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ERA24FA110

FLIGHT DATA RECORDER

Group Chair's Factual Report

June 11, 2025

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A. ACCIDENT

Location: Naples, Florida
Date: February 9, 2024
Time: 1517 eastern standard time (EST)
Airplane: Bombardier CL-600-2B16, Hop-A-Jet, N823KD

B. FLIGHT DATA RECORDER GROUP

Group Chair	Charles Cates Mechanical Engineer/Recorder Specialist National Transportation Safety Board (NTSB)
Group Member	Andrew Field Air Safety Investigator Bombardier Aviation
Group Member	Martin Nava CF34 SPOCT leader GE Aerospace
Group Member	Patrick Lusch Air and Space Accident Investigator Federal Aviation Administration (FAA)
Group Member	Michael Torrent Aviation Safety Inspector FAA

C. FEDERAL CARRIAGE REQUIREMENTS

The event aircraft, N823KD, was operating under Title 14 *Code of Federal Regulations* (CFR) Part 135. The event aircraft was manufactured in 2004 and was operating such that it was required to be equipped with a flight data recorder (FDR) that recorded, at a minimum, 57 parameters, as cited in 14 CFR Part 135.152.

D. DETAILS OF THE INVESTIGATION

An FDR group was convened on March 6, 2024. The NTSB Vehicle Recorder Division received the following FDR:

Recorder Manufacturer/Model: L3 FA2100
Part Number: 2100-4043-00
Recorder Serial Number: 01505

1.0 L3 FA2100 Description

The L3 FA2100 records airplane flight information in a digital format using solid-state flash memory as the recording medium. The FA2100 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 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 (for example, altitude, heading, and airspeed) has a specifically assigned word number within the subframe. The FA2100 is designed to meet the crash-survivability requirements of TSO-C124b.

1.1 Recorder Condition

The recorder was hand-carried to the NTSB's vehicle recorder laboratory. The recorder had a coating of soot on the exterior, but inspections showed that it was otherwise undamaged. The data were extracted normally from the recorder.



Figure 1. Exterior of flight data recorder exhibiting sooting.

1.2 Recording Description

The FDR recording contained more than 150 hours of data, spanning 56 flights including the accident flight. 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 2 hours

and 20 minutes. The parameters evaluated for the purpose of this report appeared to be in accordance with federal FDR carriage requirements. Throttle lever position was a desired parameter to review in this accident, but CFR Part 135.152 Appendix D lists throttle lever position as a recommended parameter, not a required parameter. Additionally, no parameters related to the autothrottle system (ATS) were recorded by the FDR. The ATS is independent of the aircraft autopilot system.

1.3 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 3 lists the FDR parameters verified and provided in this report. Table 4 describes the unit and discrete state abbreviations used in this report.

1.4 Time Correlation

Correlation of the FDR data from SRN to the event local time, eastern standard time (EST), was established by using the recorded Greenwich mean time (GMT) Hours, GMT Minutes, and GMT Seconds and then applying an additional 5 hours offset to change GMT to EST.²

Accordingly, the time offset for the event flight data from SRN to EST is the following: EST = SRN - 493,785.9. Therefore, for the rest of this report, all times are referenced as EST, not SRN. However, previous landings are referenced as SRN, not local time.

E. FIGURES AND TABULAR DATA

2.0 Event Flight Data

Figures 2 to 10 contain FDR data recorded during the event on February 9, 2024. All the parameters listed in table 1 are plotted except GMT Hours, GMT Minutes, and GMT Seconds.

Figures 2, 4, 6, and 8 cover the entire flight from 12:52 EST to 15:12 EST. Figures 3, 5, 7, and 10 cover the final 3.5 minutes of the recording. Figure 9 is a detail of the engine starts prior to the accident flight. These figures are configured such that

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 GMT is Greenwich mean time which is also known as coordinated universal time (UTC).

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 showed the following:

- Engine 2 was started for the accident flight at 12:54 EST. Peak ITT was 605 degrees C. Engine 1 was started for the accident flight at 12:55 EST. Peak ITT was 603 degrees C. Both engines had similar start characteristics and were well matched in time to light, time to idle, fuel flow, ITT, and shaft speeds. Idle N2 was 62.9% on both engines and idle fuel flow varied from 340-380 pounds per hour (pph) on both engines.
- The aircraft departed Ohio State University Airport (OSU), Columbus Ohio, at 13:02 EST with about 4,300 lbs of fuel in each tank. The flight to Naples Municipal Airport proceeded to the south and cruised at FL400 and then FL390 for about an hour.
- During the flight, the steady-state and transient behavior of the two engines were well matched. During the descent, the engines were operated at power settings from idle to mid-power based on the recorded N1 and N2 of the engines.
- At 15:07:25 EST, the aircraft leveled at about 1785 ft pressure altitude and 200 knots with the left side autopilot engaged.
- At 15:07:30 EST, the selected airspeed reduced to 180 knots. Engine power reduced in both engines in response to the command and the aircraft began to decelerate.
- At 15:07:48 EST, the selected airspeed reduced to 168 knots. Engine power for both engines reduced in response to the command and the aircraft continued to decelerate.
- At 15:08:00 EST, the selected airspeed was reduced to 160 knots. At 15:08:04, the flaps were selected to 30 degrees and the gear was selected down two seconds later. Engine power increased as the 160-knot airspeed target was captured. All the engine ignitors transitioned from "not active" to "active" after the gear was selected down.

- The aircraft entered a left turn followed by a right turn. Engine power for both engines stayed steady until the aircraft rolled out of the turn and began to accelerate. Power decreased as the aircraft speed increased above the 160-knot target.
- At 15:09:14, both engines began a decrease in power similar in rate to the previous power decreases.
- At 15:09:18, the autopilot was disengaged. Both engines were still decelerating to idle power.
- At 15:09:21, both engines reached the lowest N2 point in their commanded decelerations of 62.8%/63.3% (engine 1/engine 2). During the deceleration, fuel flow briefly dropped below idle rates. The manufacturer of the fuel control system confirmed during consultation with the group this is normal transient behavior consistent with commanding and capturing idle power.
- At 15:09:22, N2 increased to 65.0%/64.6% consistent with the throttle command increasing. Following that point, at 15:09:23, N2 rolled back on both engines and decreased to a sub-idle state, and ITT increased for the rest of the recording. This behavior is consistent with both engine compressors operating in an unrecoverable rotating stall. The airplane began to decelerate immediately as engine power was lost. Flaps were selected to 45 and the selected airspeed changed to 140 knots.
- At 15:09:33, the number one engine oil pressure warning was recorded, followed by the number two engine oil pressure warning at 15:09:34. Airspeed had reduced to less than 130 kts. Pitch was commanded down, and the aircraft began to descend at a rate more than 1,500 feet per minute (fpm).
- An engine warning was recorded at 15:09:40, consistent with engine ITT exceeding the redline of 889 degrees C.
- Starting at 15:09:50, engine fuel flow recorded values for both engines became intermittent. The engine manufacturer reported that the flowmeter does not report fuel flow values less than 200 pph.

- Stick shaker activation was recorded for two seconds at 15:10:21, at an altitude and airspeed of 490 feet and 112.5 kts. The aircraft's pitch reduced following the stick shaker activation.
- The aircraft touched down at 15:10:47 at about 110 kts in a 15-degree left bank and with about 1.5 degrees of nose up pitch.

2.1 Historical Flight Data Review

In addition to data recorded during the event flight, engine data was also reviewed spanning all 56 flights recorded by the FDR. The purpose of the review was for the FDR group to compare the event engine data to the recorded historical engine data and to the operation during the event. Specifically, the operation of the engine was characterized during aircraft descents during both steady state and transient engine maneuvers like those on the event flight. Also, the engines were compared to data recorded during engine starts.

2.1.1 Core Deceleration and Fuel Flow Engine Signatures

A study was undertaken by the FDR group to determine whether the engine operation prior to the event was typical or atypical in terms of engine core speed deceleration and fuel flow. This study indicated whether an engine was operating on its assigned schedules or if it had experienced some anomaly in its fuel control or combustion. To study this, the fuel flow profile during engine transient decelerations to idle power was of interest in the historical data, particularly engine idle Bodie maneuvers³ occurring during the final approach phase of flight.

To search for similar signatures, the engine core deceleration (N2dot) was calculated across the full dataset, and a search was done to find other instances of the N2dot present in the accident event recording. The peak calculated N2dot in the accident recording, in the maneuver immediately prior to the engine event was -3.8 %rpm/sec. The search list was refined based on the flight conditions and Total Air Temperature (TAT), which are the inputs to the engine's fuel control. A list of about 65 candidate events with similar conditions were found in the historic data, with peak N2dot in those cases ranging from -3.8 %rpm/sec to -4.8 %rpm/sec. This showed that the deceleration rate seen in the accident flight was in family with previous decelerations, and the event was not consistent with a fuel cutoff event, combustor blowout, or engine flameout event.

³ An idle Bodie maneuver is a transient engine maneuver where the throttle is rapidly reduced to idle power and then snapped back to a higher-power setting when the engine has reached idle power. It is typically an engine operability pinch point characterized by reduced operability margins due to the decelerating inertial energy state and high residual heat of the compressor.

The 65 events, and their associated conditions were further refined to four events on previous flights that matched the accident event data particularly well for comparison. The four conditions were identified as the following:

Condition 1, from January 1, 2024, matched initial and final conditions of the deceleration. The data was consistent with a snap to idle power with the engines capturing idle in about the same amount of time as the accident flight and continuing to run at idle power.

Condition 2, from January 3, 2024, was representative of another snap to idle power. The engines decelerated slightly faster than the accident flight with a higher peak N2dot and captured idle power, continuing to run at idle power without issue.

Condition 3, from January 8, 2024, was consistent with a Bodie maneuver. The engines ran down slightly faster than the accident flight and did not fully reach idle speed before advancing in power, successfully demonstrating a partial Bodie.

Condition 4, from January 21, 2024, was 5.5 degrees C cooler in TAT had two similar decelerations, a Bodie at -3.9 %rpm/sec followed by a deceleration to idle capture at -4 %rpm/sec. In both cases the engine responded to commands. ITT was slightly lower, likely due to the lower TAT

Each of the four matched events were time-aligned with the accident data and plotted together. See table 1 for key points from each of the four events, and figures 11-18 for plots showing the time aligned conditions.

Condition	SRN Range	Flight Date	TAT (deg C)	Peak N2dot (%rpm/sec)	Figures
1	8355-8575	01-Jan-24	22.5	-3.8	11, 12
2	91182-91402	03-Jan-24	23.0	-4.0	13, 14
3	148873-149093	08-Jan-24	23.0	-4.0	15, 16
4	285520-285740	21-Jan-24	16.25	-4.0	17, 18
Accident	548219-548440	09-Feb-24	21.75	-3.8	n/a

Table 1. Conditions matched to event flight data.

Of the matched deceleration events, three had a higher peak N2dot and one was the same as the accident flight at -3.8 %rpm/sec. Three were within 1.5 degrees C in TAT, and one was 5.5 degrees C colder than the accident TAT.

One final check that was made was to compare the data from an engine deceleration on final descent from the first flight on the recording to the accident data. Figure 19 is a plot of the engine fuel flow plotted against N2 for both engines on the first flight of the recording and the accident flight. The profile did not change across the dataset, and both engines followed the same control curve to capture idle.

In conclusion, from the review of the full FDR dataset, performance differences that would have explained the anomalous engine behavior were unable to be detected over time in the dataset. Any differences manifesting over the 150 hours of data captured by the recorder were too subtle to be shown in this data review.

2.2 Comparison of Event Data to Engine Hung Start Data

On January 15, 2024, which was 25 days prior to the accident, a series of hung engine starts⁴ were recorded by the FDR. There were ten hung starts in total between the two engines, with one successful start on engine 1 occurring during these start attempts. See figure 20 for a plot of fuel flow versus N2⁵ for the hung starts overlaid with the engine rollbacks from the accident flight. See table 2 for a list of the hung start attempts on January 15 and parameters taken from the FDR data.

⁴ A hung start, also known as a hot start or stagnated start, is defined as a start attempt that experiences a light off but does not then successfully continue to a self-sustaining idle speed before engine ITT exceeds the start redline. Hung starts may be caused by a variety of factors including weak starter performance, premature starter deactivation, a degraded or damaged compressor, incorrect scheduling of bleeds or compressor variable geometry, or bad fuel.

⁵ Fuel flow is metered to the combustor as a function of N2, TAT, and flight condition, including in the sub-idle/start regime.

Time	Engine	ITT at first motoring	N2 at WF intro	ITT at WF intro	Fuel Flow at Light Off	Peak N2	Peak ITT	Motoring time	Time to light	Run to cutoff time	Plot Label
GMT	1/2	deg C	%	deg C	pph	%	deg C	sec	sec	sec	
20:33:34	2	220	31.8	101	272	47.5	719	19	0	16	Eng2Start1
20:34:34	1	213	32.5	149	256	47.8	748	14	0	20	Eng1Start1
20:35:45	2	152	28.6	91	328	45	684	11	1	11	Eng2Start2
20:38:44	2	163	30.9	81	312	48.1	713	14	1	18	Eng2Start3
20:39:59	1	197	34.4	89	264	61.1	701	16	0	16	Eng1Start2
20:42:39	2	197	32	83	276	48.1	711	18	1	16	Eng2Start4
20:50:12	2	192	33.4	89	268	48.6	728	16	0	22	Eng2Start5
20:51:13	1	188	31.8	102	256	66	632	14	1	n/a	Eng1Start3
20:53:27	2	211	29.9	97	284	48.9	740	13	0	23	Eng2Start6
20:56:15	2	218	34.8	93	324	60.6	728	14	0	16	Eng2Start7
20:58:58	2	214	30.8	94	272	48	697	15	0	14	Eng2Start8

Table 2. Tabular summary of hung starts recorded by the FDR on January 15, 2024.

Figure 21 is a plot of the hung starts from January 15, 2024. There were a total of three start attempts on engine 1 and eight start attempts on engine 2. Of the eleven total start attempts, eight resulted in fully stagnated starts, where the engine reached a sub-idle peak N2 value but could not continue pulling away to idle without exceeding the start redline of 700 degrees C.

One start attempt, engine 1 start 3, resulted in a successful start. On figure 20, the idle capture can be seen as the pink stars at around 64% N2, which is a stable idle point for the engine.

Two start attempts, engine 1 start 2 and engine 2 start 7, resulted in N2 rollbacks where the engine nearly reached a stable idle speed before N2 began to decrease as ITT increased. Of note, the fuel flow profile of the N2 rollback portion of these two cases followed a similar curve to the N2 rollback portion of the accident flight.

In the hung starts, the engines started out at a higher residual heat state from having been run for a few minutes prior to the start. The initial ITT at starter engagement of these starts ranged from 152-220 degrees C, however, ITT decreased as the engines motored during the start attempt. Motoring time ranged from 13-19 seconds, and N2 reached 30-32.5% prior to fuel introduction. At fuel introduction, ITT ranged from 83-149 degrees C.

In conclusion from the hung start comparison study, the engines fuel and ITT behavior during the event flight was consistent with the behavior of the engines during the hung start rollbacks.

The corresponding tabular data used to create figures 2 to 21, including GMT Hours, GMT Minutes, GMT Seconds, Latitude, and Longitude, are provided in electronic comma-separated value (CSV) format as attachment 1 to this report.

Submitted by:

Charles Cates
Mechanical Engineer/Recorder Specialist

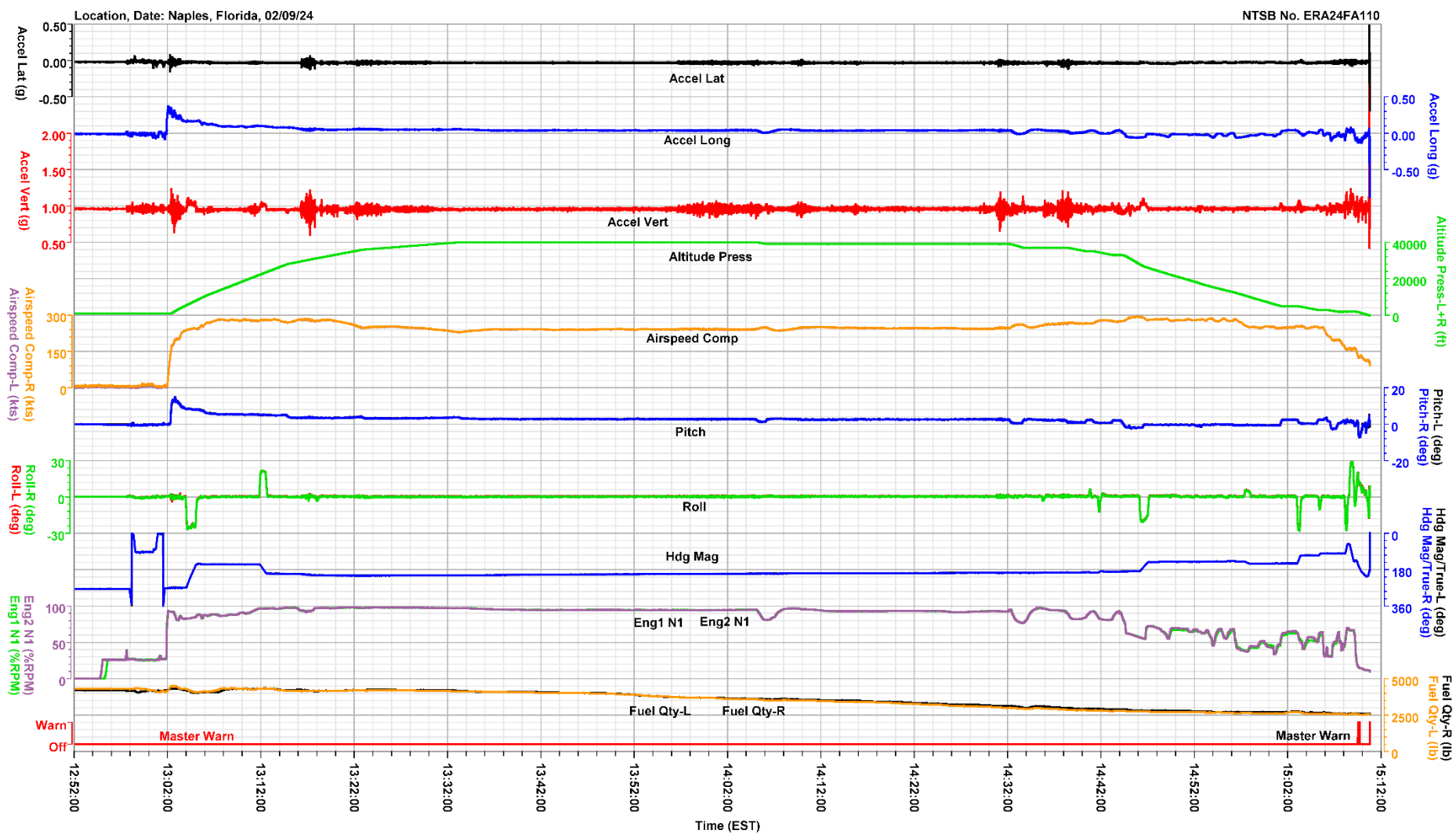


Figure 2. Plot of basic parameters for full duration of flight.

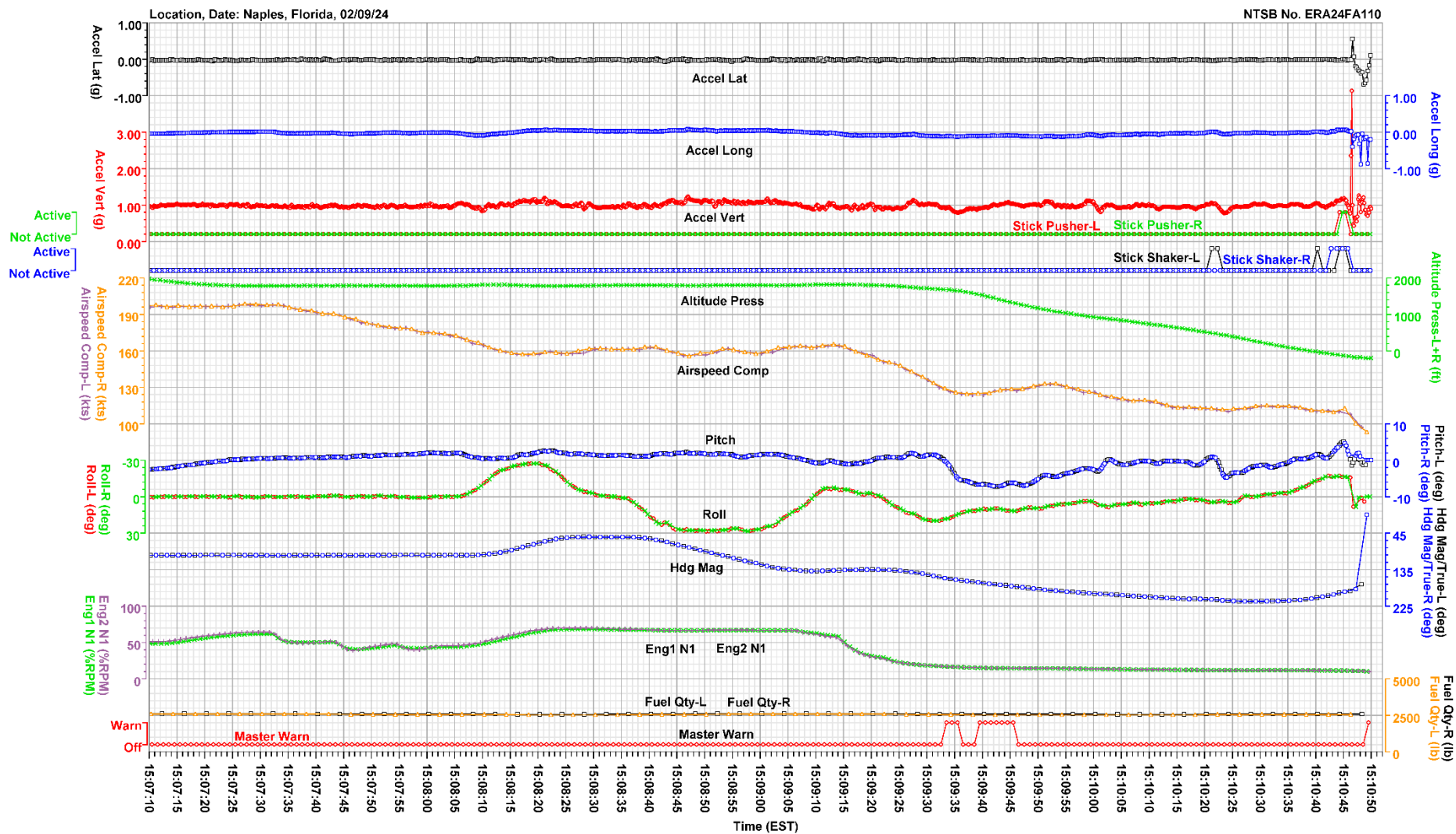


Figure 3. Basic parameters from final 3.5 minutes of recording.

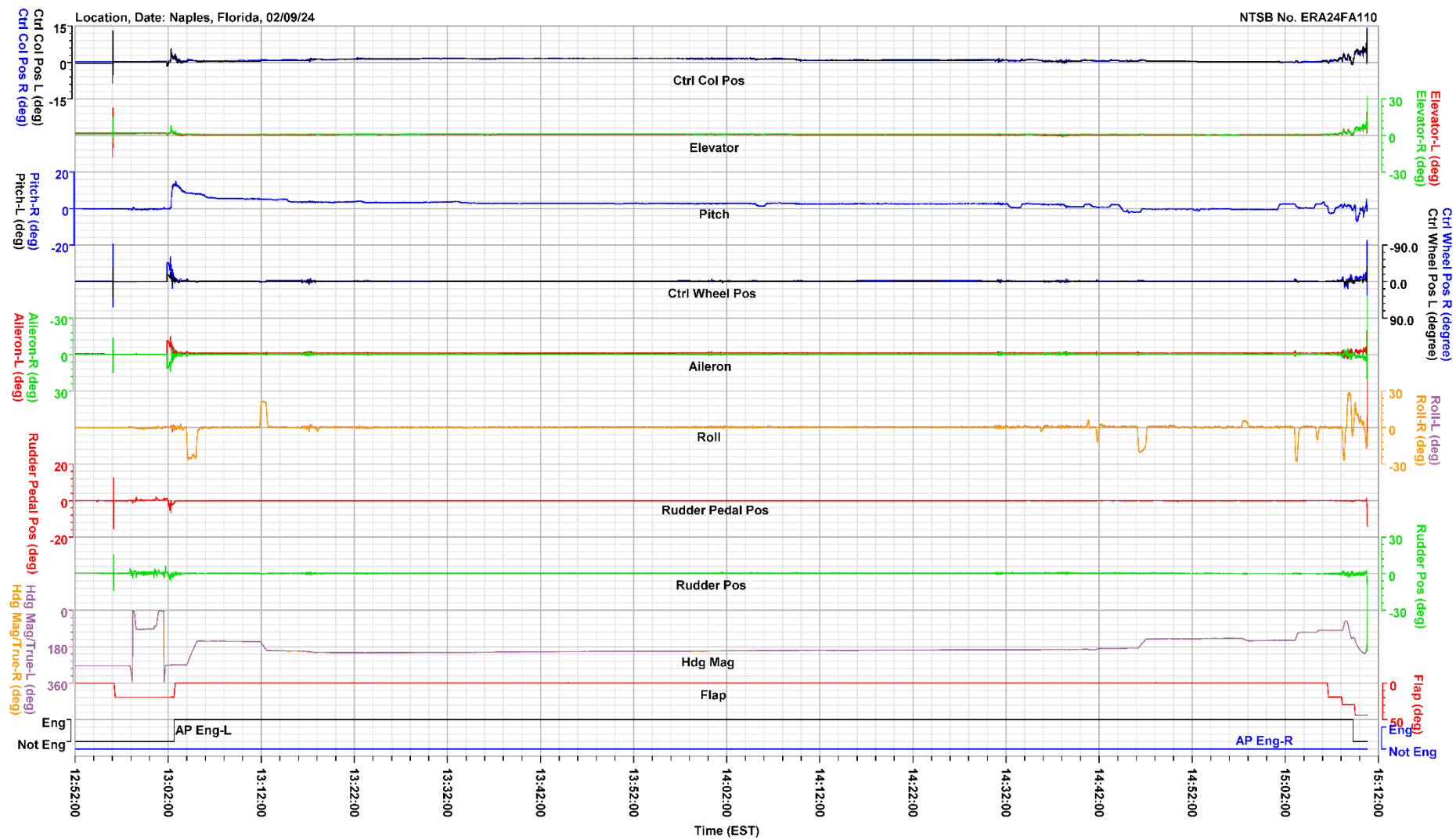


Figure 4. Plot of flight control and surface positions from full accident flight recording.

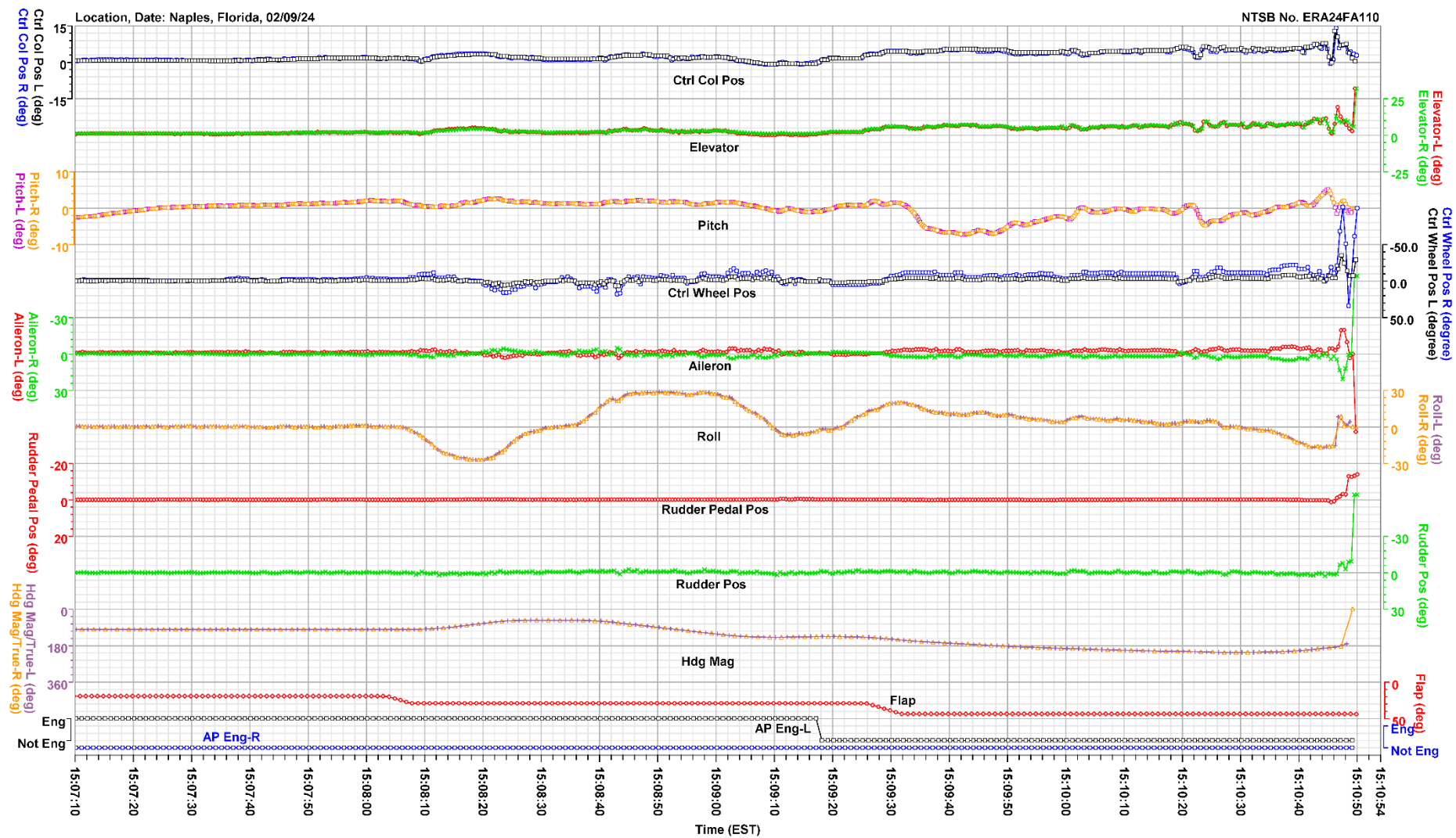


Figure 5. Plot of flight control and surface positions for final 3.5 minutes of recording.

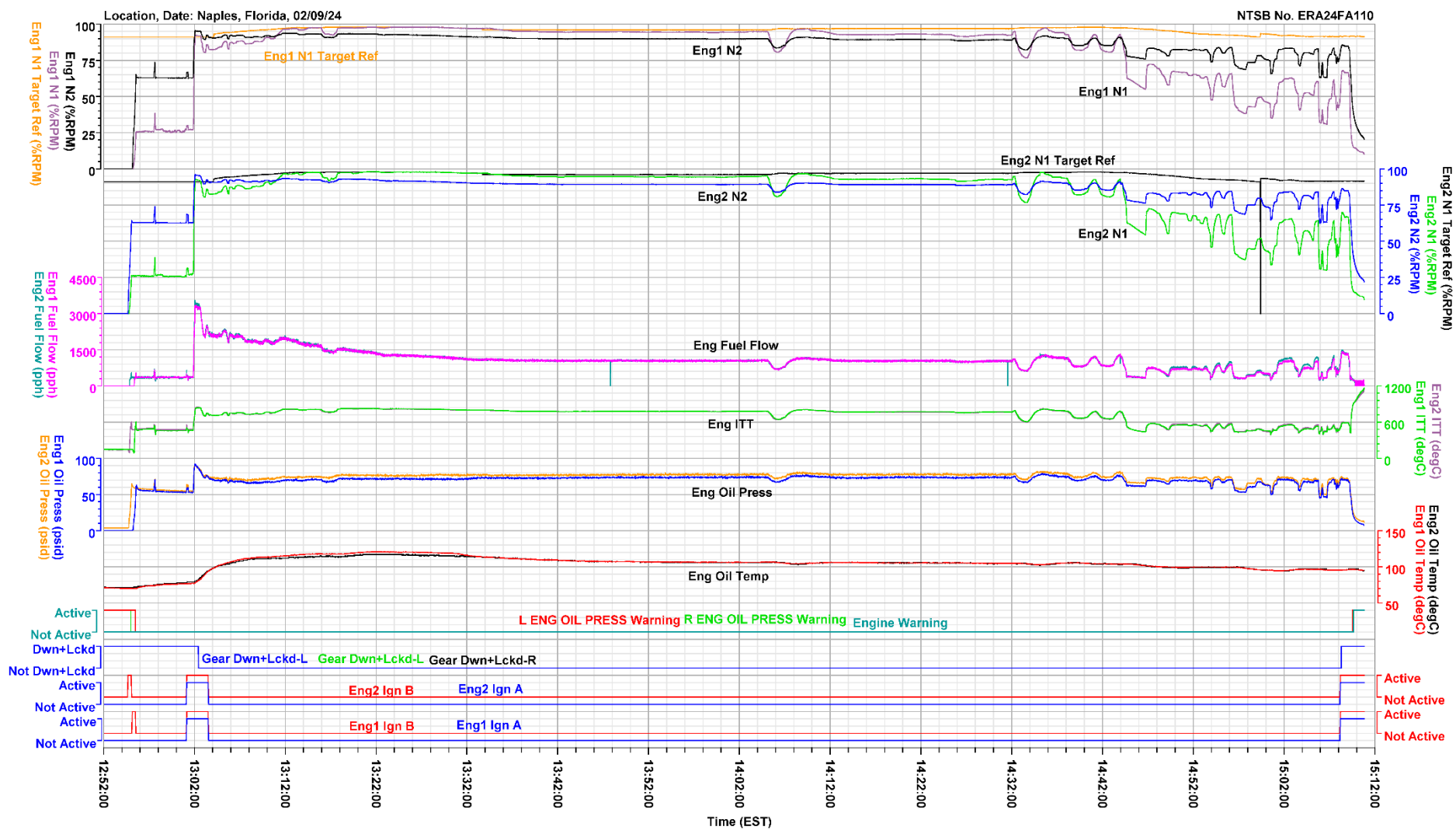


Figure 6. Plot of engine parameters from full accident flight recording.

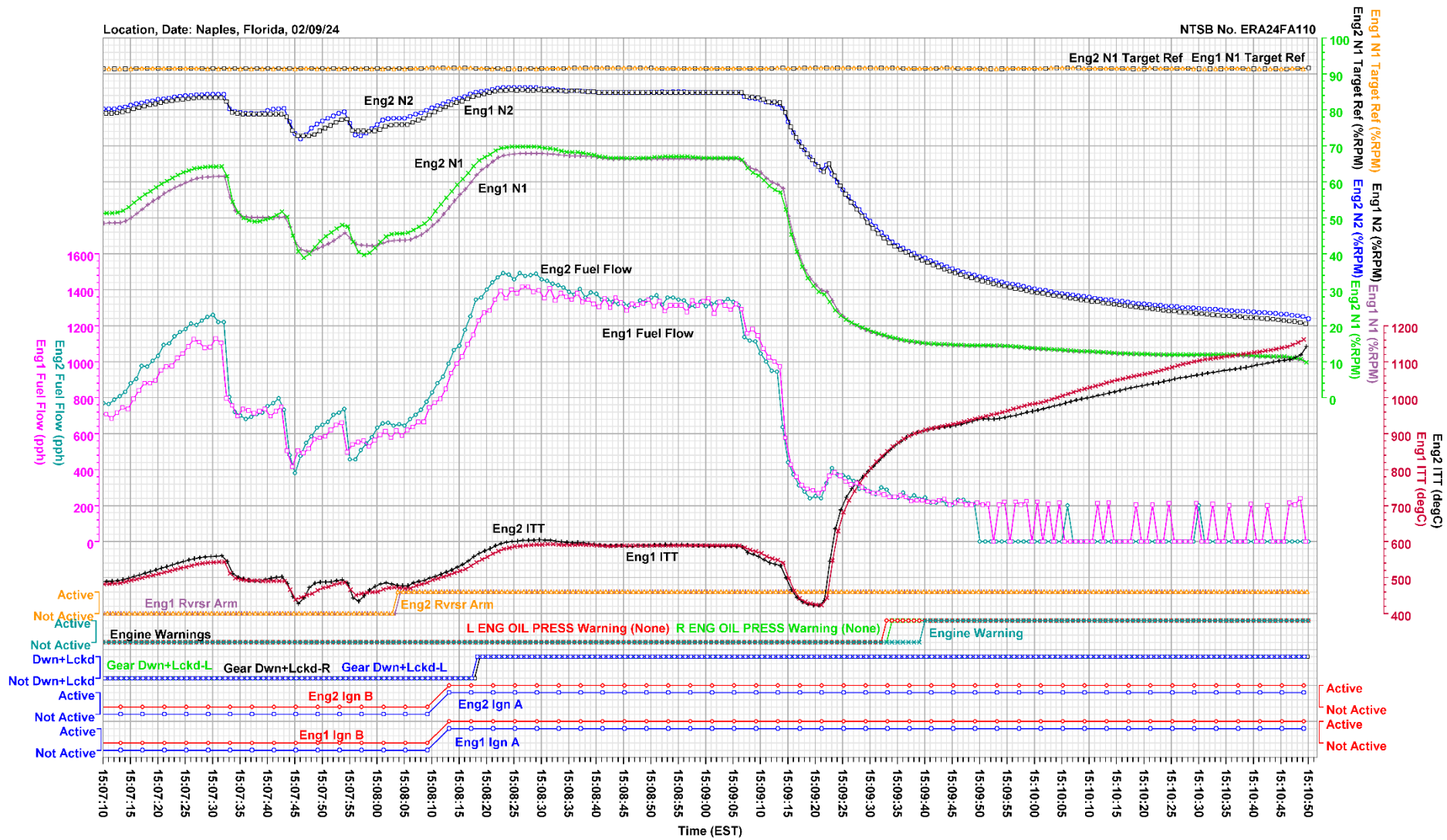


Figure 7. Plot of engine parameters from final 3.5 minutes of recording.

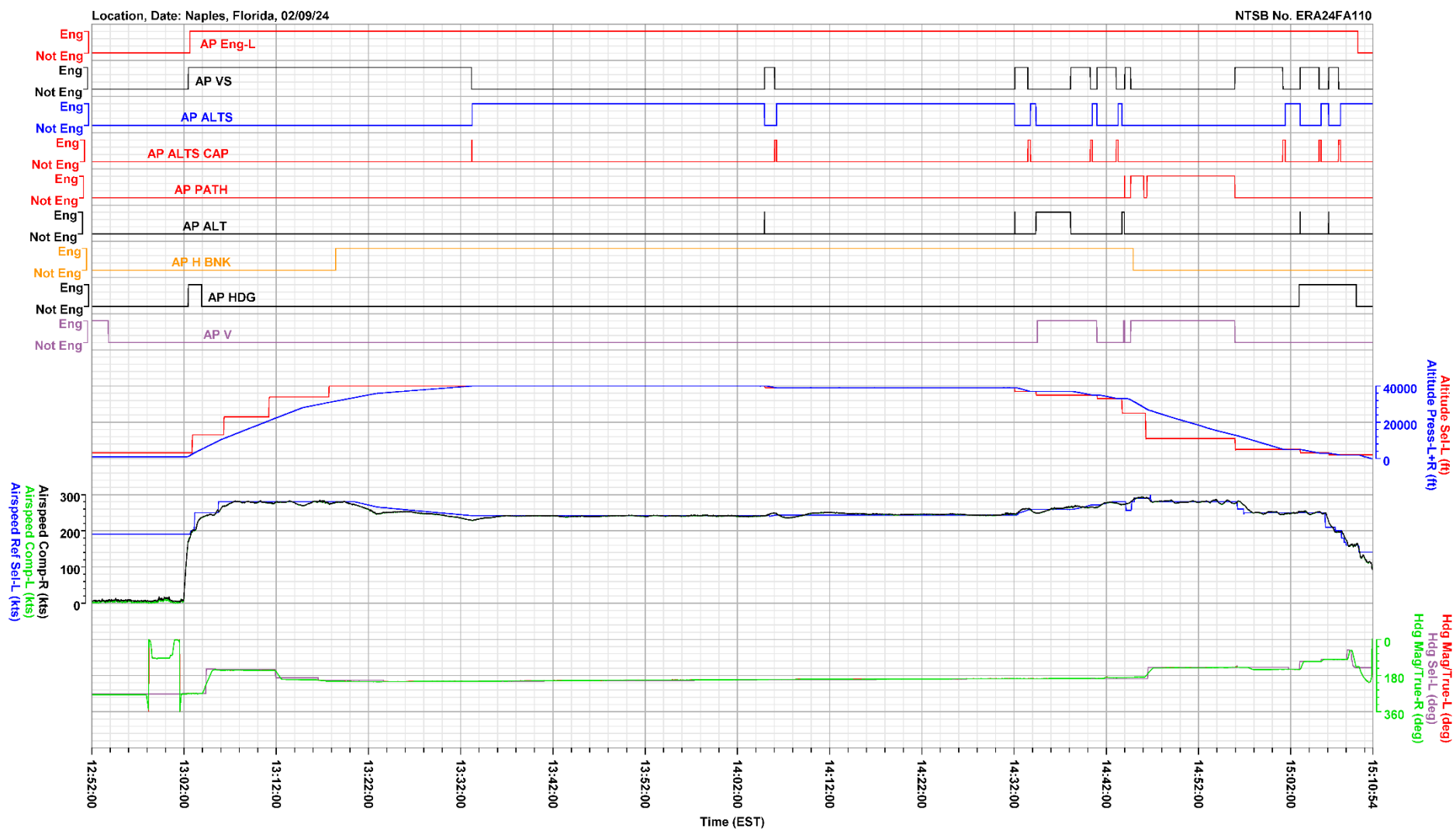


Figure 8. Plot of automation parameters from full accident flight recording.

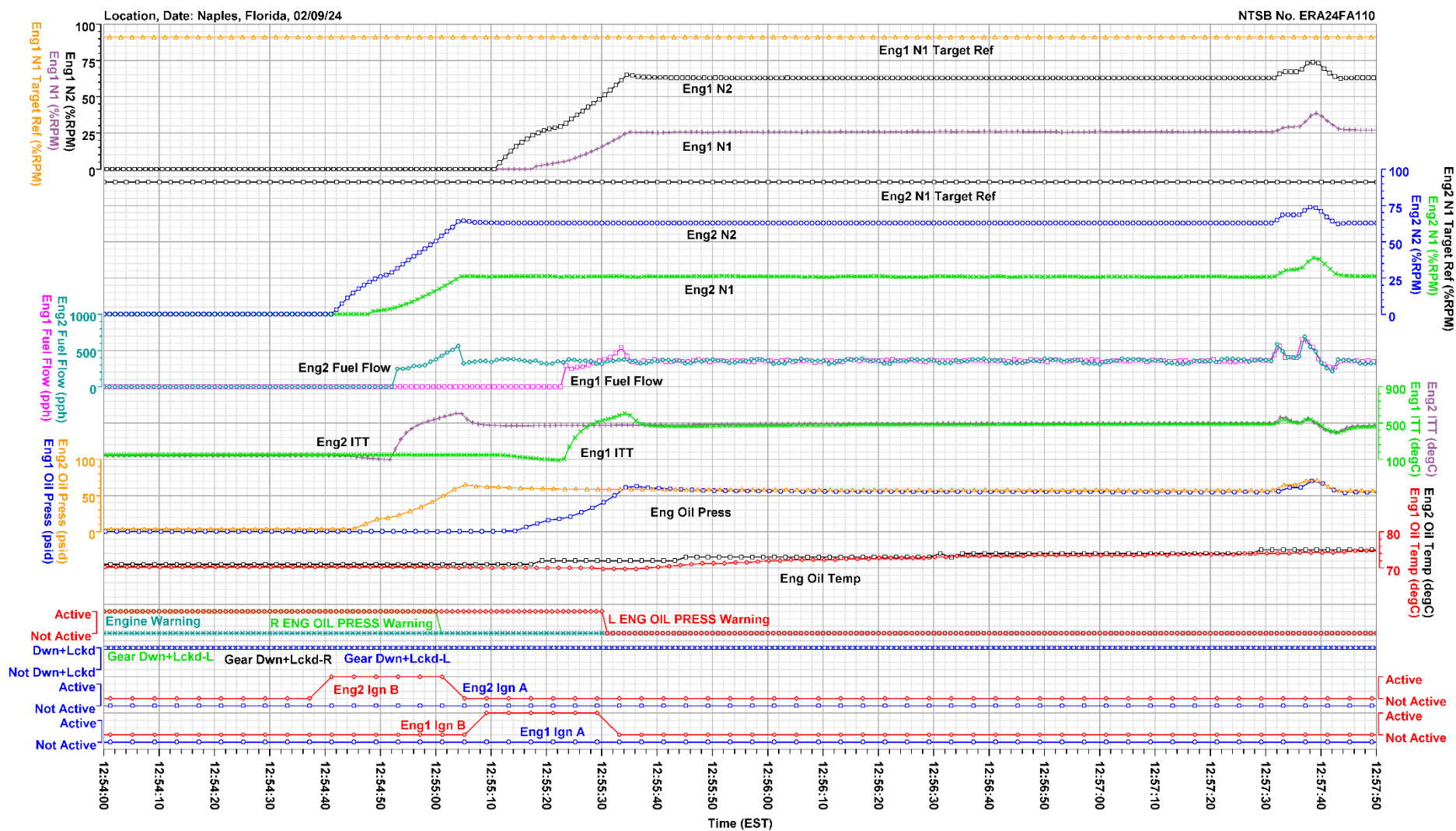


Figure 9. Plot of engine starts.



Figure 10. Map overlay of final 3.5 minutes of the FDR recording with FDR events annotated.

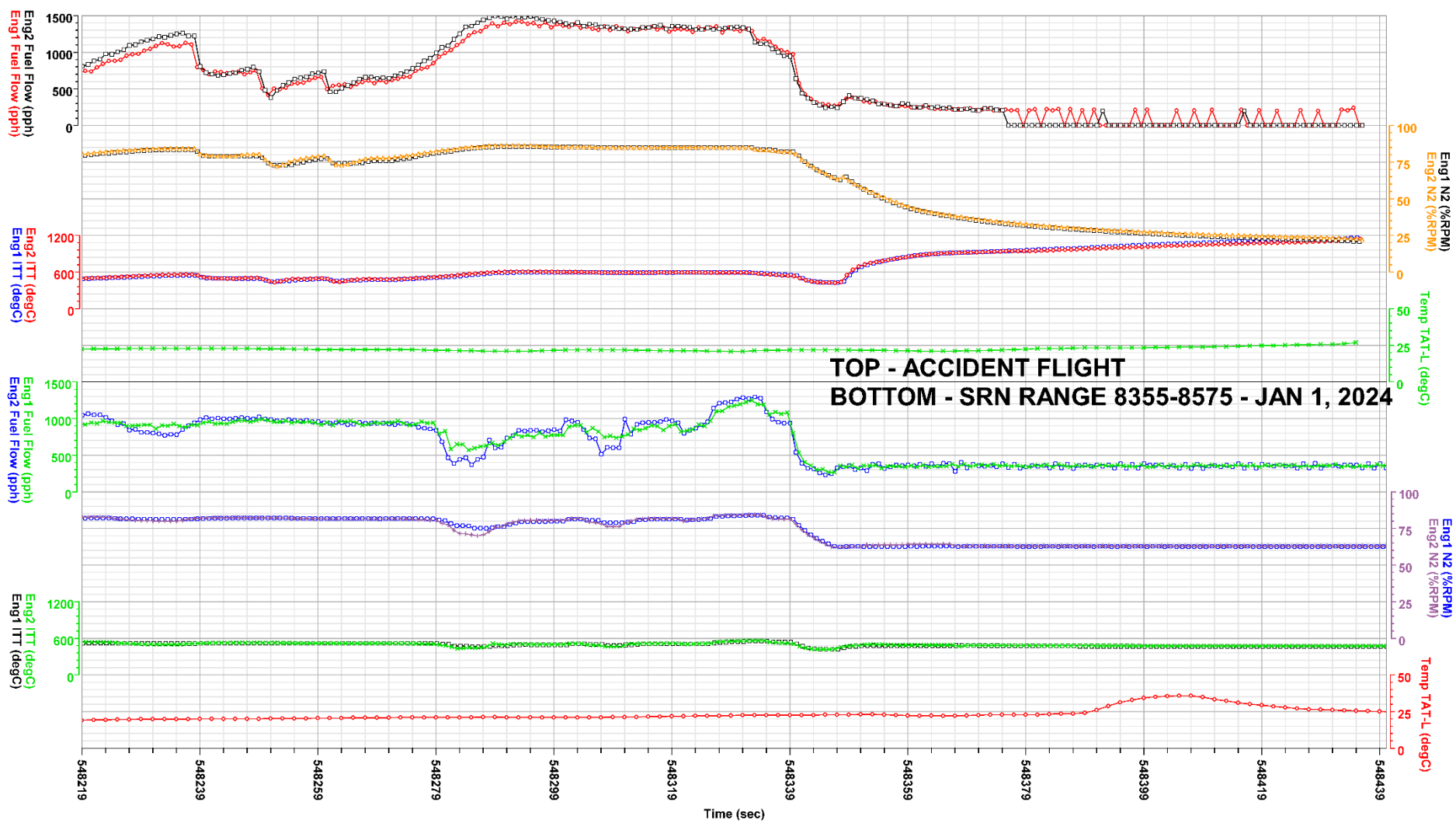


Figure 11. Matched deceleration 1.

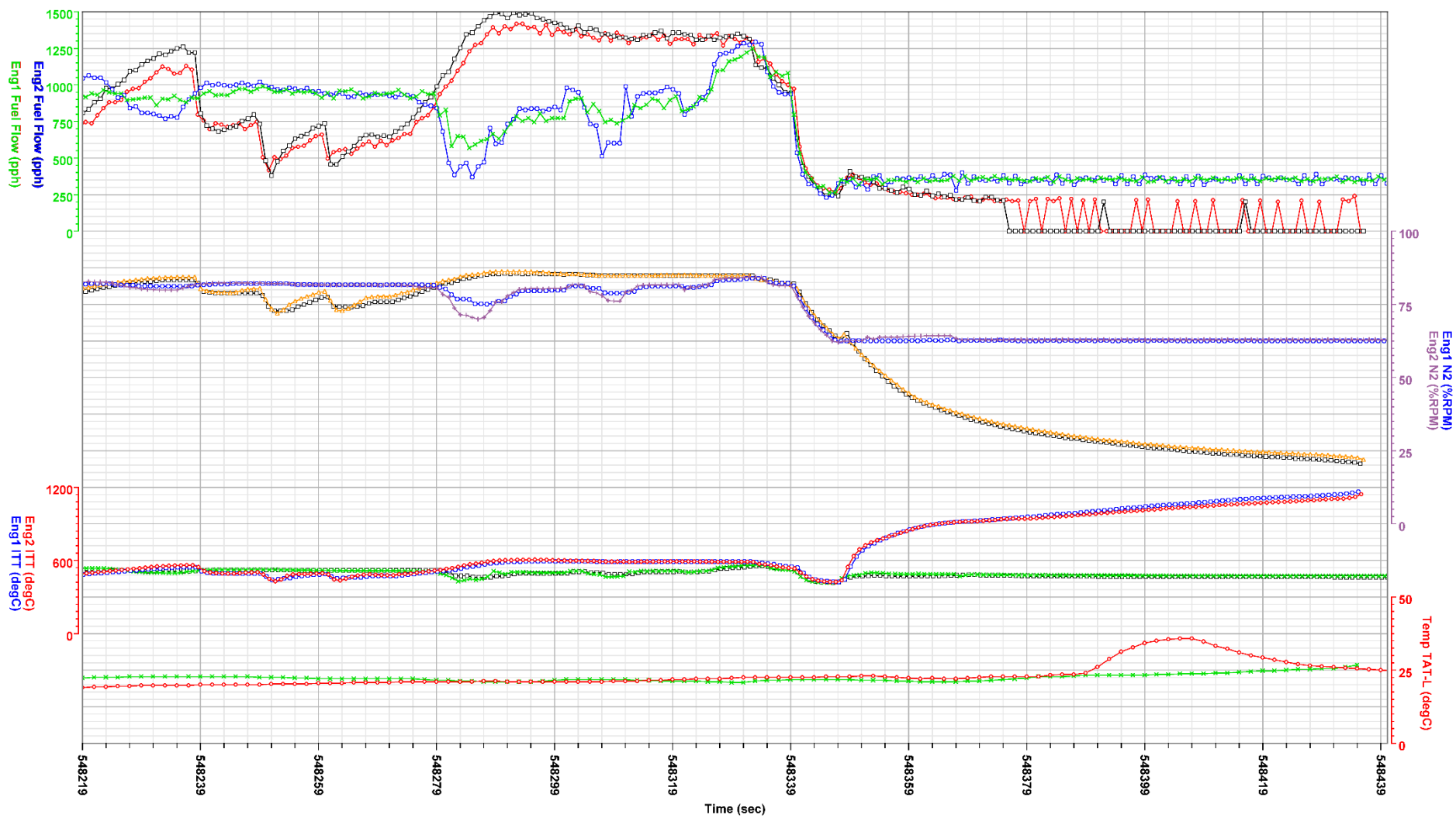


Figure 12. Matched deceleration 1 overlaid on accident flight.

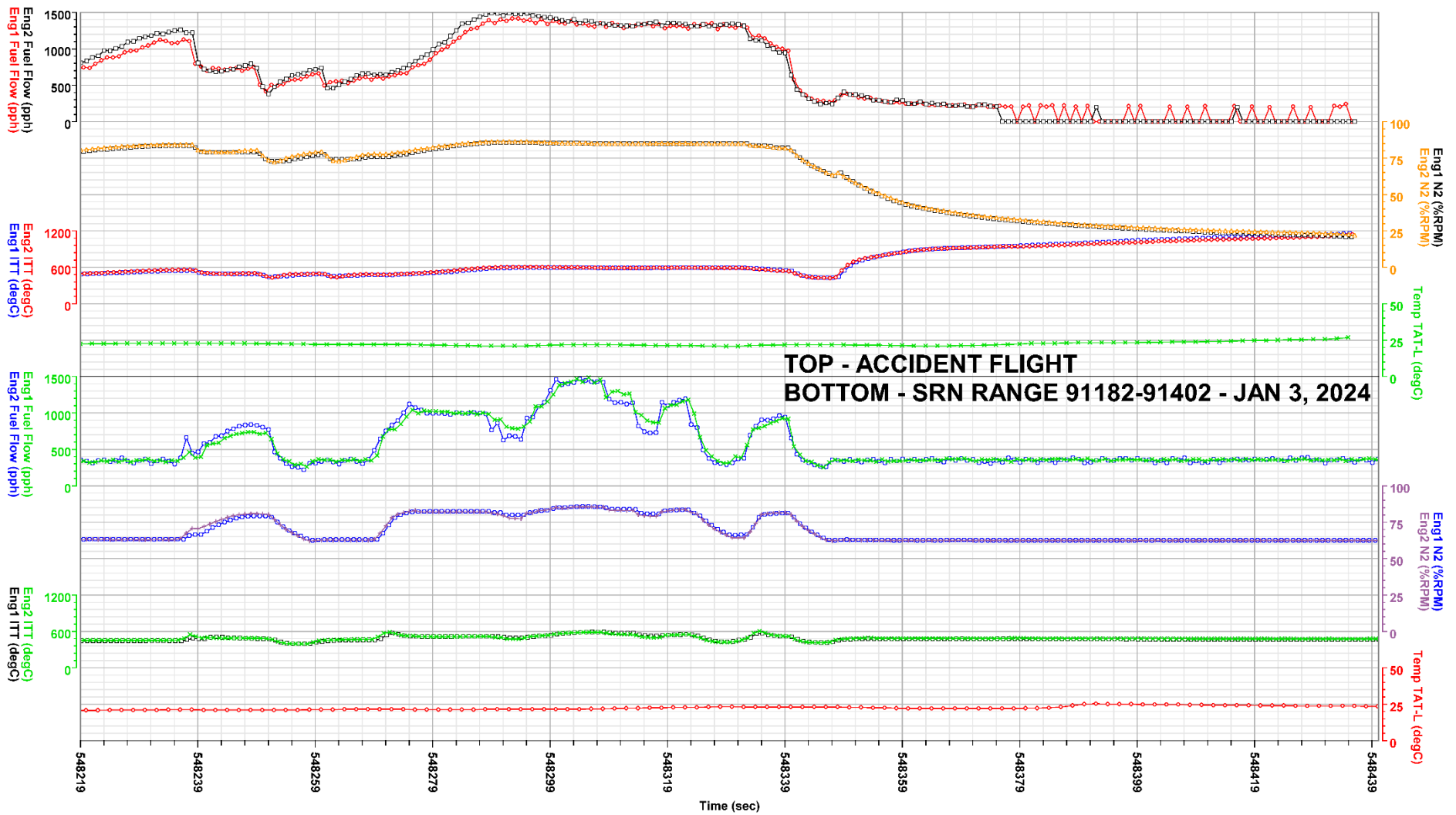


Figure 13. Matched deceleration 2.

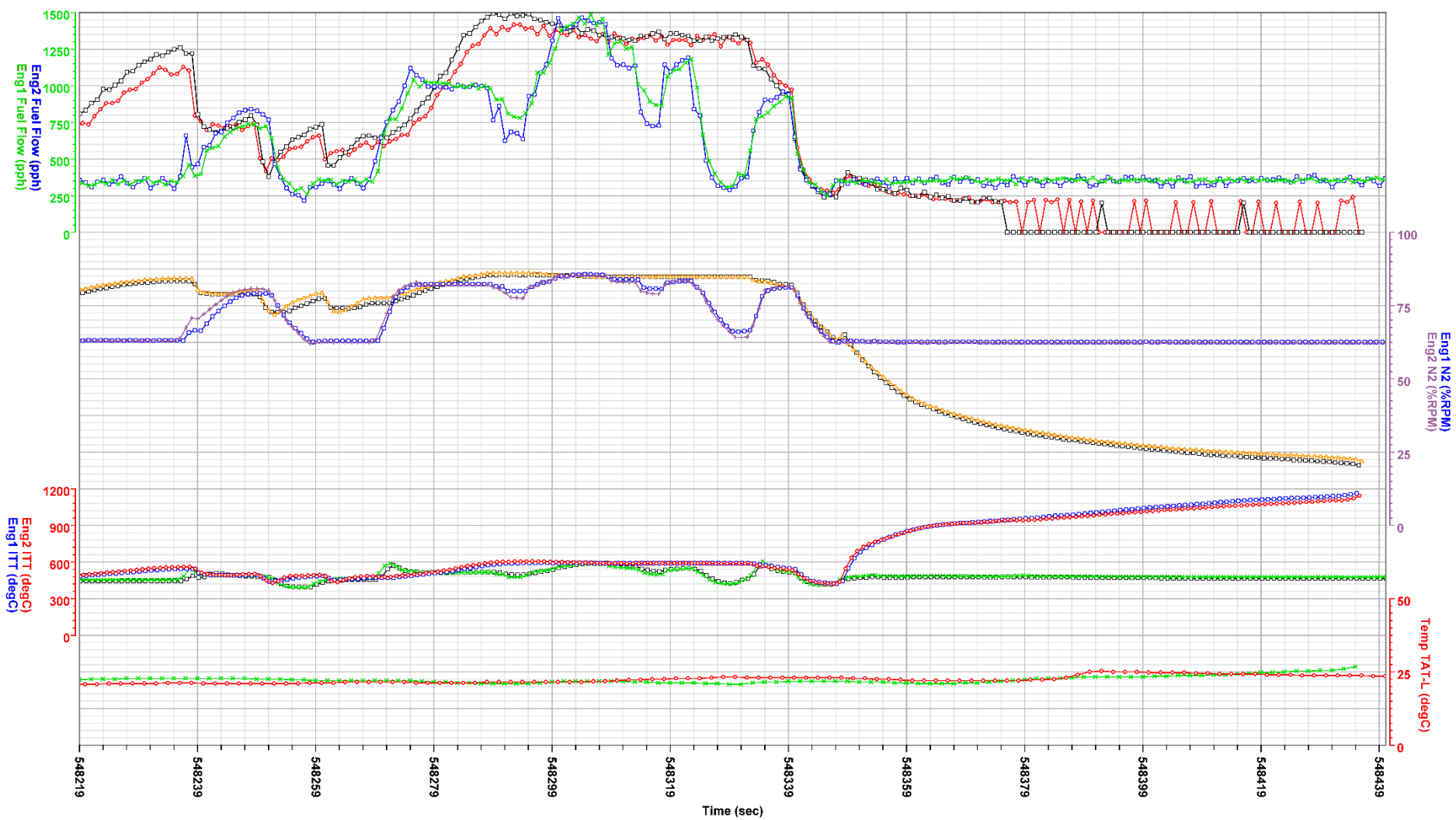


Figure 14. Matched deceleration 2 overlaid on accident flight.

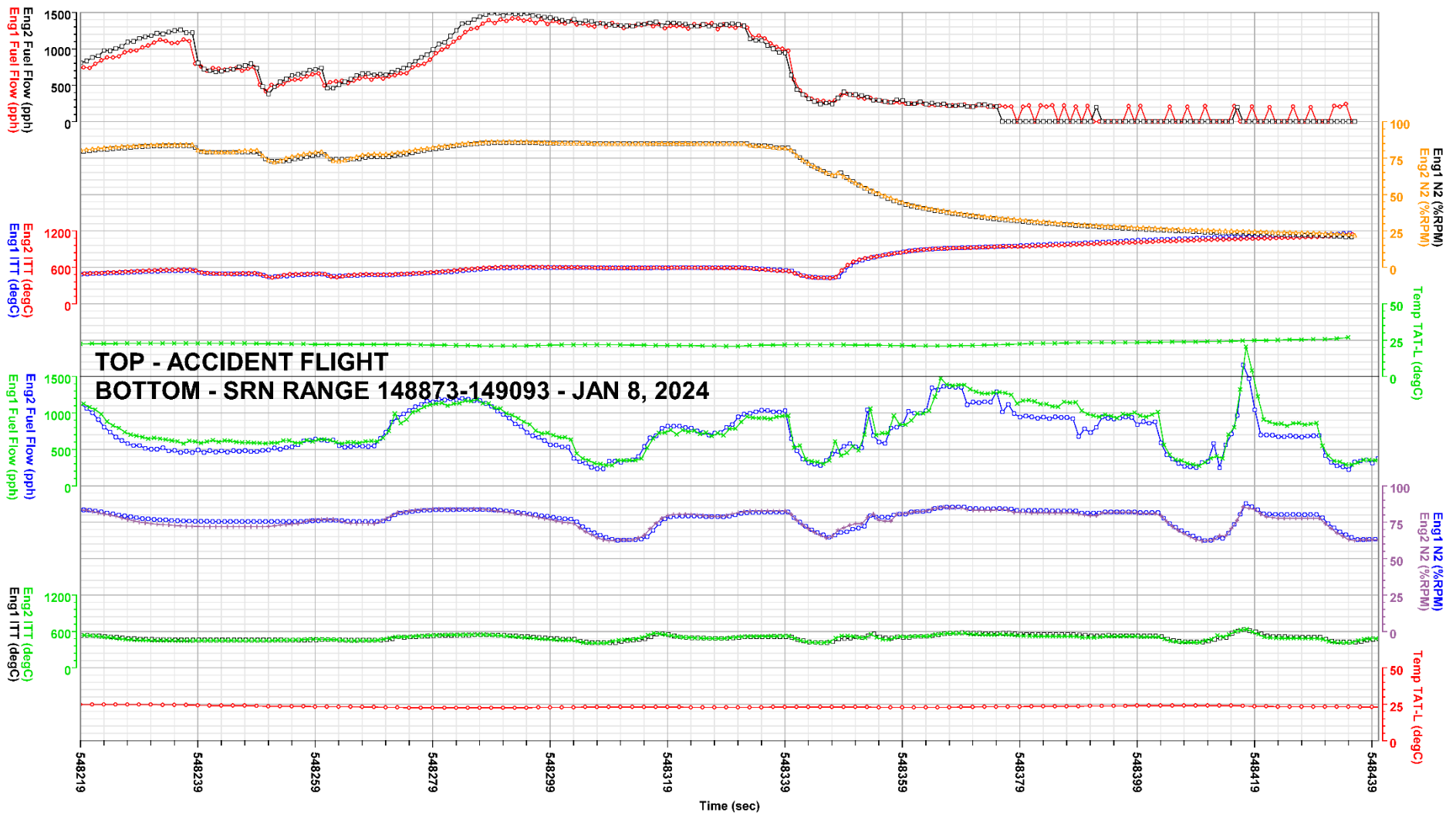


Figure 15. Matched deceleration 3.

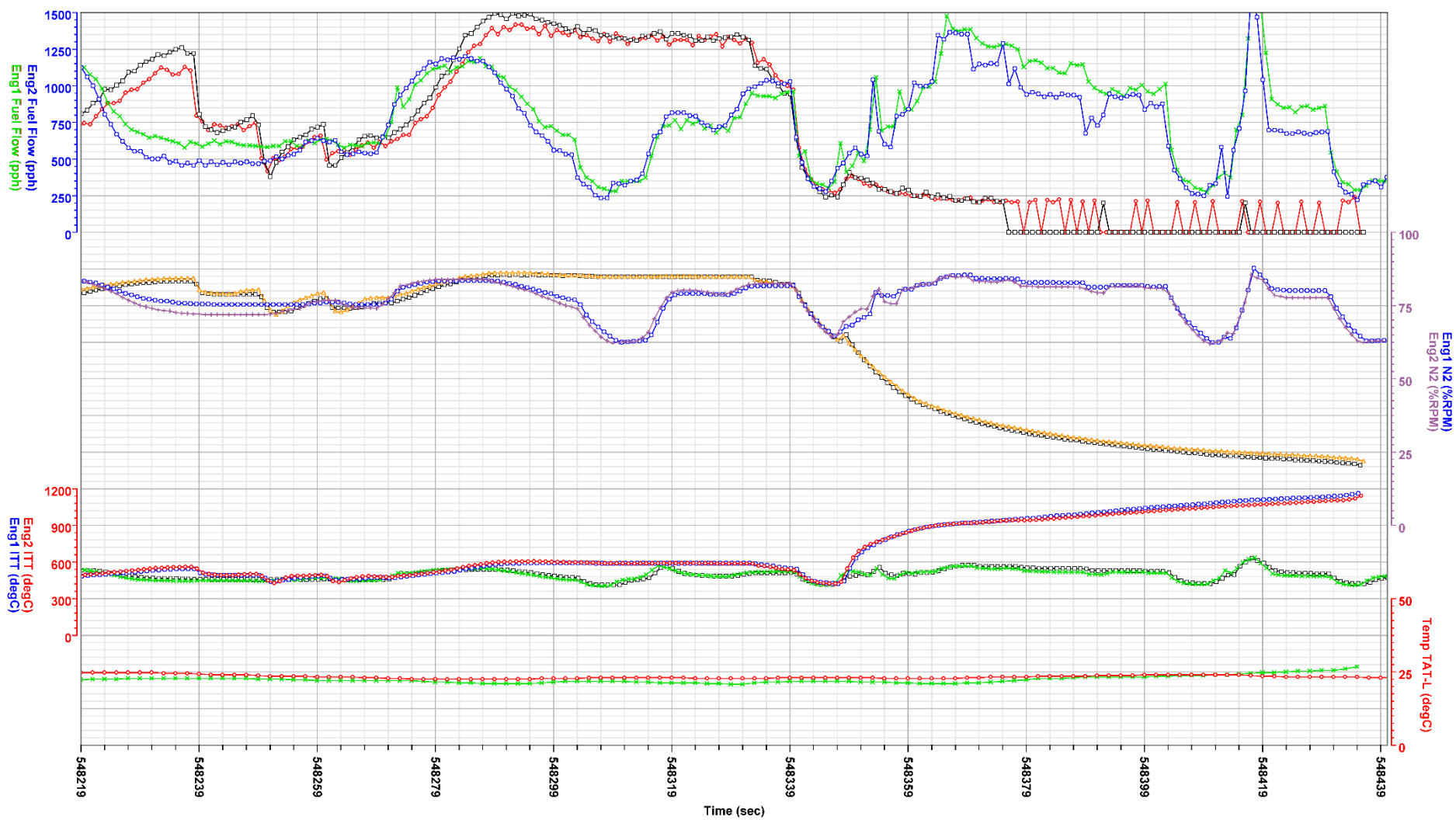


Figure 16. Matched deceleration 3 overlaid on accident flight.

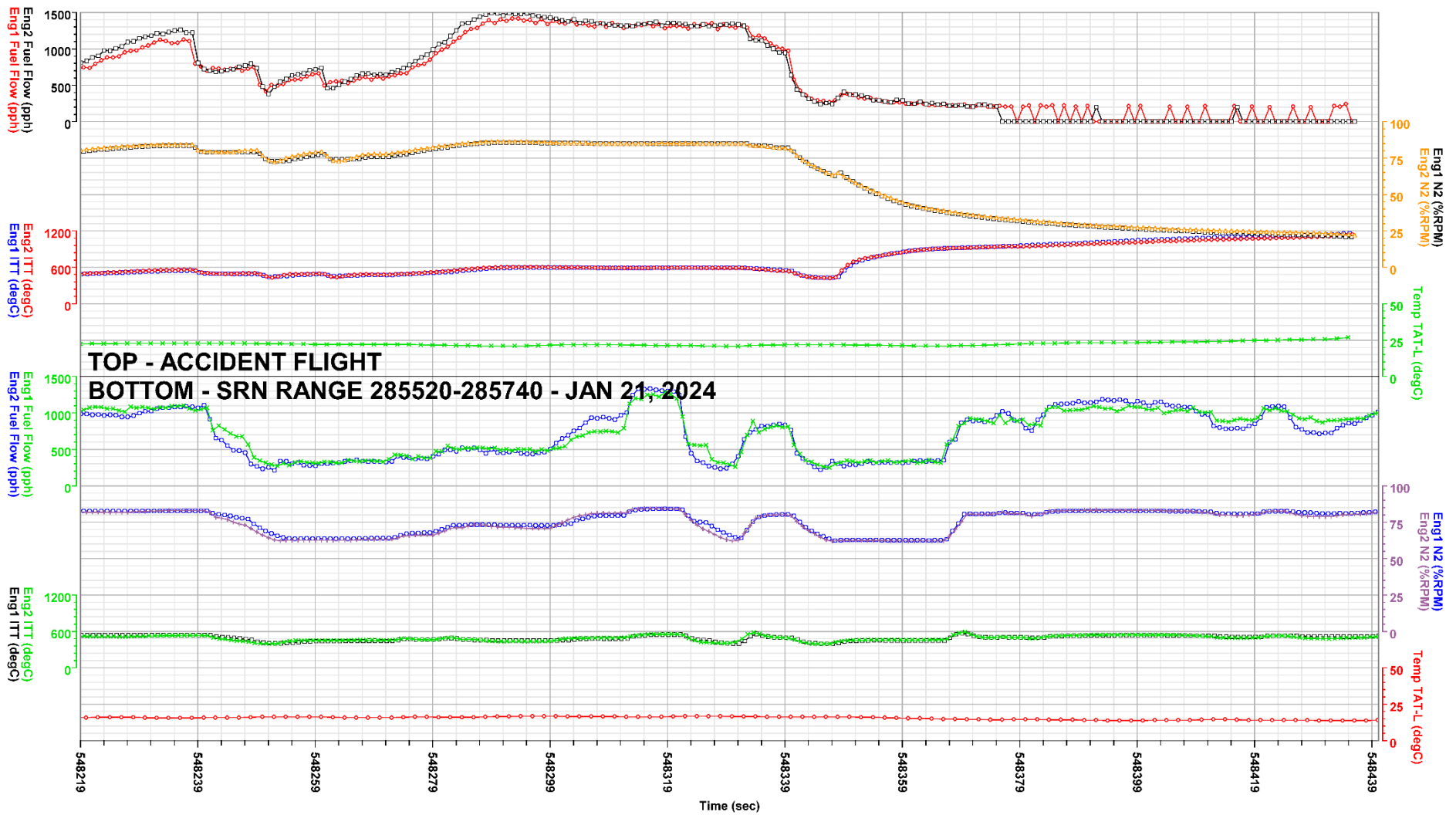


Figure 17. Matched deceleration 4.

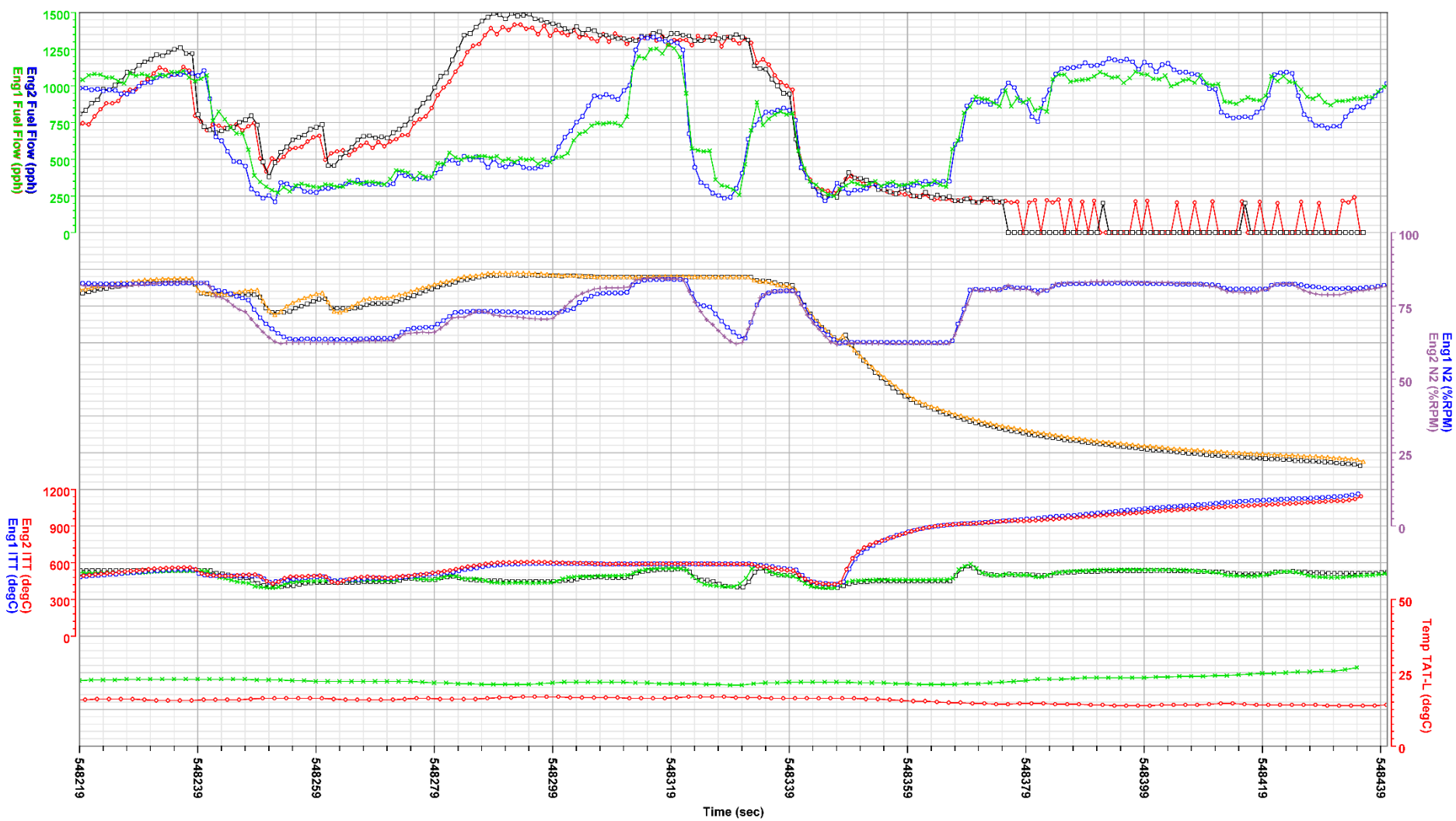


Figure 18. Matched deceleration 4 overlaid on accident flight.

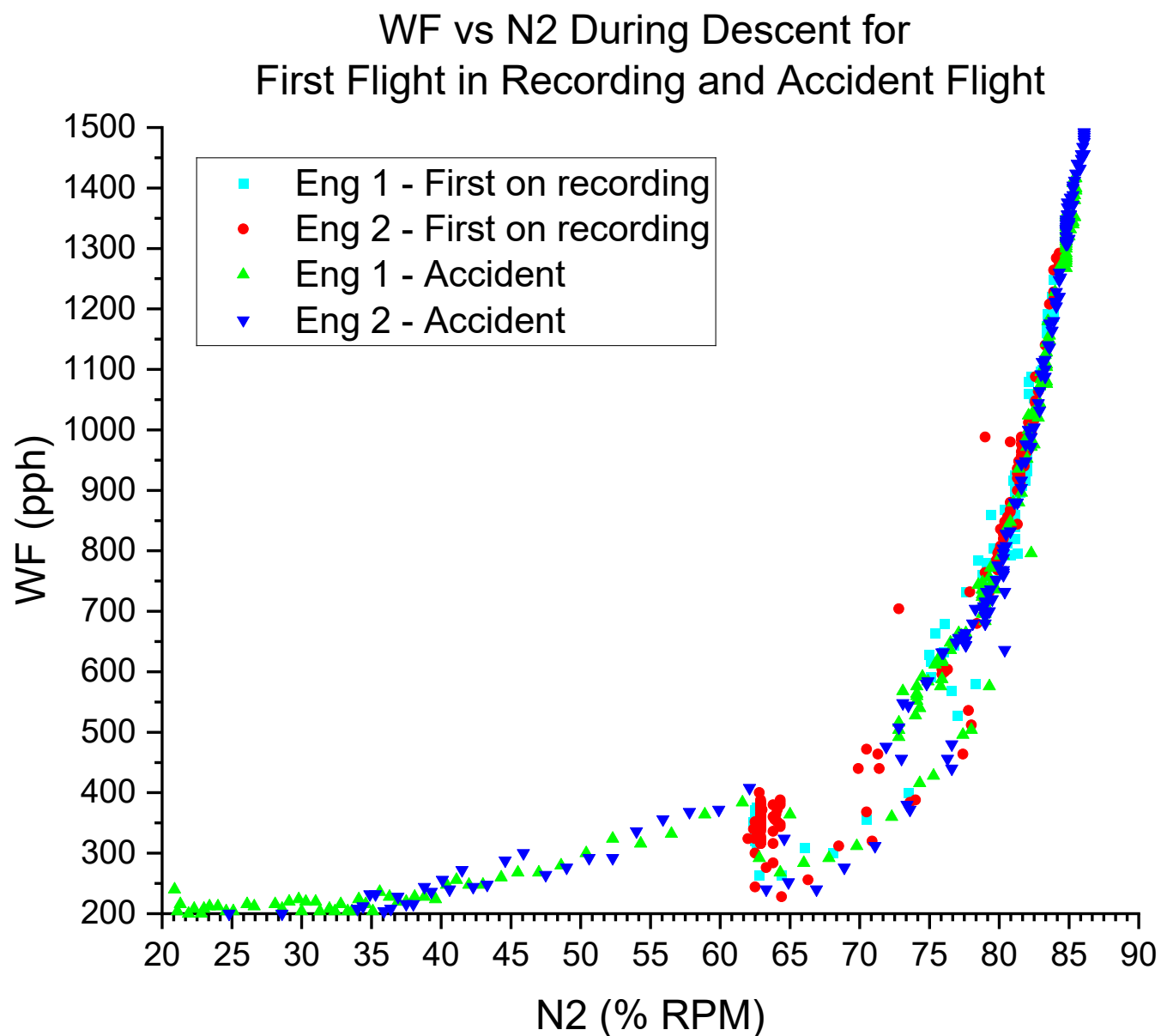


Figure 19. Fuel Flow vs. N2 from first and last flights on the FDR recording.

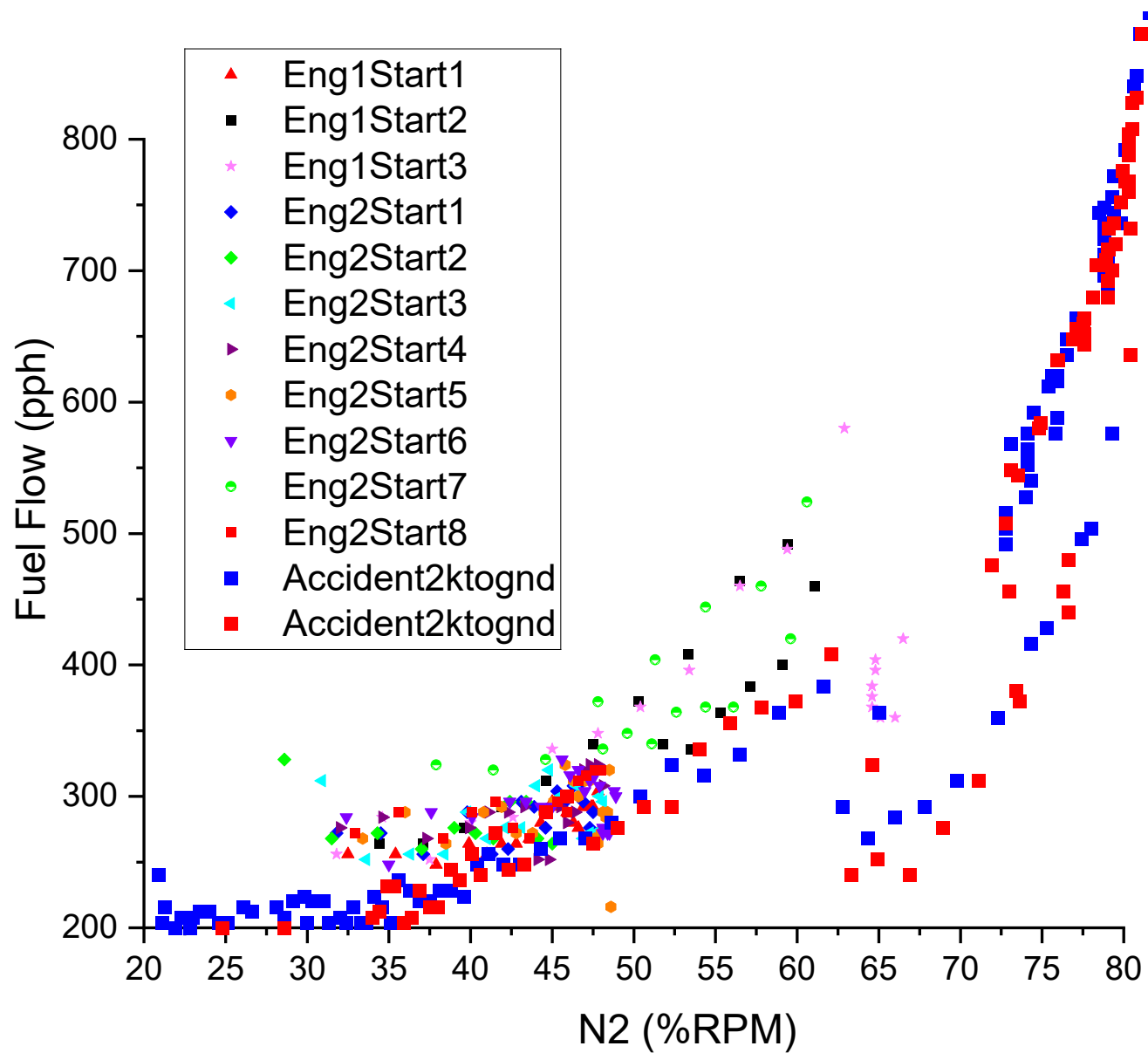


Figure 20. Comparison of hung engine start fuel flows to accident flight rollback.

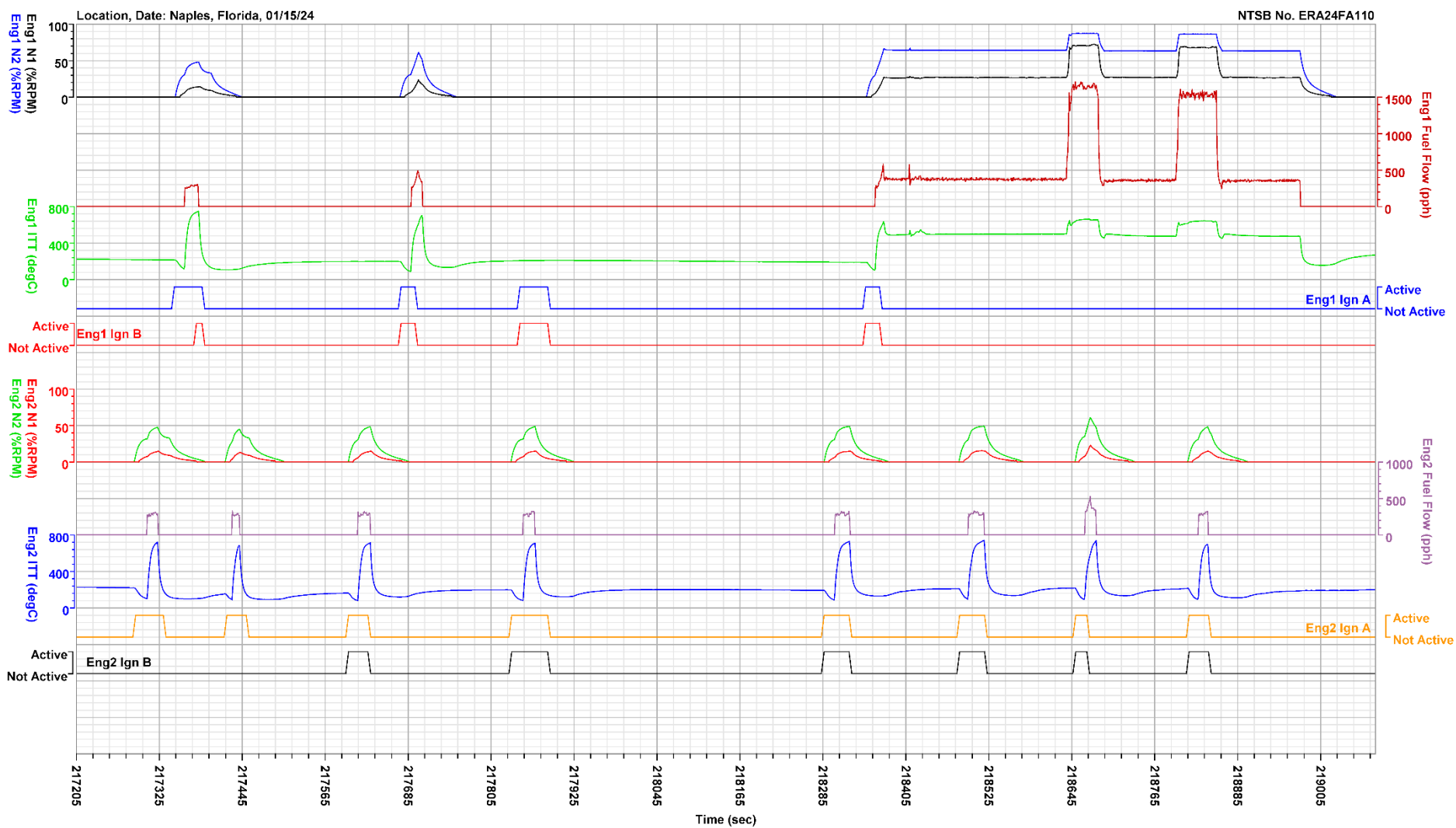


Figure 21. FDR data of hung starts occurring on January 15, 2024.

APPENDIX A. VERIFIED AND PROVIDED PARAMETERS

This appendix describes the parameters provided and verified in this report. Table 1 lists the plot/table labels, parameter names, and units. Additionally, table 2 describes the unit and discrete state abbreviations used in this report.

Table 3. Verified and provided FDR parameters.

Plot/Table Labels	Parameter Names	Units
Accel Lat	Lateral Acceleration	g
Accel Long	Longitudinal Acceleration	g
Accel Vert	Vertical Acceleration	g
Aileron-L	Left Aileron Surface Position	deg
Aileron-R	Right Aileron Surface Position	deg
Airspeed Comp-L	Left Computed Airspeed	kts
Airspeed Comp-R	Right Computed Airspeed	kts
Airspeed Ref Sel-L	Left Airspeed Select	kts
Altitude Press-L+R	Pressure Altitude	ft
Altitude Sel-L	Left Altitude Select	ft
AP ALT	Autopilot Altitude Hold Mode	
AP ALTS	Autopilot Altitude Select Mode	
AP ALTS CAP	Autopilot Altitude Select Capture Mode	
AP Eng-L	Left Autopilot Engaged	
AP Eng-R	Right Autopilot Engaged	
AP H BNK	Autopilot Half Bank Active	
AP HDG	Autopilot Heading Select Mode	
AP PATH	Autopilot Nav Path Mode	
AP V	Autopilot VNAV Mode	
AP VS	Autopilot Vertical Speed Mode	
Ctrl Col Pos L	Control Column Position	deg
Ctrl Col Pos R	Right Control Column Position	deg
Ctrl Wheel Pos L	Left Control Wheel Position	deg
Ctrl Wheel Pos R	Right Control Wheel Position	deg
Date-Days	Day	day
Date-Months	Month	month
Elevator-L	Left Elevator Surface Position	deg
Elevator-R	Right Elevator Surface Position	deg
Eng1 Fuel Flow	Engine 1 Fuel Flow	pph
Eng1 Ign A	Engine 1 Ignition A Status	
Eng1 Ign B	Engine 1 Ignition B Status	
Eng1 ITT	Engine 1 Interturbine Temperature	deg C

Plot/Table Labels	Parameter Names	Units
Eng1 N1	Engine 1 Fan Speed	% rpm
Eng1 N1 Target Ref	Engine 1 Fan Speed Target Reference	% rpm
Eng1 N2	Engine 1 Core Speed	% rpm
Eng1 Oil Press	Engine 1 Oil Pressure	psi
Eng1 Oil Temp	Engine 1 Oil Temperature	deg C
Eng1 Rvsr Arm	Engine 1 Reverser Armed	
Eng2 Fuel Flow	Engine 2 Fuel Flow	pph
Eng2 Ign A	Engine 2 Ignition A Status	
Eng2 Ign B	Engine 2 Ignition B Status	
Eng2 ITT	Engine 2 Interturbine Temperature	deg C
Eng2 N1	Engine 2 Fan Speed	% rpm
Eng2 N1 Target Ref	Engine 2 Fan Speed Target Reference	% rpm
Eng2 N2	Engine 2 Core Speed	% rpm
Eng2 Oil Press	Engine 2 Oil Pressure	psi
Eng2 Oil Temp	Engine 2 Oil Temperature	deg C
Eng2 Rvsr Arm	Engine 2 Reverser Armed	
Engine Warning	Engine Warning	
Flap	Flap Surface Position	deg
Fuel Qty-L	Left Fuel Tank Quantity	lb
Fuel Qty-R	Right Fuel Tank Quantity	lb
Gear Dwn+Lckd-L	Left Landing Gear Down and Locked	
Gear Dwn+Lckd-N	Nose Landing Gear Down and Locked	
Gear Dwn+Lckd-R	Right Landing Gear Down and Locked	
Hdg Mag/True-L	Left Magnetic Heading	deg
Hdg Mag/True-R	Right Magnetic Heading	deg
Hdg Sel-L	Left Heading Select	deg
L ENG OIL PRESS Warning	Engine 1 Oil Pressure Warning	
Latitude	Latitude	deg
Longitude	Longitude	deg
Master Warn	Master Warning Active	
Pitch-L	Left Pitch Attitude	deg
Pitch-R	Right Pitch Attitude	deg
R ENG OIL PRESS Warning	Engine 2 Oil Pressure Warning	
Roll-L	Left Roll Attitude	deg
Roll-R	Right Roll Attitude	deg
Rudder Pedal Pos	Rudder Pedal Position	deg
Rudder Pos	Rudder Surface Position	deg

Plot/Table Labels	Parameter Names	Units
Stick Pusher-L	Left Stick Pusher Active	
Stick Pusher-R	Right Stick Pusher Active	
Stick Shaker-L	Left Stick Shaker Active	
Stick Shaker-R	Right Stick Shaker Active	
Temp TAT-L	Total Air Temperature - Left	deg C
Time GMT Hrs	Greenwich Mean Time Hours	hrs
Time GMT Min	Greenwich Mean Time Minutes	min
Time GMT Sec	Greenwich Mean Time Seconds	sec
WF	Fuel Flow	pph

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 4. Unit and discrete state abbreviations.

Unit and Discrete State Abbreviations	Descriptions
deg	degrees
kts	knots
ft	feet
pph	pounds per hour
deg C	degrees Celsius
rpm	revolutions per minute
psi	pounds per square inch
hrs	hours
min	minutes
sec	seconds
Dwn+Lckd	down and locked
Eng	engaged
Not Eng	not engaged