National Transportation Safety Board
Office of Aviation Safety
Washington, DC 20594

ANC22FA041

# AIRWORTHINESS

Group Chair's Factual Report

October 24, 2022

## A. ACCIDENT

Location: Kalea, Hawaii
Date: June 8, 2022
Time: 17:26 Hawaii-Aleutian standard time
Helicopter: Bell 407, registration N402SH

## B. AIRWORTHINESS GROUP

| | |
|---|---|
| Group Chair | Chihoon Shin<br>National Transportation Safety Board<br>Washington, District of Columbia |
| Group Member | Mark Taylor<br>Federal Aviation Administration<br>Burlington, Massachusetts |
| Group Member | Jack Johnson<br>Rolls-Royce<br>Indianapolis, Indiana |
| Group Member | Lauren Douglas<br>K & S Helicopters<br>Kailua-Kona, Hawaii |
| Group Member | Gary Howe<br>Bell<br>Forth Worth, Texas |
| Group Member | Beverley Harvey<br>Transportation Safety Board of Canada<br>Gatineau, Quebec, Canada |

## C. SUMMARY

On June 8, 2022, about 1726 Hawaii-Aleutian Standard Time, a Bell 407 helicopter, N402SH, operated by K & S Helicopters doing business as Paradise Helicopters, impacted a lava rock field near Kalea, Hawaii (HI) after an inflight separation of its empennage. On June 9, 2022, the operator conducted aerial photography of the accident site. On June 10, 2022, a representative from the Federal Aviation Administration (FAA) Honolulu Flight Standards District Office (FSDO) traveled to the accident site grounds and photographed the wreckage. On June 14, 2022, members of the Airworthiness Group conducted an examination of

the wreckage at the accident site.[1] On the same day, the wreckage was recovered and transported to a hangar at Ellison Onizuka Kona International Airport (KOA). On June 15, 2022, members of the Airworthiness Group conducted an examination of the recovered wreckage.[2]

## D. DETAILS OF THE INVESTIGATION

## 1.0 Helicopter Information

### 1.1 Helicopter Description

The Bell 407 is type certificated under FAA type certificate data sheet (TCDS) No. H2SW. The Bell 407 has a four-bladed main rotor system that provides helicopter lift and thrust, and a two-bladed teetering tail rotor system that provides thrust to counteract main rotor torque and for directional control of the helicopter. The helicopter is equipped with one Rolls-Royce Model 250-C47B turboshaft engine, mounted behind the main transmission, which has a maximum continuous power rating of 630 shaft horsepower per TCDS No. H2SW. The helicopter was equipped with a skid-type landing gear.

All left, right, up and down orientations as well as clock positions referenced in this report are in the aft-looking-forward frame of reference unless otherwise specified.

### 1.2 Accident Helicopter History

The accident helicopter, N402SH, was serial number (S/N) 53118 and was manufactured in 1997. The engine installed on the accident helicopter was S/N CAE-847553. According to helicopter records, the helicopter had an aircraft total time (ATT) of 23,005.6 flight hours at the end of the day on June 6, 2022. Additional information about the maintenance history of the accident helicopter can be found in the Maintenance Records Group Chairman's Factual Report in the docket for this investigation.

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[1] Airworthiness group members present at the examination of the wreckage at the accident site included the NTSB and the FAA.

[2] Airworthiness group members present at the examination of the wreckage at KOA included the NTSB, the FAA, Bell Flight, Rolls-Royce, and Paradise Helicopters.

## 2.0 Wreckage Examination

## 2.1 Structures

### 2.1.1 Airframe Description

The Bell 407 helicopter fuselage is composed of three primary structural assemblies: the forward fuselage, the intermediate fuselage, and the tail boom (**Figure 1**).

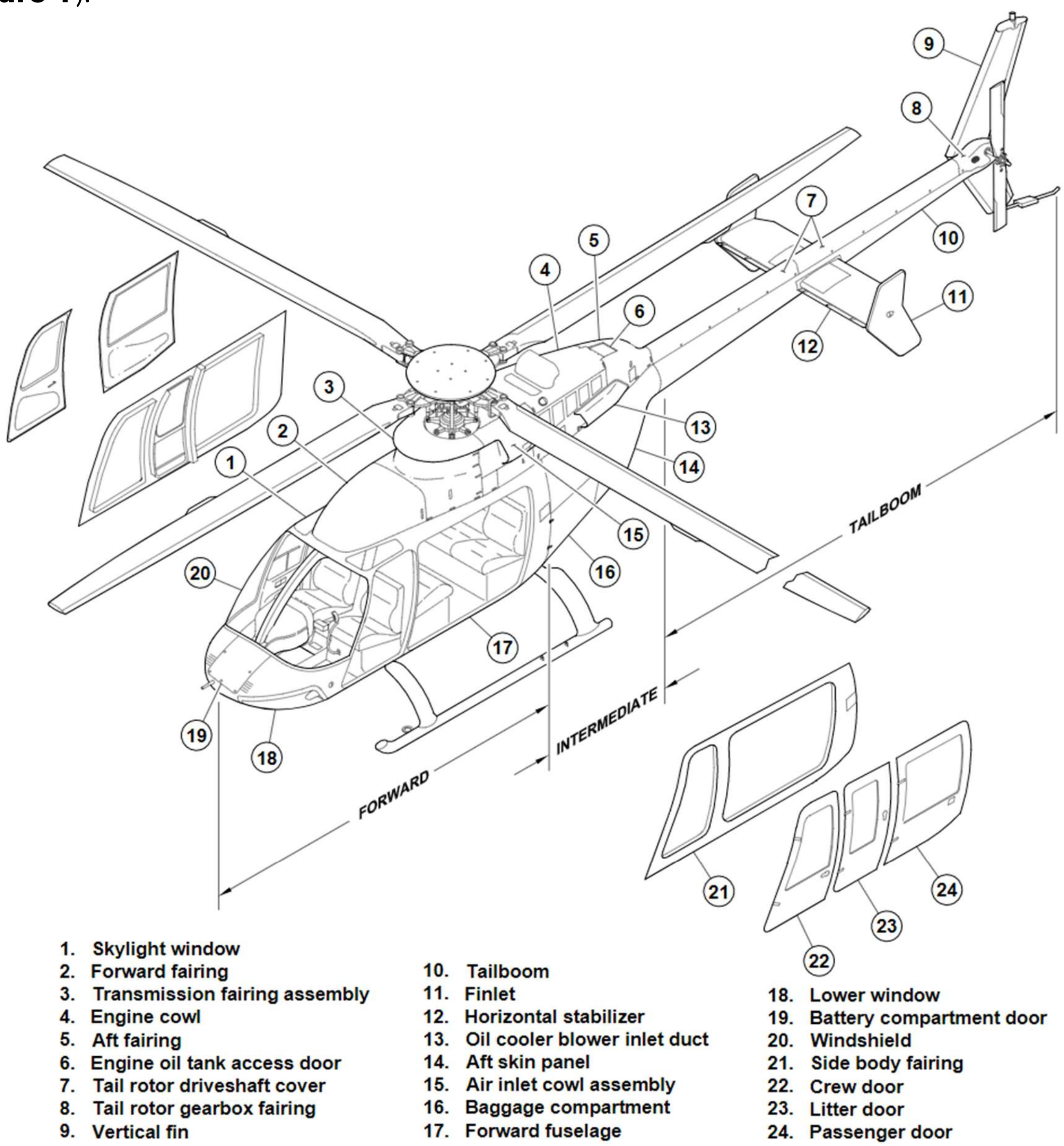


**Figure 1. A diagram showing the locations of the forward fuselage, intermediate fuselage, and tail boom. (Image courtesy of Bell.)**

The forward fuselage begins at the nose of the helicopter and extends to the rear of the passenger compartment. The intermediate fuselage begins at the rear of the passenger compartment, near frame station (STA) 150[3], and extends to the front of the tail boom, about STA 231. The tail boom begins at the aft fuselage and ends at the vertical fin and tail skid.

The intermediate fuselage is composed of bulkheads, longerons, and composite skins. The aft portion of the intermediate fuselage, from about STA 192 to STA 231, is referred to as the aft fuselage. Four aft fuselage longerons, identified in this report as upper-left, upper-right, lower-left, and lower-right, are attached to the aft fuselage bulkhead, located at the aft-most portion of the intermediate fuselage (**Figure 2**). To install the tail boom to the intermediate fuselage, fasteners (bolts, washers, and nuts) are used to connect the four aft fuselage longerons to four corresponding longerons located at the forward end of the tail boom (**Figure 3**).

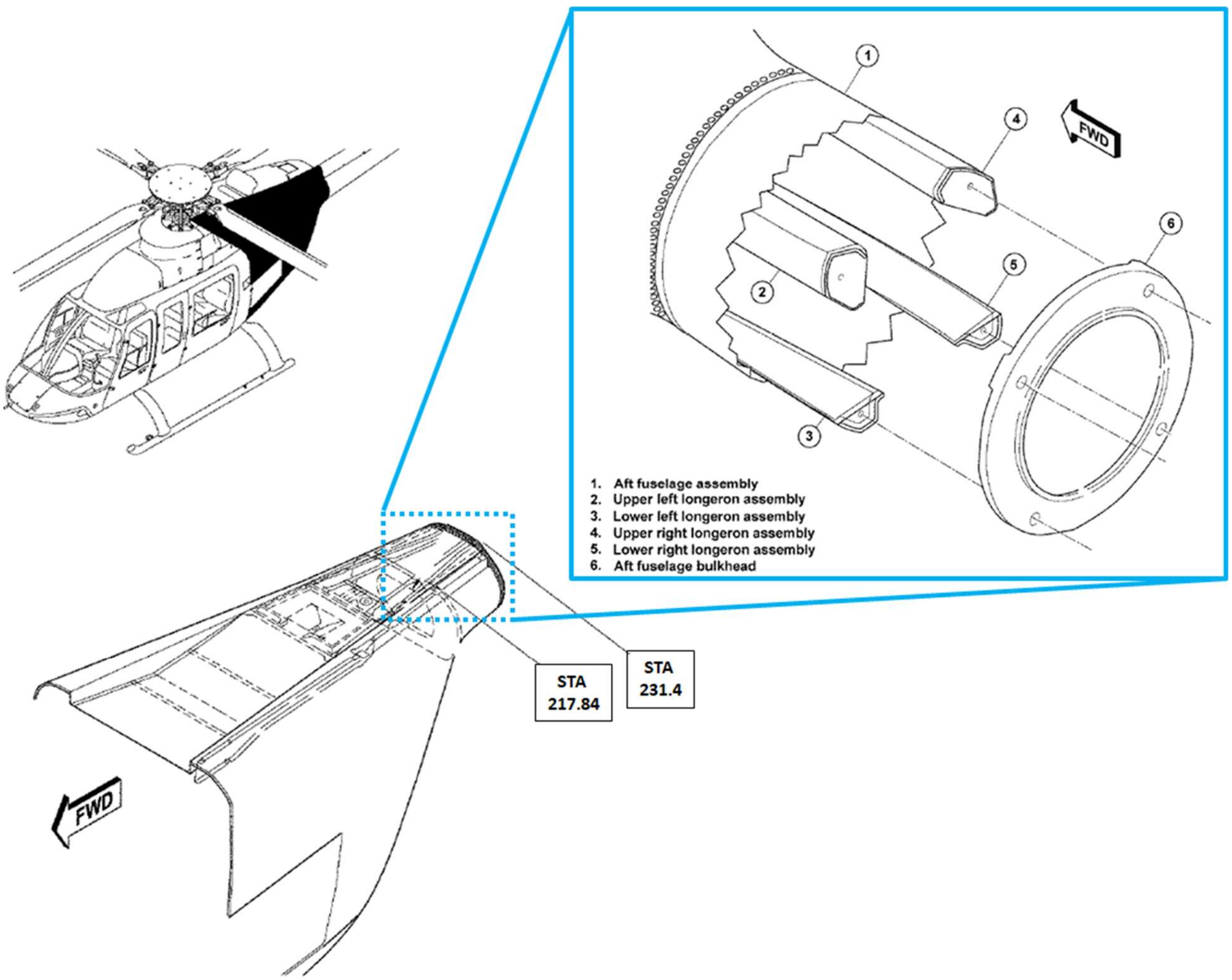


**Figure 2. A diagram showing the location of the four aft fuselage longerons and the aft fuselage bulkhead. (Images courtesy of Bell and edited by the NTSB.)**

[3] All STA are in inches. STA 0 begins near the nose of the helicopter, with the nose located at STA 1.0.

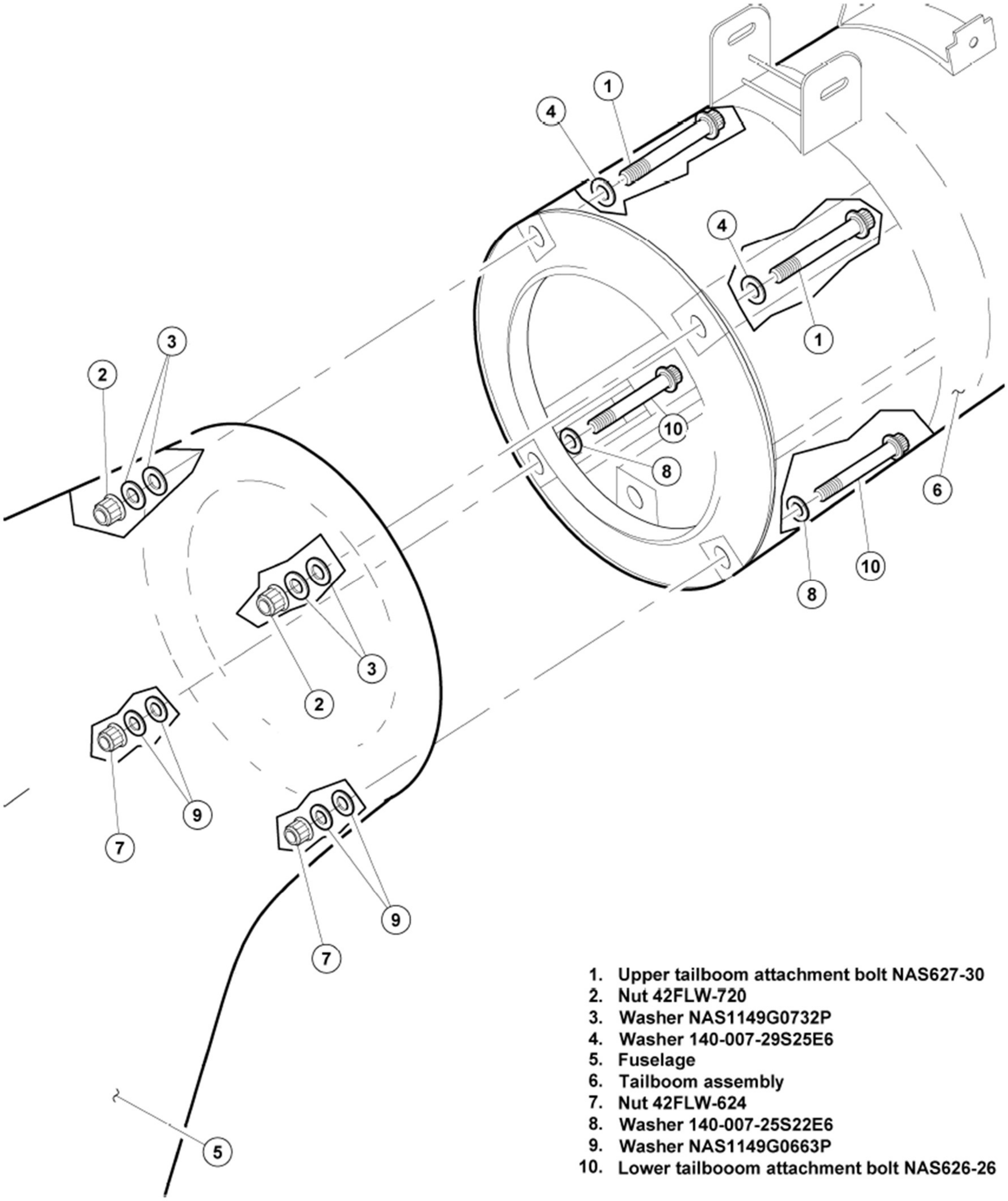


**Figure 3. The hardware used to attach the tail boom to the aft fuselage. (Image courtesy of Bell and edited by the NTSB.)**

According to Bell, tail rotor thrust results in tension loads on the two left attachment points and compression loads on the two right attachment points. The weight of the tail boom puts tensions loads on the two upper attachment points and compression loads on the two lower attachment points. Therefore, the upper-left attachment point has the highest tension loading of the four attachment points.

### 2.1.2 Accident Site Description

There were two distinct wreckage sites: the main wreckage site and the empennage wreckage site (**Figure 4**). The empennage wreckage site was about 762 feet to the northeast of the main wreckage site. The empennage wreckage site was composed of the tail boom; the aft fuselage bulkhead and portions of the upper-right, lower-left, and lower-right longeron attachment fittings still attached via their attachment hardware; the horizontal stabilizer; the vertical stabilizer; the tail rotor and its gearbox; and the tail rotor drive shafts from the tail boom attachment point aft to the tail rotor gearbox. The main wreckage site was composed of the forward fuselage, intermediate fuselage, landing gear, main rotor system, and the engine.

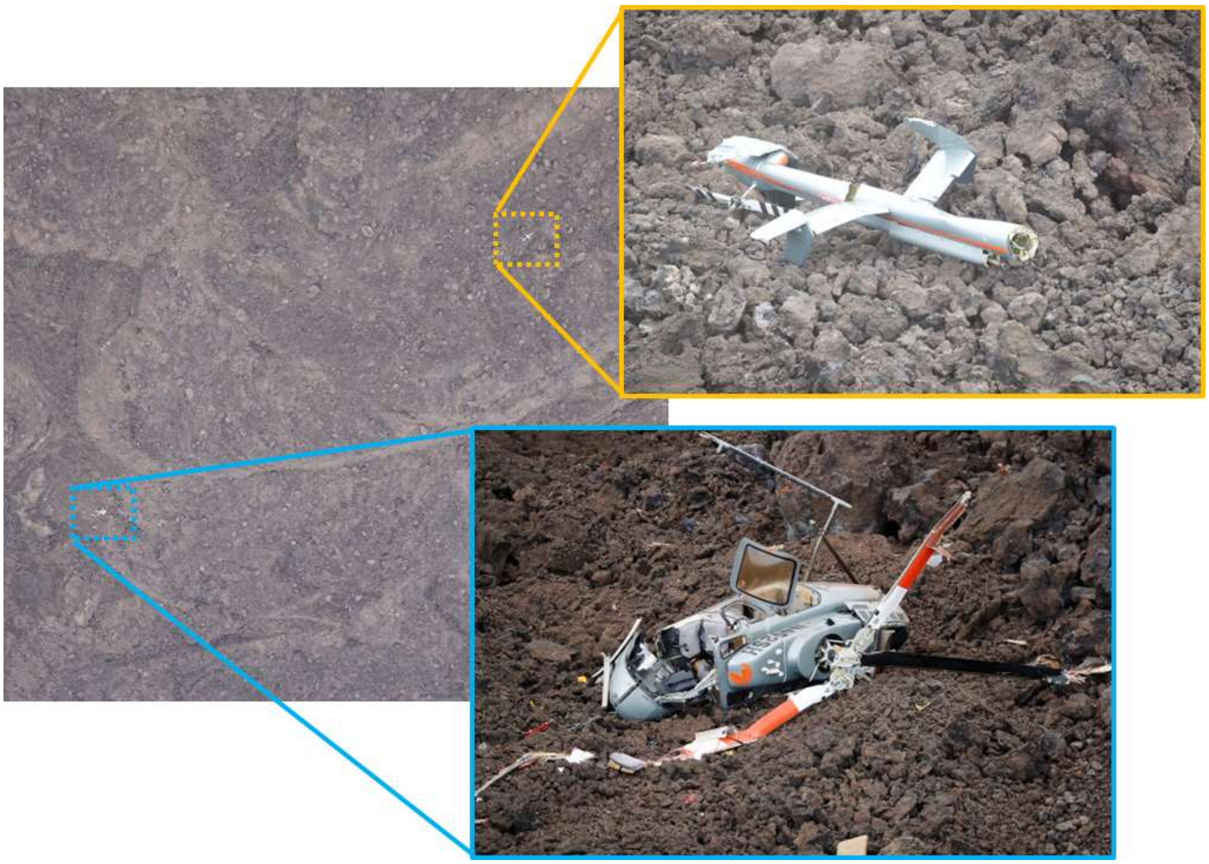

**Figure 4. An aerial view (left image) showing the main fuselage wreckage (lower-right image) and the empennage wreckage (upper-right image). (Aerial image courtesy of Paradise Helicopters and edited by the NTSB.)**

### 2.1.3 Main Fuselage Wreckage Observations

The main wreckage came to rest on its left side at a heading of about 265 degrees magnetic. The right side of the main fuselage did not exhibit evidence of contact with the ground. The nose of the helicopter was partially separated from the fuselage but remained in its normal location.

The aft fuselage exhibited impact deformation primarily in the inward, upward, and left directions in the area of the tail boom attachment points and the baggage compartment (**Figures 5 and 6**). The aft fuselage upper-left longeron was whole and remained installed to the aft fuselage but its tail boom attachment hardware was not present (**Figure 7**). The aft fuselage bulkhead was not present. The upper-right, lower-right, and lower-left longerons attachment fittings were fractured near the radius where the longitudinal wall transitions to the bolt hole. A portion of the upper-right longeron had separated from the aft fuselage and was found at the empennage wreckage site. The longerons for the lower-left and lower-right attachment fittings remained installed on the aft fuselage. The horizontal deck between the lower-left and lower-right longerons (which attaches to the aft fuselage bulkhead via 11 rivets) was present within the aft fuselage but had deformed and rotated about 90 degrees clockwise. Additional observations of these attachment fitting fractures can be found in Section 2.1.4 of this report. Portions of the aft fuselage, containing the aft fuselage longerons, were cut from the wreckage and retained by the NTSB for further evaluation. The details of the NTSB Materials Lab examination of the aft fuselage structural pieces can be found in Materials Laboratory Factual Report No. 22-071 in the docket for this investigation.

**Figure 5. An overview of the aft fuselage wreckage. (Photo courtesy of the FAA.)**

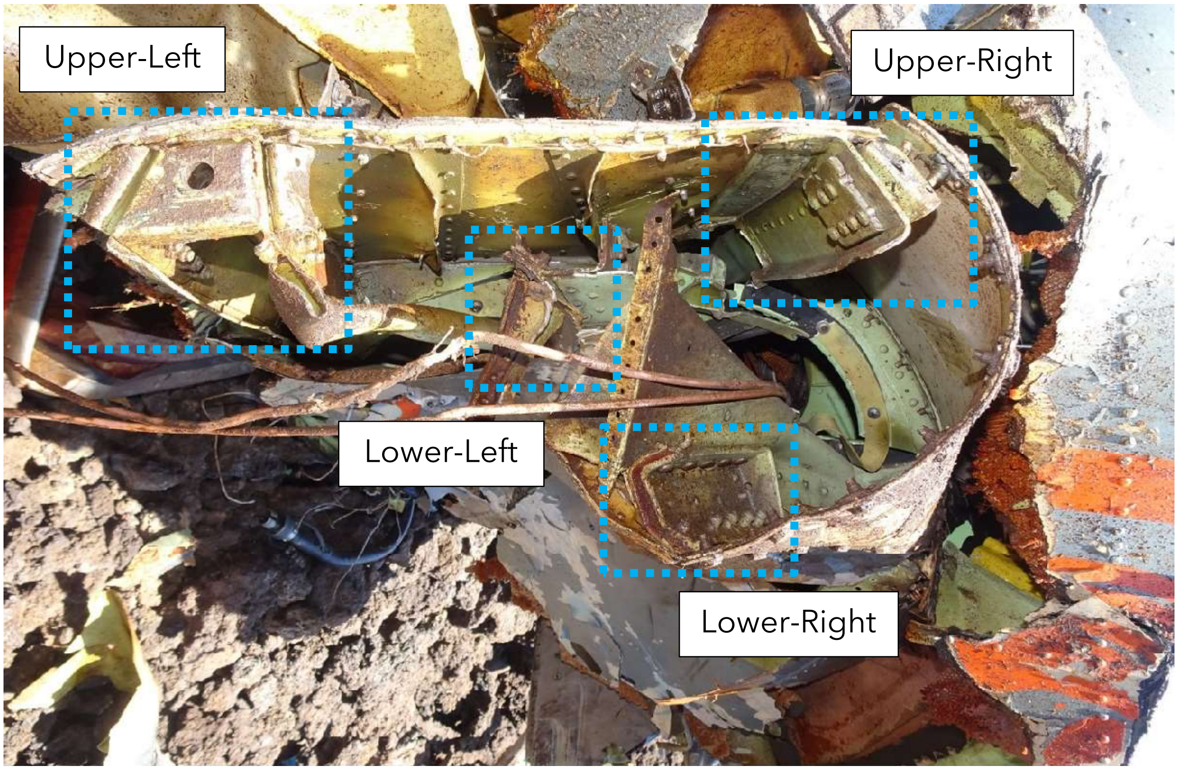


**Figure 6. The aft fuselage with the four longeron locations annotated. Note the photo has been rotated and ground level at the accident site is to the left.**

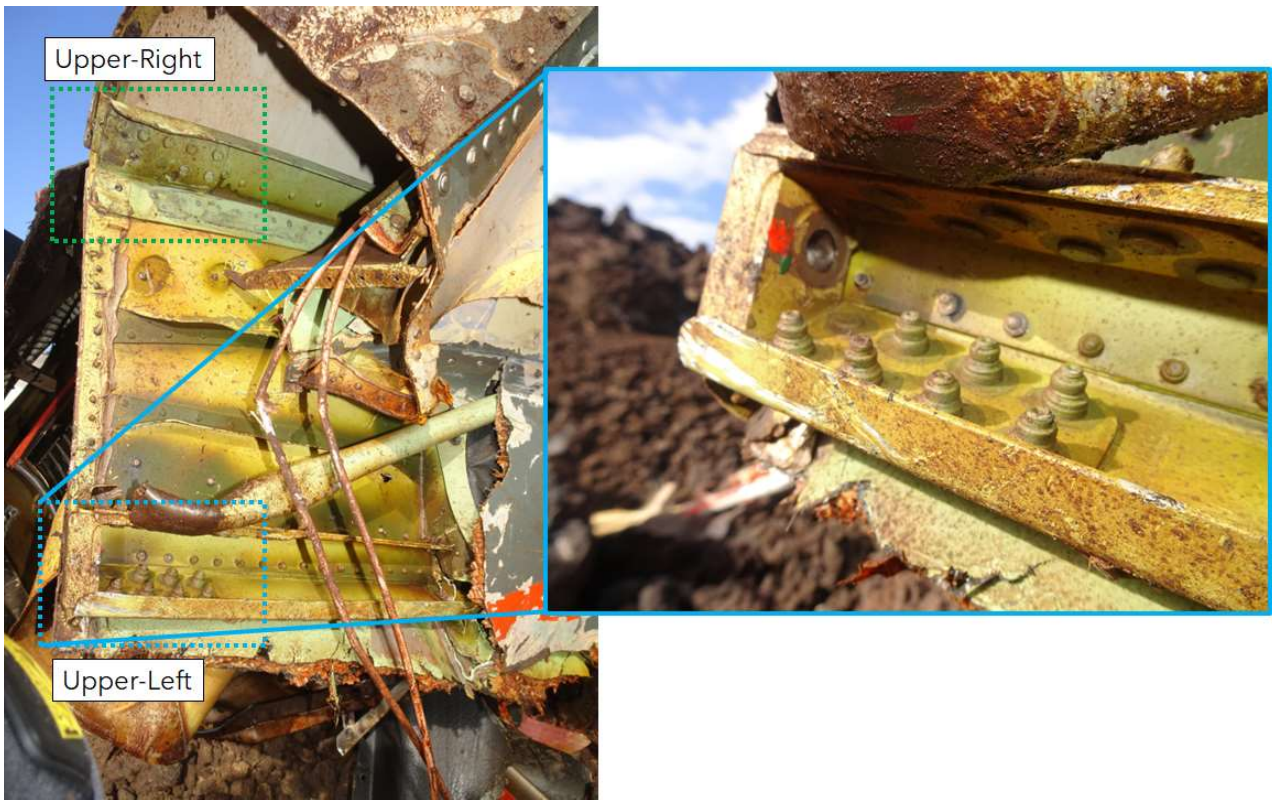


**Figure 7. A view of the aft fuselage upper-left longeron and its bolt hole.**

The main transmission deck and forward portion of the engine bay remained whole and did not exhibit significant deformation. The aft portion of the engine bay exhibited impact deformation. The upper cowlings were all present.

The forward crosstube of the landing gear had separated from the main fuselage. The aft crosstube remained partially attached via the left saddle mount and the crosstube exhibited impact deformation. A portion of the right skid tube and right step remained attached to the aft crosstube. The left skid tube and left step were separated but adjacent to the main wreckage.

### 2.1.4 Empennage Wreckage Observations

The empennage came to rest inverted at a heading of about 57 degrees magnetic (**Figure 8**). The underside of the tail boom exhibited impact deformation primarily on its forward half. The tail boom was partially separated immediately aft of the horizontal stabilizer, but remained as one assembly with the tail rotor drive train continuity intact between these two segments.

**Figure 8. The empennage wreckage at the accident site.**

The left and right horizontal stabilizers were mostly whole but exhibited chordwise bending deformation about 12 inches outboard of their root ends as well as localized punctures from ground impact. The inboard and center leading edge airfoils were separated from the right horizontal stabilizer but were found in the immediate vicinity of the empennage. The left and right finlets were present and damaged from ground impact. The lower portion of the vertical fin exhibited substantial impact deformation. The upper portion of the vertical fin was mostly intact except for damage at its upper-most end that was consistent with main rotor blade contact. The anti-collision light at the upper end of the vertical fin was not present.

The tail boom forward bulkhead, located at the forward end of the tail boom, was present and exhibited impact deformation primarily between the 3 o'clock to 6' o'clock region and was partially separated from the tail boom in this area (**Figure 9**). The aft fuselage bulkhead, except for its outer circumference that is riveted to the aft fuselage skin, remained attached to the forward end of the tail boom and exhibited a circumferential fracture along its outer circumference. The aft fuselage bulkhead also exhibited a fracture to the outboard of the upper-left and lower-left attachment fittings, from about the 8 o'clock to 10 o'clock range; this portion of the aft fuselage bulkhead was deformed in the forward direction.

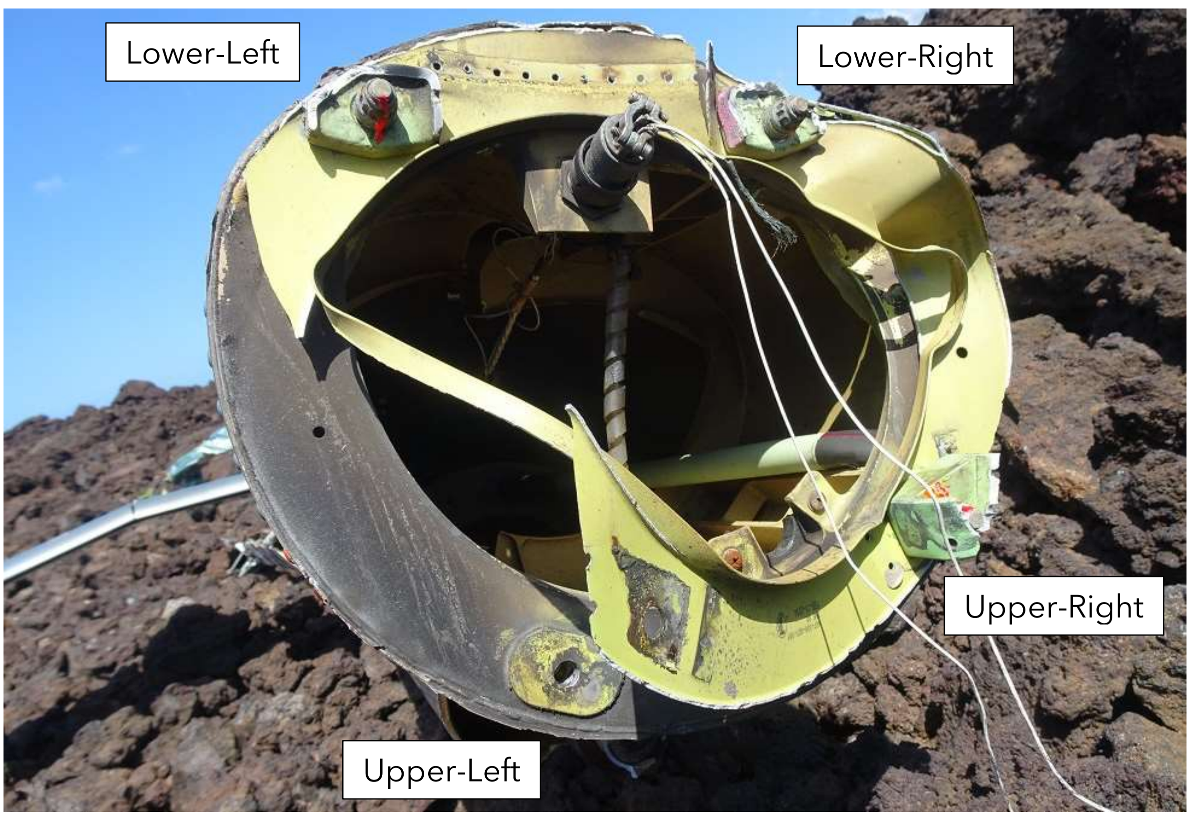


**Figure 9. The aft fuselage bulkhead (light yellow-green in color) and the remnant upper-right, lower-left, and lower-right tail boom attachment fittings and hardware found in the empennage wreckage.**

All four tail boom-side attachment fittings were present. The aft-most portions of the upper-right, lower-right, and lower-left aft fuselage-side attachment fittings remained connected to the aft fuselage bulkhead via their attachment hardware; these three attachment fittings exhibited fractures and the remainder of those longerons were found installed in the aft fuselage. The lower-left aft fuselage-side attachment fitting exhibited signatures of fatigue on the outboard side of the fracture surfaces and the remainder of the fracture exhibited signatures of overload (**Figure 10**). The lower-right aft fuselage-side attachment fitting exhibited signatures of overload as well as impact marks overload on a small portion of the fracture surfaces. The upper-right aft fuselage-side attachment fitting exhibited signatures of overload and its remnant structure was bent in the outboard/right direction. The location where the aft fuselage upper-left longeron assembly was normally installed onto the aft fuselage bulkhead exhibited a dark brown and grey discoloration. The attachment fitting hardware had remnant orange-colored torque stripe present on their nuts, nut-side threads, and on the attachment hardware clamping surface.

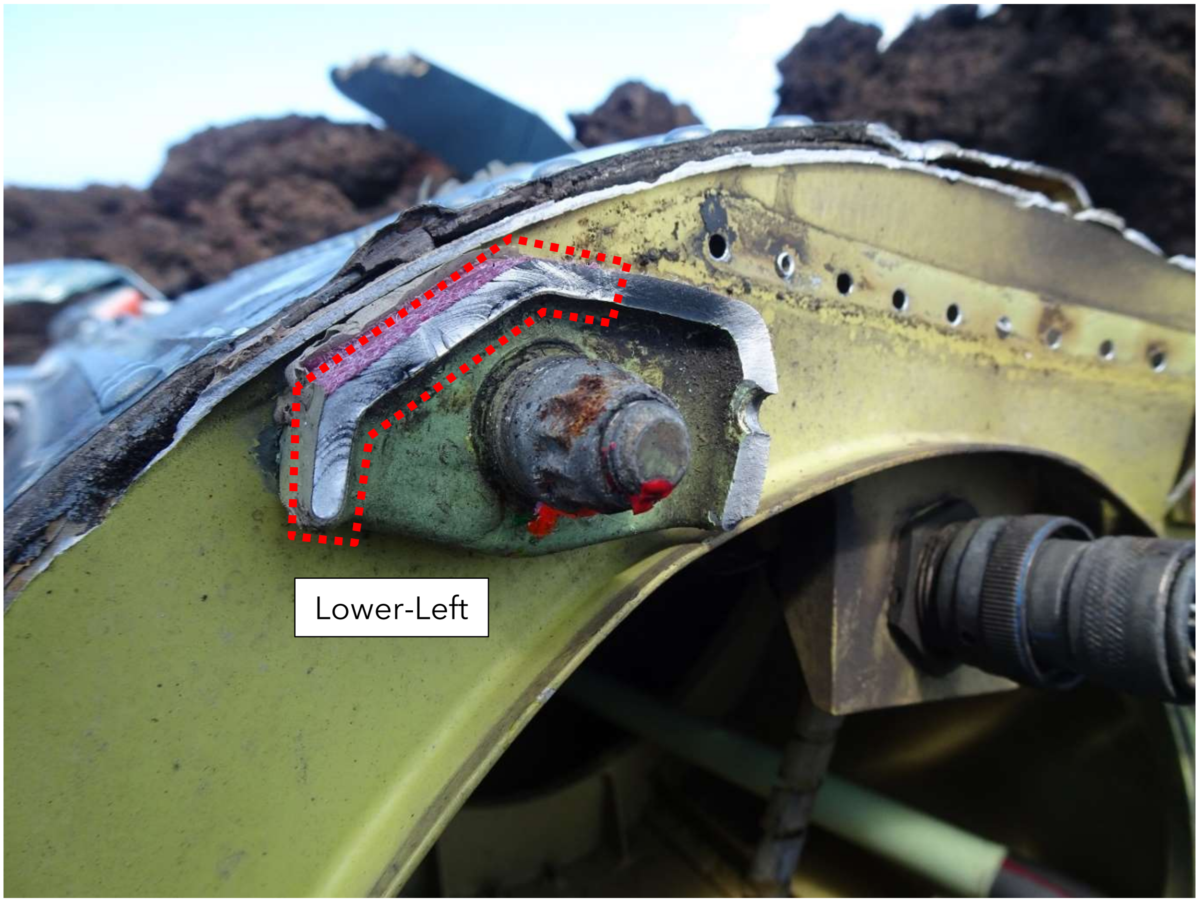


**Figure 10. On the aft fuselage lower-left attachment fitting, the area within the dotted red lines exhibited signatures of fatigue.**

The forward section of the tail boom, containing the four aft fuselage longerons, was cut from the empennage wreckage and retained by the NTSB for further evaluation. The details of the NTSB Materials Lab examination of the aft fuselage structural pieces can be found in Materials Laboratory Factual Report No. 22-071 in the docket for this investigation.

## 2.2 Main Rotor System

### 2.2.1 System Overview

Power from the engine accessory gearbox is transferred through a freewheeling unit to the main rotor gearbox via the engine-to-transmission (input) drive shaft. Kaflex couplings on both the forward and aft ends of the input drive shaft allow for minor misalignment. The accident helicopter was equipped with a rotor brake which was installed between the engine accessory gearbox output flange and the aft Kaflex coupling of the input drive shaft. The main rotor gearbox contains a single-stage sun and planetary gear system that turns the main rotor shaft (also known as the main rotor mast). The main rotor hub is splined onto the main rotor shaft. The main rotor gearbox is attached to the airframe via pylon assemblies containing elastomeric mounts for vibration dampening.

The main rotor hub is composed of a yoke which is mounted between an upper and lower [hub] plate. Each main rotor blade is connected to the yoke via a grip assembly. An elastomeric thrust bearing, which accommodates blade pitch changes, a pitch horn, and an elastomeric shear (pivot) bearing attach to the blade grip. An elastomeric lead-lag damper bearing, installed inboard of the pitch horn, is connected to the pivot bearing as well as both the upper and lower hub plates. The four main rotor blades are identified by color and the shape of identification stickers adhered to each rotor blade, presented in the order of advancing rotation: ‘blue’ (diamond), ‘orange’ (square), ‘red’ (triangle), and ‘green’ (circle). The main rotor blades are composite in construction, with a fiberglass spar, fiberglass skin, and Nomex honeycomb core. Blade pitch control is achieved via pitch change links (PCL) connected between each blade’s pitch horn and the rotating swashplate.

### 2.2.2 Wreckage Observations

The main rotor assembly remained installed onto the main rotor gearbox. The yoke exhibited fractures but remained partially attached to the main rotor upper and lower plates. All four main rotor blades remained attached to their respective grips. All four main rotor blades exhibited deformation and fractures along their spans. The main rotor blade fractures exhibited a broomstraw appearance and exhibited signatures consistent with powered impact. Fragments of main rotor blade leading edges, afterbody, and leading edge [lead] weights were found in the vicinity of the main wreckage site. The ‘blue’, ‘red’, and ‘green’ main rotor pitch change links remained installed to the rotating swashplate and their respective pitch horns and were generally intact. The ‘orange’ main rotor pitch change link remained installed to the rotating swashplate but its upper clevis was fractured at the threads; the upper clevis remained attached to the ‘orange’ pitch change horn. All four main rotor blades were documented and then cut into multiple sections to facilitate recovery from the accident site.

The main transmission remained installed on the airframe. The forward end of the engine-to-transmission (Kaflex) driveshaft remained installed onto the main transmission input flange. The aft end of the Kaflex driveshaft was fractured at the Kaflex coupling. The main rotor could be manually rotated but its range of rotation was limited due to interference with the fractured aft portion of the Kaflex driveshaft. No abnormal sounds or binding were noted with rotation of the main transmission. The main transmission oil filter remained installed and the bypass indicator was not popped out, indicating that the filter system had not gone into bypass. Oil was present within the main transmission and exhibited a normal color. Both the upper and lower chip detectors for the main transmission were inspected and contained no magnetic chips.

## 2.3 Tail Rotor System

### 2.3.1 System Overview

Power from the freewheeling unit is transferred to the tail rotor via the tail rotor drive system. The tail rotor drive system contains a total of 6 tail rotor drive shafts (TRDS): the forward short shaft, composed of steel, is mounted between the freewheeling unit and the oil cooler blower. The aft short shaft, composed of aluminum, is attached to the aft side of the oil cooler blower, followed by 4 additional TRDS, also composed of aluminum, up to the tail rotor gearbox. A flexible coupling disc pack is present at the connecting flanges of each TRDS to allow for axial and angular misalignments. The tail rotor gearbox, mounted near the aft end of the tail boom, changes the direction of drive and also reduces the output speed of rotation at the tail rotor. The tail rotor gearbox output shaft connects to the tail rotor yoke.

The two-bladed tail rotor is a semi-rigid (teetering) rotor system. Each tail rotor blade, composite in construction, is attached to the tail rotor yoke via two spherical bearings. The two spherical bearings accommodate blade pitch changes. The tail rotor blades are identified by color as ‘white’ and ‘red’.

### 2.3.2 Wreckage Observations

The forward short shaft (steel) remained installed but was impinged in the crushed aft fuselage and could not be rotated. The forward short shaft exhibited circumferential scoring marks on its outer surface. The aft end of the forward short shaft was not connected to the blower fan, the latter of which was rotated such that its splined connection was facing upward due to deformation of the aft fuselage.

The aft short shaft (aluminum) remained installed within the empennage and its forward flange exhibited fractured at its flange lobes; the fractures exhibited signatures of overload. The aft short shaft was continuous to the tail rotor gearbox (**Figure 11**). The tail rotor gearbox remained installed onto the empennage via its hanger bearings and the tail rotor remained installed. Rotation of the aft short shaft segments resulted in a corresponding rotation of the tail rotor; the rotation was smooth and exhibited no evidence of binding or restrictions. Oil was present in the tail rotor gearbox. The tail rotor gearbox chip detector was inspected and contained no magnetic chips.


**Figure 11. The tail rotor drive system and tail rotor. Note the horizontal stabilizers and portions of the tail rotor drive train were cut to facilitate recovery of the empennage wreckage.**

The two tail rotor blades remained installed and did not exhibit significant deformation or fragmentation. The tail rotor flap stops exhibited evidence of contact with the yoke. The tail rotor pitch change links remained installed and did not exhibit fractures or deformation. A small gouge was observed on one of the pitch change links.

## 2.4 Flight Control System

### 2.4.1 System Overview

The cockpit flight control system is composed of cyclic, collective, and directional (pedal) controls. The mechanical linkages for the pilot (right seat) flight controls are routed below the pilot and passenger seats, aft to the center of the helicopter, and vertically, in a compartment known as the "broom closet", to the cabin roof. On the cabin roof, the cyclic and collective flight control linkages connect to three [hydraulic] servo-actuators that are installed on the hydraulic rack in front of the main rotor gearbox. The three servo-actuators are identified as left, collective (center), and right. The left and right main rotor servo-actuators provide hydraulic assistance for the cyclic control while the collective main rotor servo-actuator provides hydraulic assistance for the collective control.

The pedal control linkages are routed from the cabin roof back to the tail rotor servo-actuator, located in the intermediate fuselage (between the main fuselage and tail boom), and then to the tail rotor. The tail rotor servo-actuator provides hydraulic assistance for the pedal controls.

### 2.4.2 Wreckage Observations

The pilot controls were installed on the right seat position. The cyclic and collective controls remained installed in the cockpit and did not exhibit fractures or significant deformation. Movement of the cyclic and collective controls was difficult due to deformation of the airframe, but resulted in a corresponding movement of the swashplate and collective lever, respectively. The right seat pedals remained installed and movement of the pedals confirmed continuity of control through the lateral interconnect, but the longitudinal push-pull tube was fractured aft of the center console. The left seat pedals were present but its two control rods were secured ("locked out") such that they were not connected to the lateral interconnect.

All three main rotor servo-actuators remained installed on the roof structure and all hydraulic lines were connected. The hydraulic reservoir remained intact and residual hydraulic fluid was observed within the reservoir. The right cyclic control tube was fractured at the threaded portion of the aft clevis connecting to the walking beam (mounted on the forward end of the main gearbox housing); the fracture exhibited signatures of overload. The lever and anti-drive lever remained installed on the swashplate.

The tail rotor push-pull tubes and bellcranks within the aft fuselage were present but deformed due to airframe deformation. The tail rotor servo remained installed. The tail rotor control tube was fractured at the location of the tail boom separation. The remainder of the tail rotor control tube was continuous within the empennage up to the tail rotor gearbox. Movement of the tail rotor control tube resulted in corresponding pitch changes to the tail rotor blades.

## 2.5 Engine

### 2.5.1 Engine Overview

The Rolls-Royce Model 250-C47B is a turboshaft engine that comprises a single-stage centrifugal compressor, a single can-type combustor, and a turbine assembly that incorporates a two-stage gas producer turbine and a two-stage power (free) turbine. The gas producer turbine and the power turbine are not mechanically connected and rotate independently of each other. The gas producer turbine drives the compressor as well as most of the engine-mounted accessories. The power turbine delivers power to the helicopter rotor system via the engine accessory gearbox. The accessory gearbox drive splines deliver power to the main rotor.

The engine incorporates a full authority digital engine control (FADEC) system. The FADEC system is composed of an airframe-mounted engine control unit (ECU) and an engine-mounted hydromechanical unit (HMU). The ECU, manufactured by Triumph Engine Control Systems, monitors engine parameters and performance, as well as the helicopter's power demands, and delivers the necessary control commands to the HMU. As a result, the HMU delivers a metered fuel flow to the engine in accordance with ECU control commands. The ECU continuously monitors the FADEC system for faults and will alert the pilot of specific faults that could significantly impact engine performance. Faults that are considered minor will not be alerted to the pilot during flight, but will be recorded and displayed during engine shutdown. The recorded fault history can be retrieved by maintenance personnel using a computer with the requisite software. Additionally, whenever certain engine parameters are exceeded, the ECU will record the exceedance in a separate incident recorder dataset; this dataset is only accessible by the engine and ECU manufacturers.

### 2.5.2 Wreckage Observations

The engine was whole and remained installed onto the airframe but its mounts were deformed due to impact. The reduction gearbox case was fractured at the exciter box attachment. The [single-stage] compressor was able to be manually rotated by hand and exhibited smooth rotation with no evidence of restrictions. The gas generator turbine-to-compressor (N1) drivetrain continuity was confirmed between the compressor and the starter-generator. One compressor blade exhibited a gouge on its leading edge while several other compressor blades had small indentations on its leading edges (**Figure 12**). The power turbine was able to be rotated manually by hand through the engine exhaust; rotation was smooth with no evidence of restrictions. A small amount of metal splatter was observed on the fourth stage power turbine blades, but there was no other damage to those blades. All fittings and B-nuts were checked by hand and did not exhibit looseness. The engine was not removed from the airframe during these examinations.

**Figure 12. A view of the engine inlet and compressor. The red arrow points to the gouge observed on one of the compressor blades.**

Fuel was present in the fuel bladders. The helicopter was defueled after recovery but prior to transportation to KOA. The airframe fuel filter was present and its bypass indicator was popped out. A portion of the engine fuel tank was present on the aft fuselage and exhibited deformation.

The ECU remained installed on the airframe. Data from the ECU incident recorder (IR) was successfully recovered along with snapshot data. A portion of the data recovered from the ECU containing helicopter rotor speed (Nr), gas generator speed (Ng), power turbine speed (Np), collective position (CLP) and absolute pressure (P1) can be found in **Appendix A** of this report.

## 3.0 Post-accident Inspections by Paradise Helicopters

As a result of this accident, the operator elected to replace the tail boom attachment hardware on their remaining five Bell 407 helicopters as a precautionary measure. At the request of the NTSB, the operator performed a torque check of all installed attachment hardware prior to their removal. The operator reported no evidence of loose tail boom attachment hardware on their remaining Bell 407 helicopters.

In additional to the attachment hardware replacements, the operator performed an eddy-current nondestructive inspection (NDI) on the aft fuselage longerons (to which the tail boom attaches) of their remaining Bell 407 helicopters as another precautionary measure. These NDIs found cracking indications on two helicopters, N807PH and N437MY. On N807PH, two crack indications were identified: 1) on the aft faying surface of the lower-left longeron at the bolt hole (**Figure 13**) and 2) within the bolt hole of the upper-left longeron. On N437MY, three crack indications were identified: 1) on the outboard surface of the outboard longitudinal channel of the upper-right longeron, 2) on the inboard surface of the outboard longitudinal channel of the upper-left longeron, and 3) on the lower surface of the outboard longitudinal channel of the upper-left longeron.

The operator provided the upper-left longeron, lower-left longeron, and attachment hardware from N807PH as well as the attachment hardware from two of their Bell 407s to the NTSB for further evaluation. At the request of the NTSB, the Bell Field Investigations Laboratory will examine the NDI indications found on the N807PH upper-left and lower-left longerons. At the time of this report, the Bell Field Investigations Laboratory is continuing their examination of these longerons.

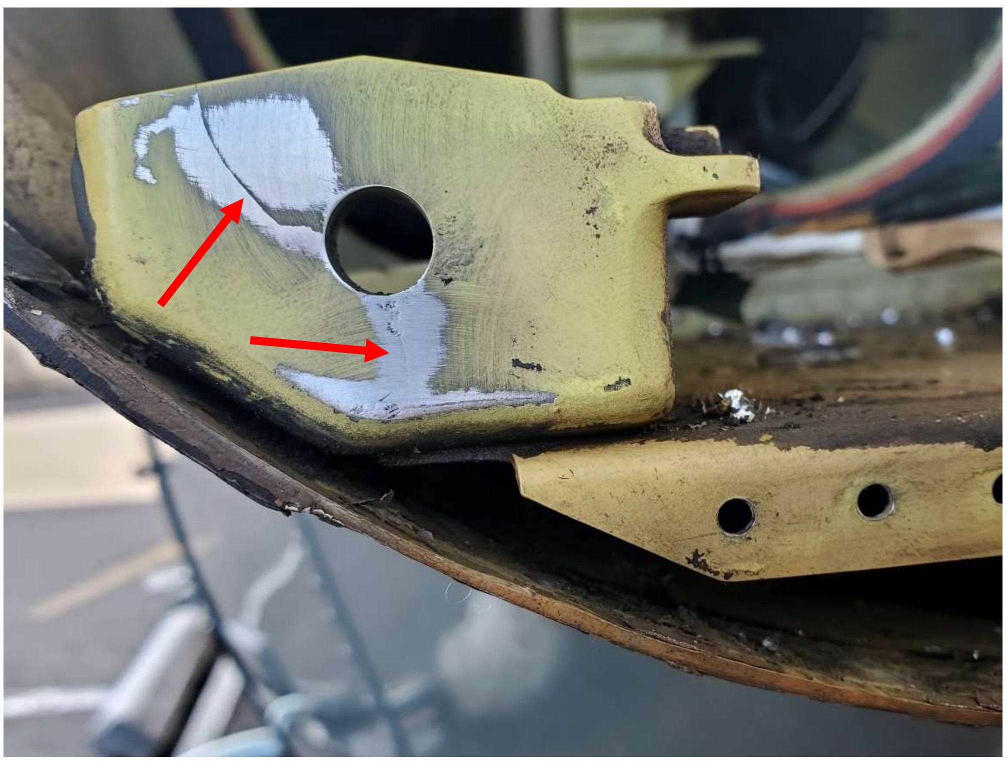

**Figure 13. The crack indications (red arrows) found via NDI on the aft fuselage lower-left longeron attachment fitting on N807PH. Note the surface coating was removed after the NDI indication to visually see the crack indication. (Photo courtesy of Paradise Helicopters.)**

## 4.0 Aft Fuselage Bulletins and Airworthiness Directives

On September 19, 2007, Bell published Technical Bulletin (TB) No. 407-07-78 which introduced a machined aft fuselage bulkhead, P/N 407-030-027-101, that could be incorporated at the customer's option. The sheet metal aft frame, which was subsequently replaced by the aft fuselage bulkhead, was P/N 206-032-308-121. On August 21, 2020, Revision A to TB No. 407-07-78 introduced a new machined aft fuselage bulkhead, P/N 407-030-027-107.

On May 3, 2010, Bell published Alert Service Bulletin (ASB) No. 407-10-93 to replace the tail boom attachment hardware with new hardware, of the same part number (P/N), with a lower installation torque for the new hardware. Furthermore, this ASB included torque check of the attachment hardware 1-5 flight hours after initial installation as well as a recurring torque check every 300 flight hours. On September 7, 2012, the FAA published Airworthiness Directive (AD) No. 2012-18-09 which directed replacement of the tail boom attachment hardware per ASB No. 407-10-93.

On July 11, 2011, Bell published ASB No. 407-11-95, a multi-part bulletin which included 1) a one-time inspection of the aft fuselage top skin; 2) a recurring inspection of certain P/N upper-left longeron channels and assemblies[4]; 3) an optional installation of external strap doublers on the upper-left longeron; 4) repair instructions for cracked longerons; and 5) the installation of certain P/N upper-left longeron assemblies[5] which was considered a terminating action to the recurring inspections of this ASB. On February 14, 2012, Bell published TB No. 407-12-96 which contained instructions for the installation of upper-left longeron assembly P/N 206-031-314-237B. On March 16, 2015, the FAA published AD No. 2015-05-04 based on ASB No. 407-11-95. According to AD No. 2015-05-04, installation of upper-left longeron assembly P/N 206-031-314-237B as well as three external strap doublers constitutes terminating action for this AD.

## 5.0 Past Relevant Occurrences

### 5.1 Upper-Left Tail Boom Attachment Bolt Fracture

According to Bell, there was one reported occurrence of a fractured tail boom attachment bolt.[6] The operator provided the Bell Field Investigations Lab with the four sets of bolts, nuts, and washers, with the upper-left bolt fractured into two pieces.[7] Metallography of the fractured bolt found multiple-origin fatigue cracking

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[4] The applicable P/Ns affected by the recurring inspection include upper-left longeron P/N 206-031-314-037, P/N 206-031-314-177 and P/N 206-031-314-219B.

[5] The applicable P/Ns for terminating action are P/N 206-031-314-237B and P/N 407-030-067-105.

[6] The affected Bell 407 was S/N 53563.

[7] The Bell Field Investigations Lab documented their examination of these components in

through about 2/3 of the fracture cross-section, with the remainder of the fracture cross-section in overload. The location of the fracture on the bolt was estimated to be co-located with the aft face of the aft fuselage bulkhead. The fractured bolt was found during a 300-hour recurring torque check. The Field Investigations Lab report stated the operator observed a gap between the aft fuselage bulkhead and the upper-left longeron as well as misalignment of the upper-left longeron bolt hole and a work aid to locate the aft fuselage longeron bolt holes. Lastly, the Field Investigations Lab report noted that the bolt threads were coated with corrosion prevention compound (CPC).[8]

The Airworthiness group chair received information from the occurrence operator and a repair station to estimate the time from the last tail boom attachment hardware installation until the time the upper-left bolt was found fractured. According to helicopter records, the upper-left longeron was found cracked and a replacement upper-left longeron, P/N 206-031-314-237B, was installed on October 12, 2017 at an ATT of 5,950.4 flight hours. Four 300-hour recurring torque checks were performed, with the upper-left bolt found fractured during the fourth 300-hour torque check on December 12, 2019 at an ATT of 7,113.3 flight hours. About 297 flight hours had elapsed since the third 300-hour recurring torque check performed on April 19, 2019.

### 5.2 Lower-Left Longeron Fatigue Crack

According to Bell, there was one reported occurrence of fatigue cracking of the aft fuselage lower-left longeron, on the radius that is adjacent to the bolt hole.[9] The operator provided the Bell Field Investigations Lab with the lower-left longeron for examination.[10] The fatigue crack was found the forward face of the lower-left longeron attachment fitting (opposite the face that contacts the aft fuselage bulkhead. Metallography of the lower-left longeron found the fatigue origin was located at a corrosion pit within the lower-left longeron transition radius to the attachment bolt fitting. Other corrosion pits were found near the origin location. According to the Field Investigations Lab report, the occurrence helicopter had an ATT of 5,310 hours at the time the crack was discovered.

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Report No. 40719M-071EXT.

[8] During the NTSB Materials Lab's examination of the N402SH aft fuselage structure and tail boom attachment hardware, no CPC was noted on the bolt threads. However, it was noted that during removal of the bolts from the longeron attachment fittings, the existing CPC would squeeze out onto the bolt threads.

[9] The affected Bell 407 was S/N 53390.

[10] The Bell Field Investigations Lab documented their examination of the lower-left longeron in Report No. 40708M-007EXT.

## APPENDIX A

### Excerpts from the downloaded ECU data

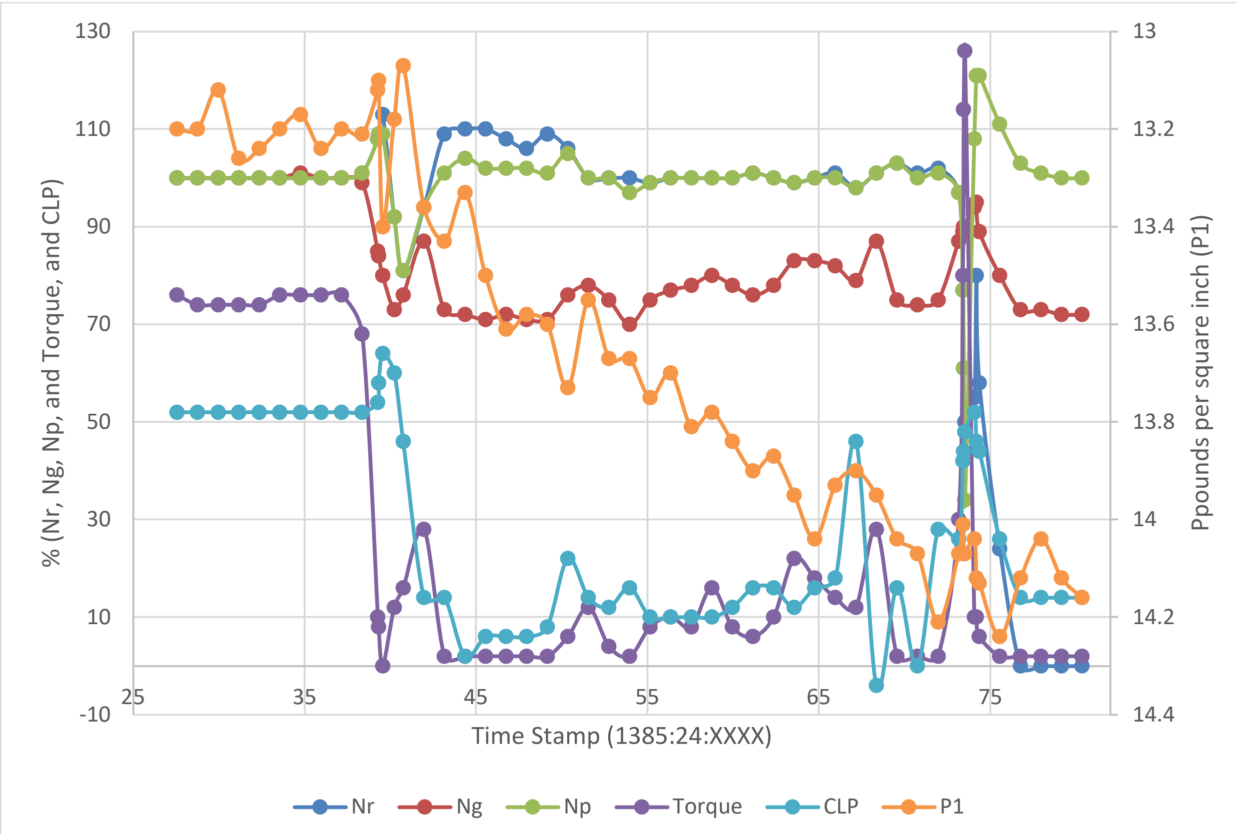


**Figure A-1. Graph showing selected parameters during the accident flight.**

**Table A-1. Excerpt of data from the ECU incident recorder.**

| Snapshot Record # | IR Data Record # | Time Stamp 1385:24:*XX.XXX* | Nr | Ng | Np | Torque | CLP | P1 |
|---|---|---|---|---|---|---|---|---|
| | 1 | 27.552 | 100 | 100 | 100 | 76 | 52 | 13.2 |
| | 2 | 28.752 | 100 | 100 | 100 | 74 | 52 | 13.2 |
| | 3 | 29.952 | 100 | 100 | 100 | 74 | 52 | 13.12 |
| | 4 | 31.152 | 100 | 100 | 100 | 74 | 52 | 13.26 |
| | 5 | 32.352 | 100 | 100 | 100 | 74 | 52 | 13.24 |
| | 6 | 33.552 | 100 | 100 | 100 | 76 | 52 | 13.2 |
| | 7 | 34.752 | 100 | 101 | 100 | 76 | 52 | 13.17 |
| | 8 | 35.952 | 100 | 100 | 100 | 76 | 52 | 13.24 |
| | 9 | 37.152 | 100 | 100 | 100 | 76 | 52 | 13.2 |
| | 10 | 38.352 | 101 | 99 | 101 | 68 | 52 | 13.21 |
| 1 | | 39.264 | 108 | 85 | 108 | 10 | 54 | 13.12 |
| 2 | | 39.312 | 109 | 84 | 109 | 8 | 58 | 13.1 |
| | 11 | 39.552 | 113 | 80 | 109 | 0 | 64 | 13.4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3 | | 40.224 | 92 | 73 | 92 | 12 | 60 | 13.18 |
| | 12 | 40.752 | 81 | 76 | 81 | 16 | 46 | 13.07 |
| | 13 | 41.952 | 94 | 87 | 94 | 28 | 14 | 13.36 |
| | 14 | 43.152 | 109 | 73 | 101 | 2 | 14 | 13.43 |
| | 15 | 44.352 | 110 | 72 | 104 | 2 | 2 | 13.33 |
| | 16 | 45.552 | 110 | 71 | 102 | 2 | 6 | 13.5 |
| | 17 | 46.752 | 108 | 72 | 102 | 2 | 6 | 13.61 |
| | 18 | 47.952 | 106 | 71 | 102 | 2 | 6 | 13.58 |
| | 19 | 49.152 | 109 | 71 | 101 | 2 | 8 | 13.6 |
| | 20 | 50.352 | 106 | 76 | 105 | 6 | 22 | 13.73 |
| | 21 | 51.552 | 100 | 78 | 100 | 12 | 14 | 13.55 |
| | 22 | 52.752 | 100 | 75 | 100 | 4 | 12 | 13.67 |
| | 23 | 53.952 | 100 | 70 | 97 | 2 | 16 | 13.67 |
| | 24 | 55.152 | 99 | 75 | 99 | 8 | 10 | 13.75 |
| | 25 | 56.352 | 100 | 77 | 100 | 10 | 10 | 13.7 |
| | 26 | 57.552 | 100 | 78 | 100 | 8 | 10 | 13.81 |
| | 27 | 58.752 | 100 | 80 | 100 | 16 | 10 | 13.78 |
| | 28 | 59.952 | 100 | 78 | 100 | 8 | 12 | 13.84 |
| | 29 | 61.152 | 101 | 76 | 101 | 6 | 16 | 13.9 |
| | 30 | 62.352 | 100 | 78 | 100 | 10 | 16 | 13.87 |
| | 31 | 63.552 | 99 | 83 | 99 | 22 | 12 | 13.95 |
| | 32 | 64.752 | 100 | 83 | 100 | 18 | 16 | 14.04 |
| | 33 | 65.952 | 101 | 82 | 100 | 14 | 18 | 13.93 |
| | 34 | 67.152 | 98 | 79 | 98 | 12 | 46 | 13.9 |
| | 35 | 68.352 | 101 | 87 | 101 | 28 | -4 | 13.95 |
| | 36 | 69.552 | 103 | 75 | 103 | 2 | 16 | 14.04 |
| | 37 | 70.752 | 101 | 74 | 100 | 2 | 0 | 14.07 |
| | 38 | 71.952 | 102 | 75 | 101 | 2 | 28 | 14.21 |
| | 39 | 73.152 | 97 | 87 | 97 | 30 | 26 | 14.07 |
| 4 | | 73.392 | 77 | 89 | 77 | 80 | 42 | 14.01 |
| 5 | | 73.44 | 61 | 90 | 61 | 114 | 44 | 14.07 |
| 6 | | 73.512 | 50 | 90 | 34 | 126 | 48 | 14.07 |
| 7 | | 74.064 | 55 | 94 | 108 | 10 | 52 | 14.04 |
| 8 | | 74.184 | 80 | 95 | 121 | 10 | 46 | 14.12 |
| | 40 | 74.352 | 58 | 89 | 121 | 6 | 44 | 14.13 |
| | 41 | 75.552 | 24 | 80 | 111 | 2 | 26 | 14.24 |
| | 42 | 76.752 | 0 | 73 | 103 | 2 | 14 | 14.12 |
| | 43 | 77.952 | 0 | 73 | 101 | 2 | 14 | 14.04 |
| | 44 | 79.152 | 0 | 72 | 100 | 2 | 14 | 14.12 |
| | 45 | 80.352 | 0 | 72 | 100 | 2 | 14 | 14.16 |
| | 46 | 81.552 | 0 | 72 | 100 | 2 | 12 | 14.09 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 47 | 82.752 | 0 | 72 | 100 | 2 | 12 | 14.07 |
| | 48 | 83.952 | 0 | 72 | 100 | 2 | 12 | 14.1 |
| | 49 | 85.152 | 0 | 72 | 100 | 2 | 12 | 14.13 |
| | 50 | 86.352 | 0 | 72 | 100 | 2 | 12 | 14.12 |
| | 51 | 87.552 | 0 | 72 | 100 | 2 | 12 | 14.27 |
| | 52 | 88.752 | 0 | 72 | 100 | 2 | 12 | 14.16 |
| | 53 | 89.952 | 0 | 73 | 101 | 2 | 16 | 14.24 |
| | 54 | 91.152 | 0 | 71 | 97 | 2 | 6 | 14.09 |
| | 55 | 92.352 | 0 | 73 | 101 | 2 | 8 | 14.19 |
| | 56 | 93.552 | 0 | 73 | 101 | 2 | 14 | 14.21 |
| | 57 | 94.752 | 0 | 72 | 100 | 2 | 14 | 14.1 |
| | 58 | 95.952 | 0 | 72 | 99 | 2 | 14 | 14.15 |
| | 59 | 97.152 | 0 | 74 | 103 | 2 | 14 | 14.09 |
| | 60 | 98.352 | 0 | 73 | 101 | 2 | 16 | 14.24 |
| | 61 | 99.552 | 0 | 73 | 101 | 2 | 16 | 14.16 |
| | 62 | 100.752 | 0 | 72 | 100 | 2 | 16 | 14.07 |
| | 63 | 101.952 | 0 | 73 | 101 | 2 | 16 | 14.19 |

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