditions present at the time of the recording. Due to low resolution of the recorded latitude and longitude on the FDR, Automatic Dependent Surveillance – Broadcast (ADS-B) data were used to generate these two figures.

The FDR data indicated the following sequence of events:

- **18:55:33 EDT:** Radio altitude left was 2,460 feet (ft), computed airspeed left was 196 knots (kt)s, and magnetic heading left was 238 degrees (deg). Flap surface position was 8 deg. The lateral and vertical deviations were 0.00 dots and -1.34 dots, respectively.³
- **18:55:45 EDT:** Radio altitude left was 2,381 ft, computed airspeed left was 190 kts, and flap surface position was 20 deg. The lateral and vertical deviations were 0.02 dots and -1.02 dots, respectively.
- **18:56:18 EDT:** Radio altitude right was 2,252 ft, computed airspeed left was 172 kts, and magnetic heading left was 238 deg. The landing gear down parameter was "Not Down and Locked" and the landing gear up parameter was "Not Up and Locked", consistent with the landing gear being in transition. The lateral and vertical deviations were -0.04 dots and -0.05 dots, respectively.
- **18:56:24 EDT:** Radio altitude right was 2,233 ft, computed airspeed right was 170 kts, and magnetic heading left was 238 deg. The lateral and vertical deviations were -0.04 dots and 0.09 dots, respectively.
- **18:56:30 EDT:** The nose and main landing gear down parameters were "Down and Locked."
- **18:56:57 EDT:** Radio altitude left was 1,571 ft, computed airspeed left was 157 kts, and magnetic heading left was 239 deg. Flap surface position was 44 deg. The lateral and vertical deviations were 0.08 dots and 0.04 dots, respectively.
- **18:57:39 EDT:** The aircraft autopilot status (left and right) transitioned from engaged to not engaged. Radio altitude left was 1,127 ft, computed airspeed left was 145 kts, and magnetic heading left was 239 deg. The lateral and vertical deviations were 0.10 dots and 0.02 dots, respectively.
- **18:58:54 EDT:** The left and right main landing gear weight on wheel (WOW) sensors changed from "air" to "ground." The ground spoilers were deployed and remained deployed.
- **18:58:55 EDT:** Ground speed was 127 kts and magnetic heading left was 240 deg.

³ Positive lateral deviation is left of the localizer (fly right) and positive vertical deviation is above the beam (fly down).

- **18:58:56 EDT:** The nose gear status was "ground." Computed airspeed right was 121 kts and magnetic heading right was 240 deg.
- **18:58:57 EDT:** The engine thrust reversers were unlocked. Ground speed was 123 kts and magnetic heading left was 239 deg.
- **18:58:58 EDT:** Computed airspeed right was 116 kts and magnetic heading right was 239 deg.
- **18:58:59 EDT:** The engine thrust reversers were deployed. Ground speed was 118 kts and magnetic heading left was 239 deg.
- **18:59:00 EDT:** Computed airspeed right was 110 kts and magnetic heading right was 240 deg. The captain applied right brake pedal.
- **18:59:01 EDT:** Ground speed was 108 kts and magnetic heading left was 239 deg. The captain applied left brake pedal.
- **18:59:02 EDT:** Computed airspeed right was 101 kts and magnetic heading right was 240 deg. The captain right brake pedal was not applied.
- **18:59:03 EDT:** Engine 2 thrust reverser transitioned to not deployed. Ground speed was 97 kts and magnetic heading left was 240 deg. The captain reapplied right brake pedal.
- **18:59:04 EDT:** Computed airspeed right was 87 kts and magnetic heading right was 244 deg.
- **18:59:05 EDT:** Engine 1 thrust reverser transitioned to not deployed. Ground speed was 82 kts and the magnetic heading left was 248 deg.
- **18:59:06 EDT:** Computed airspeed right was 73 kts and magnetic heading right was 252 deg. The first officer applied left brake pedal.
- **18:59:07 EDT:** Ground speed was 66 kts and magnetic heading left was 254 deg. The first officer applied right brake pedal.
- **18:59:08 EDT:** Computed airspeed right was 57 kts and magnetic heading right was 260 deg.
- **18:59:21 EDT:** The ground speed was 0 kts and magnetic heading left was 336 deg.
- **20:10:11 EDT:** The last recorded time sample.

The corresponding tabular data used to create figures 1 to 12, including UTC Hours, UTC Minutes, UTC Seconds, Latitude, and Longitude, are provided in electronic comma-separated value (CSV) format as attachment 1 to this report.

The corresponding tabular data used to create figures 13 and 14, including UTC Hours, UTC Minutes, UTC Seconds, Latitude, and Longitude, are provided in CSV format as attachment 2 to this report.

Figures 15 to 17 present time history plots of various braking, engine, flight control, and hydraulic parameters from 3 previous landings as shown in table 1. Figure 15 presents AWI flight 3921 which landed at KIAD. Figure 16 presents AWI flight 3836 which landed at CYYZ. Figure 17 presents AWI flight 3778 which landed at KIAD.

The corresponding tabular data used to create figures 15 to 17, including Latitude and Longitude, are provided in CSV format as attachment 3 to this report.

Submitted by:

Steven Smith
Mechanical Engineer (Recorder Specialist)

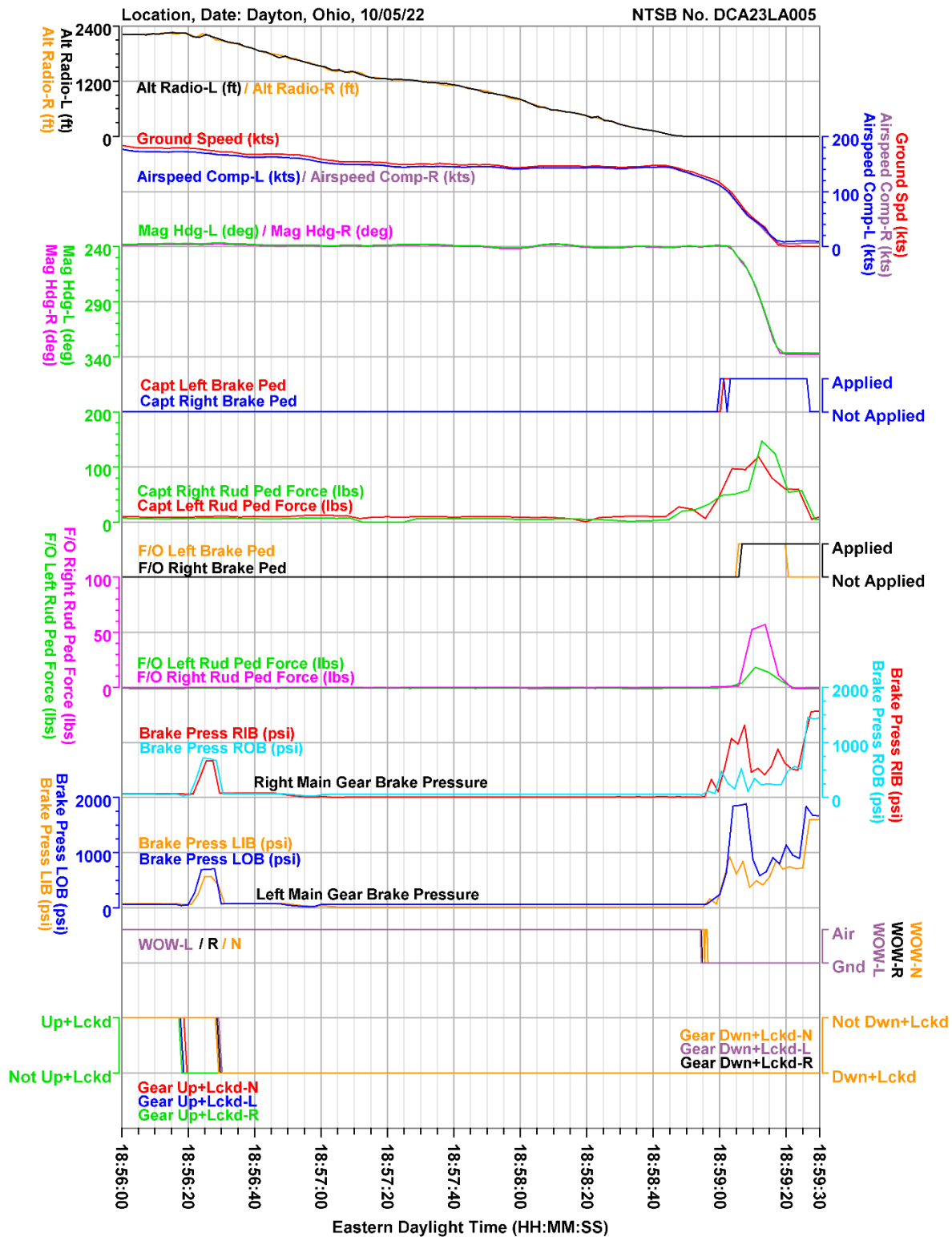


Figure 1. Time history plot of braking, gear, and pedal parameters during approach and landing.

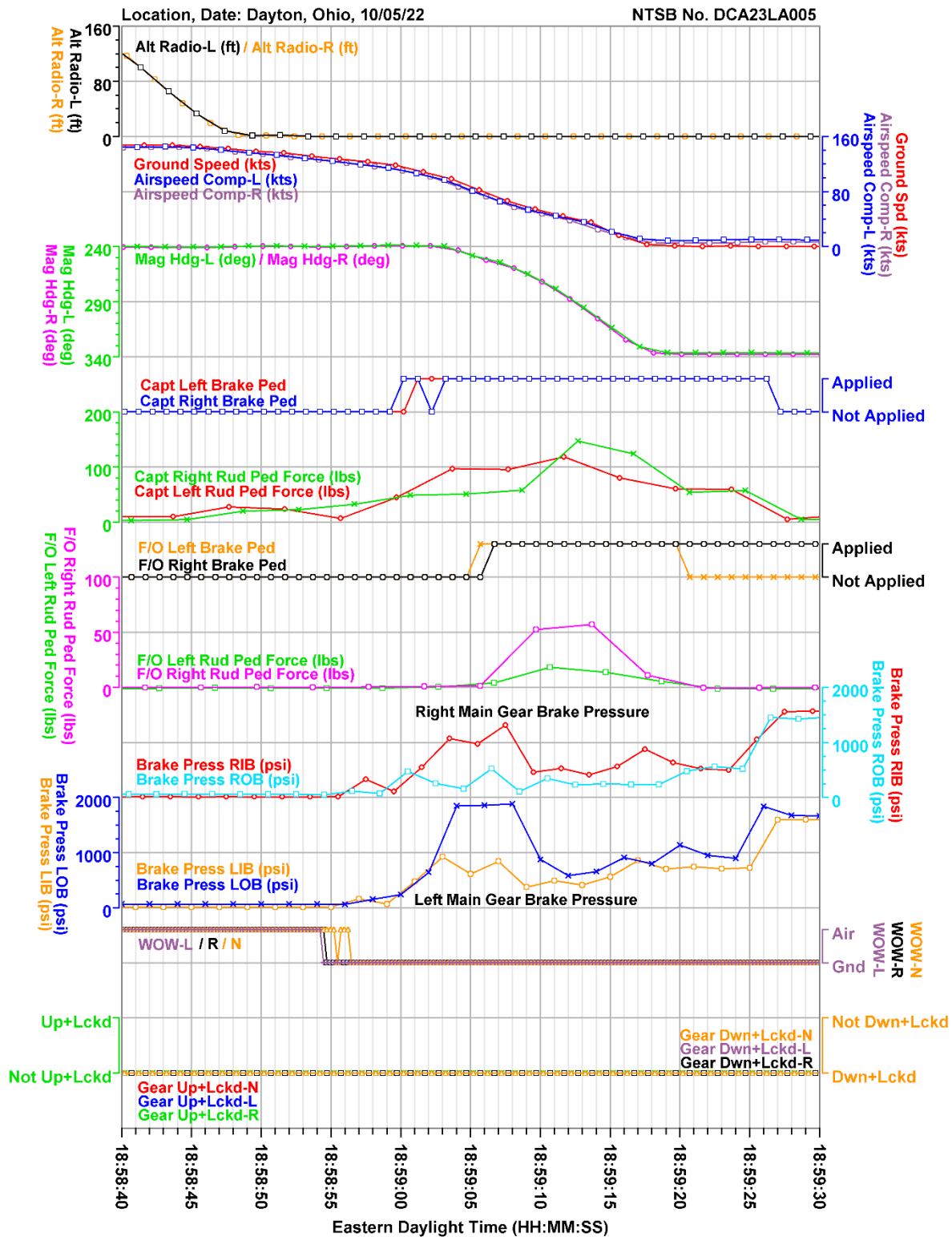


Figure 2. Time history plot of braking, gear, and pedal parameters during landing.

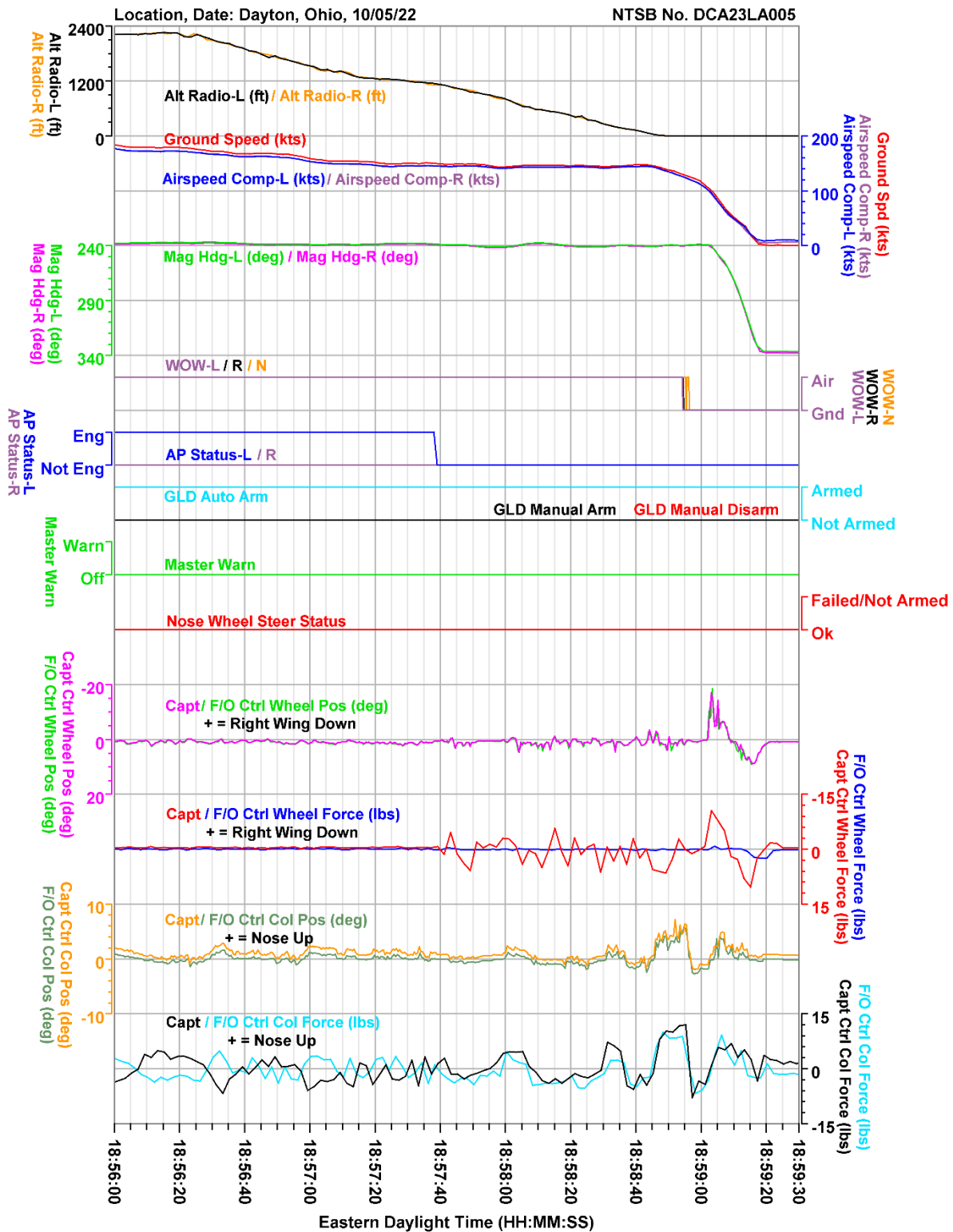


Figure 3. Time history plot of pilot inputs during approach and landing.

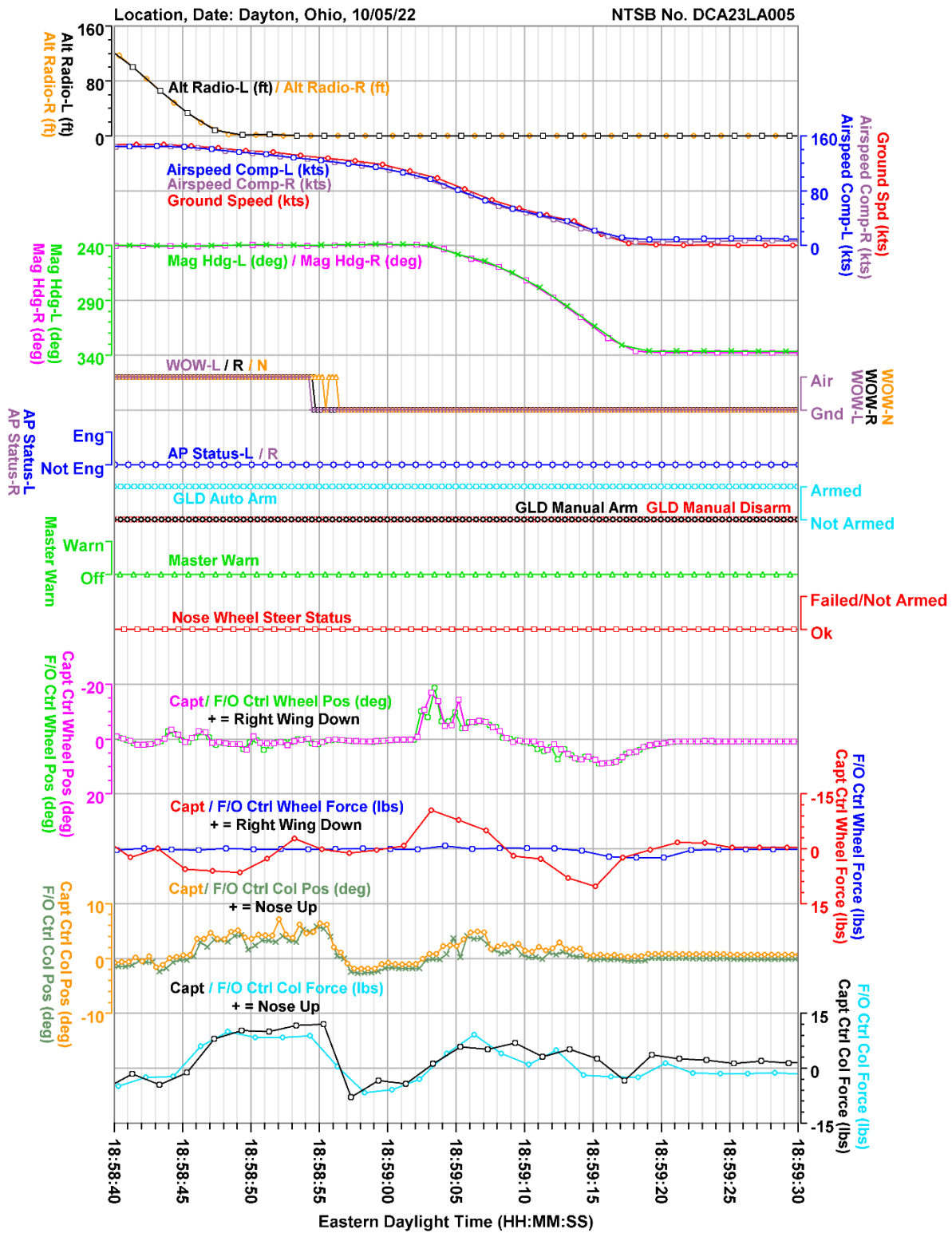


Figure 4. Time history plot of pilot inputs during landing.

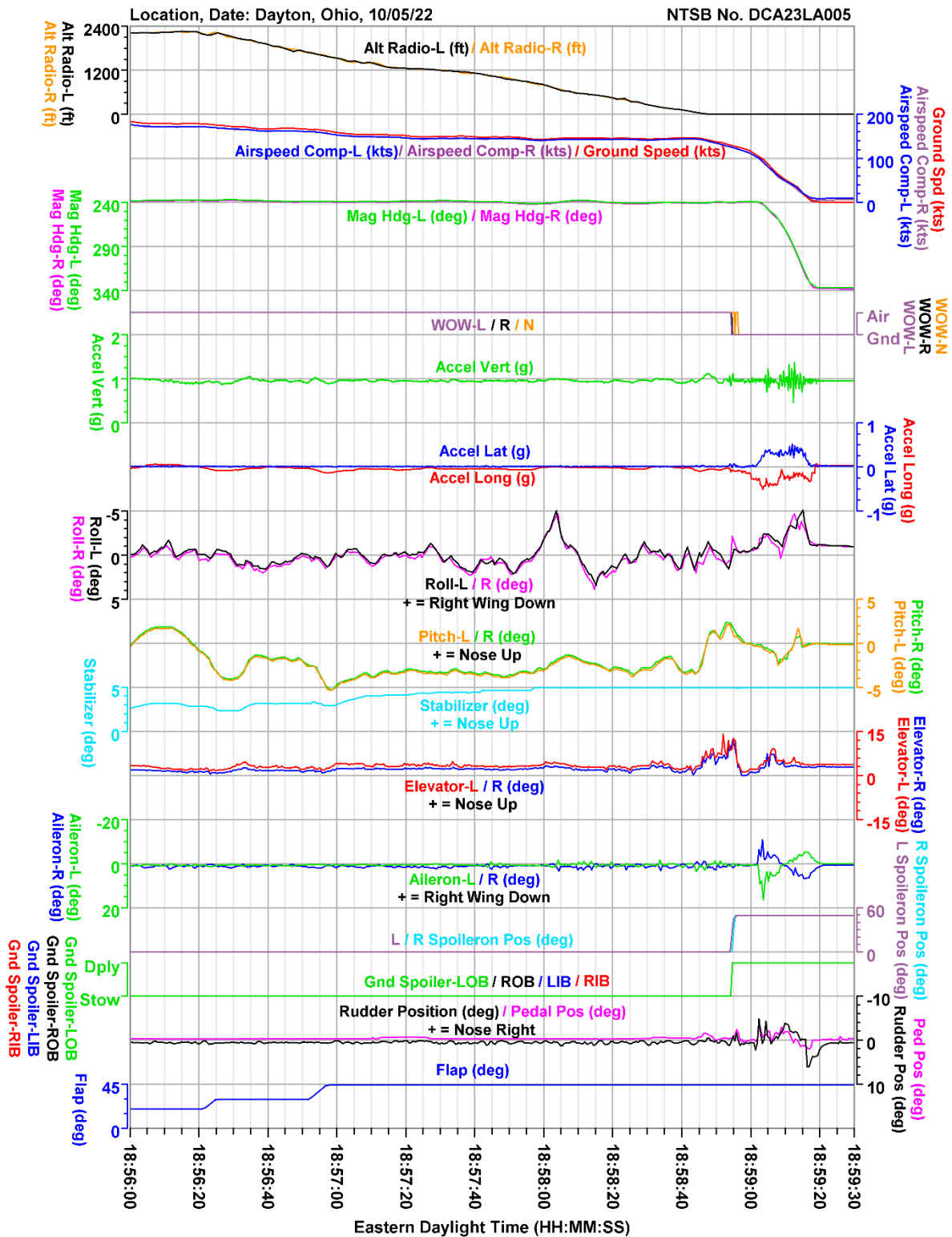


Figure 5. Time history plot of flight control surface positions during approach and landing.

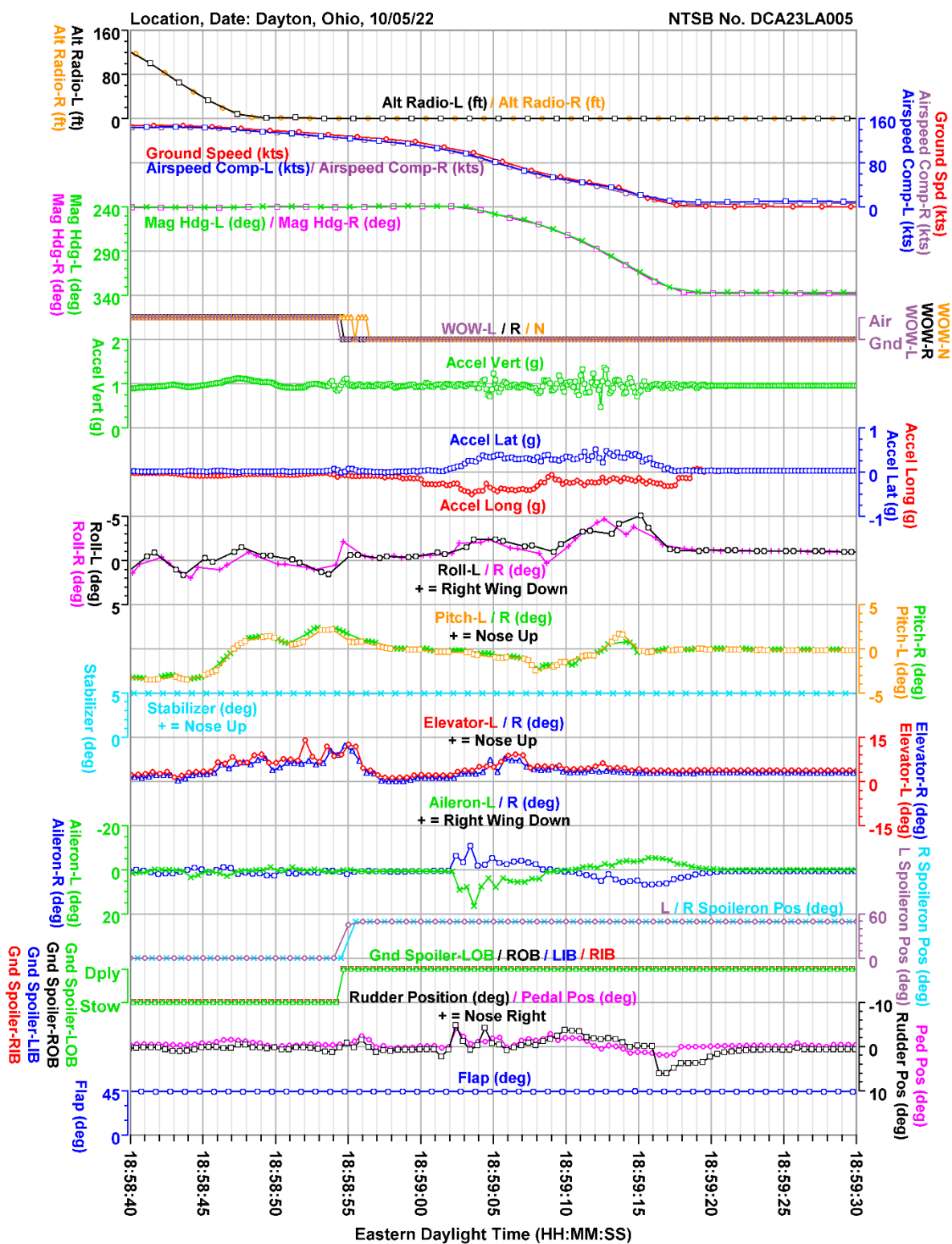


Figure 6. Time history plot of flight control surface positions during landing.

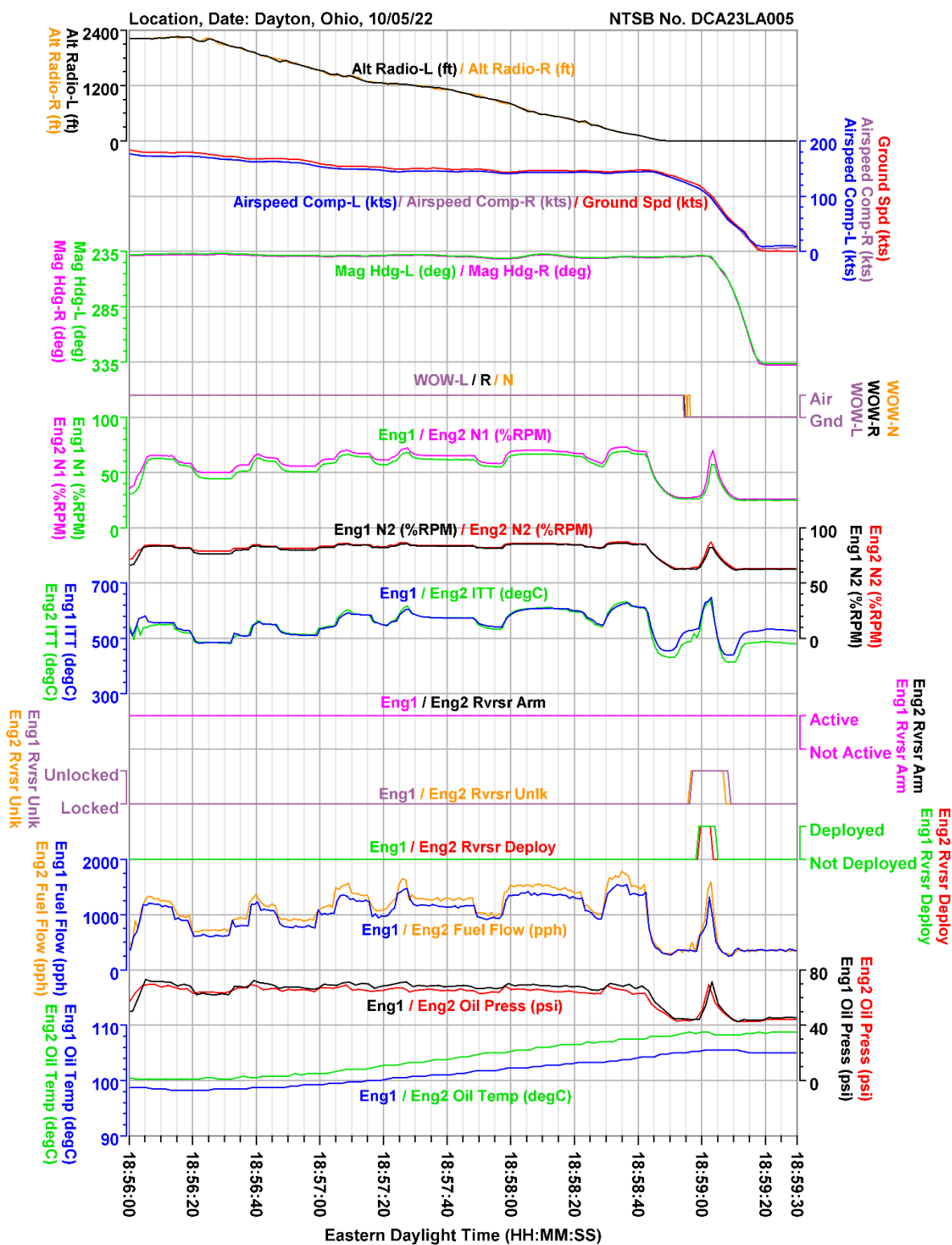


Figure 7. Time history plot of engine parameters during approach and landing.

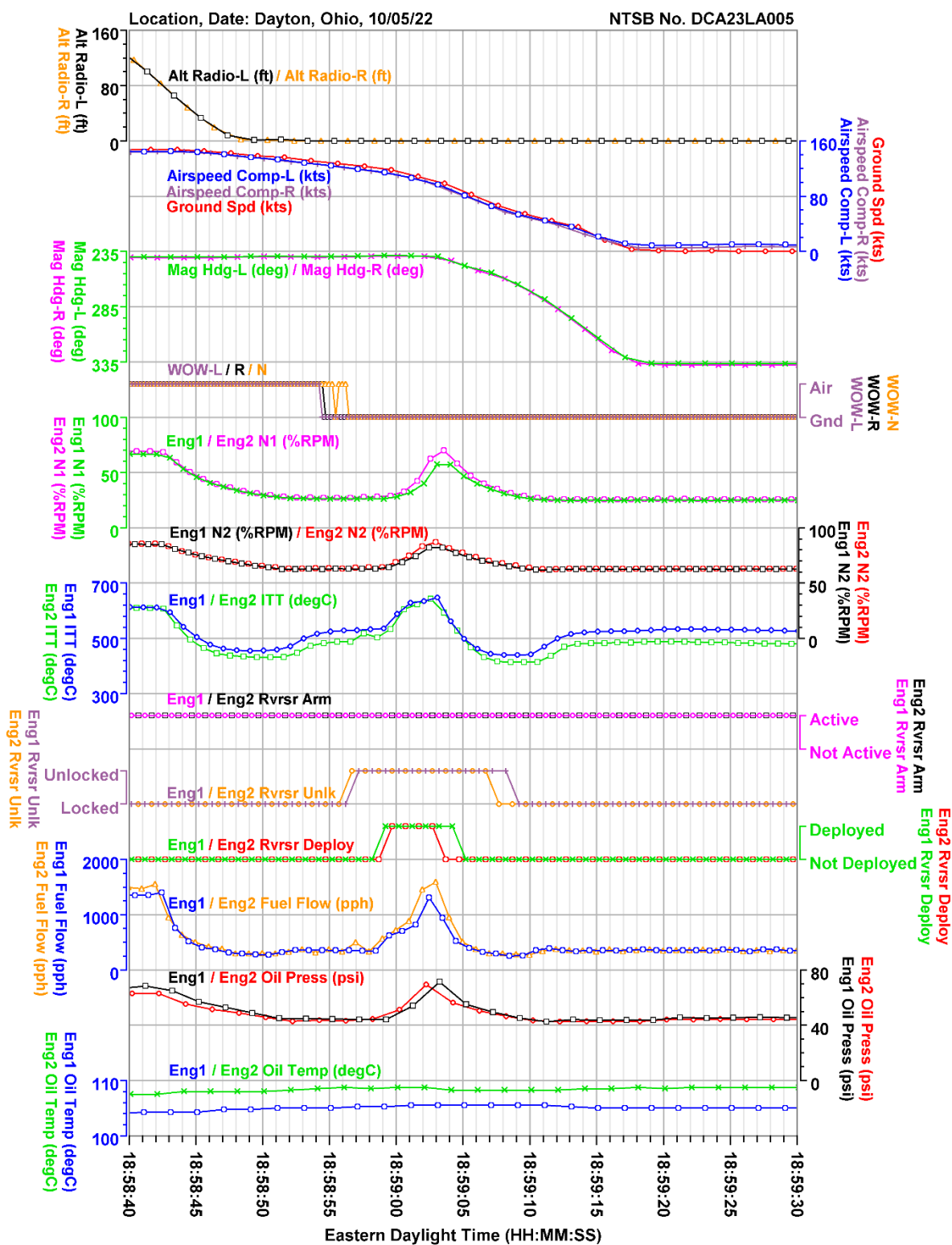


Figure 8. Time history plot of engine parameters during landing.

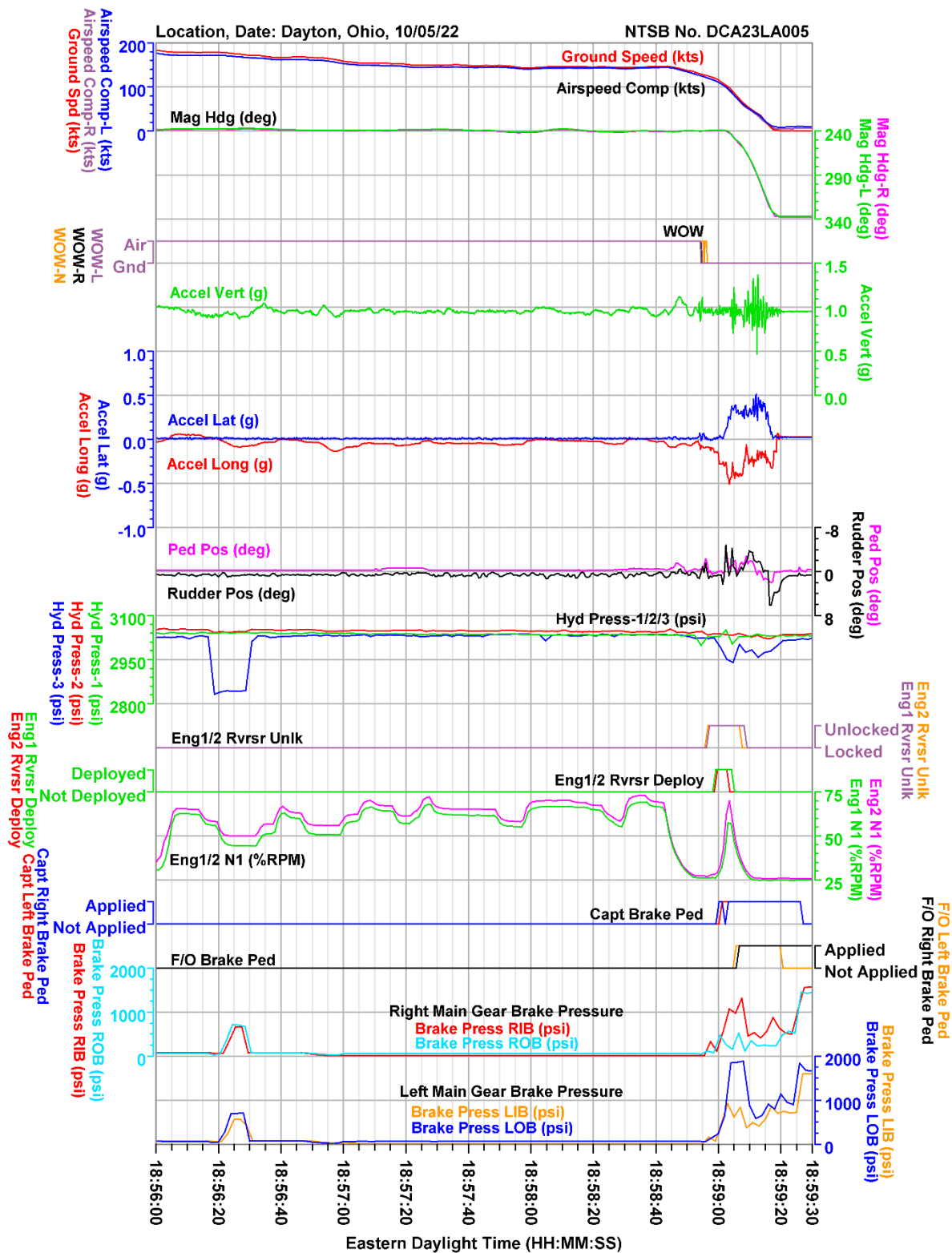


Figure 9. Time history plot of braking and hydraulic parameters during approach and landing.

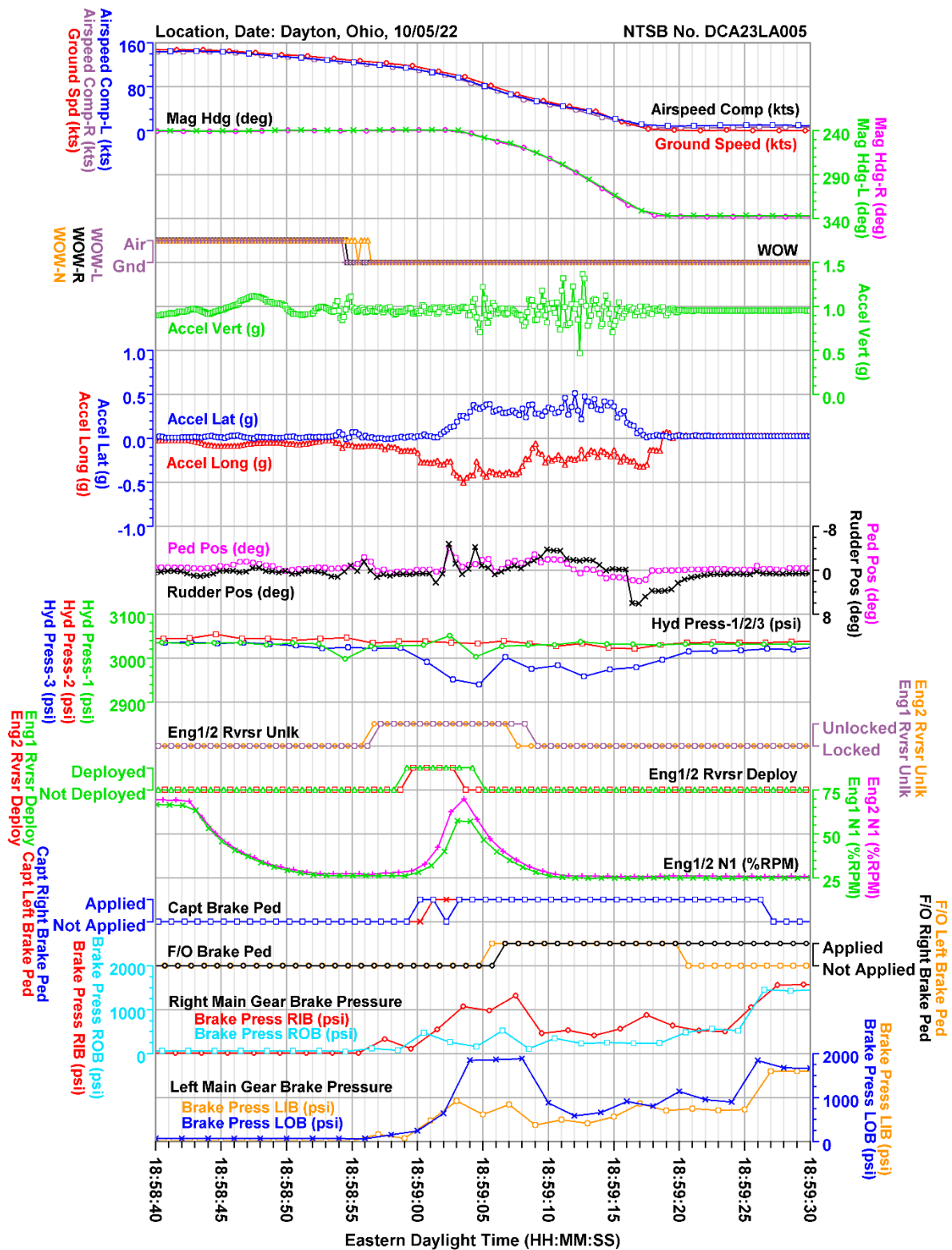


Figure 10. Time history plot of braking and hydraulic parameters during landing.

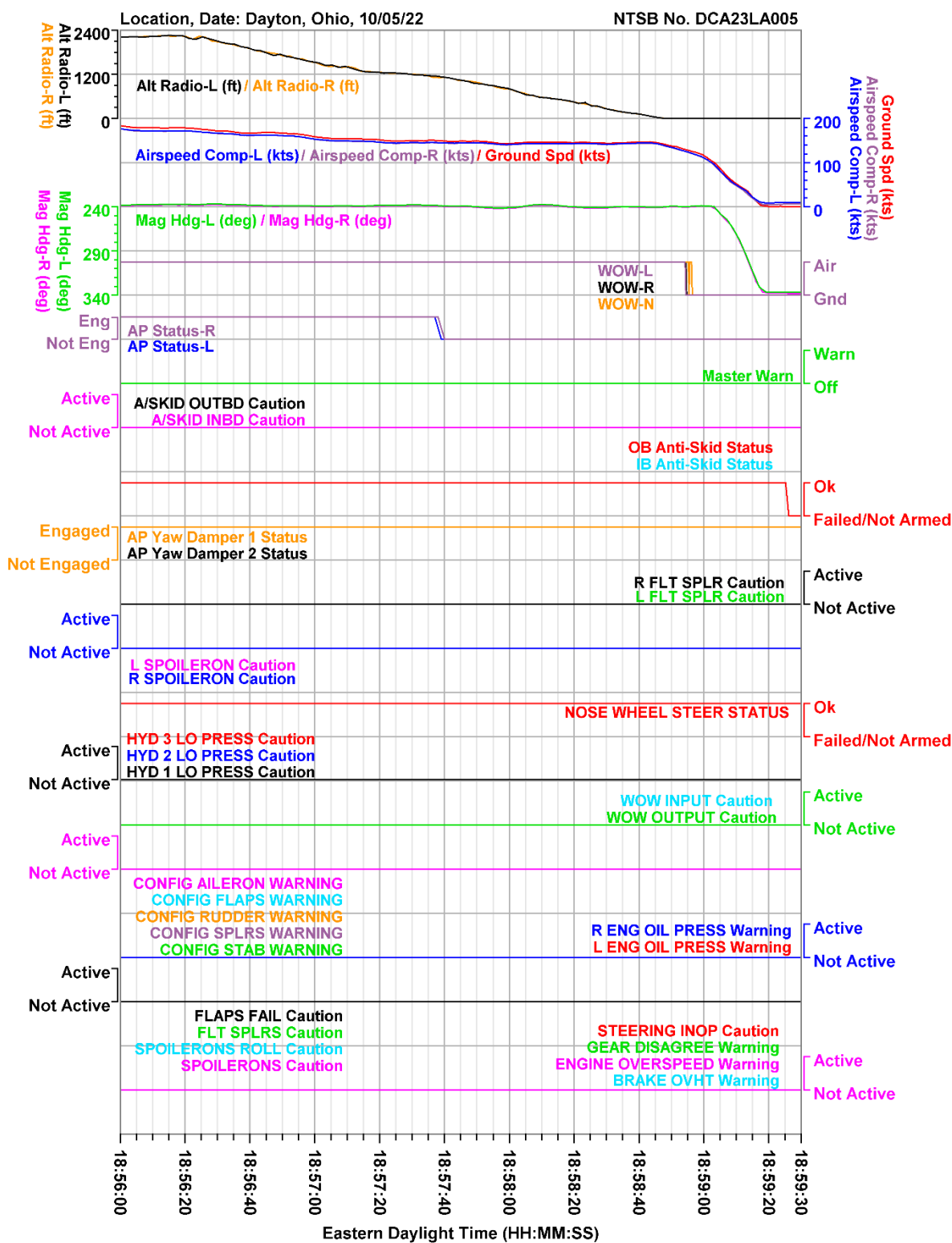


Figure 11. Time history plot of FDR warning and caution parameters for approach and landing.

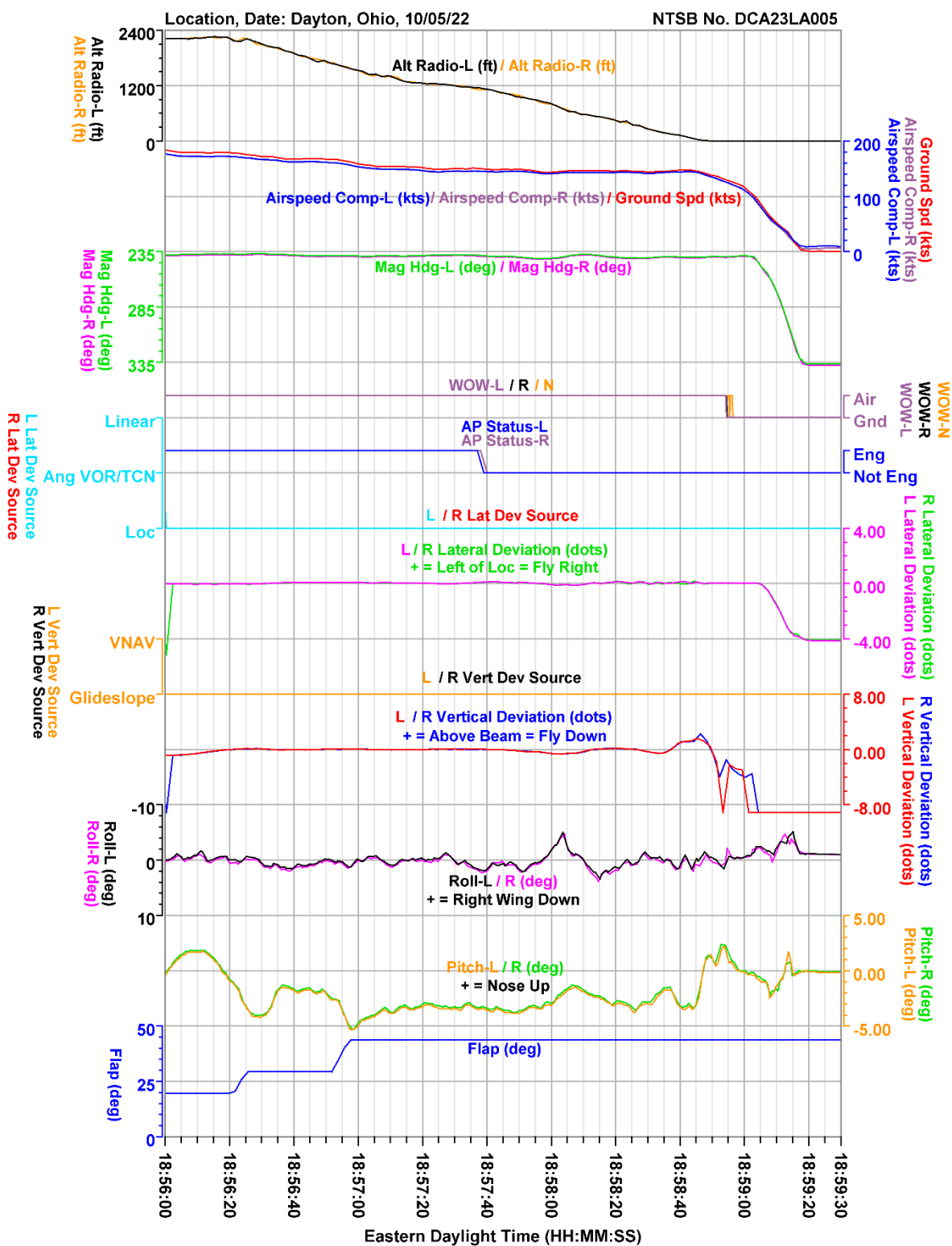


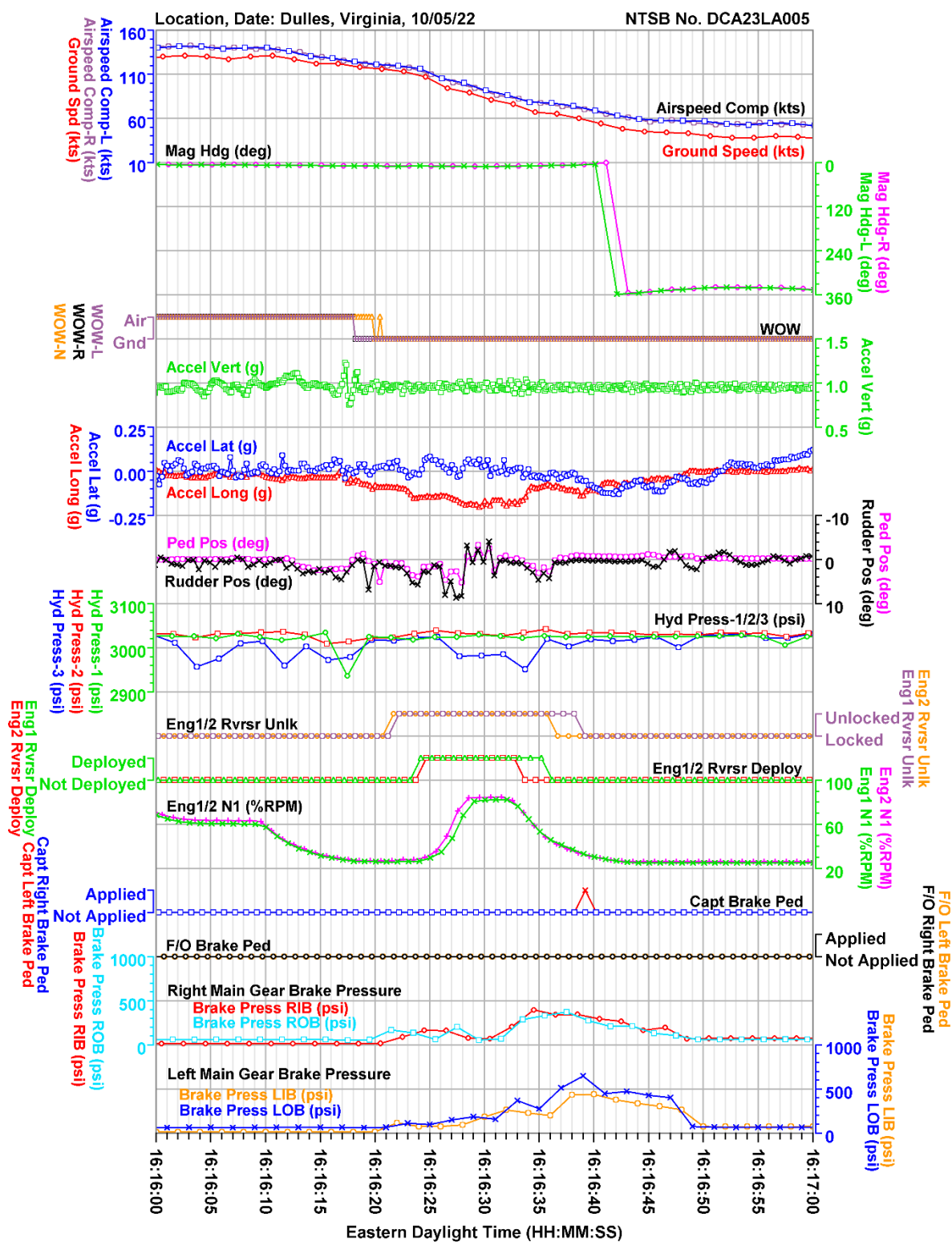
Figure 12. Time history plot displaying instrument approach and landing.



Figure 13. Google Earth overlay of the entire flight path from Dulles, Virginia to Dayton, Ohio.



Figure 14. Google Earth overlay of the landing rollout on runway 24.



Previous Landing 1: KIAD

Figure 15. Time history plot of previous landing 1 at KIAD.

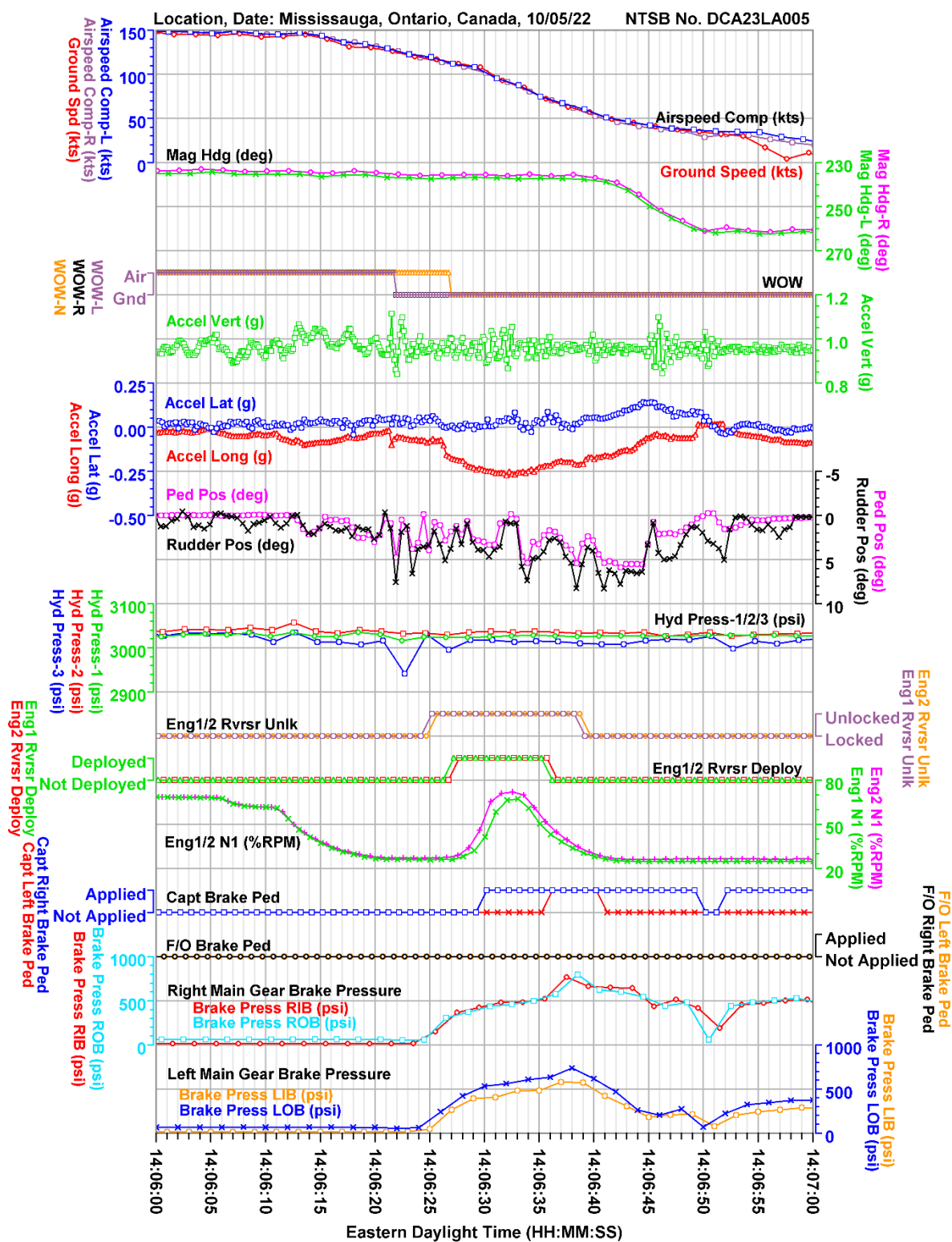
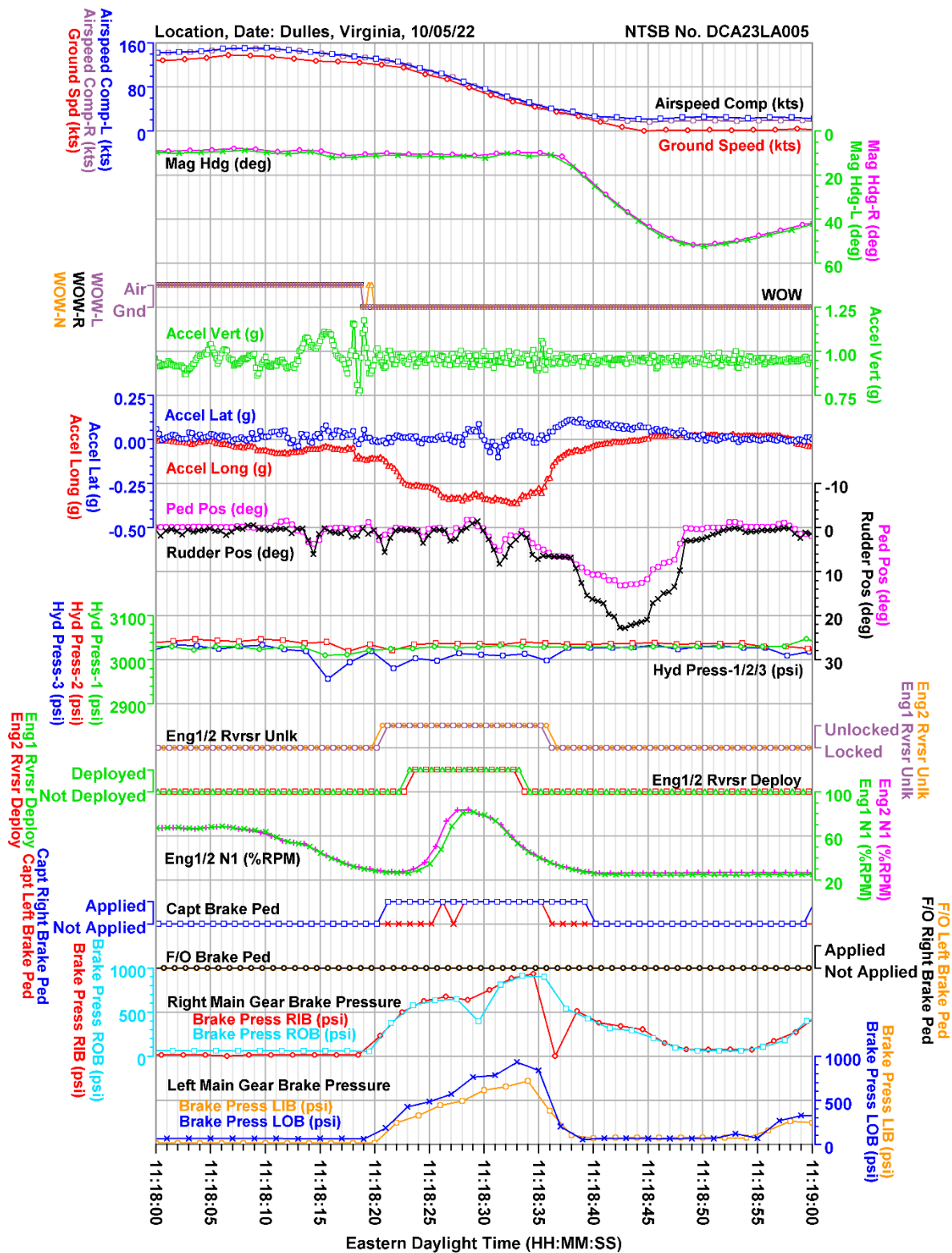


Figure 16. Time history plot of previous landing 2 at CYYZ.



Previous Landing 3: KIAD

Figure 17. Time history plot of previous landing 3 at KIAD.

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 Labels	Parameter Names	Units
A/SKID INBD Caution	Inboard Anti-Skid Caution Message	
A/SKID OUTBD Caution	Outboard Anti-Skid Caution Message	
Accel Lat	Lateral Load Factor	g
Accel Long	Longitudinal Load Factor	g
Accel Vert	Vertical Load Factor	g
Aileron-L	Left Aileron Position	deg
Aileron-R	Right Aileron Position	deg
Airspeed Comp-L	Computed Airspeed - Left	kts
Airspeed Comp-R	Computed Airspeed - Right	kts
Alt Press-L	Pressure Altitude - Left	ft
Alt Press-R	Pressure Altitude - Right	ft
Alt Rad-L	Radio Altitude - Left	ft
Alt Rad-R	Radio Altitude - Right	ft
AP Status-L	Autopilot Left Status	
AP Status-R	Autopilot Right Status	
AP Yaw Damper 1 Status	Yaw Damper 1 is Engaged	
AP Yaw Damper 2 Status	Yaw Damper 2 is Engaged	
BRAKE OVHT Warning	Brake Overheat Warning Message	
Brake Press LIB	Left Main Gear - Inboard Brake Pressure	psi
Brake Press LOB	Left Main Gear - Outboard Brake Pressure	psi
Brake Press RIB	Right Main Gear - Inboard Brake Pressure	psi
Brake Press ROB	Right Main Gear - Outboard Brake Pressure	psi
Capt Ctrl Col Force	Captain Control Column Force	lbs
Capt Ctrl Col Pos	Captain Control Column Position	deg
Capt Ctrl Wheel Force	Captain Control Wheel Force	lbs
Capt Ctrl Wheel Pos	Captain Control Wheel Position	deg
Capt Left Brake Ped	Captain Left Brake Pedal	
Capt Left Rud Ped Force	Captain Left Rudder Pedal Force	lbs
Capt Right Brake Ped	Captain Right Brake Pedal	
Capt Right Rud Ped Force	Captain Right Rudder Pedal Force	lbs
CONFIG AILERON WARNING	Aileron Configuration Warning Message	
CONFIG FLAPS WARNING	Flap Configuration Warning Message	
CONFIG RUDDER WARNING	Rudder Configuration Warning Message	
CONFIG SPLRS WARNING	Spoiler Configuration Warning Message	
CONFIG STAB WARNING	Horizontal Stabilizer Configuration Warning Message	
Elevator-L	Left Elevator Position	deg
Elevator-R	Right Elevator Position	deg
Eng1 Fuel Flow	Engine 1 Fuel Flow	pph
Eng1 ITT	Engine 1 Inter-Turbine Temperature	degC
Eng1 N1	Engine 1 Fan Speed	%RPM

Plot/Table Labels	Parameter Names	Units
Eng1 N2	Engine 1 Core Speed	%RPM
Eng1 Oil Press	Engine 1 Oil Pressure	psi
Eng1 Oil Temp	Engine 1 Oil Temperature	degC
Eng1 Rvrsr Arm	Engine 1 Reverser Armed	
Eng1 Rvrsr Deploy	Engine 1 Reverser Deployed	
Eng1 Rvrsr Unlk	Engine 1 Reverser Unlocked	
Eng2 Fuel Flow	Engine 2 Fuel Flow	pph
Eng2 ITT	Engine 2 Inter-Turbine Temperature	degC
Eng2 N1	Engine 2 Fan Speed	%RPM
Eng2 N2	Engine 2 Core Speed	%RPM
Eng2 Oil Press	Engine 2 Oil Pressure	psi
Eng2 Oil Temp	Engine 2 Oil Temperature	degC
Eng2 Rvrsr Arm	Engine 2 Reverser Armed	
Eng2 Rvrsr Deploy	Engine 2 Reverser Deployed	
Eng2 Rvrsr Unlk	Engine 2 Reverser Unlocked	
ENGINE OVERSPEED WARNING	Engine Overspeed Warning Message	
F/O Ctrl Col Pos	First Officer Control Column Position	deg
F/O Ctrl Col Force	First Officer Control Column Force	lbs
F/O Ctrl Wheel Pos	First Officer Control Wheel Position	deg
F/O Ctrl Wheel Force	First Officer Control Wheel Force	lbs
F/O Left Brake Ped	First Officer Left Brake Pedal	
F/O Left Rud Ped Force	First Officer Left Rudder Pedal Force	lbs
F/O Right Brake Ped	First Officer Right Brake Pedal	
F/O Right Rud Ped Force	First Officer Right Rudder Pedal Force	lbs
Flap	Flap Surface Position	deg
FLAPS FAIL Caution	Flap Failure Caution Message	
FLT SPLRS Caution	Flight Spoiler Caution Message	
GEAR DISAGREE Warning	Gear Disagree Warning Message	
Gear Dn+Lckd-L	Left Landing Gear Down and Locked	
Gear Dn+Lckd-N	Nose Landing Gear Down and Locked	
Gear Dn+Lckd-R	Right Landing Gear Down and Locked	
Gear Up+Lckd-L	Left Landing Gear Up and Locked	
Gear Up+Lckd-N	Nose Landing Gear Up and Locked	
Gear Up+Lckd-R	Right Landing Gear Up and Locked	
GLD Auto Arm	Ground Lift Dump is automatically armed	
GLD Manual Arm	Ground Lift Dump is manually armed	
GLD Manual Disarm	Ground Lift Dump is inhibited (no automatic deployment).	
GND Spoiler-LIB	Ground Spoiler - Left Inboard	
GND Spoiler-LOB	Ground Spoiler - Left Outboard	
GND Spoiler-RIB	Ground Spoiler - Right Inboard	
GND Spoiler-ROB	Ground Spoiler - Right Outboard	
Ground Spd	Ground Speed	kts
HYD 1 LO PRESS Caution	Hydraulic 1 Low Pressure Caution Message	
HYD 2 LO PRESS Caution	Hydraulic 2 Low Pressure Caution Message	
HYD 3 LO PRESS Caution	Hydraulic 3 Low Pressure Caution Message	
Hyd Press-1	Hydraulic System Number 1 Pressure	psi
Hyd Press-2	Hydraulic System Number 2 Pressure	psi
Hyd Press-3	Hydraulic System Number 3 Pressure	psi
IB Anti-Skid Status	Anti-Skid Status for Inboard Brake System	

Plot/Table Labels	Parameter Names	Units
Latitude	Latitude Coordinate	deg
L ENG OIL PRESS Warning	Engine 1 Oil Pressure Warning Message	
L FLT SPLR Caution	Left Flight Spoiler Caution Message	
L Lat Dev Source	Left Lateral Deviation Source	
L Lateral Deviation	Left Lateral Deviation	dots
L SPOILERON Caution	Left Spoileron Caution Message	
L Spoileron Pos	Left Spoileron Position	deg
L Vert Dev Source	Left Vertical Deviation Source	
L Vertical Deviation	Left Vertical Deviation	dots
Longitude	Longitude Coordinate	deg
Mag Hdg-L	Magnetic Heading - Left	deg
Mag Hdg-R	Magnetic Heading - Right	deg
Master Warn	Master Warning	
Nose Wheel Steer Status	Nose Wheel Steering Status	
OB Anti-Skid Status	Anti-Skid Status for Outboard Brake System	
Ped Pos	Rudder Pedal Position	deg
Pitch - L	Pitch Angle - Left	deg
Pitch - R	Pitch Angle - Right	deg
R ENG OIL PRESS Warning	Engine 2 Oil Pressure Warning Message	
R FLT SPLR Caution	Right Flight Spoiler Caution Message	
R Lat Dev Source	Right Lateral Deviation Source	
R Lateral Deviation	Right Lateral Deviation	dots
R SPOILERON Caution	Right Spoileron Caution Message	
R Spoileron Pos	Right Spoileron Position	deg
R Vert Dev Source	Right Vertical Deviation Source	
R Vertical Deviation	Right Vertical Deviation	dots
Roll-L	Roll Angle - Left	deg
Roll-R	Roll Angle - Right	deg
Rudder Pos	Rudder Position	deg
SPOILERONS Caution	Spoilerons Caution Message	
SPOILERONS ROLL Caution	Spoileron Roll Caution Message	
Stabilizer	Stabilizer Position	deg
STEERING INOP Caution	Steering In-operational Caution Message	
Time UTC-Hr	Coordinated Universal Time Hour	hrs
Time UTC-Min	Coordinated Universal Time Minutes	min
Time UTC-Sec	Coordinated Universal Time Seconds	sec
WOW-L	Left Main Landing Gear Weight on Wheels	
WOW-N	Nose Gear Weight on Wheels	
WOW-R	Right Main Landing Gear Weight on Wheels	
WOW INPUT Caution	WOW Input Caution Message	
WOW OUTPUT Caution	WOW Output Caution Message	

Note: This FDR records pressure altitude, which is based on a standard altimeter setting of 29.92 inches of mercury (inHg). The pressure altitude information presented in the FDR plots and in the electronic data have not been corrected for the local altimeter setting at the time of the event.

Note: Parameters with a blank unit description in table 2 are discrettes. 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.

Unit and Discrete State Abbreviations	Descriptions
%RPM	percent revolutions per minute
deg	degrees
degC	degrees Celsius
dots	dots of deviation
Dwn+Lck	Down and Locked
Eng	Engaged
ft	feet
g	unit of gravitation acceleration
hrs	hours
in	inches
kts	knots
lbs	pounds
min	minutes
pph	pounds per hour
psi	pounds per square inch
sec	seconds
Up+Lck	Up and Locked
WOW	Weight on Wheels