

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



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RECOVERABLE DATA MODULE

Specialist's Factual Report

April 14, 2025

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A. ACCIDENT

Location: Kill Devil Hills, North Carolina
Date: September 28, 2024
Time: 1718 eastern daylight time (EDT)
2118 coordinate universal time (UTC)
Airplane: Cirrus SR22, N1281F

B. RECOVERABLE DATA MODULE SPECIALIST

Specialist: W. Deven Chen
Electrical Engineer - Recorder Specialist
National Transportation Safety Board (NTSB)

C. DETAILS OF THE INVESTIGATION

A recorder group was not convened. The NTSB Vehicle Recorder Division received the following recoverable data module (RDM):

Device Manufacturer/Model:	Appareo RDM-300
Serial Number:	3465 (Read from Download Software)

1.0 Device Description

The Appareo RDM is designed for Cirrus aircraft to record flight data in a crash and fire-resistant housing. The unit records flight, engine, and autopilot parameters. Depending on the recording software, over 75 parameters may be recorded. Data is logged up to five times per second and stored internally on four thin small outline package (TSOP) memory chips inside the crash-hardened enclosure. When the storage limit of the memory device is reached, the oldest recording is overwritten.

1.1 Device Condition and Data Recovery

The Appareo RDM-300 had sustained severe fire damage from the accident, as shown in Figure 1. Figure 2 shows its internal circuit board. The non-reversible temperature indicator had turned dark grey from its original color (white), indicating the circuit board had exposed to temperatures of over 138 degrees Celsius. Furthermore, the white potting compound powder stiffened and attached to the circuit board, indicating there had been water or moisture intrusion. As a result, the memory module, shown in Figure 3, exhibited signs of tear damage on its printed circuit board (PCB) and damaged solder joints at its connector.

Due to the high degree of damage, a chip-swap data recovery procedure was performed. The non-volatile memory (NVM)¹ chip (shown in Figure 4) of the memory module was removed from the damaged PCB with a precision computer-aid hot-air rework machine and was read out to make a copy of the accident NVM chip. A surrogate memory module was obtained from the manufacturer, and its NVM chip was removed from its PCB using the same process and written with the image copy of the accident NVM chip. This surrogate NVM chip, which contained a copy of the accident data, was reballed and soldered back onto the surrogate memory module using the computer controlled hot-air rework machine. Last, the surrogate memory module was plugged onto a surrogate RDM, and the last five hours of raw data were downloaded normally using the manufacturer's procedure. The downloaded raw data, which was encrypted, were then decoded and converted into engineering unit data by a Cirrus Aircraft representative at NTSB headquarters.



Figure 1. Appareo RDM-300 as received.



¹ Non-volatile memory is semiconductor memory that does not require external power to retain data.

Figure 2. Internal circuit board of the Appareo RDM-300.

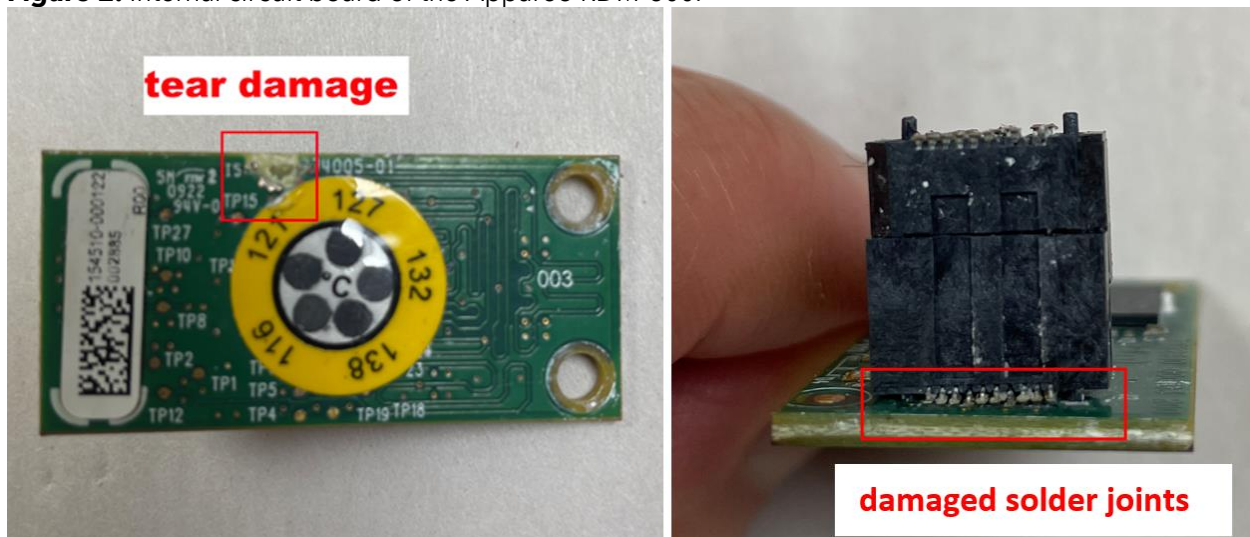


Figure 3. Memory module shown tear damage on the PCB and damaged solder joints on the connector.

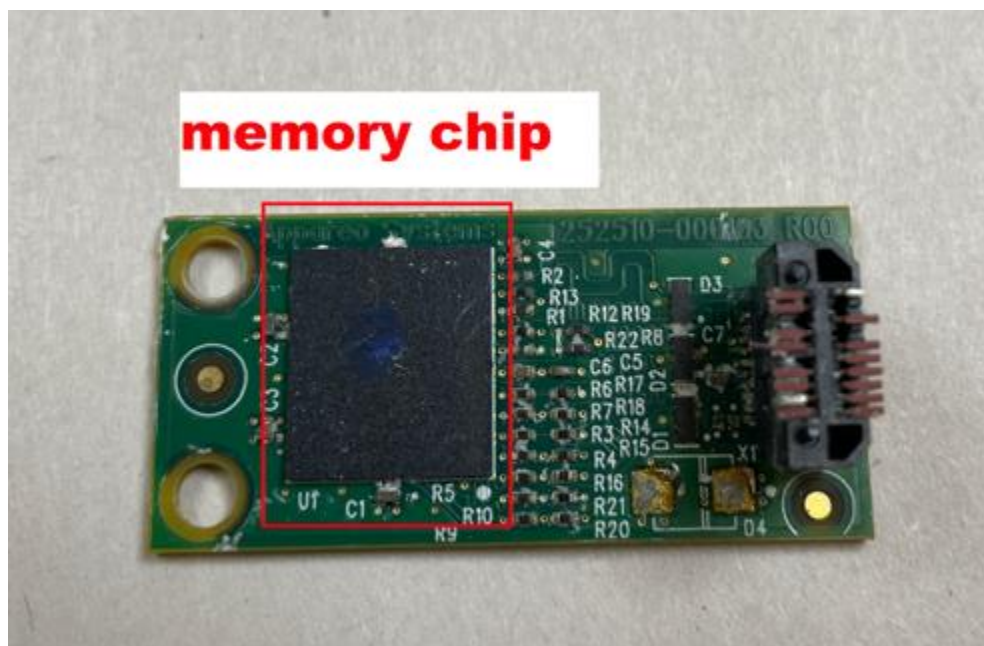


Figure 4. Non-volatile memory chip of the memory module.

1.2 Recording Description

The decoded data contained six data files in comma-separated values (CSV) format. The file recorded on September 28, 2024, from 21:02:02 to 21:18:53 UTC, was determined to be related to the accident flight. The data were sampled at 5 Hz.

1.2.1 Parameters Provided

Table 1 lists the parameters verified and provided in this report. The recorded parameters include basic flight parameters, engine parameters, autopilot, ESP² (Electronic Stability and Protection) parameters, and some selected parameters.

Table 1. Appareo RDM-300 data parameters provided.

Parameter Name (unit)	Parameter Description
Amps (A)	Circuitry bus current (amperes)
AltMSL (ft)	Geometric altitude above Mean Sea Level (feet)
AltP (ft)	Pressure altitude (feet)
AOA ESP Engaged (BIN)	1 if AOA (angle of attack) exceeds AOA threshold and the system is activated to drive the pitch angle down. Otherwise, 0.
AP/FD (BIN)	Autopilot/Flight director status (1 = engaged and 0 = off)
CAPS handle pulled (BIN)	Cirrus Airframe Parachute System activation handle pulled (1 = yes and 0 = no)
CAPS rocket deployed (BIN)	Cirrus Airframe Parachute System deployed through rocket action (1 = yes and 0 = no)
CHT# (degF)	Cylinder # head temperature (degrees Fahrenheit)
EGT# (degF)	Cylinder # exhaust gas temperature (degrees Fahrenheit)
Elevator Mistrim Up/Down (BIN)	Elevator mistrim up/down status (1 = yes and 0 = no)
Engine RPM	Engine revolutions per minute
ESP Enabled (BIN)	1 if ESP is not failed (see ESP FAIL) AND ESP is enabled in configuration, AND the pilot has not inhibited it, AND the autopilot is not engaged. Otherwise, 0.
ESP Enabled by Pilot (BIN)	0 if the pilot has deactivated ESP in the System Settings menu. Otherwise, 1.
ESP Fail (BIN)	1 if autopilot is failed OR dual AHRS (attitude and heading reference system) are not available to the GIA (Garmin Integrated Avionics) OR dual ADCs (analog-to-digital converters) are not available to the GIA OR AFCS (Automated Flight Control System) Pre-Flight Test has not completed. Otherwise, 0.
FF (GPH)	Fuel flow rate (gallons per hour)
Flaps 0%/50%/100% (BIN)	Flap extension position at 0%/50%/100% (1 = yes and 0 = no)
FQtyL/R (gal)	Fuel quantity at left/right tank (gallons)
GndSpd (kt)	Groundspeed between current and previous data point (knots)
Heading (deg)	Heading (degrees)
IAS (kt)	Indicated airspeed (knots)
LatAcc (g)	Acceleration at lateral direction (g)
Latitude (deg)	Geometric latitude (degrees)
LonAcc (g)	Acceleration at longitudinal direction (g)

² ESP - Electronic Stability and Protection is a flight auto-control system designed by Garmin, which monitors the aircraft's condition, functioning independently of the autopilot, and it applies a control force towards stable flight whenever pitch or roll deviations exceed recommended limits.

Parameter Name (unit)	Parameter Description
Longitude (deg)	Geometric longitude (degrees)
MAP (inHg)	Manifold pressure (inches of mercury)
NormAcc (g)	Acceleration at normal direction (g)
Oil P (PSI)	Oil pressure (pounds per square inches)
Oil T (degC)	Oil temperature (degrees Celsius)
Percent Power (%)	Linearized engine power in percentage (%)
Pitch (deg)	Pitch angle (degrees)
PIT Torque (in-lb)	Pitch torque (inch-pounds)
Roll (deg)	Roll angle (degrees)
ROL Torque (in-lb)	Roll torque (inch-pounds)
Rudder Mistrim Left/Right (BIN)	Rudder mistrim left/right status (1 = yes and 0 = no)
STALL - TONE (BIN)	Stall tone status (1 = on and 0 = off)
Stall Warning ACTIVE (BIN)	Stall warning active status (1 = active and 0 = not active)
STALL WARN FAIL (BIN)	Stall warning fail status (1 = failed and 0 = not failed)
TAS (kt)	True airspeed (knots)
Volts (V)	Circuitry bus voltage (volts)
Vertical Speed (fpm)	Vertical speed (feet per minute)

1.2.2 Time Correlation

The data were recorded in UTC and were kept in UTC for this report. EDT, the local time of the event is 4 hours behind UTC.

D. FIGURES AND TABULAR DATA

All parameters listed in Table 1 are plotted. Figures 5 to 16 contain data recovered from the Appareo RDM-300 for the accident flight on November 22, 2023.

Figure 5 and Figure 6 are plots of basic flight parameters from the accident flight with different time ranges: the entire flight and from 21:15 UTC to the end, respectively.

Figure 7 and Figure 8 are plots of engine parameters from the accident flight with different time ranges: the entire flight and from 21:15 UTC to the end, respectively.

Figure 9 and Figure 10 are plots of autopilot and ESP parameters from the accident flight with different time ranges: the entire flight and from 21:15 UTC to the end, respectively.

Figure 11 to Figure 13 are plots of selected parameters from the accident flight with different time ranges: the entire flight, from 21:15 UTC to the end, and from 21:17:40 UTC to the end, respectively.

These plots are configured such that right turns are indicated by the trace moving toward the bottom of the page, left turns toward the top of the page, and nose-up attitudes toward the top of the page.

Figure 14 to Figure 16 are Google Earth overlays of the accident flight.

Figure 14 is a Google Earth overlay of the entire accident flight.

Figure 15 is a Google Earth overlay of approximately the last 6 minutes of the accident flight.

Figure 16 is a Google Earth overlay showing the end of the accident flight.

The weather and lighting conditions in Google Earth are not necessarily the weather and lighting conditions present at the time of the recording. Note that the entire flight path of the accident flight recorded on the RDM presents in an abnormal zig-zag shape rather than a smooth line. This is a known issue with Appareo RDM in recording GPS location data, and the appearance of the flight track may not be representative of the airplane's actual flight track. This pattern may be attributed to the update rate of GPS parameters as well as the software encoding of the GPS input to the device.

The data show that the accident aircraft took off from the Dare County Regional Airport (MQI), Dare County, North Carolina, at around 21:06 UTC and traveled northeast. At around 21:15, the accident aircraft performed a touch-and-go on runway 3 at the First Flight Airport (FAA), Kill Devil Hills, North Carolina, during which a stall warning activated. The event occurred during the accident aircraft's second touchdown on the runway 3 at around 21:18 UTC. The stall warning activated again at 21:18:37 UTC and persisted until one second before the end of the recording at 21:18:53 UTC.

The corresponding tabular data used to create figures 5 to 15 are provided as attachment 1 in CSV format to this report.

Submitted by:

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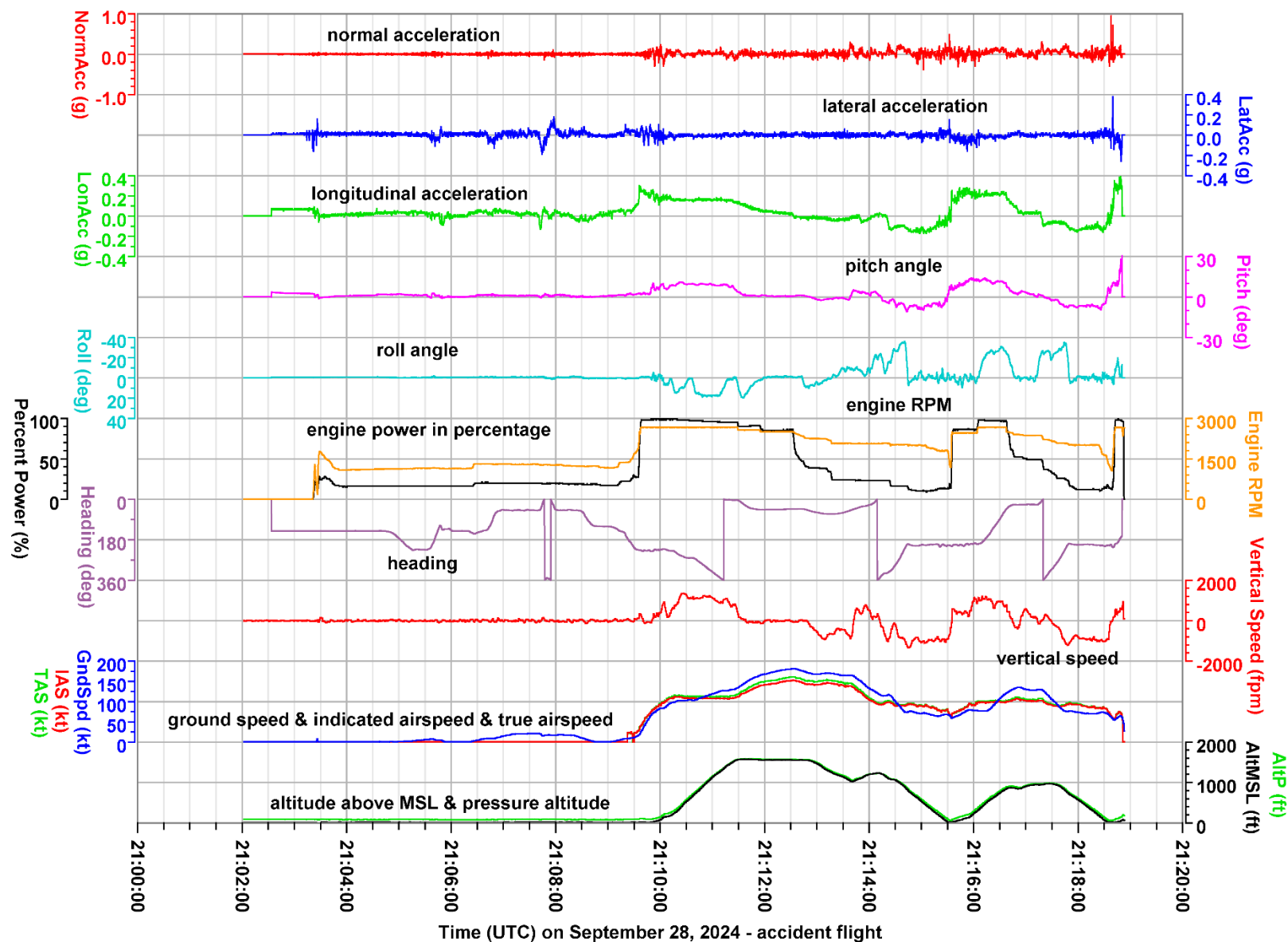


Figure 5. Plot of basic flight parameters of the entire accident flight recording.

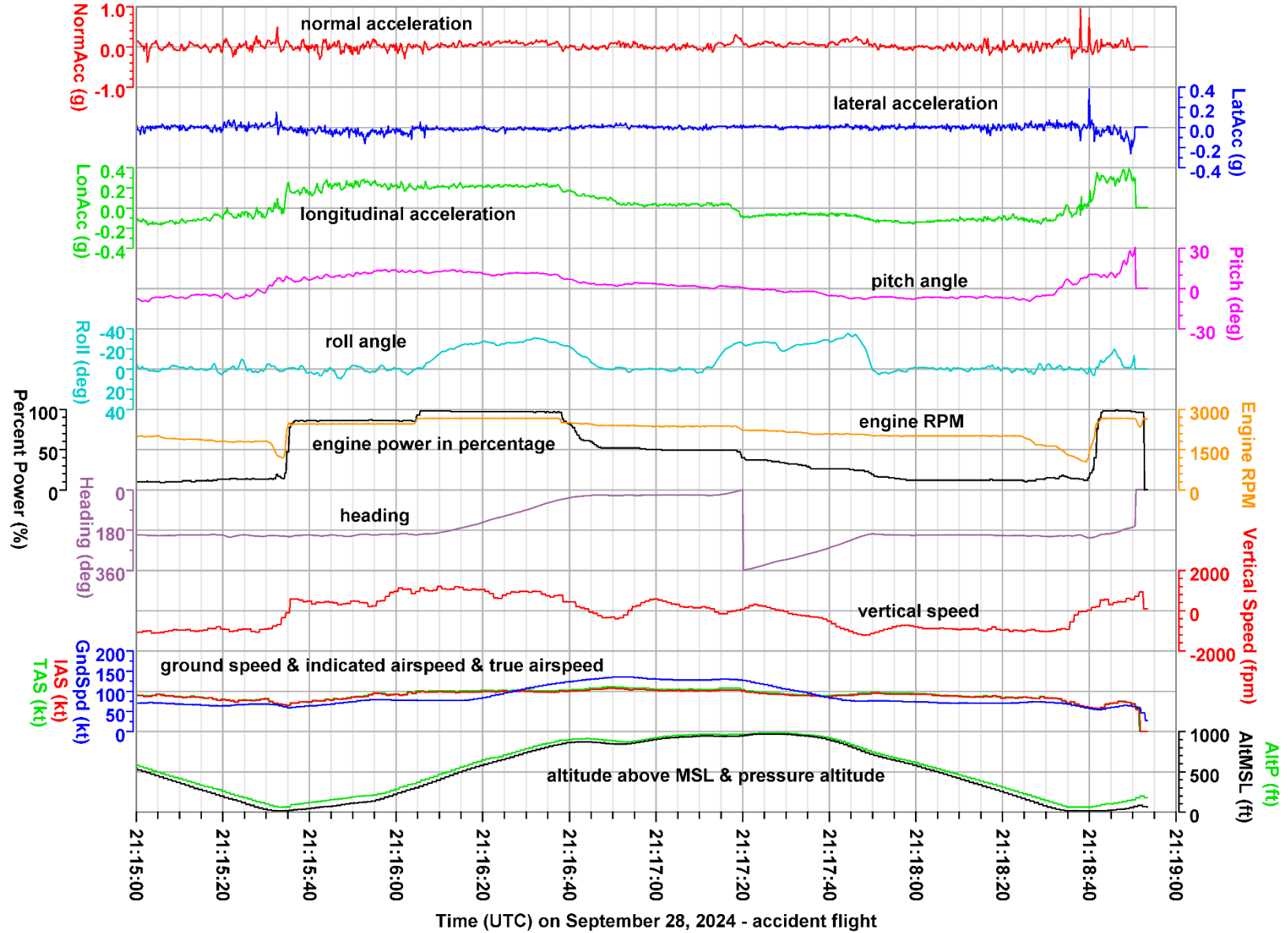


Figure 6. Plot of basic flight parameters with a range from 21:15 UTC to the end of the accident flight.

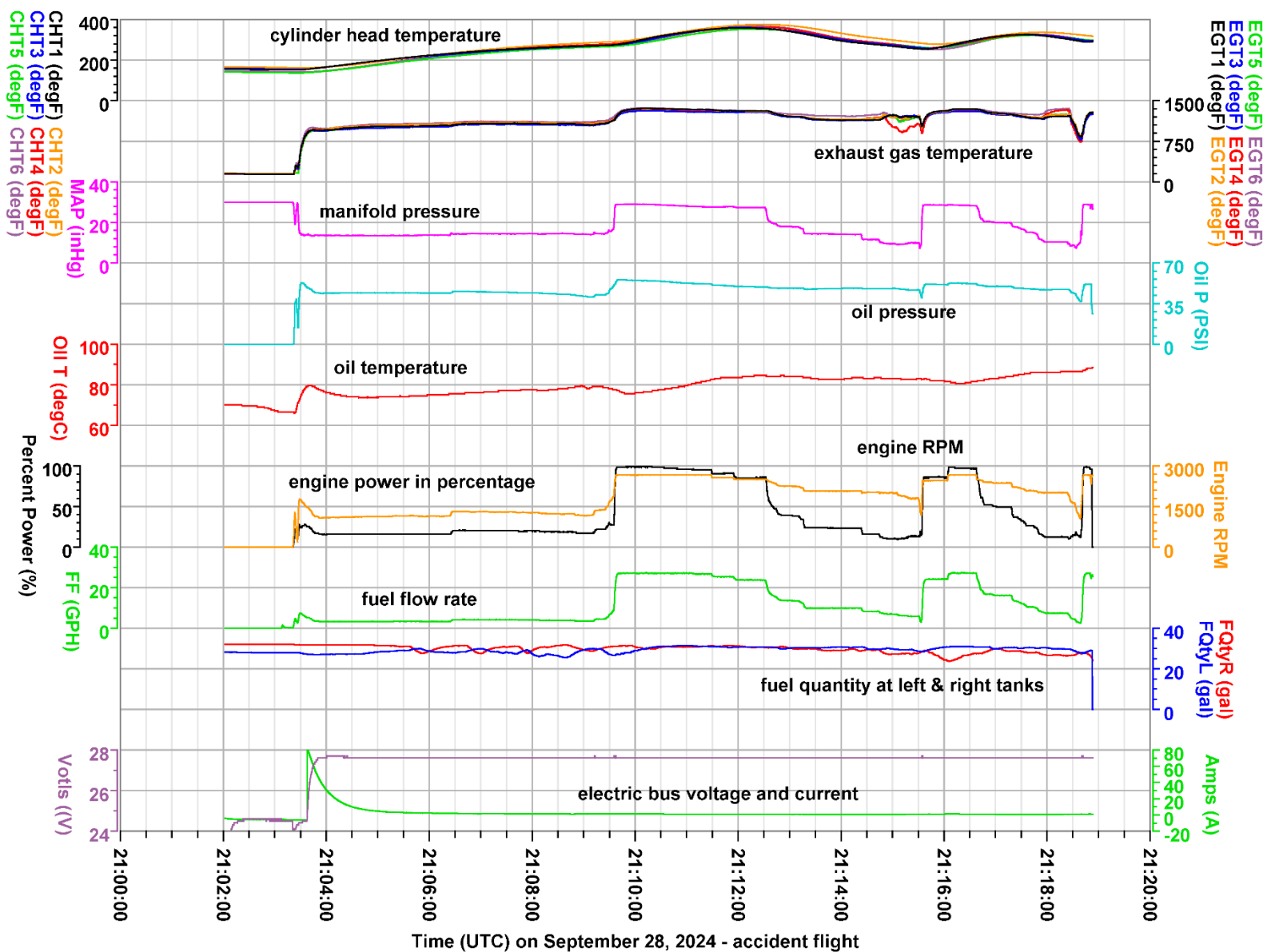


Figure 7. Plot of engine parameters of the entire accident flight recording.

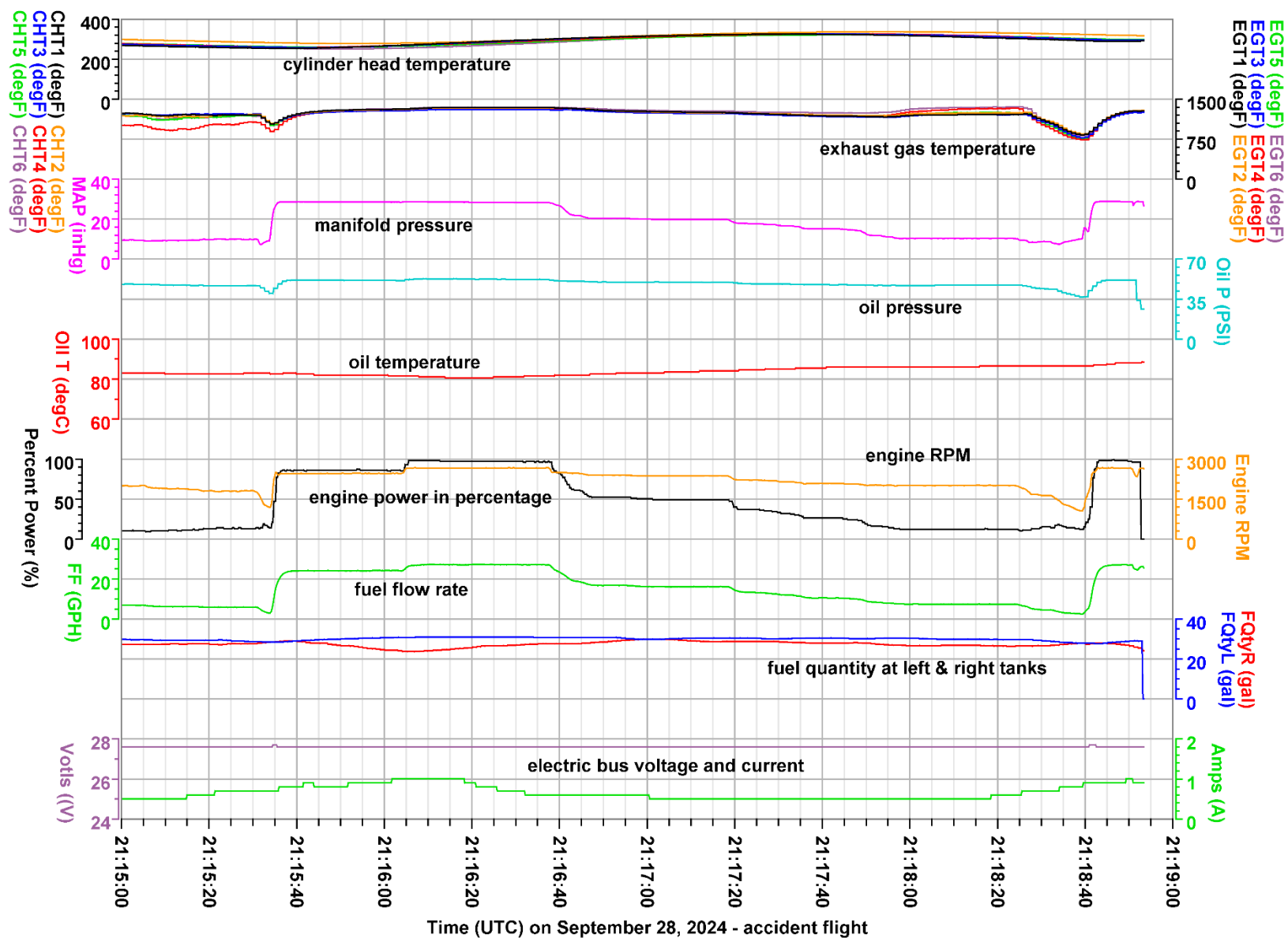


Figure 8. Plot of engine parameters with a range from 21:15 UTC to the end of the accident flight.

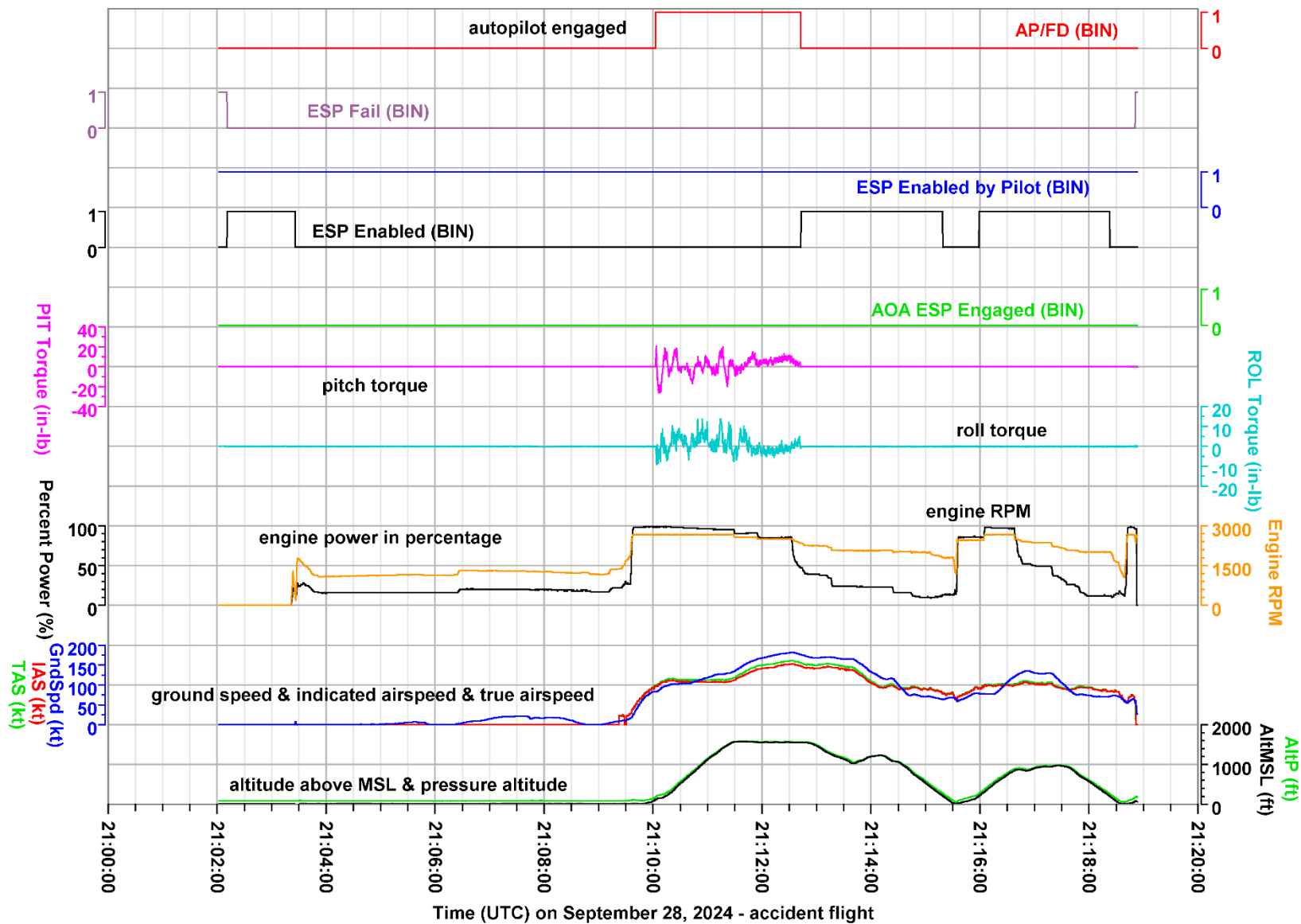


Figure 9. Plot of autopilot and ESP parameters of the entire accident flight recording.

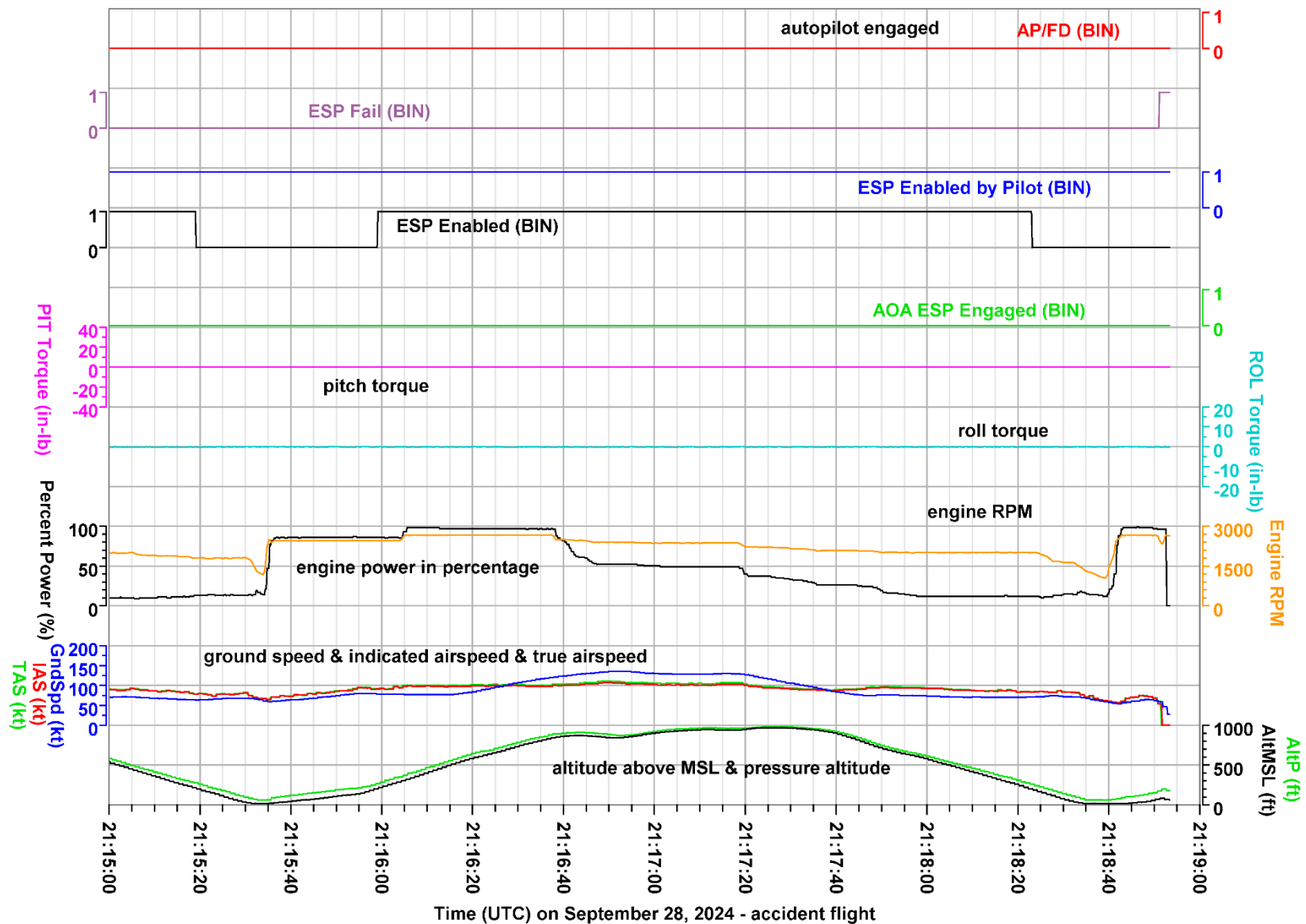


Figure 10. Plot of autopilot and ESP parameters with a range from 21:15 UTC to the end of the accident flight.

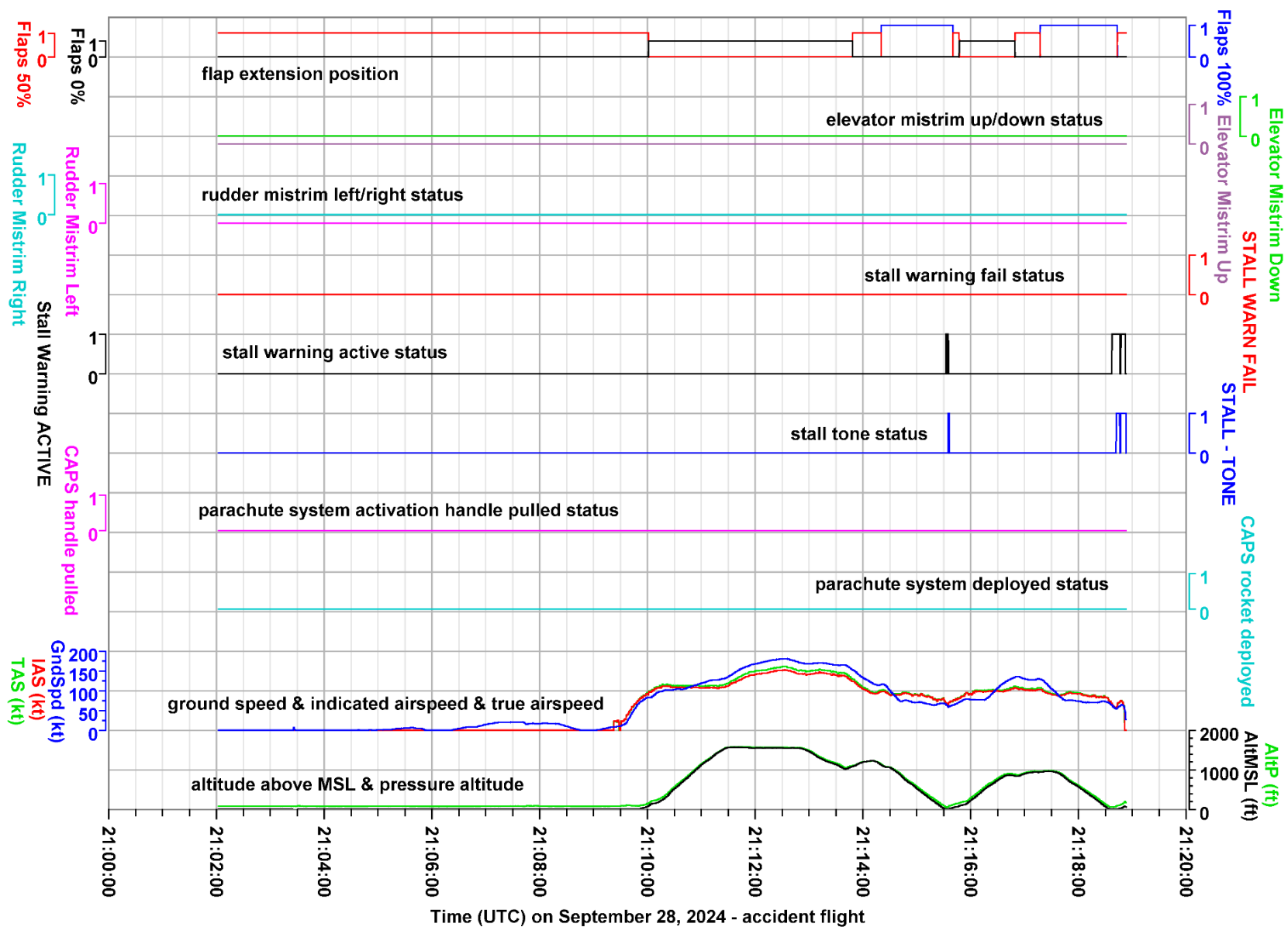


Figure 11. Plot of selected parameters of the entire accident flight recording.

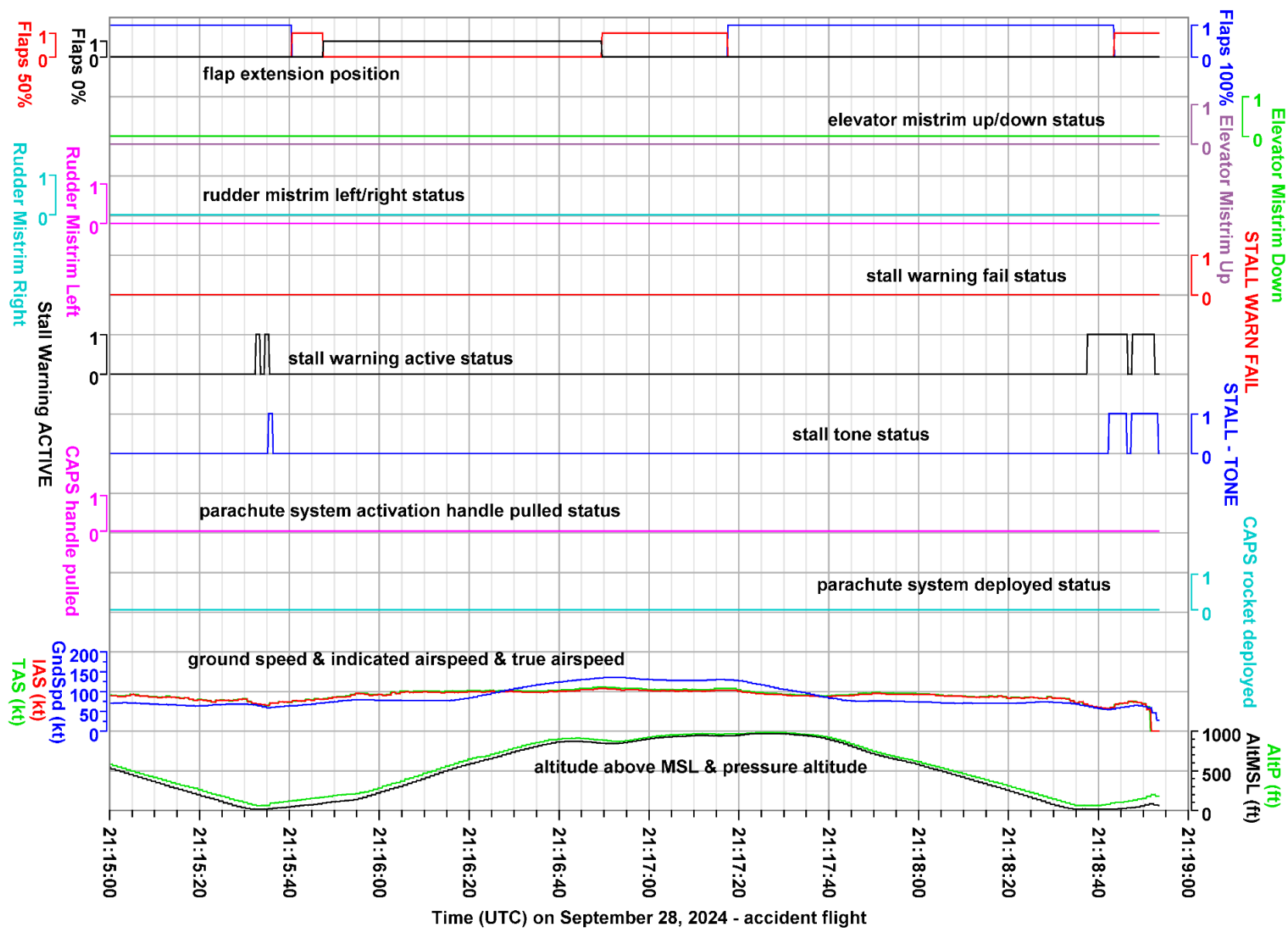


Figure 12. Plot of selected parameters with a range from 21:15 UTC to the end of the accident flight.

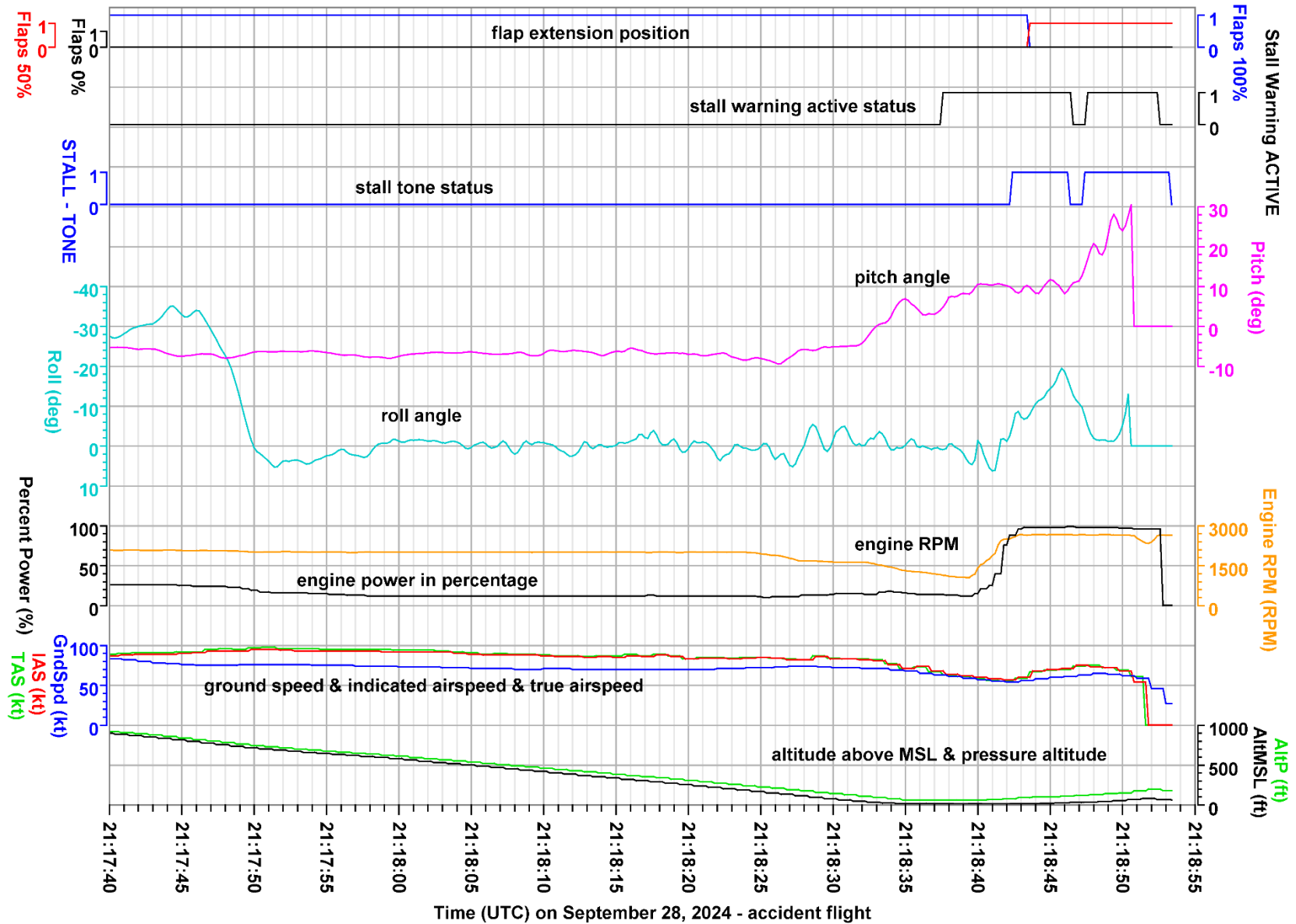


Figure 13. Plot of selected parameters with a range from 21:17:40 UTC to the end of the accident flight.



Figure 14. Google Earth overlay of the entire accident flight. Note that the zig-zag shape flight path was due to an Appareo RDM issue in recording GPS location data and not necessarily the exact flight pattern.



Figure 15. Google Earth overlay of the final portion of the accident flight. Note that the zig-zag shape flight path was due to an Appareo RDM issue in recording GPS location data and not necessarily the exact flight pattern.

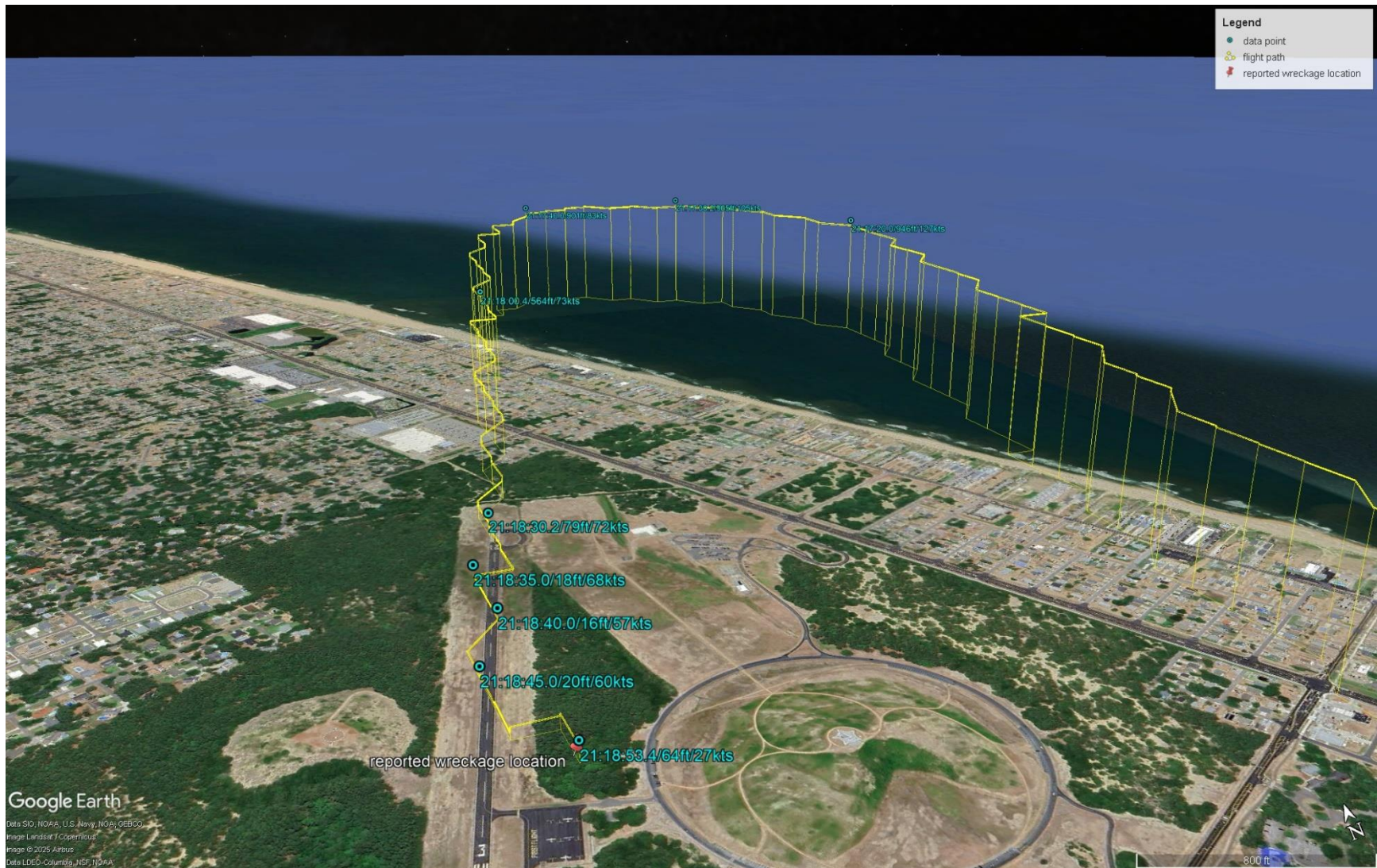


Figure 16. Google Earth overlay showing the end of the accident flight. Note that the zig-zag shape flight path was due to an Appareo RDM issue in recording GPS location data and not necessarily the exact flight pattern.