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

ERA24FA003

AIRWORTHINESS FACTUAL REPORT

October 8, 2024

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A. ACCIDENT

Location: Croydon, New Hampshire
Date: October 8, 2023
Time: 1932 Eastern Daylight Time (EDT)
2332 Coordinated Universal Time (UTC)
Aircraft: Bell 407, N802JR

B. AIRWORTHINESS FACTUAL REPORT

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C. SUMMARY

On October 8, 2023, about 1932 eastern daylight time, a Bell 407 helicopter, N802JR, was involved in an accident near Croydon, New Hampshire. The commercial pilot was fatally injured. The helicopter was operated by JBI Helicopter Services under the provisions of Title 14 *Code of Federal Regulations* Part 91 as a positioning flight.

D. DETAILS OF THE INVESTIGATION

The accident helicopter was examined at the accident site on October 10, 11, 2023 by the NTSB and investigative team. The helicopter was recovered toa secure facility in Smithwick, MA. These notes contain the factual findings pertaining to the helicopter examination and its airworthiness.

E. WRECKAGE AND IMPACT INFORMATION

The wreckage was oriented on a southernly heading of about 193° and spanned about 485 ft from the initial impact point to the fuselage and engine. The initial impact point coincided with a tall pine tree about 100 ft tall. Evidence of broken tree branches and plexiglass were located at this point. Several additional broken tree branches were located along the wreckage path. All major components of the helicopter were located in the debris field and portions of the helicopter were heavily fragmented along the debris area.

Figure 1: Major components located in the debris field.

F. AIRCRAFT INFORMATION

The Bell 407 is a four-blade, single-engine, seven-place helicopter equipped with a Rolls-Royce 250-C47B, 650 SHP, reverse flow turboshaft engine, serial number CAE-848246. The accident aircraft, serial number 53971, was manufactured in January 2010.

According to the Hobbs meter the accident aircraft flight hours were 2,990.7. The engine had accumulated 2,781.9 hours. Aircraft logbooks and records were reviewed, and no anomalies were observed with their manufacturer inspection program.

The helicopter was equipped with an onboard image recorder, an Appareo Vision 1000. The Appareo Vision 1000 is a self-contained image, audio, and data recorder. The device was mounted in the overhead panel in the cockpit. It records an image at a rate of four times per second with its internal camera. A GPS receiver is included that receives GPS satellite-based aircraft time, position, altitude, and speed. The device has a self-contained real-time inertial measuring unit that records 3-axis acceleration, and derived pitch, roll and yaw data.

The unit recorded data, audio, and images during the accident flight. Refer to the NTSB public docket for an image recorder specialist report detailing the findings.

G. AIRFRAME EXAMINATION

Flight Controls

The cyclic and collective had been removed from the left side of the cockpit prior to the flight. The pilot cyclic (right side) was manipulated by hand showing corresponding movement of the control tubes to the right and left servo actuators. Control tube continuity was observed to all three servo actuators. There were multiple fractures of the control tubes aft of the servo actuators and continuity to the swashplate could not be determined. The right collective was manipulated by hand showing corresponding movement to the center servo actuator. The left side anti-torque pedals were present and appeared to be "locked-out." Directional control continuity was observed from the right-side anti-torque pedals to a fractured control tube aft of the servo actuators. There were multiple fractures of the control tubes aft of the servo actuators and continuity could not be established. All three main rotor servos remained attached to the support and hardware was present. No flight control issues were suspected.

Fuel System

The components of the fuel system, including the two fuel cells (forward and main), one electrically operated fuel boost pump, one electrically operated fuel transfer pump, fuel cell interconnect tubes, forward/aft quantity probes, fuel/vent lines, fuel shutoff valve, and the airframe fuel filter were substantially damaged by impact forces. A strong odor of fuel was present at the accident site. The components of the fuel system had separated from the airframe and were located in the debris path. The airframe fuel filter was present but could not be examined due to the damage to the fuselage.


Figure 2: Fuel system component (Bell Photo).

Hydraulics

The components of the hydraulic system, including the hydraulic pump and reservoir, 3 collective/cyclic servo actuators, 1 tail rotor servo actuator, hydraulic manifold, solenoid and relief valves, hose assemblies, and hydraulic filters were substantially damaged or destroyed by impact forces. All three main rotor servos remained installed on the roof structure and all hydraulic lines were connected.


Figure 3: Servo Actuators (Bell Photo).

Landing Gear

The landing gear and steps fragmented into several pieces due to contact with the trees and ground impact. All components of the skid landing gear were recovered.

Doors and Windows

All windows and doors were substantially damaged or destroyed by impact forces.

Fuselage

The vertical fin separated from the tailboom followed by the tail rotor gearbox. The vertical fin showed an impact mark on the lower section of the fin. The stinger was found separated from the tailboom. The components of the forward airframe (cockpit area) were substantially damaged by impact forces. The cockpit area of the forward fuselage section remained in an upright position. However, the intermediate section along with sections of the roof beam assembly/shell were found to be “upside down,” rotated 180° from the normal position. The tail boom separated just aft of the intercoastal support. The left horizontal stabilizer and finlet had separated from the tailboom. The right elevator remained in place but missing the finlet.

Figure 4: View of the fuselage and tail boom.

<u>Main Rotor</u>

The "Blue Blade" (P/N 407-015-001-137, S/N A-4617) remained attached to the blade grip and the yoke flexure separated from the yoke. The blade exhibited fracturing outside of the aft root closure where the spar was bent 90 degrees. The fracturing appeared to be consistent with a sudden stoppage due to contact with trees. Most of the blade after-body was missing. The tip weight remained attached. The remaining three main rotor blades were found attached to the yoke/mast where the fuselage was located. The remaining blades exhibited various degrees of damage, but the damage appeared to be decreasing by blade order (Orange, Red, and Green).

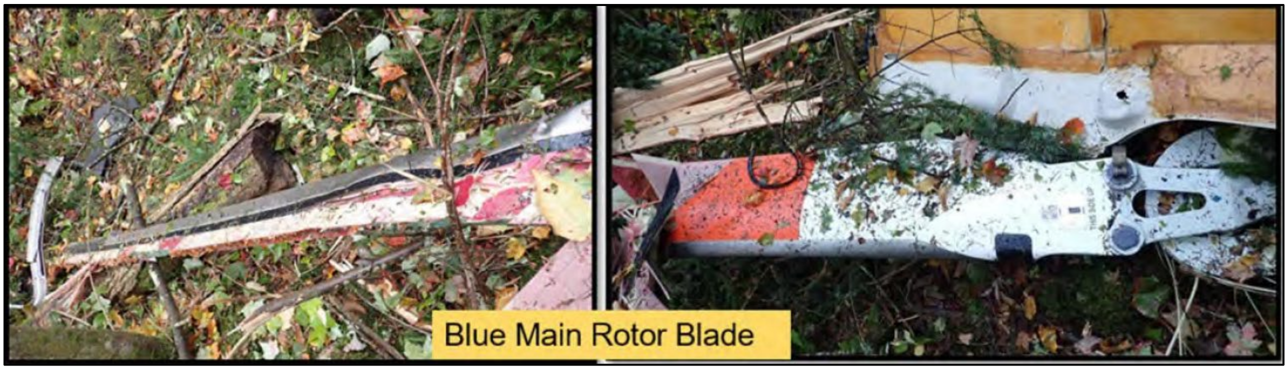

Figure 5: "Blue" Main Rotor Blades (Bell Photo).

Figure 6: "Orange, Red, and Green" Main Rotor Blades (Bell Photo).

<u>Main Rotor Drive System.</u>

There was no evidence of main rotor drive discontinuity prior to the accident sequence. The main transmission remained attached to the airframe. Main rotor continuity was not confirmed due to how the fuselage came to rest. The steel drive shaft was rotated by hand, in both directions, indicating freewheel unit operation and movement of the turbine section of the engine. Due to the resting position of the fuselage, the transmission could not be inspected.

<u>Tail Rotor</u>

The two tail rotor blades had fractured approximately 12 inches from the blade root. The tail rotor flap stops exhibited evidence of contact with the yoke assembly. The tail rotor pitch change links remained installed, were slightly deformed, and did not exhibit fractures. The tail rotor hub was unremarkable. The pitch of the tail rotor blades was manipulated by hand with appropriate control movement to the fractured control mechanism on the tail rotor gearbox.

Figure 7: Tail Rotor.

Tail Rotor Drive System

No pre-impact anomalies were observed with the tail rotor drive system. The aluminum tail rotor drive shafts were present. The #4 and #5 drive shaft segments remained attached to the tailboom. The #5 drive shaft segment had been pulled from the tail rotor gearbox. The #3 drive shaft segment had fractured in overload approximately 8 inches forward of the #2 segment. The #2 segment was present, but the forward end was pulled out and was attached to the #1 segment hangar bearing. The #1 segment was present, and the forward end remained attached to the oil cooler blower shaft.

Along the tail rotor drive shaft, multiple areas of rotational scoring were observed. The oil cooler blower shaft was rotated by hand. The tail rotor gearbox and tail rotor had separated from the tailboom support during the accident sequence. Rotation of the tail rotor gearbox was accomplished by turning the tail rotor yoke by hand. The rotation was smooth and exhibited no evidence of binding or restrictions. Oil was present within the tail rotor gearbox. The oil was of normal color with no abnormal smell. The tail rotor gearbox chip detector was removed and contained no magnetic particles.

Figure 8: Views of the tail rotor drive shaft.

H. ENGINE EXAMINATION

<u>Engine Information</u>

Engine Model:	Rolls-Royce 250-C47B
Rating:	650 HP
Serial Number:	CAE-848246
Engine Total Hours:	2779.5 Hours
Time Since Overhaul:	781.1 Hours

The aft fuselage, including the engine compartment, was found inverted and partially buried in mud. The main output drive shaft could be rotated by hand. Rotation was smooth, with no unusual binding or noise from the power turbine and N2 drive drain. Engagement/disengagement of the Spragg clutch was smooth and unremarkable. Manual rotation of the tail rotor drive output shaft produced similar results. Visual examination of the compressor revealed minor hard-body impacts to the compressor blades' leading edges, as well as several blades with tip bending in the opposite direction of rotation. Manual rotation of the compressor (N1) revealed the compressor rotated smoothly. The Electronic Control Unit (ECU) was located in the wreckage and removed. The ECU exhibited impact damage which breached the outer case.

The damaged ECU was shipped to Triumph (the ECU manufacturer) in West Hartford, Connecticut for detailed examination and data extraction.

ECU Investigation and Download

ECU Purpose and Operation

The ECU electronically monitors specific engine performance parameters and controls engine performance during normal engine operation. The ECU has a limited ability to store data and is not a ruggedized Flight Data Recorder. It is designed to ease pilot workload, and to assist maintenance personnel in diagnosing potential issues by storing engine performance data when certain engine parameters exceed pre-determined values.

Only when specific engine parameters are exceeded does the ECU record data to electronic memory. During normal engine operation, the ECU will hold performance data for 12 seconds, and then that data is over-written. However, if a parameter exceedance occurs, that 12 seconds of data is written to memory, and the ensuing 48 seconds of data is also stored. The result is the potential to capture 12 seconds of data before an exceedance occurs, as well as the ensuing 48 seconds of performance data after the exceedance occurs. This set of stored data is called Incident Recorder data, or IR data for short. The memory device where this data is stored is called an Electronically Erasable and Programable Memory, or EEPROM device. This data is stored on the EEPROM only until the engine has been shut-down and re-started three times, then the data is erased.

When the Incident Recorder is triggered by an exceedance, data is recorded at 1.2 second intervals (1.2Hz). Additionally, a single line of data is recoded at the moment an exceedance occurs, and is stored in a separate dataset called "Snapshot Data". Together, the IR data and Snapshot data can be combined to interpolate engine performance immediately prior to, as well as after an exceedance occurs.

Data Download and Examination at Triumph

The ECU was shipped to Triumph and remained in secure storage until November 14th, 2023, when the data was extracted under the auspices of the FAA.

In order to extract the data from the ECU, Triumph engineers opened the ECU housing, removed the EEPROM device and installed it into a slave unit. The data was then extracted using Triumph's Incident Recorder and Maintenance Terminal software.

The Incident Recorder data was truncated due to the accident's very rapid sequence of events. The ECU lost power before all 12 seconds of data preceding the IR triggering event could be written to the EEPROM. Six complete lines of IR data was recorded, along with one complete and one partial line of Snapshot data. This suggests the ECU lost power only moments after the accident sequence began. Therefore, only 4.8 seconds of data from before the triggering event, and a single line of data after the triggering event occurred were written to memory.

Data Examination

Numeric Record	Time Seconds	HH:MM:SS.mmm	Ng %Ng	Nr %Nr	MGT Deg	Q %Q	Np %Np	WfAct pph	NDOTFilt %Ng/Sec	P1 psia	Mode	CP %CP
1	0.000	0000:00:00.000	0	0	0	0	0	0	0	0	0	0
2	1.200	0000:00:00.000	0	0	0	0	0	0	0	0	0	0
3	2.400	0000:00:00.000	0	0	0	0	0	0	0	0	0	0
4	3.600	0000:00:00.000	0	0	0	0	0	0	0	0	0	0
5	4.800	0000:00:00.000	0	0	0	0	0	0	0	0	0	0
6	6.000	3220:38:35.808	99	100	1300	94	100	368	0.1	13.72	1	66
7	7.200	3220:38:37.008	99	100	1300	94	100	368	0.0	13.64	1	66
8	8.400	3220:38:38.208	99	100	1300	96	100	388	1.2	13.66	1	66
9	9.600	3220:38:39.408	99	100	1300	96	100	380	0.1	13.78	1	66
10	10.800	3220:38:40.608	100	99	1320	100	100	416	1.8	13.78	1	68
SNAPSHOT 1	11.230	3220:38:40.968	101	99	1340	110	97	388	2.2	13.73	1	62
11	12.000	3220:38:41.808	96	102	1240	78	102	216	-8.9	13.92	1	58
Partial Snapshot	0.000	0000:00:00.000	94	89	1160	90	88	248	-9.9	1.04		0

Figure 9: Download of incident recorder data.

The first five lines of IR data are blank, due to the truncation from the sudden loss of electrical power.

IR Data lines #6 through #10 record the 4.8 seconds of flight before the triggering event. This data indicate the engine is performing at or near 100% power. The engine is operating in "Normal Mode" (Mode 1) and is being governed by Power Turbine speed. The engine is responding normally to power demand and no faults are noted. Power Turbine speed (%Np) and Main Rotor speed (%Nr) track together, indicating normal power delivery to the main rotor system.

Data line #10: Collective Pitch (%CP) increases slightly, Main Rotor (%Nr) decreases slightly, Torque (%Q) and Power Turbine Speed (%Np) and Compressor Speed (%Ng) are all at 100%, while the engine is increasing fuel flow to near maximum flow.

The event that triggered the Incident Recorder was an exceedance of engine torque (%Q) of 110%. This exceedance is labeled SNAPSHOT 1. A Second (partial) line of SNAPSHOT data occurred shortly after the initial exceedance. Although power was lost to the ECU before a timestamp could be recorded for the line of data, the trends of the engine data suggest the second SNAPSHOT line occurred immediately after data line #11. The second SNAPSHOT was triggered by main rotor (Nr) droop of 89%.

Data line #11: This line of data indicates the engine continues to respond to rapidly changing power demands. Both Main Rotor (%Nr) and Power Turbine (%Np) speeds are at 102%, with the engine responding to the excessive speed by reducing fuel flow as rapidly as it can. (Data not shown in this chart: "INDOTWORD 23", which translates as "Stepper Motor Rate Limit"). The engine torque value (%Q) recorded at this time is significantly lower than previous lines. Combined, these data would indicate a sudden removal of a significant load on the engine, which would be consistent with separation of the tail rotor from the drive system.

The final line of partial SNAPSHOT data suggests the aircraft is breaking up as the data is being recorded. There is insufficient data to determine engine performance at this moment. However, the ambient air pressure reading (P1) of 1.04 PSIA is well outside of normal parameters and suggests the ECU is being damaged as the data is written. (The ambient air pressure sensor is located within the ECU housing).

From the Engine History data page, a peak toque value of 115.5% occurred during the accident flight, with engine torque exceeding 100% for a combined total of 23.23 seconds. (Simply exceeding 100% torque does not trigger the incident recorder, but the total time above 100% torque is recorded for maintenance purposes).

Based on data gathered from previous Bell 407 accidents, a sudden torque exceedance of less than 125% would be consistent with a tail rotor strike of a solid object. Main rotor strikes of solid objects typically produce much higher peak torque values. It should also be noted that the collective pitch (%CP) was not increased at the moment of the spike in torque value, which suggests the torque spike was caused by rotor impact, and not pilot-induced.

<u>Summary of Engine Findings</u>

All available evidence is consistent with normal engine operation throughout the flight, up until impact. No evidence of engine malfunction, fire or loss of performance during the flight was found. Data and physical evidence support the engine producing high power (at or near 100%) throughout the flight.

Submitted by:

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