

National Transportation Safety Board

Office of Research and Engineering

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FLIGHT DATA RECORDER

Specialist's Factual Report

November 18, 2022

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A. ACCIDENT

Location: Honolulu, Hawaii
Date: July 2, 2021
Time: 0145 Hawaii standard time (HST)
1145 coordinated universal time (UTC)
Airplane: Boeing 737-200, N810TA, Rhoades Aviation Inc, dba TransAir Flight 810

B. FLIGHT DATA RECORDER SPECIALIST

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C. FEDERAL CARRIAGE REQUIREMENTS

The event aircraft, N810TA, was operating as Title 14 *Code of Federal Regulations* (CFR) Part 121. The event aircraft was manufactured in 1975 and was operating such that it was required to be equipped with a flight data recorder (FDR) that recorded, at a minimum, 18 parameters, as cited in 14 CFR Part 121.344(b).

D. DETAILS OF THE INVESTIGATION

An FDR group was not convened. NTSB Vehicle Recorder Division received the following FDR:

Recorder Manufacturer/Model: Allied Signal SSUFDR-RQUS
Part Number: 980-4120-RQUS
Recorder Serial Number: 20352

1.0 Allied Signal SSUFDR Description

The Allied Signal (now Honeywell) Solid State Universal Flight Data Recorder (SSUFDR) records airplane flight information in a digital format using solid-state flash memory as the recording medium. The model is an update resulting from a modification of a Universal Flight Data Recorder (UFDR) from magnetic tape to solid-state memory.

This installation used only analog sensors wired directly to the FDR in an ARINC 542A configuration. The FDR has an internal data acquisition unit that converts the analog sensor signals into digital data in ARINC 573/717 format for storage in memory. The recorder is configured to capture 64 words of digital information every

second, with each word being 12 bits in length. Each grouping of 64 words (or 768 bits) is called a subframe. Each subframe has a unique 12-bit synchronization (sync) word identifying it as either subframe 1, 2, 3, or 4. The sync word is the first word in each subframe. Each grouping of consecutive 1, 2, 3, and 4 subframes comprise a frame (i.e., four seconds of data). The data stream is "in sync" when successive sync words appear at the proper 64-word intervals.

The recorder was installed on the aircraft via supplemental type certificate (STC) instructions. The STC included the installation of sensors and transducers, wiring, and the flight data recorder hardware.

1.1 Recorder Condition

The recorder was recovered from the wreckage at a depth of 350-450 feet after about 4 months. The recorder was immediately rinsed and repacked with fresh water and arrived at the NTSB's vehicle recorder laboratory in a cooler filled with fresh water. The recorder after removal from the water is shown in figure 1. The memory module was removed from the recorder, as shown in figure 2. As seen in figure 3, the red rubberized RTV sealant surrounding the module was found to be defective in several places due to the way the sealant was applied and cured at the time of manufacture. The RTV was thin and cracked along one edge and had never fully sealed around the connector end of the boards. The RTV is designed to protect the boards from water damage and corrosion and should fully envelop the entire circuit board assembly with a uniform thickness of sealant. This defect allowed a path for sea water to flood the circuit boards as the recorder sank with the aircraft wreckage.

The memory module's red rubberized RTV was peeled back for cleaning, drying, and inspection. Figure 4 shows the cleaned circuit board. Some spots in the board conformal coating were compromised and had become hazy, but microscopic inspection found no evidence of corrosion in any of the leads, connections, or solder pads.

Two capacitors near the connector were found to be damaged, likely from extended contact with sea water. These capacitors were included on the board for the purpose of power conditioning and preventing "dirty" transient power effects from reaching the electronics. In a lab environment with a known good power supply this power conditioning effect is unnecessary, so these two capacitors were removed from the board with no ill effects to the recovery of data. Figure 5 shows a detail view of the area around the removed capacitors.

A new ribbon cable was attached to the memory module and the memory module was downloaded using NTSB's equipment and the recorder manufacturer's software.



Figure 1. Exterior of flight data recorder after removal from water.



Figure 2. Memory module removed from the recorder.



Figure 3. Memory module showing defective RTV sealant around the connector end of the board.

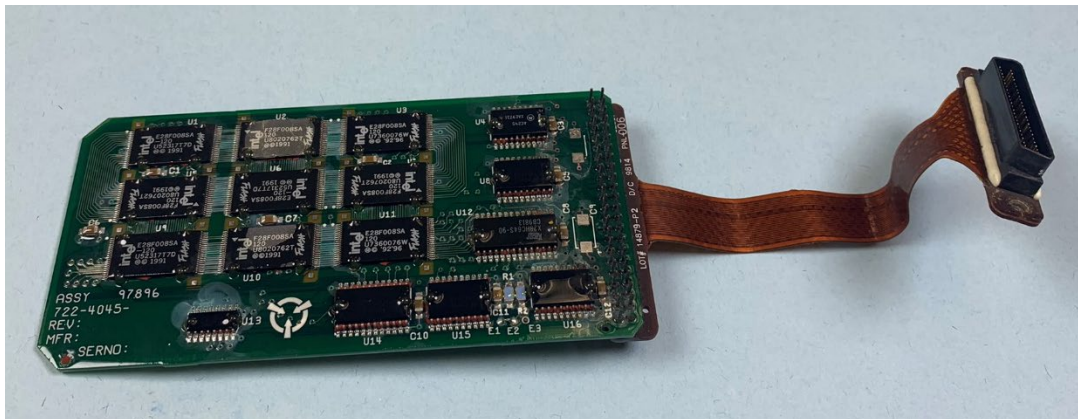


Figure 4. Memory module after cleaning, drying, and cable replacement.



Figure 5. Detail view of area where two damaged capacitors were removed prior to readout.

1.2 Recording Description

The FDR recording contained approximately 27 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 26 minutes. The parameters evaluated for the purpose of this report appeared to be in accordance with federal FDR carriage requirements, except rudder position. The lateral acceleration parameter was intermittently valid and invalid throughout the course of the 27-hour recording, however it was fully valid for the accident flight. The operator was informed of the parameter deficiency.

A problem was discovered with the timing of the data when it was compared with the timing of the cockpit voice recorder and air traffic control transcript. For more details, see section 1.3 Time Correlation.

1.2.1 Engineering Unit Conversions

The engineering unit conversions used for the data contained in this report are based on documentation from the STC holder. The conversions provided for the control wheel position and rudder pedal position transducers were shown by the performance study to be generated with invalid extents. These were corrected to their actual travel limits with a linear scaling factor in the performance study data¹. Additionally, aircraft installation issues were detected in several transducers requiring adaptations when developing new conversions. Rudder surface position recordings were invalid.

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=+).²

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

1.3 Time Correlation

When the FDR data was overlaid with the CVR transcript and the Air Traffic Control (ATC) transcript in support of an Aircraft Performance Study, it was discovered that the timing of the FDR data did not line up with the other 2 sources. Over the course of the ~22 minutes that could be paired between the FDR and

¹ For additional information on the corrections to the recorded data used in the performance study, see the Aircraft Performance Group Study, available in this docket.

² 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 = +.

CVR/ATC transcripts the FDR recording was shorter by about 9 seconds from the CVR and ATC.

An investigation was undertaken into why the FDR data could not be time aligned with other data sources. Because the FDR is a converted ARINC 542A recorder, there is no external flight data acquisition unit (FDAU) supplying data from other aircraft systems. The FDR reads analog sensor values directly, converts them to digital readings, and generates the digital ARINC 717 data stream to be recorded in crash protected memory at 768 bits per second. There is also no independent time source recorded, only the recorder's internal frame counter and subframe reference number, with each subframe count supposed to represent 1 second.

The frame counter advanced as expected throughout the accident recording, indicating that there was no missing or discontinuous data in the FDR recording or recorder resets during the flight. The drift between recorded transmissions on the CVR and ATC and the recorded FDR radio keying parameter was linear throughout the recording, starting at 0 and linearly increasing with time to be about 9 seconds off by the final recorded transmission. This was indicative of a problem with the way the data stream was encoded in the recorder and transmitted to memory.

To stretch the recording to match the other sources meant that 1 subframe corresponded to 1.0069659 seconds instead of the expected 1:1 ratio of subframes to seconds. With this stretch applied to the output, the FDR radio transmission keys and CVR/ATC transmissions aligned perfectly with each other. For the recorder to have generated this data stream it indicates that the ARINC 717 data stream was running at 762.7 bits per second, not the expected 768 bits per second.

The circuitry generating the FDR's internal clock signal and data stream was removed from the recorder and inspected to look for damage that could explain the data rate issue. Figure 6 shows the processor and data acquisition portion of the recorder chassis. Each individual board making up the main processing and data acquisition functions was removed and visually inspected. One board, A7, which is a data acquisition and multiplexing board aiding in processing some parameters, was found to have burn or scorch marks on the connector and pins, see figures 7 and 8. These marks were consistent with electrical arcing inside the connector. The burned pins were data signal pins, however it could not be determined which signals would have been affected without having access to the full aircraft wiring. It was not possible to determine if the arcing was present before the accident or was a result of the recorder entering the water, and it was also not possible to test the boards due to the corrosion present after four months in sea water.

Accordingly, correctly timed data was generated by adjusting the expected data rate in software and syncing it with the ATC transcript. The time offset for the event flight data from SRN to local HST is the following: $HST = SRN - 92,514$. Therefore, for the rest of this report, all times are referenced as HST, not SRN.



Figure 6. Processor and data acquisition cards inside FDR.

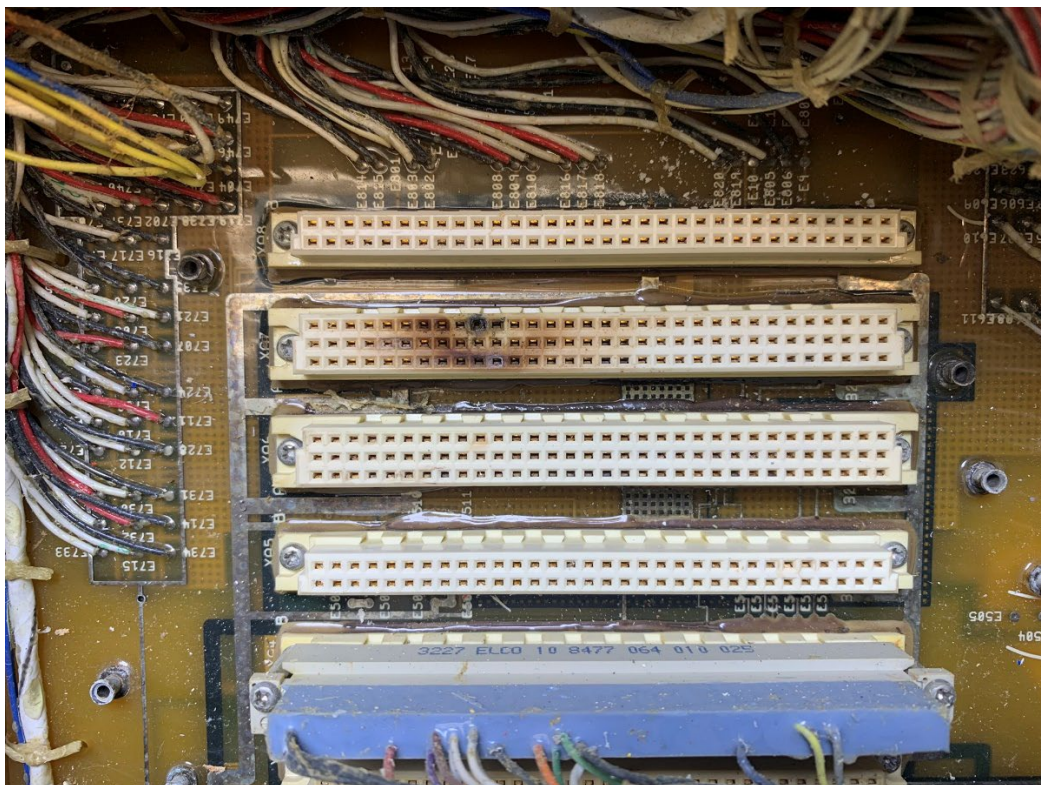


Figure 7. Processor and data acquisition card connectors in FDR chassis.

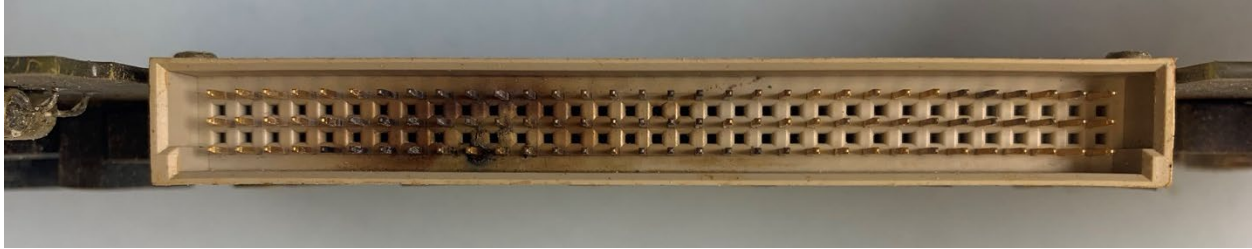


Figure 8. Connector pins on data acquisition card A7.

E. FIGURES AND TABULAR DATA

Figures 9 and 10 contain FDR data recorded during the event on July 2, 2021. All the parameters listed in table 1 are plotted.

Figure 9 shows the valid parameters recorded by the FDR from 01:32:00 HST to 01:45:30 HST. This starts with the aircraft prior to turning on to the runway and ends when the aircraft ditches in the ocean.

Figure 10 shows FDR data from 01:33:00 HST to 01:36:10 HST. This provides greater detail of the takeoff sequence and engine failure than figure 9.

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.

In the accident flight, the engines were advanced to takeoff power starting at 01:33:08 HST, and both stabilized at an EPR consistent with takeoff. Engine 1 (the left engine) was at 2.00 EPR and engine 2 (the right engine) was at 1.97 EPR. Longitudinal acceleration peaked at 0.2055 g during the takeoff roll. The aircraft rotated at about 140 knots and took off on a heading of 80 degrees.

As the aircraft passed through about 390 ft at 155 knots, engine 2 EPR suddenly dropped to 1.43, while engine 1 remained at its previously set takeoff power. Immediately after engine 2 EPR dropped, the rudder pedal moved to about 5.5 degrees of left rudder, consistent with a command to counteract the adverse yaw of losing thrust on the right engine. The climb paused at 1,000 feet for 25 seconds, then continued to 2,000 ft.

At 2,000 feet, engine 1 EPR reduced to a value of 1.051, which is consistent with idle power in previous flights. It stayed at this value for the remainder of the flight.

Engine 2 EPR also reduced at 2,000 feet, however it continued to be advanced and reduced several times until the end of the flight.

Altitude and airspeed decreased over the next 9 minutes until the end of the recording. At the end of the recording, engine 2 EPR was 1.462 and engine 1 EPR, having been stable since it reduced at 2,000 feet, was still consistent with previous flight idle settings at 1.052.

The corresponding tabular data used to create figures 9 to 10 are provided in electronic comma separated value (CSV) format as attachment 1 to this report.

Submitted by:

Charles Cates
Mechanical Engineer/Recorder Specialist

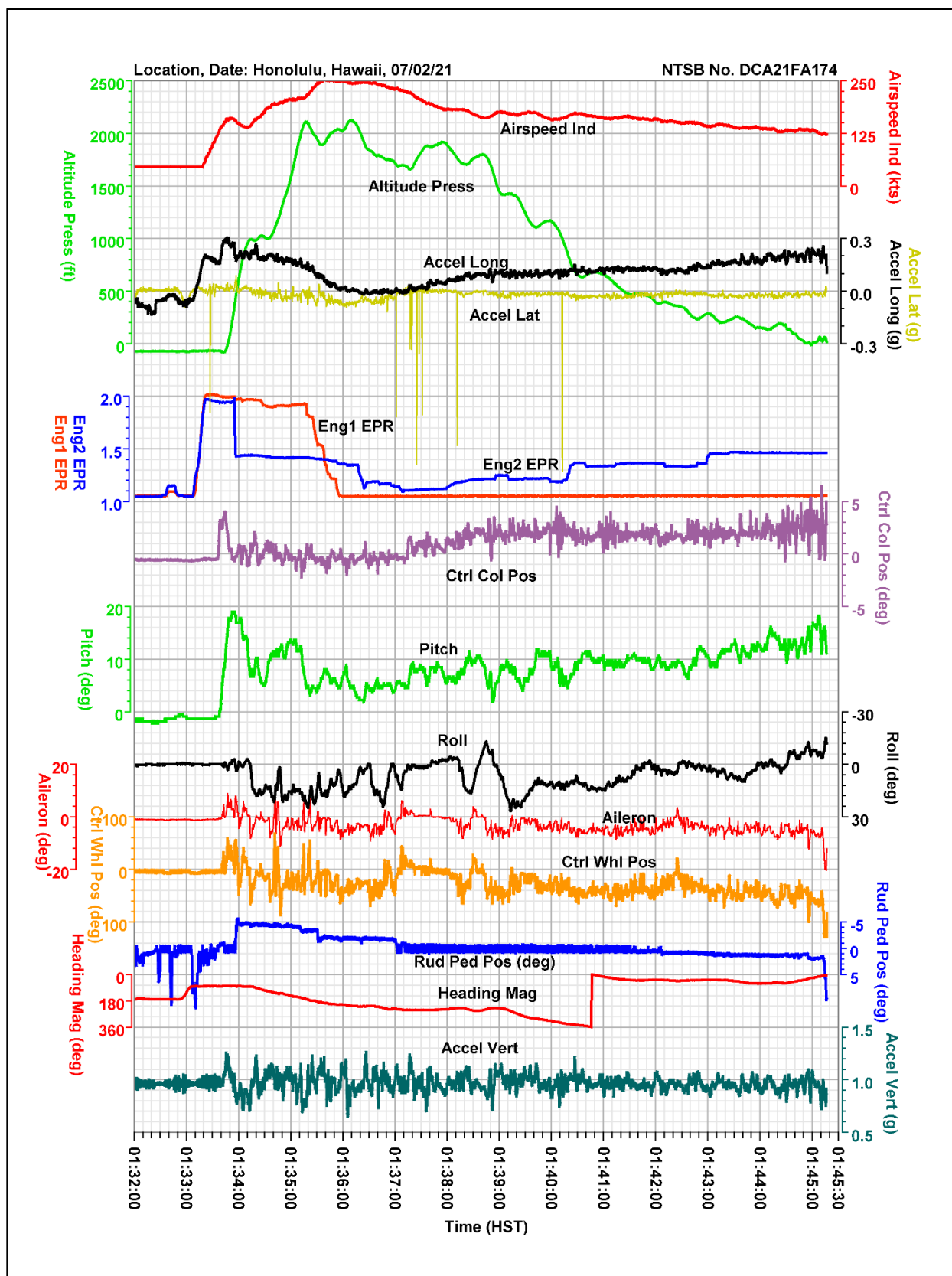


Figure 9. Plot of FDR data from the entire flight.

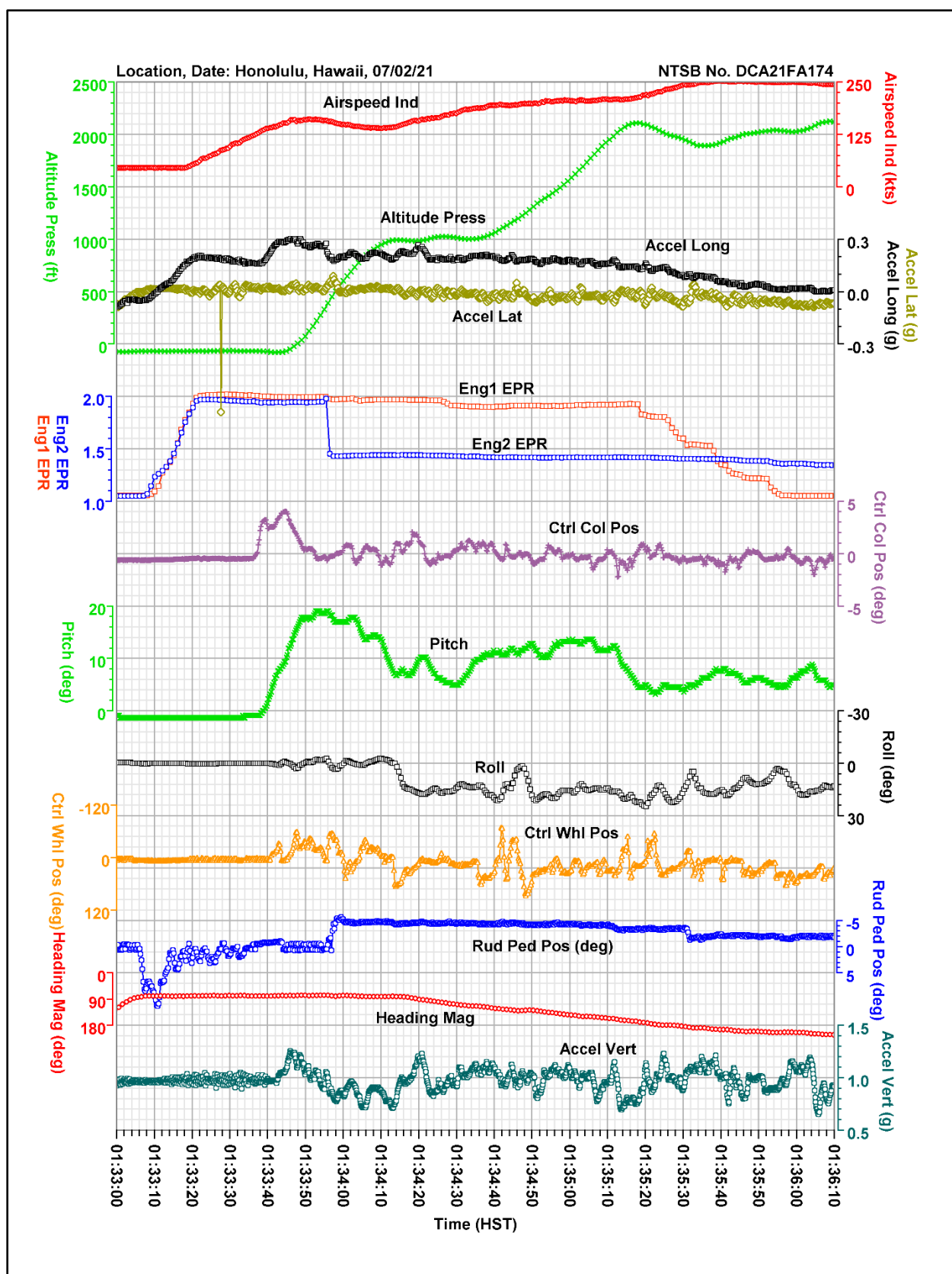


Figure 10. Plot of FDR data from the takeoff portion of the flight.

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 abbreviations used in this report.

Table 1. Verified and provided FDR parameters.

Plot/Table Labels	Parameter Names	Units
1. Accel Lat	Lateral Load Factor	g
2. Accel Long	Longitudinal Load Factor	g
3. Accel Vert	Vertical Load Factor	g
4. Aileron	Aileron Position	deg
5. Airspeed Ind	Indicated Airspeed	kts
6. Altitude Press	Pressure Altitude	ft
7. AP Eng	Autopilot Engaged	
8. Ctrl Col Pos	Control Column Position	deg
9. Ctrl Whl Pos	Control Wheel Position	deg
10. Elevator	Elevator Position	deg
11. Eng1 EPR	Engine 1 Engine Pressure Ratio	ratio
12. Eng2 EPR	Engine 2 Engine Pressure Ratio	ratio
13. Heading Mag	Magnetic Heading	deg
14. Key VHF	VHF Radio Keyed	
15. Pitch	Aircraft Pitch Angle	deg
16. Roll	Aircraft Roll Angle	deg
17. Rudder Pedal Position	Rudder Pedal Position	deg

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 abbreviations.

Unit Abbreviation	Description
g	gravitational acceleration
deg	degrees
kts	knots
ft	feet