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

ERA21FA195

AIRWORTHINESS

Group Chair's Factual Report

February 27, 2023

A. ACCIDENT

Location: Eden, North Carolina
Date: April 28, 2021
Time: 1326 eastern daylight time
Helicopter: Bell 429, registration N53DE

B. AIRWORTHINESS GROUP

Group Chair	Chihoon Shin National Transportation Safety Board Washington, District of Columbia
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C. SUMMARY

On April 28, 2021, about 1324 eastern daylight time, a Bell 429 helicopter, N53DE, was destroyed after impacting trees and terrain in Eden, North Carolina (NC). The pilot was fatally injured and two crewmembers were seriously injured. The flight was conducted under the provisions of Title 14 *Code of Federal Regulations* Part 91 as a powerline patrol flight.

From April 29 to May 2, 2021, members of the Airworthiness Group convened at the accident site to document, recover the helicopter wreckage, and review the helicopter maintenance records. From June 9-10, 2021, members of the Airworthiness Group convened at Atlanta Air Salvage in Griffin, Georgia to examine the engines, empennage, main rotor head, hydraulic system, and main rotor blades. The main and tail rotor servo actuators were retained for further evaluation. The main and tail rotor hydraulic servo actuators were scanned using computed tomography to document the condition of the internal components prior to disassembly. From March 15-17, 2022, members of the Airworthiness Group convened at Woodward facilities in Santa Clarita, California to examine and disassemble the main and tail rotor servo actuators. On June 6, 2022, members of the Airworthiness Group convened at Atlanta Air Salvage to section the forward-left pitch restraint mount from the main transmission housing. The forward-left pitch restraint mount was submitted to the National Transportation Safety Board (NTSB) Materials Laboratory in Washington, District of Columbia to examine the fracture surfaces of the forward-left pitch restraint mounting studs.

D. DETAILS OF THE INVESTIGATION

1.0 Helicopter Information

1.1 Helicopter Description

The Bell 429 helicopter is type certificated under Federal Aviation Administration (FAA) type certificate data sheet (TCDS) No. R00003RD. The Bell 429 has a four-bladed main rotor that provides helicopter lift and thrust and a four-bladed tail rotor that provides directional control.[1] The flight control system includes a dual hydraulic system and a three-axis autopilot (pitch, roll, and yaw), with the option for a fourth axis (collective).[2] The helicopter is equipped with two Pratt and Whitney Canada PW207D1 turboshaft engines mounted behind the main transmission. The accident 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, N53DE, was serial number (S/N) 57380 and was manufactured in 2019. The engines installed on the accident helicopter were S/N PCE-BL0795 (No. 1, left position) and S/N PCE-BL0796 (No. 2, right position). According to helicopter records, the helicopter had an aircraft total time (ATT) of 283.5 hours on the day of the accident.

[1] The main rotor system rotates counterclockwise when view from above.
[2] The accident helicopter was equipped with a 4-axis autopilot.

2.0 Helicopter Wreckage Observations

2.1 Structures

2.1.1 Airframe Description

The Bell 429 helicopter airframe is composed of two primary structures, the fuselage and tail boom, that are composed of a mix of aluminum and composite parts. The fuselage contains the cockpit, cabin, baggage compartment, and an upper section containing the main transmission, engines, and hydraulic system. The tail boom contains the tail boom frame, horizontal stabilizer (with finlets), the vertical stabilizer, and the tail rotor and its drive system. The fuel system is composed of multiple bladder-type cells located underneath the cabin floor.

2.1.2 Fuselage Wreckage Observations

The helicopter impacted wooded terrain and came to rest at a heading of about 251° magnetic. The main wreckage site, composed of the majority of the helicopter including the fuselage and tail boom, was located at 36° 29′ 49″ north by 79° 43′ 07″ west at an elevation of about 570 feet. The fuselage came to rest on its right side at the base of a tree (**Figures 1 and 2**). A postcrash fire occurred and damaged the majority of the fuselage.

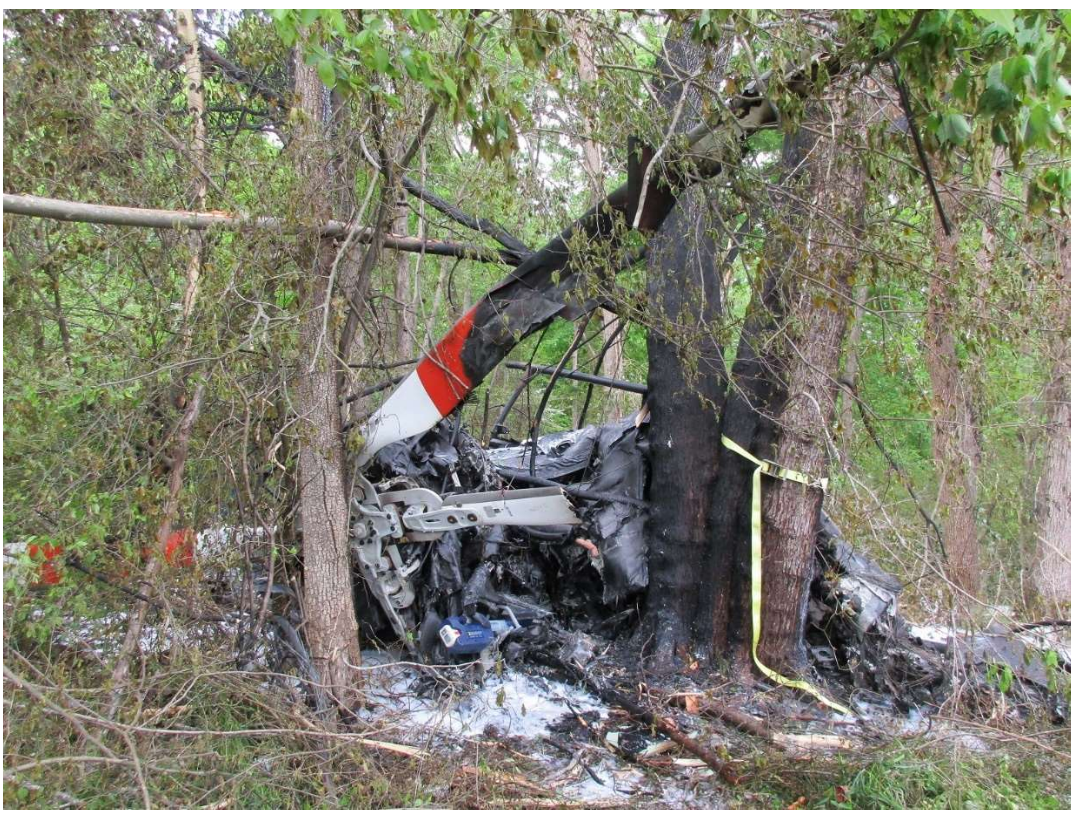

Figure 1. The main wreckage site. (Image courtesy of the FAA)

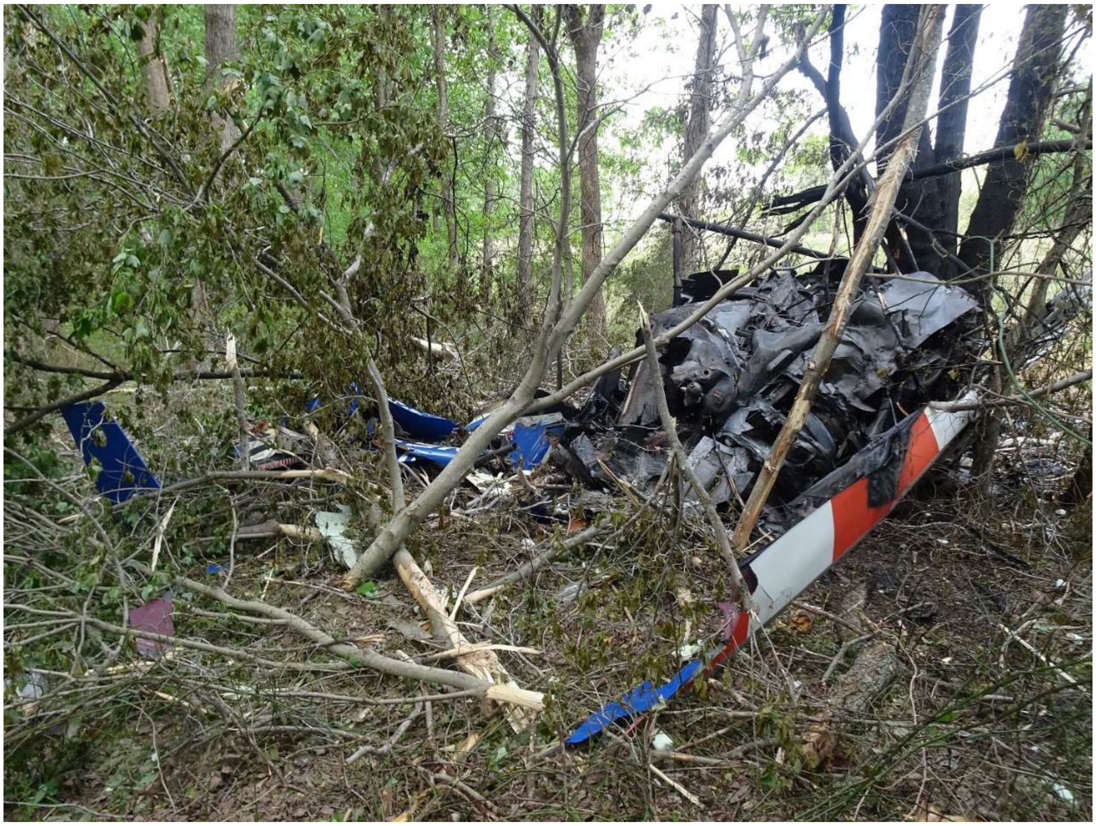

Figure 2. The main wreckage site.

The nose section was consumed by the postcrash fire. Remnant cockpit avionics and wiring were found strewn outside the nose section with pieces of wood branches embedded within the remnant wiring. Remnant carbon fiber layup was present in the area of the upper cowlings, fuselage skin, and doors. A portion of one seat was found near the area of the cockpit wreckage. The remainder of the seats were consumed by the postcrash fire. Multiple floor seat tracks were found within the main wreckage but did not contain seat attachments.

The cockpit and cabin floor were both present with aluminum and composite core visible on the belly of the fuselage. The metal exterior of the forward fuel cell access panel (on the belly of the fuselage) was torn outward. The middle and aft fuel cell access panels (on the belly of the fuselage) were partially melted in place. Remnant portions of the three fuel cells were visible behind the belly, and all three fuel cells were partially consumed by the postcrash fire. A mixture of fuel and water, most likely from the postcrash firefighting, was present within all three fuel cells.

The main transmission and engine decks were thermally damaged but present in the wreckage. The transmission deck carbon fiber layup had folded over toward the swashplate assembly. The structural (arch) beam, to which the main transmission's aft mounts attach, was present in the wreckage. The forward engine firewall was crushed underneath the main transmission. The engine deck remained attached to the fuselage via remnant composite layup and wiring.

2.1.3 Tail Boom Wreckage Observations

The tail boom had fractured into multiple pieces, the majority of which were found adjacent to and behind the fuselage. The major pieces of the tail boom at the main wreckage site included the vertical fin, the horizontal stabilizer, and the side portion of the tail boom containing the registration number. None of the tail rotor drive shaft covers remained installed on the tail boom. The horizontal stabilizer remained attached to a separated portion of the tail boom. The left horizontal stabilizer was generally whole with a puncture near the inboard side of its lower surface as well as a puncture near the outboard side of its upper surface. The left finlet remained attached with the lower portion intact and the upper portion fractured and partially separated. The right horizontal stabilizer was generally whole on its inboard end but was fractured at its outboard end. The lower portion of the right finlet was fractured and partially separated, remaining attached only by wiring. The upper portion of the right finlet was fractured and completely separated. The leading edge slats were present on the inboard portions of both left and right horizontal stabilizers but were fractured and separated on their outboard sections. Pieces of blue-colored composite fairing consistent with the tail rotor drive shaft cowling were found in the flight path leading up to the main wreckage. The leading edge of the upper vertical fin showed evidence of impact deformation and separation above its attachment point but was generally whole. The lower vertical fin was whole and remained attached to the tail boom. The tail stinger remained attached to the bottom of the lower vertical fin.

The landing gear left skid tube remained attached to both forward and aft crosstubes. The right skid tube was found on the ground adjacent to the fuselage, near its normally installed location, and was fractured and separated from the upper end of the forward crosstube but still attached to the aft crosstube. The forward crosstube was found near its normally installed location but was partially detached from the fuselage. The aft crosstube remained attached to the fuselage. The left and right steps were fractured and separated from the fuselage. The right skid tube had a platform that was partially separated from the skid tube. The hoist, normally installed on the right side of the helicopter, was not installed at the time of the accident flight.

2.2 Main Rotor System

2.2.1 System Overview

Power from each engine reduction gearbox is delivered to the main transmission via two KAflex-type engine-to-transmission drive shafts. The main transmission drives both the main rotor system, via the mast assembly, and the tail rotor drive system. The main transmission also drives the two hydraulic pumps for the Nos. 1 and 2 hydraulic systems. The main transmission is mounted to the fuselage via pylon assembles on the left and right side of the transmission housing. Each pylon assembly is composed of a beam (attached to the cabin roof), a vertical Liquid Inertia Vibration Eliminator (LIVE) mount, a pitch restraint spring, and a stop assembly.

The main rotor system is composed of the hub assembly, four blade assemblies, and rotating controls. The hub assembly is composed of two composite flexible beams (flexbeams) that are stacked. Each flexbeam supports two main rotor blades. Each end of a flexbeam, along with the upper and lower mount plate assemblies, supports the pitch horn and grip assembly, centrifugal force (CF) bearing, shear bearing, and elastomeric lead-lag dampers for each blade. Each main rotor blade is retained to their respective grip via two blade bolts.

The main rotor blades are composite in construction and are composed of a fiberglass C-shaped spar, a foam core afterbody, carbon fiber upper and lower skins, a nickel-cobalt abrasion strip, and a tip cap. The four main rotor blades and their associated components 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). Blade pitch control is achieved via pitch change links (PCL) connected between each blade's pitch horn and the rotating swashplate.

2.2.2 Main Rotor Head Wreckage Observations

The main rotor hub remained attached to the mast assembly and the mast nut remained installed (**Figure 3**). The 'blue' blade flexbeam was partially fractured and deformed in the direction opposite of normal rotation. The remaining blade attachments on the flexbeams did not exhibit significant fragmentation but had several layers of laminate separated on their lower sides. The upper and lower mount plate assemblies and lead-lag dampers remained installed. The 'blue' lead-lag damper was partially sheared on its lower end. All blade grips remained installed and the CF bearings were attached to their respective grips except for the 'blue' CF bearing, which was torn and separated at its elastomers due to partial separation of the 'blue' blade and grip. The 'red' CF bearing elastomer was separated near its outboard end. The 'green' and 'orange' CF bearing elastomers were separated about mid-way outboard. The up-flap stops for the 'orange' and 'green' blades were fractured, with the corresponding up-flap stops on the 'orange' and 'green' blade grips exhibiting impact marks biased toward the blade-advancing side. The 'red' up-flap stop was impact-damaged. The up-flap stop on the 'red' blade grip had a large impact mark at its center and a smaller impact mark biased toward the blade-advancing side. The 'blue' up-flap stop was relatively undamaged with the up-flap stop on the 'blue' blade grip exhibiting multiple small impact marks and a large impact mark near its blade-retreating side.

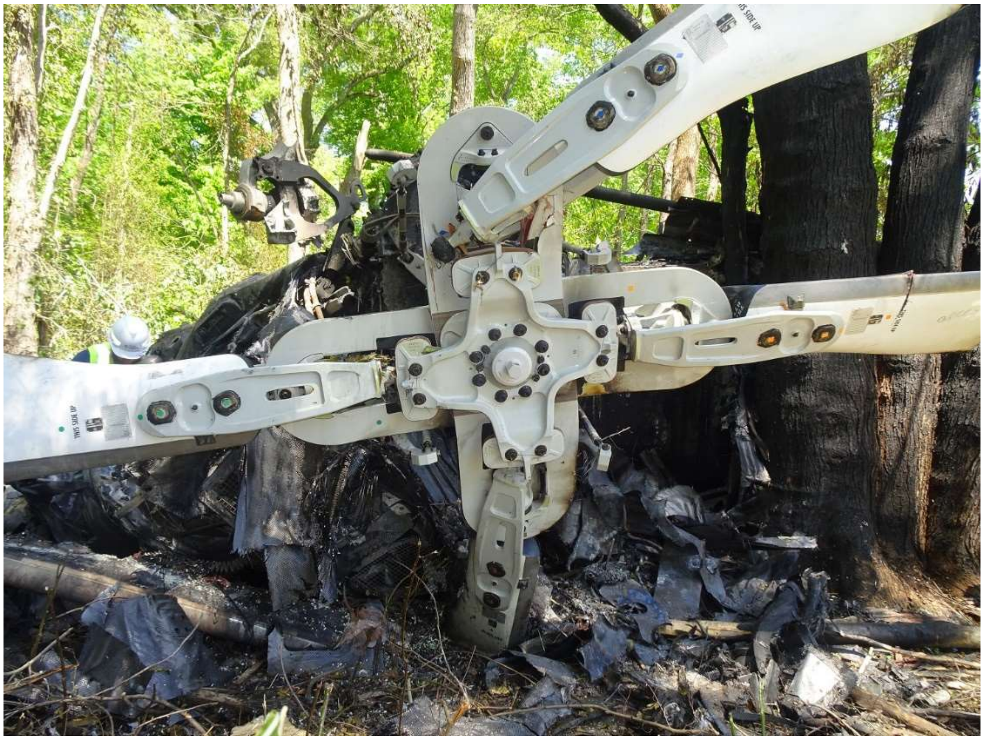

Figure 3. The main rotor head with all four main rotor blades present.

2.2.3 Main Rotor Blade Wreckage Observations

All four main rotor blades remained installed to their respective grips via blade pins. All four pitch horn and grip assemblies remained intact. Two separated tip weight boxes and two tip weight box covers were recovered in the debris field surrounding the main wreckage site. The 'blue' main rotor blade tip weight box and its cover remained installed in the blade. The fourth tip weight box and its cover were not found. **Figure 4** show a reconstruction of the recovered main rotor blades.

The 'blue' main rotor blade was continuous from its inboard end to the tip weight box, but exhibited spar fractures in multiple locations along its span. The inboard side of the 'blue' blade was thermally damaged due to the postcrash fire and the blade afterbody was not present from the blade midspan area (painted white) to its tip end.

The 'orange' main rotor blade was cut near its inboard end by first responders. The separated 'orange' blade was found on the ground and exhibited thermal damage due to the postcrash fire. The 'orange' blade afterbody was not present from the blade midspan area to its tip end.

The 'red' main rotor blade was missing the majority of its afterbody throughout its span. The 'red' blade spar exhibited multiple fractures on its inboard end and was bent and embedded into the ground. The outboard section of the remnant 'red' blade was thermally damaged.

The inboard portion of the 'green' main rotor blade (painted orange) was thermally damaged near its trailing edge. The 'green' blade afterbody was present until the end of the midspan area of the blade. The remaining outboard section of the 'green' blade exhibited fragmentation.

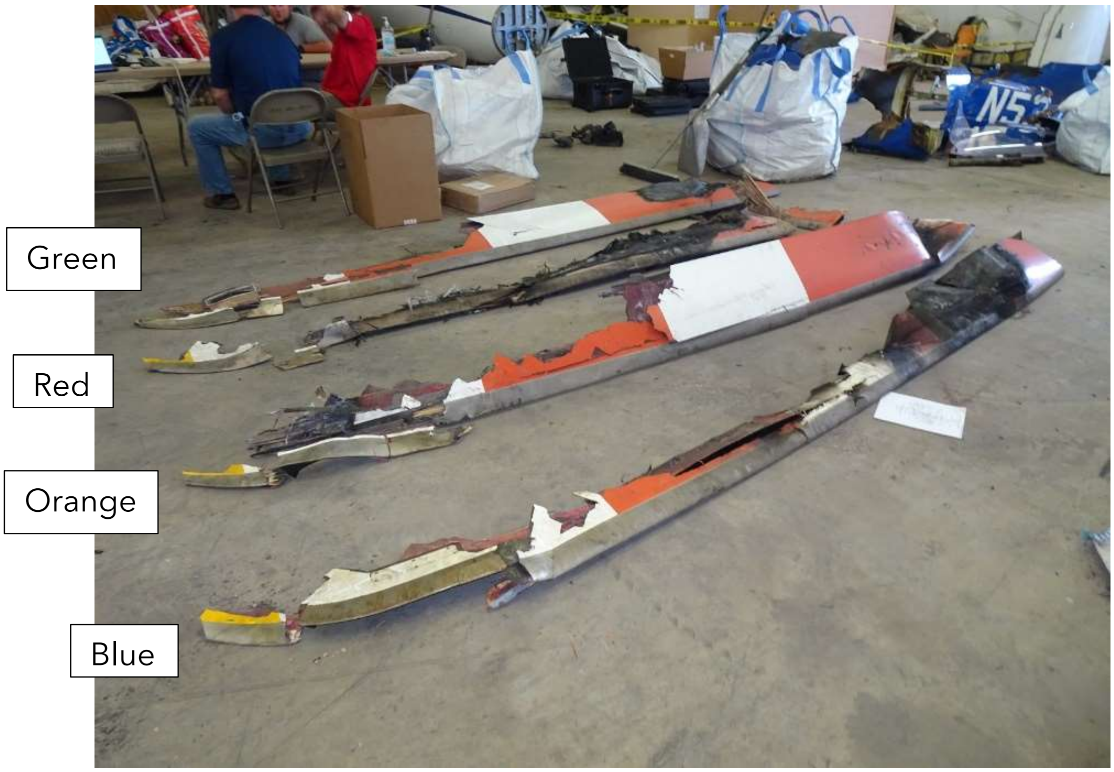

Figure 4. A reconstruction of the four main rotor blades.

Three separated leading edge pieces near the tip end, including the tip cap lap joint, also known as the "taco patch", were found in the debris field surrounding the main wreckage. Two swept tip ends, which were fractured and separated, were reconstructed by the investigation team to the 'blue' and 'orange' main rotor blades. Two additional swept tip ends, also fractured and separated, exhibited impact damage with a width consistent with contact with the tail rotor drive system aft snubber and belonged to the 'red' and 'green' main rotor blades (**Figure 5**). All four swept tip ends were found in the debris field leading up to and around the main wreckage.

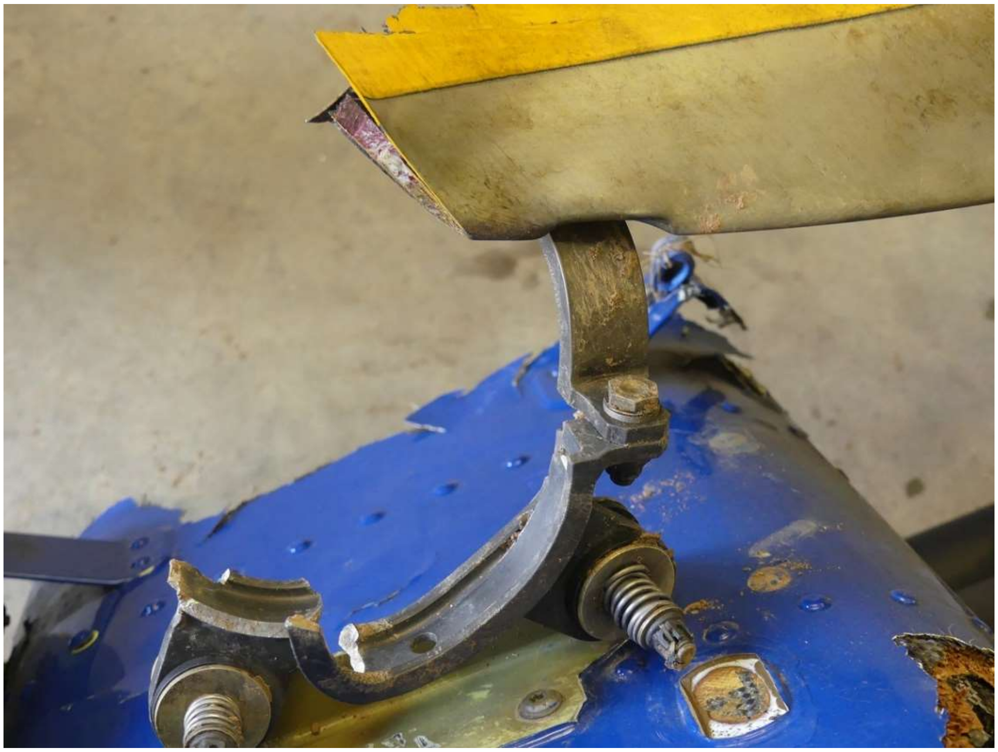

Figure 5. A leading edge impact mark on the tip end of the 'red' main rotor blade matched to the aft snubber. (Image courtesy of Bell.)

2.2.4 Main Rotor Controls Wreckage Observations

All four main rotor blade PCLs remained connected to their respective pitch horns and to the rotating swashplate. The swashplate assembly was present and the two drive links remained installed between the main mast and the rotating swashplate. The swashplate uniball sleeve had traveled to its upper limit, impinging the uniball's rubber boot and its plastic tie-wrap against the drive link hub.

The longitudinal and lateral cyclic control rods remained installed on the stationary swashplate but both control rod tubes were fractured about mid-length. The stationary swashplate had rotated to the left about 45°. The collective lever was present but separated from the uniball sleeve. The left clevis connection between the collective lever and the uniball sleeve had fractured; the inner clevis was present but the outer clevis had fractured and remained attached to the collective lever. The right clevis connection between the collective lever and the uniball sleeve had fractured and separated; it was not found.

2.2.5 Main Rotor Drive System Wreckage Observations

The main transmission was present in the main wreckage, was covered in soot but was whole. Portions of the main transmission housing exhibited thermal damage. The upper portion of the right LIVE mount remained attached to the transmission housing but its lower portion had separated due to thermal damage and was found on the ground. The forward rod end of the right pylon pitch restraint remained connected to the forward-right fuselage support and the aft rod end of the right pylon pitch restraint remained connected to a remnant piece of the right LIVE mount, but the body of the right pylon pitch restraint was not observed in the wreckage. The aft-right fuselage support remained attached to the fuselage but was fractured and separated from the right LIVE mount support. The left LIVE mount was fractured and separated from the transmission housing but partially attached to the aft-left fuselage support, the latter of which remained attached to the fuselage. The two forward transmission fuselage mounts were found fractured and separated but remained attached to remnant portions of the fuselage. The left pylon pitch restraint was present, remained connected on both ends to remnant structure, and its housing had fractured longitudinally. The left pylon pitch restraint stop, integral to the left LIVE mount, showed no evidence of contact damage to its inner surfaces. The left and right pylon pitch restraint stops that are attached to the airframe were found in the wreckage and did not exhibit significant deformation. The aft-left pitch restraint mount remained attached to a fractured piece of the transmission housing, with the fracture surfaces exhibiting signatures of overload. The forward-left pitch restraint mount was submitted to the NTSB Materials Laboratory in Washington, District of Columbia, to examine the fracture surfaces of the forward-left pitch restraint mounting studs. Lab examination of those fracture surfaces found signatures of overload.[3]

The main rotor mast chip detector was removed and contained no magnetic debris. The left sump chip detector was removed but its sleeve was stuck onto it; no magnetic material was observed on the left sump chip detector. The right sump chip detector was not present.

Turning the rotor brake disc resulted in a corresponding rotation of the main mast and the left and right KAflex (engine-to-transmission) couplings. Freewheeling unit functionality was confirmed on both left and right KAflex couplings. The left and right KAflex drive shafts were near their normally installed location but both shafts had fractured at the KAflex couplings at both ends. The rotor brake disc and the grease pack’s interior splines remained attached to the main transmission tail rotor drive quill. Remnant, thermally degraded grease was observed within the grease pack. The grease pack’s exterior spline adapter remained attached to the forward end of the steel tail rotor drive shaft but was separated from the grease pack.

[3] For additional details of the forward-left pitch restraint mounting stud examination, see NTSB Materials Laboratory Report No. 22-051 in the docket for this investigation.

2.3 Tail Rotor System

2.3.1 System Overview

Power from the main transmission is transferred to the tail rotor via the tail rotor drive system. The forward-most tail rotor drive shaft, connected to the main transmission, is a steel tail rotor drive shaft that is located beneath the engines. The steel tail rotor drive shaft is connected at its aft end to the fan blower shaft, the latter of which turns the oil cooler blower. Subsequent to the fan blower shaft, two composite tail rotor drive shafts, also known as the forward and aft segmented drive shafts, continue tail rotor drive to the tail rotor gearbox. A hanger bearing connects and aligns the two composite drive shafts. A snubber, used to limit the deflection of each shaft, is located about mid-length of each composite drive shaft. The tail rotor gearbox changes the direction of drive and reduces the input drive speed. The tail rotor gearbox output shaft drives the tail rotor hub assembly.

The tail rotor is composed of the hub assembly, four tail rotor blades, and its rotating controls. The hub assembly is composed of two stacked yokes, each yoke retaining a tail rotor blade at each end. The two yokes are offset about 70° to result in a scissored tail rotor configuration. Each tail rotor blade is composite in construction with a nickel abrasion strip. The four tail 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). Blade pitch control is achieved via PCLs connected between each blade's pitch horn and the tail rotor crosshead.

2.3.2 Tail Rotor Wreckage Observations

The tail rotor gearbox output shaft had fractured and separated, but the tail rotor remained attached to the tail rotor gearbox via the tail rotor pitch control rod, the latter of which was bent about 90°. The tail rotor hub remained attached to the outboard portion of the tail rotor gearbox output shaft (**Figure 6**). The inboard yoke ('blue' and 'red' tail rotor blades) was able to be manually teetered but the outboard yoke ('green' and 'orange' tail rotor blades) exhibited resistance to manual teetering. The curvic coupling between the upper and lower yokes were disengaged allowing for independent rotation of the upper yoke from the lower yoke.

All four tail rotor blades remained installed to their respective yokes. The 'blue' tail rotor blade had partially fractured chordwise, about midspan, and bent outboard, but the entire span of the 'blue' blade was present. The 'blue' blade tip was generally intact. Chordwise scuff marks were visible on the outboard portion of the 'blue' blade on both inboard and outboard surfaces of the blade. The 'orange' tail rotor blade was whole with no evidence of leading edge or spar fractures. The tip end of the 'orange' blade was embedded into the ground. The 'red' tail rotor blade exhibited no evidence of fractures on its leading edge or spar and was generally intact except for the loss of a portion of the blade afterbody at its tip end. The ‘green’ tail rotor blade was partially fractured chordwise, about midspan, and bent outward. Chordwise scuff marks were present at the tip end of the ‘green’ blade, on both inboard and outboard surfaces. The paint on the inboard side of the ‘green’ blade exhibited bubbling consistent with exposure to the postcrash fire.

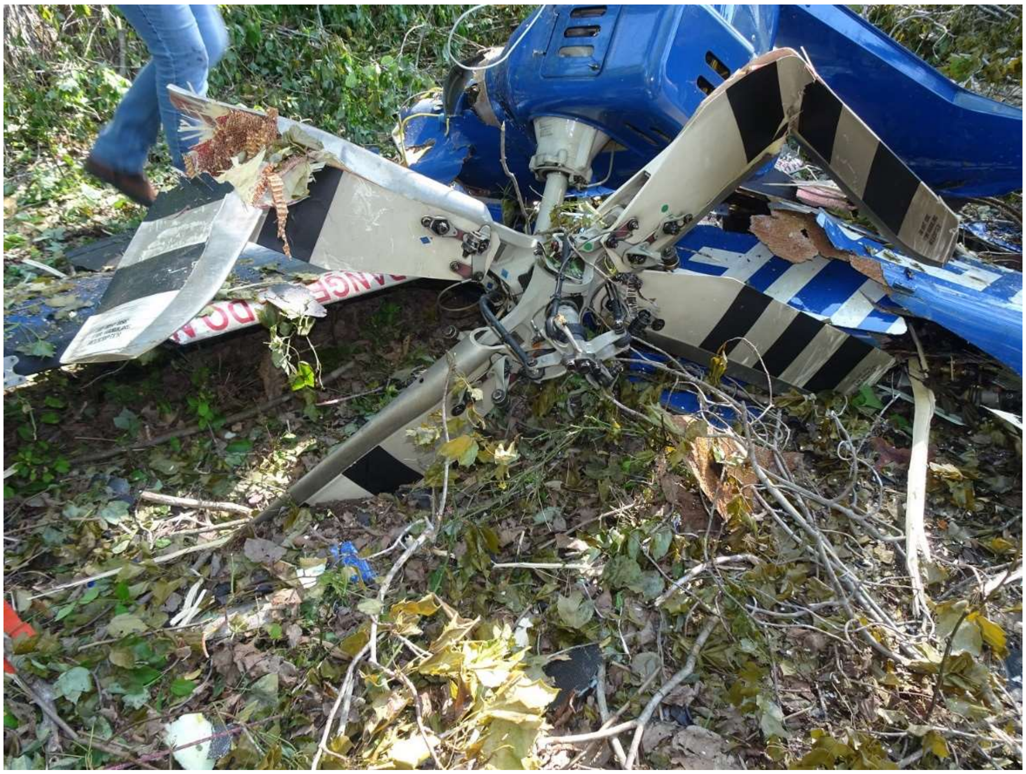

Figure 6. The tail rotor and tail rotor gearbox.

2.3.3 Tail Rotor Controls Wreckage Observations

The tail rotor servo actuator remained installed within the aft portion of the fuselage wreckage. The tail rotor control tube, aft of the tail rotor servo actuator, was fractured in multiple locations. The forward clevis of the tail rotor control tube remained attached to the bellcrank but was fractured at the clevis threads. The aft end of the control tube remained attached to the tail rotor bellcrank within the aft end of the tail boom wreckage. The tail rotor control lever remained connected to the tail rotor gearbox and tail boom. Manual actuation of the tail rotor control lever was not possible due to bindings caused by the bent tail rotor pitch control rod within the tail rotor gearbox output shaft.

The pitch change crosshead remained installed at the outboard end of the tail rotor. All four tail rotor PCLs remained attached between the pitch change crosshead and their respective tail rotor pitch horns. The ‘green’ and ‘blue’ PCLs exhibited significant compression deformation. The 'red' and 'orange' PCLs exhibited only slight deformation. None of the four PCLs exhibited evidence of fractures.

2.3.4 Tail Rotor Drive System Wreckage Observations

The steel tail rotor drive shaft was continuous to the fan blower shaft. The fan blower shaft and oil cooler blower remained installed on the airframe but were crushed from impact forces. The forward segmented drive shaft was attached at its forward end to the fan blower shaft but one of the trilobe flanges had fractured. The forward segmented drive shaft was fractured about 25 inches aft of its forward attachment flange. Two additional pieces from the forward segmented drive shaft were recovered: 1) the midsection of the forward segmented drive shaft, containing the stainless steel snubber sleeve, was found in the wreckage adjacent to the tail boom and 2) the aft section of the forward segmented drive shaft, about 40 inches in length, remained attached to a separated section of the tail boom and remained connected to a forward portion of the aft segmented drive shaft, about 23 inches in length, and the hanger bearing between them. The aft portion of the 34-inch section of the aft segmented drive shaft exhibited an angled cut (**Figure 7**). The segmented drive shaft hanger bearing and its mount remained attached to the tail boom. A 34-inch long section of the aft segmented drive shaft was found embedded near-vertically into the ground, about 18 inches of which was embedded into the ground.

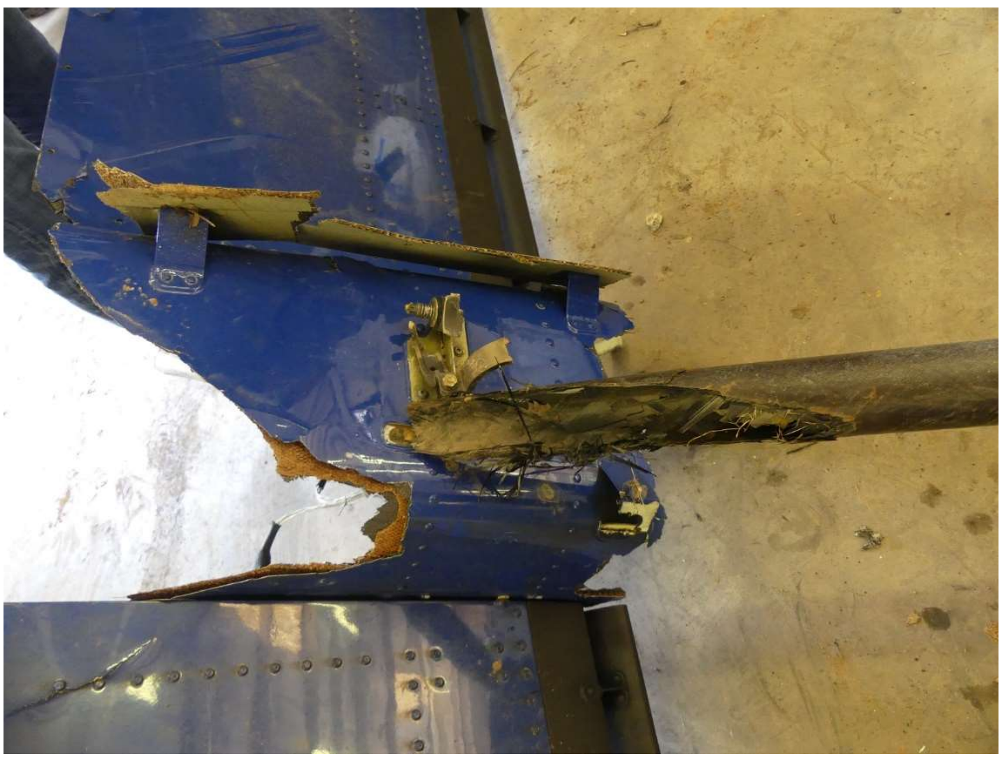

Figure 7. The 34-inch long section of the aft segmented drive shaft, the aft end of which exhibited the angular cut.

The forward snubber remained attached to a portion of the tail boom and did not exhibit impact deformation (**Figure 8**). A 5-inch long section of the aft segmented drive shaft remained connected to the tail rotor gearbox. A stainless steel sleeve for the aft snubber was found in the debris field and exhibited significant deformation. For the aft snubber mount on the tail boom, the left snubber mount remained attached but the snubber was fractured immediately adjacent to the mount. Additionally, the right snubber mount remained attached with a portion of the upper and lower halves of the snubber present and leaning to the right. A piece of a tail rotor drive shaft, semi-circular in its cross-section, was found about 172 feet from the main wreckage. Additional smaller fragments of composite tail rotor drive shaft were found in the debris field leading up to the main wreckage.

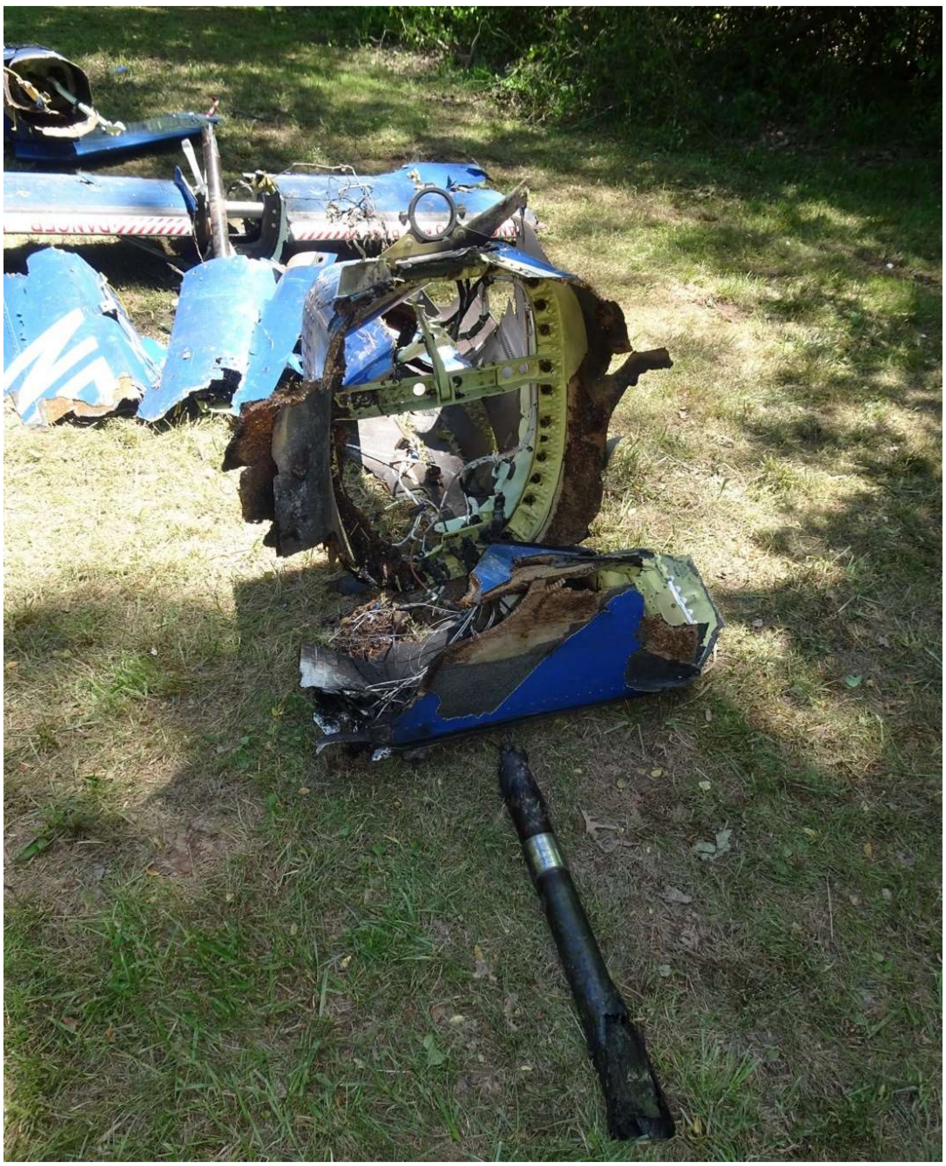

Figure 8. The midsection of the forward segmented drive shaft and the forward snubber installed on a piece of the tail boom.

The tail rotor gearbox remained attached to the tail boom. Rotation of the tail rotor gearbox input resulted in a corresponding rotation of the inboard portion of the tail rotor gearbox output shaft. The tail rotor gearbox output shaft had fractured immediately below the lower tail rotor yoke, exposing the tail rotor pitch control rod. Both halves of the output shaft fracture exhibited a dull silver color with orange-colored deposits on its fracture surface.

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 left and right cockpit controls are interconnected laterally underneath the cockpit floor and routed to the mixer bellcranks. The cyclic and collective control linkages are routed up the right side of the cockpit, then to the three main rotor [hydraulic] servo actuators mounted in front of the main transmission. The lateral servo actuator (left position) and longitudinal servo actuator (right position) transmit their outputs to the main rotor stationary swashplate. The collective servo actuator (center position) transmits its output to the collective lever, which moves the swashplate assembly up and down.

The directional control inputs from the pedal are transmitted through a series of control tubes and a push-pull control cable (Teleflex-type) to the tail rotor [hydraulic] servo actuator, located at the aft end of the fuselage. The tail rotor servo actuator transmits its output to the tail rotor crosshead via push-pull tubes and bellcranks.

The cyclic pitch and roll dual stability and control augmentation system (SCAS) actuators are located forward of the main rotor servo actuators and the directional control SCAS actuator is located forward of the tail rotor servo actuator. Pitch, roll, and yaw trim actuators, located underneath the cockpit floor, provide feedback loads and, in conjunction with the autopilot, can input cyclic and pedal commands to control the helicopter.

The dual hydraulic system, identified as Nos. 1 and 2, is composed of two separate, independent hydraulic systems to assist in moving the flight controls. Each hydraulic system is composed of a hydraulic pump, integrated hydraulic module (IHM), and hoses and tubes that provide hydraulic power to the four flight control servo actuators. Each IHM contains a reservoir, filter, pressure indicators, and valves. The No. 1 IHM is located on the left of the three main rotor servo actuators and the No. 2 IHM is located to the right.

2.4.2 Flight Control System Wreckage Observations

The accident helicopter as configured with only the pilot-side (right seat) cockpit flight controls installed. The cockpit flight controls for the left seat were not installed at the time of the accident. Various portions of clevis ends and bellcranks with varying degrees of thermal damage were observed in the main wreckage; the majority of the cockpit flight controls were consumed by the postcrash fire. The cyclic grip was found fractured and separated in the wreckage and was partially melted but the remainder of the cyclic control was not found. The collective control was found in the wreckage and was separated from its mounting base and continuous to the collective control head attachment point but the head was not present. The collective jackshaft was found in the cockpit wreckage. One pedal mount was found fractured and separated in the wreckage but the pedals were not found.

The majority of the flight control linkages from the cockpit flight controls to the stationary swashplate were thermally damaged or consumed by the postcrash fire. In the remnant pieces of the flight controls, none of the connection points between linkages and bellcranks exhibited evidence of fastener disconnection or separation. The main rotor servo actuator mounts, on the forward side of the main transmission housing, were mostly consumed by the postcrash fire and found separated and on the ground. The three main rotor servo actuators were found separated on the ground near the forward end of the main transmission. All three main rotor servo actuators exhibited thermal damage, and the data tags for the three servo actuators were separated and not found (**Figure 9**). The hydraulic lines remained connected to the three servo actuators, allowing for identification of their positions. The tail rotor servo actuator was found in the tail boom wreckage and its hydraulic lines remained connected. The control linkages connecting to the tail rotor servo actuator were present but fractured in overload. Additional details of the servo actuators can be found in Section 4.0 of this report.

Figure 9. The three main rotor servo actuators after recovery.

The collective trim actuator was found near the collective jackshaft in the cockpit wreckage and exhibited thermal damage. The aft actuator of both the lateral and longitudinal SCAS actuators remained attached to their respective servo actuator input arms and exhibited significant thermal damage. The remainder of the SCAS actuators were not attached and not found in the wreckage. Both directional SCAS actuators remained connected to the tail rotor servo actuator and did not exhibit thermal damage.

2.4.3 Hydraulic System Wreckage Observations

The right IHMs was found on the ground in front of the main transmission and was partially melted. The reservoir housing was fractured and a portion of the reservoir housing was consumed by the postcrash fire, exposing the spring within the reservoir. The differential pressure indicator for the return line was extended[4] while the differential pressure indicator for the pressure line was fractured and not present. Both filter housings were present with no cracks evident on those housings. The filter housings for both the pressurized line and return line were removed and their

[4] When the differential pressure indicator is retracted, the hydraulic filter is not being bypassed. When the filter becomes clogged and causes a differential pressure of 40 pounds per square inch (psi) across the filter element, the differential pressure indicator will extend, indicating the filter is being bypassed.

respective filter bowls and elements contained no debris but were thermally damaged. Remnant hydraulic lines were adhered to the IHM via melted aluminum.

The left IHM was found within the transmission deck wreckage, closer to the swashplate assembly, and was whole but covered in soot. The differential pressure indicator for the return line was extended while the differential pressure indicator for the pressure line was fractured and not present. The servicing indicator was fractured and not present. Both filter housings were present and the bottom sides of both housings were cracked. The filter housings for both the pressurized line and return line were removed and their respective filter bowls and elements contained no debris but were thermally damaged. The bleed/relief valve line was present but the valve had separated and was not present. The solenoid valve and pressure/temperature transducer were present but their cannon plugs were not present. Remnant portions of the IHM airframe mount were present but had melted due to exposure to the postcrash fire.

The right hydraulic pump was partially melted. The pump shaft was present and not sheared. The shaft was removed and its retaining ring and spring were present, but the spring was deformed and resting near the spline relief. The shaft external splines and the pump internal splines showed no anomalous wear.

The left hydraulic pump was whole and its exterior was thermally damaged. The left hydraulic pump mounts (to the main transmission) were fractured but its attaching hardware remained installed on the main transmission. The shaft adapter was present and was not fractured. The pressure line was fractured and separated at its port on the left hydraulic pump housing. The supply line remained attached to the left hydraulic pump. Continuity of drive through the pump was observed but rotation was extremely limited. Partial disassembly of the left hydraulics pump showed no evidence of anomalous wear of the splined connections between the shaft and the pump.

The Nos. 1 and 2 hydraulic manifolds were present in front of the main transmission and both exhibited thermal damage.

2.5 Engines

2.5.1 Engine Overview

The Pratt and Whitney Canada PW207D1 is a turboshaft engine that comprises a single-stage centrifugal compressor, a reverse flow annular combustion chamber, a single stage compressor turbine, driven by the centrifugal compressor,and a single stage power turbine (free turbine). The power turbine delivers power to a reduction gearbox that subsequently drives the helicopters rotor transmission and drive system. Each engine incorporates an electronic engine control (EEC) that commands the fuel management module when the engine fuel control is in the automatic (primary) mode. Each engine's fuel management module can be manually manipulated (manual/backup mode) via its twist grip on the collective control.

2.5.2 No. 1 Engine Wreckage Observations

The No. 1 engine remained installed on the engine deck and was thermally damaged (**Figure 10**). Its front-left mount was present but the mount bolt had fractured in overload. The aft mount remained installed but had bent forward. The inlet barrier filter was partially separated from its frame, but the inlet screen was intact. The inlet barrier filter was removed and the first stage compressor blades were examined and exhibited no damage to their leading edges. The No. 1 engine data collection unit (DCU) remained attached to the engine but its housing was thermally compromised, exposing its internal circuit card. The starter-generator could not be manually rotated, but the engine output coupling was able to be manually rotated. The No. 1 EEC remained attached to the airframe and its housing was covered in soot.

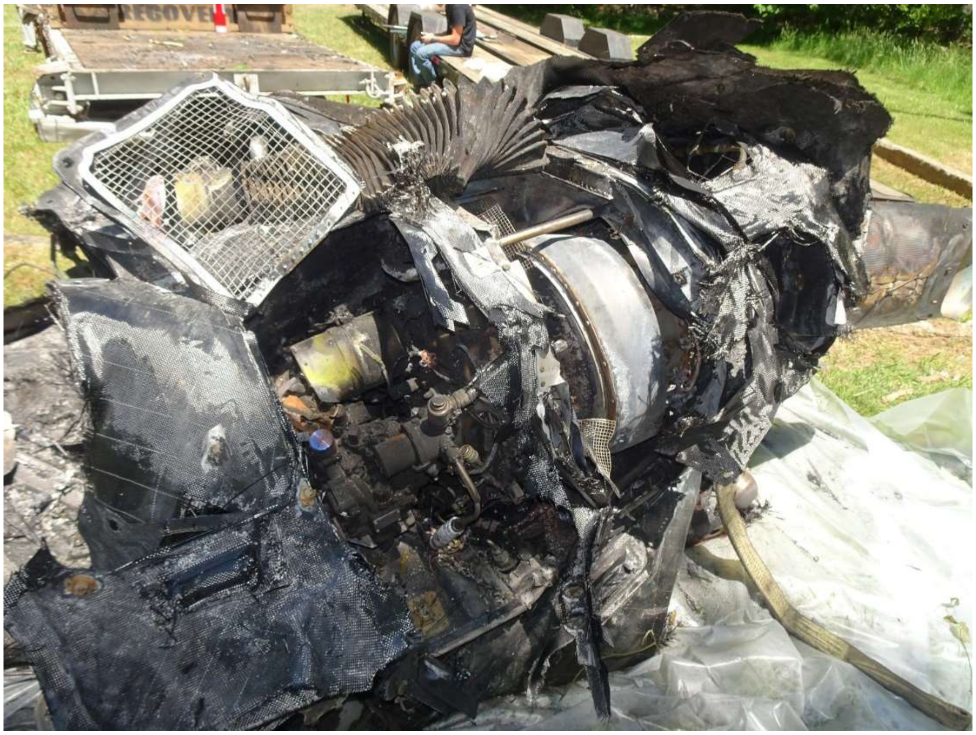

Figure 10. The No. 1 engine on the engine deck after removal from the main wreckage site. The inlet screen and barrier filter were removed by investigators.

The engine fuel filter bowl was removed and neither filter element nor bowl showed evidence of clogs or significant debris. A few drops of residual, clear-colored liquid was present within the fuel filter bowl. The exterior of the fuel filter bowl was covered in soot and its internal surfaces had a shiny color. Portions of the filter element had soot on it.

The magnetic chip detector and its housing were removed from the accessory gearbox and residual oil [from within the accessory gearbox] that drained had a clear, brown color. The chip detector was bent within its housing and could not be removed. The visible portions of the chip detector had no magnetic debris adhered to it. The oil filter bypass indicator was extended.[5] The oil filter bowl and filter element were removed. The oil filter bowl contained residual oil that had a clear, brown color with no debris present. The filter element also contained no significant debris.

The compressor was examined using a video borescope. All compressor blades were present with no significant damage to their leading edges. The power turbine was examined using a video borescope. All power turbine blades were present with no anomalous damage found on the blades.

The DCU and EEC from the No. 1 engine were removed and retained for further examination (see Section 3.0 of this report).

2.5.3 No. 2 Engine Wreckage Observations

The No. 2 engine remained installed on the engine deck and was thermally damaged (**Figure 11**). The inlet barrier filter remained installed on its frame and the inlet screen was intact. The inlet barrier filter was removed and the first stage compressor blades were examined and exhibited no damage to their leading edges. The No. 2 engine data collection unit (DCU) remained attached to the engine but its housing was thermally compromised, exposing its internal circuit card. The starter-generator was manually rotated and a corresponding rotation of the first stage compressor was observed. The engine output coupling was not able to be manually rotated. The No. 2 EEC remained attached to the airframe and its housing was covered in soot.

The engine fuel filter bowl was removed and the filter element was thermally degraded and covered in soot. No residual liquid was present within the fuel filter bowl and its interior surfaces had a blackened appearance.

The magnetic chip detector and its housing were removed and no residual oil drained after removal of the chip detector housing. The chip detector could not be removed from its housing. The chip detector had a hardened substance, likely thermally degraded oil, on its tip. The oil filter bypass indicator had not extended. The oil filter bowl was removed and a small amount of residual oil was present within the filter bowl. The filter element had a blackened appearance and contained no significant debris.

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[5] When the oil filter bypass indicator is retracted, the oil flows through the filter and the filter is not being bypassed. When the oil filter bypass indicator is extended, the filter is being bypassed.

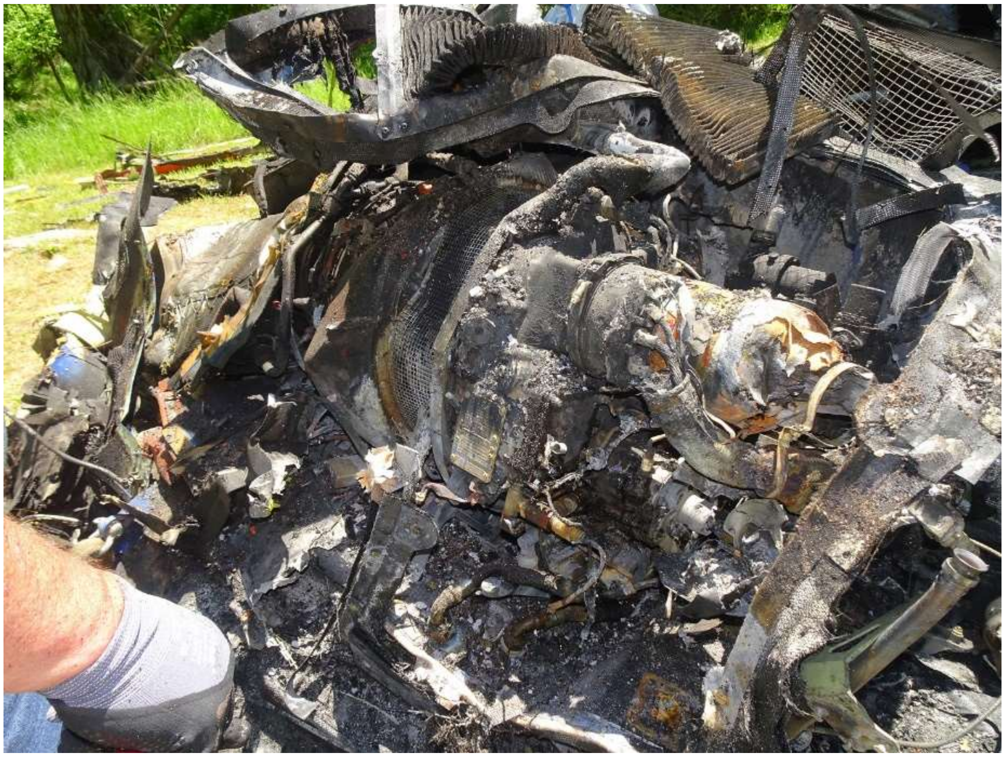

Figure 11. The No. 2 engine on the engine deck after removal from the main wreckage site. The inlet screen and barrier filter were removed by investigators.

The compressor was examined using a video borescope. All compressor blades were present with no significant damage to their leading edges. The power turbine was examined using a video borescope. All power turbine blades were present with no anomalous damage found on the blades.

The DCU and EEC from the No. 2 engine were removed and retained for further examination (see Section 3.0 of this report).

2.6 Miscellaneous Items

The cockpit was equipped with display units manufactured by the Astronautics Corporation of America. The display units were present in the cockpit wreckage but exhibited thermal damage. The standby attitude gyro was in the cockpit wreckage and was thermally damaged. The nose camera was not installed at the time of the accident, but its mount was found bent into the wire protection system's lower blade at the forward portion of the main wreckage. The helicopter was equipped with a health usage and monitoring system (HUMS), manufactured by GPMS. The HUMS data unit was found in the aft section of the fuselage and retained by the NTSB for further evaluation.[6]

[6] For additional details of the HUMS data download, see the Rotorcraft Condition Monitor Specialist's Factual Report in the docket for this investigation.

3.0 Engine DCU and EEC Download

The EECs and DCUs for both Nos. 1 and 2 engines were shipped to Pratt and Whitney Canada in Longueuil, Quebec, Canada to attempt a download of those units. The initial evaluation, conducted on May 31, 2021, revealed both DCUs and both EECs could not be downloaded through normal means due to damage of those units. Subsequently, the EECs and DCUs were shipped to the Transportation Safety Board of Canada in Gatineau, Quebec, Canada for forensic data recovery. In June 2021, evaluation of both EECs and both DCUs retrieved a limited dataset but ultimately the data was unusable for analysis due to corruption of the data.

4.0 Flight Control Servo Actuators

4.1 Initial Examination

The lateral servo actuator exhibited thermal damage. The system 1 return (forward-left position) hydraulic line was separated at its standoff. The remaining three hydraulic lines remained attached. The fixed end of the actuator was present. The power piston was bent and thermally damaged, but all attaching hardware was present. The lower power piston housing was fractured, with an outward directionality, and the power piston head was visible through this fracture. A remnant portion of the aft SCAS actuator remained attached to the input arm.

The longitudinal servo actuator was thermally damaged. The system 1 return (forward-left position) hydraulic line had fractured and separated at its attachment base. The remaining three hydraulic lines remained attached. The fixed end of the actuator was present and exhibited a slight twist. The power piston attaching hardware was present. A remnant portion of the aft SCAS actuator remained attached to the input arm. When the system 2 return line (aft-right position) was removed, debris that was fine in consistency and gray in color was present.[7]

The collective servo actuator was thermally damaged. The system 2 pressure (aft-left position) hydraulic line was fractured at its base and had separated. The remaining three hydraulic lines remained attached. The fixed end of the actuator had fractured and was partially melted at its aft end. A cap on the actuator housing, located immediately above the fixed end, had fractured, exposing its internal spring. The power piston attaching hardware was present. The input arm remained attached to the servo with a push-pull tube rod end remaining attached to the input arm.

The tail rotor servo actuator exhibited no significant thermal damage. All four hydraulic lines remained attached to the actuator. The actuator was whole with no

[7] Subsequent analysis of the debris by the NTSB Materials Laboratory found the particles to be consistent with aluminum oxide as well as silicon oxide. Additional details can be found in NTSB Materials Laboratory Report No. 22-051 in the docket for this investigation.

evidence of cracks or fractures. The directional control SCAS actuators were removed from the input arm at the accident site.

From July to August 2021, all four flight control servo actuators were imaged using computed tomography (CT), under the direction of the NTSB, at Varex, Inc. in Chicago Illinois.[8] Subsequently all four flight control servo actuators were shipped to Woodward, Inc. in Santa Clarita, California for examination.

4.2 Teardown Examination

From March 15-17, 2022, members of the Airworthiness Group convened at Woodward facilities in Santa Clarita, California to conduct a teardown examination of the flight control servo actuators.

4.2.1 Lateral Servo Actuator

There was no evidence of looseness on the pilot input stop and the upper manifold when wiggled by hand. All hardware and lockwire were present. A torque check of the bolts attaching the upper manifold to the cylinders found they were about 10 to 15 inch-pounds (in-lbs) except for one bolt. The pilot input stop bolts were about 15 in-lbs. The pilot input arm and stops were removed prior to removing the upper manifolds. The upper manifolds were separated from the cylinders. The transfer tubes were present and were not clogged. Thermally degraded O-rings and backup rings were present on the transfer tubes. The torque for the fixed support bolts were checked and found to be around 20-30 in-lbs.

The fixed support was removed from the cylinder housings, exposing the aft ends of the pistons. The two pistons were not aligned due to bending deformation of the pistons at their forward ends (the rod end side). The end glands had thermally degraded, black-colored material on their outer surfaces, similar to that observed on the right cyclic actuator's piston end glands. The lower cylinder housing had a long, gouge-type opening near the rod end side of the piston, and its end cap was slightly bulged outward (in the direction of the rod end, the system 2 side of the actuator). The two pistons were removed. The piston heads remained installed and there was no evidence of scoring or other anomalous damage on the piston aside from soot and discoloration from exposure to heat. The end glands were present, but their O-rings were thermally degraded.

The upper manifold of system 1 was disassembled. The main control valve (MCV) assembly, composed of the sleeve (outer component), the bypass spool (middle component), and the servo spool (inner component), was removed. The O-rings and backup rings were present but thermally degraded. The MCV was disassembled, and

[8] For additional details of the CT imaging of the flight control servo actuators, see the Computed Tomography Specialist's Factual Report in the docket for this investigation.

the servo spool and bypass spool were thermally tinted but had no evidence of scoring or other anomalous damage. All valve covers exhibited low torque during their removal. The differential relief valve was removed and a coarse, gray-colored particulate came out with the plunger and seat. The remainder of the valve component had no anomalous damage. The bypass check valve and the sequence/return shutoff and thermal relief valve were removed. All components within the valves were present and all O-rings and backup rings exhibited thermal degradation but were present.

The upper manifold of system 2 was subsequently disassembled. The MCV was removed and the O-rings were thermally degraded but the backup rings were present and mostly whole. The two inner sleeves were removed and they did not exhibit scoring or other anomalous damage aside from staining. All valve covers exhibited low torque during their removal. A portion of the inlet check and differential relief valve was removed. No remnant O-ring material was present on the cap. The seat for the differential relief valve could not be removed. The bypass check valve was removed. The seat had a piece of extruded backup ring on the outer surface. The remainder of the bypass valve showed no anomalous damage other than thermally degraded seals and O-rings. The sequence/return shutoff and thermal relief valve was removed. The required O-rings and backup rings were present and exhibited slight thermal degradation. The valve piece parts had no other anomalous damage.

4.2.2 Longitudinal Servo Actuator

The plate and two sleeves on the outboard side of the pilot input stop were not present and most likely melted due to the postcrash fire. Residual material, most likely from these sleeves, was present on the bolt threads. The pilot input arm was not able to be moved by hand. The attachment hardware for the pilot input stop was present with all safety wiring. The pilot input stop and the whole upper manifold was able to be wiggled by hand. The torque of the bolts holding the pilot input stop was checked with a torque wrench. All four bolts moved around 15 in-lbs. (Required to be 55-60 in-lbs.) The upper manifold bolts were checked with a torque wrench. The front-right bolt was about 45 in-lbs, the aft-right bolt was about 25 in-lbs. Both left-side bolts were around 15 in-lbs. The pilot input arm and stops were removed prior to removing the upper manifolds. The upper manifolds were removed. The O-rings for the transfer tubes were thermally degraded. The transfer tubes had residual material within but were not clogged. All hardware for the fixed support was present. The torque of the eight bolts were checked and were about 40 in-lbs, with one closer to 60 in-lbs. (Required to be 55-60 in-lbs.) Both the fixed support and the piston-side cylinder housing cap were removed, exposing both end glands on each side. A black-colored, thermally degraded material, likely the seals for the end glands, was found adhered to and extruded out of the end glands. Samples of this material were collected. Removal of the piston rod end was attempted but the hardware was seized, precluding further disassembly of the piston rod end. The piston was partially pressed out of the cylinder housings using an arbor press. The rod end-side end glands came out of the cylinder housing and were whole. Thermally degraded O-ring material was present on the end gland and the piston head surfaces. The pistons were removed from the cylinder housings and both the piston rod and piston head showed no anomalous damage aside from thermally degraded O-rings. The servo body interior had residual thermally degraded O-ring material, but no evidence of scoring or other anomalous damage. The upper cylinder housing had an anomalous indication at the contact face with the aft-side end gland. The upper cylinder housing was soaked in a solvent and a dye penetrant inspection was performed. The dye penetrant inspection found no evidence of cracks on the cylinder housing. On the upper manifold, the left- and right-side threaded covers for the input crank were removed and exhibited a slight bulge outward. The pilot input cover hardware was present. The torque of the four bolts for the pilot input cover was checked and all were around 15 in-lbs. The servo cover hardware was present. The torque of the four bolts for the pilot input cover was checked and all were around 15 in-lbs.

The upper manifold for system 1 was disassembled. The MCV assembly was removed. Thermally degraded O-rings and backup rings were present on the valve. The lands on the spool and sleeve showed no evidence of scoring or other anomalous damage. The inlet check and differential relief valve cap was removed and exhibited little torque. The outer portion of the differential relief valve was removed but the lower portion could not be removed.

The upper manifold for system 2 was subsequently disassembled. The MCV assembly was removed. The lands on the sleeves showed no evidence of scoring or other anomalous damage other than localized rust-colored corrosion. The inlet check and differential relief valve cap was removed and exhibited low torque. For the inlet check and differential relief valve, the poppet cage and seat could not be removed. The valve cap for the bypass check valve was partially removed by several threads, but then hung up and could not be removed. The cap for the sequence/return shutoff and thermal relief valve was removed and exhibited little torque. A portion of the valve was removed but the inner portion could not be removed.

4.2.3 Collective Servo Actuator

The pilot input stop and the upper manifold could be wiggled by hand when moderate force was applied. The lower cylinder housing was deformed slightly inward, about mid-length of the housing. The bolts attaching the pilot input stop exhibited low torque, under 5 in-lbs. The bolts attaching the cylinders to the upper manifold were around 35 in-lbs. The pilot input arm had to be pried off from the actuator. There was no damage to the square drive fitting to the input arm. The upper manifolds were removed from the cylinders. The transfer tubes were present with remnants of thermally degraded O-rings. The cylinder end plate was removed, revealing the [rod end side] end glands. The end glands had thermally degraded material on it. An attempt was made to remove the rod end, but the lower piston would not rotate while the upper piston's rotation was limited. The fixed support was removed from the cylinders, revealing the end glands. Thermally degraded material was present on the end gland surfaces, but no other anomalous damage to the end glands was observed. The upper cylinder was removed and its bore had no anomalous gouges or other damage aside from thermal damage. The piston and piston head was whole but had soot on its surfaces and was thermally damaged. The lower cylinder's piston was cut near the rod end using a band saw and the piston was removed using an arbor press. The piston head and piston did not exhibit anomalous damage aside from thermal damage. The cylinder bore had a silver-colored mark on its inner surface and damage near where the outer cylinder housing was dented inward. The servo control arm and nut were able to be removed by hand (the nylon locking feature of the nut melted off). The servo control arm was removed and exhibited no anomalous damage.

The upper manifold for system 1 was disassembled. The MCV assembly was removed. The bypass and servo spools were pressed out. Neither spool exhibited scoring or other anomalous damage aside from thermal tinting and soot. All O-rings and backup rings on the sleeve exhibited thermal degradation. The inlet check and differential relief valve was removed and all subcomponents were present. All O-rings and backup rings were thermally degraded. The bypass check valve was removed and all subcomponents were present. All O-rings and backup rings exhibited thermal degradation. The sequence/return shutoff and thermal relief valve was partially removed. The plunger spring was removed but not the plunger due to it being stuck.

The upper manifold for system 2 was subsequently disassembled. The MCV assembly was removed and the bypass and servo spools were pressed out. There was no scoring or other damage on the spools but they were thermally damaged. All O-rings and backup rings were thermally degraded on the sleeve, but the sleeve had no other anomalous damage. The input check and differential relief valve was removed and all subcomponents were present. All O-rings and backup rings were thermally degraded. The bypass check valve was removed and all subcomponents were present. All O-rings and backup rings were thermally degraded. The sequence/return shutoff and thermal relief valve was partially removed. The plunger spring was removed but not the plunger itself due to it being stuck.

4.2.4 Tail Rotor Servo Actuator

The torque of several attachment bolts were checked and were within 55-60 in-lbs. The test ports were removed and the piston was manually actuated to pump out any residual fluid within the servo. Residual fluid within systems 1 and 2 had an orange-pink colored appearance. The input arm was removed and had no anomalous damage. The upper manifolds were separated from the cylinders. The transfer tubes were in good condition and all O-rings and backup rings were present. The fixed support and rod-end side end plate were removed, exposing the end glands. The end glands were in good condition with no evidence of thermal damage. There was a small amount of particulate debris at the end gland scraper seal, most likely due to prior manual actuation of the piston (to remove fluid), the piston which had dirt on its surface. The rod end was separated from the piston and the pistons removed from their cylinders. Both pistons were in good condition. All O-rings and backup rings were present and in good condition. The control arm was removed and it exhibited no anomalous damage.

The upper manifold for system 1 was disassembled. The servo and bypass spools were removed. They had no anomalous damage and separated easily. The MCV sleeve was removed from the manifold body. All O-rings and backup rings were present and in good condition. There was no anomalous damage within the MCV manifold bore. The inlet check and differential relief valve was removed and its subcomponents were all present and in good condition. The bypass check valve was removed and its subcomponents were all present and in good condition. The sequence/return shutoff and thermal relief valve was removed and its subcomponents were in good condition.

The upper manifold for system 2 was subsequently disassembled. The servo and bypass spools were removed. They had no anomalous damage and separated easily. The MCV sleeve was removed from the manifold body. All O-rings and backup rings were present and in good condition. There was no anomalous damage within the MCV manifold bore. The inlet check and differential relief valve was removed and its subcomponents were all present and in good condition. The bypass check valve was removed and its subcomponents were all present and in good condition. The sequence/return shutoff and thermal relief valve was removed and its subcomponents were in good condition.

5.0 Maintenance

The accident helicopter was maintained by the operator under the manufacturer's recommended inspection program. A helicopter flight/maintenance log was kept in the helicopter and completed with each day's flight. Tracked information, such as ATT, engine starts and times, torque events, and landings, were completed for the start of the day and the end of the day. Any helicopter discrepancies would be annotated in the "remarks" section of the day's log and the maintenance department would be contacted to discuss those discrepancies. The log sheets were sequentially numbered.

A binder, containing helicopter flight/maintenance log sheets, was found at the accident site. Log sheet 1071, which was undated but presumably the day of the accident, showed that at the start of the day, the helicopter had an ATT of 283.5 hours and both engines had an engine total time of 283.5 hours. Log sheet 1070, dated April 27 (the day before the accident), showed the helicopter flew about 7.4 hours that day. In the "remarks" section of log sheet 1070, it was noted that ½ quart of engine oil was added to both the Nos. 1 and 2 engines and that the transmission oil pressure Crew Alerting System (CAS) message was intermittent. Attachment 1 contains log sheets 1070 and 1071 found in the wreckage.

According to maintenance records, the last recorded maintenance action performed on the accident helicopter was the replacement of the pilot's cyclic control friction cup and insert on April 15, 2021, at an ATT of 266.0 hours. The last scheduled inspections took place between February to March 2021, at an ATT of 265.1 hours. These scheduled inspections included the 200-hour, 600-hour, 800-hour, 1-month, and 12-month inspections. Additionally, FAA Airworthiness Directive 2019-06-04 and Bell Service Bulletins 429-19-47 and 429-11-03 were also accomplished. Attachment 2 contains the maintenance records of the last maintenance action that took place on April 15, 2021, as well as the last scheduled inspections that took place between February to March 2021.

In October 2020 and December 2020, various maintenance was conducted by Bell on the accident helicopter's hydraulic systems and flight control servo actuators. In October 2020, a discrepancy was reported of high hydraulic system pressure of 1,900 psi when the No. 1 engine was running.[9] Troubleshooting conducted at a Bell facility in Fort Lauderdale, Florida, found metal contaminant in the hydraulic system. According to a maintenance record entry dated October 12, 2020, at an ATT of 181.7 hours, the three main rotor servo actuators and the tail rotor servo actuator were removed and replaced with new servo actuators.[10] Additionally, the No. 1 hydraulic pump and its drive shaft were removed and replaced with a hydraulic new pump and drive shaft, all four hydraulic filters from the Nos. 1 and 2 IHMs were removed and replaced with new filters, and the No. 1 IHM was removed and replaced with a new IHM. After, the hydraulic systems were flushed, the IHMs were bled and serviced with Brayco 881 hydraulic fluid. On December 4, 2020, at a Bell facility in Piney Flats, Tennessee, at an ATT of 258.9 hours, the No. 2 hydraulic pump was removed and replaced with a new hydraulic pump. Attachment 3 contains the maintenance logbook entries for the hydraulic system work performed in October 2020 and December 2020.

E. LIST OF ATTACHMENTS

Attachment 1 – N53DE Helicopter Flight/Maintenance Log Sheet 1070 and 1071

Attachment 2 – N53DE Last Maintenance Action and Last Scheduled Inspections

[9] The hydraulic system pressure should normally be about 1,500 psi.

[10] The Bell 429 maintenance manual states that if a component is replaced or a change is made in the flight control system, that a rigging check must be performed. According to Bell, a rigging check was not performed after installation of the four servo actuators during this maintenance activity. Additionally, Bell stated that for the accident helicopter, there would have been no impact to the rigging of the helicopter if only the servo actuators were removed and replaced.

Attachment 3 – N53DE Hydraulic System Maintenance Actions on October 2020 and December 2020

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