TransAir Flight 810

Boeing 737-200 Water Recovery

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“Accidents: The Current Which Lies Beneath”

Authors' Biographical Data

Clinton R. Crookshanks *has been an aerospace engineer and aircraft structures investigator in the National Transportation Safety Board's (NTSB) Office of Aviation Safety since 2002. He has participated in numerous domestic and international investigations including United Airlines Flight 328 (2021), Atlas Air Flight 3591 (2019), Lion Air Flight 610 (2018), SpaceShip Two (2014), Malaysia Airlines Flight 370 (2014), UPS Flight 1354 (2013), and the Reno Air Races P-51D "Galloping Ghost" (2011). Mr. Crookshanks has particular experience and expertise in the recovery of aircraft from the water having directed and participated in almost all water recoveries in which the NTSB has participated since 2002. Prior to joining the NTSB, Mr. Crookshanks worked for various aircraft manufacturers in engineering and design. He holds a Bachelor of Science degree in Mechanical Engineering from the University of Nevada-Reno, a Master of Science degree in Aerospace Engineering Sciences from the University of Colorado, and a private pilot certificate.*

Abstract

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On July 2, 2021, about 0145 Hawaii-Aleutian standard time (HST), Rhoades Aviation flight 810, dba TransAir flight 810, a Boeing 737-200, N810TA, experienced engine anomalies in both engines and subsequently ditched into Mamala Bay shortly after takeoff from Daniel K. Inouye International Airport (HNL), Honolulu, Hawaii. The two flight crewmembers were rescued, and the airplane was destroyed. The flight was operating under 14 *Code of Federal Regulations* Part 121 as a cargo flight from HNL to Kahului International Airport (OGG), Kahului, Hawaii. The airplane wreckage sank within about 1 hour of the accident about 2 miles from the southern coast of Oahu, Hawaii. The United States Coast Guard (USCG) responded with a rescue helicopter and small watercraft to retrieve the two crewmembers, one from a floating piece of cargo and the other from the floating tail section of the airplane. The last known positions of the airplane were determined from recorded automatic dependent surveillance broadcast (ADS-B) data provided by air traffic control, which last showed the airplane at an altitude of 50 feet (ft) above mean sea level (msl), and the location of the floating tail section, the coordinates for which were provided by the USCG. The location and retrieval of the wreckage represented the most significant deep-water search and recovery operation undertaken by the U.S. National Transportation Safety Board (NTSB) in decades. Maintaining compliance with the stringent constraints of the Endangered Species Act requirements and the Essential Fish Habitat protections imposed by federal and state agencies in the Hawaiian Islands increased the complexity of the operation.

The NTSB worked with the operator's insurance company which funded the search for the wreckage beginning on July 3, 2021. The initial search utilized a side-scan sonar examination of the seafloor, an acoustic underwater beacon (pinger) locator provided by The Boeing Company (a party to the investigation), and visual examination of the seafloor using a submersible remotely operated vehicle (ROV). The airplane wreckage, consisting of two very large pieces and numerous smaller items, was located on July 7 at water depths between 340 and 440 feet, and a full mapping of the debris field was performed. The forward fuselage was mostly intact from the nose to just forward of the wing and was separated from the mostly intact larger aft fuselage section, which extended from the wing aft to the tail and included the attached wings and stabilizers. The wreckage survey revealed that the flight data recorder was likely still installed in the aft fuselage ceiling, and it was uncertain if the cockpit voice recorder was still installed in the lower aft fuselage but deemed likley. Neither could be retrieved without recovering the entire aft fuselage section. The engines, nose landing gear, and portions of the lower fuselage were separated. Due to the depth of the water and the size of the larger items, the use of unique recovery companies with specialized equipment for the recovery was needed. Additionally, the State of Hawaii mandated that all the wreckage be recovered from the seafloor

to protect sensitive habitat. Several recovery proposals were received with costs ranging from $2.1 million to $9.6 million. The insurance company selected Eclipse Group Inc. for the recovery under the direction of the NTSB.

After weeks of planning, the recovery operation began on October 12, 2021, and successfully concluded on October 31 with the transfer of the wreckage to a storage facility on shore, where NTSB investigators retrieved the flight recorders and began their examination of the airplane. The NTSB and Boeing provided shipboard support throughout the operation, assisting with individual item identification, weight estimates, locations for rigging to lift, and calculation of loads to ensure the large items would not break apart further during recovery. All the rigging was performed with a ROV equipped with two manipulator arms. Wind and sea state conditions limited the available windows for recovery of the large items. The recovery of the mostly intact forward fuselage section, which weighed about 15,500 pounds, occurred during a weather window on October 20. The recovery of the mostly intact aft fuselage section, which weighed about 110,000 pounds with at least 40,000 pounds of trapped and absorbed water, occurred during a weather window on October 30. The recovery of the aft fuselage section represented the largest intact airplane section recovered from deep water by ship-borne assets ever conducted by the NTSB and Eclipse Group. To preserve the integrity of the wreckage, the techniques utilized had to ensure that the airplane was lifted in a mostly horizontal attitude to take advantage of the inherent structural strength of the airplane. For this reason, the rigging of the equipment to lift the aft fuselage had to be carefully planned and executed.

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Abbreviations

ADS-B	automatic dependent surveillance-broadcast
AMC	American Marine Corporation
APU	auxiliary power unit
BMP	best management practices
Boeing	The Boeing Company
BS	body station
COVID-19	coronavirus disease 2019
Curtin	Curtin Maritime Corp.
CVR	cockpit voice recorder
DAR	State of Hawaii, Department of Land and Natural Resources, Division of Aquatic Resources
EFH	Essential Fish Habitat
EGI	Eclipse Group Inc.
EGPWS	enhanced ground proximity warning system
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FDR	flight data recorder
ft	feet
GPS	global positioning system
HEER	State of Hawaii, Department of Health, Hazard Evaluation and Emergency Response Office
HNL	Daniel K. Inouye International Airport, Honolulu, Hawaii
HST	Hawaii-Aleutian standard time
IAD	Washington Dulles International Airport
IIC	investigator-in-charge
kHz	kilohertz
kips	kilo-pounds
kt(s)	knot(s)
LSR	Lone Star Retrieval
m	meter
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NTSB	National Transportation Safety Board

OGG	Kahului International Airport, Kahului, Hawaii
ORD	Chicago O'Hare International Airport
OSRV	oil spill response vessel
PENCO	Pacific Environmental Corporation
PFD	personal flotation device
PLB	personal locator beacon
RFQ	request for quote
ROV	remotely operated vehicle
R/V	research vessel
SEI	Sea Engineering Inc.
SERT	Salvage Engineering Response Team
ULB	underwater locator beacon
USBL	ultra-short baseline
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service

1.0 Introduction

On July 2, 2021, about 0145 Hawaii-Aleutian standard time, Rhoades Aviation flight 810, dba TransAir flight 810, a Boeing 737-200, N810TA, experienced an engine anomaly shortly after takeoff from Daniel K. Inouye International Airport (HNL), Honolulu, Hawaii, and was subsequently ditched into Mamala Bay (in the Pacific Ocean) about 5.5 miles southwest of HNL. The captain sustained serious injuries, the first officer sustained minor injuries, and the airplane was destroyed. The flight was operating under Title 14 *Code of Federal Regulations* Part 121 as a cargo flight from HNL to Kahului International Airport (OGG), Kahului, Hawaii. The NTSB accident identification number is DCA21MA174, and the public docket can be viewed here. The final accident report was published on June 15, 2023, and can be downloaded here.

2.0 Initial Response

The United States Coast Guard (USCG) joint rescue coordination center was first notified of an aircraft in distress about 0144 HST on July 2, 2021, and launched a MH-65 helicopter and a C-130 airplane from USCG Air Station Barbers Point to the last known position of the airplane. At the same time, the USCG launched a small boat from Base Honolulu and diverted the *USCG Cutter Joseph Gerczak* to the site. The MH-65 arrived at the accident site about 0230 HST, identified by a fuel slick and debris on the water, and identified two survivors, one hanging onto a section of the tail and the other on a pile of floating cargo. The first responders from the USCG reported that the aft section of the airplane was floating when they arrived and included the horizontal stabilizers and a portion of the fuselage forward of the tail about 10 to 20 feet (ft) long.

3.0 Wreckage Search

The NTSB team arrived in Honolulu the afternoon of July 2 and met with the USCG, which provided the coordinates for the floating tail section; a representative from the operator's insurance company, AIG, and a representative from Lone Star Retrieval (LSR), which had been contracted for recovery of the airplane. AIG and LSR were instrumental in providing support and the funding necessary to complete the search and recovery of the airplane.

The recovery team selected a local company, Sea Engineering Inc. (SEI), which had the necessary side-scan sonar and remotely operated vehicle (ROV) capabilities to perform an underwater search for the wreckage. The underwater search began on July 6 with the recovery team on board SEI's 43-ft workboat *Huki Pono* (Figure 1). The vessel was equipped with a hand deployed C-MAX CM2 side-scan sonar system towfish (Figure 2). The vessel utilized a Trimble SPS 461 differential GPS for navigation and positioning. Xylem's Hypack/Hysweep 2021 navigation and data collection software was used for collection of the sonar data and for marking points of interest. The vessel was also equipped with a hand-deployed, tethered Seamor Chinook inspection class ROV (Figure 3) for the search. The ROV position was tracked with an Applied Acoustics Easytrak ultra-short baseline (USBL) transducer attached to a pole on the side of the vessel.

Figure 1. *Huki Pono* workboat.

Figure 2. C-MAX CM2 side-scan sonar towfish.

Figure 3. Seamoor Chinook ROV.

3.1 Search Details

The weather conditions were not ideal on July 6 (day 1) with winds 13 to 17 knots (kts) gusting to 21 kts and seas 5 to 6 ft. The team decided to initiate the search at the location where the MH-65 found the tail of the airplane and one survivor, 21º16'38.52" N, 158º1'44.16" W (green triangle in Figure 4) which was west of the last ADS-B position (airplane icon in Figure 4). The search area focused west and south of the last known location due to the prevailing currents in the area. The side-scan sonar, set to 200-m resolution with the 325 kilohertz (kHz) transducer, was deployed in the water and towed in a grid pattern that covered an area about 2,600 ft by 5,700 ft, first aligned with the sea bottom contours running from northeast to southwest and then perpendicular to the sea bottom contours from northwest to southeast (red lines in Figure 4). The depth of the area was about 150 ft on a shelf that extended out from the shore of Oahu.

Several anomalous targets were identified and marked in real time during the search (black triangles). The side-scan sonar had to be recovered and redeployed twice during the day after it flipped upside down during the 180° turn at the end of a scan due to slack cable caused by the sea swells. Toward the end of the day, the team identified a target with an angled shape that differed from the other targets identified (orange cross). The side-scan sonar was recovered, and the ROV was deployed to the location of the target. A large, angled rock was identified on the seafloor at the target location. An additional target was examined with the ROV that also was a rocky area of the seafloor. A review of the sonar information at the end of the day showed a large line of targets that matched the bottom contour and that were consistent with an undersea ledge and some concentrated areas of targets consistent with rock outcroppings.

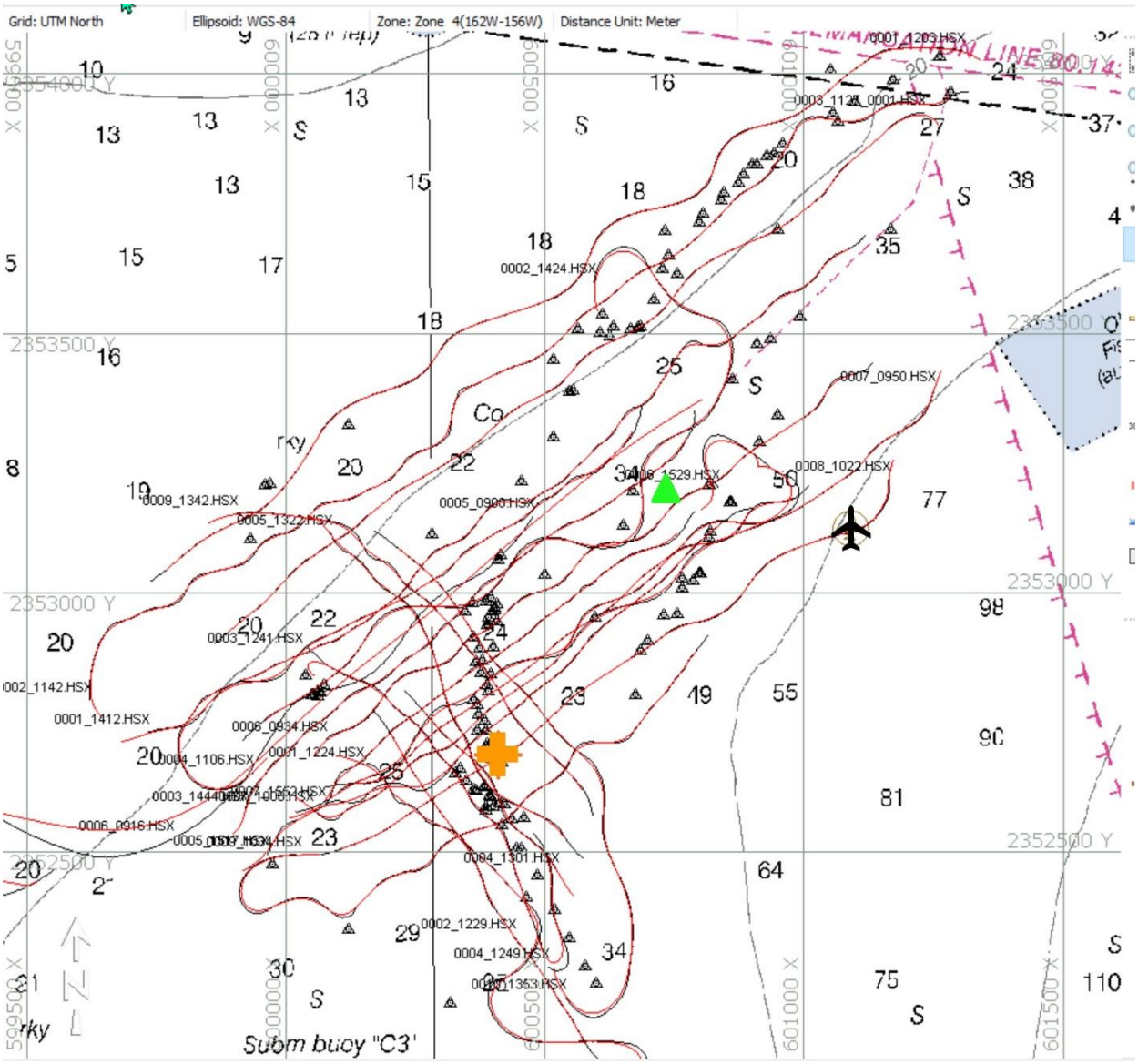

Figure 4. Side-scan sonar survey lines and identified targets from day 1.

On July 7 (day 2), the team boarded the *Huki Pono* with the Boeing-provided RJE PRS-275 handheld pinger receiver to search for the underwater locator beacons (ULB) on the flight recorders. The weather conditions were similar to day 1 with the same winds and sea state. The pinger receiver was set to 37.5 kHz and deployed in the water near the location where the USCG identified the tail. Immediately, pinging was detected with two distinct pings indicating both ULBs were active. The team covered the area and obtained nine distinct points with bearings towards the detected pings (Figure 5). There was no obvious coalescence of the bearings to indicate a precise location of the ULBs, but an area in the middle was decided to be the most probable location. The water depth in this area was 300 to 500 ft. The side-scan sonar was deployed and towed in a grid pattern around the most probable location, but it was difficult getting the towfish deep enough to provide adequate coverage at 200 m resolution. A 12-ft chain was added to the ROV tether line for additional weight in an attempt to increase the sonar towfish depth. No obvious targets were identified with the side-scan sonar.

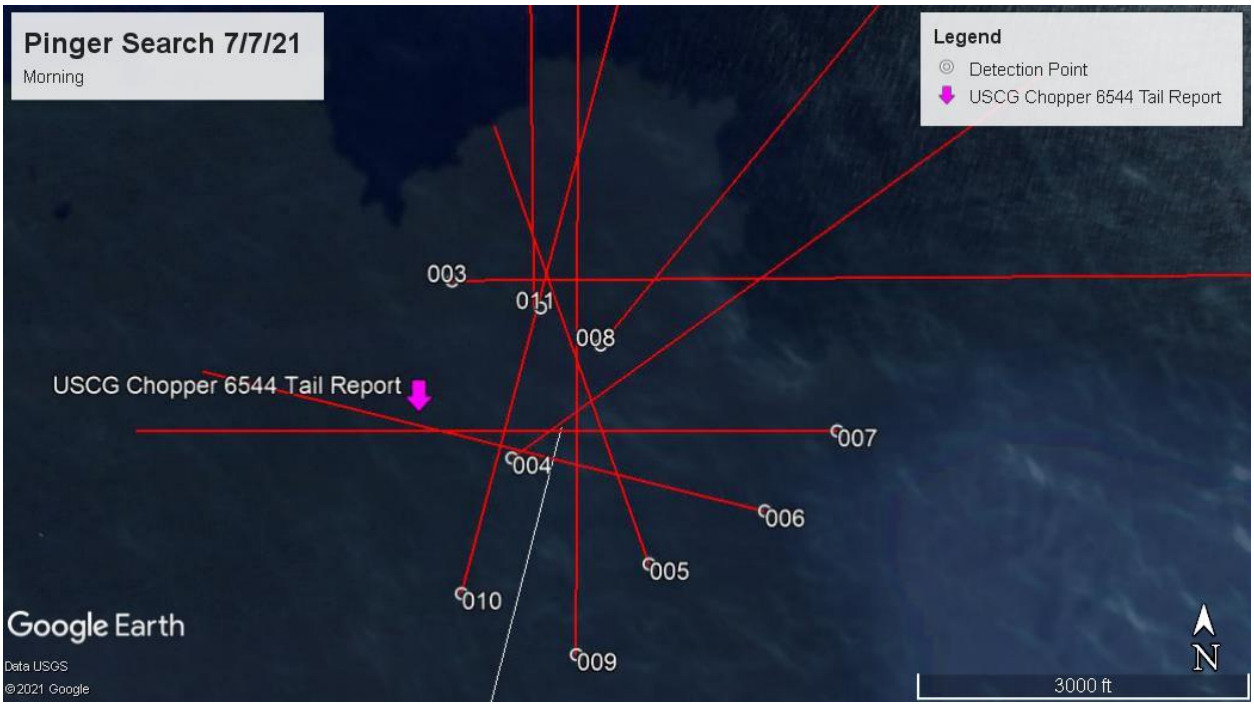

Figure 5. Pinger survey 1, July 7 (day 2) morning.

The team elected to do additional pinger locating work around the area of interest in the afternoon. Six additional locations were surveyed, and the bearing to the ping location was obtained (Figure 6). A definite coalescence of the bearings was evident when the data was plotted and was located about ¼ mile east-northeast of the USCG-identified tail location. The charted water depth in this area was in excess of 300 ft with a steep drop to deeper water to the south and east. The location was about 0.1 mile north of the last ADS-B point recorded at 21º16’37.43” N, 158º1’31.87” W.

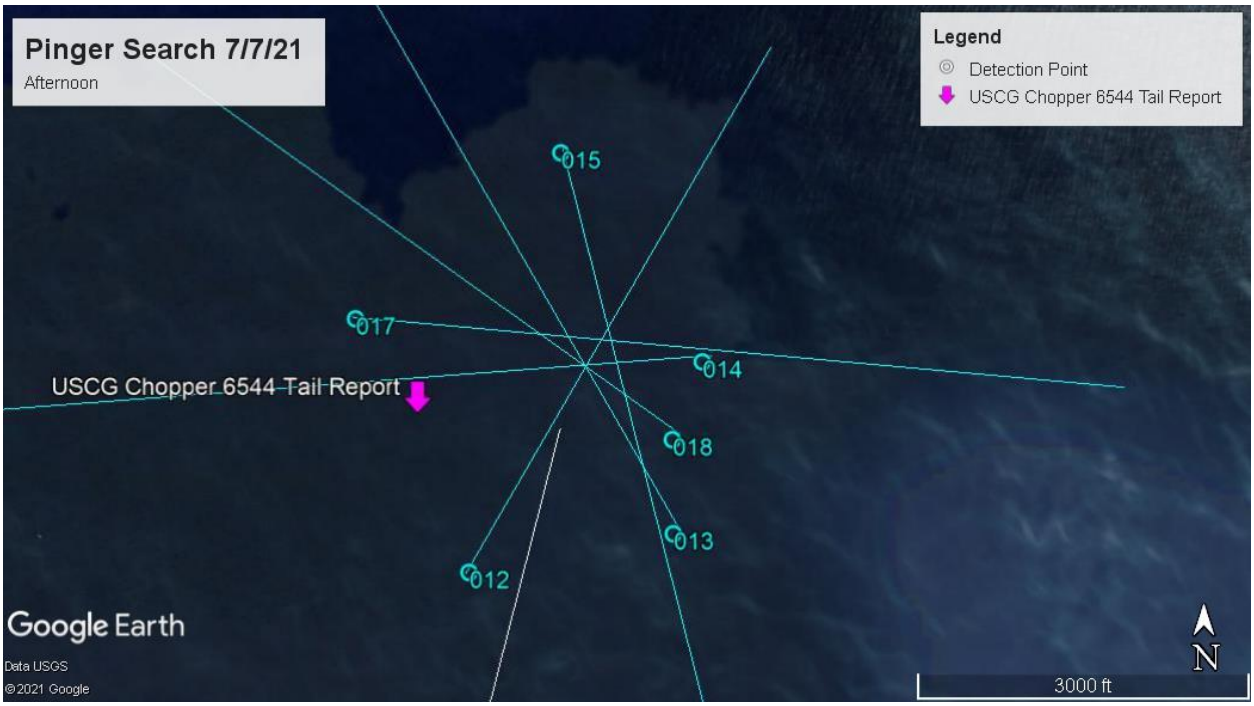

Figure 6. Pinger survey 2, July 7 (day 2) afternoon.

The side-scan sonar was redeployed at 200-m resolution with the additional weight still installed on the tow line to increase its depth. A small grid search around the probable location was performed, and the group identified two distinct targets with sonar (Figure 7). The larger target had the distinct angular shape of an airplane's wings and tail. Additional smaller targets were identified on sonar between the two items.

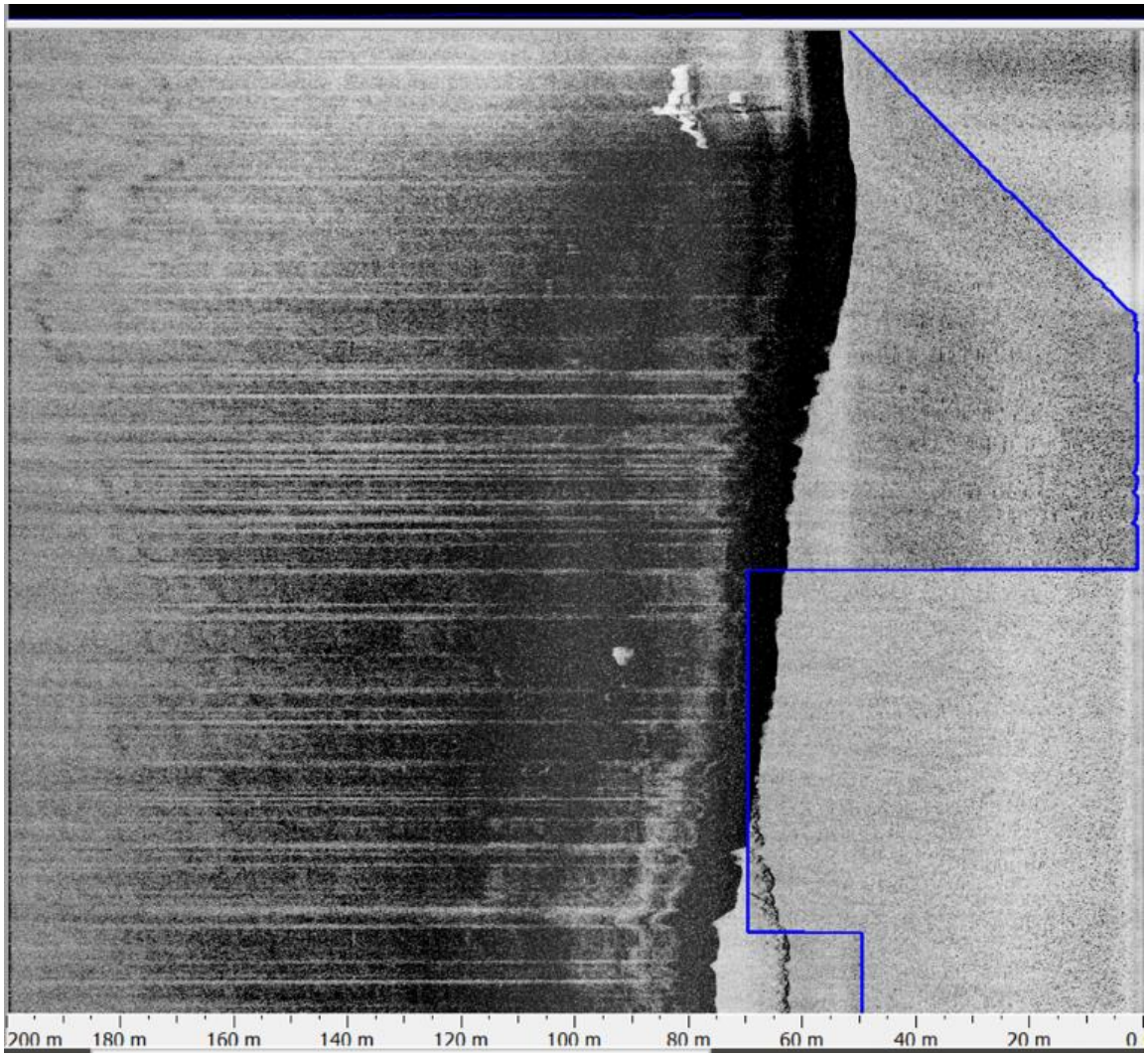

Figure 7. Side-scan sonar targets.

The side-scan sonar was recovered, and the ROV was deployed to the area of the airplane-shaped target. During the descent, about 80 ft above the seafloor, the aft portion of the airplane appeared on the monitor (Figure 8). The wreckage was located on a sloped area of the seafloor with the forward end of the aft fuselage at a depth of about 340 ft and the tail at a depth of about 363 ft. A full video survey of the aft fuselage section was performed with the ROV. The fuselage was fractured near body station (BS) 540, the location of the wing forward spar, and was mostly intact to the tail at BS 1217. There was some damage evident to the lower portion of the fuselage, but the extent could not be determined. Both wings remained attached to the fuselage, but both engines were separated from the wings. The flaps and ailerons remained attached to the wings. The left wing fixed leading edge was separated between the wing root and the engine location, and all of the left wing slats were separated except a small portion at the outboard end. The right wing inboard slat was separated, and the remaining right wing slats were attached. The horizontal stabilizer, elevators, vertical stabilizer, and rudder remained intact and attached. The auxiliary power unit (APU) doors appeared to be separated. The cargo containers were evident in the forward end of the aft fuselage. The aft fuselage section was located about

0.31 miles east-northeast of the USCG-identified tail location, 210 ft northeast of the identified pinger location, and about 0.14 miles north-northeast of the last ADS-B point.

Figure 8. Aft fuselage wreckage on seafloor.

On July 8 (day 3), the team returned to the site and deployed the ROV to the second, smaller target south of the aft fuselage. Upon reaching the seafloor, the ROV video showed identifiable aircraft debris. A full ROV survey was performed of the surrounding area and the forward fuselage, both engine cores, both thrust reversers, both inlet cowls, the nose landing gear, a section of keel beam, two cargo containers, and various items of cargo were located along with many other small pieces of wreckage and avionics boxes.

Initially it was thought that only one engine had been located, so about a half a day was spent surveying the debris field looking for the second engine. The powerplants investigative group examined the ROV video survey at the completion of the day's operation and concluded that both engine cores were located within about 3 ft of each other on the seafloor and adjacent to one thrust reverser. The #2 engine inlet case had separated from the engine and was located in the debris field.

The forward fuselage was partially intact from the forward pressure bulkhead to about BS 540. Significant damage to the lower portion was evident, but the extent could not be determined. The radome was separated. The main deck cargo door was closed, the cockpit emergency windows were open, and the left entry door was ajar with the handle in the stowed position. No cargo was present in the forward fuselage. The nose landing gear remained attached to the wheel well structure and was in the up and locked position but the whole assembly was separated from the forward fuselage.

The debris field was about 0.12 miles long north-south and about 0.10 miles wide east-west (Figure 9). All major portions of the airplane were identified in the debris field.

Figure 9. Wreckage Diagram

3.2 Survey Photos of Wreckage

The following Figures 10 through 15 are snapshots from the ROV video survey of major identified items of wreckage.

Figure 10. Aft fuselage, wings, and tail.

Figure 11. Engine cores and one thrust reverser.

Figure 12. Forward fuselage.

Figure 13. Engine #2 inlet case.

Figure 14. Nose landing gear.

Figure 15. Thrust reverser.

4.0 Wreckage Recovery Planning

The recovery of the wreckage was a multi-faceted operation that required the use of several different companies and consultation with the USCG, the State of Hawaii, and federal authorities. The group worked extensively with AIG and LSR throughout the process.

4.1 Request for Quote

The group developed a Request for Quote (RFQ) that was sent on July 9 and stipulated that any quote should cover the recovery of the major airplane wreckage from the seafloor and transportation to Kalealoa Barbers Point Harbor in Kapolei, Hawaii. The offloading of the wreckage and storage were to be the responsibility of LSR already under contract to AIG. The major items of interest to the investigation were the forward fuselage, aft fuselage (containing the flight recorders), and the engines. The enhanced ground proximity warning system (EGPWS) computer was also of interest, if located. The recovery would have to be coordinated with the State of Hawaii and federal authorities for possible impacts to endangered species that could require recovery of the smaller wreckage items so any quote would need to cover those items. The timing of the quoted recovery was to include the necessary time to ready equipment and the effects of weather. The ROV survey videos were supplied to the companies that were interested in submitting a quote. Three updates to the RFQ were supplied to the companies which set the due date for July 23, supplied the GPS coordinates of the major items, provided the airplane load manifest and fueling information, provided the Boeing 737 Aircraft Recovery document, and extended the deadline for submissions to July 26. The group received four recovery proposals with some of the companies partnering together and all involving subcontractors with quoted prices ranging from $2.1 million to $9.6 million.

4.2 Contract Award

The NTSB provided feedback to AIG on the received quotes based on the companies' experience in recovering aircraft, the recovery of all items including smaller debris, the endangered species monitoring, and the cost. AIG selected and informed Eclipse Group Inc. (EGI) of their successful bid on August 5, 2021, after consultation with the co-insurers. AIG and LSR also selected Pacific Environmental Corporation (PENCO) to provide all spill-response operations and American Marine Corporation (AMC) for the offload and storage of the airplane at Kaleloa Harbor. The EGI recovery proposal was shared with the State of Hawaii, Hazard Evaluation and Emergency Response Office, PENCO, and AMC. After the contract was awarded, the NTSB provided EGI with Boeing provided preliminary weight estimates for the larger items and the cargo manifest. AIG and EGI executed the contract on September 16, 2021, after working out several discrepancies with specific clauses.

4.3 Recovery Plan

EGI began converting the proposal to a draft recovery plan and provided an initial draft of the recovery plan to the NTSB on August 20, 2021, with a projected start date of September 22, 2021. The draft plan had large sections missing at this point, and both the NTSB and EGI understood that this initial incomplete draft of the recovery plan would be continuously edited over the course of the planning process. The relevant stakeholders involved with the recovery

were made aware of the planning process, and paragraphs and sections were continuously exchanged. More complete updates to the recovery plan were provided on August 31 and September 1, 14, and 17. Throughout the planning process, numerous meetings were held to flush out the details of the plan between EGI, LSR, NTSB, Boeing, Curtin Maritime Corp. (vessel subcontractor), AMC, and PENCO. EGI finalized the recovery plan on September 22, 2021, with a project start date of October 8, 2021.

4.4 Federal and State Consultations

After the accident, as the search efforts were going on, the NTSB was advised by SEI and the USCG to contact several federal and state agencies regarding the wreckage recovery efforts.

4.4.1 FAA Consultation

The FAA Office of Accident Investigation supported the initial response and recovery of the airplane. The FAA issued a notice to airmen (NOTAM) establishing a temporary flight restriction closing the airspace above the wreckage in a 2-mile diameter circle centered on the aft fuselage location from October 11-26, 2021.

4.4.2 USCG Consultation

The NTSB was also in contact with USCG Sector Honolulu throughout the planning, search, and recovery and they were instrumental in the success of the operation. The USCG established a 3-mile safety zone around the area of impact that was in place throughout the initial search operations and reestablished it for the wreckage recovery operations October 9 through November 6. The finalized recovery plan was shared with USCG Sector Honolulu and USCG Marine Safety Center Salvage Engineering Response Team (SERT) on October 1 for final review, comment, and approval. The SERT provided advisory comments on the recovery plan to the NTSB on October 4 that were incorporated into the operation.

Once the wreckage was located and recovery discussions began, the USCG recommended contacting the National Oceanic and Atmospheric Administration (NOAA) regarding Endangered Species Act (ESA) Section 7 consultation requirements and Essential Fish Habitat (EFH) consultation requirements for the recovery of the airplane wreckage.

4.4.3 NOAA National Marine Fisheries Service Consultation

The NTSB made initial contact with the National Marine Fisheries Service (NMFS) on July 13 for both ESA and EFH consultation and provided them with the location of the wreckage, ROV survey videos, and the general plan for wreckage recovery. Under the ESA, as soon as practicable after the emergency is under control, the action agency (NTSB) initiates formal consultation with the NMFS if listed species or critical habitat have been adversely affected. The ESA-listed species expected to occur in the wreckage area were the North Pacific green sea turtle, hawksbill sea turtle, Hawaiian monk seal, oceanic whitetip shark, giant manta ray, and the main Hawaiian Islands insular false killer whale. They suggested also contacting the US Fish and Wildlife Service (USFWS) regarding ESA consultation. NMFS provided interim

suggested best management practices (BMPs) to reduce any potential impacts on marine species for the wreckage recovery.

NMFS also provided information on the EFH consultation. EFH in the main Hawaiian Islands has been designated in the marine water column from the surface to a depth of 1,000 m, from the shoreline to the outer boundary of the Exclusive Economic Zone (200 nautical miles), and the seafloor from the shoreline out to a depth of 700 m. Similar to the ESA, as soon as practicable after the emergency is under control, the action agency (NTSB) should initiate formal EFH consultation for any actions that may have an adverse effect to the water column and bottom substrate that occur during the operation. The NMFS provided conservation recommendations for physical impacts to EFH.

They recommended providing an EFH assessment after the recovery operation containing a description of the action, a determination as to how the action will affect EFH, an assessment of the adverse effect, and proposed ways to mitigate for the adverse effects. An adverse effect to EFH is anything that reduces the quantity or quality of EFH. This assessment could be combined with the ESA consultation.

All ESA and EFH monitoring and reporting requirements during the recovery were assigned to the environmental consultant, Darla White, MSc., MGIS, working for EGI. At the conclusion of the operation, the EGI environmental consultant submitted an ESA Environmental Statement and a separate EFH Environmental Statement to NMFS on behalf of the NTSB. The ESA report concluded there were no adverse effects to ESA-listed species and was accepted by NMFS requiring no further action. The EFH report concluded there were likely adverse effects to EFH from the recovery due to sedimentation, physical damage from falling debris, chemical contamination, and the possibility for introducing invasive species that could not be avoided. The BMPs were followed during the operation so the report was accepted by NMFS.

4.4.4 United States Fish and Wildlife Service Consultation

The group made initial contact with the USFWS on July 13 for ESA consultation and provided them with the location of the wreckage, ROV survey videos, and the general plan for wreckage recovery. According to USFWS, in addition to ESA requirements, the recovery operation would need to comply with the provisions of the Fish and Wildlife Coordination Act. Utilizing the ROV survey videos, the USFWS evaluated if any trust resources, such as deep-water corals, were present. Their analysis was that the area consisted mostly of a sandy bottom with some hard bottom presence. The hard bottom appeared to be low-relief basalt with little observable benthic community and no corals were noted within the wreckage area. The USFWS recommended that, in the course of the recovery operation, the team should take note of high relief areas and avoid them to the extent that is practical. They stated that the recovery operation may have minimal natural resource impacts. At the conclusion of the operation, they were satisfied with the reporting that was done and required no additional actions.

4.4.5 State of Hawaii Consultation

Initial telephone contact with the State of Hawaii, Department of Health, Hazard Evaluation and Emergency Response Office (HEER) was made on July 3, 2021, to discuss their

concerns with respect to the airplane wreckage in the water. A follow up meeting with HEER occurred on July 9 once the wreckage had been located and included a representative from the State of Hawaii, Department of Land and Natural Resources, Division of Aquatic Resources (DAR). The HEER and DAR representatives were mainly concerned with the cargo onboard, the hazardous materials on the airplane, and the possible impact to any seafloor organisms, such as coral. The load manifest and ROV survey videos were supplied for review. On July 12, HEER provided their concerns to be addressed in the recovery planning and execution. The summary was that all available wreckage should be recovered from the seafloor to address their concerns.

5.0 Wreckage Recovery Operations

EGI utilized the *R/V Bold Horizon* (Figure 16) as the main vessel for most work. The *Bold Horizon* was outfitted with the GP-50 work class ROV deployed off the stern using an A-frame crane. A J-frame crane on the starboard side was used for transporting the wreckage storage baskets from the ship to the seafloor and a telescoping deck crane was used to lift wreckage from the surface to the deck. EGI subcontracted to Curtin for the *DB Salta Verde* barge with a Manitowac 4600 crawler crane to lift and transport the large items of wreckage and the barge assist tug *Shirley C*. The *Bold Horizon*, *DB Salta Verde*, and *Shirley C* were based in southern California and had to transit the ocean prior to the operation.

Figure 16. *R/V Bold Horizon* (provided by EGI)

Figure 17. GP-50 remotely operated vehicle (provided by EGI)

The recovery vessel was staffed with two NTSB investigators, two Boeing engineers, and one representative from LSR for most of the operation. One of the Boeing engineers and the LSR representative had to depart before the conclusion of the operation.

5.1 Safety Gear

Recovery operations on board the *Bold Horizon* presented the potential for some unique dangers to personnel working on the deck. EGI held ultimate authority for the safety of personnel on board the *Bold Horizon* and limited the personnel allowed on the lower working deck during recovery operations. The NTSB investigators were allowed on the main working deck during recovery operations with the required safety equipment outlined below. The list of safety equipment was developed with NTSB management and Office of Marine Safety personnel and some exceeded EGI required equipment.

- Personal Flotation Device (PFD) – USCG Type III PFD required when on deck. NTSB provided inflatable PFDSs for the investigators.
- Personal Locator Beacon (PLB) – NTSB investigators attached company provided PLBs to PFDs.
- Hard Toe Boots – Required when on deck. Closed toe shoes were required in interior spaces of the vessel.
- Hard Hat – Required on work deck.
- Long Pants – NTSB requirement for working around airplane wreckage.
- Gloves – Leather or cut resistant gloves required for handling of wreckage. Latex gloves underneath for handling cargo or hydraulic fluid contaminated wreckage.

- Chem Lights – Required for night work on deck. Investigators had them attached to PFDs.
- Eye Protection – Required when working around wreckage.

5.2 Weather

Available information indicated that the optimum time, weather wise, for the recovery of the airplane was late summer and early fall when the winds and sea state would be most favorable. EGI contracted with DTN to provide *WeatherOps* ongoing weather reporting and forecasting for the duration of the recovery. EGI had established color-coded limits (green, yellow, red) for wind and waves that were incorporated into their subscription weather service product. The group received two weather reports per day at 0600 and 1800 HST that included an ongoing 7-day forecast. The EGI wind limits were green below 25 kts, yellow 25 to 40 kts, and red above 40 kts. The wave height limits were green below 8 ft, yellow 8 to 19 ft, and red above 19 ft.

The winds for the duration of the operation were predominantly from the northeast or east-northeast. The first 2 weeks of the operation saw the strongest winds with winds in the 10 to 15 kt range and gusts in the 20 to 25 kt range. On several days, the gusts exceeded 25 kts going into the yellow range. The last week of the operation saw a decrease in the winds with several days where the winds and gusts were less than 10 kts.

The sea swell was predominantly from the southeast or south-southeast for the first 2 weeks of the operation with a significant wave height of 3 to 5 ft and a maximum wave height mostly in the 6 to 7 ft range. There were some days during this time when the maximum wave height was 8 ft or greater, in the yellow range. The third week of the operations saw the sea swell predominantly from the south with a significant wave height of 2 to 3 ft and a maximum wave height of 4 to 6 ft.

5.3 COVID Protocols

The entire operation occurred during the coronavirus disease 2019 (COVID-19) pandemic, requiring specific policies to ensure the safety of personnel. The State of Hawaii required all travelers to the state to either have proof of vaccination or a negative test less than 72 hours prior to arrival. The federal government already had a vaccination mandate for NTSB personnel. EGI and NTSB agreed on protocols for all personnel who would be present for the operation since a positive infection on the ship could bring the operation to a halt. The team elected to minimize the transfer of personnel from shore to ship by requiring all personnel to board the ship at the beginning of the operation and remain for the duration or until they departed. There would be no ongoing transfer of personnel from shore to ship or vice-versa. EGI policies already required all personnel on the *Bold Horizon* to be vaccinated and the group required all personnel not sailing on the *Bold Horizon* from California to Hawaii to have a negative COVID-19 test after arriving in Hawaii but prior to boarding the *Bold Horizon*. The *DB Salta Verde* personnel were either vaccinated or had a negative test prior to leaving California for the 12-day transit to Hawaii. There were no infections or exposures reported during the operation.

5.4 Wreckage Recovery

The team boarded the *Bold Horizon* at the port of Honolulu on October 12, 2021, to begin the recovery operations. EGI and NTSB agreed that all wreckage inventory would be performed by the NTSB and Boeing personnel. Pre-dive ROV checks, test dives, ROV maintenance, and afternoon increases in the wind and sea state prevented deploying the ROV for recovery on October 12 and 13. A decision was made to adjust the operation times to line up better with calmer seas based on the experience from the first two days and the weather forecast. Operations would begin at 0400 HST (all times in this section are HST) and run until the seas became too rough for safe operations, usually in the mid to late afternoon.

On October 14, several ROV dives were accomplished to examine the four barge anchor sites and the sewage outfall located nearby. The ROV rigged the nose landing gear with a nylon strap around the axle with the opposite end connected to the lifting eye on the ROV. The ROV was then recovered to the surface and the strap was transferred to the *Bold Horizon* crane for recovery to the deck. This method would be used for all the larger wreckage items that wouldn't fit in the debris baskets. The nose landing gear, the first item of wreckage recovered, was recovered to the *Bold Horizon* deck about 1500 on October 14.

No wreckage recovery was accomplished on October 15 due to repair of electrical anomalies on the ROV. The #1 engine core, #2 engine core, #2 engine inlet case, and both engine inlet cowls were recovered to the deck of the *Bold Horizon* by the morning of October 17. The decision was made to transfer the engine wreckage to shore to free up deck space on the *Bold Horizon* and to give the shore side powerplants investigators wreckage to examine. Much preplanning and logistics were required by both the NTSB investigator-in-charge (IIC) and EGI to secure space at the AMC/PENCO facility on pier 14, a docking permit for the *Bold Horizon* to arrive, stevedores (trade union personnel responsible for loading and unloading ships at port) to oversee the unloading, and a berth for the *Bold Horizon* to spend the night at the port of Honolulu. The *Bold Horizon* arrived at pier 14 about 1030 on October 17 and offloaded the engine wreckage at the AMC/PENCO facility.

The Curtin tug *Shirley C* and *DB Salta Verde* arrived in Hawaiian waters at Kalealoa Harbor on October 14 and began transitioning from transit to recovery operations. EGI and NTSB personnel met with Curtin personnel the afternoon of October 17 to discuss the recovery plan, provide the anchor locations, and examine the barge equipment. EGI had been discussing alternate lifting plans for the large aft fuselage section and indicated to the NTSB that they were considering a vertical lift of this section. NTSB and Boeing engineers met the evening of October 17 to examine the feasibility and provide recommendations. The NTSB IIC and investigators and the Boeing party coordinator and engineers met with EGI the morning of October 18 onboard the *Bold Horizon*. The investigative team suggested that a vertical lift of the aft fuselage would likely result in structural failure and recommended the original horizontal lift plan be used. Two NTSB investigators, one Boeing engineer and one representative from LSR reboarded the *Bold Horizon* and departed for the site about 1200. A NTSB media representative also boarded the *Bold Horizon* to document the recovery of the larger items. The *Shirley C* and *DB Salta Verde* transited to the site the morning of October 18 to set anchors. The weather and sea state forecasts were favorable for recovery of the forward fuselage in the following few days.

The *Bold Horizon* arrived on station at the site about 1300 on October 18 and deployed the ROV to the forward fuselage location to begin rigging. The forward end of the forward fuselage was rigged with a 5/8" steel wire rope through the open cockpit side windows accomplished by passing a fiberglass pole with the wire rope attached though the windows. The tool was pre-rigged on board the *Bold Horizon* deck and taken down by the ROV. The wire rope loops were laid on the seafloor on the left side of the forward fuselage. The aft end of the forward fuselage was rigged with a 5/8" wire rope passing underneath the structure utilizing the same tool and method as before on the morning of October 19. The wire rope loops were also laid on the left side of the fuselage and the location for the barge winch hook was provided to the *DB Salta Verde*. The *DB Salta Verde* relocated on its anchor lines to position the barge over the forward fuselage and dropped the winch hook to the bottom. The ROV attached the wire loops to the winch lifting eye. Originally, the forward and aft lines were going to be used in a basket configuration with all the wire loops on the lifting eye. The forward line was changed to a choke configuration with only one loop on the lifting eye to keep the section mostly horizontal for the lift. The lift of the forward fuselage was started and before any appreciable weight could be taken up by the winch, a problem with the winch transmission developed. The *DB Salta Verde* crew diagnosed the problem and began repairs. All further work was stopped due to sea state and darkness with plans for a lift at first light the following morning.

The morning of October 20 dawned with calm seas and little wind, even less than forecast. LSR arranged for the PENCO *OSRV Century* to be on site throughout the lift to handle any unexpected fuel or hydraulic fluid spills. The ROV was deployed to check the rigging and connection to the barge winch before the lift began at 0730. After verifying the rigging and letting the forward fuselage dangle off the seafloor for a while, the ROV was recovered and the *Bold Horizon* moved out of the way. NTSB personnel were transferred to the barge for the remainder of the lift. The forward fuselage section was recovered to the *DB Salta Verde* about 1100 (Figure 18) and placed lying on its left side. There was no evidence of fuel or hydraulic fluid spills during the lift. The lower fuselage was examined and photographed before the section was rotated upright and lashed to the deck (Figure 19). There was extensive damage to the lower fuselage below the floor, only one avionics box remained, and all the floor beams were fractured. The *DB Salta Verde* crane operator reported that the forward fuselage weighed about 6 kips (kilo-pounds) in the water, a maximum of about 22 kips at the air-water interface, and about 15.5 kips in the air after draining. The decision was made to have the *DB Salta Verde* transit to Kalealoa Harbor and offload the forward fuselage prior to recovery of the aft fuselage due to the limited space available on the deck and contrary to the EGI plan. The *Shirley C* and *DB Salta Verde* departed for Kalealoa to offload the forward fuselage under the direction of the NTSB IIC. The ROV was redeployed to survey the aft fuselage section and set cables on the seafloor for rigging. The second debris basket was placed on the seafloor near the location of the cargo containers.

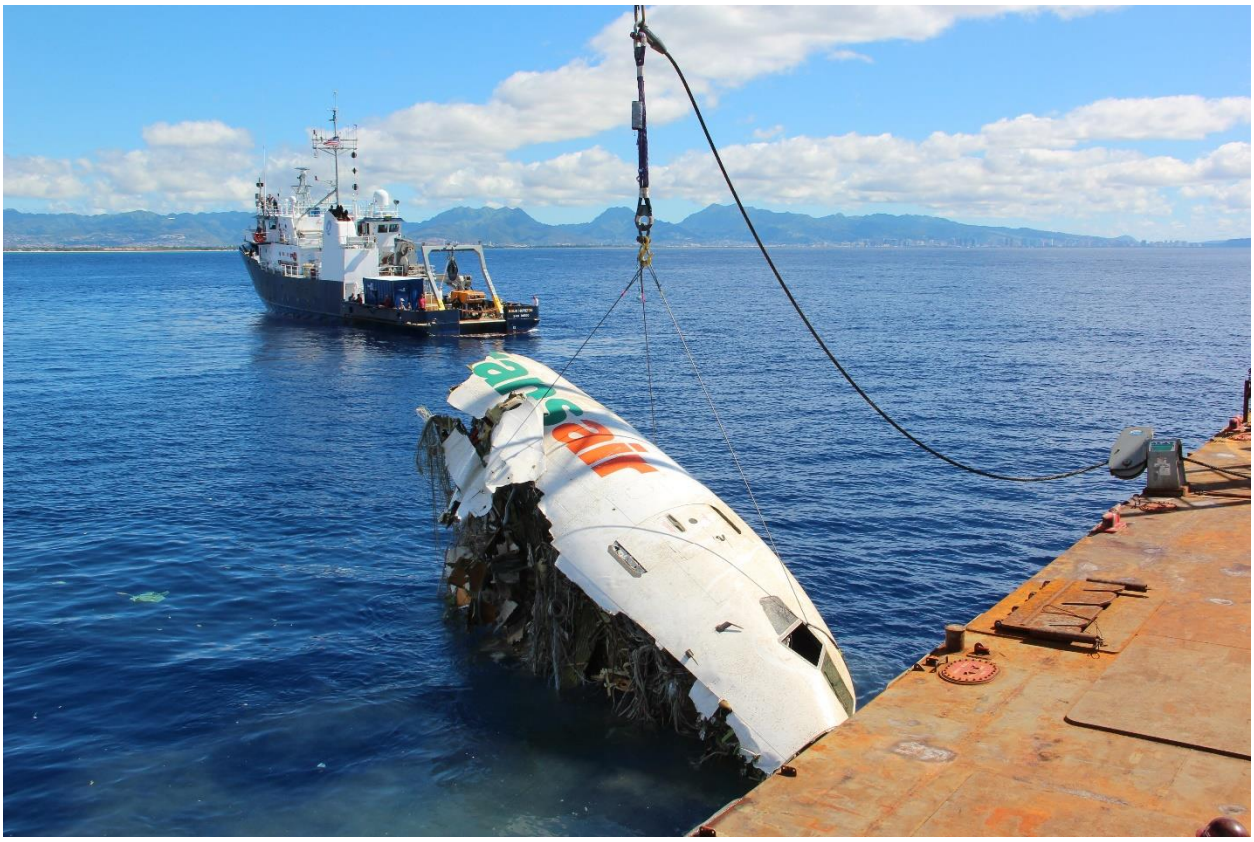

Figure 18. Forward fuselage recovery.

Figure 19. Forward fuselage on barge.

The ROV was deployed on the aft fuselage section the morning of October 21 to continue the survey and to rig the tail. Two 12-inch-wide nylon lift straps were slid along the seafloor underneath the tail of the airplane near the area of the aft entry doors and aft pressure bulkhead. The loops were brought to the top of the fuselage for connection in a basket configuration to a third 10 ft nylon lift strap. The wing root areas were examined in detail to show that the forward

spar on each side of the fuselage was intact. The forward spar was fractured in the wing center tank area but deemed to be intact enough for the lift. Without the *DB Salta Verde* on station to drop the heavy wing lift cables or to lift large items, the choice was made to recover additional smaller items. The thrust reverser assemblies were recovered to the deck of the *Bold Horizon* around 1535 and 1830.

The wind and sea state forecast indicated that it would not be favorable for recovering the aft fuselage for a few days, so the decision was made to recover the smaller items of wreckage until there was a window of good weather. The crew of the *DB Salta Verde* was instructed to remain in port at Kalealoa until there was a good weather window. The ROV transited the debris field around the location of the forward fuselage and picked up individual items and placed them in the debris basket. The larger items were rigged with nylon straps or cables and recovered to the *Bold Horizon* deck. The EGPWS computer was located in the debris field on October 22 and placed in the basket. A fuel control unit and a fuel pump were also identified and placed in the basket. The APU and keel beam were recovered to the deck of the *Bold Horizon* on October 22.

The recovery of small items continued October 23 to 25. Additional identified items included engine bleed air lines, several pieces of forward fuselage structure, an engine mount, and an engine bypass duct. The first basket was recovered to the deck of the *Bold Horizon* on October 23 (Figure 20), unloaded, and sent back down. The EGPWS computer was rinsed with fresh water and placed in a cooler of distilled water for eventual transport to the NTSB laboratory. The evening of October 23, the *Bold Horizon* had glancing contact with a raised area of seafloor while loitering off Honolulu harbor. Initial inspection revealed no damage or water intrusion into the hull. The evening of October 24 the *Bold Horizon* transited to Kalealoa and tied up alongside the *DB Salta Verde* that was still waiting out the weather. The thrust reversers, APU, nose landing gear, baskets, and debris on the *Bold Horizon* deck were offloaded onto the barge for transfer to the pier before the *Bold Horizon* transited back to the site.

Figure 20. Debris basket with airplane wreckage.

The ROV developed an electrical problem with the thrusters while recovering wreckage the morning of October 25. The ROV was recovered, repaired, and redeployed. Another basket of debris was recovered to the deck of the *Bold Horizon* that included the electronic and equipment bay door, a segment of the forward lower cargo door, a fuselage skin panel with a static port, and the lower forward access door. The ROV was recovered about 1630 after a hydraulic leak developed on the left manipulator. The *Bold Horizon* transited to the port of Honolulu the evening of October 25 where it stayed overnight. On October 26 the compressor was replaced on the deck, garbage was offloaded, and more groceries and water were taken aboard. EGI had a diver inspection of the hull performed that revealed damage to the hull coating layers but no denting or penetration from the bottom contact. The State of Hawaii was notified of the bottom contact. The sealed EGPWS cooler was transferred to the IIC for transport to Washington, DC.

The wind and sea state forecasts were improving and looked to be favorable for recovering the aft fuselage, so the *DB Salta Verde* departed Kalealoa for the site about 0600 on October 27. Anchors were set and the *DB Salta Verde* was on station about 1300 so the *Bold Horizon* departed Honolulu for the site. The ROV was deployed and continued picking up small debris and placing it in the baskets after surveying the new barge anchor positions. The crew on the *DB Salta Verde* and the *Bold Horizon* prepared the wire rope wing rigging and established the procedures for the barge to deliver the heavy rigging to the seafloor with the winch. October 28 was spent with the ROV rigging each of the wings. Long 5/8” 8-braid steel wire ropes were laid on the seafloor at the wing tips and drug inboard to the wing root areas using the winch and

ROV. The wing wire rope loops and the tail nylon strap loops were connected to a master link in a basket configuration. The ROV had to be recovered near midday to repair a hydraulic hose that was cut by the wreckage. The aft fuselage rigging was complete by about 1830. The ROV was deployed the morning of October 29 for a final check of all the rigging and the *DB Salta Verde* moved into position over the wreckage. The winch cable was lowered to the seafloor and the master link was attached to the winch cable. Tension on the cable was slowly applied while the ROV recorded video and photographs. The winch recorded a maximum load of about 63 kips, which set the wing cables into the flap structure and partially lifted the airplane (Figure 21). The aft fuselage was observed rocking on the seafloor while the horizontal stabilizer leading edge was moving up and down through its range of travel. The afternoon sea state was not conducive for a lift, so the tension was taken off the winch cable overnight. The ROV continued picking up smaller parts to include portions of engine cowling, sections of the lower forward fuselage, and numerous other smaller parts. LSR made arrangements for the *OSRV Century* to be on site the following morning to contain any fuel spills during the aft fuselage lift.

Figure 21. Aft fuselage rigging under tension.

October 30 dawned with calm seas and very light winds that were favorable for a lift. The ROV was deployed to install a tag line on the outboard end of the right wing to prevent rotation of the airplane as it was lifted. Tension was applied on the winch line starting about 0830 and the aft fuselage came off the bottom about 5 minutes later with a load of about 80 kips recorded. The airplane attitude as rigged was mostly horizontal and tail-low. The aft fuselage was slowly lifted through the water column until the master link was at the surface. The largest load recorded in the water was about 170 kips during a heave with a steady load of about 70 kips. The ROV observed the lift from the bottom to the surface before being recovered. The barge crane hook was then connected to a short stinger that was previously installed on the master link for the lift out of the water and onto the barge. The winch cable remained attached to the master link during the lift. The aft fuselage broke the surface about 1000 and was slowly lifted through the air-water

interface (Figure 22). The crane would lift until the load meter showed about 95 kips before stopping to let water drain to about 75 kips and then repeated. Once the forward end of the section and the wing leading edge were above the barge height, the section was moved onto the barge for support while water drained. The aft fuselage lift was completed about 1030 (Figure 23). The maximum load recorded on the crane was about 130 kips during a heave while the airplane was still transitioning through the interface. The maximum load recorded when the airplane was fully out of the water was about 110 kips. The *OSRV Century* was on site during the entire lift and no evidence of a fuel or oil sheen on the water was observed.

Figure 22. Aft fuselage section at water surface.

Figure 23. Aft fuselage section on barge.

Once the aft fuselage was lashed to the barge, the NTSB investigators were transferred to the tug *Shirley C* for the transit to Kalealoa Harbor where the wreckage was going to be offloaded and stored. The *DB Salta Verde* and *Shirley C* tied up alongside pier 7 at Kalealoa Harbor about 1700 on October 30. Once the barge was tied up, PENCO personnel boarded it to offload any fuel and water remaining in the recovered wing tanks. They reported that the left wing tank was about ¾ full of water with no fuel present, the right wing had about 1-2 inches of water at the wing root with no fuel evident, and the center tank had about 6-8 inches of water with about ½ inch of fuel on the surface. All the tanks were sucked dry totaling 1336 gallons. The aft fuselage and all the smaller wreckage were transferred to the pier by the barge crane on October 31. The rigging was removed from both the forward and aft sections and returned to the barge. The two engines and the #2 inlet case were crated after examination by the powerplants group at the AMC facility. The crates were transferred to the barge for the return trip to California where the Powerplants investigative group took custody. The *Bold Horizon* concluded operations on October 31 after performing a post-operation survey of the wreckage area and anchor locations. The *Bold Horizon* personnel offloaded the additional wreckage they recovered at AMC on November 1, and it was transferred to Kalealoa.

5.5 Flight Recorder Recovery and Shipment

NTSB investigators were able to access the flight recorders once the *DB Salta Verde* was tied up at the harbor. The flight data recorder (FDR) located in the aft galley ceiling was accessed through the right aft entry door. The FDR remained installed in the rack and was

undamaged. The cockpit voice recorder (CVR) located in the lower cargo compartment could not be accessed through the aft cargo door due to the fuselage damage. Investigators cut a hole through the right lower fuselage skin to access the CVR. The CVR remained installed in the rack, although the rack was partially separated from the fuselage. The CVR was undamaged. The FDR and CVR were placed in a cooler of distilled water for shipment to the NTSB laboratory in Washington, DC (Figure 24). The cooler with both recorders and water was too heavy for shipment, so a second cooler was purchased, and the recorders were separated with each cooler filled with distilled water.

The NTSB special operations group coordinated the shipment of the flight recorders with United Airlines Cargo, the Transportation Security Administration (TSA), and the Federal Bureau of Investigation (FBI). Since there were no nonstop flights to Washington, DC, at the time, a connecting flight was required. FBI personnel transferred the flight recorders at the connection and NTSB investigators met the inbound flight at Washington-Dulles International Airport on November 3 and retrieved the two coolers with the flight recorders.

Figure 24. Flight recorders from accident airplane.

6.0 Post-Operation Reporting

EGI provided a project final report to the NTSB and AIG on February 8, 2022. Additional post operation reports were supplied to NOAA and NMFS as described earlier.

The costs for the search and recovery of the accident airplane were borne by AIG. The NTSB worked extensively with AIG and LSR throughout the process. The total cost for the search, recovery, and storage of the airplane was about $4.5 million with the recovery making up more than half of the total. The other items in descending order were the environmental response by PENCO, storage and shoreside logistics by AMC, project management and disposal by LSR, and the search by SEI.

7.0 Lessons Learned

During the initial search for the airplane the group elected to utilize the USCG-provided on-scene location of the tail floating on the surface as the starting location for the side-scan sonar work. The search was initially focused west of the tail location due to the prevailing currents. After not locating the wreckage with the sonar, the group utilized the Boeing pinger locator to pinpoint the position of the wreckage. A full day was spent searching the location around the USCG provided GPS coordinates with sonar prior to using the pinger locator. The available evidence indicates that the provided tail location was likely in error. With the USCG reporting that the tail of the airplane was mostly intact, the use of the pinger locating equipment should have been the first step in the search. Or, in hindsight, it would have been prudent, at least, to deploy with the pinger locator on the search vessel on day one in case it was needed.

The development of the RFQ involved significant work between the NTSB and the insurance company. The NTSB's prior experience with water recoveries and contacts with several potential contractors saved time in the process. Multiple meetings and telephone calls were held with each of the proposal submitters as they were developing their proposals prior to selection. Once the contractor was selected, there was significant pre-planning and collaboration between the NTSB, Boeing, the insurance company, and the recovery contractor. The development of the project plan took about 1 month with daily communication between the participants. There were some difficulties between the insurance company and the contractor with contract details that did not get finalized until mid-September, but the development of the project plan proceeded while negotiations were ongoing. The contract difficulties delayed the start date of the recovery operation multiple times. This resulted in NTSB and party personnel changes to support the operation.

The operation occurred during the COVID-19 pandemic. The success of the operation depended on not having a COVID outbreak on the recovery vessel. The federal government had a vaccine requirement in place at the time and the State of Hawaii required vaccination proof or a negative test prior to boarding any flight for Hawaii. The team decided that every participant boarding the vessel in Honolulu required a negative test result after arriving in Hawaii and prior to boarding the vessel. For those required crew members that boarded the search and recovery vessels in California and transited the ocean to Hawaii, there were vaccine requirements and, the 2-week trip ensured they were symptom free. There was no outbreak or sickness reported during the operation. However, it was discovered that some of the contractor personnel did not follow the agreed protocols.

The proposed operation was estimated to take 10 days assuming a 24-hour operation onboard the vessel. The NTSB staffed the operation based on this assumption. The wind and sea state conditions experienced prevented the operation from being safely performed around the clock. There were several mechanical anomalies with the ROV that resulted in delays of about 3 days. The *Bold Horizon* made three unscheduled port calls to unload wreckage and take on additional supplies that further extended the operation. Additionally, the contractor did not have enough personnel to support a 24-hour operation. The full recovery operation lasted 20 days due to these issues.

The State of Hawaii Department of Transportation had stringent requirements for the vessel to arrive in the port of Honolulu. The vessel had to have a designated and approved agent with a scheduled time slot for arrival. The unloading of wreckage and supplies from the vessel to the pier required the use of trade union stevedores paid for by the company. Significant additional and unneeded personnel were present for the unloading events. The unloading of wreckage was significantly more expensive and difficult than planned.

The operation at sea was supported by NTSB and Boeing personnel on board the recovery vessel. One of the Boeing personnel had significant seasickness and elected to go ashore before the operation was complete. The impact would have been much greater if it was a 24-hour operation. During rigging and lifting it was imperative that the Boeing engineers and NTSB staff were available to assess the structural integrity of the wreckage and provide updated weight estimates. The team was able to support the recovery only because the operation was not run 24-hours a day. The location of the recovery site close to shore was in cell phone range so communication with the removed engineer could continue. The water visibility was exceptional for the duration of the operation and made the rigging much easier.

The initial recovery plan was analyzed thoroughly and discussed extensively in the month prior to the operation with agreement from all team members. The recovery contractor proposed an alternate lift plan immediately prior to departure of the ship from Honolulu after the engines were unloaded. The NTSB and Boeing had to quickly evaluate the plan and identify the deficiencies. The NTSB team proved to the contractor that the alternate lift plan was much riskier that the original lift plan and informed them that the NTSB team would not support the alternate plan.

The barge anchor locations were planned to not interfere with the recovery operation and were given to the barge crew prior to deployment. The anchors were dropped in somewhat random locations, but it did not interfere with the operation. The locations did prove to be difficult for the post operation assessment of the seafloor effects required for the reporting.

The location of the wreckage close to shore proved beneficial for staying in contact with shore side personnel. Cell phone and internet connectivity allowed all team members to be in constant contact. A location further out to sea would have been problematic for communication, especially since the advertised satellite internet connectivity on the vessel was not very capable.

The need for federal and state consultations in accordance with ESA and EFH regulations was not known prior to the planning stage. Fortunately, SEI provided guidance and information to the NTSB during the search phase that they would be needed. All communication between the federal and state entities had to be done by the NTSB. The requirements were not too onerous but necessitated the use of an environmental consultant on board the vessel that knew the laws and the local contacts for the various agencies. The ESA and EFH reports were accepted by the necessary agencies.

The operation was the most significant deep-water search and recovery undertaken by the NTSB in decades. The recovery of the aft fuselage section represented the largest intact airplane section recovered from deep water by ship-borne assets ever conducted by the NTSB and Eclipse Group. The collaboration between the federal and state agencies was outstanding from the initial

response through the recovery operation. The insurance company provided the necessary support and funding to successfully conclude the operation.

The NTSB completed the investigation and published the final report with probable cause on June 15, 2023.

Reference List

The following documents are available in the NTSB's public docket for accident DCA21FA174, accessible from the NTSB's Accident Dockets web page by searching using the accident number.

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