



Aviation Investigation Final Report

Location:	Elba, New York	Accident Number:	ERA22FA207
Date & Time:	April 26, 2022, 13:00 Local	Registration:	N507TJ
Aircraft:	BELL HELICOPTER TEXTRON CANADA 429	Aircraft Damage:	Substantial
Defining Event:	Abrupt maneuver	Injuries:	2 Fatal
Flight Conducted Under:	Part 91: General aviation - Instructional		

Analysis

The flight instructor was providing recurrent training to the operator’s pilots. During the first training flight of the day, a pilot who received instruction from the flight instructor described that the instructor told him to perform a vortex ring state (VRS) recovery maneuver, which the pilot accomplished, but shortly afterwards, the instructor requested that the pilot perform the maneuver again. During the second entry into VRS, the helicopter developed a very high descent rate, and the pilot was surprised when the flight instructor pilot did not intervene as the helicopter got deeper into the state. The pilot, feeling uncomfortable at that point, exited the very high descent rate on his own rather than waiting for further guidance from the instructor. The remainder of the first flight was uneventful.

The second training flight of the day was the accident flight. A review of the recovered parametric data for this flight showed that the helicopter had been performing training maneuvers, and that shortly before the accident the helicopter was operating within the VRS envelope with a vertical descent rate between -800 to -1,300 feet per minute (fpm). This was consistent with the instructor directing the accident pilot to enter VRS for training purposes. Shortly thereafter, multiple abrupt control inputs were recorded, which including a forward cyclic input, followed by a nearly full-aft cyclic input within 1 second, as well as a concurrent full-down collective input with an increasing left pedal input. Based on contact signatures found on the helicopter’s main rotor blades and tailboom after the accident, it is likely that these abrupt control inputs resulted in the main rotor blades contacting the tail boom and the subsequent in-flight breakup of the helicopter. The parametric data and physical evidence observed during a postaccident examination of the wreckage revealed no evidence of any mechanical malfunctions or failures of the helicopter that would have precluded recovery from VRS. Based on this information, the reasons why the pilot(s) might have applied these abrupt

control inputs could not be determined. Given the contextual commentary from the pilot of the previous training flight, it is likely the flight instructor did not provide adequate information to the accident pilot on how he would receive training for VRS, to include how they would identify, enter, and exit VRS.

Probable Cause and Findings

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

The pilots' inappropriate flight control inputs while in vortex ring state, which resulted in main rotor blade contact with the tail boom and a subsequent in-flight breakup. Also causal was the flight instructor's inadequate monitoring of the flight.

Findings

Personnel issues	Aircraft control - Pilot
Aircraft	Main rotor blade system - Capability exceeded
Personnel issues	Task monitoring/vigilance - Instructor/check pilot
Personnel issues	Delayed action - Instructor/check pilot

Factual Information

History of Flight

Maneuvering	Settling with power/vortex ring state
Maneuvering	Inflight upset
Maneuvering	Abrupt maneuver (Defining event)
Maneuvering	Part(s) separation from AC

On April 26, 2022, at 1300 eastern daylight time, a Bell Helicopter Textron Canada, 429, N507TJ, was substantially damaged when it was involved in an accident near Elba, New York. The flight instructor and pilot receiving instruction were fatally injured. The helicopter was operated as a Title 14 *Code of Federal Regulations* Part 91 instructional flight.

A representative of the operator stated that the instructional flight was recurrent training being conducted by the helicopter manufacturer's flight instructor with multiple training flights planned throughout the day; the accident flight was the second flight of the day. The first pilot who received training from the flight instructor on the morning of the accident flight stated that during their flight they entered vortex ring state (VRS) with a very high descent rate, which was confirmed by the flight data recovered from the accident helicopter. While in VRS, the pilot stated that he didn't know why they were going so deep into VRS and that the instructor was just sitting there, "hands on his lap." So, the pilot, feeling uncomfortable at that point, had to exit this very high descent rate on his own rather than waiting for further guidance from the instructor pilot.

The helicopter was equipped with an Electronic Data Recorder (EDR) within its Display Unit (DU), also known as the Pilot Flight Display and Multi-Function Display, that recorded flight, navigation, engine, and usage parameters every half second. It was also equipped with a SKYTRAC transceiver that facilitated real-time fleet awareness, group communications, and systems performance trending and analysis. The accident flight was also recorded by automatic dependent surveillance-broadcast (ADS-B).

ADS-B data, combined with the DU and SKYTRAC data sources, revealed that the accident pilot and the flight instructor departed Genesee County Airport (GVQ) Batavia, New York at 1111, and performed multiple maneuvers in the immediate vicinity of the airport before departing to the east. About 20 minutes later, the helicopter returned to the airport and performed additional maneuvers in the airport traffic pattern for about 30 minutes before again departing the traffic pattern. From about 1223 to 12:55, the pilot and instructor practiced single-engine training and dual-engine failure training with autorotations. These training maneuvers were completed about 4 minutes and 30 seconds before the accident occurred.

About 12:56, the helicopter was flying over the airport and turned north. About 12:58, the helicopter was approximately 2 nm north-northeast of the airport and began a clockwise circular pattern. From 12:59:26 to 12:59:44 (18 seconds), the helicopter was operating in an envelope conducive to VRS. At 12:59:47 there were multiple abrupt control inputs; the cyclic was nearly full forward and to the left with right antitorque pedal input applied. The collective lever position was in the full down position; the airspeed was decreasing from 26 knots to 9 knots with the helicopter's vertical descent rate increasing from -800 to -1,300 fpm.

Several eyewitnesses observed and heard the helicopter flying overhead before the accident and throughout the accident sequence. One stated that he observed the helicopter "almost stationary" after it flew over, and then as it started to fly away, he heard a loud "bang", and the helicopter began to descend out of control. An additional witness stated that the helicopter was hovering before it "fell apart" with the fuselage falling separately, and another witness stated she did not see the helicopter but heard what sounded like an engine making a "whooshing" sound, and then "three loud and rapid cracks" in succession. She further stated that she heard the helicopter impact the ground and heard the rotor blades striking the ground rapidly.

AIRCRAFT INFORMATION

The accident helicopter was maintained by the operator under the manufacturer's recommended inspection program. The last entry in the helicopter's airframe maintenance logbook was dated April 24, 2022, and reflected airframe and engine total times of 1,039.6 hours.

Each engine contained an electronic engine control (EEC) and a data collection unit (DCU). Attempts were made to recover stored data within these units, but no data could be recovered from the No. 1 engine EEC and DCU due to impact damage. However, data were recovered from the No. 2 engine EEC and DCU. The recovered data showed that there were no faults or exceedances recorded during the flight.

WRECKAGE AND IMPACT INFORMATION

The helicopter fuselage, containing the cockpit, engine, transmission, and rotor head assembly, struck electrical distribution wires as it impacted the terrain at an elevation of about 1,220 ft msl and was oriented on a heading of about 190°. The helicopter came to rest on its left side; the fuselage impacted the ground and crushed inwards and fractured into two large sections, leaving no occupiable space in the cockpit. A small post-impact fire developed in the engine compartment but was quickly extinguished by first responders. The wreckage path was about 2,500 ft-long and oriented in a direction of 250° magnetic from the first wreckage pieces towards the main fuselage resting place.

The tail boom had fractured and separated into two sections with angled fracture lines consistent with main rotor blade contact. The forward tail boom section remained attached to the upper section of the fuselage about 8 ft aft of the engine exhaust. The aft tail boom,

containing the tail rotor, partial drive shaft, vertical fin, and horizontal stabilizer remained largely intact and was discovered about 390 ft on a heading of about 075° from the main wreckage.

A 16-inch section of the tail rotor drive shaft cover and a partial carbon fiber tail rotor shaft was discovered 1,620 ft and a 072° heading from the main wreckage; it exhibited an angled slice line consistent with main rotor blade contact.

The tail rotor remained installed on the tail rotor gearbox, which itself remained installed on the separated empennage. The four tail rotor blades did not exhibit significant damage. The tail rotor input control was manually actuated and a corresponding change of pitch for all four tail rotor blades was observed. The tail rotor pitch control tube had fractured forward of the tail rotor gearbox and exhibited multiple fractures through its normal routing through the tail boom. The tail rotor servo actuator and stability and control augmentation system (SCAS) actuator remained installed and connected to the tail rotor pitch control tube. The forward tail rotor drive shaft remained connected to the main gearbox but had fractured about midway to the fan blower shaft. The fan blower remained installed on the airframe. The forward segmented drive shaft remained attached to the fan blower shaft and was continuous through the forward snubber but had fractured near its connection to the aft segmented drive shaft and the hanger bearing; the hanger bearing was not present. The aft segmented drive shaft had fractured near its forward end and at the tail gearbox input flange. A portion of the aft snubber remained attached to its snubber mount. The tail rotor gearbox remained installed on the empennage. The tail rotor was manually rotated through several 360° rotation of the tail rotor gearbox input flange and resulted in a corresponding rotation of the tail rotor. The rotation was smooth and there were no abnormal sounds or evidence of binding or other restrictions.

Examination of the flight control system consisting of the cyclic and collective push-pull tubes were traced through cuts made to facilitate recovery and overload separation damage to each of their respective servo actuators, cockpit controls, and their respective hydraulic system. The collective push-pull tube was continuous through the forward bellcrank up to the collective servo actuator. Control continuity was established between the collective servo actuator and the collective lever. The lateral cyclic push-pull tube was continuous to the forward bellcrank, to which the forward [of the two] roll SCAS actuators was attached. All the damage had features that were consistent with overload due to impact and aerodynamic forces. There was no anomalous preimpact damage or irregularity to the flight control system. Control continuity was confirmed for both collective, cyclic, and tail rotor directional control.

Examination of the hydraulic system consisting of two separate and independent pressurized hydraulic systems were used to assist cyclic, collective, and antitorque flight controls. All damage was consistent with impact; there was no preimpact anomalous damage or other irregularity noted in the hydraulic modules, actuator pumps, or associated systems.

Examination of all four main rotor blades, identified as 'orange', 'blue', green', and 'red', revealed they were separated from the main rotor head and discovered within the debris field northeast

of the main wreckage. The span of all four blades were recovered. The tip ends of all four blades exhibited impact marks. The 'red' main rotor blade afterbody was generally whole and its leading edge did not exhibit significant fractures. On the lower surface of the 'blue' main rotor blade, an impact gouge was present, its location (about 89 inches from the inboard blade bolt) and size was consistent with the antenna mounted immediately aft of the engine exhaust pipes.

The upper rod end of the 'blue', 'orange', 'red', and 'green' main rotor blade pitch change links (PCL) remained attached to its pitch horn but had fractured at their threaded connection to their respective PCL. The fracture on all four PCL upper rod end threads exhibited signatures consistent with overload and was deformed in the inboard direction. The lower rod ends of all four PCLs remained attached to the rotating swashplate but had fractured features consistent with overload. Three PCL bodies, 'orange', 'blue', and 'red', were recovered. The 'orange' PCL exhibited slight deformation of the link body. The 'blue' PCL exhibited no significant deformation. The swashplate assembly remained installed on the main rotor mast. The two rotating scissor link assemblies remained installed and attached between the rotating swashplate and the main rotor mast. All 4 rotor blades and their subcomponents were damaged by impact forces both during the initial flight breakup and through impact with the terrain.

The main rotor drive system gear box remained partially attached to the airframe, with both left and right longitudinal pitch restraints separated from their respective stops. Both input driveshafts could be manually rotated counterclockwise in the freewheeling direction but could not be manually rotated in the clockwise direction, likely due to impact damage.

Both engines were located within the main wreckage. The No. 1 engine's first stage compressor blade contained one individual blade that was bent in the direction of normal rotation and the leading edge contained several indentations and marks. The other blades appeared intact and free of impact or thermal damage. The power turbine blades visible through the engine exhaust did not exhibit anomalous damage or deformation, and all blades were present.

The No. 2 engine's first stage compressor blades exhibited impact damage and gouges on their leading edges. Scrapes were present on the inner housing of the first stage compressor blades in line with the blade tip path. The power turbine blades visible through the engine exhaust did not exhibit anomalous damage or deformation, and all blades were present. Postaccident examination of both engines and their respective components revealed no evidence of any preimpact mechanical malfunctions or failures that would have precluded their normal operation.

The engine switches in the cockpit located in the center below the glareshield exhibited minor deformation. The No. 1 engine switch was undamaged and functioned smoothly. It was discovered in the "OFF" position. The No. 2 engine switch was slightly bent and was

discovered in the "ON" position. No pre impact anomalies were observed with the avionics or the electrical system.

TESTS AND RESEARCH

A vehicle performance study was conducted using parametric data for the accident flight as well as the flight immediately preceding the accident flight. A VRS envelope for the Bell 429 was calculated based on the conditions of the day and the helicopter's estimated gross weight. The performance study determined that the helicopter had penetrated the VRS envelope on both the morning flight and the accident flight.

According to airframe manufacturer's analysis of the flight data, before entering an autorotation, the helicopter was flying a north-west heading and entered a right turn to stabilize in an eastern heading of about 100°. The helicopter entered a VRS condition as evidenced by an increased sink rate and low airspeed. At 12:59:44, a longitudinal rapid forward cyclic input from 32% (aft) to 70% (fwd) was recorded and the helicopter started pitching nose down from 4.6 degrees up to -17.05 degrees nose down. This was followed a second later at 12:59:45 by a rapid aft longitudinal cyclic input to 5.75% (0% being the aft longitudinal stop, 50% being a centered cyclic and 100% being the forward longitudinal stop). The rapid cyclic input recorded would not have allowed sufficient time for the airframe attitude to adjust to the main rotor inputs from the cyclic because of the rapid aft cyclic movement (-65% in 1 second).

A Vuichard exit method for VRS requires opposite side pedal to the lateral cyclic position. From the data analysis, the cyclic position was mostly aft and right while the pedal position was also to the right side before the rapid aft cyclic input. The collective position was 24.83% at the first forward cyclic input and down to 0.62% while the cyclic was quickly moved to a close to full aft position.

The airframe manufacturer also conducted a blade arc study. They placed the tail rotor drive shaft cover that was recovered from the accident helicopter on an exemplar helicopter. The resulting installation and measurements showed that the main rotor blades could contact the cover at the same position as observed on the accident wreckage, and that a further result would be main rotor blade contact with an antenna and the tail rotor drive shaft.

MEDICAL AND PATHOLOGICAL INFORMATION

The Office of the Medical Examiner, Monroe County, New York, performed autopsies of the instructor pilot and company pilot. Both pilots' causes of death were multiple blunt force injury and their manners of death were accidental.

ADDITIONAL INFORMATION

Vortex Ring State

According to the FAA's *Helicopter Flying Handbook* (FAA-H-8083-21B), a vortex ring state "describes an aerodynamic condition in which a helicopter may be in a vertical descent with 20

percent up to maximum power applied, and little or no climb performance." The handbook also states the following:

A fully developed vortex ring state is characterized by an unstable condition in which a helicopter experiences uncommanded pitch and roll oscillations, has little or no collective authority, and achieves a descent rate that may approach 6,000 feet per minute (fpm) if allowed to develop....

Situations that are conducive to a VRS condition are attempting to hover out of ground effect (OGE) without maintaining precise altitude control, and approaches, especially steep approaches, with a tailwind component.

According to the airframe manufacturer's training manual, when recovering from a VRS condition, the pilot tends first to try to stop the descent by increasing collective pitch. The traditional recovery is accomplished by increasing airspeed, and/or partially lowering collective to exit the vortex. Another method to recover from VRS, known as the Vuichard recovery technique, results in the quickest exit from VRS and requires the increase in collective to a climb power setting and the application of left pedal to maintain heading; simultaneously applying right cyclic to 20-degrees angle of bank - then back to wings level, to generate lateral movement. As soon as the advancing rotor blade reaches the upward flow of the vortex, the recovery is completed. This will be indicated by the VSI less than 300 fpm, and then apply cyclic and collective as necessary to return to the directed altitude and airspeed.

Vortex Ring State Training

According to the FAA's *Helicopter Instructor's Handbook* (FAA-H-8083-4), vortex ring state (also known as settling with power) can safely be introduced and practiced at altitudes allowing distance to recover. The handbook also states the following:

Ensure the student understands that settling with power can occur as a result of attempting to descend at an excessively low airspeed in a downwind condition, or by attempting to hover OGE at a weight and density altitude greater than the helicopter's performance allows....

Recovery is accomplished by...if altitude allows, reducing collective and lowering the nose to increase forward speed. This moves a helicopter out of its downwash and into translational lift. When the helicopter is clear of the disturbed air, or downwash, confirm a forward speed indication and initiate a climb to regain the lost altitude.

Flight instructor Information

Certificate:	Airline transport; Commercial; Flight instructor	Age:	60, Male
Airplane Rating(s):	Single-engine land; Multi-engine land	Seat Occupied:	Left
Other Aircraft Rating(s):	Helicopter; Unmanned (sUAS)	Restraint Used:	5-point
Instrument Rating(s):	Airplane; Helicopter	Second Pilot Present:	Yes
Instructor Rating(s):	Helicopter; Instrument helicopter	Toxicology Performed:	Yes
Medical Certification:	Class 1 With waivers/limitations	Last FAA Medical Exam:	March 18, 2022
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	
Flight Time:	(Estimated) 2850 hours (Total, all aircraft), 500 hours (Total, this make and model)		

Pilot Information

Certificate:	Airline transport; Commercial; Flight instructor	Age:	60, Male
Airplane Rating(s):	Single-engine land; Multi-engine land	Seat Occupied:	Right
Other Aircraft Rating(s):	Helicopter	Restraint Used:	5-point
Instrument Rating(s):	Helicopter	Second Pilot Present:	Yes
Instructor Rating(s):	Airplane multi-engine; Airplane single-engine; Helicopter; Instrument airplane; Instrument helicopter	Toxicology Performed:	
Medical Certification:	Class 2 With waivers/limitations	Last FAA Medical Exam:	August 25, 2021
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	
Flight Time:	6030 hours (Total, all aircraft), 580 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Make:	BELL HELICOPTER TEXTRON CANADA	Registration:	N507TJ
Model/Series:	429 NO SERIES	Aircraft Category:	Helicopter
Year of Manufacture:	2017	Amateur Built:	
Airworthiness Certificate:	Normal	Serial Number:	57332
Landing Gear Type:	Skid	Seats:	
Date/Type of Last Inspection:	April 24, 2022 Continuous airworthiness	Certified Max Gross Wt.:	7000 lbs
Time Since Last Inspection:		Engines:	2 Turbo shaft
Airframe Total Time:	1039 Hrs at time of accident	Engine Manufacturer:	Pratt & Whitney
ELT:	Installed, activated, did not aid in locating accident	Engine Model/Series:	PW207
Registered Owner:	MERCY FLIGHT INC	Rated Power:	
Operator:	MERCY FLIGHT INC	Operating Certificate(s) Held:	On-demand air taxi (135)

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	Condition of Light:	Day
Observation Facility, Elevation:	ROC,540 ft msl	Distance from Accident Site:	21 Nautical Miles
Observation Time:	12:54 Local	Direction from Accident Site:	81°
Lowest Cloud Condition:		Visibility	10 miles
Lowest Ceiling:	Broken / 3400 ft AGL	Visibility (RVR):	
Wind Speed/Gusts:	10 knots /	Turbulence Type Forecast/Actual:	/
Wind Direction:	290°	Turbulence Severity Forecast/Actual:	/
Altimeter Setting:	30.07 inches Hg	Temperature/Dew Point:	12°C / 4°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Batavia, NY (CVQ)	Type of Flight Plan Filed:	None
Destination:	Batavia, NY (CVQ)	Type of Clearance:	None
Departure Time:	11:10 Local	Type of Airspace:	Class G

Airport Information

Airport:	Genesee County Airport GVQ	Runway Surface Type:	
Airport Elevation:	910 ft msl	Runway Surface Condition:	
Runway Used:		IFR Approach:	None
Runway Length/Width:		VFR Approach/Landing:	None

Wreckage and Impact Information

Crew Injuries:	2 Fatal	Aircraft Damage:	Substantial
Passenger Injuries:		Aircraft Fire:	On-ground
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	2 Fatal	Latitude, Longitude:	43.063838,-78.139356

Administrative Information

Investigator In Charge (IIC):	Mccarter, Lawrence
Additional Participating Persons:	Matthew Rigsby; FAA AVP; Haslet, TX Beverly Harvey; Transportation Safety Board of Canada; Gatineau, OF Dennis Crandall; Mercy Flight Inc.; Buffalo, NY Benoit Albert; Bell Helicopters ; OF Merryn Spielman; Pratt and Whitney Canada; OF
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Investigation Class:	Class 3
Note:	
Investigation Docket:	https://data.nts.gov/Docket?ProjectID=105004

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