

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



CEN23FA359

ELECTRONIC DEVICES

Specialist's Factual Report

June 2, 2026

A. ACCIDENT

Location: Virden, Illinois
Date: August 12, 2023
Time: 08:48 central daylight time (CDT)
Aircraft: Bierman/Van's RV-14A, N6161

B. ELECTRONIC DEVICES SPECIALIST

Specialist Sean Payne
Branch Chief - Vehicle Recorder Division
National Transportation Safety Board (NTSB)

C. DETAILS OF THE INVESTIGATION

In agreement with the Investigator-In-Charge, an Electronic Devices group was not convened, and a summary was prepared.

The NTSB Vehicle Recorder Division received the following electronic devices:

Device Manufacturer/Model: Ray Allen T3-12A (Elevator Trim Motor)
Device Serial Number: N/A

Device Manufacturer/Model: Canopy Latch Micro Switch
Device Serial Number: N/A

Device Manufacturer/Model: Astronics Vertical Power VP-X Pro
Device Serial Number: 3562

Device Manufacturer/Model: Garmin G3X Configuration Module
Device Serial Number: N/A

Device Manufacturer/Model: Garmin GSA 28 Servo (Roll)
Part Number: 011-02927-00
Device Serial Number: 2PG014861

Device Manufacturer/Model: Garmin GSA 28 Servo (Pitch)
Part Number: 011-02927-00
Device Serial Number: 2PG015048

Device Manufacturer/Model: Garmin G3X Touch PFD
Device Serial Number: N/A

Device Manufacturer/Model:	Garmin G3X Touch MFD
Device Serial Number:	N/A
Device Manufacturer/Model:	Garmin G3X PFD SD Card
Device Serial Number:	N/A
Device Manufacturer/Model:	Garmin G3X MFD SD Card
Device Serial Number:	N/A

1.0 Device Description

Ray Allen T3-12A Servo

The Ray Allen T3-12A Servo is a compact, high-torque electric trim servo commonly used in experimental and light sport aircraft. It provides precise actuation for trim tabs and features a 1.2-inch travel range and a built-in position feedback sensor.

Canopy Latch Micro Switch

The canopy latch micro switch in a Van's RV aircraft is a compact electrical switch installed on the canopy latch mechanism to detect whether the canopy is securely closed and latched. It provides a discrete signal to the cockpit, when wired correctly, it can interface with an Electronic Flight Information System (EFIS) to provide an alert to the pilot as to the canopy's latch position.

Vertical Power VP-X Pro

The Vertical Power VP-X Pro is an electronic circuit breaker system designed for experimental and light-sport aircraft, offering an alternative to traditional thermal breakers and fuses. Utilizing solid-state technology, the unit allows direct connections from the VP-X to each electrical device, eliminating the need for circuit breakers, bus bars, relays, and other complex components. The VP-X can detect short circuits, over-current faults, and open circuits; provides real-time monitoring of individual and total current draw, as well as main and auxiliary battery voltages. The unit supports 31 user-configurable power circuits with solid-state protection, including dedicated circuits for trim and flap motors. The VP-X provides an option to control flaps and trim, with features like variable-speed pitch trim based on airspeed, flap over-speed warnings, and starter disable when the engine is running.

Garmin G3X Configuration Module

The Garmin G3X Configuration Module is a small component containing non-volatile memory (NVM) that is installed in a back-shell of the G3X wiring harness. The

module stores critical configuration and calibration data, ensuring consistent system settings across power cycles and during maintenance or display replacements. The unit is compatible with several different Garmin GDU models and is typically included in the display unit's associated installation kit.

Garmin GSA 28 Servo

The Garmin GSA 28 Autopilot Servo is a lightweight servo designed for experimental and light-sport aircraft equipped with Garmin G3X Touch or G5 avionics systems. The unit contains a brushless DC motor and an engagement clutch, providing smooth control inputs and allowing for manual override with minimal friction when the autopilot is disengaged. The servo also includes built-in auto-trim functionality and supports Garmin's Electronic Stability and Protection (ESP-X) system.

Garmin G3X Touch

The Garmin G3X is a series of displays certified to be installed on certified aircraft. The model comes in 10.6-inch and 7-inch display versions. The unit employs a touch-screen user interface and can be utilized as a Primary Flight Display (PFD), Multi-Function Display (MFD), Engine Monitoring Device (EDM), or a combination of all, depending on how the unit is integrated with other compatible avionics products. The unit has the ability to record data via an externally removable SD card mounted under the center of the screen, or internally on a series of non-volatile memory (NVM) chips.

If not disabled, the unit is capable of logging historical information at a variable rate of up to 10 Hertz to internal NVM. Historical logs may be copied to a standard SD card inserted into the slot provided on the front of the unit, starting the GDU 460 in configuration mode, and selecting the touchscreen option "Copy to SD Card." Data is exported in engineering units, in a comma-delimited value (CSV) format. Each record contains UTC date and time, as well as an integer number of milliseconds since the unit was last powered on.

1.1 Data Recovery

Ray Allen T3-12A Servo

The trim servo was found installed in the wreckage per the Van's aircraft installation instructions. The trim servo was removed during the wreckage exam and is pictured in figure 1. The trim servo appeared to utilize an unmodified Elevator Trim Pushrod (E-01401A, assembly) provided by the airframe manufacturer. No obvious anomalies were present in the construction.

The trim servo arm was measured to be 1 inch extended as recovered. The trim motor was tested and determined to be functional and moved freely along the

shaft screw despite paint overspray on the shaft. Figure 2 is a photo of the measurement taken in the lab.

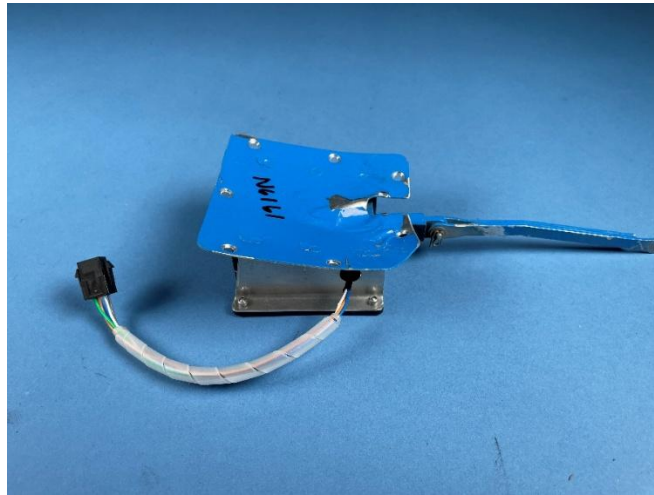


Figure 1. The Ray Allen T3-12A pitch trim motor.

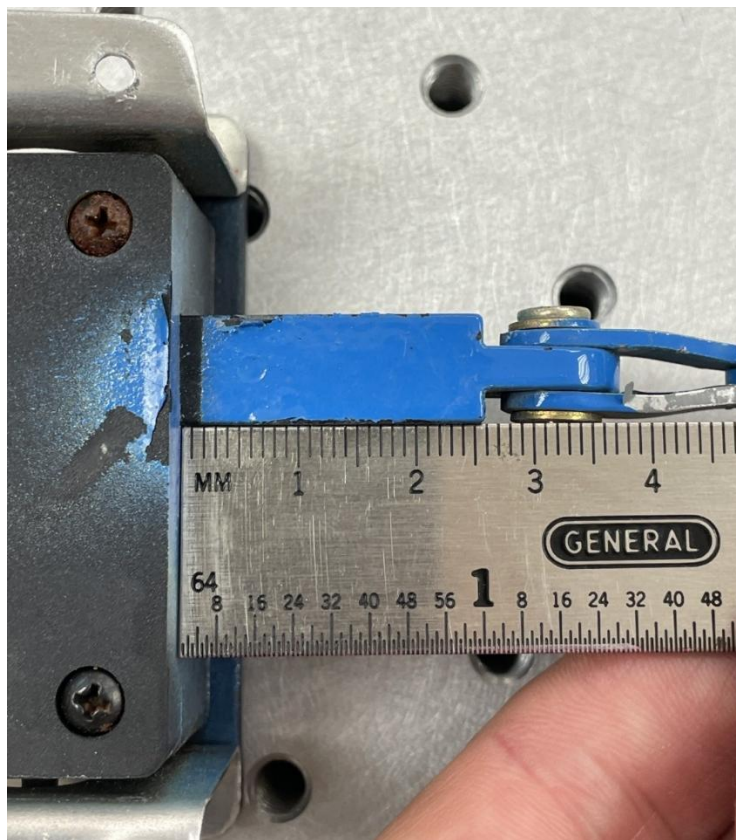


Figure 2. The Ray Allen T3-12A pitch trim motor final trim setting of around 25.5 mm or about 1 inch.

Canopy Latch Micro Switch

The canopy latch micro switch was installed in the location prescribed by the plans. The switch was tested with a multimeter and was functional. The associated canopy latch pin was inserted into the canopy frame. The canopy latch pin traveled 0.46 inches until the microswitch changed state. The canopy latch pin traveled 0.53 inches until it could no longer be inserted while the switch remained in an engaged state.

The canopy latch micro switch is pictured as recovered in figure 3. The canopy latch microswitch appeared to be installed as per the airframe manufacturer's instructions and was installed such that the microswitch was adjusted to the adjustment point closest to the roll bar (toward the aft of the aircraft).

The recorded canopy latch condition, as recorded by the Garmin EFIS, is discussed in the G3X section of this report. The canopy latch state did not appear to indicate a canopy position configuration type on the ground until the 25th recorded flight session.



Figure 3. The canopy latch micro switch as recovered, installed in the location defined in the aircraft's plans.

Vertical Power VP-X Pro

The Vertical Power VP-X Pro is pictured in figure 4. The VP-X sustained some impact damage. The manufacturer of the VP-X unit was contacted and provided a configuration that was uploaded by the builder. Vertical Power reported that they were not able to determine the date of the configuration upload. Figure 5 is the relevant portion of the configuration file that deals with the aircraft's trim system, as

uploaded by a user who associated the file in the VP-X database as belonging to N6161, the accident aircraft. The configuration showed that the following pins highlighted in figure 5 were enabled and were associated with the pitch trim system. The configuration uploaded by the user is provided to this report as attachment 1.

Because the date of the configuration upload could not be determined, it may not have been representative of the VP-X configuration at the time of the accident. The accident configuration was obtained by using a surrogate unit provided by the manufacturer (Astronics), swapping the appropriate memory chips, and performing a download. The configuration was retrieved using Vertical Power's consumer software tools. The configuration downloaded from the accident unit is provided to this report as attachment 2.



Figure 4. The condition of the VP-X Pro Unit.

J1

pin	bank	VP-X pin name	power pin name	current draw	wire size	circuit breaker	switch	current fault detect
1	A	2A-1 output	CO Monitor	0.1	20	1.0	always on	No
2	A	2A-2 output	GMC 507autopilot	0.7	20	2.0	always on	No
3		Roll Trim: +2.5v	enabled					
4		Roll Trim: gnd	enabled					
5		Roll Trim: pos input	enabled					
6	A	Roll Trim: motor power	enabled					
7	A	Roll Trim: motor power	enabled					
8		Pitch Trim: +2.5v	enabled					
9		Pitch Trim: gnd	enabled					
10		Pitch Trim: pos input	enabled					
11	A/B	Pitch Trim: motor pwr	enabled					
12	A/B	Pitch Trim: motor pwr	enabled					
17		Flap pos input	enabled					
18		Flap pos gnd	enabled					
19		Flap pos +2.5v	enabled					
20		Serial TX						
21		Serial GND						
22		Serial RX						

Figure 5. The portion of the configuration profile associated with the pitch trim system.

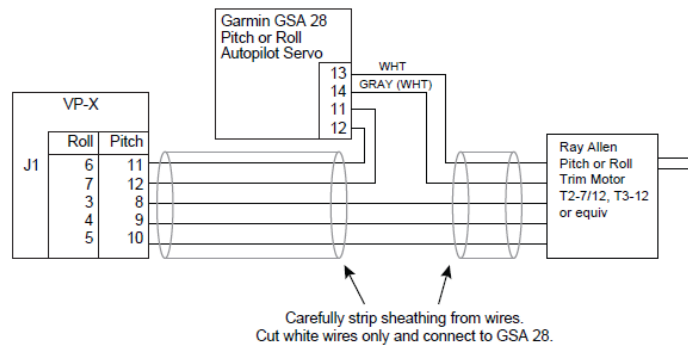
Figure 6 is a screenshot of the portion of VP-X installation manual related to the trim configuration settings for a Garmin G3X system.

5.19g Garmin GSA 28 With Auto-Trim

The diagram below shows how to install the Garmin G3X system with one or two GSA 28 autopilot servos. These servos also include auto trim functionality. Repeat this wiring for the pitch and roll servo. If you have a third yaw servo, that is wired outside the VP-X as shown in the Garmin manual.

Be sure to turn off the variable speed trim function on the VP-X unit as this functionality is included in the G3X system. Using the VP-X Configurator (later, when you get to the configuration section), go to **Pitch Trim Configuration** section, then set the **Speed** setting to 0.

Note	Not all wiring to complete each module is shown. Consult the respective installation manuals for complete details on other wiring.
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Turn off variable speed trim on VP-X.
Details for non-white wires in VP-X Install Manual.
Orientation of white/gray (or white/white) wires does not matter to VP-X, and can be changed using the configurator.
Consult Garmin manual for correct orientation of white wires between GSA 28 and trim motor.

Wiring GSA 28 Servos to the VP-X.

Figure 6. The portion of VP-X installation manual related to the setting the trim configuration settings for a Garmin G3X system.

Refer to notes from the wreckage examination, in the public docket for this accident. In summary, the Van's C411J fuselage connector was examined and found connected to the WH-0057 fuselage wiring harness. Specifically, C1037 and C1036 wires were present. Due to damage to the aircraft wreckage, further wiring interfaces to either the Garmin equipment or the Vertical Power equipment, could not be verified.

Garmin G3X Configuration Module

Figure 7 is a photo of the recovered Garmin configuration module. Garmin offered to read out the configuration module using a proprietary process. The configuration module was provided to Garmin in July of 2025 after discussion of how the configuration module data should be retrieved.

Garmin was successful in recovering the configuration settings from the module and provided the raw configuration file as well as screenshots of the configuration screens operating while the configuration files were loaded into a surrogate G3X. These screenshots are attached to this report as attachment 3.

Garmin provided a summary of the settings recovered from the configuration module. They are summarized as follows:

- Autopilot Pitch Engagement Limits were enabled, which limited the attitudes where the autopilot would NOT engage and Electronic Stability Protection (ESP) would not function. The values were set to ± 75 degrees for roll and ± 50 degrees for pitch.
- Pitch Trim Motor control was disabled. This means that automatic pitch trim control via the GSA 28 was inhibited, and that the GSA 28 could not move the pitch trim on its own. In this configuration, a manual input to the electric trim, via a hat switch for example, would move the trim, but would not disengage the autopilot.
- "Miscompare Monitoring" was enabled for the GDU ADHRS (G3X) and the Garmin G5. Since the recovered G3X data did not show a miscompare flag (See G3X Data Recovery section below), the G3X ADHRS and the G5 would have been sensing the same attitude, airspeed, and altitude.
- Most servo gain settings were set to 1.00, which is known to be a starting point for gain values when configuring Vans RV-7/8 aircraft.
- Maximum torque values were set at 45% for both pitch and roll.
- ESP limits were set for 45 degrees for bank and 10 degrees for pitch. The minimum airspeed for ESP engaging was set to 100 knots.
- ESP was set to enable upon power up. Garmin noted that this setting, in conjunction with a minimum ESP enable airspeed of 100 knots, would result in ESP providing stick forces during critical phases of flight, such as after takeoff and before landing, when not below the AGL height threshold that inhibits ESP.



Figure 7. The recovered Garmin configuration module.

Garmin GSA-28 Servo

Two Garmin GSA 28 servos were installed in the accident aircraft. Servo PN 011-02927-00 SN 2PG014861 (figure 8 Left) was installed in the roll position, and Servo PN 011-02927-00, SN 2PG015048 (figure 8 Right) was installed in the pitch position.

Both of these servos were subject to Service Bulletin 23038 Rev A. (GSA 28 Service Life Extension Program (Non-Certified), which was issued on May 4, 2023. The service bulletin is attached to this report as attachment 4.

The stated purpose of the service bulletin is as follows:

"Garmin has implemented several design and manufacturing process improvements to improve GSA 28 reliability. The latest update has been added to a consolidation of all past improvements into a single effort we are calling a GSA 28 Service-Life Extension Program. The Service-Life Extension Program allows up to five years to exchange, under warranty, all affected GSA 28 servos for servos marked with Mod 1."



Figure 8. The roll servo recovered (left) and the pitch servo (right). Note that the servos had been removed by the salvager, and the condition is not necessarily representative of the installed state.

Garmin Service Bulletin 23038 Rev A was issued in part due to an NTSB investigation (ENG22LA004¹) into a November 2021 inflight upset involving a Beech F33, where sulphuration caused electrical degradation in a GSA 28 pitch servo, leading to erroneous signals from the pitch trim servo and full nose-down pitch trim command upon autopilot engagement. Garmin noted the sulphuration issues in the ENG22LA004 investigation differed from a previously issued service bulletin (SB 2063) in which sulphuration caused premature failures that were absent of any erroneous signaling.

The service bulletin called for the replacement of the servos installed in the RV-14 aircraft, but neither were complied with by the accident pilot.

¹ ENG22LA004 - Beech F33, November 12, 2021, Bellefontaine, OH - Incident Investigation

As stated in the above section covering the configuration module recovered from the accident aircraft, the automatic pitch trim function was disabled in the G3X system configuration. Furthermore, a review of recovered flight data, discussed in the G3X Device Recording Description section below, showed that the pitch trim servo's recorded position did not move substantially during the accident flight, and no pitch trim movement was present just prior to the onset of the accident sequence.

Garmin G3X Touch

Two Garmin G3X Touch displays were recovered from the accident site. Each display contained an SD memory card capable of recording flight data. The displays are pictured in Figure 9. The SD card from the pilot side (herein referred to as the PFD) was recovered and read out normally. The section below covers information from the SD card associated with the PFD only.



Figure 9. The recovered SD card from the pilot's side G3X display (left) and the passenger side G3X Touch display (right).

G3X Touch Software Information

The CSV file associated with the accident flight contained the following header information related to software load, log version and system ID:

Log Version 1.00
Log Content Version 1.02
Unit SW Part Number 006-b1727-2K
SW Version 8.91
System ID 60002C9EF70F7

As noted in the CSV header information, the G3X display in the accident aircraft was running software version 8.91. On December 9, 2022, Garmin issued a mandatory service bulletin 22112 Rev B titled "Automatic Trim/GDU 4XX Reset." The service bulletin described the purpose as, "In G3X, G3X Touch, and G5 systems with GSA 28 autopilot servos connected to trim actuators, an un-commanded automatic trim runaway may occur when the autopilot is first engaged. The G3X Touch display may intermittently reset during flight." The service bulletin issued the following warning: "In G3X, G3X Touch, and G5 systems with GSA 28 autopilot servos connected to trim actuators, an un-commanded automatic trim runaway may occur when the autopilot is first engaged."

The service bulletin asked the operators of the system to either update the G3X Touch software to version 9.13 or later, or allowed operators to comply by disabling the trim motor control on the pitch, roll, and yaw axes in the configuration mode. In the section above discussing the recovery of the configuration settings from the configuration module, the trim motor control was found to be disabled. The recovered G3X software version from the accident aircraft was version 8.91, and the accident pilot had not updated the unit.

Garmin Service Bulletin 22122 Rev B is attached to this report as attachment 5.

G3X Device Recording Description

The recovered SD card contained 100 recorded sessions, 40 sessions were recorded flights of the aircraft, while other sessions appeared to be consistent with the avionics powering on the ground only. The earliest recorded flight occurred on November 2, 2022, and the last recorded session was the accident flight which occurred on August 12, 2023.

The 40 flights are summarized below in table A-1. The table shows the flight number, the filename, the duration of the flight in the format HH:MM, the maximum airspeed achieved in flight given in knots indicated airspeed (KIAS), the canopy warning status recorded by the EFIS, and a notes section which mostly contains information on the pilot's usage of the autopilot (AP).

For the canopy warning parameter, the following notation was used:

- NPG – Not Present Ground – Canopy unlatched condition was not present on the ground
- NPA – Not Present Air – Canopy unlatched condition was not present while in air
- PG – Present Ground – Canopy unlatched condition was present on the ground
- **PA** – Present Air – Canopy unlatched condition was present while in air

A review of the recorded G3X data suggested that pilot/builder had not configured the canopy warning mechanism until flight 25. All canopy warning statuses prior to

flight 25 did not have canopy warning information. From flight 25 forward, there was evidence that the canopy warning status had been configured on the EFIS because the log data began to show that, at times, the canopy position was generally triggered (unlatched) while the aircraft was on the ground, and no warning (latched) when the aircraft was generally in the air. The table below shows additional detail.

Table 1 . Table of basic flight information.

Flight No.	Filename	Flight Time	Max Airspeed (KIAS)	Canopy Warning	Notes
1	log_20221102_134900_3LF.csv	0:24	157.7	NPG, NPA	No AP usage
2	log_20221102_141838_3LF.csv	0:40	162.3	----, NPA	File began in flight, No AP usage
3	log_20221118_140701_3LF.csv	0:49	171.3	NPG, NPA	Contained first autopilot usage
4	log_20221118_152944_3LF.csv	1:23	173.6	NPG, NPA	Majority AP usage
5	log_20221120_094352_3LF.csv	1:18	175.4	NPG, NPA	Majority AP usage
6	log_20221120_113821_KALN.csv	2:47	184.8	NPG, NPA	Majority AP usage
7	log_20221120_150234_KALN.csv	0:20	175.8	NPG, NPA	No AP usage
8	log_20221121_113331_3LF.csv	2:12	173.9	NPG, NPA	Majority AP usage
9	log_20221121_144743_KIJX.csv	1:43	175.3	NPG, NPA	Majority AP usage
10	log_20221122_130731_3LF.csv	3:06	175.1	NPG, NPA	Majority AP usage
11	log_20221123_105129_3LF.csv	2:02	174.1	NPG, NPA	Majority AP usage
12	log_20221123_143510_3LF.csv	1:00	173.1	NPG, NPA	Minimal AP usage
13	log_20221125_145046_3LF.csv	1:36	180.6	NPG, NPA	Majority AP usage
14	log_20221128_141409_3LF.csv	1:24	173.5	NPG, NPA	Majority AP usage
15	log_20221215_110238_3LF.csv	3:18	186.2	NPG, NPA	Majority AP usage
16	log_20221218_115504_KBTR.csv	3:20	188.2	NPG, NPA	Majority AP usage
17	log_20230212_132807_3LF.csv	1:14	179.8	NPG, NPA	Majority AP usage
18	log_20230213_134747_3LF.csv	0:47	177.5	NPG, NPA	Majority AP usage
19	log_20230215_140801_3LF.csv	0:42	172.3	NPG, NPA	Majority AP usage
20	log_20230220_142034_3LF.csv	0:43	178.7	NPG, NPA	Majority AP usage
21	log_20230221_135433_3LF.csv	0:51	183.5	NPG, NPA	Majority AP usage
22	log_20230226_135527_3LF.csv	0:21	170.6	NPG, NPA	Majority AP usage
23	log_20230226_155628_1H2.csv	0:26	179.3	NPG, NPA	Majority AP usage
24	log_20230304_080719_3LF.csv	0:29	183.0	NPG, NPA	Majority AP usage
From this session forward, Canopy Warning State appeared in the log data.					
25	log_20230304_090900_KPCD.csv	2:38	172.5	PG, NPA	Majority AP usage
26	log_20230306_121647_KBTR.csv	3:05	181.2	PG, NPA	Majority AP usage
27	log_20230514_093324_3LF.csv	0:16	167.5	PG, PA	No AP usage
28	log_20230518_104601_3LF.csv	3:18	173.9	NPG, NPA	Majority AP usage
29	log_20230522_110341_KREG.csv	3:12	177.6	PG, NPA	Majority AP usage
30	log_20230524_094131_3LF.csv	0:20	170.4	PG, NPA	No AP usage
31	log_20230528_190721_3LF.csv	0:29	163.6	PG, NPA	Minimal AP usage
32	log_20230603_094902_3LF.csv	0:24	173.1	PG, NPA	No AP usage
33	log_20230608_094931_3LF.csv	0:19	174.0	PG, NPA	No AP usage
34	log_20230610_105212_3LF.csv	0:25	177.0	PG, NPA	No AP usage
35	log_20230610_121954_3LF.csv	0:15	169.7	PG, NPA	No AP usage
36	log_20230617_075920_3LF.csv	3:06	176.1	PG, NPA	Majority AP usage
37	log_20230617_124140_KDNN.csv	2:38	172.9	PG, NPA	Majority AP usage
38	log_20230617_155555_KPMH.csv	2:07	180.3	PG, NPA	Majority AP usage
39	log_20230806_105802_3LF.csv	0:38	162.9	PG, PA	No AP usage
40	log_20230812_083232_3LF.csv	>0:09	170.1*, 198.7	PG, PA	Accident flight

*** 170.1 knots was the maximum recorded KIAS just prior to the negative pitch event. 198.7 knots was the maximum recorded KIAS after the negative pitch event.**

The following sections describe flight data from the G3X Touch displays for various flights recovered from the pilot's side SD card. The flight number, date, description of the flight, and references to figures are provided.

Flight 27 - May 14, 2023 - log_20230514_093324_3LF.csv

The recording began at 9:33:24 CDT. The flight conducted on May 14, 2023, was local to Litchfield Municipal Airport (3LF), Litchfield, IL, and contained no autopilot use. The EFIS warning for a canopy open condition was present upon the start of the EFIS recording, and at various positions on the ground prior to the flight. The canopy open warning alerted while the aircraft was on takeoff roll, but was no longer present as the aircraft continued its takeoff roll. Around 9:45 CDT, the EFIS warning began triggering intermittently while the aircraft was at 155 KIAS and 1380 feet MSL. By 9:46:40 CDT, the canopy warning was recorded as 'Canopy Open' for the remainder of the flight. The aircraft continued to fly with the canopy warning present until the aircraft landed at 3LF. The maximum airspeed achieved on this flight was 167.5 KIAS which was recorded at 9:52:40.

Figure 10 is a plot of basic parameters during the flight conducted on May 14, 2023, and contains the conditions of the canopy warning status parameter.

The data for this recorded session is provided in this report as attachment 6 and is in comma-separated values (.CSV) format.

Flight 37 - June 17, 2023 - log_20230617_124140_KDNN.csv

Times for this session are given in UTC because the aircraft was on a cross-country flight and crossed a time zone in this session. The recording started at 16:41:40 UTC. The flight was the second recorded session in a series of cross-country legs around the Midwest and southern United States. During the session, the aircraft departed Dalton Municipal Airport, Dalton, Georgia (KDNN), and made landings at Pickens County Airport, Pickens, South Carolina (KLQK), Rutherford County Airport Marchman Field, Rutherfordton, North Carolina (KFQD), Virginia Highlands Airport, Abingdon, Virginia (KVJI), South West Virginia Regional Airport, Williamson, West Virginia (KEBD), and shut down after landing at Greater Portsmouth Regional Airport Portsmouth, Ohio (KPHM). The flight was approximately 2 hours and 38 minutes in the air. The data show that the majority of the legs were conducted using the autopilot, and only 34 minutes of flight time were hand flown. The following figures are appended:

Figure 11 is a plot of basic flight and autopilot related parameters for the entire recorded session. Throughout the recorded session, the canopy warning system indicated the canopy remained in a closed condition during flight. The plot also shows the pilot's method of autopilot usage. For most of the time the system was

engaged and in level flight, values for AP Pitch Torque and AP Roll Torque generally averaged around the 0% axis for both parameters.

Figure 12 is a plot of the portion of the session between KDNN and KLQK. Throughout the recorded session, the canopy warning system indicated the canopy remained in a closed condition during flight. The plot also shows the pilot's method of autopilot usage.

Figure 13 is a plot of the portion of the session between KLQK and KFQD. Throughout the recorded session, the canopy warning system indicated the canopy remained in a closed condition during flight. The plot also shows the pilot's method of autopilot usage.

Figure 14 is a plot of the portion of the session between KFQD and KVJI. Throughout the recorded session, the canopy warning system indicated the canopy remained in a closed condition during flight. The plot also shows the pilot's method of autopilot usage.

Figure 15 is a plot of the portion of the session between KVJI and KEBD. Throughout the recorded session, the canopy warning system indicated the canopy remained in a closed condition during flight. The plot also shows the pilot's method of autopilot usage.

Figure 16 is a plot of the portion of the session between KEBD and KPMH. Throughout the recorded session, the canopy warning system indicated the canopy remained in a closed condition during flight. The plot also shows the pilot's method of autopilot usage. Tracklog data for this session ends on the ramp area of KPMH.

The data for this recorded session is provided in this report as attachment 7 and is in comma-separated values (.CSV) format.

Flight 38 - June 17, 2023 - log_20230617_155555_KPMH.csv

Times for this session are given in UTC because the aircraft was on a cross-country flight and crossed a time zone in this session. The recording began at 19:55:55 UTC. The flight was the third recorded session in a series of cross-country legs around the Midwest and southern United States. This third session was a cross-country flight between KPHM and 3LF, with a landing at Gene Snyder Airport Falmouth, Kentucky (K62) and Madison Municipal Airport, Madison, Indiana (KIMS). The flight was approximately 2 hours and 7 minutes in the air. The data show that the majority of these flights during the recorded session were conducted using the autopilot, and only 19 minutes of flight time were hand flown. This flight exhibits the last autopilot usage before the accident flight. The following figures are appended:

Figure 17 is a plot of basic flight and autopilot related parameters for the entire recorded session. Throughout the recorded session, the canopy warning system indicated the canopy remained in a closed condition during flight. The plot also shows the pilot's method of autopilot usage. For the majority of the time the system was engaged and in level flight, values for AP Pitch Torque and AP Roll Torque generally averaged around the 0% axis for both parameters.

Figure 18 is a plot of basic flight and autopilot parameters. The plot shows the pilot's usage of the autopilot during a climb and level off phase of flight.

Figure 19 is an expanded time scale of the previous plot and focuses on the pilot's autopilot usage.

Figure 20 is a plot of basic flight and autopilot parameters for a different climb phase when the aircraft departed K62. The plot shows the pilot's usage of the autopilot during a climb and level off phase of flight.

Figure 21 is a plot of basic flight and autopilot parameters showing the pilot's autopilot usage after departure from K62 on an expanded time scale display.

The data for this recorded session is provided in this report as attachment 8 and is in comma-separated values (.CSV) format.

Flight 39 - Previous Flight to the Accident - August 6, 2023 - log_20230806_105802_3LF.csv

The recording started at 10:58:02 CDT. The flight conducted on August 6, 2023, was local to 3LF and contained no autopilot use. The EFIS warning for a canopy open condition was present upon the start of the EFIS recording². By 11:03 CDT, the canopy warning ceased, and the aircraft was near the ramp and hangars of 3LF. Around 11:07:30 CDT, the canopy warning was recorded intermittently while the aircraft was on a taxiway. The canopy warning continued to trigger intermittently until around 11:10 CDT while the aircraft was on takeoff roll. The canopy warning ceased as the aircraft departed 3LF. The canopy warning triggered intermittently during the early phase of the flight. The aircraft landed at 3LF around 11:48 CDT.

Figure 22 is a plot of basic parameters during the flight conducted on August 6, 2023, and contains the conditions of the canopy warning status parameter.

The data for this recorded session is provided in this report as attachment 9 and is in comma-separated values (.CSV) format.

² RV-14 canopy latch system is designed with a taxi position to facilitate airflow. With the canopy in the taxi position, a properly wired canopy warning system will indicate an open canopy.

Accident Flight
Flight 40 - August 12, 2023
log_20230812_083232_3LF.csv

All times are given in CDT.

All airspeeds in this section are reported in both IAS and TAS.

The recording started at 8:32:32. The aircraft was on the ramp area near a series of T hangars at the northeast corner of 3LF. The canopy warning status was recorded as a canopy open condition at the start of the recording.

At 8:33:57, the navigational identifier was recorded as "KCWI" (Clinton Municipal Airport, Clinton, Iowa). The active navigational source was recorded as "GPS1". Neither parameter would change for the remainder of the recorded session.

Around 8:34:20, the aircraft began taxiing from the ramp. Around 8:36:40, the aircraft stopped near the hold short area of runway 27. Around 8:37:05, the canopy warning status transitioned to canopy closed. Around 8:37:35, the engine RPM increased to around 1800 RPM, and the aircraft was still holding short of runway 27. RPM was then recorded between 1000 and 1300 rpm. By 8:38:05, the aircraft had crossed the hold short line for runway 27 and by 8:38:37, the aircraft had lined up on runway 27. Power advanced gradually, data show engine instruments within normal limits for this engine during takeoff roll. By 8:38:48, the data show the aircraft was airborne and climbing from runway 27. The canopy warning status remained as "canopy closed."

The aircraft made a climbing right turn from runway 27. By 8:40:20, the aircraft had turned to a heading of roughly 345 degrees magnetic and was climbing through 2500 mean sea level (MSL) with the autopilot off.

At 08:40:36, the autopilot was engaged in ROL (roll) and PIT (pitch) mode. The commanded FD Pitch Command was 4.5 degrees nose up, the AP Pitch Command also at 4.5 degrees nose up, the aircraft's recorded pitch was 4.6 degrees nose up, and AP Pitch Torque was -3% nose down. The aircraft's roll was roughly level. The aircraft was climbing through 2800 feet.

At 8:41:03, the autopilot remained in ROL mode and the vertical mode transitioned to ALT (altitude) mode. Based on the data for this mode transition, Garmin stated this action would have been the result of the pilot pressing the "ALT" button (either on the GMC controller, or the GDU display) to activate altitude hold mode.

Within the next 15 or so seconds, the FD Commanded Altitude transitioned to 3500 feet. The aircraft continued to climb. The aircraft reached 3500 feet, altitude oscillated less than 100 feet, and the aircraft settled to an altitude of just under 3500 feet.

At 8:42:00, the FD Lateral Mode was changed to GPS mode. The selected heading had been 278 degrees, and the aircraft began rolling left to intercept the selected course. The aircraft remained at 3500 feet, and at 2500 RPM the computed true airspeed was recorded as 173 KTAS (160.1 KIAS). Fourteen seconds later, the data indicated the vertical mode transitioned back PIT mode. Based on the data for this mode transition, Garmin stated this would have been a result of the pressing the "ALT" button which would have canceled the selected altitude hold mode. The aircraft's left turn was arrested, and the aircraft's track was in agreement with the selected flight plan's course. The aircraft descended slightly from 3500 feet.

At 8:42:32, the autopilot remained in GPS lateral mode, and the vertical mode transitioned to PIT (ALTS), the FD Altitude was then recorded as 4500 feet. The aircraft was around 3420 feet. The FD Pitch Command was recorded as -1.5 degrees nose down. The aircraft's pitch in the next ten seconds became slightly nose up. The value for AP Pitch Torque was recorded around this time as a local maximum of 42% nose down. Between 8:42:32 and 8:47:00 (the onset of the negative pitch and roll leading to the accident) the value for AP Pitch Torque was always recorded as negative values, reaching as high as 43% nose down torque command. The aircraft's pitch for this time interval would remain generally between level and slightly nose up, while values recorded for FD Pitch Command were continually recorded as slightly negative. During this time range, the autopilot state was recorded as "AP/TRIM DOWN".

At 8:43:06, while the aircraft was at about 3900 feet MSL, the autopilot vertical mode changed from PIT to VS (ALTS). Based on the data for this mode transition, Garmin stated this would have been a result of the pilot pressing the "VS" button. The initial conditions were recorded as a FD Commanded Altitude of 4500 feet, and a selected AP VS Command of +800 feet per minute. In the next couple of seconds, the FD Altitude was selected down to 4200. Based on the data recorded, Garmin stated that this would have been the result of the pilot changing the selected altitude bug. The AP VS Command was recorded as +300 feet per minute. A few seconds later, at 8:43:21, the autopilot state was recorded as ALT and recorded data show FD Altitude was recorded as 4030 feet. Based on the data recorded, Garmin stated that this would have been the result of the pilot pressing the "ALT" button. When ALT mode is activated in this manner, that target altitude will be set to the current aircraft altitude. See figures 29 through 33 for detailed information about the recorded autopilot data, air data and pitch data at this time.

At 8:43:40, the aircraft was oscillating slightly around 4040 feet MSL in GPS FD lateral and FD altitude hold mode. At this time the first in a series of intermittent, but frequent canopy open warning state information was recorded. This intermittent but frequent canopy open warning state information would persist until a few data samples prior to the negative pitch and roll event that led to the aircraft's impact with the ground. The aircraft's computed true airspeed at this time was around 167 KTAS (153 KIAS). The autopilot state at this time was recorded as "AP/TRIM DOWN" and values for AP Pitch Torque were generally between 15% nose down and 42% nose down in this area of the data. The data indicated the pitch trim did not move at this time. The aircraft's pitch at this time would increase to about 3 degrees nose up, while the FD Pitch Command remained slightly nose down.

In the next two minutes, the aircraft climbed slightly. Pitch was recorded as positive, and the FD Vertical Command remained nose down, reaching a local minimum value of about 2 degrees nose down command. The aircraft reached about 4450 feet MSL. Computed True Airspeed decreased to about 168 KTAS (153.5 KIAS). Around 8:46:00, the aircraft was in a descent, and computed True Airspeed increased to around 184 KTAS (170 KIAS). The aircraft descended to around 4100 feet MSL. The intermittent but frequent canopy open warning state persisted.

At 8:46:08, the FD Lateral Mode changed to (TRK) track mode while FD Vertical Mode remained in ALT. The Navigation Waypoint remained KCWI, as it had been for the majority of the flight. The barometric altitude was recorded as just under 4100 feet MSL and the computed True Airspeed was around 185 KTAS (169.6 KIAS). RPM was recorded as around 2400 and manifold pressure just under 25 inches of mercury. These power settings would remain generally unchanged until the time of the negative pitch event. The intermittent but frequent canopy open warning state persisted.

Despite the aircraft descending to around 4100 feet MSL previously, by 8:46:40, the aircraft pitched nose up and began to climb again. Autopilot settings remained AP Engaged (AP / TRIM DOWN), FD Lateral TRK, Selected Altitude 4500 Feet and FD Vertical Mode ALT. The aircraft climbed and airspeed bled off slightly. The intermittent but frequent canopy open warning state information persisted.

The following describes the negative pitch event that led to the aircraft's impact with terrain. It is best to reference figure 33 at this time as it is a hyper-expanded time scale describing the onset of the event with individual recorded samples indicated as individual symbols on the plot. It is important to note that the sampling rate of the Garmin system is 1 Hz and caution should be applied when performing an analysis of a dynamic event with this data alone.

In general, the negative pitching and rolling event can be described as a quarter outside loop with a 90-degree heading change to the southwest while the

aircraft performed a right outside roll to inverted. During the negative pitching and rolling event, Normal Acceleration (Z), reached about -2.7 g.

Refer to figure 33. At 8:46:57, the airplane was at 4178 feet MSL at a computed True Airspeed of 175 KTAS (161 KIAS), FD Lateral Mode was TRK, and FD Vertical Mode was ALT. AP Pitch Torque was recorded as negative values (nose down) as discussed previously, AP state was recorded as AP engaged and "AP / TRIM DOWN." The aircraft's pitch was slightly nose low. Canopy status was temporarily recorded as canopy closed (while it had been intermittently open in the samples before starting at 8:43:30).

In the next second, 8:46:58, the canopy status parameter transitioned to indicate a canopy open condition. The canopy status parameter would remain indicating a canopy open condition for the remainder of the recording (it had been intermittent since 8:43:40).

Two seconds later, at 8:47:00, Normal Acceleration (Z) changed from +1.02 g to +0.35 g within one sample (one second). At this time, AP Pitch Torque transitioned from 25% nose down to 16% nose down (nose down force had lessened). The aircraft had begun to pitch nose down. In the next second, AP State changed from AP engaged and "AP / Trim Down" to "AP." AP Pitch Torque changed to a positive value for the first time. In the next second, the AP State changed to AP Engage "AP / TRIM UP" for a single sample. AP Pitch Torque changed to 38% nose up. The aircraft's pitch at this time was 10 degrees nose down. Indicated Airspeed during these past few seconds decreased within a few seconds by about 7 knots to about 153 KIAS despite the aircraft's nose low condition. Indicated Airspeed is referenced here instead of computed True Airspeed because the dynamic nature of the event could cause computed data to become temporarily unreliable. For analysis of this portion of the accident event, refer to the Aircraft Performance Study, which is available in the public docket for this event.

From 08:47:00 through 08:47:07 the pitch and roll servo torque values indicated that the AP servos were working to return the aircraft to level flight, but the aircraft attitude continued toward negative pitch and excessive roll. At 08:47:08 the aircraft attitude exceeded AP engagement limits, and the data shows that the servos disconnected.

In the next second, at 8:47:03, AP State was recorded as "Manual Disengage / ESP Roll / ESP Pitch." Based on the data recorded, Garmin stated that this would have been the result of the pilot pressing the "AP DISC" button or the "AP" button on the GMC keypad or GDU display. The aircraft's pitch was about 17 degrees nose low and about 20 degrees right roll. Indicated Airspeed remained about 153 KIAS.

The aircraft continued to pitch nose down and roll right. At 8:47:04, the AP State was recorded as "ESP ROLL / ESP PITCH." At this time, pitch and roll servo torque values that the AP servos were attempting to return the aircraft to level flight. The aircraft began to gain airspeed. Indicated Airspeed increased to 155 KIAS and continue to increase rapidly for the next couple of seconds. Torque values for AP Pitch Torque and AP Roll Torque appeared to respond accordingly, providing an opposing force. The system continued to record a canopy open position.

By 8:47:08, the AP State was recorded as "Fail" and information provided by Garmin's download of the configuration module showed that the autopilot was outside of engagement limits at this time. Pitch was 52 degrees nose low and about 46 degrees right roll. Indicated Airspeed continued to increase rapidly, and altitude continued to decrease rapidly. Normal Acceleration (Z) was around -1g at this time.

At 8:47:14, computed True Airspeed and Indicated Airspeed both reached their maximum recorded values of 208 KTAS (199 KIAS), respectively. The aircraft was now flying inverted coming left of its original course to a heading of roughly 233 degrees. Normal Acceleration (Z) reached near the maximum recorded value of negative g at -2.66 g.

During the dynamic negative pitch event, engine parameters were recorded as follows: RPM rapidly increased to a maximum of around 2700 RPM, oil pressure decreased significantly, and manifold pressure decreased significantly. Exhaust Gas Temperatures (EGTs) decreased across all four cylinders by a few hundred degrees Fahrenheit.

As the recorded data neared the end of the log, the aircraft was flying inverted on a southwesterly heading, while still decreasing in altitude but slowly leveling (still flying inverted). The data set ended at 107 knots Indicated Airspeed and 1165 feet MSL Barometric Altitude, Normal Acceleration (Z) was recorded around 0 g. GPS data showed the aircraft's track approaching a tree line near the edge of a field southwest of the city center of Virden, Illinois. The dataset appeared to end just prior to impact based on recorded GPS locations of the wreckage.

On this flight, the aircraft achieved a maximum IAS of 170.1 knots prior to the negative pitch event. In reference to table A-1, this speed maximum recorded IAS was lower than maximum recorded IAS on other previous flights.

Accident Flight Figure Descriptions
Flight 40 - August 12, 2023
log_20230812_083232_3LF.csv

Figure 23 is a plot of basic parameters during the accident flight on August 12, 2023, and contains the conditions of the canopy warning status parameter.

Figure 24 is an expanded time scale plot of basic parameters during the accident flight on August 12, 2023, and contains the canopy warning status parameter. The plot shows the last approximately 8 minutes of flight.

Figure 25 is an expanded time scale plot of basic parameters during the accident flight on August 12, 2023, and contains the canopy warning status parameter. The plot shows the last approximately 45 seconds of flight. Note that individual samples are denoted by symbols that show exactly when the values were recorded.

Figure 26 is a plot of recorded engine-related parameters for the entire accident flight.

Figure 27 is an expanded time scale plot of recorded engine-related parameters for the entire accident flight. The plot shows the last approximately 8 minutes of flight.

Figure 28 is an expanded time scale plot of recorded engine-related parameters for the entire accident flight. The plot shows the last approximately 45 seconds of flight.

Figure 29 is a plot of basic parameters and numerous autopilot-related parameters during the accident flight on August 12, 2023. The plot contains the condition of the canopy warning status parameter. Note that the values for AP Pitch Torque % differ from previously plotted flights in which autopilot usage was engaged.

Figure 30 is an expanded time scale plot of basic parameters and numerous autopilot-related parameters during the accident flight on August 12, 2023. The plot contains the condition of the canopy warning status parameter. The plot shows the last approximately 8 minutes of flight.

Figure 31 is an expanded time scale plot of basic parameters and numerous autopilot-related parameters during the accident flight on August 12, 2023. The plot contains the condition of the canopy warning status parameter. The plot shows the last approximately 3 minutes of flight. Canopy warning state change, the time the autopilot disengaged, and the time the Electronic Stability Protection (ESP) disengaged are annotated as vertical lines at the appropriate recorded times.

Figure 32 is an expanded time scale plot of basic parameters and numerous autopilot-related parameters during the accident flight on August 12, 2023. The plot contains the condition of the canopy warning status parameter. The plot shows the last approximate 100 seconds of flight. Canopy warning state change, the time the

autopilot disengaged, and the time the Electronic Stability Protection (ESP) disengaged are annotated as vertical lines at the appropriate recorded times.

Figure 33 is a hyper-expanded time scale plot of basic parameters and numerous autopilot-related parameters during the accident flight on August 12, 2023. The plot is focused on the time interval during which the data recorded a significant negative pitch. Canopy warning state change, Normal (Z) acceleration state change, and autopilot disengage are annotated as vertical lines at the appropriate recorded times.

Figure 34 is a depiction of the aircraft's recorded track log and altitude for the entire accident flight displayed on Google Earth. The orientation of the image is roughly north up. Note that the weather and lighting conditions present in the Google Earth depiction do not necessarily reflect the weather and lighting conditions at the time of the accident.

Figure 35 is a depiction of the aircraft's recorded track log and altitude for the last two and a half minutes of flight displayed on Google Earth. The orientation of the image is roughly north up.

Figure 36 is a depiction of the aircraft's recorded track log and altitude for the last one and a half minutes of flight displayed on Google Earth. The orientation of the image is roughly north up.

Figure 37 is a depiction of the aircraft's recorded track log and altitude for the last forty seconds of flight displayed on Google Earth. The orientation of the image is roughly north up.

Figure 38 is a depiction of the aircraft's recorded track log and altitude for the entire flight in relation to the KCWI waypoint, which was entered as the active navigational waypoint in the G3X system at the time of the accident. The orientation of the image is north up.

The data for this recorded session is provided in this report as attachment 10 and is in comma-separated values (.CSV) format.

Previous Aerobatic Maneuvers

Previous flights were investigated to see if the pilot performed aerobatic maneuvers. Only one flight had a single maneuver that resulted in a bank angle greater than 40 degrees. The bank angles for all other flights rarely exceeded 30 degrees. None of the flights had a nose-down pitch greater than 10 degrees. There was no evidence in the recorded data that the pilot performed any aerobatic maneuvers during any of the previous flights.

Autopilot Usage on Previous Flights

Recall table A-1, which summarizes the data from all previous flights that were recorded on the device's SD card. Table A-1 indicates which flights contain autopilot usage, and a generalized comment related to the nature of the autopilot usage. Further, an EFIS playback tool was utilized to gain insight into the pilot's use of the autopilot during previous flights. The data show that at least 29 of the previous flights contained autopilot usage. Most of the flights that contained autopilot usage, at minimum, involved using a heading selection mode and an altitude selection mode. Some of the flights contained recorded data showing the pilot used advanced autopilot features, including, but not limited to using different types of vertical navigation modes. Furthermore, on the flights that did contain data related to simple autopilot use, such as altitude hold modes, the data suggested the pilot had proficiency in using the system.

Recorded Pitch Trim Settings Across Flights

Recorded pitch trim data was evaluated across various flights and was not found to be anomalous.

Flight Data Recovered from a Previous RV-14 Canopy Open In-Flight Event

The NTSB was made aware by Van's Aircraft of a previous RV-14A canopy open in-flight event that was reported years prior to this accident. The event itself was not a reportable event to the NTSB and thus there is no associated NTSB accident number.

Vans indicated that the pilot had reported that he failed to latch the canopy prior to the flight, and that the latch operational condition may have been affected by a recent painting operation. The NTSB contacted the owner of this aircraft, which was equipped with a Dynon HDX EFIS display. The NTSB requested the flight data from this event. The owner of the aircraft attempted to retrieve the data but reported that the data had been overwritten by the time they attempted to access the system's logs. No flight data from this event was retrieved.

Microsoft Flight Simulator 2024 Playback

A playback was constructed from the recorded accident flight data and converted into a file that could be played back on Microsoft Flight Simulator 2024. The playback has been captured with a single camera view that appropriately displays the aircraft motion during the accident event. Only the time interval around the accident event is shown. The playback file is attached to this report as Attachment 11 – Microsoft Flight Simulator 2024 Animation.MP4.

List of Attachments and Filenames

Attachment 1: Attachment 1 - VPX Uploaded Configuration.pdf
Attachment 2: Attachment 2 - VPX Accident Recovered Configuration.pdf
Attachment 3: Attachment 3 - Garmin G3X Recovered Configuration Screenshots.pdf
Attachment 4: Attachment 4 - Garmin Service Bulletin 23038 Rev A.pdf
Attachment 6: Attachment 5 - Garmin Service Bulletin 22122 Rev B.pdf
Attachment 7: Attachment 6 - Recorded G3X Data Flight 27.CSV
Attachment 8: Attachment 7 - Recorded G3X Data Flight 37.CSV
Attachment 9: Attachment 8 - Recorded G3X Data Flight 38.CSV
Attachment 10: Attachment 9 - Recorded G3X Data Flight 39.CSV
Attachment 11: Attachment 10 - Recorded G3X Data Accident Flight 40.CSV
Attachment 12: Attachment 11 - Microsoft Flight Simulator 2024 Animation.MP4

Submitted by:

Sean Payne
Branch Chief - Vehicle Recorder Laboratory

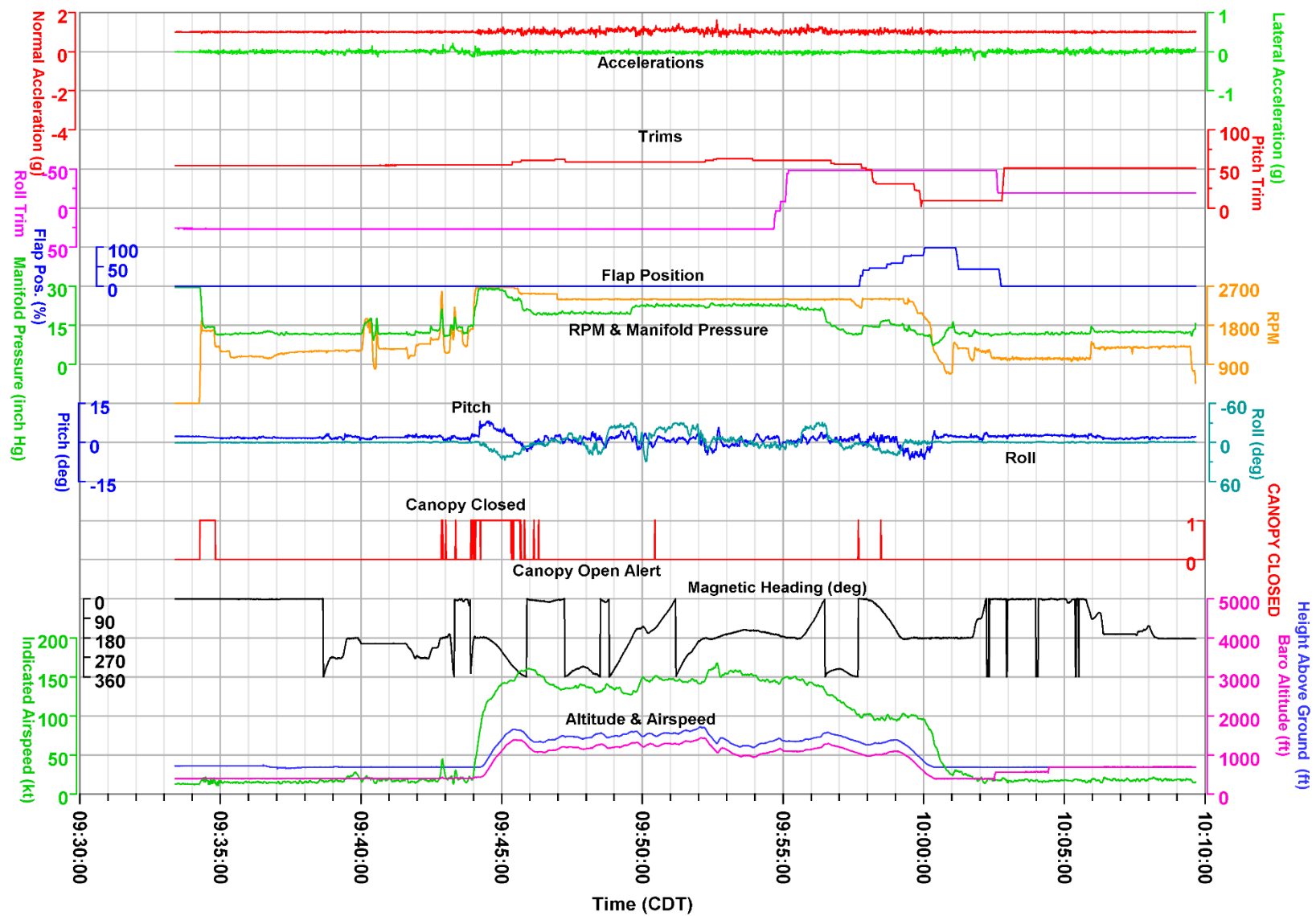


Figure 10. A plot of basic parameters during flight 27, which was conducted on May 14, 2023, showing canopy status.

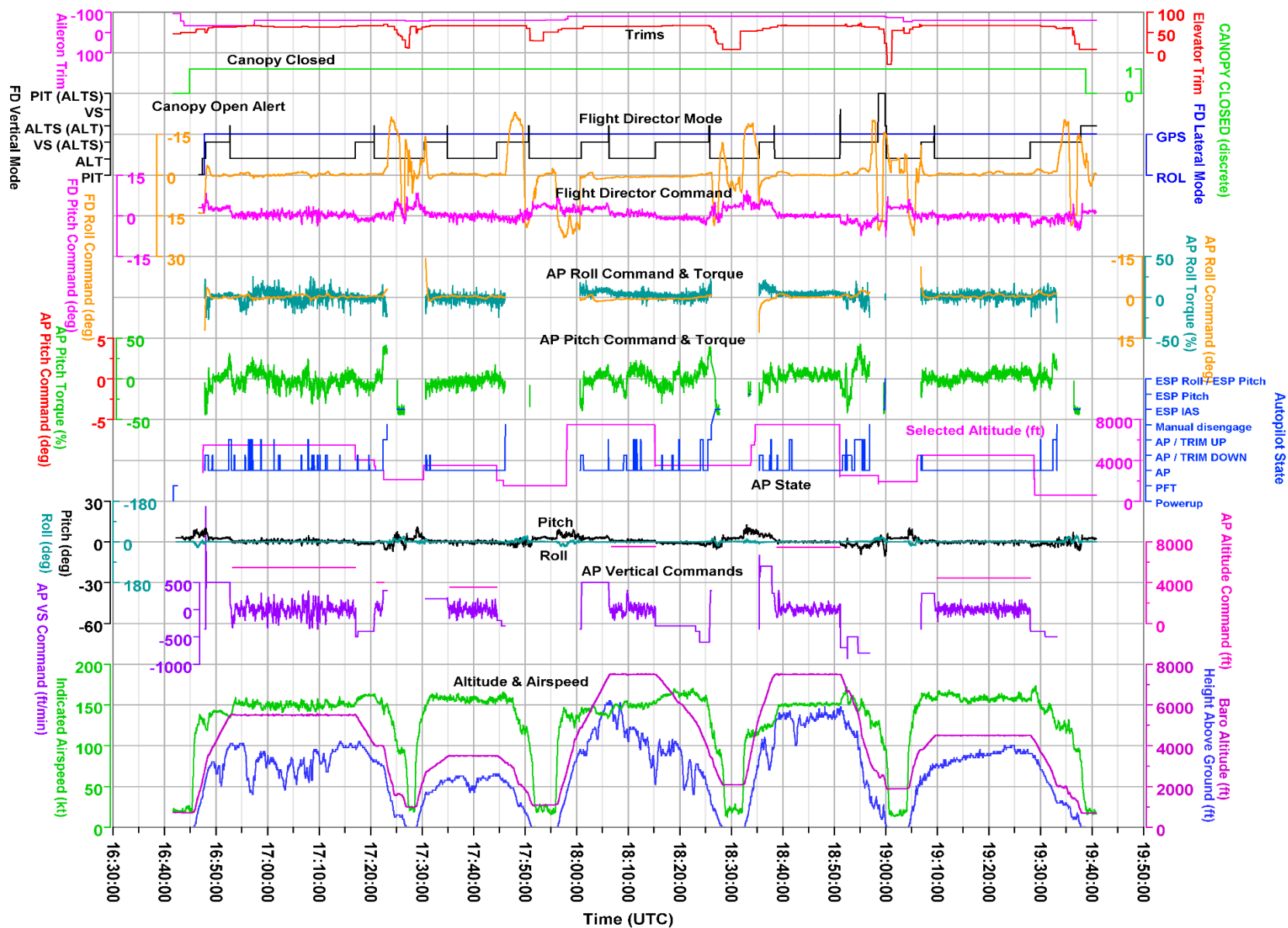


Figure 11. A plot of autopilot parameters during flight 37 which was conducted on June 17, 2023, showing all legs of the flight.

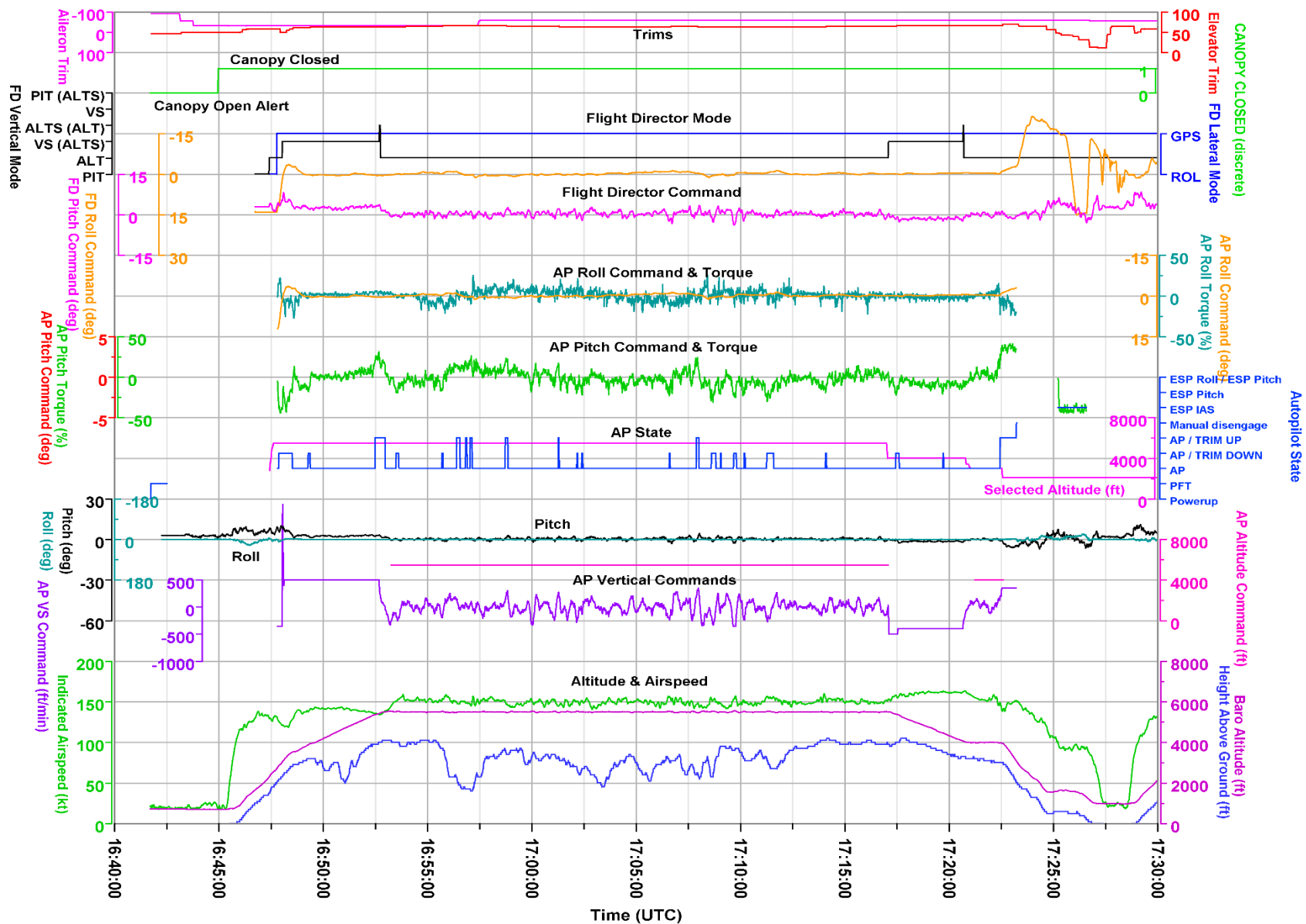


Figure 12. A plot of autopilot parameters during flight 37 which was conducted on June 17, 2023, showing the first leg of the flight.

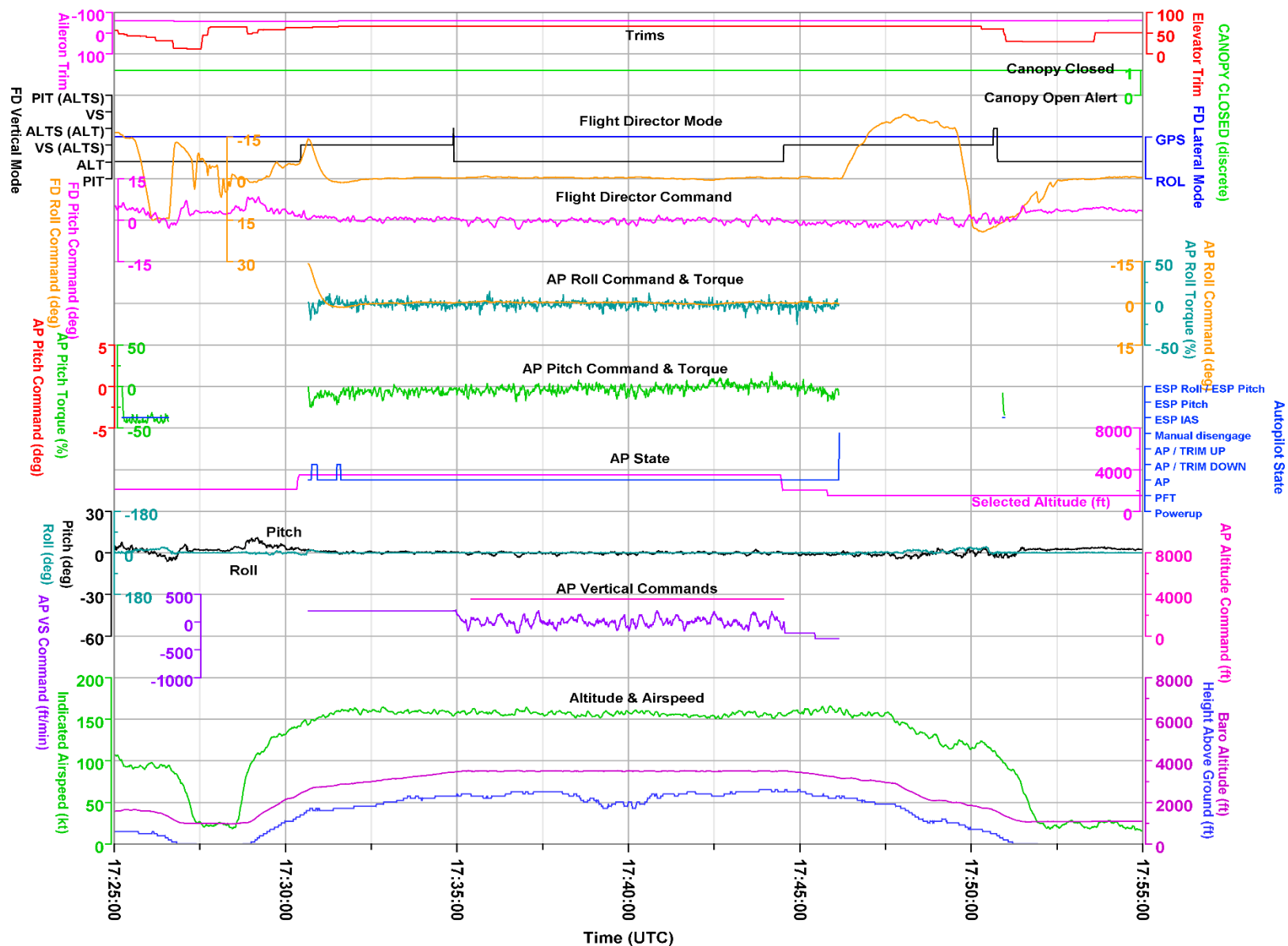


Figure 13. A plot of autopilot parameters during flight 37 which was conducted on June 17, 2023, showing the second leg of the flight.

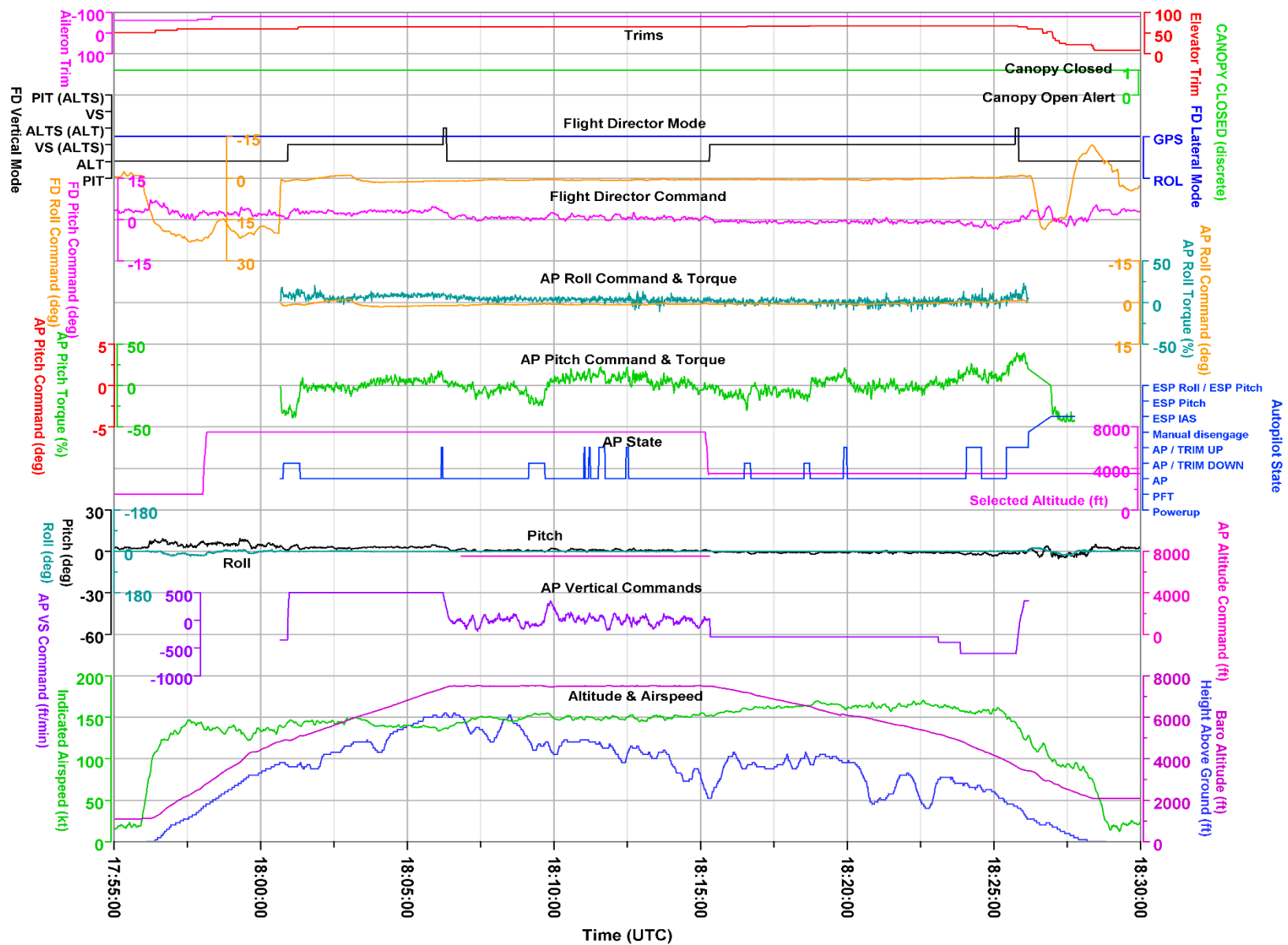


Figure 14. A plot of autopilot parameters during flight 37 which was conducted on June 17, 2023, showing the third leg of the flight.

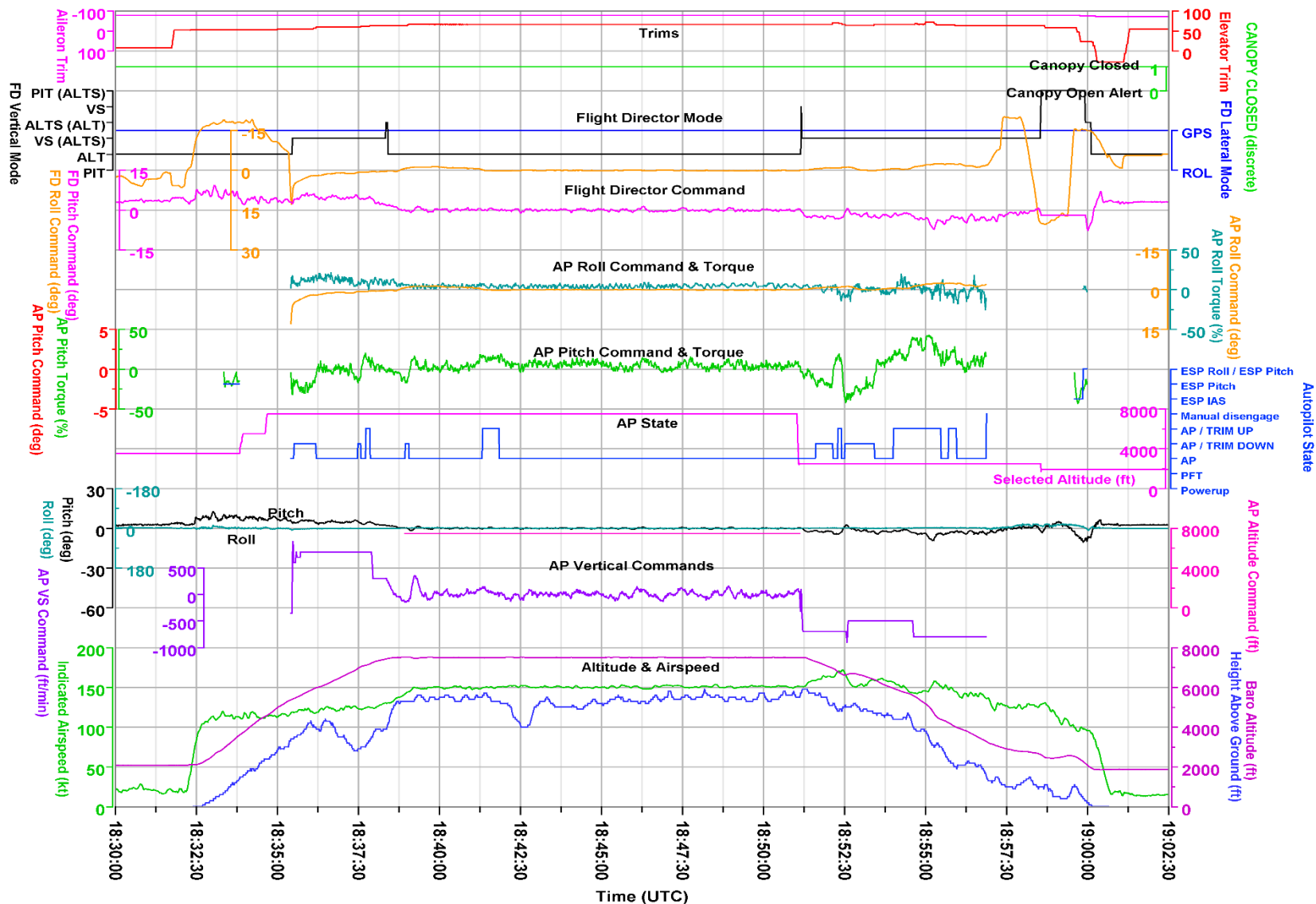


Figure 15. A plot of autopilot parameters during flight 37 which was conducted on June 17, 2023, showing the fourth leg of the flight.



Figure 16. A plot of autopilot parameters during flight 37 which was conducted on June 17, 2023, showing the fifth leg of the flight.

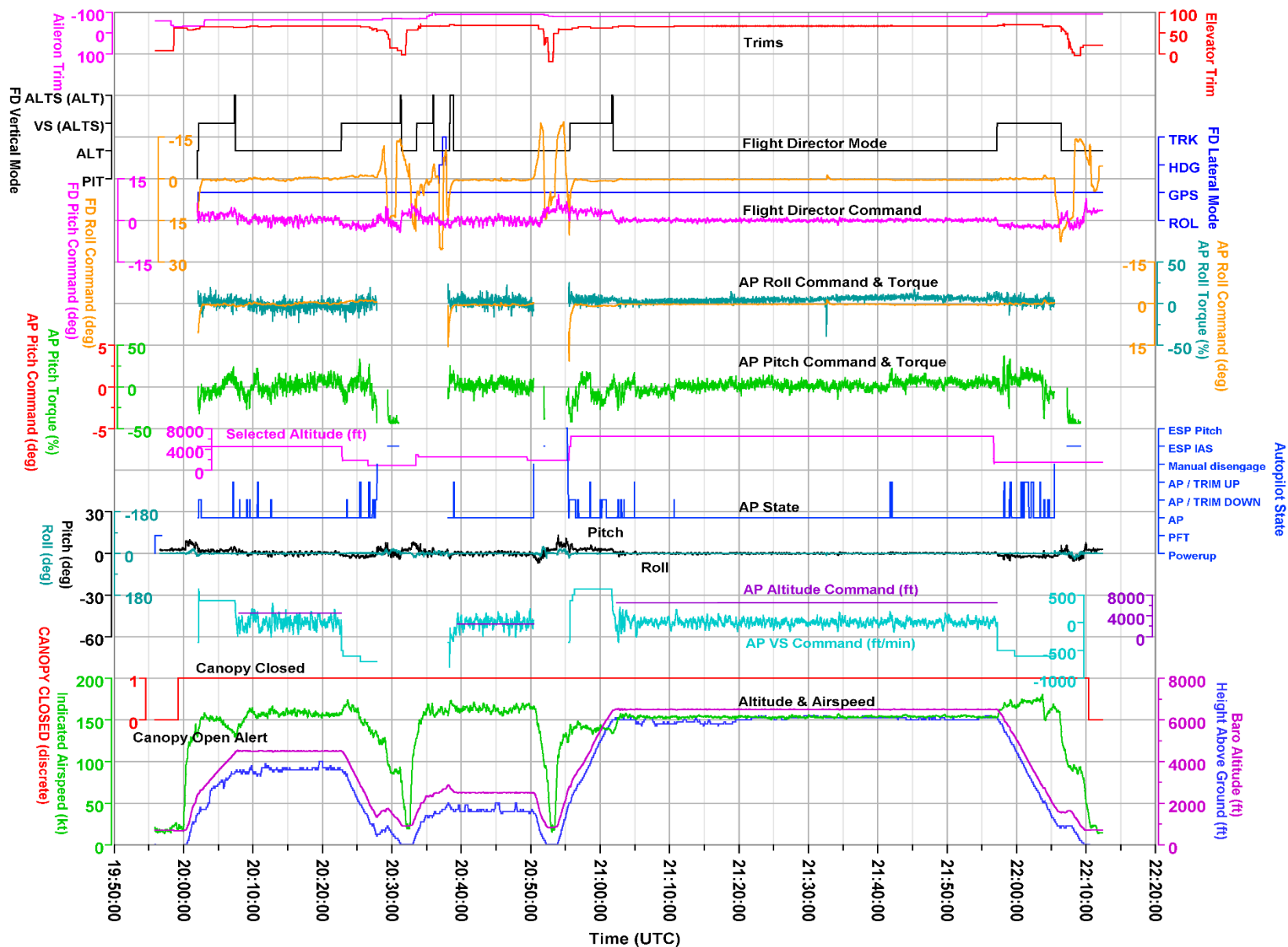


Figure 17. A plot of autopilot parameters for a session recorded on June 17, 2023. The Canopy warning parameter has been added.

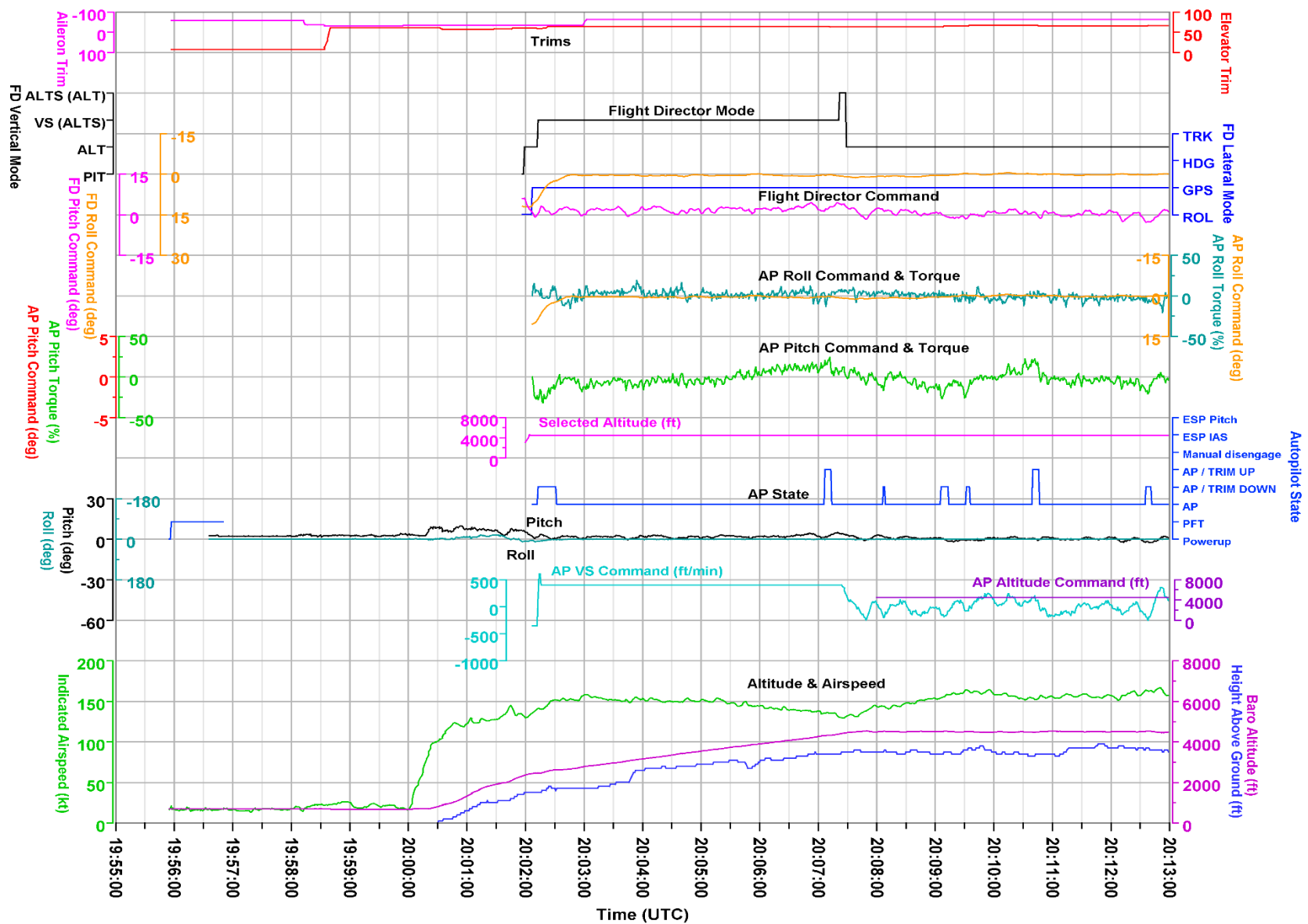


Figure 18. A plot of autopilot parameters for a portion of a session recorded on June 17, 2023, that showed the aircraft performing a climb using the autopilot.

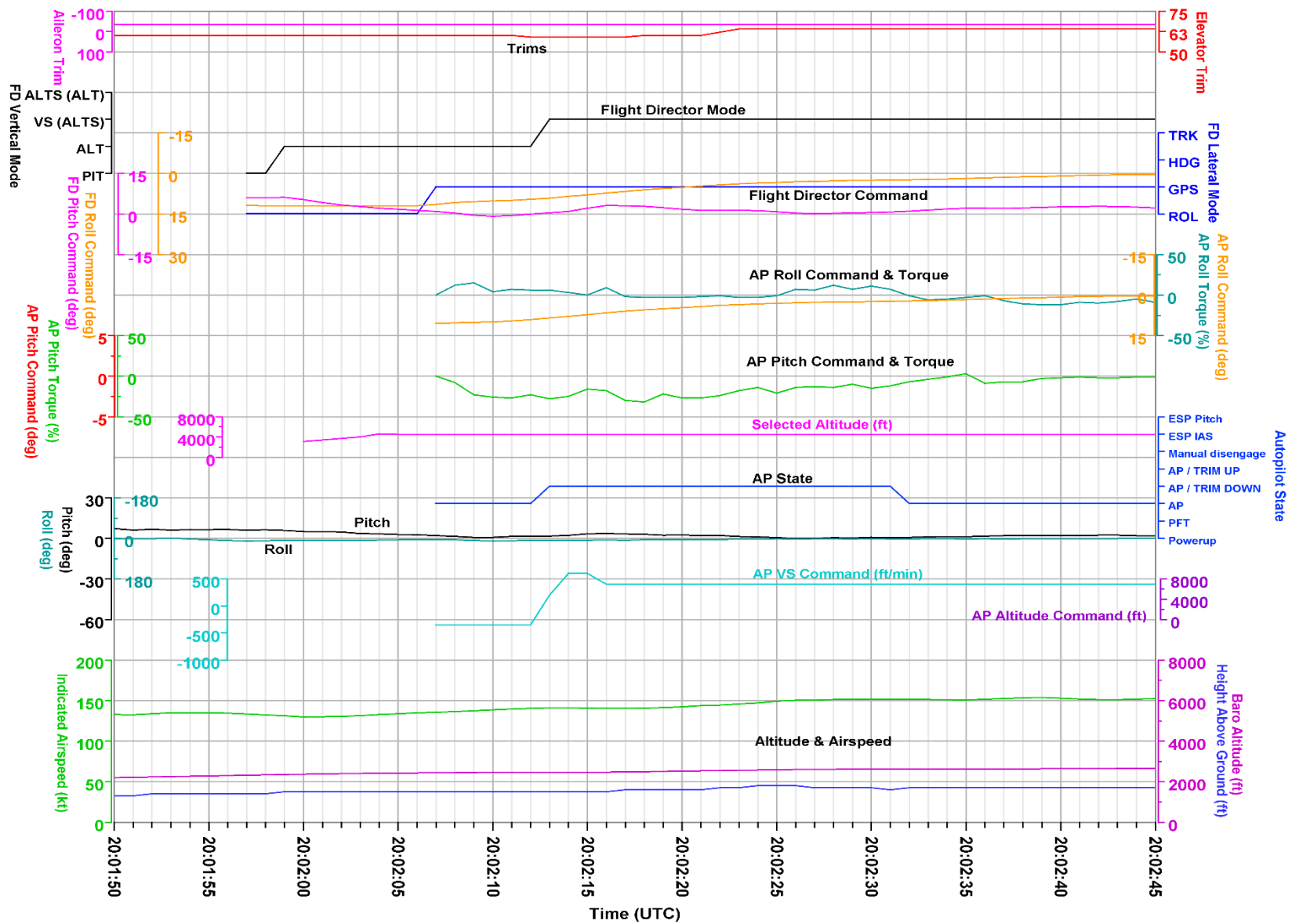


Figure 19. A plot of autopilot parameters for a portion of a session recorded on June 17, 2023, that details the aircraft performing a climb using the autopilot.

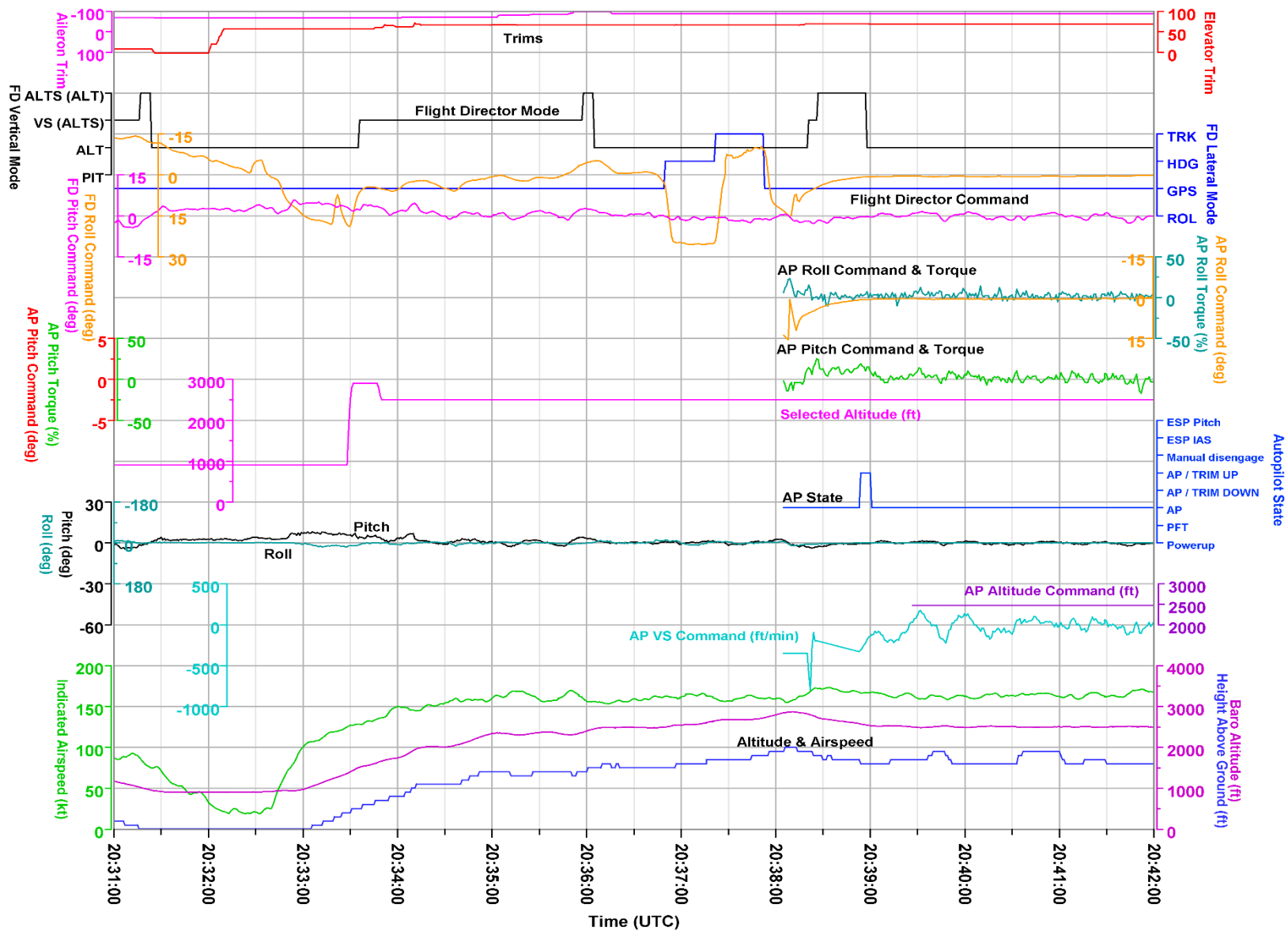


Figure 20. A plot of autopilot parameters for a portion of a session recorded on June 17, 2023, that showed the aircraft performing a different climb phase later in the session without using the autopilot and then engaging the autopilot.

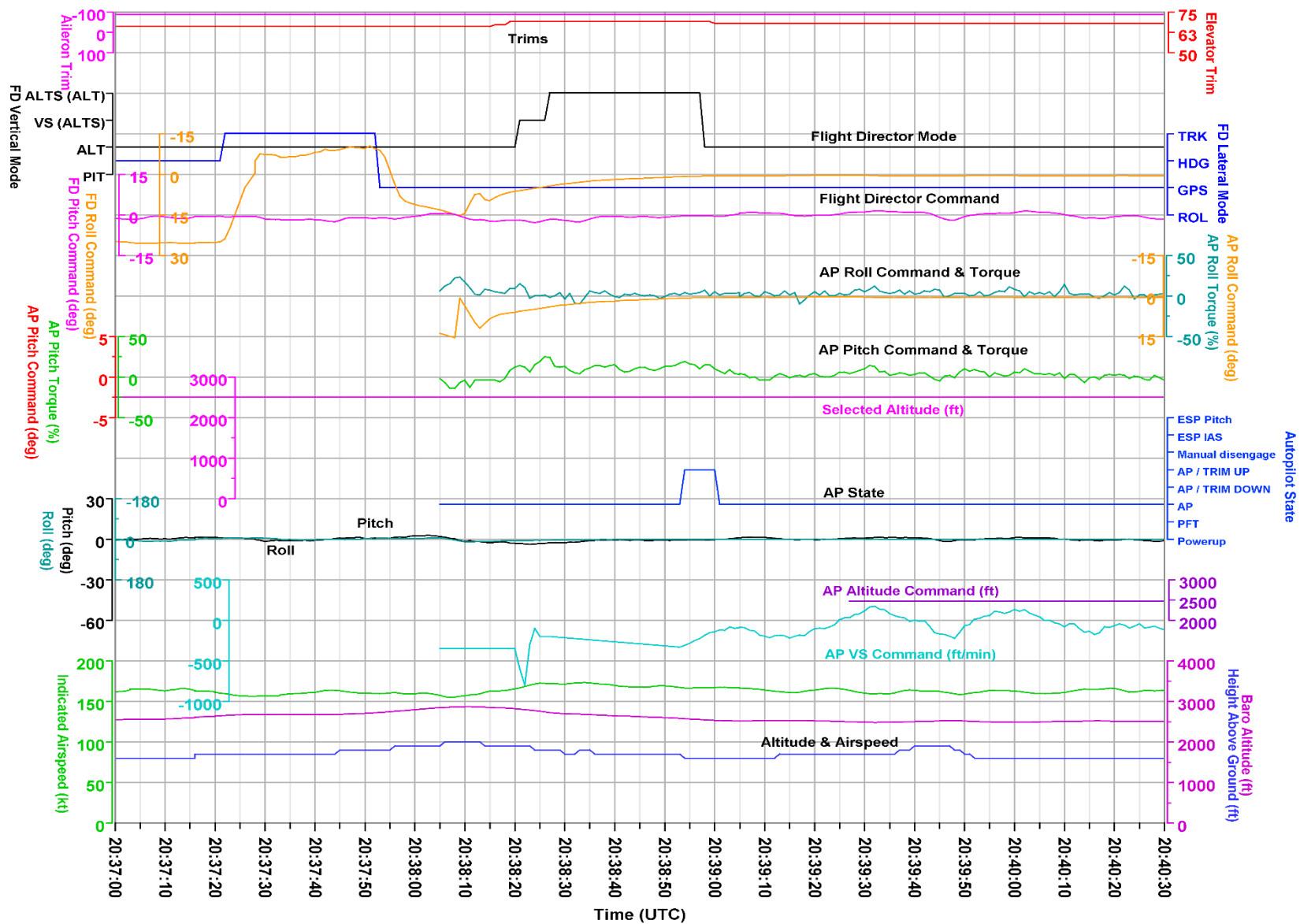


Figure 21. A plot of autopilot parameters for a portion of a session recorded on June 17, 2023, that details the aircraft completing a second climb and the portion of this session where the autopilot was reengaged.

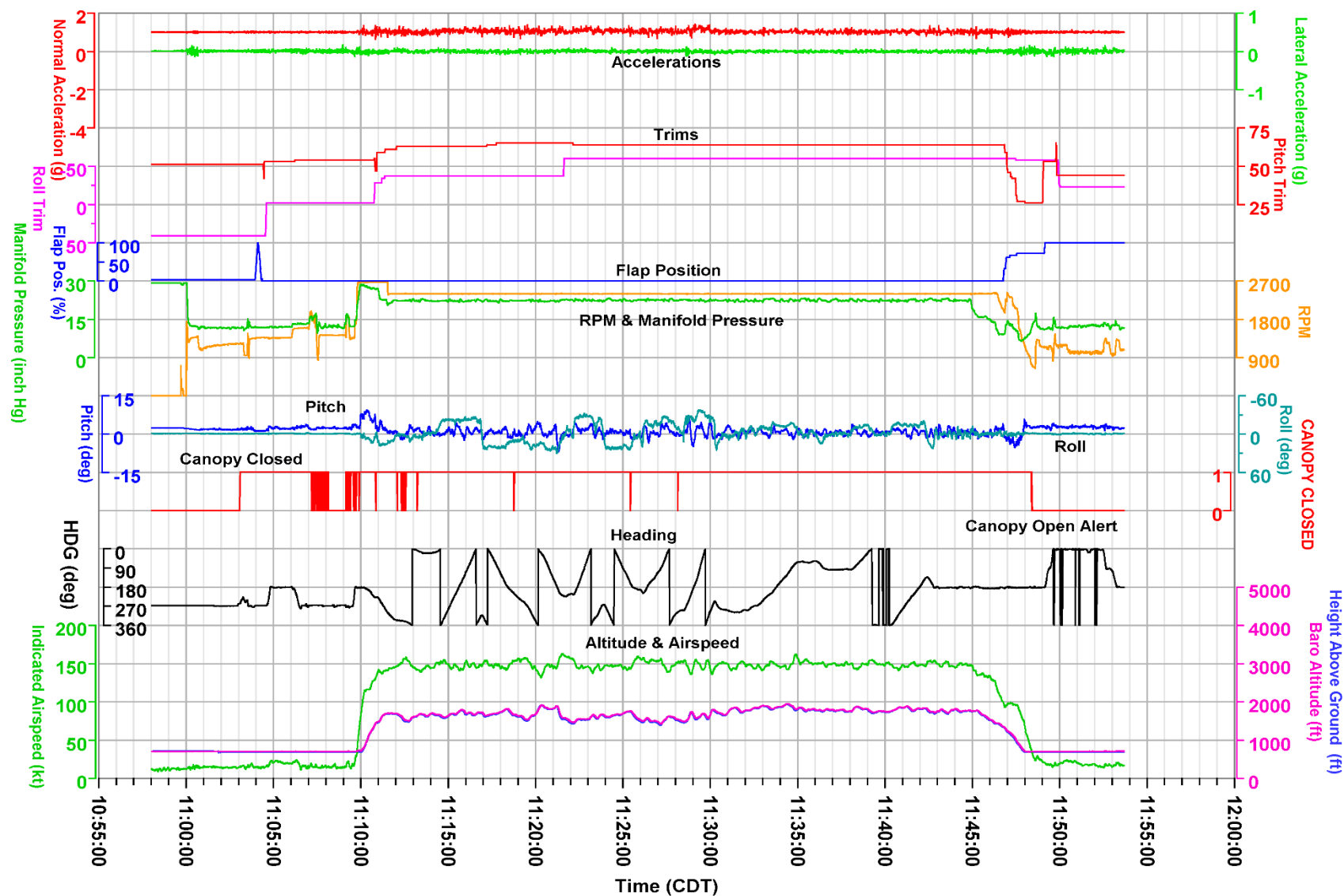


Figure 22. A plot of basic parameters during flight 39 which was conducted on August 6, 2023, showing canopy status.

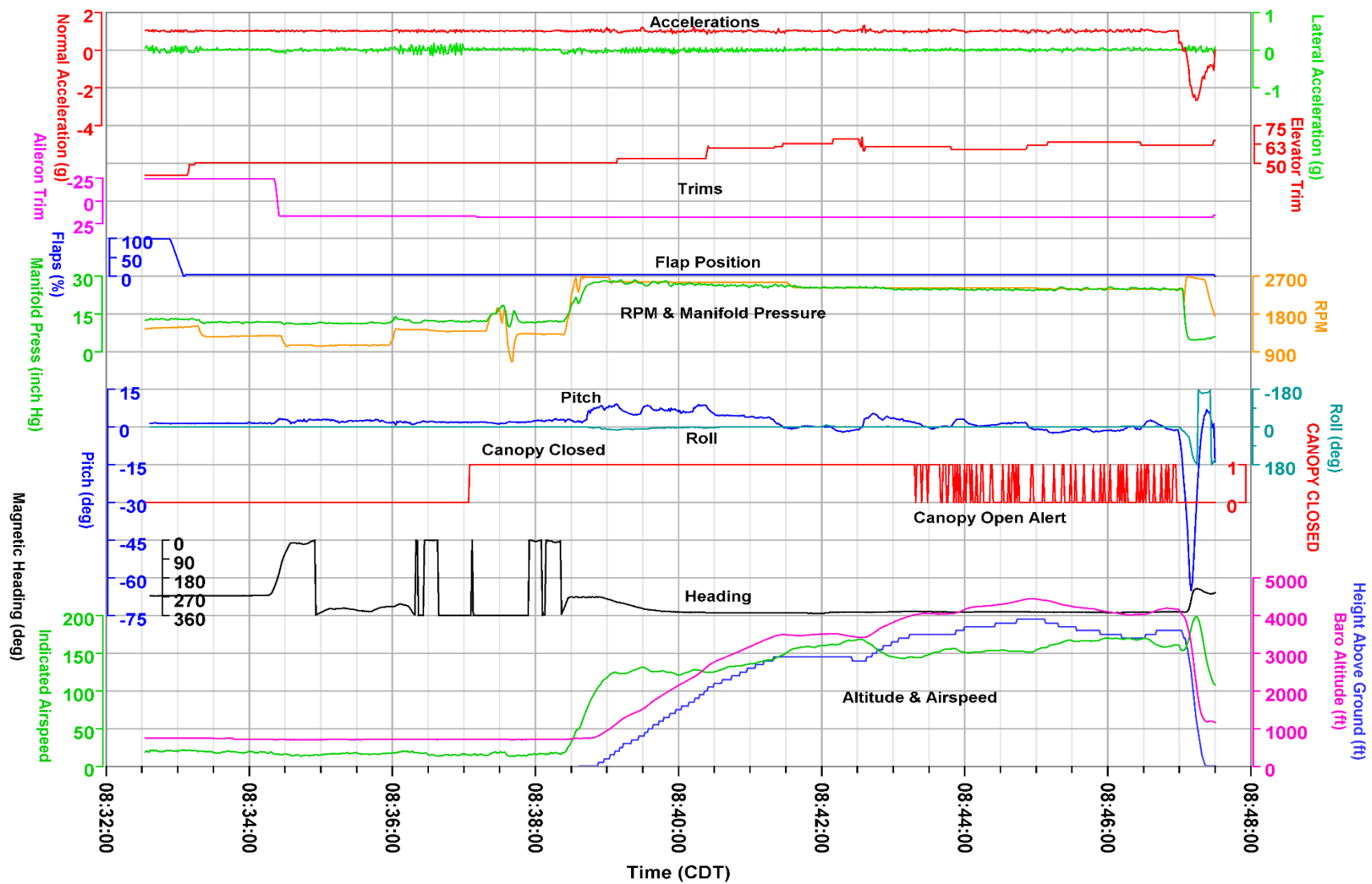


Figure 23. A plot of basic flight and engine parameters for the entire accident flight (flight 40).

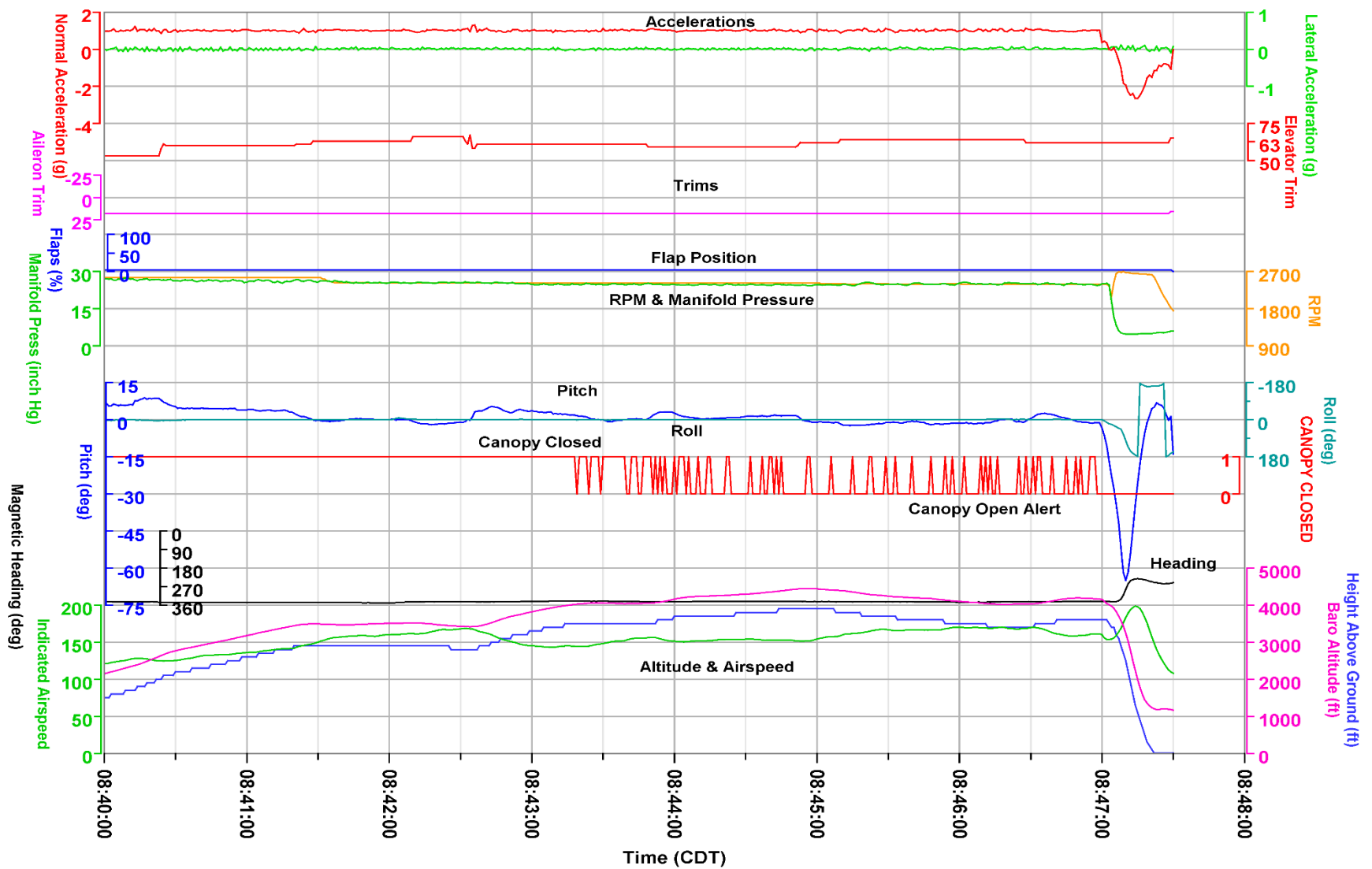


Figure 24. A plot of expanded basic flight and engine parameters for the last approximately 8 minutes of the accident flight.

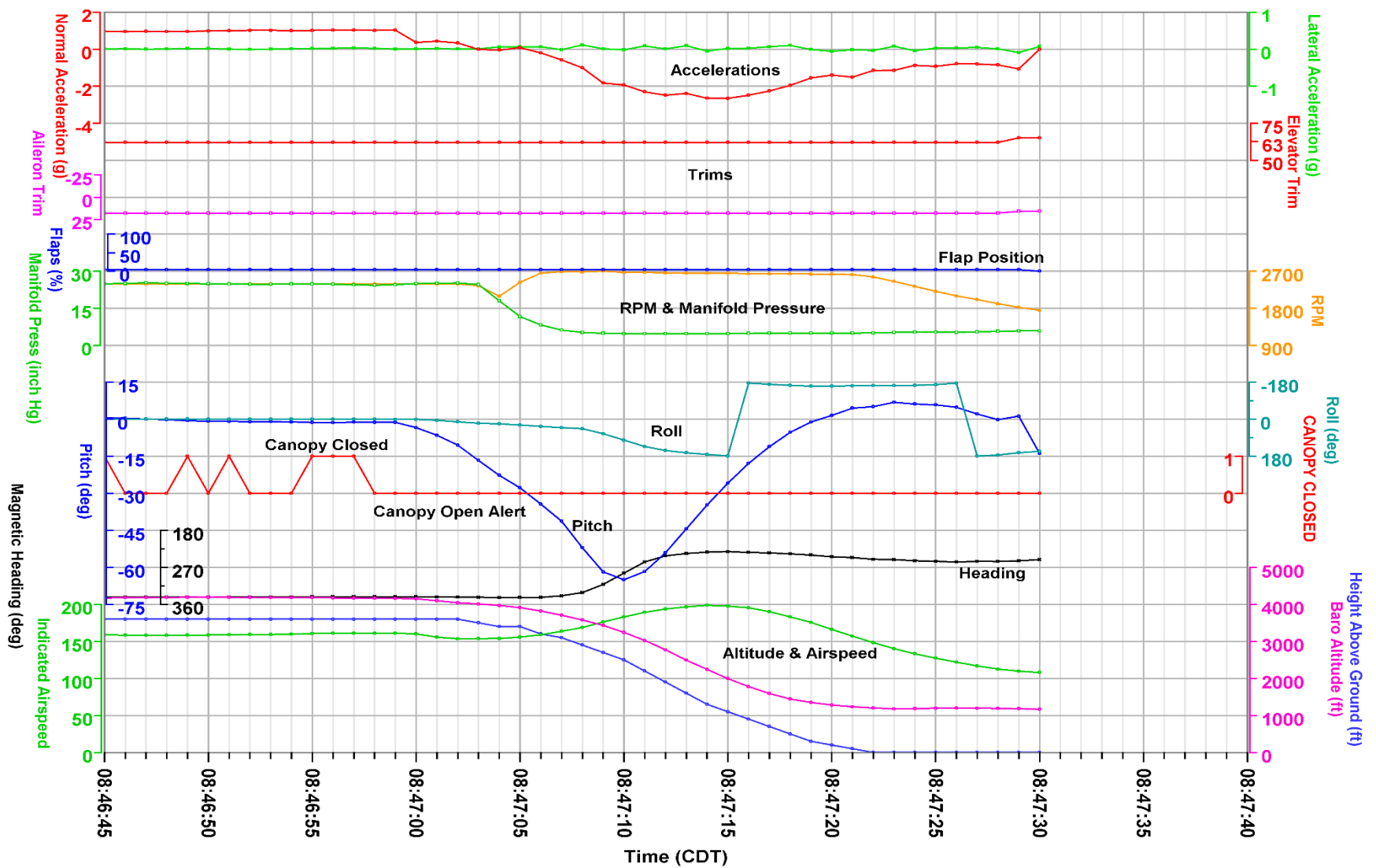


Figure 25. A plot of expanded basic flight and engine parameters for the last 45 seconds of flight.

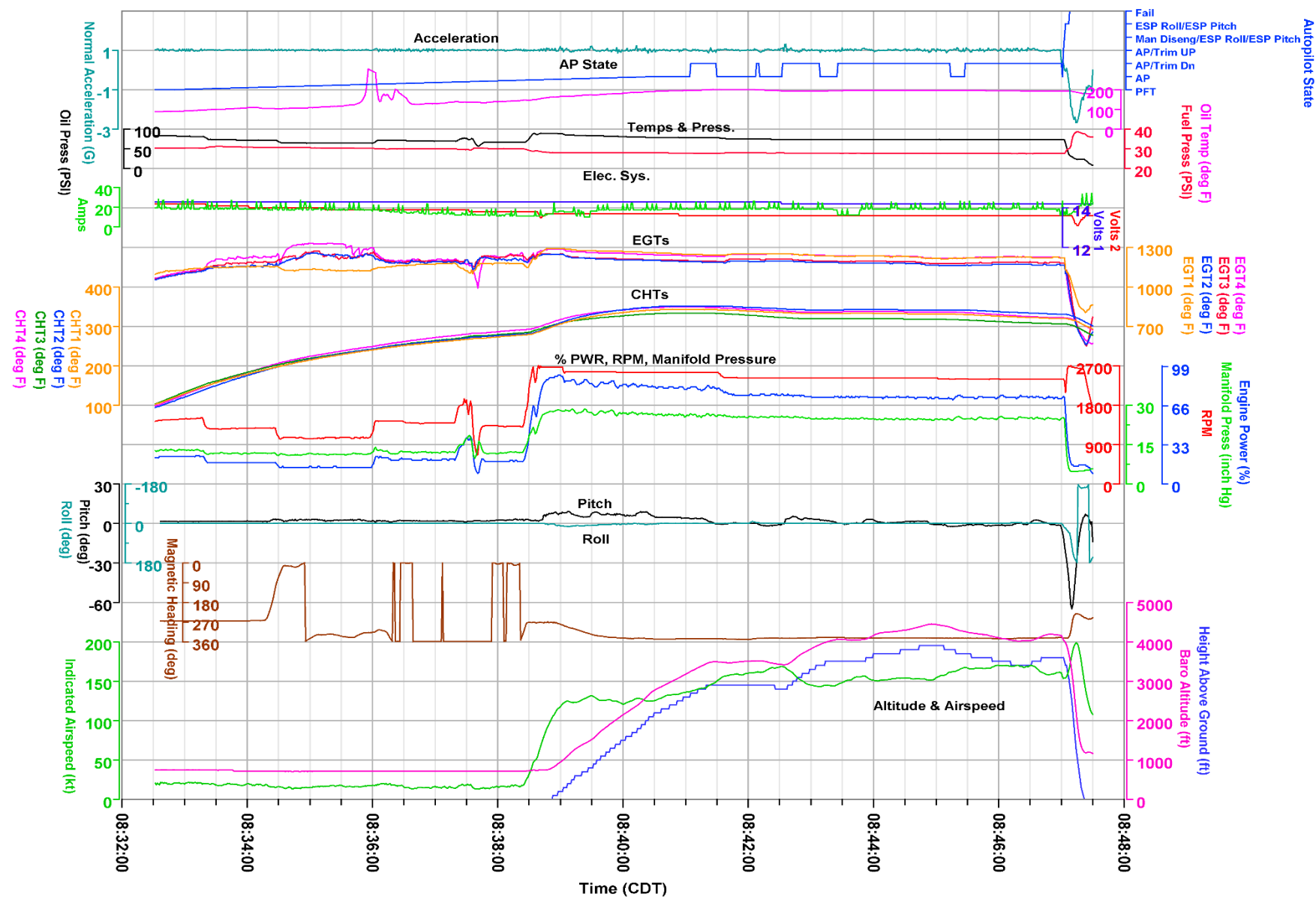


Figure 26. All available engine parameters for the entire accident flight.

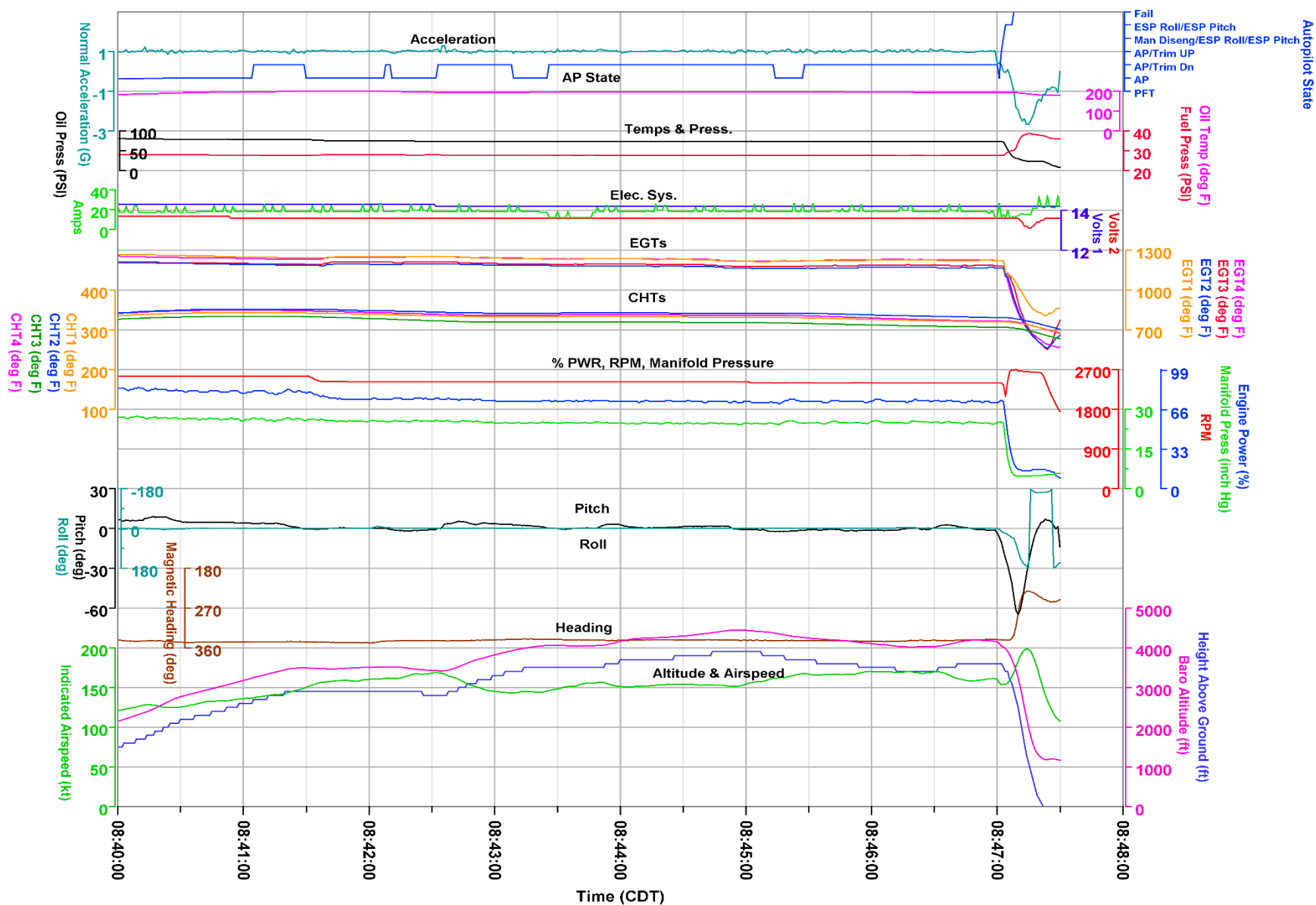


Figure 27. A plot of engine parameters for the last approximately 8 minutes of flight.

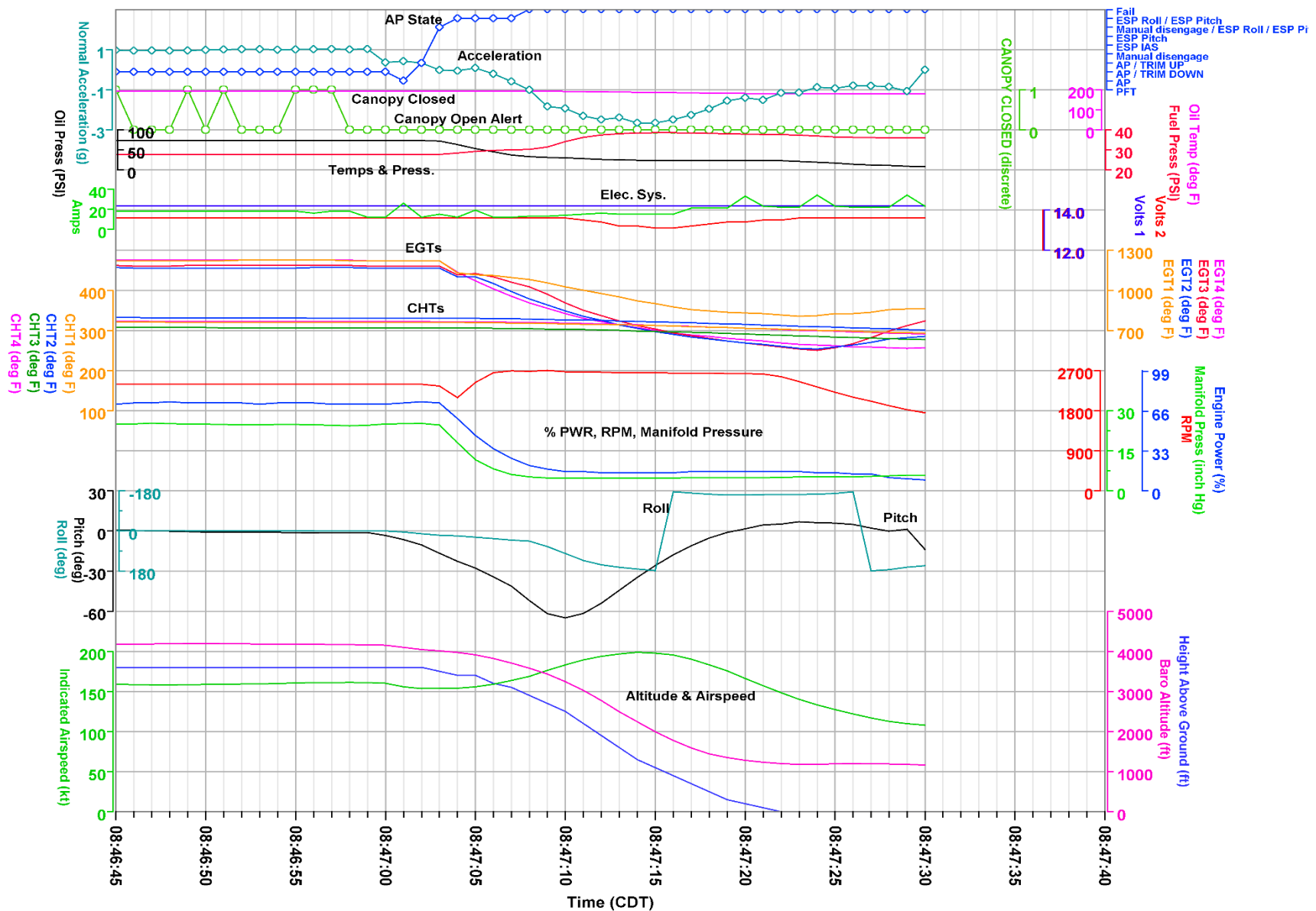


Figure 28. A plot of engine parameters for the last 45 seconds of flight. Canopy Status has been added to this plot.

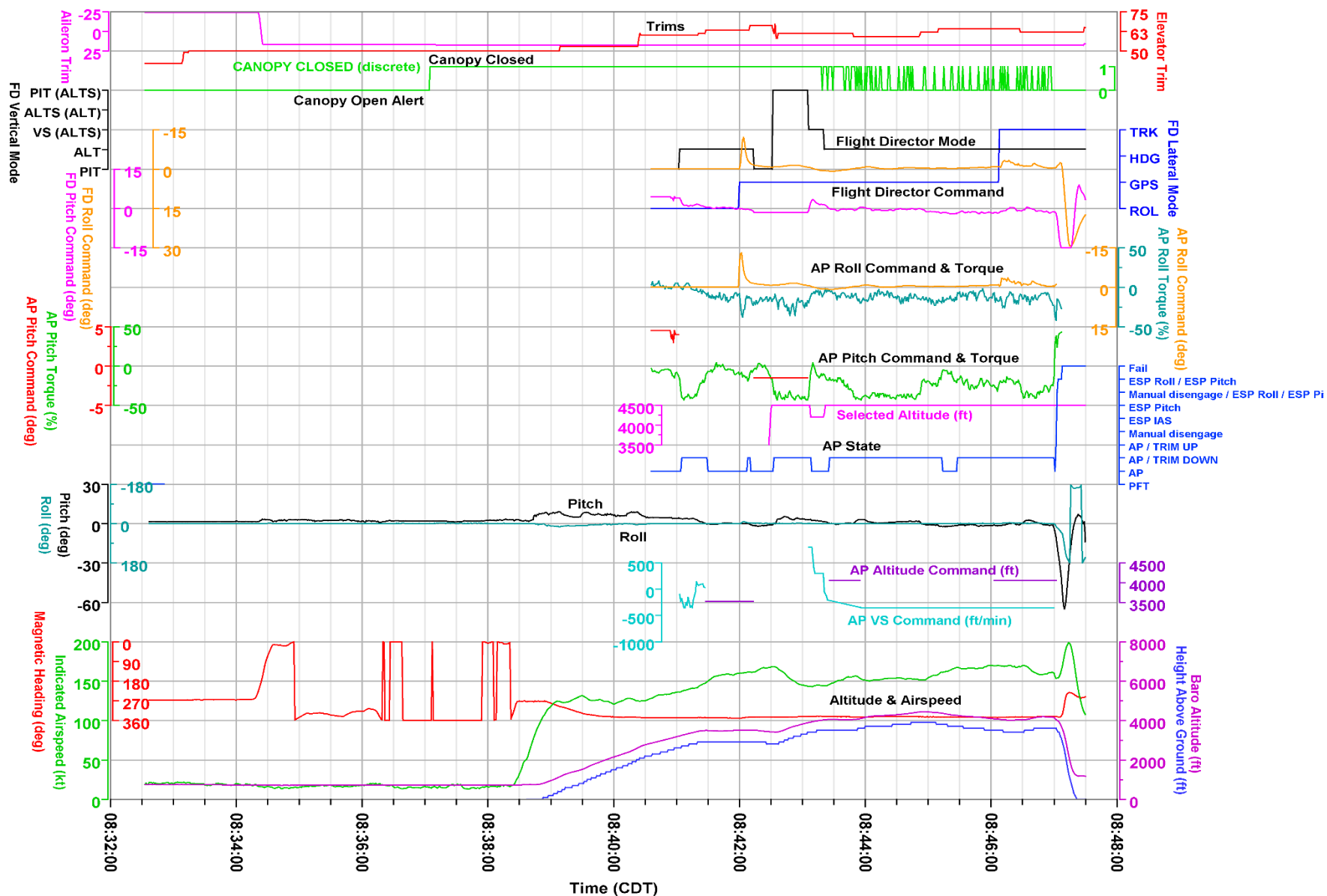


Figure 29. A plot of autopilot related parameters for the entire accident flight.

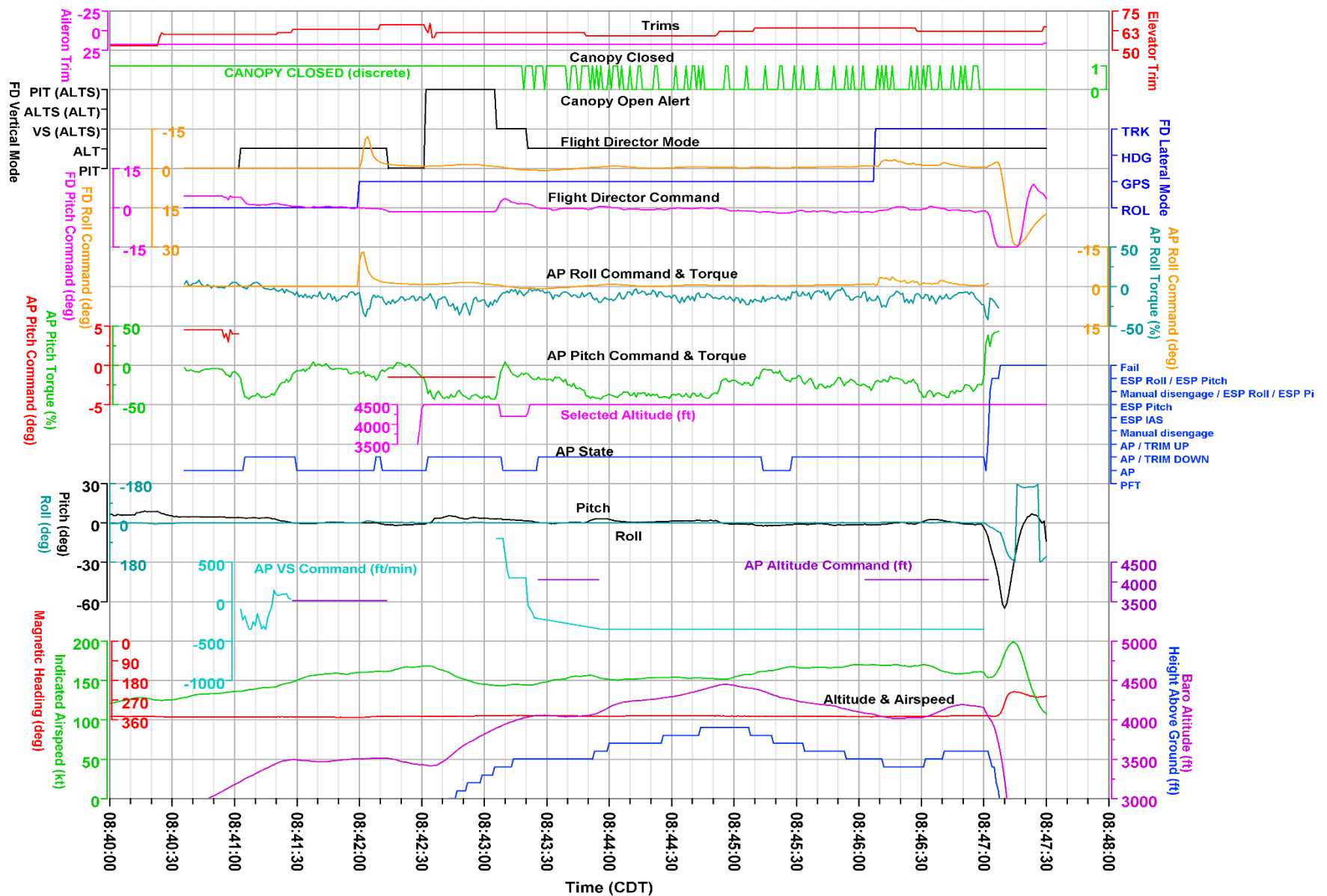


Figure 30. A plot of autopilot related parameters for the last approximately 8 minutes of flight.

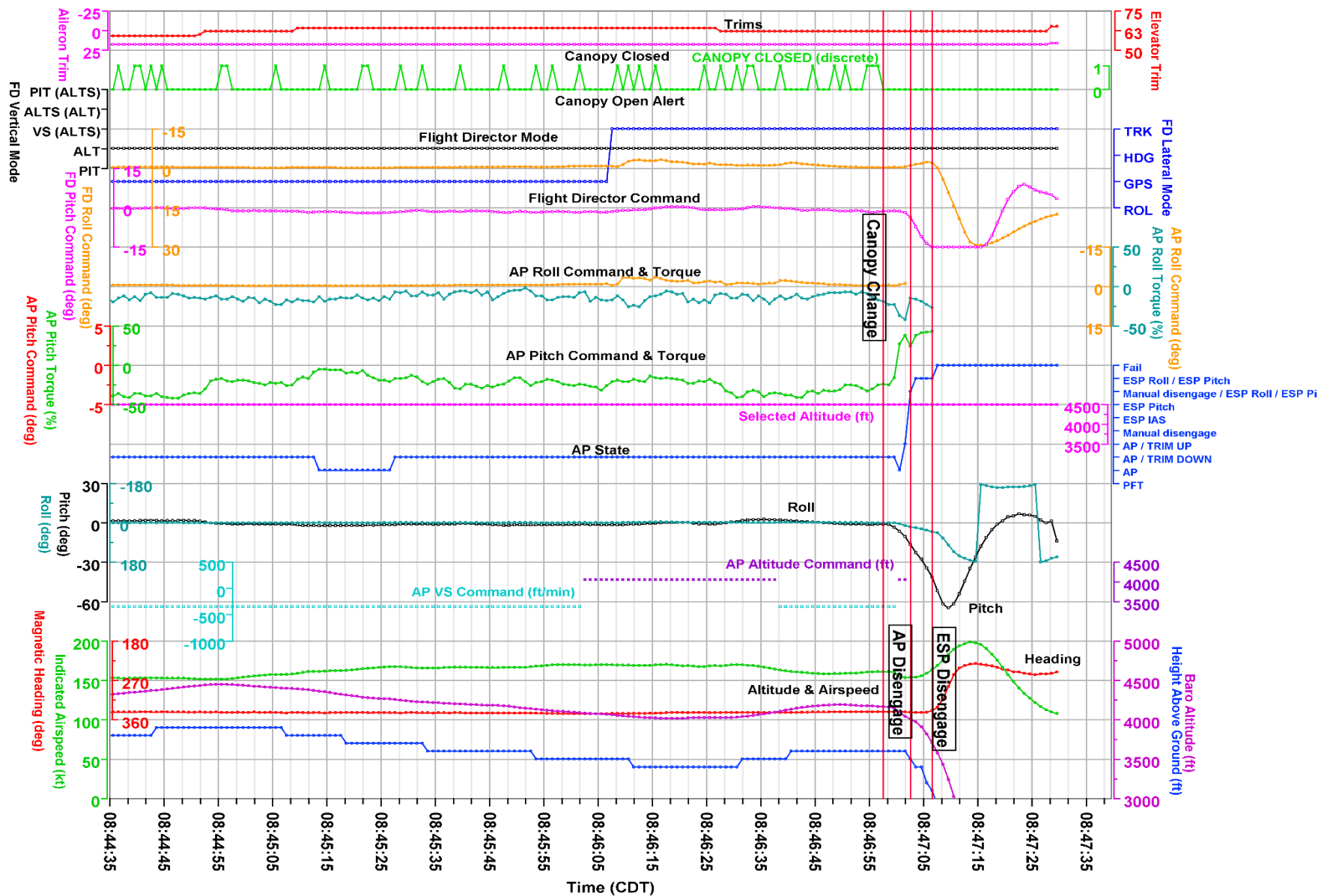


Figure 31. A plot of autopilot related parameters for the last 3 minutes of flight.

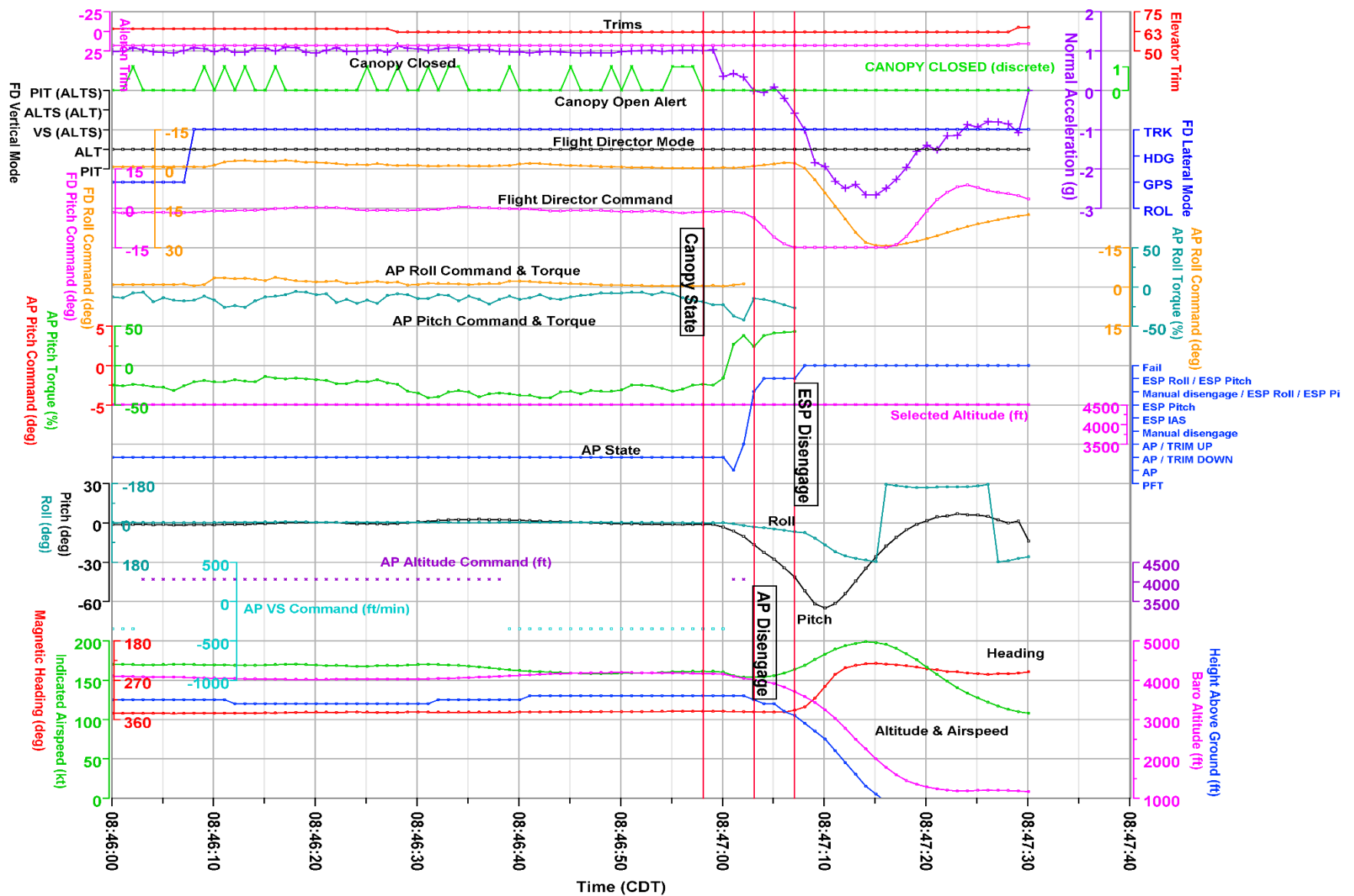


Figure 32. A plot of autopilot related parameters for the last 100 seconds of flight. The values for Normal Acceleration (Z Accel.) have been added to this plot.

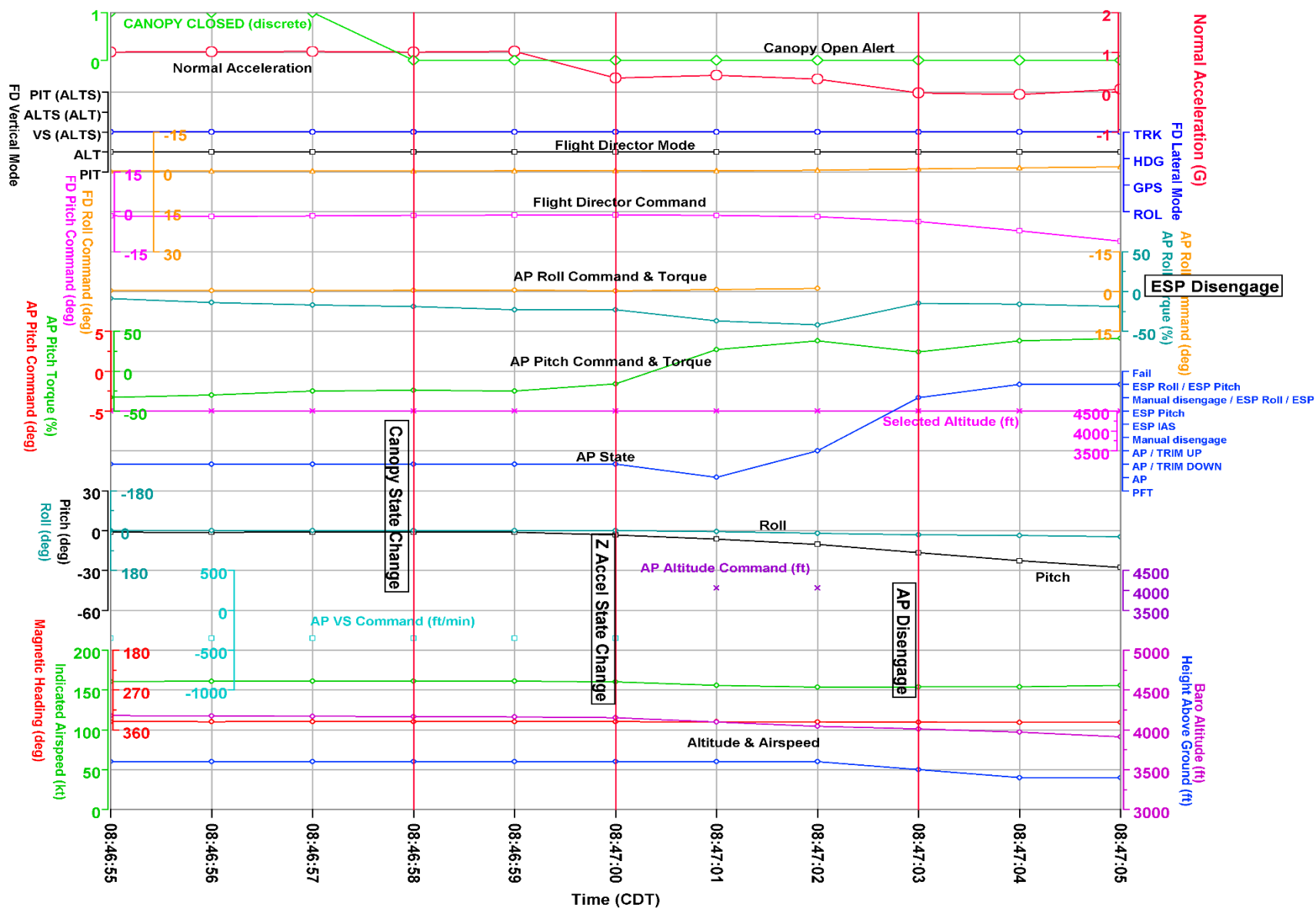


Figure 33. A plot of autopilot related parameters for the portion of time centered around the time of the onset of the negative pitch event. The values for Normal Acceleration (Z Accel.) have been added to this plot.

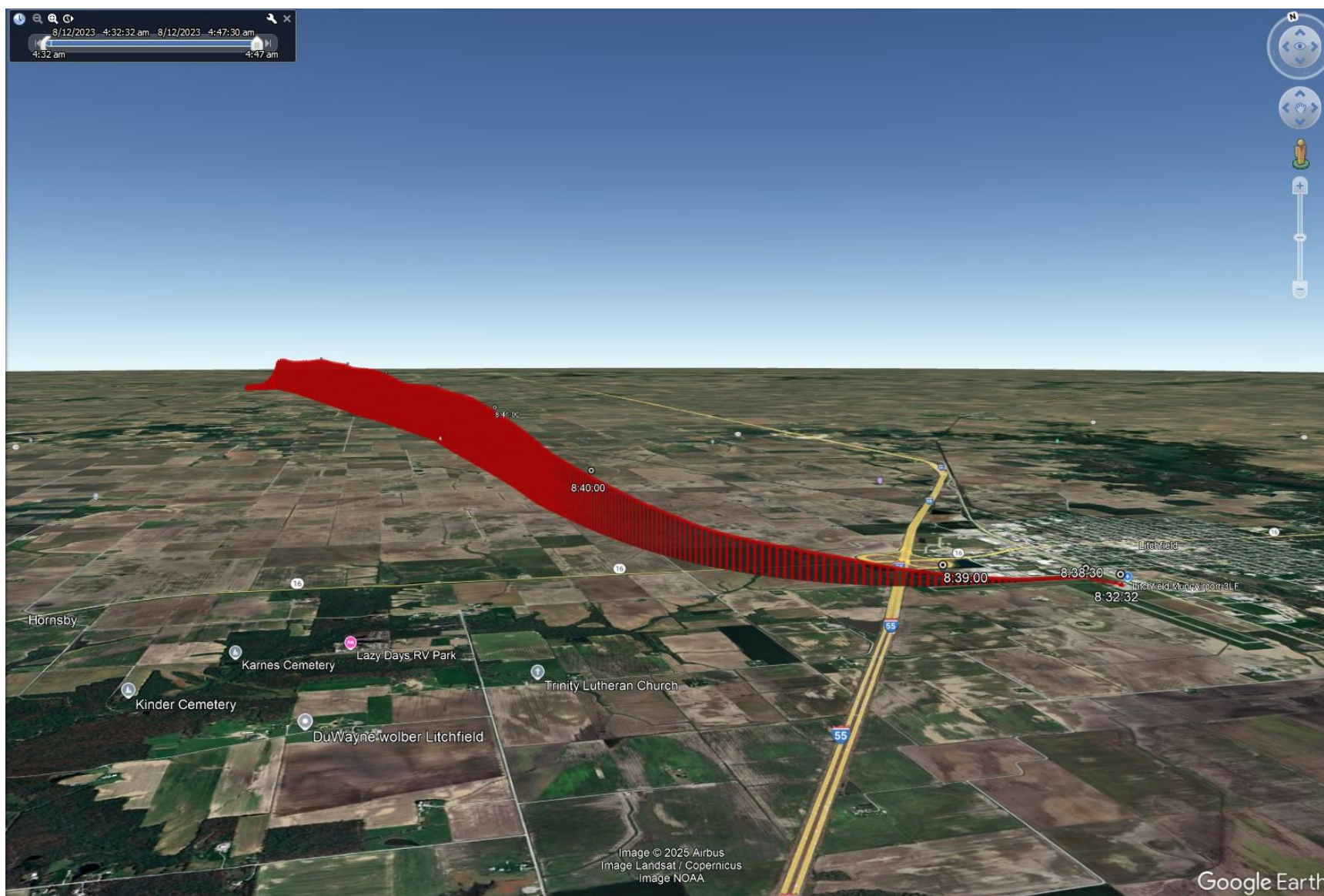


Figure 34. A Google Earth KML of the accident flight track for the entire flight. The orientation is roughly north-up.

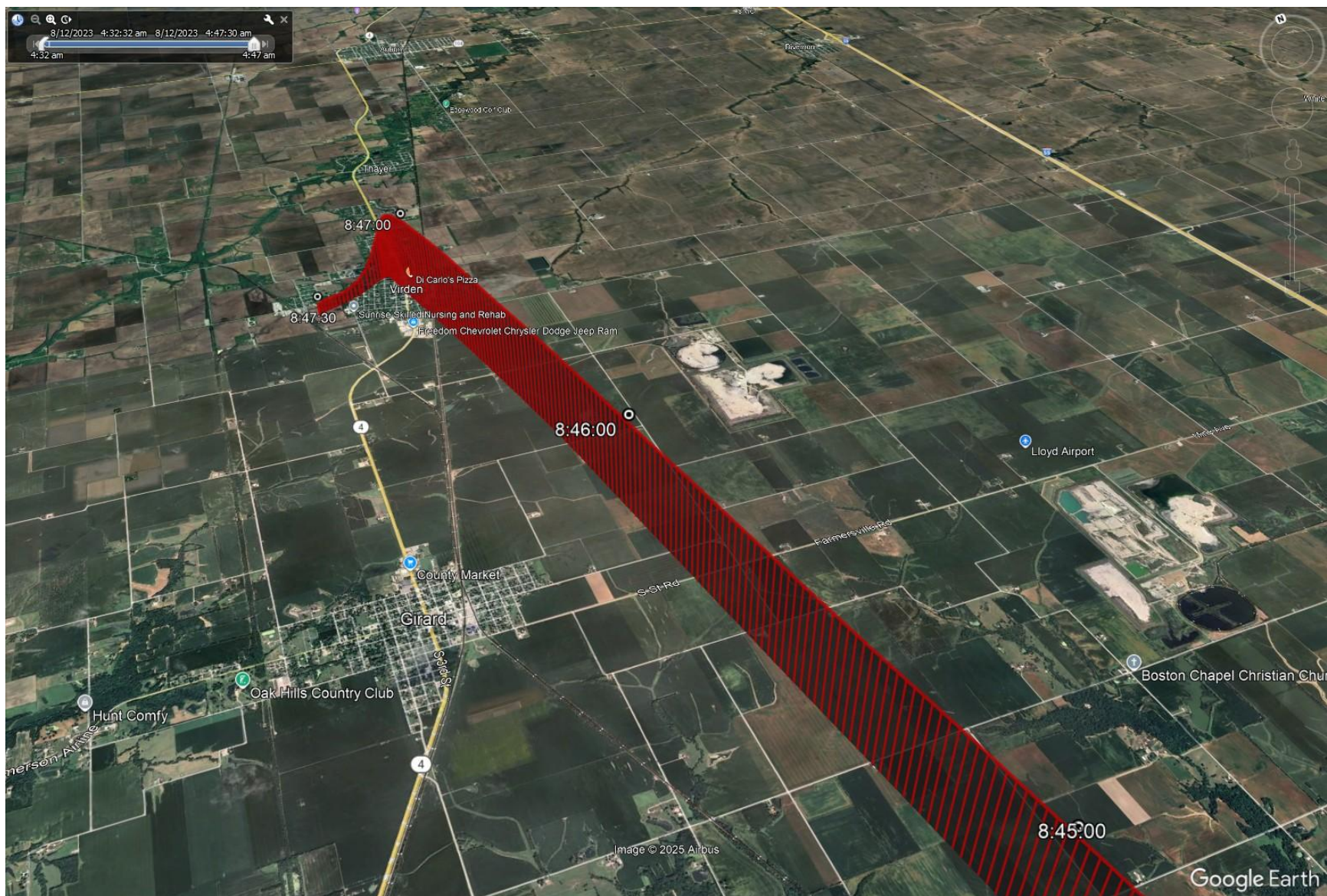


Figure 35. A Google Earth KML of the accident flight track for the last two and half minutes of flight. The orientation is roughly north-up.

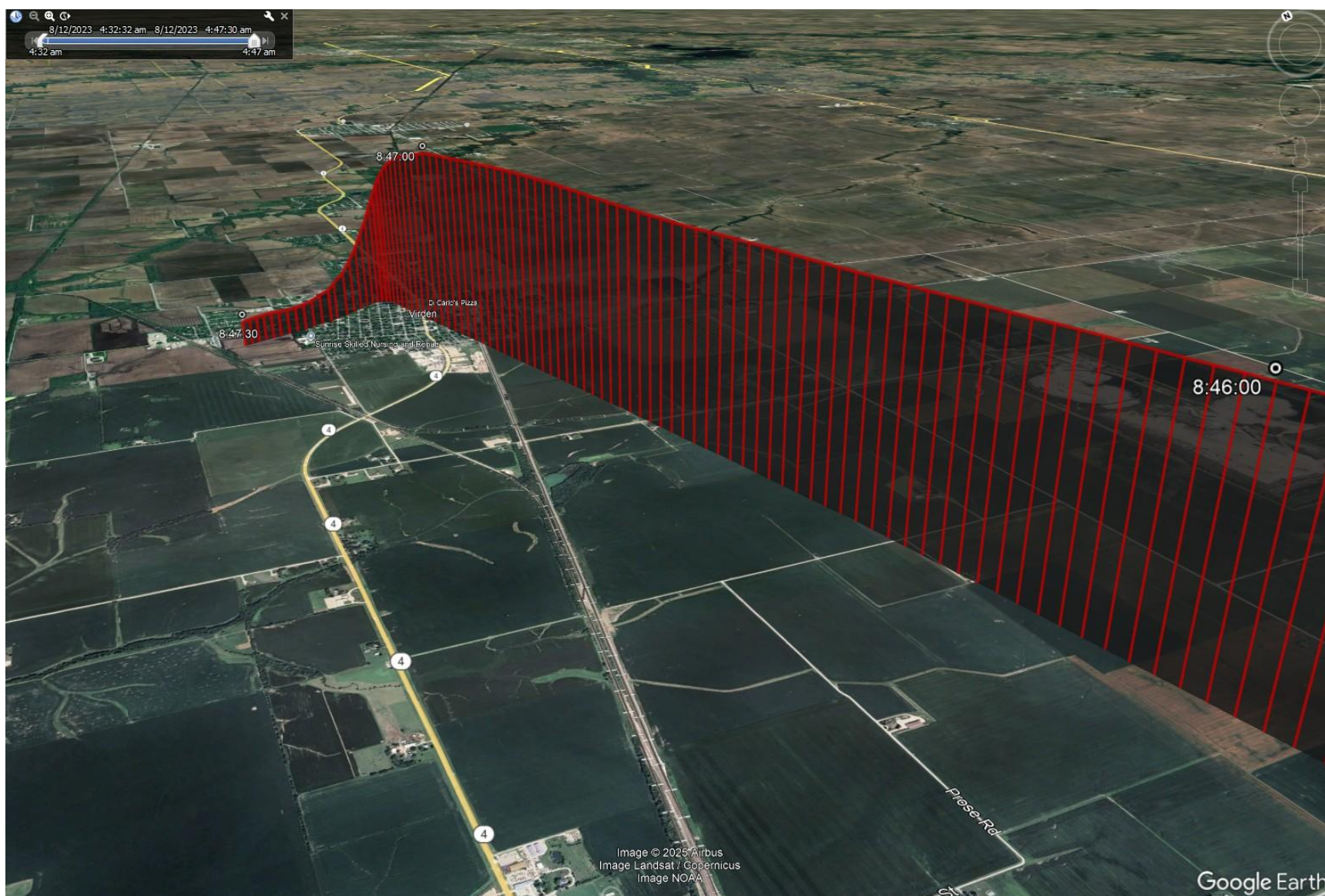


Figure 36. A Google Earth KML of the accident flight track for the final minute and a half of flight. The orientation is roughly north-up. Note, the recorded altitude used to construct this KML may not accurately represent the aircraft's height above ground.



Figure 37. A Google Earth KML showing the aircraft's descent to the wreckage site. Note, the recorded altitude used to construct this KML may not accurately represent the aircraft's height above ground.

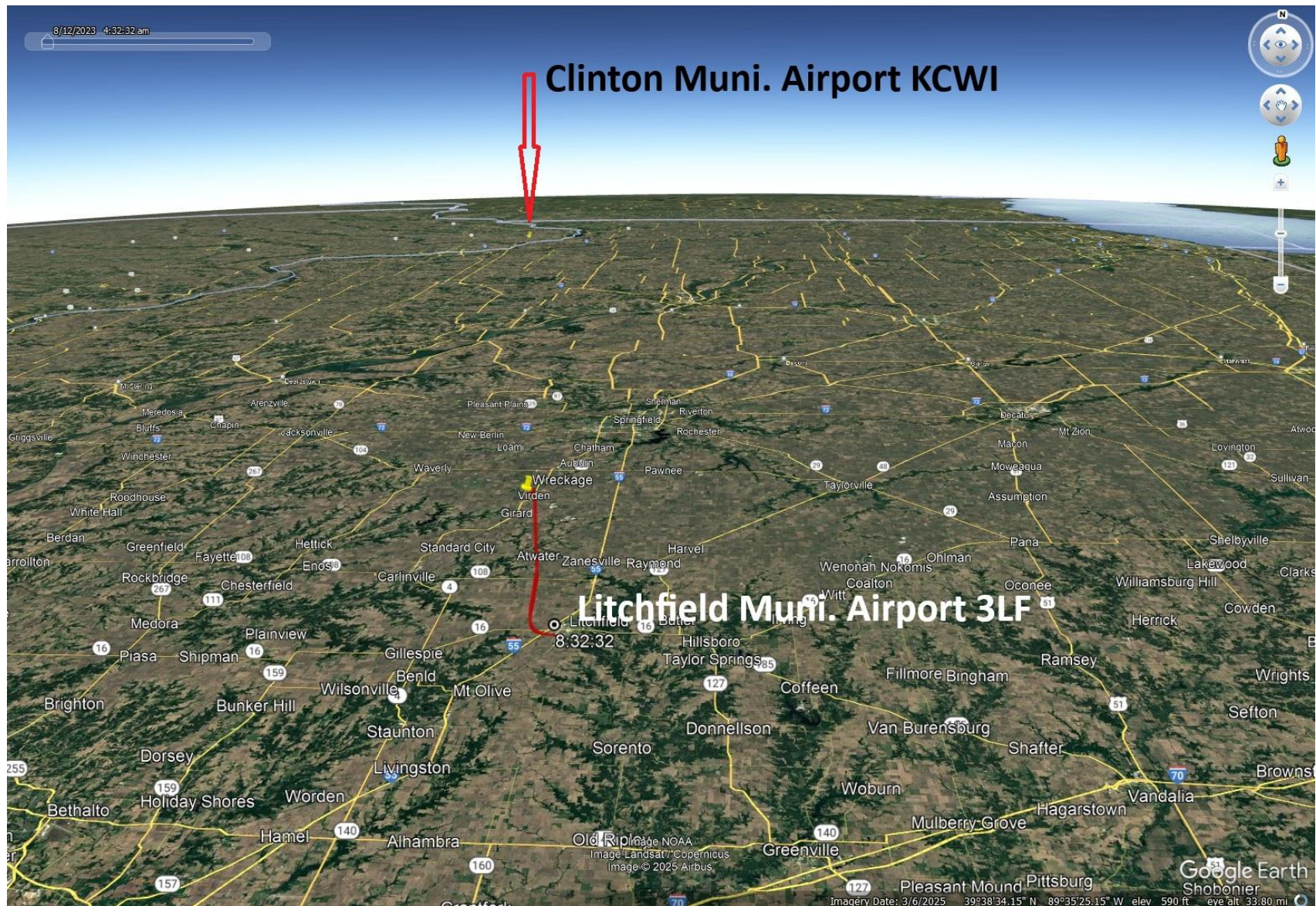


Figure 38. A Google Earth KML showing the aircraft's ground track in relation to the KCWI waypoint, which was entered into the Garmin G3X.

Table A-2. Parameter and Unit Definitions.

Parameter Name (Units)	Parameter Definition (Unit Definition)
Date	Date Given In Gregorian Calendar
Time	Local Time Based on Unit's Position
UTC Offset	Hours offset from UTC to local time
Latitude (deg)	Latitude (degrees)
Longitude (deg)	Longitude (degrees)
GPS Altitude (ft)	Global Positioning System (GPS) altitude/Height Above Ground (feet)
GPS Fix Status	Positive GPS Fix and Given Source (3D, 3DDiff)
GPS Time of Week (sec)	Elapsed Seconds in Standard GPS Week (seconds)
GPS Ground Speed (kt)	Groundspeed (knots)
GPS Ground Track (deg)	Ground Track (degrees True)
GPS Velocity E (m/sec)	Ground Track Velocity Vector Easterly Component (meters per second)
GPS Velocity N (m/sec)	Ground Track Velocity Vector Northerly Component (meters per second)
GPS Velocity U (m/sec)	Ground Track Vector Upward Component (Meters per second)
Magnetic Heading (deg)	Magnetic Heading (degrees magnetic)
GPS PDOP	GPS Position Dilution of Precision
GPS Sats	Number of Connected GPS Satellites (number of satellites)
Pressure Altitude (ft)	Pressure Altitude (feet)
Baro Altitude (ft)	Barometric Altitude (feet)
Vertical Speed (ft/min)	Vertical Speed (feet per minute)
Indicated Airspeed (kt)	Indicated Airspeed (knots)
True Airspeed (kt)	True Airspeed (knots)
Pitch (deg)	Pitch Angle (degrees)
Roll (deg)	Roll Angle (degrees)
Lateral Acceleration (g)	Lateral Acceleration (g)
Normal Acceleration (g)	Normal Acceleration (g)
AOA Cp	Angle of Attack Calculated Coefficient of Pressure
AOA	Calculated Angle of Attack (Units 0-1, where 0 is minimum displayable and 1 is the calibrated AoA stall.)
Selected Heading (deg)	Selected Heading (degrees)
Selected Altitude (ft)	Selected Altitude (feet)
Selected Vertical Speed (ft/min)	Selected Vertical Speed (Autopilot) (feet per minute)
Selected Airspeed (kt)	Selected Airspeed (Autopilot) (knots)
Baro Setting (inch Hg)	Barometric Pressure Setting (inches of Mercury)
COM Frequency (MHz)	Selected Communications Radio Frequency (Megahertz)
Active Nav Source	Active Navigational Source (CDI/GPS)
Nav Annunciation	Navigational System Message Available
Nav Identifier	Selected Navigational Identifier (IDENTIFIER)
Nav Distance (nm)	Distance to Selected Waypoint (Nautical Miles)
Nav Bearing (deg)	Bearing to Selected Waypoint (degrees)

Nav Course (deg)	Course to Selected Waypoint (degrees)
Nav Cross Track Distance (nm)	Cross track distance in Relation to Selected Waypoint (Nautical Miles)
Horizontal CDI Deflection	Course Deviation Indicator - Deflection on the Horizontal Scale (1.0 represents full scale deflection which is equal to 2 dots)
Horizontal CDI Full Scale (ft)	Course Deviation Indicator - Horizontal Deflection in Feet Corresponding to Full-Scale Deflection of 2 Dots (feet)
Horizontal CDI Scale	Displayed Horizontal Course Deviation Indicator Scale Size (ENROUTE, TERMINAL, APPROACH)
Vertical CDI Deflection	Course Deviation Indicator - Deflection on the Vertical Scale (1.0 represents full scale deflection which is equal to 2 dots)
Vertical CDI Full Scale (ft)	Course Deviation Indicator - Vertical Deflection in Feet Corresponding to Full-Scale Deflection of 2 Dots (feet)
VNAV CDI Deflection	Course Deviation Vertical Navigation Deflection - (1.0 represents full scale deflection which is equal to 2 dots)
VNAV Altitude (ft)	Selected Vertical Navigation Altitude Limit (feet)
Autopilot State ³	Autopilot Operational Condition
Autopilot State - Powerup	Autopilot State - Boot/Power UP Condition
Autopilot State - PFT	Autopilot State - Preflight Test in Progress
Autopilot State - AP	Autopilot State - Autopilot Engaged
Autopilot State - AP / Trim Down	Autopilot State - Autopilot Engaged and Annunciating Trim Down
Autopilot State - AP / Trim Up	Autopilot State - Autopilot Engaged and Annunciating Trim UP
Autopilot State - Manual Disengage	Autopilot State - Manual Disengaged by User
Autopilot State - ESP IAS	Autopilot State - ESP Activated Based on IAS Limit
Autopilot State - ESP Roll	Autopilot State - ESP Activated in Roll Axis
Autopilot State - ESP Pitch	Autopilot State - ESP Activated in Pitch Axis
Autopilot State - Fail	Autopilot State - Autopilot Engagement Not Possible, ESP Unavailable
FD Lateral Mode	Active Flight Director Lateral Mode Followed by (Armed Lateral Mode)
FD Lateral Mode - ROL	Flight Director Lateral Mode - Bank Angle Hold upon AP Engagement, Failure or Cancelation of the Previously Active Mode.
FD Lateral Mode - GPS	Flight Director Lateral Mode - GPS Guidance
FD Lateral Mode - HDG	Flight Director Lateral Mode - Heading Select
FD Lateral Mode - TRK	Flight Director Lateral Mode - Track Select
FD Vertical Mode	Active Flight Director Selected Vertical Mode Followed by (Armed Vertical Mode)
FD Vertical Mode - PIT	Flight Director Vertical Mode - Pitch Angle Hold upon AP Engagement, Failure or Cancelation of the Previously Active Mode.
FD Vertical Mode - PIT(ALTS)	Flight Director Lateral Mode - Pitch Hold Mode (Selected Altitude Capture Mode is Armed)
FD Vertical Mode - ALT	Flight Director Vertical Mode - Altitude Hold

³ This parameter can show multiple states at once separated by a forward slash - '/'. For example at 08:47:02 the data shows the AP State was: "Manual disengage / ESP Roll / ESP Pitch"

FD Vertical Mode - VS (ALTS)	Flight Director Vertical Mode - Vertical Speed Hold Mode Active (Selected Altitude Capture Mode is Armed)
FD Vertical Mode - ALTS (ALT)	Flight Director Vertical Mode - Altitude Hold Mode is Active (Altitude Hold Mode is Armed)
FD Roll Command (deg)	Flight Director Commanded Roll (degrees)
FD Pitch Command (deg)	Flight Director Commanded Pitch (degrees)
FD Altitude (ft)	Flight Director Target Altitude (feet, Baro-Corrected Altitude)
AP Roll Command (deg)	Autopilot Commanded Roll Input (degrees)
AP Pitch Command (deg)	Autopilot Commanded Pitch Input (degrees)
AP VS Command (ft/min)	Autopilot Commanded Vertical Speed (feet per minute)
AP Altitude Command (ft)	Autopilot Commanded Altitude (feet, Pressure Altitude)
AP Roll Torque (%)	AP Measured Output Roll Torque on Output Shaft (percent) Positive (+) Torque Indicates Right Roll, when Installed and Configured Correctly.
AP Pitch Torque (%)	AP Measured Output Pitch Torque on Output Shaft (percent) Positive (+) Torque Indicates Nose Up, when Installed and Configured Correctly.
Magnetic Variation (deg)	Magnetic Variation (degrees)
Outside Air Temp (deg C)	Outside Air Temperature (degrees Celsius)
Density Altitude (ft)	Computed Density Altitude (feet)
Height Above Ground (ft)	GPS Altitude Offset Per Terrain Database (feet above ground level)
Wind Speed (kt)	Calculated Wind Speed (knots)
Wind Direction (deg)	Calculated Wind Direction (degrees True)
AHRS Status	Attitude Heading Reference System Status, Confidence Rating for AHRS Attitude Solution
AHRS Dev (%)	AHRS Gyro/Accelerometer Deviation from Recent Average - GROUND USE ONLY
Magnetometer Status	Magnetometer Status (Confidence Rating)
Network Status	CANBUS Network Health Status
Transponder Code	Selected Transponder Code
Transponder Mode	Transponder Mode
Transponder Mode - GND	Transponder Mode Ground
Transponder Mode - STBY	Transponder Mode On but Not Broadcasting
Transponder Mode - ALT	Transponder Mode Broadcast Altitude
Carbon Monoxide (ppm)	Concentration of Carbon Monoxide Detection in Parts Per Million (parts per million units of air)
Oil Temp (deg F)	Engine Oil Temperature (degrees Fahrenheit)
Fuel L Qty (gal)	Fuel Quantity in Left Tank (gallons)
Fuel R Qty (gal)	Fuel Quantity in Right Tank (gallons)
Fuel Press (PSI)	Fuel Pressure (pounds per square inch)
Oil Press (PSI)	Oil Pressure (pounds per square inch)
RPM	Engine RPM (revolutions per minute)
Manifold Press (inch Hg)	Manifold Pressure (inches of Mercury)
Volts 1	Voltage Buss 1 (Volts)
Volts 2	Voltage Buss 2 (Volts)

Amps	Amperage (Amperes)
Fuel Flow (gal/hour)	Fuel Flow (gallons per hour)
Elevator Trim	Elevator Trim Position
Aileron Trim	Aileron Trim Position
Flaps (%)	Flap Position (Units Dependent on Configuration)
CHT# (deg F)	Cylinder Head Temperature - Cylinder # (degrees Fahrenheit)
EGT# (deg F)	Exhaust Gas Temperature - Manifold # (degrees Fahrenheit)
STBY PWR ON (discrete)	Builder Configured - Avionics on Standby Power 0 = Ship Power, 1 = Standby Power
STALL SWITCH (discrete)	Builder Configured Stall Indicator (discrete) 0 = Not Stall ,1 = Stall
CANOPY CLOSED (discrete)	Builder Configured CANOPY CLOSED (discrete) 0 = Open Sense, 1 =Close Sense
PITOT TEMP (discrete)	Builder Configured PITOT TEMP (discrete) 0 = Temperature Sense OFF, 1 =Temperature Sense ON
Engine Power (%)	Calculated Engine Power (percent)
CAS Alert	Caution Alerting System (message type given, can be builder configured)
Terrain Alert	Terrain Alerting Feature (message type given)
Engine 1 Cycle Count	Number of Engine Cycles