

20 January 2023  
66-CB-H220-ASI-19290

Sathya Silva  
Investigator In Charge  
National Transportation Safety Board  
490 L'Enfant Plaza, SW  
Washington DC 20594



Subject: Boeing Submission for the Transair 737-200C N810TA Accident near  
Honolulu, Hawaii, 02 July 2021

References: E-mail, 19 December 2022, NTSB to Boeing, Transair Docket Release Today  
5pm EST

Dear Dr. Silva

As requested in the reference e-mail regarding the technical review, please find the attached Boeing submission on the subject accident. Per your request we are sending this electronic version to you attention for distribution within the NTSB.

The information included with this correspondence is controlled under the US Export Administration Regulations (15 CFR Parts 300-799) and has been categorized as ECCN: 9E991.

We would like to thank the NTSB for giving us the opportunity to make this submission. Please feel free to contact us if you have any questions.

Best regards,

Robert J. McIntosh  
Director, Product Safety

Enclosure: Boeing Submission to the NTSB for the subject accident



Submission to the  
National Transportation Safety Board  
for the

**Rhoades Aviation 737-200C N810TA  
Loss of Engine Thrust and Ditching  
Honolulu, Hawaii  
02 July 2021**

**The Boeing Company  
20 January 2023**



## INTRODUCTION

On 02 July 2021, at approximately 0145 Hawaii Standard Time, a Boeing 737-200C airplane, N810TA, owned by Rhoades aviation and operating as Transair Flight 810 on a flight from Daniel K. Inouye Honolulu International Airport to Kahului, Hawaii, lost engine power shortly after takeoff and performed a water landing into Mamala Bay, just south of the Hawaiian island of Oahu. The two members of the flight crew, the only occupants of the airplane, evacuated the flight deck and were rescued by the US Coast Guard and an Airport Rescue and Firefighting (ARFF) unit from Honolulu International Airport, and the airplane sank in approximately 350 feet of water. Night visual meteorological conditions prevailed at the time of the accident.

### Submission Abstract

- Weather at the time of the accident did not contribute to the accident sequence.
- The Boeing Company, as the airplane's manufacturer, is an invited party to the investigation and provides technical and operational assistance to the National Transportation Safety Board (NTSB) in their investigation.
- The conclusions presented in this submission are based on factual information received from the NTSB, Boeing expertise, the use of analytical tools, and a methodical investigation process.
- Examination of aircraft engine hardware after the accident showed damage to first-stage high-pressure (T1) turbine blades in engine #2 (right-hand), and no evidence of pre-impact damage to engine #1 (left-hand).
- Shortly after liftoff and on initial climb, the #2 engine experienced a sudden drop in power, likely due to damage in the engine's T1 blades, as identified during engine examination.
- Shortly after the sudden loss of power in engine #2 (right-hand), engine #1 (left-hand) power was slowly reduced, likely the result of the associated thrust lever being manually moved aft in the flight deck.
- Review of data from the Flight Data Recorder (FDR), Cockpit Voice Recorder (CVR), Enhanced Ground Proximity Warning System (EGPWS), Automatic Dependent Surveillance – Broadcast (ADS-B), and recovered airplane wreckage and systems components showed no evidence of a system malfunction or any other evidence of airplane structural or systems anomalies prior to impact.
- As the Engine Pressure Ratio (EPR) setting on engine #1 reached its minimum (where it stayed through the remainder of the flight), the total thrust produced by both engines fell below that required to sustain level flight and did not increase beyond that value through the end of the flight.



## **BOEING ASSISTANCE WITH THIS INVESTIGATION**

The National Transportation Safety Board (NTSB) is conducting the investigation into this Rhoades Aviation 737-200C accident. Assisting the NTSB in their investigation are the Federal Aviation Administration (FAA), Rhoades Aviation, Pratt & Whitney, Boeing, and other designated parties.

As the manufacturer of the 737-200C airplane, Boeing's specific role in this investigation has been to assist the NTSB by providing technical information regarding the airplane design, manufacture, and operation.

The NTSB requested that all parties submit proposed findings drawn from the factual information established during the course of the investigation. Boeing has responded to the NTSB request with this document, which:

- Provides an assessment of the factual information and other pertinent data
- Identifies knowledge gained from the investigation
- Identifies conclusions supported by the knowledge gained from the investigation

## **BOEING ASSESSMENT**

The Boeing assessment of the accident is based upon the facts as documented in the NTSB's factual reports. These reports are observations of the airplane and accident site, post-accident examination of airplane systems and components, Flight Data Recorder (FDR) data, Automatic Dependent Surveillance – Broadcast (ADS-B) data, Enhanced Ground Proximity Warning System (EGPWS) data, the cockpit voice recorder (CVR) transcript, and flight crew interview information.



## THE ACCIDENT AIRCRAFT

The Boeing Company delivered the accident airplane (registration N810TA, serial number 21116) on October 10, 1975 to another airline customer. The airplane was built as a 737-200C, or convertible, airframe that allowed the airplane operator to change the configuration of the main deck interior to carry cargo or passengers as circumstances required, and at the time of the accident the interior was equipped in the cargo configuration. The airplane had accumulated 72,871.20 hours and 69,446 cycles at the time of the accident, and was equipped with two JT8D-9A engines.

## WEATHER

The accident takeoff was recorded at approximately 1:33am Hawaii Standard Time (HST). The Automated Terminal Information System (ATIS) weather received by the flight crew prior to departure reported conditions consistent with night Visual Meteorological Conditions: winds from the east-northeast at 10 knots, visibility 10 statute miles or greater, few clouds at 2,500 feet AGL<sup>1</sup>, scattered clouds at 4,500 feet AGL, temperature 26° C, dew point 18° C, altimeter 30.04, with ILS<sup>2</sup> or visual approaches in use to Runways 4 and 8. The moon was in a waning crescent phase with 44% of its disk illuminated.<sup>3</sup> Recorded data show the accident aircraft remained below all cloud levels and within 16 nautical miles of the Honolulu airport for the duration of the accident flight.

## AIRPLANE SYSTEMS

During post-accident interviews, the flight crew noted that while preparing to depart on the accident flight, the first officer noticed fluid in the area of the left main landing gear, which the crew suspected could be the result of a left hydraulic system leak.<sup>4</sup> After discussing the fluid with maintenance and with the captain, the crew operated hydraulic pumps to pressurize the hydraulic system and verify system integrity. Finding no leaks and no reduction in hydraulic fluid quantity in the system, the crew accepted the airplane for dispatch.

After the accident, the recovered wreckage was segregated at a dock on Oahu to be examined by the NTSB systems group with the onsite participation of a Boeing group member. The Enhanced Ground Proximity Warning System (EGPWS) was recovered and downloaded to supplement other recorded data from the Flight Data Recorder (FDR). The investigation considered the recorded airplane performance using FDR, EGPWS, and Automatic Dependent Surveillance – Broadcast (ADS-B) data and observed proper response of hydraulically-powered flight controls, flaps, and landing gear to pilot commands; and showed no evidence of

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<sup>1</sup> Altitudes marked “AGL” are measured above ground level. Altitudes marked “MSL” are measured above Mean Sea Level.

<sup>2</sup> Instrument Landing System, a ground-based radio system to provide lateral and vertical guidance to a runway.

<sup>3</sup> NTSB Meteorology Group Chairman’s Factual Report, dated 23 August 2021, page 12.

<sup>4</sup> NTSB Operations Group Chairman’s Factual Report, dated 20 July 2022, page 8.



pre-impact system component failures or anomalies.<sup>5</sup> The available evidence indicates that all airplane systems were functioning as designed prior to impact.

## **PROPULSION**

The accident aircraft was equipped with two P&W JT8D-9A engines. Both engines were recovered from the accident site and were delivered to an onshore facility for teardown and review with NTSB and other parties, including Boeing, present. Both engines showed evidence of damage consistent with impact. Engine #1 (left-hand) showed no other signs of damage. Engine #2 (right-hand) exhibited the mid-span fracture of two blades in the first-stage turbine (T1) section, with associated damage downstream consistent with the blades exiting the engine through the exhaust. Engine indicators and control positions were recorded for each engine after the flight deck portion of the fuselage was recovered. Both fuel control switches were found in the RUN position, and the Engine Pressure Ratio<sup>6</sup> (EPR) gauges after recovery displayed values of 1.04 EPR for the #1 (left-hand) engine, and 1.6 for the #2 (right-hand) engine.<sup>7</sup> These values are consistent with the last recorded values for EPR on the #1 and #2 engines in the FDR data.

## **OPERATIONAL FACTORS / HUMAN PERFORMANCE**

The flight crew consisted of the Captain (CA) and First Officer (FO). The FO was the Pilot Flying (PF) for the accident flight takeoff, and the CA was the Pilot Monitoring (PM).

### **History of Flight**

The airplane departed on the accident flight from PHNL Runway 08R. Shortly after lifting off, the FDR recorded a sudden drop in Engine Pressure Ratio (EPR) in engine #2 (the right-hand engine), and the flight crew heard sounds similar to a “pop”<sup>8</sup> and “whoosh”<sup>9</sup>. The FDR recorded, and both pilots reported, an initial yaw to the right, consistent with a reduction in power on the #2 (right-hand) engine. The FO reported he identified a problem with the #1 (left-hand) engine. The CA reported he also initially informed the FO that the airplane had “lost engine number 1”, but on further review corrected his statement by saying, “No, never mind, I think it’s number 2”.<sup>10</sup>

The flight crew started a right-hand turn after departure to an intended heading of 220 degrees and continued their climb to 2,000 feet MSL, to provide time to troubleshoot the issue. After leveling off, the FO reported that he pulled power levers back to manage his speed, and after the CA finished coordinating with Air Traffic Control (ATC), the FO informed him that the #1

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<sup>5</sup> NTSB Performance Group Chairman’s Factual Report, dated 13 December 2022, page 27.

<sup>6</sup> Engine Pressure Ratio (EPR) is a ratio of the static pressure of the air entering the engine inlet to the pressure downstream of the compressor section of the engine, and provides a measure of the thrust being produced by the engine.

<sup>7</sup> NTSB Systems Group Chairman’s Factual Report, dated 19 December 2022, page 12

<sup>8</sup> NTSB Operations Group Chairman’s Factual Report, dated 20 July 2022, page 9

<sup>9</sup> NTSB Operations Group Chairman’s Factual Report, dated 20 July 2022, page 10

<sup>10</sup> NTSB Operations Group Chairman’s Factual Report, dated 20 July 2022, page 10



(left-hand) engine had failed, and that the #2 (right-hand) engine was running hot. The CA took over control of the airplane and told the FO to open the Quick Reference Handbook (QRH) and run the Engine Failure or Shutdown checklist.<sup>11</sup> The FDR value of EPR for the #1 (left-hand) engine during this period reduced from the takeoff value of approximately 1.96 to a value of approximately 1.05 over the course of 90 seconds.<sup>12</sup>

The FO reported that after being requested to run the checklist, he noted that the airplane began losing airspeed and altitude. He observed the CA advance the #2 thrust lever and the #2 exhaust gas temperature (EGT) increase above redline, and suggested that the crew return to Honolulu airport, reporting that the deteriorating condition of the airplane led him to abandon the QRH checklist without completing it. The CA concurred with abandoning the checklist and instead directed the FO to assist him in setting up an approach to return to the airport.<sup>13</sup>

After coordinating with ATC and turning back toward PHNL, the airplane's airspeed and altitude continued to reduce. The CA reported pushing the engine #2 thrust lever to the forward stop. Recorded EPR values at this point show engine #1 maintaining an EPR of approximately 1.05, consistent with a forward idle setting, and engine #2 increasing incrementally to a maximum value of approximately 1.46 for the last 2 minutes and 13 seconds of recorded data. The CA reported that as the airplane descended, he focused his efforts on maintaining an airplane attitude with wings level and the nose slightly high until impact with the water.<sup>14</sup>

## Crew Use of Procedures

The Engine Failure or Shutdown checklist is an 11-step checklist intended to secure an inoperative or failing engine and reduce the risk of subsequent failures and a negative effect on adjacent airplane systems. Like all checklists dealing with engine anomalies, the Engine Failure or Shutdown checklist includes the word "Confirm" at the step that closes the throttle to the affected engine.<sup>15</sup> The QRH includes the following text under the "Non-Normal Checklist Use" heading:

*The word "Confirm" is added to checklist items when both crewmembers must verbally agree before the action is taken. During an inflight non-normal situation, verbal confirmation is required for:*

- *An engine thrust lever*
- *An engine start lever*
- *An engine, APU, or cargo fire switch*

The Boeing 737 Flight Crew Training Manual (FCTM) airplane states, in section 8.8 "Recommended Technique for an In-Flight Engine Shutdown",

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<sup>11</sup> NTSB Operations Group Chairman's Factual Report, dated 20 July 2022, page 12

<sup>12</sup> NTSB Performance Group Chairman's Factual Report Attachment 5, dated 13 December 2022, page 27

<sup>13</sup> NTSB Operations Group Chairman's Factual Report, dated 20 July 2022, page 13

<sup>14</sup> NTSB Operations Group Chairman's Factual Report, dated 20 July 2022, page 14

<sup>15</sup> NTSB Operations Group Chairman's Factual Report Attachment 13, dated 4 May 2022, page 11



*Any time an engine shutdown is required in flight, good crew coordination is essential. Airplane incidents have turned into airplane accidents as a result of the flight crew shutting down the incorrect engine.*

*When the flight path is under complete control, the crew should proceed with a deliberate, systematic process that identifies the correct engine and ensures that the operating engine is not shut down. Do not rush through the shutdown checklist, even for a fire indication.*

During post-accident interviews, the FO was asked whether he read the confirm-close step in the Engine Failure or Shutdown checklist, he responded that he had not, and that the QRH checklist was not completed.<sup>16</sup>

## **MAINTENANCE**

Rhoades Aviation, Incorporated maintained the accident airplane under an FAA maintenance authorization that included their Continuous Airworthiness Maintenance Program (CAMP). This arrangement included the use of Boeing's FAA approved Maintenance Review Board Report (MRBR), the Boeing Maintenance Planning Document (MPD), and the Boeing Airplane Maintenance Manual (AMM); in addition to the P&W JT8D Maintenance Manual when maintaining the engines.<sup>17</sup>

Logbooks for the accident airplane included write-ups for engine compressor stalls in November 2020 and May 2021. In both cases, the mechanic involved in resolving the write-ups reported that they performed general visual inspections to the engines and ran them in accordance with AMM tasks that were found in Chapter 71, Engines, and did not perform a borescope inspection to observe the machinery in the interior of the engine. This borescope inspection was expected in both Boeing and P&W maintenance documentation with specific inspections given in Chapter 5 of the Boeing AMM, and in the P&W JT8D Maintenance Manual.<sup>18</sup>

## **AIRPLANE PERFORMANCE**

The performance of the airplane during the accident flight was evaluated by the investigation using information from the FDR, CVR, EGPWS, and ADS-B data. The data show a normal taxi out and full-length departure from PHNL Runway 08R. Approximately 11 seconds after liftoff, the #2 (right-hand) engine recorded EPR setting dropped from approximately 1.98 to 1.45 within the span of a 1 second sampling by the FDR. Approximately 30 seconds after this reduction, the recorded EPR for the #1 (left-hand) engine slowly reduced in value over the course of 89 seconds, pausing at incremental values between the takeoff setting (~1.96 EPR) and a setting corresponding to forward idle (1.05 EPR). After this reduction concluded, the #2 (right hand) engine power setting varied among power settings between minimum and

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<sup>16</sup> NTSB Operations Group Chairman's Factual Report, dated 20 July 2022, page 13

<sup>17</sup> NTSB Maintenance Group Chairman's Factual Report, dated 13 December 2022, page 5

<sup>18</sup> NTSB Maintenance Group Chairman's Factual Report, dated 13 December 2022, page 17



maximum EPR values of approximately 1.09 and 1.46, respectively, until the end of the flight.<sup>19</sup>

Recorded airplane attitude and flight control inputs immediately after the sudden reduction in #2 (right-hand) engine power were consistent with an initial airplane yaw to the right, and an associated input of left rudder pedal and trailing-edge left rudder to compensate for the yaw and maintain coordinated flight. Over the course of the subsequent EPR reduction on the #1 (left-hand) engine, and later variations in the recorded EPR of the #2 (right-hand) engine, the magnitude of rudder pedal inputs reduced below the levels expected to maintain coordinated flight, given the difference in recorded EPR values. The relationship between recorded control input deflections (control wheel, control column, and rudder pedal) and recorded control surface deflections (aileron, elevator, and rudder<sup>20</sup>) is consistent with the flight control system maintaining system integrity throughout the flight. Comparisons of the recorded airplane performance to Boeing simulated airplane performance models is also consistent with the flaps and landing gear systems maintaining system integrity throughout the flight.<sup>21</sup>

## **KNOWLEDGE GAINED DURING THE INVESTIGATION (Findings)**

The following knowledge gained is pertinent to drawing conclusions:

- Weather at the time of the accident did not contribute to the accident sequence.
- Examination of aircraft engine hardware after the accident showed damage to first-stage high-pressure (T1) turbine blades in engine #2 (right-hand), and no evidence of pre-impact damage to engine #1 (left-hand).
- Shortly after liftoff and on initial climb, the #2 engine experienced a sudden drop in power, likely due to damage in the engine's T1 blades, as identified during engine examination.
- Shortly after the sudden loss of power in engine #2 (right-hand), engine #1 (left-hand) power was slowly reduced, likely the result of the associated thrust lever being manually moved aft in the flight deck.
- Review of data from the Flight Data Recorder (FDR), Cockpit Voice Recorder (CVR), Enhanced Ground Proximity Warning System (EGPWS), Automatic Dependent Surveillance – Broadcast (ADS-B), and recovered airplane wreckage and systems components showed no evidence of a system malfunction or any other evidence of airplane structural or systems anomalies prior to impact.
- As the Engine Pressure Ratio (EPR) setting on engine #1 reached its minimum (where it stayed through the remainder of the flight), the total thrust produced by both engines fell below that required to sustain level flight and did not increase beyond that value through the end of the flight.

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<sup>19</sup> NTSB Performance Group Chairman's Factual Report Attachment 9, dated 13 December 2022, page 58.

<sup>20</sup> A review of the FDR data showed that the relationship between control wheel and aileron, and rudder pedal and rudder, did not match the expected values based on the design of the flight control system. The dataframe was verified to be erroneous based on a recording from a sibling airplane with a similar FDR installation. Adjustments were made to some parameters and validated to be correct based on airplane simulator matches. The data for rudder surface deflection was declared to be invalid.

<sup>21</sup> NTSB Performance Group Chairman's Factual Report Attachment 9, dated 13 December 2022, page 73



## **CONCLUSIONS**

Boeing believes that the evidence supports the following conclusions for the accident:

The subject accident occurred due to the flight crew's inability to maintain altitude following the partial loss of power in the #2 (right-hand) engine shortly after takeoff. Contributing to the accident were the crew's failure to correctly identify the engine that had experienced the power loss, and their decision to retard the throttle lever of the operational engine.