Aviation Investigation Final Report

Location:	Fairfield, New Jersey	**Accident Number:**	ERA22FA257
Date & Time:	June 4, 2022, 12:01 Local	**Registration:**	N98ZA
Aircraft:	BELL HELICOPTER TEXTRON CANADA 407	**Aircraft Damage:**	Substantial
Defining Event:	Loss of control in flight	**Injuries:**	1 Serious
Flight Conducted Under:	Part 91: General aviation - Positioning		

Analysis

The pilot of the helicopter was conducting a positioning flight. About 5 minutes after departure, the onboard video recorder captured him saying, “what is going on here?” The pilot subsequently contacted air traffic control and requested to return to the departure airport, but he did not declare an emergency or state that he needed assistance. Upon initial contact with the tower controller at the destination airport, the pilot stated that he “might need the runway”; several minutes later, the controller cleared the pilot to land on the runway numbers. As the helicopter approached the airport and its indicated airspeed began to decay below about 30 knots, the helicopter entered a right yaw and completed several 360° rotations around the main rotor mast before impacting terrain next to the runway, resulting in substantial damage.

Postaccident examination of the helicopter revealed that the tail rotor crosshead drive plate, which was positioned behind the pitch change rod attachment nut, was not bolted to the tail rotor crosshead. The two attachment bolts were not present, and no remnants of any bolts were found in the threaded receptacles in the crosshead. The threads were undamaged and showed no signs of corrosion, deformation, smearing, or cross-threading, indicating that the attachment bolts were likely not installed.

The tail rotor was installed on the day before the accident after the replacement of four feathering bearings. The operator’s director of maintenance (DOM) performed the installation and had a mechanic verify that the mast nut torque was correctly applied. After the DOM completed the installation, another mechanic verified the work. A company maintenance pilot then completed a preflight inspection of the helicopter, ground functional checks, and three consecutive maintenance runs. The accident flight was the first flight after the completion of this work.

According to the DOM, between the mast nut torque application and completion of the installation, he was “called out” to consult on two different aircraft repairs. He did not recall the amount of time that had elapsed before he resumed the installation work. At some point during the installation, the DOM failed to properly secure the tail rotor crosshead drive plate. This error was subsequently not detected by the mechanic during his check of the DOM’s work, the maintenance pilot while balancing the tail rotor, or the accident pilot during the preflight check.

The helicopter experienced a loss of tail rotor antitorque control due to the separation of the crosshead drive plate, but the helicopter was still controllable at speeds at or above effective translational lift. It is likely that the increased efficiency of the main and tail rotors, the streamlining effect of the fuselage, and the increased effectiveness of the vertical stabilizer at cruise speed all prevented the helicopter from entering an uncontrolled yaw while the pilot was returning to the airport. However, the increased engine power required to slow the helicopter to perform a normal approach to a hover to land on the runway numbers resulted in a torque moment that could not be overcome given the loss of tail rotor antitorque control. A run-on landing, during which the pilot would have maintained a forward speed above effective translational lift, would have afforded greater yaw stability, and thus have increased the chance for a successful landing.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

The failure of maintenance personnel to properly secure the tail rotor crosshead drive plate and the failure of maintenance personnel, the maintenance pilot, and the accident pilot to detect the error, which led to the helicopter’s loss of tail rotor antitorque. Also causal was the pilot’s failure to maintain the helicopter’s airspeed at or above effective translational lift and perform a run-on landing, which resulted in a loss of control.

Findings

Aircraft	Tail rotor head - Incorrect service/maintenance
Personnel issues	Post maintenance inspection - Maintenance personnel
Personnel issues	Preflight inspection - Pilot
Aircraft	Airspeed - Not attained/maintained
Personnel issues	Aircraft control - Pilot

Factual Information

History of Flight

Enroute	Flight control sys malf/fail
Landing	Loss of control in flight (Defining event)

On June 4, 2022, about 1201 eastern daylight time, a Bell 407 GXP helicopter, N98ZA, was substantially damaged when it was involved in an accident near Fairfield, New Jersey. The commercial pilot was seriously injured. The helicopter was operated as a Title 14 *Code of Federal Regulations* Part 91 positioning flight.

The helicopter departed Essex County Airport (CDW), Caldwell, New Jersey, about 1147 for John F. Kennedy International Airport (JFK), Queens, New York. A review of automatic dependent surveillance-broadcast (ADS-B) data showed the helicopter in a cruise profile on a southeasterly track at an altitude of about 500 ft mean sea level (msl). Air traffic control data and review of the helicopter's Appareo Vision 1000 onboard recording system revealed that, about 1152, when the helicopter was about 2 miles south of Teterboro International Airport (TEB), Teterboro, New Jersey, the pilot stated, "what is going on here?" About 1 minute later, the pilot contacted the controller and requested to return to CDW. The controller asked the pilot if he needed assistance, and the pilot declined.

The helicopter turned left and proceeded toward CDW at an altitude of about 500 ft msl and an indicated airspeed of about 85 knots. About 1155, the pilot contacted the CDW tower controller and stated that he "may need the runway." The controller advised the pilot to report when the helicopter was 2 miles from the airport and expect runway 28 at CDW. About 1158, the pilot reported that the helicopter was 2 miles from the airport, and the controller subsequently cleared the helicopter to land "on the numbers" for runway 28. The pilot acknowledged. About this time, the helicopter's indicated airspeed was 95 knots, and the airspeed continued to decrease as the helicopter approached CDW.

About 1200, the helicopter crossed airport property with its nose slightly pitched up and an indicated airspeed that was decreasing below 65 knots. About 1201, at an altitude of 250 ft msl and with the runway visible (via the left chin bubble below the helicopter), the helicopter began yawing to the right as the indicated airspeed decreased below 35 knots. At that time, the helicopter was flying over a grass area north of and parallel to runway 28. The helicopter's right yaw increased significantly as its airspeed decayed below 30 knots.

When the helicopter was near the ground about treetop level, and an indicated airspeed of 0 knots, the right yaw ceased, and the helicopter began to yaw to the left and roll slightly to the left. The helicopter subsequently entered a rapid right yaw, pitched forward, and began to

descend as the helicopter rotated right around the main rotor mast. The helicopter completed several 360° rotations before impacting terrain north of runway 28, which caused substantial damage to the fuselage and tailboom, as shown in figure 1.

Figure 1. Helicopter after ground impact (Source: FAA).

Airport surveillance video captured the helicopter's approach, its alignment with the runway, and its decreasing airspeed as the nose pitched upward. The video showed that, as the helicopter slowed, its nose yawed to the right, and the helicopter became unstable and started to descend vertically while rotating around the main rotor mast. About 3 seconds into the vertical descent, the right yaw slowed and then stopped, and the helicopter rotated to its left as it descended and contacted the ground. After ground contact, the main rotor continued to turn, and the main rotor blades continued to strike the ground, shedding about 50% of the span of each blade.

Pilot Information

Certificate:	Commercial	**Age:**	33,Male
Airplane Rating(s):	None	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	4-point
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	Helicopter; Instrument helicopter	**Toxicology Performed:**	
Medical Certification:	Class 2 Without waivers/limitations	**Last FAA Medical Exam:**	March 24, 2022
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	872 hours (Total, all aircraft), 29 hours (Total, this make and model), 811 hours (Pilot In Command, all aircraft), 29 hours (Last 90 days, all aircraft), 29 hours (Last 30 days, all aircraft), 5 hours (Last 24 hours, all aircraft)		

In addition to his commercial pilot certificate with ratings for rotorcraft-helicopter and instrument helicopter, the pilot held a flight instructor certificate with the same ratings.

Review of the pilot's employee records revealed that he received 16 hours of initial ground instruction in the Bell 407 (including systems, performance planning, and emergency procedures) as well as general subjects such as meteorology and flight planning. He also received 5 hours of flight training and satisfactorily completed a Part 135 airman competency/proficiency check in the Bell 407 on May 16, 2020. The pilot demonstrated satisfactory knowledge of emergency procedures related to settling with power and tail rotor failure.

Aircraft and Owner/Operator Information

Aircraft Make:	BELL HELICOPTER TEXTRON CANADA	**Registration:**	N98ZA
Model/Series:	407	**Aircraft Category:**	Helicopter
Year of Manufacture:	2015	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	54635
Landing Gear Type:	Emergency float; Skid	**Seats:**	8
Date/Type of Last Inspection:	May 25, 2022 AAIP	**Certified Max Gross Wt.:**	5000 lbs
Time Since Last Inspection:		**Engines:**	1 Turbo shaft
Airframe Total Time:	2251.8 Hrs as of last inspection	**Engine Manufacturer:**	Rolls Royce
ELT:	C126 installed, activated, did not aid in locating accident	**Engine Model/Series:**	250-C47B/8
Registered Owner:	98ZA LLC	**Rated Power:**	650 Horsepower
Operator:	Zip Aviation	**Operating Certificate(s) Held:**	Commuter air carrier (135)
Operator Does Business As:	Zip Aviation	**Operator Designator Code:**	

According to the operator, the tail rotor was installed on the day before the accident after the replacement of four feathering bearings. The director of maintenance (DOM), who performed the task, stated that he conducted the tail rotor assembly installation by laying out the parts on a maintenance cart; performing the installation procedure, including the mast nut torque application; and having a mechanic verify the mast nut torque. He then finished the installation and had another mechanic verify the work. A company pilot performed a preflight inspection of the helicopter, ground functional checks, and three consecutive maintenance runs to balance the tail rotor. The accident flight was the first flight after completion of this work.

According to the DOM, between the mast nut torque application and completion of the tail rotor assembly installation, he was “called out” to consult on two different aircraft repairs. The DOM did not recall the amount of time that elapsed before he resumed the installation work.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KCDW,171 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	12:05 Local	**Direction from Accident Site:**	302°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	5 knots / None	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	260°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.88 inches Hg	**Temperature/Dew Point:**	26°C / 9°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Caldwell, NJ (CDW)	**Type of Flight Plan Filed:**	Company VFR
Destination:	New York, NY (JFK)	**Type of Clearance:**	VFR
Departure Time:	11:47 Local	**Type of Airspace:**	Class D

Airport Information

Airport:	Essex County Airport CDW	**Runway Surface Type:**	Asphalt
Airport Elevation:	172 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	28	**IFR Approach:**	None
Runway Length/Width:	3719 ft / 75 ft	**VFR Approach/Landing:**	Forced landing;Straight-in

Wreckage and Impact Information

Crew Injuries:	1 Serious	**Aircraft Damage:**	Substantial
Passenger Injuries:	N/A	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Serious	**Latitude, Longitude:**	40.877638,-74.275796(est)

Postaccident examination revealed that the tail rotor crosshead drive plate, which was positioned behind the pitch change rod attachment nut, was not bolted to the tail rotor crosshead, as prescribed in the maintenance manual. The two attachment bolts were not present, and no remnants of any bolts were found in their threaded receptacles in the crosshead drive plate, as shown in figure 2. The threads were undamaged and showed no signs of corrosion, deformation, smearing, or cross-threading.

Figure 2. Tail rotor crosshead/drive plate attachment bolt bore threads (Source: Bell Helicopters).

Main rotor flight control continuity was confirmed from the cockpit to several breaks to each respective rotor blade. Tail rotor control was confirmed from the pedals to breaks to the tail rotor gearbox to the pitch control rod. Movement of the pitch change push-pull tube resulted in smooth movement of the pitch change rod; the attached tail rotor crosshead drive plate moved with the pitch change rod but moved independently of the crosshead (to which the tail rotor crosshead drive plate was no longer bolted).

Additional Information

The *Bell 407 Rotorcraft Flight Manual*, "Emergency and Malfunction Procedures," section 3.5, Tail Rotor, stated the following:

> *There is no single emergency procedure for all types of anti-torque malfunctions. One key to a pilot successfully handling a tail rotor emergency lies in the ability to quickly recognize the type of malfunction that has occurred.*

The manual also stated that the indications of a loss of tail rotor thrust were (1) uncontrollable yawing to the right (left side slip), (2) nose-down tucking, and (3) possible roll of fuselage. The manual noted that the "severity of initial reaction of helicopter will be affected by AIRSPEED, CG [center of gravity], power being used, and H_D [density altitude]."

In addition, the manual stated the following about an in-flight complete loss of tail rotor thrust:

> *Reduce throttle to IDLE, immediately enter autorotation and maintain a minimum airspeed of 55 KIAS* [knots indicated airspeed] *during descent.*
>
> *Note: When a suitable landing site is not available, vertical fin may permit controlled flight at low power levels and sufficient airspeed. During final stages of approach, a mild flare should be executed, making sure all power to rotor is off. Maintain helicopter in a slight flare and smoothly use collective to execute a soft, slightly nose-high landing. Landing on aft portion of skids will tend to correct side drift. This technique will, in most cases, result in a run-on landing.*

The FAA's *Helicopter Flying Handbook*, FAA-H-8083-21B, chapter 11, Helicopter Emergencies and Hazards, stated the following:

> *An antitorque failure with a high-power setting at a low airspeed results in a severe spinning to the right. At low power settings and high airspeeds, the spin is less severe. High airspeeds tend to streamline the helicopter and keep it from spinning….*
>
> *A mechanical control failure limits or prevents control of tail rotor thrust and is usually caused by a stuck or broken control rod or cable. While the tail rotor is still producing antitorque thrust, it cannot be controlled by the pilot. The amount of antitorque depends on the position at which the controls jam or fail. Once again, the techniques differ depending on the amount of tail rotor thrust, but an autorotation is generally not required.*

The US Army Training Circular 3-04.4, "Fundamentals of Flight," stated the following:

> *According to Newton's law of action/reaction, action created by the turning rotor system causes the fuselage to react by turning in the opposite direction. The fuselage reaction to torque turning the main rotor is torque effect. Torque must be counteracted to maintain control of the aircraft; the antitorque rotor does this….*

> *Improved rotor efficiency resulting from directional flight is translational lift. The efficiency of the hovering rotor system is improved with each knot of incoming wind gained by horizontal movement or surface wind…. In addition, the tail rotor becomes more aerodynamically efficient during the transition from hover to forward flight. As the tail rotor works in progressively less turbulent air, this improved efficiency produces more thrust, causing the nose of the aircraft to yaw left (with a main rotor turning counterclockwise) and forces the aviator to apply right pedal…in response.*

As a result of this investigation, the operator developed a required inspection program, which was published and amended to the *General Operating Manual*. The program was submitted to the appropriate FAA Certificate Holder District Office, and the manual revisions were accepted.

Administrative Information

Investigator In Charge (IIC):	Rayner, Brian
Additional Participating Persons:	Thomas Mancuso; FAA (FSDO); Teterboro, NJ Jon-Adam Michael; Rolls Royce; Indianapolis, IN Gary Howe; Bell Helicopter; Ft. Worth, TX
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Last Revision Date:	
Investigation Class:	Class 3
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=105184

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