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

ANC22FA041

AIRWORTHINESS

Group Chair's Factual Report - Addendum

June 27, 2023

A. ACCIDENT

Location: Kalea, Hawaii
Date: June 8, 2022
Time: 1726 Hawaii-Aleutian standard time
Helicopter: Bell 407, registration N402SH

B. AIRWORTHINESS GROUP

Group Chair	Chihoon Shin National Transportation Safety Board Washington, District of Columbia
Group Member	Mark Taylor Federal Aviation Administration Burlington, Massachusetts
Group Member	Jack Johnson Rolls-Royce Indianapolis, Indiana
Group Member	Lauren Douglas K & S Helicopters Kailua-Kona, Hawaii
Group Member	Gary Howe Bell Fort Worth, Texas
Group Member	Beverley Harvey Transportation Safety Board of Canada 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 November 9, 2022, members of the Airworthiness Group examined the accident helicopter wreckage stored at Ellison Onizuka Kona International Airport (KOA) on the island of Hawai'i.

D. ADDITIONAL INFORMATION

1.0 Upper-Left Longeron and Aft Fuselage Bulkhead Installation

On the accident helicopter, the upper-left longeron was observed to have design features unique to part number (P/N) 206-031-314-237B.[1] The three external strap doublers remained installed with no evidence of looseness or separation from the airframe (**Figure 1**). The channel of the upper-left longeron had the following hand-written marking on its inboard surface: "WB72373-00". At frame station (STA) 217, for the upper-left longeron, both clips pointing inboard were fractured at the clip but its rivets remained installed. The fractured showed no obvious signatures of fatigue. The third clip pointing outboard remained installed but slightly deformed and lifted off from STA 217. The channel of the upper-left longeron remained continuous through STAs 217 and 204 and connected at its forward end to the engine pan longeron. Aft of the channel's [forward end] connection to the engine pan longeron, the channel was deformed and folded over (**Figure 2**).

Figure 1. The strap doubler installation visible on the exterior of the aft fuselage.

[1] According to Bell Alert Service Bulletin (ASB) No. 407-11-95 and Federal Aviation Administration (FAA) Airworthiness Directive (AD) No. 2015-05-04, installation of upper-left longeron assembly P/N 206-031-314-237B and installing three external strap doublers constitutes terminating action for the ASB and AD, respectively. Revision D of Bell ASB No. 407-11-95, issued on August 21, 2020, introduced a new 2-piece upper-left longeron assembly, P/N 407-030-067-105, which could be installed via Bell Technical Bulletin (TB) No. 407-17-125.

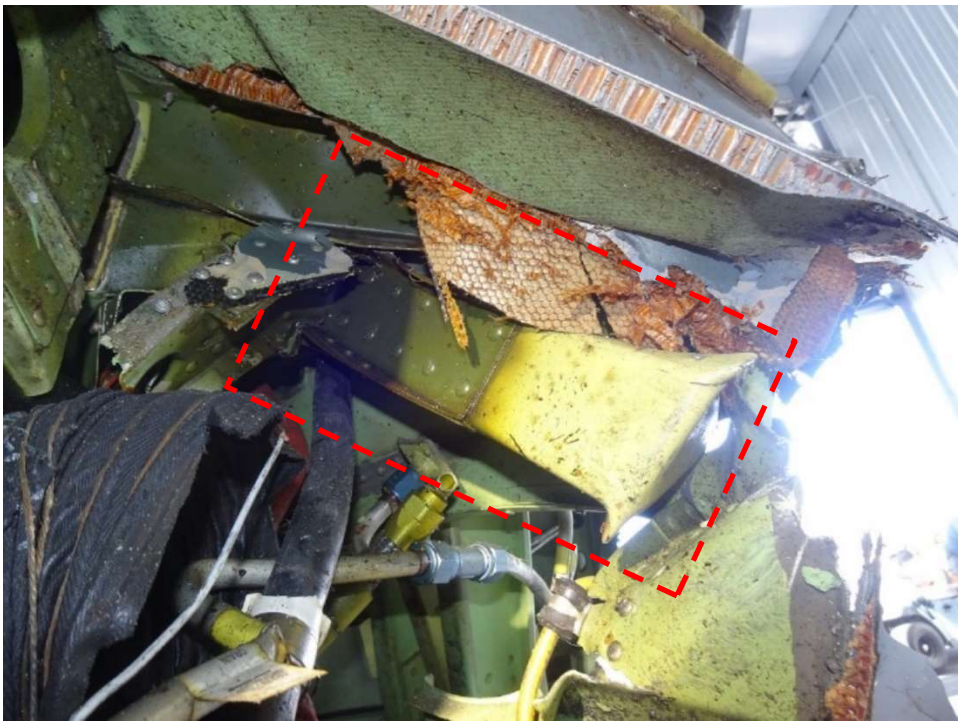


Figure 2. The upper-left longeron's connection to the engine pan longeron.

On the accident aft fuselage bulkhead, the faying surface to which the upper-left longeron was attached showed evidence of sealant (**Figures 3 and 4**). Additionally, the aft fuselage bulkhead contained the following part marking (**Figure 5**):

407-030-027-101
CHG 00
FEB-11-2014

According to Phoenix Heliparts Inc. work order No. 1105, signed on July 3, 2014, assistance was provided to accomplish Bell TB No. 407-12-96 Revision A[2] on the accident helicopter. Work order 1105 did not contain information about the installation of aft fuselage bulkhead P/N 407-030-027-101 or the accomplishment of TB No. 407-07-78.[3] Within the accident helicopter's maintenance records, the TB record paperwork did not contain entries for TBs between, and including, Nos. 407-04-58 thru 407-14-106; thus, there were no entries in the TB record for TB Nos. 407-07-78 and 407-12-96. **Attachment 1** contains an excerpt from Phoenix Heliparts work order No. 1105.

[2] The subject of Bell TB No. 407-12-96 is the introduction of aft fuselage upper left longeron assembly P/N 206-031-314-237B. The original TB was issued on February 14, 2012, with Revision A issued on June 22, 2012. Compliance with this TB meets the intent of Part V of Bell ASB No. 407-11-95.
[3] The original issue of Bell TB No. 407-07-78, dated September 19, 2007, introduced an improved machined aft fuselage bulkhead, P/N 407-030-027-101. Revision A of this TB, issued on August 21, 2020, simultaneous to Bell TB No. 407-17-125, introduced a new machined aft fuselage bulkhead, P/N 407-030-027-107.

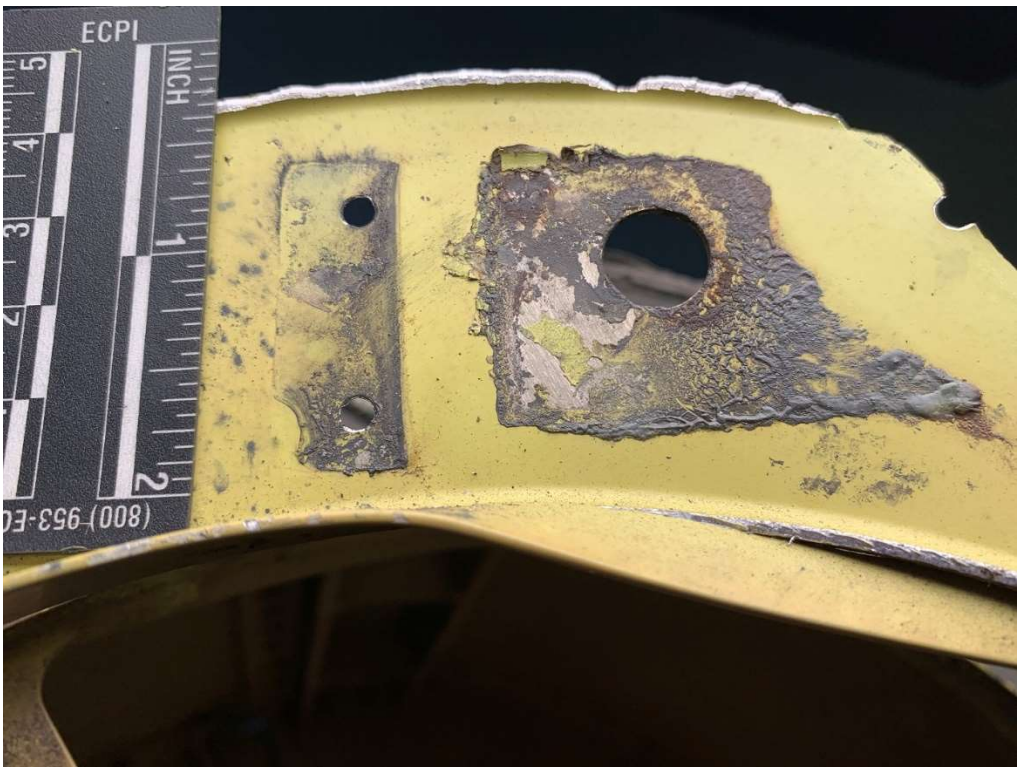


Figure 3. The aft fuselage bulkhead faying surface to which the upper-left longeron fitting's aft face contacted.

Figure 4. The upper-left longeron fitting's aft face.

Figure 5. Part markings seen on the aft fuselage bulkhead.

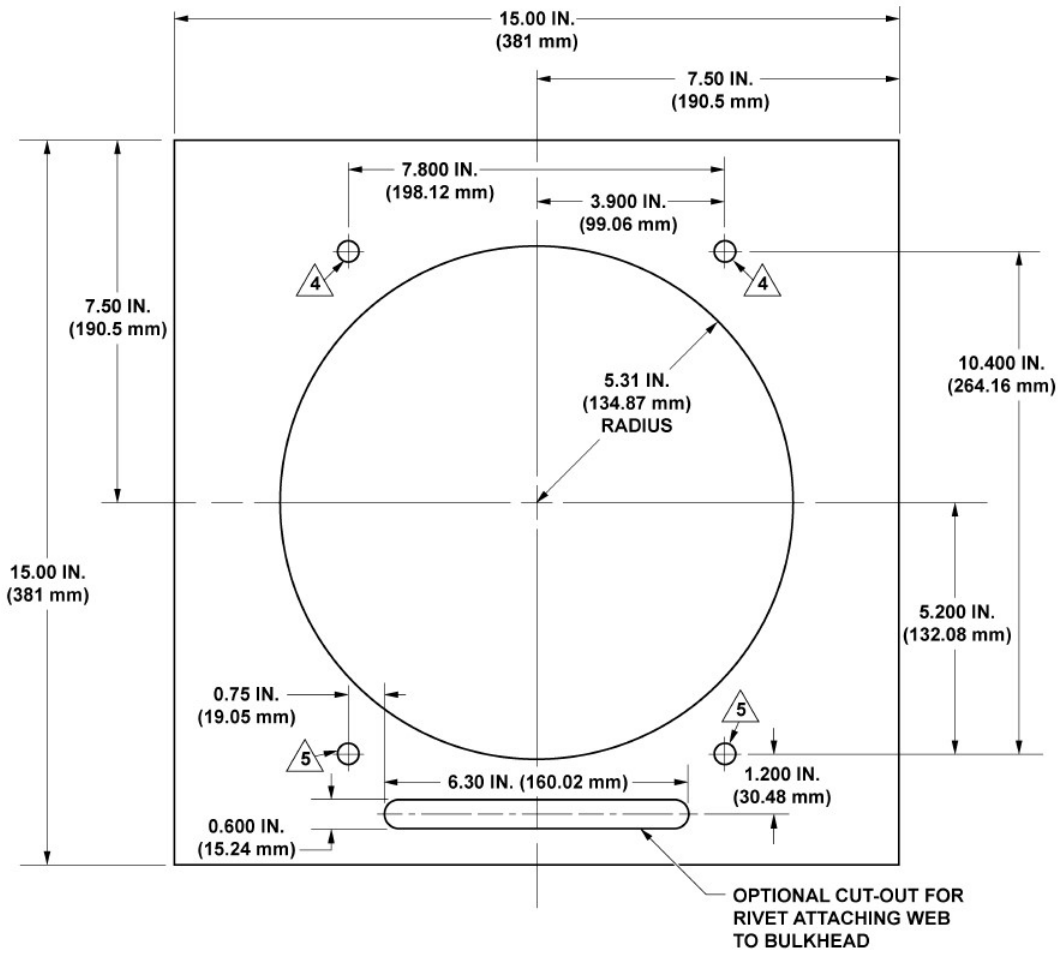
2.0 Bell Technical Bulletins for the Aft Fuselage

Bell TB No. 407-07-78 provides instructions for the installation of a new improved machined aft fuselage bulkhead at frame station (STA) 231.4. TB No. 407-07-78 provides instructions in three parts. Part I contains instructions for the removal of the aft fuselage bulkhead and positional verification of the longeron fittings. Part II contains instructions for the installation of a new machined aft fuselage bulkhead using the existing 3/16-inch pilot holes on the aft fuselage bulkhead and is considered the preferred method of installation. Part III contains instructions for drilling new pilot holes onto the aft fuselage bulkhead and the existing pilot holes are not used. Part III is considered the alternate method for installing the aft fuselage bulkhead.

Both Bell TB No. 407-07-78 and TB No. 407-12-96 utilize an aluminum drill plate[4] to verify the location and planar alignment between the four tail boom attachment fittings and their bolt holes (**Figure 6**). Within TB No. 407-12-96, prior to the final installation of the upper-left longeron and aft fuselage bulkhead to the aft fuselage, a note recommends installing the new improved machined aft fuselage

[4] Both TB No. 407-07-78 and 407-12-96 state the drill plate is to be locally manufactured. Both TBs contain identical manufacturing requirements for the drill plate.

bulkhead per TB No. 407-07-78. Additionally, this note states it is acceptable to reinstall the existing sheet metal aft fuselage bulkhead. Within TB No. 407-07-78, prior to step that accomplishes the final ream for upper-left bolt hole, a note states not to accomplish this step if the aft fuselage bulkhead installation are accomplished in conjunction with the installation of a replacement upper-left longeron per TB No. 407-12-96 or TB No. 407-17-125.



NOTES

1. Make from 0.50 Aluminum plate-surface flat within ±0.001 inch (0.0254 mm).
2. Install drill bushings in four holes for extended plate life.
3. Tolerance (in inches) .XXX = ±0.003, .XX = ±0.01, except as noted.

4 Drill and ream perpendicular to surface 0.4385 to 0.4405 inch (11.138 to 11.189 mm).

5 Drill and ream perpendicular to surface 0.3760 to 0.3780 inch (9.550 to 9.601 mm).

Figure 6. The manufacturing requirements for the drill plate utilized in Bell TB No. 407-07-78 and TB No. 407-12-96. (Image courtesy of Bell)

2.1 Drill Plate Fastener Bushings

In TB No. 407-07-78, the new aft fuselage bulkhead is initially secured to the four longeron fittings and the drill plate via four 3/16-inch diameter bolts that are torqued to 50 inch-pounds.[5] At the four bolt hole locations, bushings are utilized to attached to fill the gap between the 3/16-inch diameter bolt and the larger diameter bolt holes of the longeron fittings and the drill plate (**Figure 7**). (The aft fuselage bulkhead pilot holes are 3/16-inch diameter.)

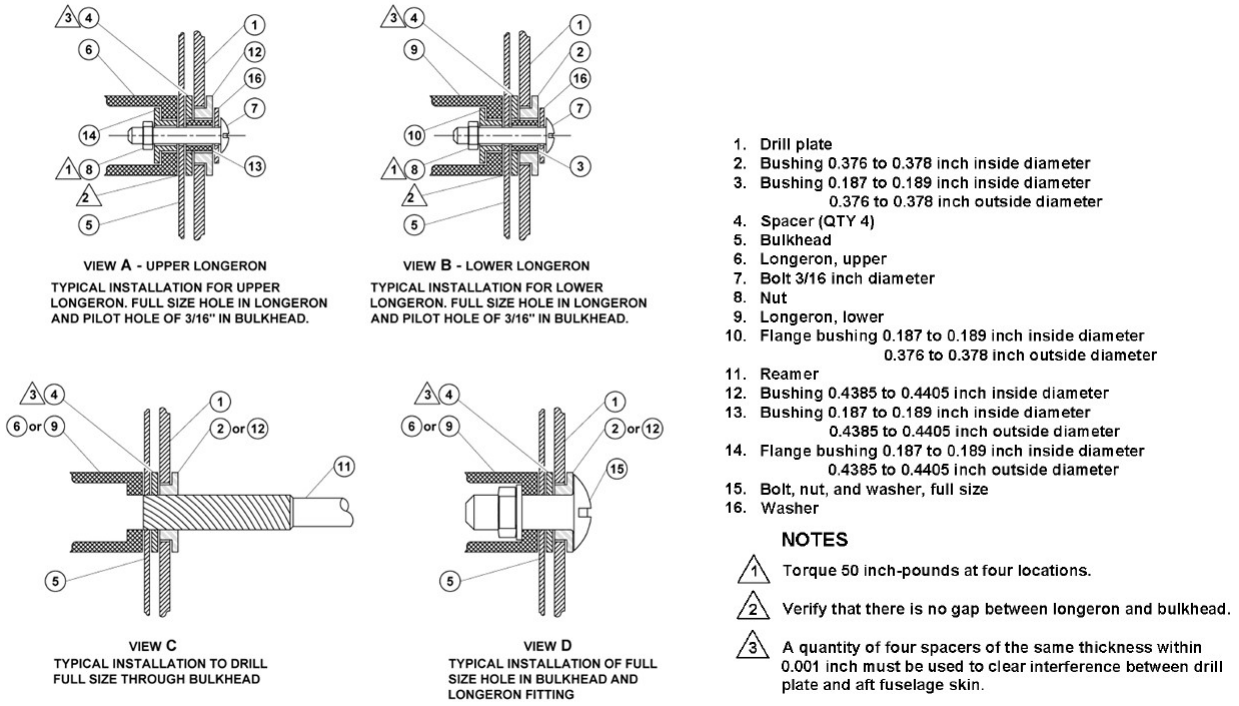


Figure 7. The bushing installation between the drill plate, aft fuselage bulkhead, and longerons utilized in TB No. 407-07-78. (Image courtesy of Bell)

In TB No. 407-12-96, after removal of the existing longeron and a first-fit installation of the new upper-left longeron, the drill plate is temporarily secured to the upper-right, lower-left, and lower-right longeron fittings using the existing fasteners and torqued to 50 inch-pounds.[6] The new upper-left longeron, whose fitting has a 3/16-inch diameter pilot hole, is secured to the drill plate using a 3/16-inch diameter bolt.[7] TB No. 407-12-96 does not specify instructions to use bushings for the installation of the 3/16-inch diameter bolt to secure the upper-left longeron to the drill plate. A note preceding this step states that it is acceptable to hold the new upper-left longeron to the drill plate using a C-clamp until it is completely riveted to the fuselage.

[5] Bell TB No. 407-07-78, Part II, Step 1.
[6] Bell TB No. 407-12-96, Step 16.
[7] Bell TB No. 407-12-96, Step 17.

2.2 Planar Alignment of Longeron Fittings

In TB No. 407-07-78, the last step in Part I is to verify the four longeron fittings are in plane within 0.002 inches.[8] Specifically, the drill plate is attached to the four longeron fittings using the existing hardware that is torqued to 50 inch-pounds. A gap check is conducted between the drill plate and the aft face of each longeron fitting. If a gap is in excess of 0.002 inches on only one longeron fitting, the affected longeron must be replaced prior to the installation of the new aft fuselage bulkhead. If a gap is in excess of 0.002 inches on more than one longeron fitting, the affected longerons much be replaced and the helicopter must be installed on a Bell-approved fuselage fixture to perform that task.

In TB No. 407-12-96, after removal of the existing longeron and a first-fit installation of the new upper-left longeron, the drill plate is secured to the upper-right, lower-left, and lower-right longeron fittings using the existing fasteners.[6] The new upper-left longeron, whose fitting has a 3/16-inch diameter pilot hole, is secured to the drill plate using a 3/16-inch diameter bolt.[7] A note preceding this step states that it is acceptable to hold the new upper-left longeron to the drill plate using a C-clamp until it is completely riveted to the fuselage. Subsequent to securing the new upper-left longeron to the drill plate, the instruction states to verify no gap exists between the longeron assembly and the drill plate and/or the spacer.

2.3 Sealant Application on Faying Surfaces

In TB No. 407-12-96, before the installation of rivets for the upper-left longeron and aft fuselage bulkhead, sealant is applied to these items. Specifically Step 23 of TB No. 407-12-96 states the following:

> *23. Apply a coat of sealant (C-251) to faying surfaces of longeron assembly (2), aft fuselage bulkhead (6), the splices joining affected bulkhead sections and if needed the shims made in Step 20 before installing in place with drill plate (8). Secure longeron assembly (2) and bulkhead (6) with applicable rivets wet with sealant (C-251). Do not install rivets common to oil cooler fairing retainers (1, 2, Figure 2), the side skin panel (16, Figure 7) and the top skin (1, Figure 6) at this time, but secure any applicable shims made earlier with clecos.*

According to Bell, if TB No. 407-07-78 is to be accomplished in conjunction with TB No. 407-12-96, then the aft fuselage bulkhead would be installed immediately before Step 23 of TB No. 407-12-96. Additionally, according to Bell the engineering drawing for the aft fuselage bulkhead installation does not require sealant between the contact surfaces of the aft fuselage bulkhead and the upper-left longeron.

[8] Bell TB No. 407-07-78, Part I, Step 4.

In TB No. 407-07-78, both Parts II and III contain instructions to apply sealant to the faying surfaces of the shim and aft fuselage bulkhead.[9]

3.0 N402SH Lower-Left Longeron Fatigue Fracture Band Count

At the request of the National Transportation Safety Board (NTSB), the Bell Field Investigations (FI) Lab conducted a band count analysis of the fatigue fracture on the aft fuselage lower-left attachment fitting of the accident helicopter. According to Bell, bands are a result of relatively higher amplitude loads, such as helicopter takeoffs and landings, or lifting of heavy loads; fatigue striations are formed by relatively lower cyclic loads. For the lower-left attachment fitting, takeoffs are expected to create bands as it "opens" a fatigue crack, whereas a landing would likely coincide with a band created during the subsequent takeoff.

For both the single-origin corrosion pit fatigue crack and multiple-origin fatigue crack, high-cycle fatigue initiated and then progressed into a pattern of fatigue and overload bands. The Bell FI Lab selected the single-origin corrosion pit fatigue crack to conduct the band count analysis. Due to smearing damage at the fatigue crack origin, no bands could be observed for the first 0.048 inches of the fatigue crack. Between the first band counted at 0.048 inch and the end of the crack, about 0.625 inches from the origin, a total of 128 bands were counted. **Table 1** shows the results of the Bell FI Lab's band count.

Table 1. Band count results for the single-origin corrosion pit fatigue crack.

Distance from origin (inches)	Bands	Cumulative Bands	Overload Bands	Cumulative Overload Bands
0.048	Obscured by damage			
0.100	30	30	0	0
0.150	21	51	1	1
0.200	10	61	1	2
0.250	14	75	2	3
0.300	11	86	1	5
0.350	7	97	0	6
0.400	6	103	0	6
0.450	8	110	1	6
0.500	6	116	0	7
0.550	5	122	4	7
0.600	3	125	3	11
0.625	3	128	3	14

[9] Bell TB No. 407-07-78, Part II Steps 16 and 20, and Part III Steps 20 and 24.

Based on a review of the aircraft logbook, the accident helicopter accumulated 158 landings from May 4, 2022 (the date of the last Event 6 progressive inspection) until June 7, 2022 (the day prior to the accident).

4.0 N807PH Longeron Examination by Bell

After the accident occurred, the operator conducted eddy-current nondestructive inspection (NDI) on the aft fuselage longerons of their remaining Bell 407 helicopters. On N807PH[10], the eddy current inspection found cracking indications on the aft faying surface of the lower-left longeron bolt hole and within the bolt hole of the upper-left longeron. At the request of the NTSB, the Bell FI Lab conducted an examination of the two longerons (**Figure 8**).

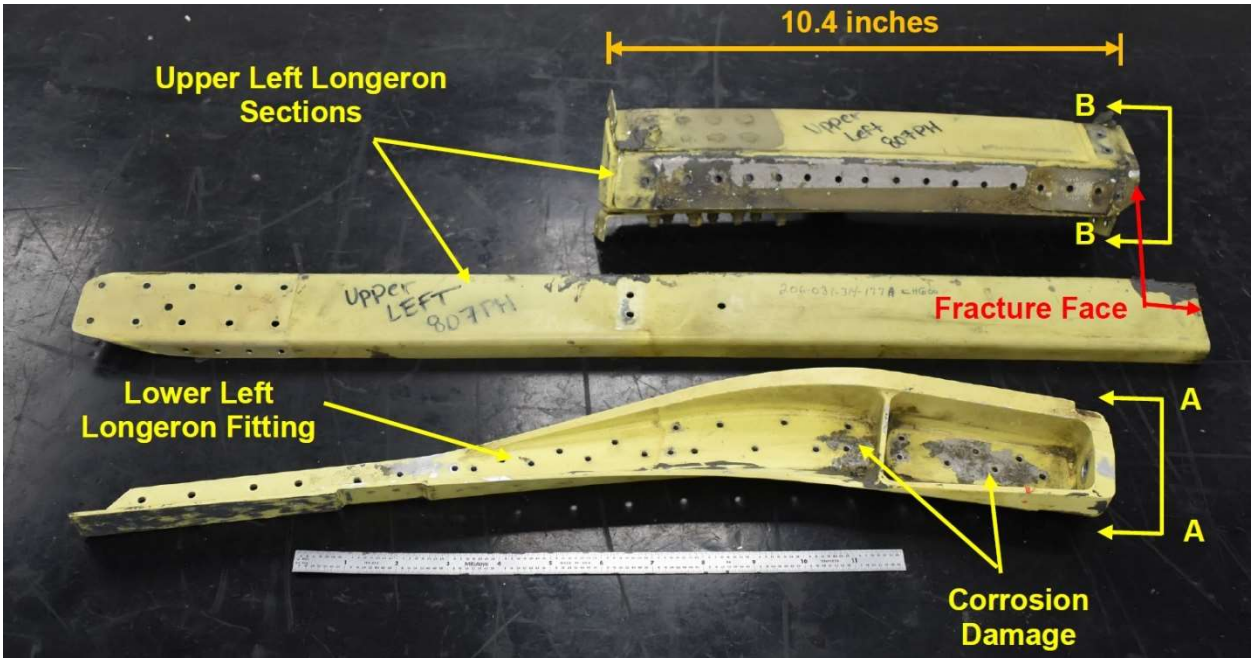


Figure 8. The upper-left and lower-left longerons from N807PH received by the Bell FI Lab. (Image courtesy of Bell)

On the lower-left longeron, two cracks were present on the aft face of the longeron (Section A-A in **Figure 8**). The two cracks had not propagated to a complete fracture and had to be opened by the lab for examination. Examination of the crack surfaces found signatures of fatigue (**Figure 9**). The fatigue crack located near the 6 o'clock location of the bolt hole originated from a corrosion pit about 0.011 inches deep. The fatigue crack located near the 9 o'clock location of the bolt hole originated from a material anomaly at the surface, about 0.010-inch deep by 0.030-inch wide (**Figure 10**). The material anomaly at the surface did not exhibit crack features and thus could not be well defined. The lower-left longeron met drawing requirements for material composition and hardness.

[10] N807PH was airframe serial number (S/N) 53656.

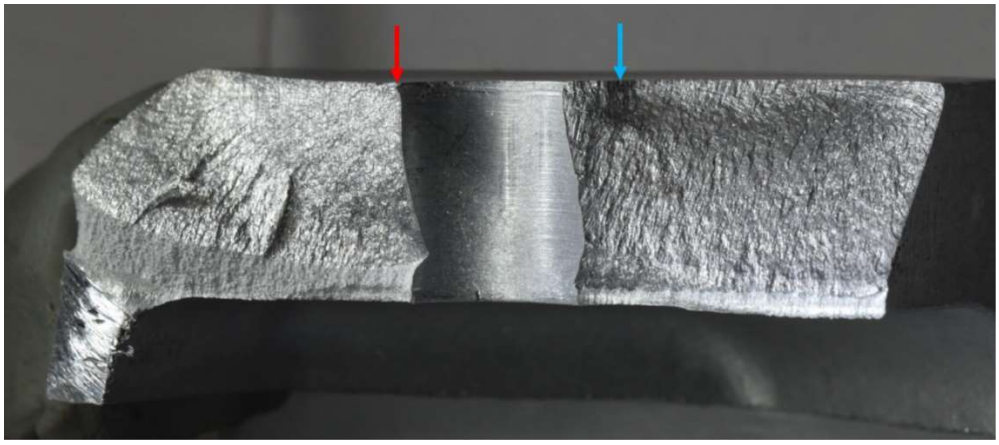


Figure 9. The crack origins on the lower-left longeron bolt hole. The red arrow points to the fatigue crack originating at the 6 o'clock location and the blue arrow points to the fatigue crack at the 9 o'clock location. (Image courtesy of Bell)

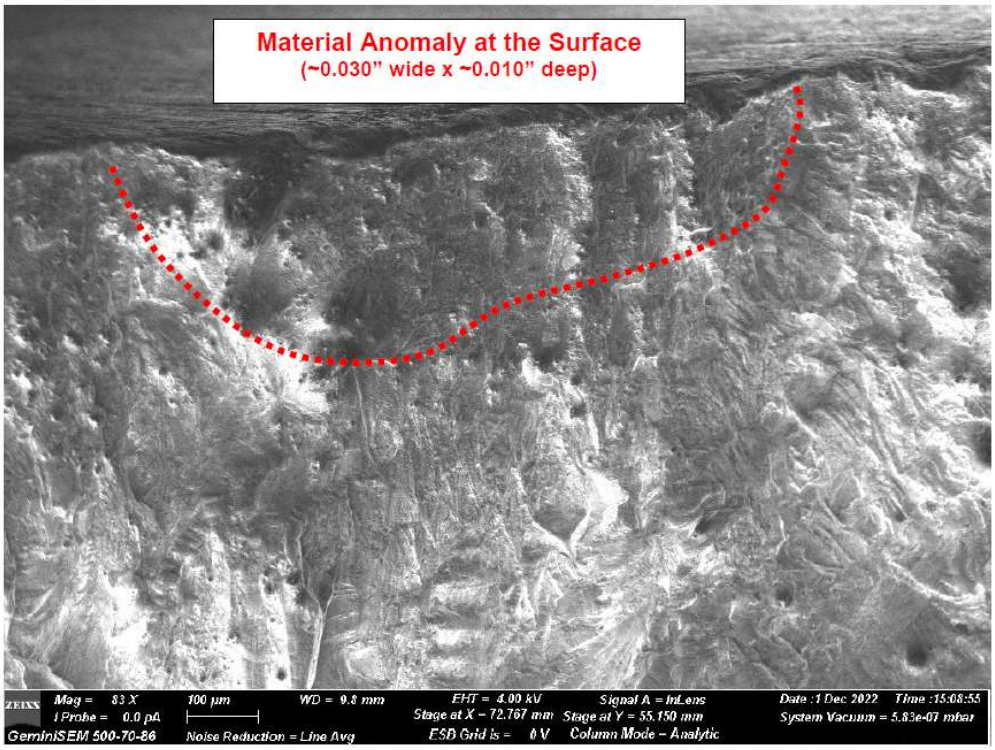


Figure 10. The anomaly at the surface of the fatigue crack located at the 9 o'clock location. Signatures of fatigue was observed emanating from this anomaly. (Image courtesy of Bell)

On the upper-left longeron, a fracture was observed through a rivet hole about 10.4 inches forward of the aft face of the longeron (Section B-B in **Figure 8**). Signatures of fatigue was observed at the rivet hole (**Figure 11**), but mechanical damage, likely from the rivet removal process, had obscured the origin areas. The spot face on the radius block of the upper-left fitting was observed to have been

uneven in depth (**Figure 12**). The upper-left longeron met drawing requirements for material composition and hardness.

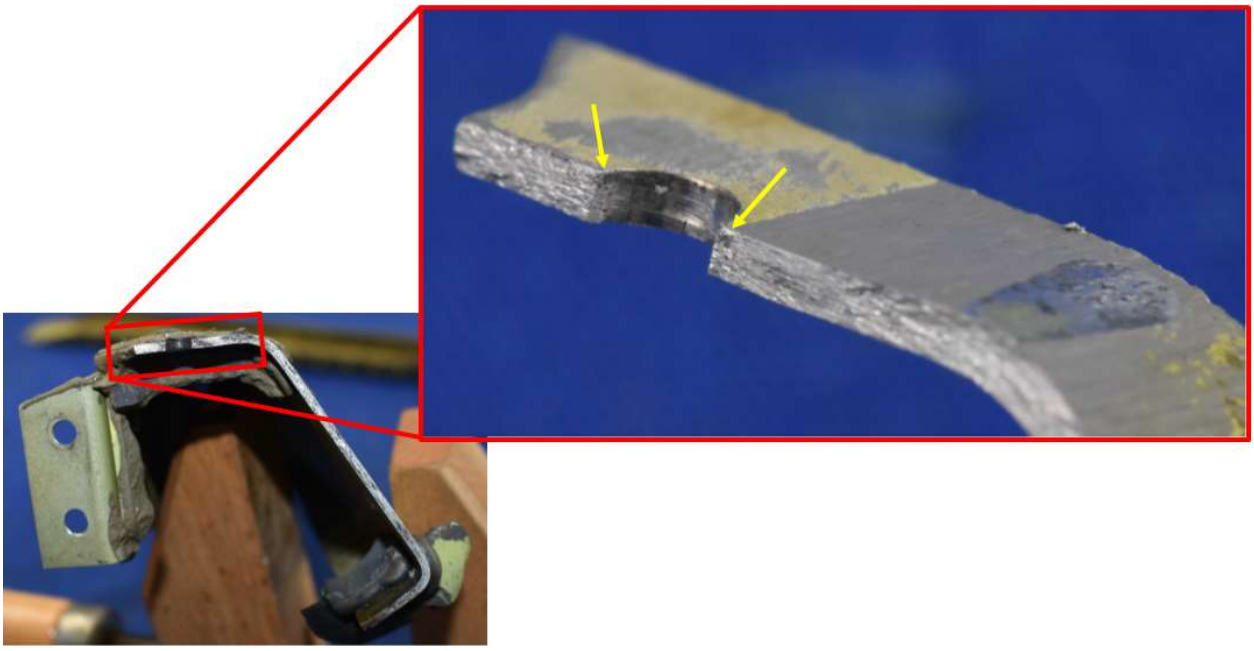


Figure 11. The upper-left longeron section containing a fracture about 10.4 inches forward of the aft face. The yellow arrows shows the location of the rivet hole in which cracks with signatures of fatigue were present. (Images courtesy of Bell)

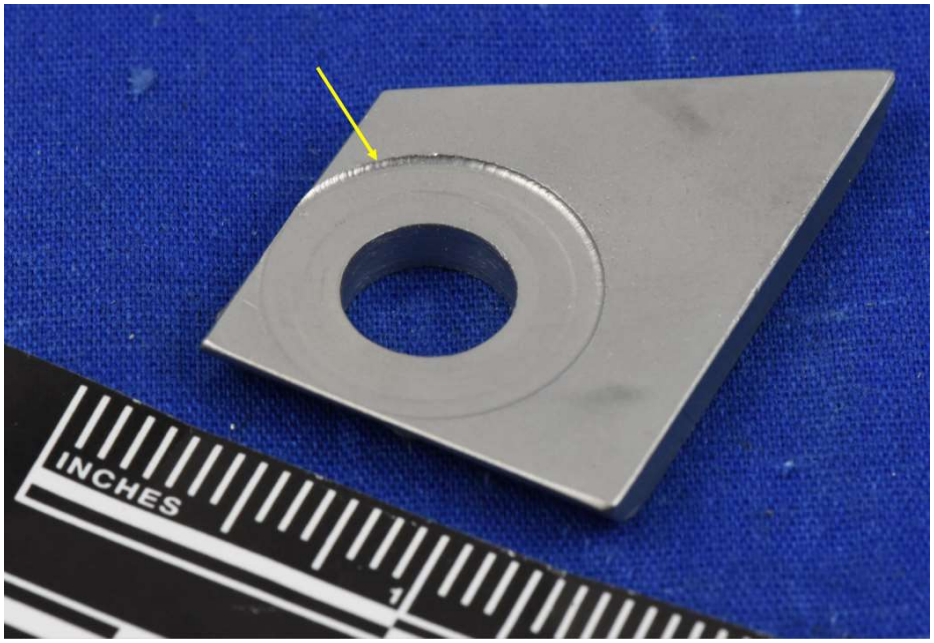


Figure 12. The radius block from the upper-left longeron fitting whose spot face (yellow arrow) exhibited an uneven depth. (Image courtesy of Bell)

5.0 Bell 407 S/N 53563 Upper-Left Attachment Bolt Fracture

The Airworthiness Group Chair's Factual Report for this investigation, dated October 24, 2022 and found in the docket for this investigation, discussed a past occurrence involving a Bell 407 in which the operator found a fractured upper-left attachment bolt during a scheduled 300-hour recurring torque check. Metallography of the fractured bolt found multiple-origin fatigue cracking through about 2/3 of the fracture cross-section, with the remainder of the fracture cross-section in overload (**Figures 13 and 14**). The location of the fracture on the bolt was estimated to be co-located with the aft face of the aft fuselage bulkhead.

Figure 13. The fractured bolt found on Bell 407 S/N 53563. (Image courtesy of Bell)

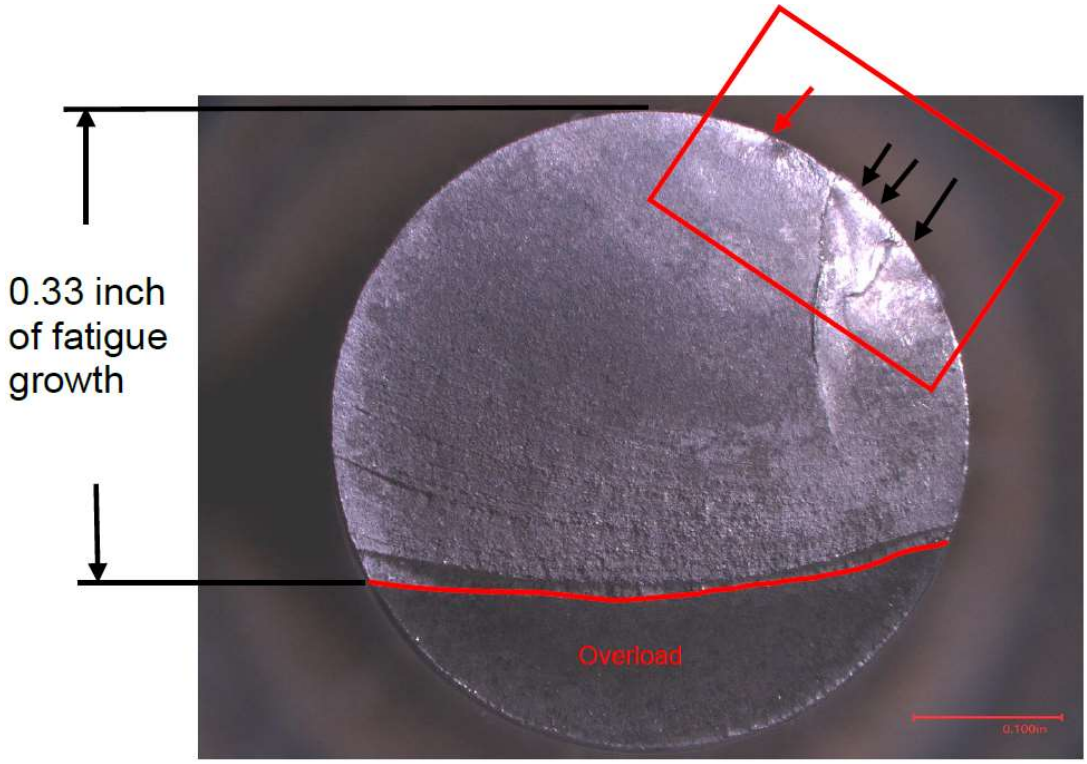


Figure 14. The black arrows point to fatigue origins with the red arrow pointing to the primary fatigue origin. (Image courtesy of Bell)

The Airworthiness Group Chair received information from the repair station that conducted the replacement of the upper-left longeron on S/N 53563 after discovery of the fractured bolt. **Appendix A** of this report contains images from the repair station that annotated installation anomalies discovered during the previous upper-left longeron installation, prior to the discover of the upper-left bolt fracture.

6.0 Post-accident Safety Actions

On December 1, 2022, the NTSB issued safety recommendations A-22-28 thru A-22-31 to the Federal Aviation Administration (FAA) and Transport Canada Civil Aviation (TCCA) to conduct torque checks of the tail boom attachment hardware and visual inspection of the tail boom attachment fittings both immediately and at an interval less than the required 300-hour inspection interval. On December 8, 2022, Bell issued Alert Service Bulletin (ASB) No. 407-22-128 (**Attachment 2**) for a one-time torque check and inspection of the tail boom attachment hardware and fittings. Subsequently, TCCA and the FAA released Airworthiness Directive (AD) No. CF-2022-68 (**Attachment 3**) and No. 2022-27-08 (**Attachment 4**), respectively, to require the actions of Bell ASB No. 407-22-128. The TCCA AD was effective December 29, 2022 and the FAA AD was effective on January 12, 2023.

On March 28, 2023, Bell provided the NTSB, TCCA, and FAA a briefing of the responses to the ASB and ADs. Bell received a total of 554 responses, with some responses including multiple aircraft results. Of these results, there were 2 reported movements of the upper-left fastener; no reported movements of the upper-right fastener; 9 reported movements of the lower-left fastener; and 4 reported movements of the lower-right fastener. Of the total results of reported movement of the fasteners, none were characterized as significantly below installation torque. There was only one report of damage found on the attachment fittings, specifically a crack indication at the upper-right portion of the aft fuselage bulkhead.

E. LIST OF ATTACHMENTS

Attachment 1 – Phoenix Heliparts Work Order No. 1105.
Attachment 2 – Bell ASB No. 407-22-128
Attachment 3 – TCCA AD No. CF-2022-68
Attachment 4 – FAA AD No. 2022-27-08

Submitted by:

Chihoon Shin
Aerospace Engineer – Helicopters

Appendix A - Photos of Bell 407 S/N 53563

Figure A-1. Two views of the aft fuselage bulkhead. (Image courtesy of Arrow Aviation)

Figure A-2. A gap, measured to be about 0.008 inches, identified between the upper-left longeron and aft fuselage bulkhead. (Image courtesy of Arrow Aviation)

Figure A-3. A gap, measured to be about 0.035 inches, identified between the drill plate and the upper-left longeron attachment fitting. (Image courtesy of Arrow Aviation)

Figure A-4. Misalignment identified between the drill plate (work aid) and the upper-left longeron bolt hole. (Image courtesy of Bell)

Figure A-5. The lower-left bolt hole. (Image courtesy of Arrow Aviation)

Figure A-6. The lower-right bolt hole. (Image courtesy of Arrow Aviation)

Figure A-7. The upper-right bolt hole. (Image courtesy of Arrow Aviation)