

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



ENG24LA014

FLIGHT DATA RECORDER

Specialist's Factual Report

October 28, 2024

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A. INCIDENT

Location: Singapore, SN
Date: May 14, 2024
Time: 1400 Local
Airplane: Boeing 787-9, United Airlines, N27957

B. FLIGHT DATA RECORDER SPECIALIST

Specialist Charles Cates
Mechanical Engineer/Recorder Specialist
National Transportation Safety Board (NTSB)

C. FEDERAL CARRIAGE REQUIREMENTS

The event aircraft, N27957, was operating under Title 14 *Code of Federal Regulations* (CFR) Part 121: Air carrier. The event aircraft was manufactured on August 30, 2015, and was operating such that it was required to be equipped with a flight data recorder (FDR) that recorded, at a minimum, 88 parameters, as cited in 14 CFR Part 121.344: Air carrier.

D. DETAILS OF THE INVESTIGATION

A FDR group was not convened. The NTSB Vehicle Recorder Division received the following cockpit voice and data recorders (CVDR):

Recorder Manufacturer/Model:	GE EAFR-2100
Part Number:	182690-002
Recorder Serial Number:	41X357
Recorder Manufacturer/Model:	GE EAFR-2100
Part Number:	182690-002
Recorder Serial Number:	41X4FM

1.0 Recorder Description

The General Electric model EAFR-2100 enhanced airborne flight recorder is a multifunction recorder that records flight (FDR) data, audio (CVR) data, and communication, navigation, and surveillance air traffic management messages (known as datalink). Boeing 787 aircraft have two EAFR recorders installed, known as the forward and aft recorders, which are powered by the left and right 28-volt DC buses, respectively. The forward recorder also has an independent power supply to

provide backup power to the recorder for about 10 minutes in the event that the left 28-volt bus loses power.

The EAFR has an integral flight data acquisition function, which receives data from various sources and transmits those data in a recording format that allows for multiple predefined frames of data. Each frame can vary in length and structure. If no new data has been received since the last time a parameter's value was sent to the FDR, the flight data acquisition function continues to transmit the last value received from the source. These data are referred to as stale data.

For some parameters, the flight data acquisition function has multiple prioritized data sources from which it receives parameter values. For those parameters, a source index parameter indicating the source is generated and recorded by the FDR. For parameters with a source index, stale data are indicated by the index being set to "no source available." Parameters that only have a single source do not have a recorded indication that the data could be stale.

1.1 Recorder Condition

Both recorders were in good condition and the data were extracted normally from them. Data from the forward recorder was used for this report.

1.2 Recording Description

The FDR recording contained approximately 49.6 hours of data. Timing of the FDR data is measured in subframe reference number (SRN), where each SRN equals one elapsed second. The event flight was the last flight of the recording, and its duration was approximately 2 hours and 30 minutes. The parameters evaluated for the purpose of this report appeared to be in accordance with federal FDR carriage requirements.

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 stored onboard the recorder. Where applicable, the conversions have been changed to ensure that the parameters conform to the NTSB's standard sign convention that climbing right turns are positive (CRT=+).¹

¹ 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 = +.

Table 1 lists the FDR parameters verified and provided in this report. Additionally, table 2 describes the unit and discrete state abbreviations used in this report.

1.4 Time Correlation

Correlation of the FDR data from SRN to coordinated universal time (UTC) was established by using the recorded UTC Hours, UTC Minutes, and UTC Seconds.

Accordingly, the time offset for the event flight data from SRN to UTC is the following: $UTC = SRN - 123,304.2$. Therefore, for the rest of this report, all times are referenced as UTC, not SRN.

E. FIGURES AND TABULAR DATA

Figures 1 to 6 contain FDR data recorded during the event on May 14, 2024. All the parameters listed in table 1 are plotted except UTC Hours, UTC Minutes, and UTC Seconds.

Figures 1-3 contain parameters showing the operation of engine 1. Figures 4-6 contain parameters showing vibration levels from engine 1.

Figures 1 and 4 cover the time from the engine start to the end of the recording. Figures 2 and 5 cover the flight time of the aircraft. Figures 3 and 6 cover the time leading up to and immediately after the engine event.

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

The data show that the aircraft departed Singapore at 1336 UTC and climbed uneventfully to 31,000 ft (FL310).

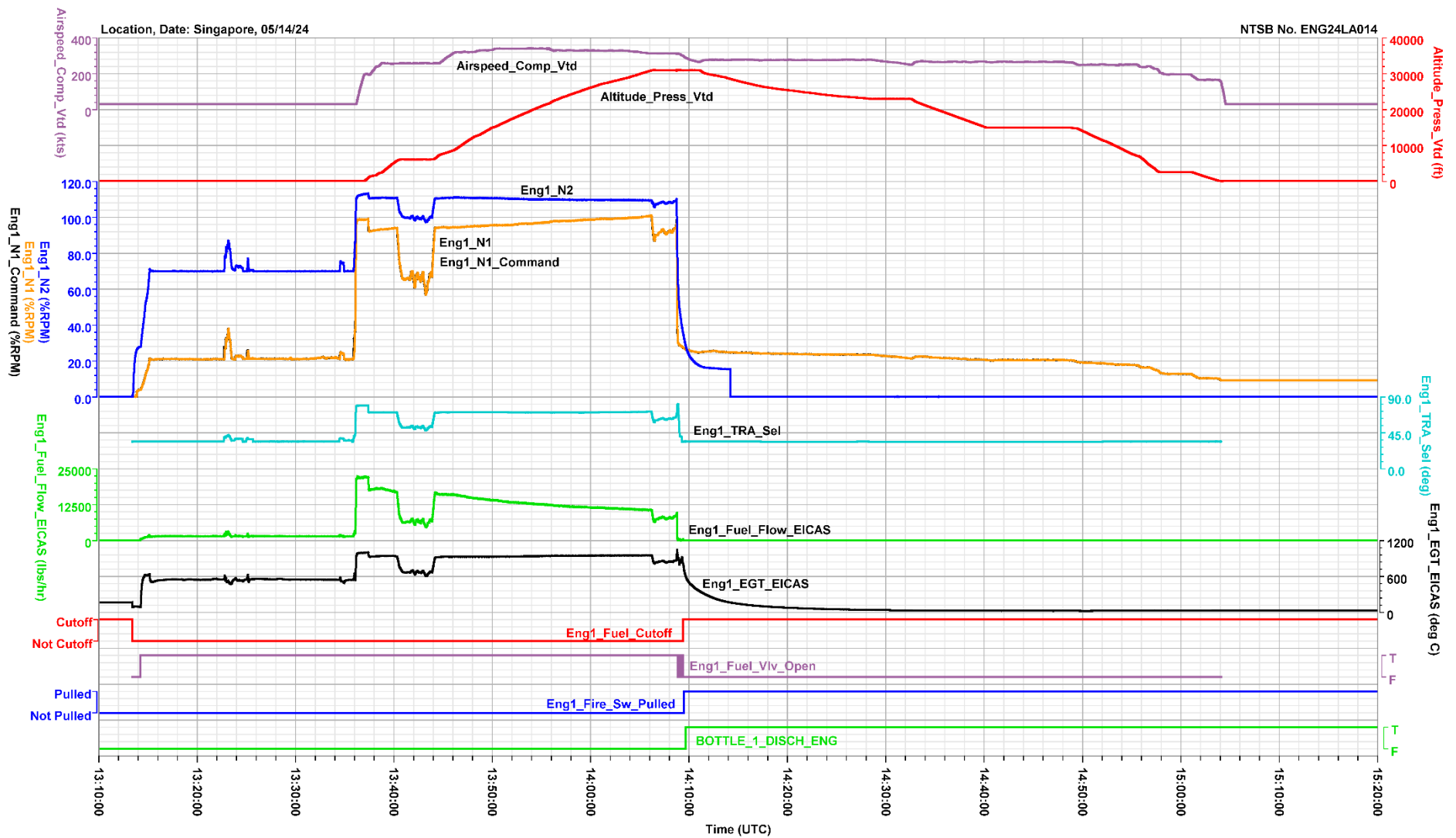
At 1408:48 UTC, with the aircraft stable at FL310 and 312 kts computed airspeed, engine 1 (the left engine) N1, N2, and fuel flow all abruptly decreased, and the left engine fire warning became active at 1408:55. The engine 1 fuel cutoff switch was moved from the run position to the cutoff position at 1409:24 UTC. The engine 1 fire switch was pulled at 1409:28 UTC, and the left engine fire bottle was discharged at 1409:40 UTC. The left engine fire warning cleared at 1409:55 UTC.

The aircraft returned to Singapore and made an uneventful single-engine landing at 1504 UTC.

The corresponding tabular data used to create figures 1 to 6, including UTC Hours, UTC Minutes, and UTC Seconds, are provided in electronic comma-separated value (CSV) format as attachment 1 to this report.

Submitted by:

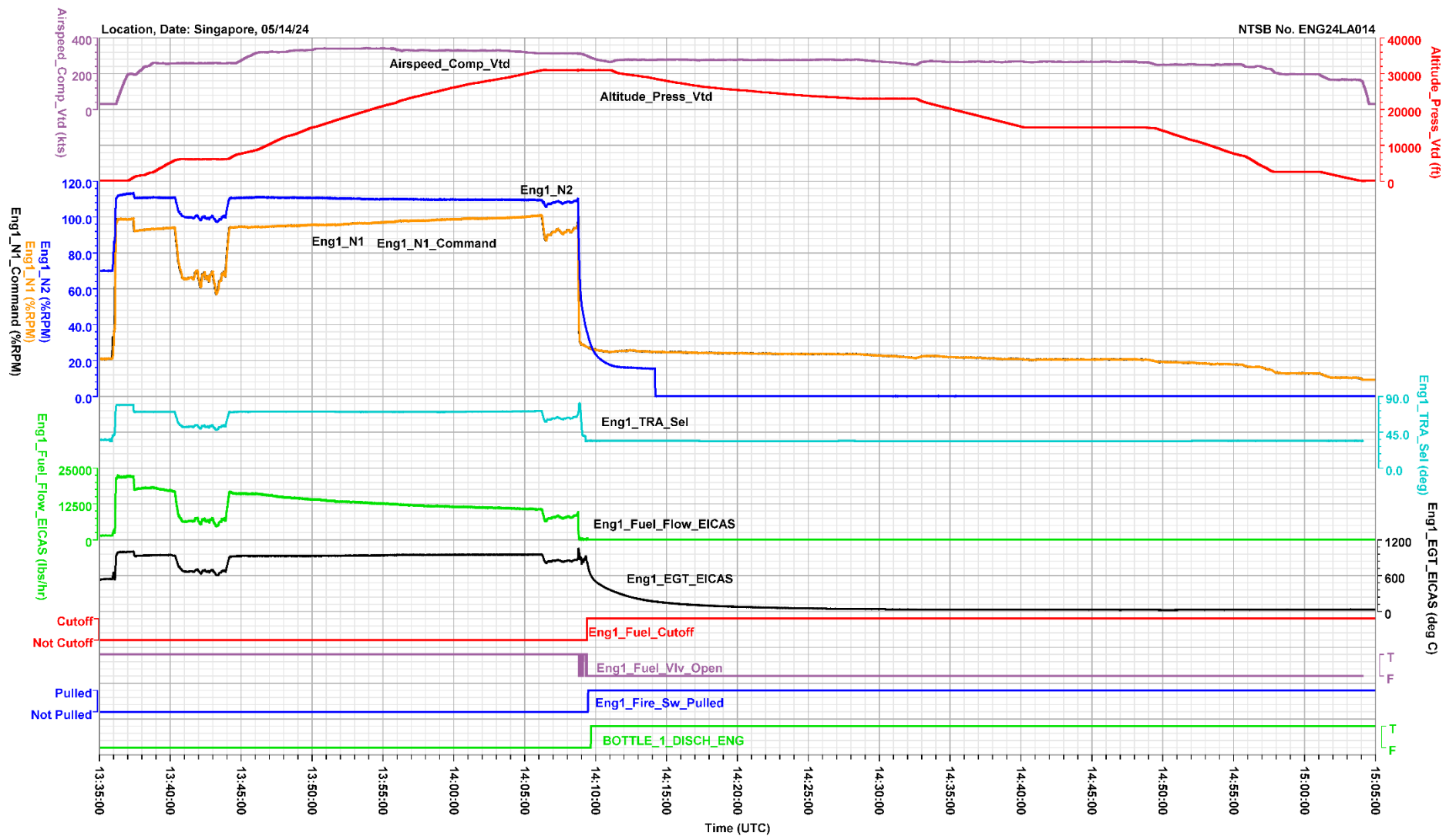
Charles Cates
Mechanical Engineer/Recorder Specialist



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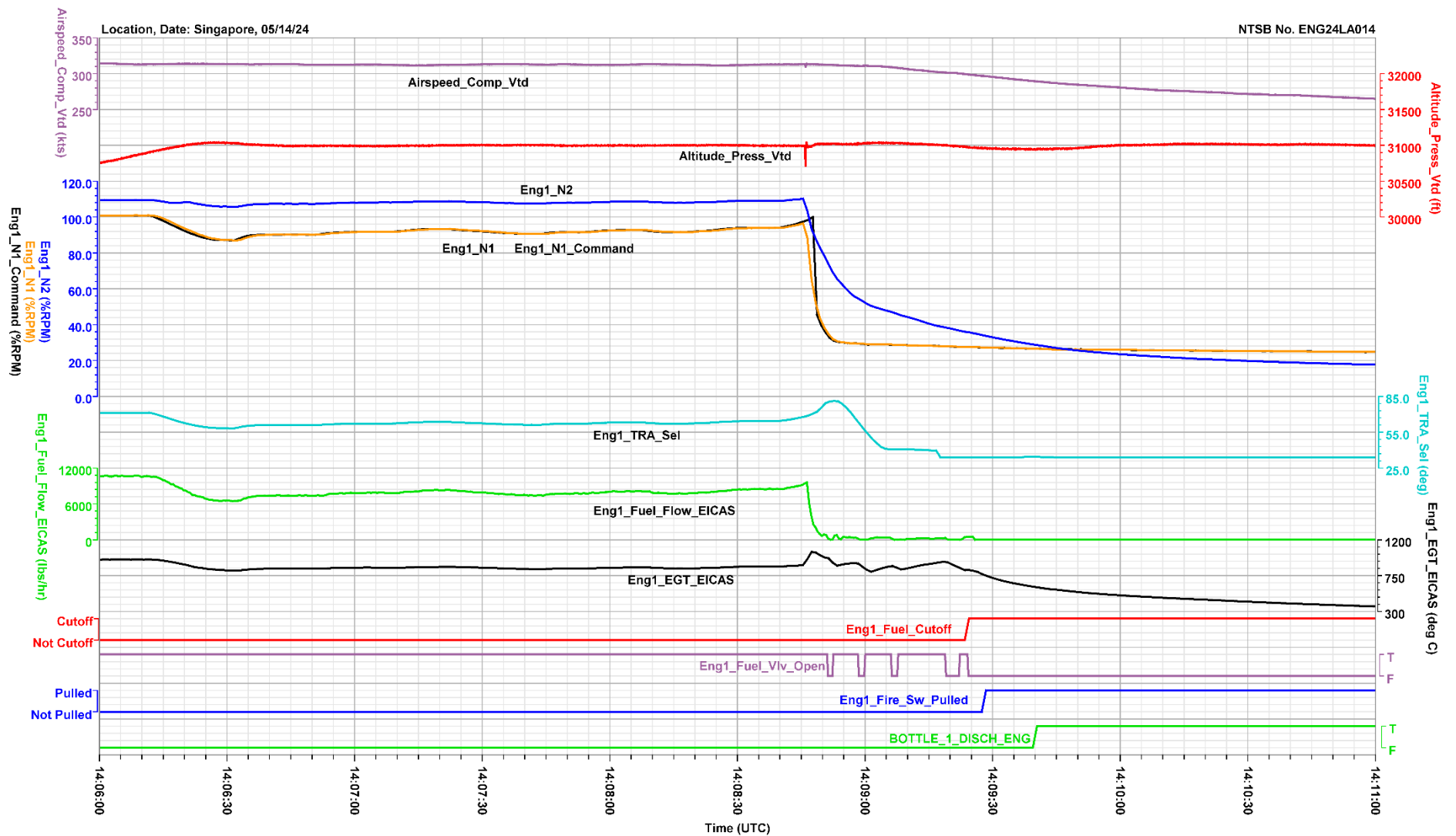
Figure 1. Plot of engine 1 parameters from engine start until end of session.



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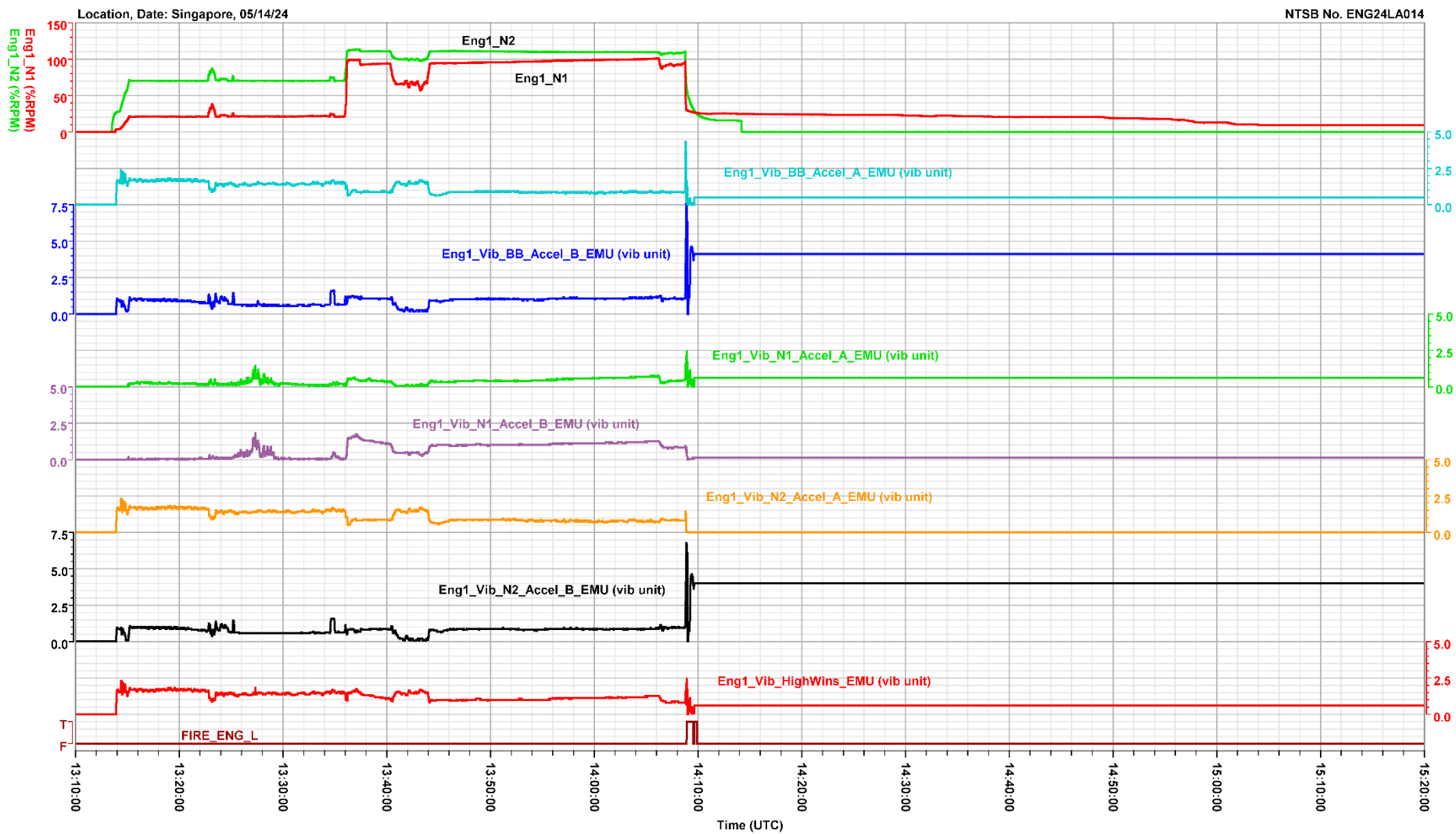
Figure 2. Plot of engine 1 parameters from flight time.



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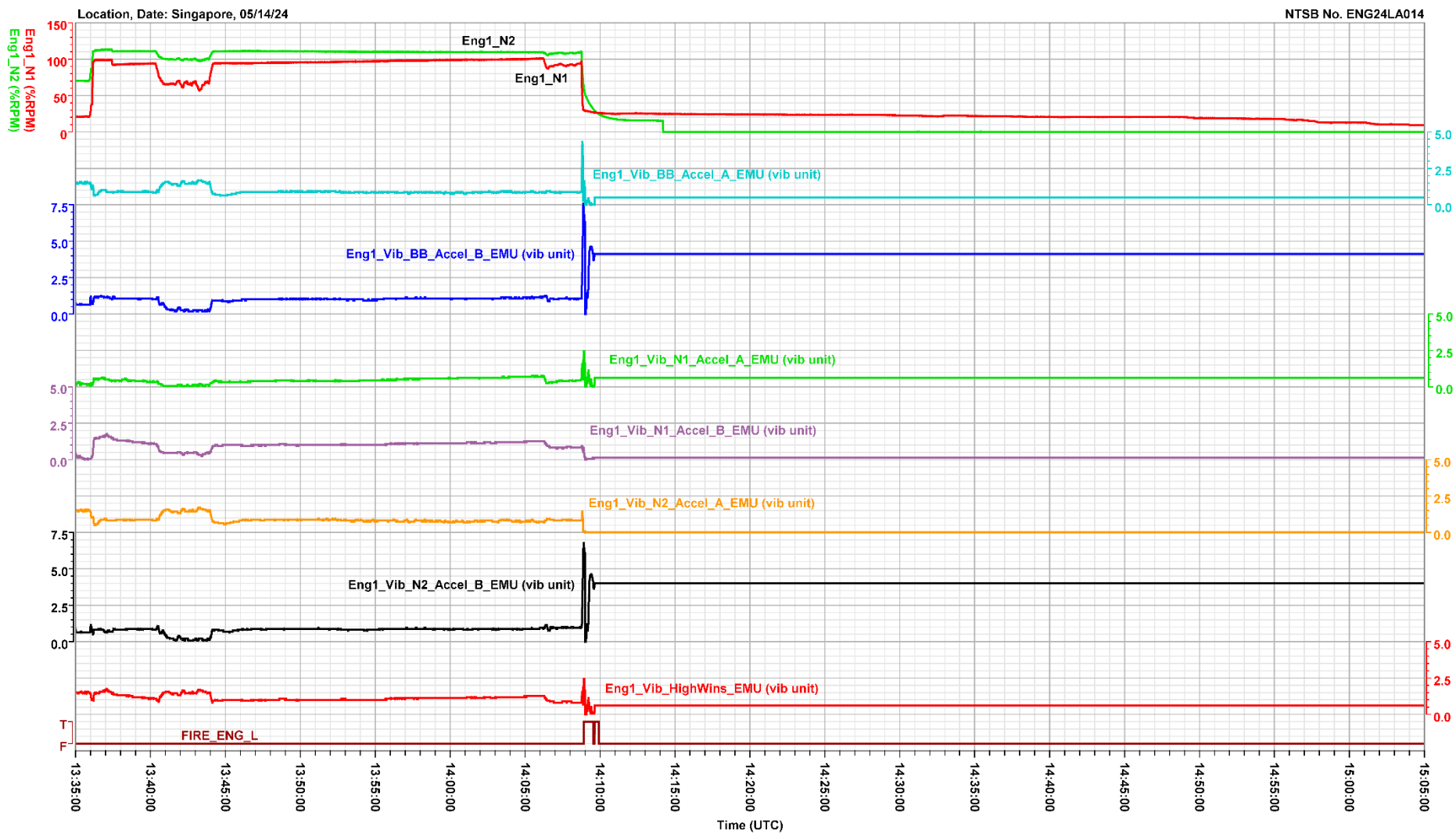
Figure 3. Plot of engine 1 parameters from around the time of the engine event.



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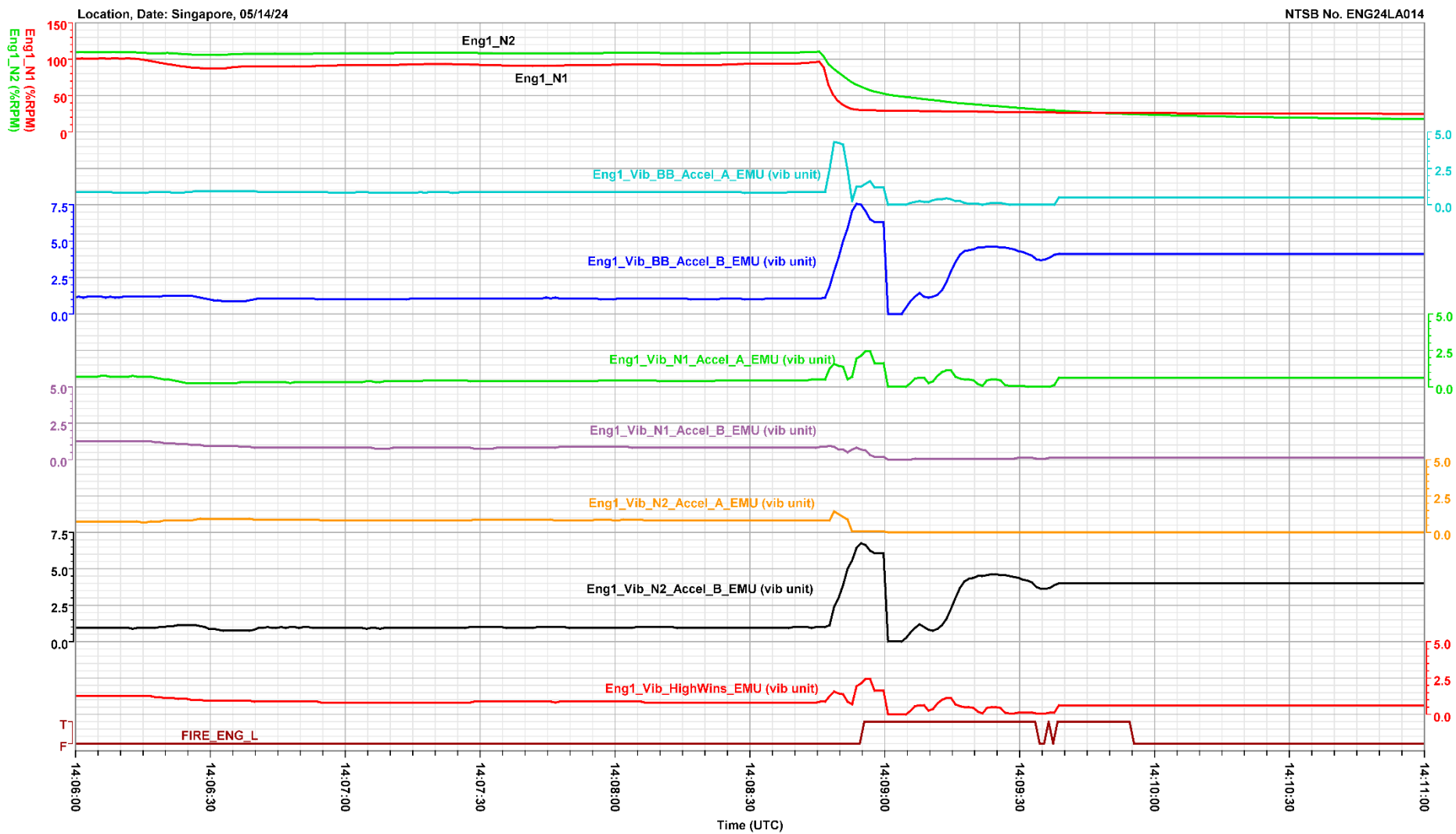
Figure 4. Plot of engine 1 vibration parameters from engine start until end of session.



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Figure 5. Plot of engine 1 vibration parameters from flight time.



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Figure 6. Plot of engine 1 vibration parameters from around the time of the engine event.

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 1. Verified and provided FDR parameters.

Plot/Table Label	Parameter Name	Units
1. Airspeed_Comp_Vtd	Computed Airspeed	kts
2. Altitude_Press_Vtd	Pressure Altitude	ft
3. BOTTLE_1_DISCH_ENG	Engine Fire Bottle 1 Discharged	
4. Eng1_EGT_EICAS	Engine 1 Exhaust Gas Temperature	deg C
5. Eng1_Fire_Sw_Pulled	Engine 1 Fire Switch Pulled	
6. Eng1_Fuel_Cutoff	Engine 1 Fuel Cutoff Switch Position	
7. Eng1_Fuel_Flow_EICAS	Engine 1 Fuel Flow	lbs/hr
8. Eng1_Fuel_Vlv_Open	Engine 1 Fuel Valve Open	
9. Eng1_N1	Engine 1 Fan Speed	% rpm
10. Eng1_N1_Command	Engine 1 Commanded Fan Speed	% rpm
11. Eng1_N2	Engine 1 Core Speed	% rpm
12. Eng1_TRA_Sel	Engine 1 Selected Throttle Resolver Angle	deg
13. Eng1_Vib_BB_Accel_A_EMU	Engine 1 Broadband Vibration A	fdu
14. Eng1_Vib_BB_Accel_B_EMU	Engine 1 Broadband Vibration B	fdu
15. Eng1_Vib_HighWins_EMU	Engine 1 Highest Rotor Vibration Level	fdu
16. Eng1_Vib_N1_Accel_A_EMU	Engine 1 Fan Vibration Level A	fdu
17. Eng1_Vib_N1_Accel_B_EMU	Engine 1 Fan Vibration Level B	fdu
18. Eng1_Vib_N2_Accel_A_EMU	Engine 1 Core Vibration Level A	fdu
19. Eng1_Vib_N2_Accel_B_EMU	Engine 1 Core Vibration Level B	fdu
20. FIRE_ENG_L	Left Engine Fire Detected	

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 2. Unit and discrete state abbreviations.

Unit and Discrete State Abbreviation	Description
BB	broadband
deg	degrees
deg C	degrees Celsius
EMU	engine monitoring unit
fdu	flight deck units
ft	feet
kts	knots
lbs/hr	pounds per hour
rpm	revolutions per minute
vtd	voted