

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



DCA22LA212

AIRCRAFT SYSTEMS

Group Chair's Factual Report

September 18, 2024

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A. INCIDENT

Location: Los Angeles, California
Date: September 22, 2022
Time: About 1200 Local Time
Airplane: Hawaiian Airlines Flight 3, an Airbus A330-243, registration N393HA

B. AIRCRAFT SYSTEMS GROUP

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C. SUMMARY

On September 22, 2022, at about 1200 pacific daylight time, Hawaiian Airlines Flight 3, an Airbus A330-243, registration N393HA, reported a pitch motor failure and erratic movement of the flight deck pitch trim manual wheel while during cruise flight. There were no injuries to the passengers or flight crew. The flight was operated as a 14 Code of Federal Regulations Part 121 flight. The flight originated from Los Angeles International Airport and was destined for Honolulu, Hawaii.

Following the flight on September 22, the airplane's pitch trim actuator was removed and replaced. The airplane then experienced additional flight control faults during flights on October 3, October 22, November 3, and November 5, 2022. On November 7, 2022 following a flight from Los Angeles International Airport to Kahului Airport, Hawaii, the resultant flight data recorder (FDR) information showed a fluctuation in the horizontal stabilizer position. As a result, the trimmable horizontal stabilizer actuator was removed and replaced.

From September 22 to November 14, 2022, the following components were removed from the incident airplane for further examination:

1. Trimmable Horizontal Stabilizer Actuator (THSA)
Part Number: 47172-530
Serial Number: 1454
2. Pitch Trim Actuator (PTA)
Part Number: 47148-122
Serial Number: 1590
3. Digital Electronic Module (DEM), Position 1
Part Number: D90ST4209-100
Serial Number: 6816
4. Command Rotary Variable Differential Transformer (COM RVDT)
Part Number: 450102
Serial Number: AR00450
5. Monitor Rotary Variable Differential Transformer (MON RVDT)
Part Number: 423473-100
Serial Number: 823

This report summarizes the examinations conducted by the Systems Group for the investigation. Unless otherwise noted, the Bureau d'Enquêtes et d'Analyses (BEA) conducted each of the examinations and/or group meeting and provided the NTSB with the results.

The group met to examine the Trimmable Horizontal Stabilizer Actuator (THSA) and Pitch Trim Actuator (PTA) installed on the airplane at the time of the incident (September 22). The group met at the Collins Aerospace facility in Saint-Ouen L'Aumône, France, on January 19, 2023. Several components fitted on the as-received THSA differed from the components installed on the THSA at the time of the September 22 incident flight; the COM RVDT, the MON RVDT, and the PTA had all been removed and replaced since the September 22 flight.

After the COM RVDT installed on the THSA at the time of the September 22 incident flight was obtained, the group met again at the Collins facility to perform an additional Acceptance Test Procedure on the THSA with the incident flight COM RVDT re-installed. The test was conducted on March 14, 2023.

The group met on July 20th, 2023, to examine the COM RVDT installed at the time of the September 22 incident flight and the MON RVDT that was installed in November 2022 and removed when the THSA was removed on November 14, 2022. The RVDT packs were examined at the Collins Aerospace facility in Saint-Ouen L'Aumône, France. Representatives from the COM and MON RVDT sensor manufacturer ARTUS were also in attendance.

The group, under the witness of the United Kingdom Aircraft Accident Investigation Bureau (AAIB), examined the Digital Electronic Module (DEM) 1 on August 2, 2023 at the Triumph facility in Flintshire, United Kingdom.

Following the DEM examination, Triumph was asked by Airbus (and the group) to develop possible scenarios within the THS system that could lead to behavior like the September 22 incident flight. As a result, Triumph conducted tests on an engineering DEM. The tests did not completely reproduce a behavior like the incident flight.

The DEM (position 1) was further examined at the BEA's headquarters at Le Bourget Airport in Paris, France on June 13, 2024. The examination was witnessed by Triumph, BEA, Collins, and Airbus. The DEM was visually examined, followed by X-ray and Computed Tomography (CT) scan inspections.

None of the examinations or testing were able to determine a cause or replicate the oscillations noted on the airplane during the September 22 incident flight.

A search of the Hawaiian maintenance database in August, 2024 found that, since the replacement of the PTA and THSA in November 2022, there have only been two pitch faults noted. Both faults were noted in March 2024, and both were corrected by flightcrew resets.

D. DETAILS OF THE INVESTIGATION

According to the operator, during the September 22 incident flight, the airplane was "porpoising" with one or both autopilots engaged; the flight deck pitch trim wheel would constantly move/rotate, which caused the airplane's pitch to oscillate. When the autopilot was disengaged, the pitch trim wheel continued to move but the airplane stopped "porpoising".

Following the flight, a post flight report accessed through the Multi-Function Control and Display Unit (MCDU) by the airline revealed a fault message "PITCH TRIM ACTR OVERRIDE SWITCH". See Figure 1.



Figure 1. Post Flight Report Fault Message, as displayed on the airplane's MCDU.

The fault message, along with guidance from Airbus, led Hawaiian Airlines maintenance personnel to perform Airbus' A330 Troubleshooting Manual (TSM) Task 27-44-00-810-801-A. The TSM task, when accomplished, required the replacement of the PTA via Aircraft Maintenance Manual (AMM) 27-44-57. The PTA serial number 1590 was replaced by PTA serial number 414. Once the PTA was replaced, the THS actuator tested good per AMM 27-44-00-710-805-A, "Operational Test of the Trimmable Horizontal (THS) Actuator". The maintenance crew was unable to replicate the fault on ground.

Following the flight of September 22, during October and November 2022, the airplane experienced flights with annunciated flight control faults. In response, multiple components within the THS were replaced. Table 1 lists the removed and replaced components, in addition to the annunciated fault.

Table 1. Removed Components in Chronological Order

DATE (All Dates 2022)	Fault Annunciated	Component Removed	Component Replaced	Components Swapped
22 September	Pitch Trim Override	Pitch Trim Actuator (s/n 1590)	Pitch Trim Actuator (s/n 414)	N/A
3-5 October	Flight Control/PRIM 3	FCPC3	FCPC3 (same unit refitted)	N/A
7 October	“	FCPC3 (s/n 09536)	FCPC3 (s/n 08955)	N/A
15 October	“	N/A	N/A	DEM2 (s/n 8253) swapped with DEM3 (s/n 7353)
19 October	“	N/A	N/A	FCPC1 (s/n 2K2009563) swapped with FCPC3 (s/n 2K2008955)
22 October	Flight Control/PRIM 3, FCPC3/Pitch Trim Actuator Elec Motor	Pitch Trim Actuator (s/n 414), on 2 November	Pitch Trim Actuator (s/n 920)	N/A
3-5 November	Flight Control 1 Pitch Fault, Pitch Trim Actuator	MON RVDT (s/n AR00476)	MON RVDT (s/n 823)	N/A
6 November	“	COM RVDT (s/n AR00450)	COM RVDT (s/n AR00066)	N/A
7 November	STAB drift	THSA (s/n 1454) removed 14 November	THSA (s/n N/A)	N/A

On November 7, 2022 the airplane experienced a second flight in which the trimmable horizontal stabilizer (THS) position fluctuated. The THSA was removed from the airplane for further examination on November 14, 2022. Based on the recommendation of Airbus, some of the previously removed components were quarantined for further examination. See list in Section C., Summary.

The NTSB was notified of the September 22, 2022 incident flight by the operator. The flight data recorder information was provided to the NTSB; Airbus was asked to convert and plot the resultant data. Although the NTSB was not alerted to the October and November flights with annunciated flight control faults, the operator alerted the NTSB of the details of the November 7, 2022 flight and provided quick access recorder data to the NTSB.

1.0 HORIZONTAL STABILIZER PITCH TRIM SYSTEM

Based on the circumstances of the incident, the group's investigation focused on the airplane's horizontal stabilizer system.

1.1 DESCRIPTION OF SYSTEM

The Airbus A330 has a traditional trimmable horizontal stabilizer (THS), with two elevators along the trailing edge of the stabilizer, for pitch and pitch trim control. The THS is connected to the airplane fuselage and moves about a local axis to provide airplane pitch trim. See Figure 2.

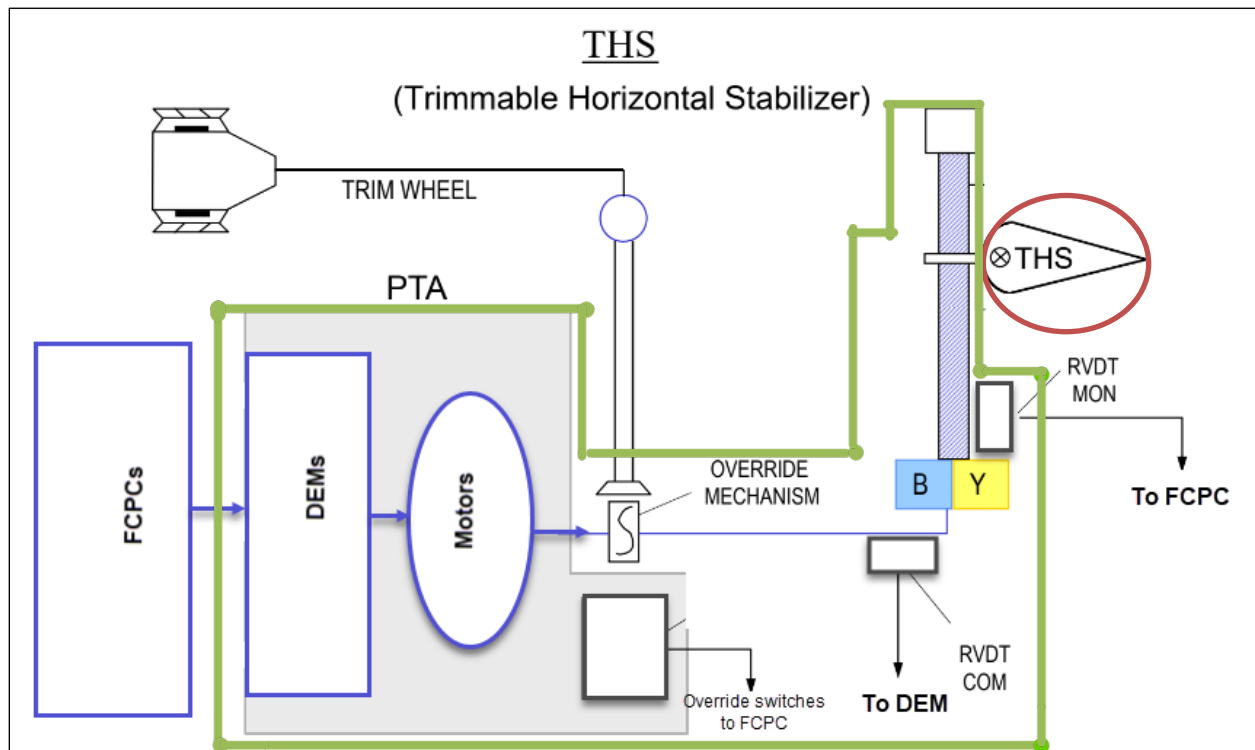


Figure 2. A schematic illustration of the Trimmable Horizontal Stabilizer (THS) System. Illustration courtesy of Airbus. (Illustration courtesy of Airbus.)

Note: The NTSB added to Airbus' illustration by circling (in red) the THS and outlining the THS actuator (in green).

The THS is moved hydromechanically via a ball screw THS Actuator (THSA). The THSA is powered by two hydraulic motors¹ and held by brakes. The electrical control of the THSA is for the auto trim function in Auto and Manual flight, while the mechanical control acts as a standby system which can be used in flight or on the ground to trim the THS.

Mechanical control is achieved by the two flightdeck control wheels, located on

¹ One motor from each of the Blue (B) and Yellow (Y) Hydraulic Systems.

either side of the center pedestal (see Figure 3). Cables from the control wheels are connected to the mechanical input shaft of the THSA. The mechanical control can be used by the crew to override the electrical control. When the crew acts on the trim wheel, electrical control is overridden provided that a sufficient torque is applied on the trim wheel, during pitch trim movement or when standing still.

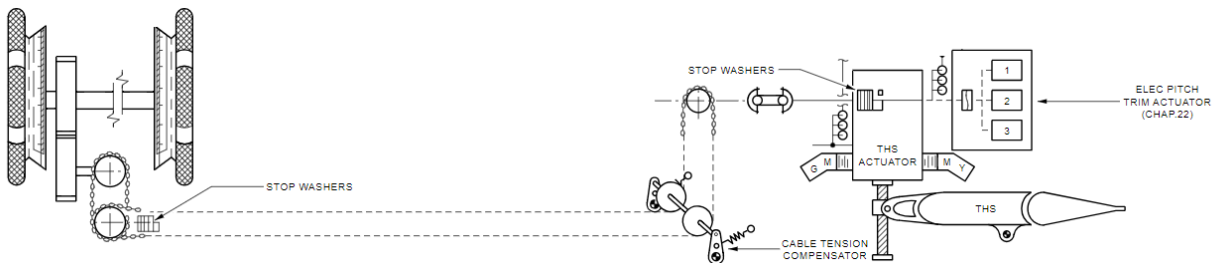


Figure 3. The flight deck pitch trim control wheels and connections to the THSA. (Illustration courtesy of Airbus)

The THS Actuator (THSA) moves the THS. When the THSA is operating in electrical modes, the electrical commands from the three Flight Control Primary Computers (FCPC) are converted to hydraulic actuation by the Pitch Trim Actuator (PTA). The PTA is a sub-component of the THSA. It has three DC motors, each of which is controlled by its own controller, and an associated Digital Electronic Module (DEM1, 2, or 3). The DEMs adjust its order to compensate the difference between the position feedback from the sensor to the target value from the associated FCPC. See Figure 4.

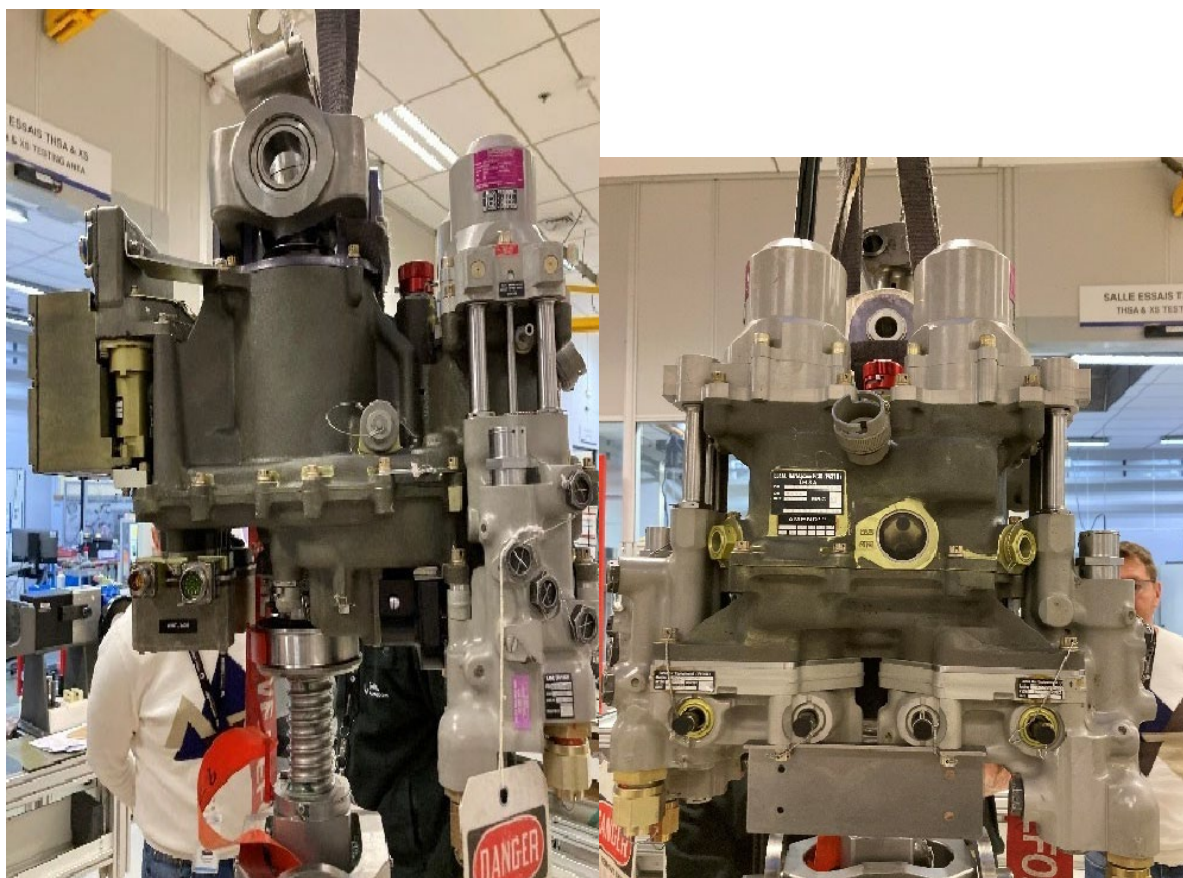


Figure 5. The THSA, as received at Collins.

2.1 VISUAL EXAMINATION OF THE THSA

The following was noted during the visual examination of the THSA, once it was removed from its shipping container:

1. The sub-component MON RVDT (part number 423473-100, serial number 823) was different than the MON RVDT (s/n AR00476) that was installed on the THSA for the September 22 incident flight. The incident MON RVDT was removed in November, 2022.
2. The sub-component COM RVDT (part number 450102, serial number AR00066) was different than COM RVDT s/n AR00450) that was installed on the THSA for the September 22 incident flight. The incident COM RVDT had been removed and replaced from the THSA in November, 2022.
3. The sub-component PTA (part number 47148-122, serial number 920) was different than the PTA (47148-122, serial number 1590) installed on the THSA at the time of the incident, as the PTA was replaced following the September 22 incident flight.
4. No significant physical damage was noted on the unit.

2.2 EXAMINATION TEST OF THE THSA

Prior to testing, the PTA installed on the THSA for the September 22 incident flight (serial number 1590) was reinstalled, with PTA (serial number 920) removed.

The THSA was placed onto a Collins test bench. The THSA was tested according to its CMM Section 27-44-54. The THSA passed the testing with no faults found, with the following notes highlighted:

1. Using the mechanical input, the THSA was operated to its limits – full nose down position and then full nose up position.
2. The THSA was commanded to a neutral position (0 degrees) on all 3 channels, with no oscillations of the THSA noted.
3. The THSA was then commanded to the -2.5 degrees position, which corresponded to one of the positions recorded during the event. No THSA oscillations were noted.
4. The operation of the override mechanism was successfully checked.
5. The accuracy of the MON and COM RVDT position transducers with the THSA at 0° and -13.5° positions were successfully checked. The transducer accuracy at these positions were within CMM limits.
6. The PTA was removed from the THSA and placed in a climatic chamber at -40 degrees Celsius for two hours. The PTA was remounted on the THSA and the CMM test was run again. No anomalies were identified.

3.0 EXAMINATION OF PITCH TRIM ACTUATOR

The Pitch Trim Actuator (PTA) serial number 1590 was examined at the Collins Aerospace (formerly Goodrich Actuation Systems, SAS) facility in Saint-Ouen L'Aumône, France, on January 19, 2023 – during the same group examination activity as the THSA examination. The examination was conducted under the supervision and witness of the BEA. The PTA was tested according to the pertinent portions of the THSA CMM Section 27-44-54.

In summary, the results of the tests were as follows:

- Microswitch Operation Check: The PTA contains three microswitches. The CMM limits on the microswitch movement are between 1.16 millimeters and 1.21 millimeters (mm). Each of the microswitches were measured beyond the CMM limits – Microswitch Number 1 at 1.30 mm, Microswitch Number 2 at 1.26 mm, and Microswitch Number 3 at 1.29 mm.
- Internal Friction Torque Measurement: The PTA internal friction torque was measured slightly above CMM limit of 700 cm-g; the torque was measured at 750 cm-g.
- Test of Simulated PTA Performance: This was an automated test that was run twice. The test checked the voltage at which the microswitches triggered. For

both tests, the results were within CMM limits.

- Ground Continuity: The ground continuity of the PTA was successfully tested within CMM limits (20 mega Ohms).

4.0 RE-TEST OF THSA WITH INCIDENT COM RVDT RE-INSTALLED ON THSA

The group met at the Collins facility on March 14, 2023 to re-examine the THSA.

The COM RVDT (s/n AR00450) that was installed on the THSA for the September 22 incident flight was re-installed on the THSA and the CMM Acceptance Test Procedure (ATP) was accomplished. The THSA was considered to have passed the ATP with the following minor discrepancies:

- The bonding resistance between the THSA and the RVDT attaching screws was found beyond the CMM limits. The resistance was measured at 48 mega Ohms (mOhms) with a maximum allowed value of 10 mOhms. [Note: According to Collins, these observed values were considered typical for in-service equipment, without functional effect.]
- The MON RVDT Transducers Number 1 position (of three) at 0 degrees THS was slightly above CMM limits. For the accuracy determination, the two root mean square (RMS) voltages for each of the three position transducers is calculated to a ratio. For Transducer 1, the measured ratio values of -0.0027 and -0.0025 were both above the maximum allowed value of ± 0.0022 , for each of the two checks, respectively.

5.0 COM AND MON RVDT PACKS SUB-ASSEMBLY TESTS

The COM RVDT (s/n AR00450) and MON RVDT (s/n 823) packs were examined in accordance with their CMM Section 27-44-54. The COM RVDT was installed at the time of the September 22 incident flight, while the MON RVDT was installed in November, prior to the November 7th event, and removed (with the THSA) on November 14, 2022². See Figure 6.

² According to the BEA, both the MON RVDT and COM RVDT installed for the September 22 incident had been removed and sent to Collins for repair. The MON RVDT was repaired while the COM RVDT was located by the BEA prior to any repair and made available for further examination.



Figure 6. The COM RVDT, serial number AR00450, prior to its sub-assembly test.

The examinations were conducted July 20th, 2023 at the Collins Aerospace facility in Saint-Ouen L'Aumône, France. The summary of the examinations is as follows:

- For both RVDTs, the visual examination determined no evidence of physical damage or corrosion. The black sealant compound on both packs was in good condition.
- For both RVDTs, no anomalies were found with the electrical connectors.
- The check of the COM RVDT position sensor accuracy at a THS position of 0 degrees and 14.9 degrees passed within CMM limits.
- The check of the MON RVDT position sensor accuracy at a THS position of 0 degrees was out of CMM limits. For the accuracy determination, the two root mean square (RMS) voltages for each of the three position transducers is calculated to a ratio. The ratio should be within ± 0.0016 to be considered within CMM limits. The ratio was calculated at -0.0048, -0.0025, and -0.0036 for the MON transducer Number 1, Number 2, and Number 3, respectively. When checked second time, the ratio was calculated at -0.0047, -0.0019, and -0.0033

for the MON Transducer Number 1, Number 2, and Number 3, respectively. The check at a THS position of 14.9 degrees passed within CMM limits.

- The check of ground continuity per CMM section 27-44-54 was conducted on both RVDT packs. The continuity exceeded CMM limits for both units; however, it was noted that the values were typical of units in service, and the tests passed for both units after surface contact cleaning.
- The check of insulation resistance for both components was found within CMM limits.
- In addition to the CMM tests, the DC resistance for the units was checked. All sensors measured were compliant, except for the Number 2 sensor of the RVDT MON, which exceeded the sensor data. The resistance was measured at 74.3 ohms instead of the maximum allowed value of 28.76 ohms.
- The packs were disassembled, and the units checked for humidity or corrosion. No visual evidence of humidity or corrosion were noted. No physical damage was noted inside the units.
- Following the disassembly, the two units were placed into a climatic chamber and cold-soaked at -55 degrees Celsius for 85 minutes. Following the climatic chamber, the COM RVDT and MON RVDT were again checked for their DC resistance. For the COM RVDT, all the measured values were consistent with the previously measurements. For the MON RVDT, all the measured values were consistent with those previously measured, and the Sensor #2 failed again.

6.0 DEM SUB-ASSEMBLY TESTS

The DEM from position 1, serial number 6816, was examined at the Triumph facility on August 2, 2023, under witness by Collins, Airbus, and United Kingdom AAIB. The examination was conducted at the Triumph Aerospace facility in Flintshire, England. See Figure 7.



Figure 7. The DEM1, prior to examination.

The DEM examination was summarized as follows:

- The isolation and bonding tests were found within CMM limits.
- The DEM leakage test failed as the recorded pressure was below the CMM minimum limit³. For the test, the DEM internal pressure is raised to 199.0 kilo Pascals (kPA) and checked after 1 minute; the pressure should not drop by more than 40 kPA during the minute. The recorded pressure after 1 minute was 124.7 kPA.
- The DEM passed the automatic test equipment tests within CMM limits.
- The DEM was placed in a climatic chamber, the temperature lowered to -55 degrees C and held for twenty minutes, and the unit then re-tested to the CMM. The DEM passed; no anomaly or oscillations were noted.

³ Triumph indicated that they do not perform leakage tests on returned units (as they are opened and resealed as part of the maintenance and repair process), so the values recorded for this unit may or may not be typical.

Following the DEM examination, Triumph was asked by Airbus (and the group) to develop possible scenarios within the system that could lead to behavior like the September 22 incident flight. In response, Triumph developed three possible scenarios. The scenarios, in general, involved either changes to one bit of the DEM's internal memory or internal airplane pitch attitude data, or a misinterpretation of the RVDT analog input signal by the DEM - all from unknown reasons.

Based on group discussion, Triumph tested one scenario on an engineering unit. The tests were conducted internally by Triumph during March, 2024. Using one of the scenarios, Triumph performed tests on two pins of a Resolver to Digital Converter (RDC) microchip on the Control Board of an engineering DEM. The testing did not completely reproduce a behavior like the September 22 incident flight. No further testing was accomplished.

7.0 DEM COMPUTED TOMOGRAPHY SCANS AND DISASSEMBLY

An additional examination of the DEM1's internal circuit boards was conducted at the BEA's headquarters at Le' Bourget Airport in Paris, France on June 13, 2024.

Once disassembled, the DEM1's two internal circuit boards - Control Board and Power Board - were visually examined. See Figures 8 and 9.

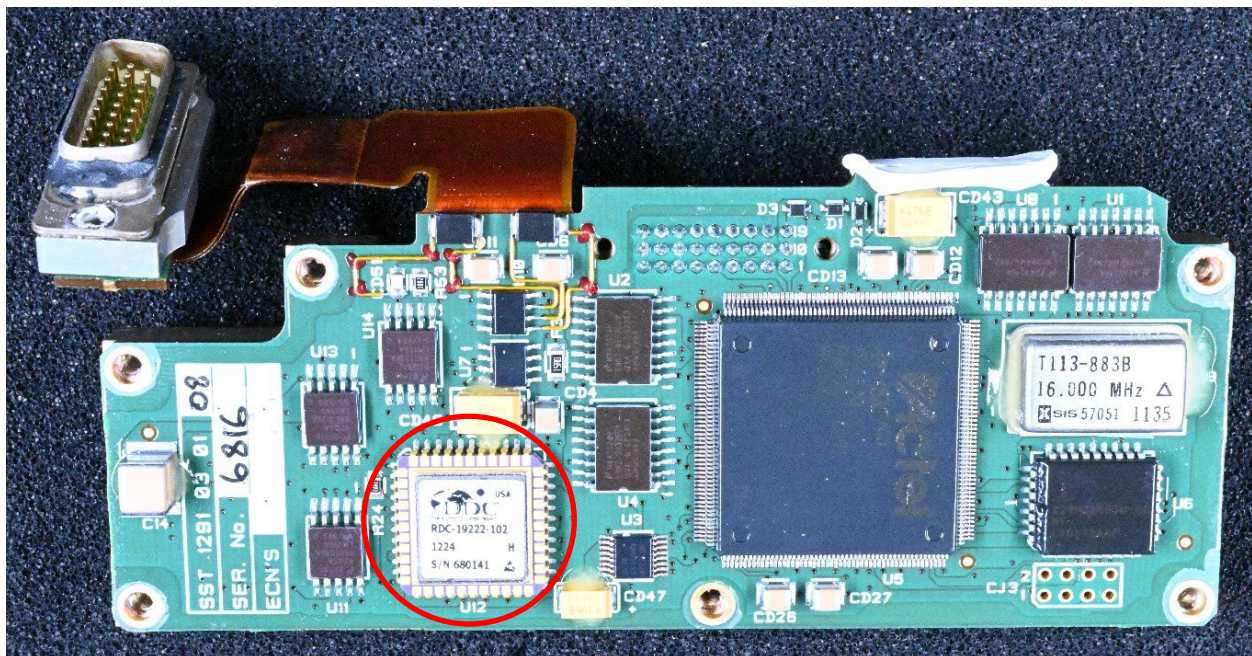


Figure 8. The DEM1's Control Board, external side. The RDC device (U12) is circled in red.

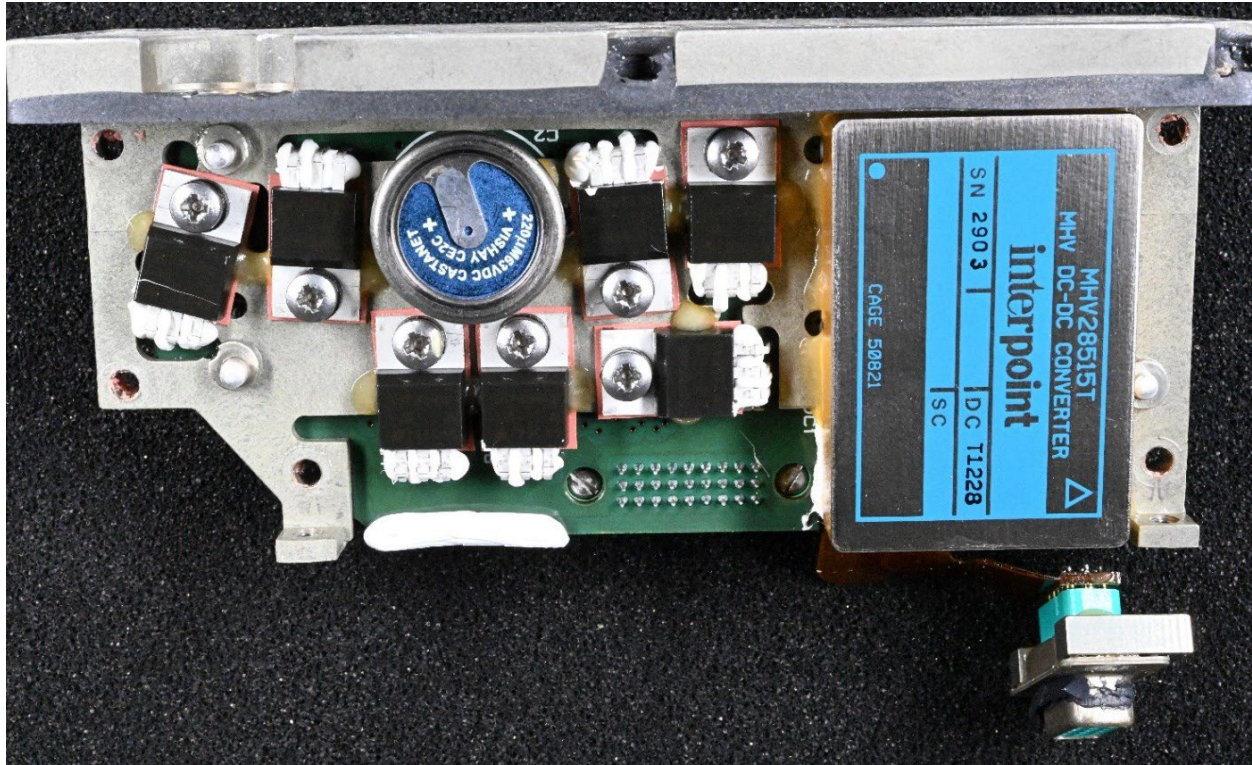


Figure 9. The DEM1's Power Board, external side.

The visual inspections were followed by X-ray and Computed Tomography (CT) scan inspections of the internal circuit of the control board.

The examinations were summarized as follows:

- The boards were examined under microscopes. The boards were noted in good condition with no traces of moisture or corrosion noted.
- No anomalies were observed on the interconnectors or the boards' surface components.
- A detailed examination of the RDC digital controller was conducted. The connector pins were observed to be in good condition, with no faults noted on any of the pin solder joints. See Figure 10.

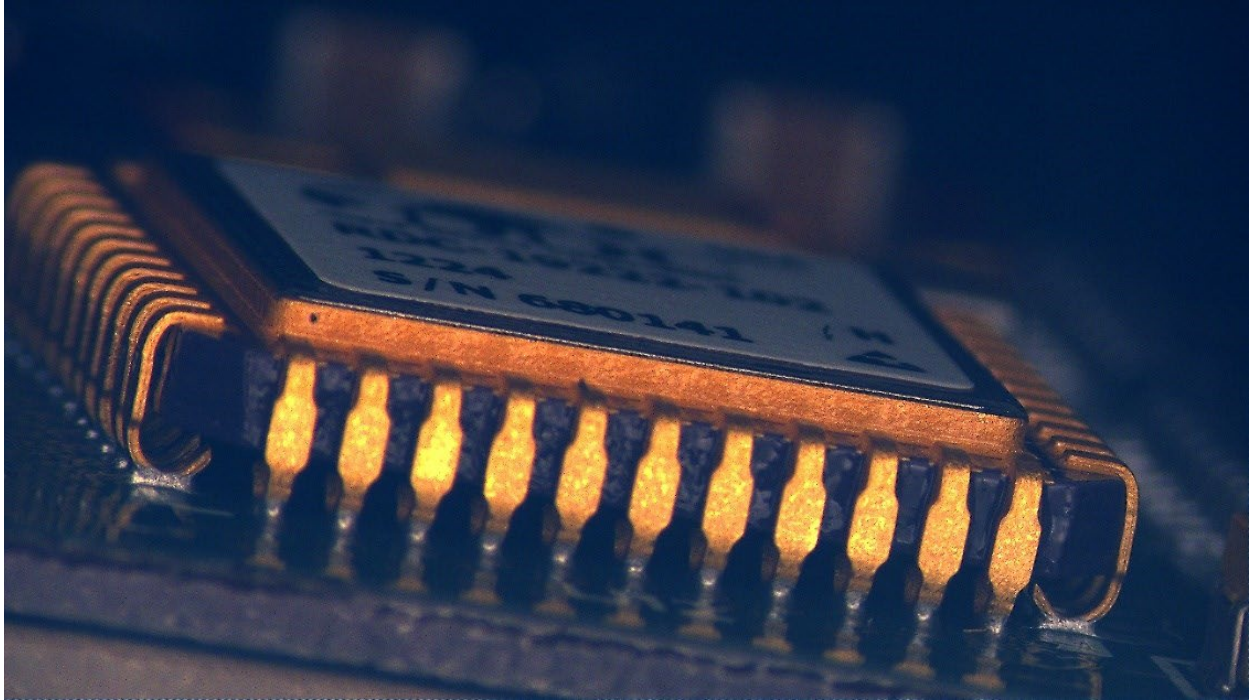


Figure 10. The RDC device, side view to show connector pins.

- An X-ray examination of the control board was performed, with no faults observed on the interconnection circuit nor on the surface components or connection bonding.
- A CT scan was performed on the control board. After the scans were conducted and the board rendered in three dimensions, all the RDC pins were examined individually, with no damage observed. No anomalies were noted on the tracks from RDC data pins to the field-programmable gate array.

According to the group, no faults were observed on the electronic boards of the DEM.

8.0 AIRPLANE FAULT MESSAGES RELATED TO PITCH CONTROL

In August, 2024, NTSB requested that Hawaiian search for any pitch and pitch trim fault codes annunciated on the incident airplane (N393HA) since the removal of the THSA in November, 2022. Hawaiian Air Lines responded that a search of their internal maintenance databases determined that, since the replacement of the PTA and THSA in November 2022 until August 2024, there have only been two defects for pitch faults annunciated, both in March 2024 as follows:

1. On March 6, 2024 : "PRIM 2 PITCH FAULT (RESET OK)" defect was noted by the pilot, with the corrective action "BITE TEST OF PRIM 2 ACCOMPLISHED. NO FAULTS FOUND. OK FOR SERVICE".

2. On March 29, 2024 the following fault description was noted: "INFO TO MX: DURING ENG 2 START, ECAM "F/CTL SEC PITCH FAULT" RESET SYSTEM ONCE PER QRH AND MOC. RESET SUCCESSFUL." The following resolution description was provided: "INFO NOTED. OK TO CONT."

Hawaiian indicated that both faults were corrected by flightcrew resets. In addition, Airbus indicated that neither of the faults were similar nor associated with the fault codes annunciated during the incident flight.

Tom Jacky
Aircraft Systems Investigator