Aviation Investigation Final Report

Location:	Mechanicsburg, Pennsylvania	**Accident Number:**	ERA20FA074
Date & Time:	January 9, 2020, 20:29 Local	**Registration:**	N450MC
Aircraft:	Robinson R66	**Aircraft Damage:**	Destroyed
Defining Event:	Abrupt maneuver	**Injuries:**	2 Fatal
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The helicopter pilot was conducting a night cross-country flight in visual meteorological conditions. Recorded data showed that while the helicopter was flying at an altitude of about 2,300 ft mean sea level and at an indicated airspeed of about 107 knots, slight pitch and roll oscillations occurred for about 20 seconds followed by a left roll that continued until the helicopter was inverted. A main rotor blade contacted the tailboom, leading to an in-flight breakup over a residential area. Postaccident examination of the airframe, flight controls, and engine assembly revealed no evidence of a preimpact failure or malfunction.

Because the helicopter's pitch and roll values changed only minimally before the in-flight upset, the autopilot was likely engaged when the pitch and roll oscillations started. The pitch and roll oscillations might have been the result of the autopilot reacting to an external disturbance, specifically, the moderate-to-severe turbulence that was reported in the area. Another possible cause of the pitch and roll oscillations was the pilot manually manipulating the cyclic control. Additionally, an in-flight malfunction of the autopilot's roll servo actuator could not be ruled out as the source for the pitch and roll oscillations. While any of these scenarios might have precipitated the initial oscillations, none would have precluded the pilot from overriding the autopilot and manually flying the helicopter.

Even though the helicopter was equipped with devices that recorded flight and engine data at a rate of at least one parameter every second, the lack of an on-board crash-resistant cockpit imaging system precluded a determination of the pilot's actions, or lack of actions, in response to the pitch and roll oscillations. About 6 months after this accident, the National Transportation Safety Board issued a safety recommendation requesting that major helicopter manufacturers, including the manufacturer of the accident helicopter, install crash-resistant flight recorders with cockpit imaging systems for existing helicopters. The helicopter manufacturer responded that it incorporated a cockpit camera system as standard equipment on all similar model helicopters manufactured beginning the year after the accident and offered as a kit for existing helicopters the same year. The cameras were not designed to be crash-resistant.

The pilot was not likely impaired or incapacitated by his diagnosed obstructive sleep apnea given the information about his effective continuous positive airway pressure device use. Also, some or all the ethanol detected in the pilot's specimens might have been from a source other than ingestion. The possibility of an impairing or incapacitating medical event or impairing effects from the pilot's use of clonazepam (alone or in combination with ethanol effects) could not be determined from the available evidence. However, no operational evidence indicated that the pilot's performance was deficient during the flight time preceding the oscillations.

Probable Cause and Findings

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

A severe left roll excursion after the onset of pitch and roll oscillations, which were not arrested by the pilot for undetermined reasons. This resulted in main rotor blade contact with the airframe and a subsequent inflight breakup of the helicopter.

Findings

Personnel issues	Aircraft control - Pilot
Aircraft	(general) - Not attained/maintained
Not determined	(general) - Unknown/Not determined

Factual Information

History of Flight

Enroute	Abrupt maneuver (Defining event)
Other	Part(s) separation from AC
Uncontrolled descent	Collision with terr/obj (non-CFIT)

On January 9, 2020, about 2029 eastern standard time, a Robinson R66, N450MC, was destroyed after it was involved in an accident near Mechanicsburg, Pennsylvania. The private pilot and the passenger were fatally injured. The helicopter was operated as a Title 14 *Code of Federal Regulations* Part 91 personal flight.

According to a chronological summary of flight communications prepared by the Federal Aviation Administration (FAA), about 1954, the pilot contacted ground control at Martin State Airport (MTN), Baltimore, Maryland, and requested visual flight rules (VFR) flight following to Buffalo Niagara International Airport (BUF), Buffalo, New York, at 3,000 ft mean sea level (msl). About 1957, the pilot contacted local control at MTN and advised that the flight was ready to depart, and was then approved to do so. About 1959, the pilot was instructed to contact Potomac Approach Control.

According to FAA automatic dependent surveillance-broadcast (ADS-B) data and a transcription of audio communications, the helicopter climbed to about 2,300 ft msl and proceeded on a north-northwesterly track. The helicopter remained at that altitude and on that track from about 2002 to 2023, during which time the pilot made initial contact with the Harrisburg approach sector. At 2023:15, the controller instructed the pilot to fly along a heading of 310°, and the helicopter turned to a northwest heading, consistent with the instruction. The helicopter's altitude remained about the same until 2028:50, at which time the helicopter began descending. About 2029, radar contact with the helicopter was lost, and the controller attempted to contact the pilot but received no response. Also about 2029, the Harrisburg approach radio frequency recorded a "grunt-type sound" from an unidentified source. The last radar target, at 2029:17, showed that the helicopter was at an altitude of about 1,150 ft msl.

The helicopter was equipped with a Garmin GTN 750, a Garmin GDU 1060, and an engine monitoring unit (EMU), which recorded data at a rate of at least one sample per second. The synchronized downloaded data from the devices depicted that the final portion of the flight contained no pitch or roll excursions, nor any significant heading changes until about 2028:46 (which was 29 seconds before the end of the GDU 1060-recorded data and 32 seconds before the end of the EMU-recorded data). Immediately before that time, pitch was steady at -3°, roll was steady at near-zero values, and the engine's torque was about 58%. From 2028:46 to 2029:05, the helicopter's pitch began to oscillate slightly and eventually reached -12°, and the helicopter began to roll to the left with an increasing rate, reaching about 8 to 10° between

2029:03 and 2029:05. After 2029:05, the left roll continued to increase quickly (within about 5 to 7 seconds); during the rapid left roll, the engine torque spiked briefly and then decreased. At 2029:06, the normal acceleration parameter trended negatively during the next 3 seconds, reaching -1 G.

Between 2028:07 and 2029:07, the average indicated airspeed was about 107 knots. During the same timeframe, the average recorded G loading was -0.035, with the G loading decreasing afterward to -1 with the corresponding left roll. One second later, at 2029:08, the indicated airspeed was zero.

At 2029:10, the helicopter's left roll was about 119°, pitch was -8°, and engine torque was about 30%; 1 second later, the helicopter was in a left roll of 179° and a -23° pitch, and the engine torque increased to 64%. This time corresponded with the grunt sound that was recorded by the Harrisburg air traffic control facility. Between 2029:11 and 2029:12, the helicopter's pitch decreased to -46°, the torque decreased to about 35%, the power turbine speed (N2) increased from 98% to 101%, and the left roll continued past 180° (inverted) to 114° to the right.

At 2029:13, the helicopter's pitch was -58°, roll was 126° right, N2 was about 99%, and torque was about 32%. One second later, the helicopter's pitch was -36°, N2 was about 75%, and torque was at about 13%. At 2029:15, the helicopter's N2 was about 128% (overspeed), and the torque was about 1%. The last ADS-B target about 2029:17 depicted the helicopter being at about 1,150 ft msl. At 2029:18, the compressor speed, N2, and torque values were 72%, 111%, and less than zero, respectively.

A witness, who was outside and located about 986 ft east of the accident site, reported hearing and seeing a low-flying helicopter that was "struggling to fly." The witness reported hearing a high-pitched noise that sounded as if the rotor was having difficulty turning, and then she heard a loud "boom" and saw a flash of light. At that point, the helicopter disappeared from her view.

Another witness who was in his house located about 800 ft northeast of the accident site reported hearing a "thumping" sound that slowed. The witness then heard a loud "bang," which shook his house. The witness also reported hearing a "percussion" sound before the sound of impact. His house had a doorbell video camera that also recorded audio; the video camera was provided to the National Transportation Safety Board (NTSB) for examination. (See the Video Study section of this report for further information.)

Pilot Information

Certificate:	Private	**Age:**	58,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	
Instrument Rating(s):	None	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	November 4, 2013
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	July 23, 2019
Flight Time:	(Estimated) 2042 hours (Total, all aircraft), 167 hours (Total, this make and model), 1700 hours (Pilot In Command, all aircraft)		

During 2001 and 2009, the pilot was diagnosed with obstructive sleep apnea and coronary artery disease, respectively. According to documentation provided to the FAA, cardiac catheterization had shown mild-to-moderate triple-vessel coronary artery disease that did not require stenting or surgery, and the pilot did not have any typical symptoms of related heart pain or congestive heart failure.

Medical records from the pilot's most recent visit to his primary care provider on November 27, 2019, showed that the pilot was using a continuous positive airway pressure (CPAP) device to treat his sleep apnea with good adherence and symptom control. The records also showed that the pilot was not adhering to treatment for high blood pressure but that he had no cardiovascular symptoms and a blood pressure of that was slightly higher than his goal.

During the year preceding the accident, the pilot used his CPAP 85% of the time with an average use of 8 hours 6 minutes. During the 7 days preceding the accident, the pilot used his CPAP every night with an average use of 7 hours 38 minutes per night and 8 hours 6 minutes of use on the night before the accident.

According to records provided by Robinson Helicopter Company, the pilot attended a safety course in February 2019 for the R66. At that time, the pilot had not accumulated any hours in the R66. On the evaluation document, the instructor indicated that the pilot had "very good control" of the helicopter when performing normal and emergency procedures and that he was "very comfortable practicing the [autorotations]." The instructor suggested that the pilot obtain more training on emergency procedures. The pilot was rated "average" on all demonstrated maneuvers.

Aircraft and Owner/Operator Information

Aircraft Make:	Robinson	**Registration:**	N450MC
Model/Series:	R66 No Series	**Aircraft Category:**	Helicopter
Year of Manufacture:	2019	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	0916
Landing Gear Type:	Skid	**Seats:**	5
Date/Type of Last Inspection:	January 28, 2019	**Certified Max Gross Wt.:**	2700 lbs
Time Since Last Inspection:	163 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	167 Hrs at time of accident	**Engine Manufacturer:**	Rolls-Royce
ELT:	C126 installed, not activated	**Engine Model/Series:**	250-C300/A1
Registered Owner:	On file	**Rated Power:**	224 Horsepower
Operator:	On file	**Operating Certificate(s) Held:**	None

The helicopter was manufactured in January 2019 and was purchased shortly afterward by a company associated with the pilot. At the time of the accident, the hour meter indicated about 167 hours. The helicopter was equipped with a semirigid rotor system that rotated counterclockwise (when viewed from above). According to Robinson Safety Notice (SN) 11, Low-G Pushovers – Extremely Dangerous, pushing the cyclic forward following a pull-up or rapid climb, or even from level flight produces a low-G (weightless) flight condition. The notice goes on to state that if forward cyclic is applied, the main rotor torque reaction will then combine with tail rotor thrust to produce a powerful right rolling momement of the fuselage.

The helicopter was equipped with a Genesys Aerosystems HeliSAS two-axis autopilot system comprised of a flight control computer, HeliSAS control panel, and two servo-actuators (one each for the pitch and roll axes). The autopilot system was designed to record faults in the system. The downloaded data were unrecognizable by the manufacturer; therefore, no accident-related data were available from the HeliSAS.

According to the R66 Pilot's Operating Handbook Supplement for the HeliSAS,

> *The primary autopilot mode is stability augmentation system (SAS) mode which maintains a steady helicopter attitude by applying corrective inputs to the cyclic. The autopilot does not provide any collective or pedal inputs. Additional modes providing heading hold, altitude hold, and navigation functionality are also selectable.*

The SAS mode of the autopilot was engaged by pressing either the SAS button on the control panel or the trim button mounted on the cyclic for more than 1.25 seconds. With the SAS mode engaged, the pilot can "fly through" the SAS to achieve a desired attitude and can subsequently press and release the trim button to reset the baseline attitude for the system to the current attitude. Pushing the SAS button on the control panel or the "AP [autopilot] OFF" button on the cyclic disengages the SAS mode (for manual control), and four aural beeps would sound in the pilot's headset. Additionally, the HeliSAS is designed to automatically disengage when one of several predefined faults or malfunctions is detected, which would also produce four aural beeps in the pilot's headset. Disengagement of an autopilot mode, such as heading or navigation, not commanded by the pilot (caused by, for example, the loss of a valid navigation signal) would be accompanied by a single beep in the pilot's headset. Any intentional disengagement of an autopilot mode other than SAS would not trigger a beep sound in the pilot's headset (because SAS mode would remain engaged).

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Night
Observation Facility, Elevation:	CXY,347 ft msl	**Distance from Accident Site:**	8 Nautical Miles
Observation Time:	20:30 Local	**Direction from Accident Site:**	94°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	7 knots / None	**Turbulence Type Forecast/Actual:**	Unknown / Unknown
Wind Direction:	110°	**Turbulence Severity Forecast/Actual:**	Unknown / Moderate
Altimeter Setting:	30.67 inches Hg	**Temperature/Dew Point:**	-2°C / -10°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Baltimore, MD (MTN)	**Type of Flight Plan Filed:**	Unknown
Destination:	Buffalo, NY (BUF)	**Type of Clearance:**	VFR flight following
Departure Time:	19:58 Local	**Type of Airspace:**	

According to the NTSB's weather study, at the helicopter's cruising altitude of about 2,300 ft, the wind was from about 190° at 27 knots. At that altitude, there was an 87% probability of moderate-to-severe turbulence. The study also indicated that pilot reports confirmed strong-to-severe low-level windshear and moderate-to-severe turbulence between 2,300 and 3,000 ft over the accident area during the overnight and early morning hours. The Robinson Helicopter *Pilot's Operating Handbook* and the FAA-approved *Rotorcraft Flight Manual* recommended an indicated airspeed range between 60 and 70 knots during significant turbulence.

The closest National Weather Service Weather Surveillance Radar-1988 Doppler radar over the region showed no precipitation echoes along the flightpath or the accident site during the time surrounding the accident.

At the time of the accident the Sun had already set, and the Moon was approximately 49° above the horizon at an azimuth of 95° and was 99% illuminated.

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	1 Fatal	**Aircraft Fire:**	None
Ground Injuries:		**Aircraft Explosion:**	None
Total Injuries:	2 Fatal	**Latitude, Longitude:**	40.227779,-77.020278

The helicopter crashed in a residential area that was located about 61 miles north-northwest of MTN. The main wreckage area, consisting of the fuselage, was located in the backyard of a residence. The fuselage was nearly inverted and was resting on its right side along a magnetic heading of 334°. The fuselage structure was not damaged, but the windshield bow had extensive impact damage. The bow retained its shape but was fractured at the roofline, and the windshield had fractured. Sections of windshield pieces remained attached to the bow. A portion of the tailboom was located about 30 to 40 ft above ground level in a tree next to the fuselage resting location. A ground scar about 10 inches deep was located about 30 ft from the nose resting position.

Wreckage consisting of a section of a main rotor blade, the main rotor mast with attached sections of a main rotor blade, the tail rotor, the tail rotor control tubes, airframe structural tubes, and plexiglass were found away from the main wreckage, with the farthest located about 700 ft away. No evidence of pre- or postimpact fire was found on any portion of the wreckage. No bird remains or feathers were found in the main wreckage consisting of the fuselage, or in locations of the separated main rotor mast and tail rotor gearbox.

A main rotor blade section that was about 5 ft long was located on the ground near the trunk of a small tree in the front yard of a residence; the blade section was located about 700 ft and 161° from the main wreckage. The leading edge of the blade was embedded into the ground, and the trailing edge of the blade was curved and exhibited red and black paint transfer on the upper surface near the fracture surface. Several feathers were found on the ground adjacent to the blade and near the tree, and several feathers were found adhered to the blade. The feathers and swabs of debris that had adhered to the separated portion of the main rotor blade were analyzed by the Smithsonian Institution’s Feather Identification Lab. The feathers were matched to museum specimens of a mourning dove, and the swabs of debris did not contain bird remains.

Examination of the tail rotor drive, tail rotor flight controls, and main rotor flight controls revealed no evidence of preimpact failure or malfunction. Examination of the tailboom, which consisted of 7 bays, revealed damage to several of the bays. A horizontal dent was noted on the left side to the lower surface of bays 5, 6, and 7; the dent was consistent with contact with the leading edge of the blue main rotor blade. The rivet spacing of the tailboom in that area matched the indentations made in the blue main rotor blade. The tailboom was fractured at the aft bulkhead (bay 7). Yellow paint transfer was noted between bays 6 and 7 on the bottom.

Slight paint transfer was noted on the left side of bay 4. An impact area (which had partially ruptured and was flattened) was noted on the left and lower side of bay 3. Bays 2 and 3 exhibited red, black, and yellow paint transfer on the left side.

Examination of the engine revealed that all engine mounts were fractured in a manner consistent with overload. The engine-to-transmission shaft was fractured on both ends, and the shaft tube was found within the wreckage. This shaft's forward flange remained attached to the forward flex plate and main gearbox input yoke, and its aft flange remained attached to the aft flex plate and sprag clutch. All fractures on the shaft had signatures consistent with overstress failure. The engine bay cowling was crushed tightly around the engine, consistent with impact in a tail-low inverted attitude. All engine control fittings (including pneumatic, electronic, and oil lines; B-nuts; clamps; and associated hardware) were checked by hand and found to be at least hand tight. All B-nuts were marked with blue and/or white torque paint. The engine and its systems showed no evidence of preimpact failure or malfunction.

The sprag clutch remained installed onto the engine accessory gearbox. The clutch was operationally checked by hand and performed satisfactorily. The clutch was also examined using computed tomography and was then partially disassembled and examined at the NTSB's Materials Laboratory in Washington, DC. Both examinations revealed no evidence of preimpact failure or malfunction.

The main rotor mast and the upper portion of the main gearbox housing were found separated from the main wreckage. Examination of the fracture surfaces on the main rotor gearbox housing showed no evidence of progressive cracking.

Components of the autopilot system were removed from the helicopter and operationally tested at the manufacturer's facility. Both the flight control computer and the HeliSAS control panel functioned normally. Operational testing of the pitch servo actuator could not be performed likely due to a damaged wire within a wire bundle leading to the motor. The pitch servo actuator was then disassembled and examined, which revealed that the shrink-wrapped wire bundle sleeve was partially dislodged from the motor housing, exposing some of the wires, one of which was cut. Surface corrosion was noted on the magnet and friction plate.

The roll servo actuator passed the resolver test and the acceptance test protocol. The roll servo actuator was connected to an exemplar flight control computer and HeliSAS control panel but failed the system-level test, which included driving the servo clockwise and counterclockwise as well as manually back-driving the servo clockwise and counterclockwise. No obvious visible damage was observed on the servo actuator motor's wire bundle, but internal damage to the wires could have resulted in a failure of the system-level test. The autopilot manufacturer did not have the capability to perform electrical testing of the roll servo actuator motor and its wire bundle.

Medical and Pathological Information

An autopsy of the pilot was performed by Forensic Pathology, Cumberland County Coroner's Office

Additional Information

Video Study

The NTSB conducted a video study using a 22.8-second doorbell camera video. The helicopter became visible in the video at 8.5 seconds and was last seen in the video at 15.3 seconds.

The study analyzed the first 19 seconds of audio recorded by the doorbell camera video. The study revealed the pattern of spectral peaks generated by the interaction of the tail rotor and main rotor wake were present through the first 12 seconds of the video, indicating that both main and tail rotors were operating at their normal rotational speeds through that time. After that time, the contribution of the main rotor to the sound spectrum was no longer present. The study also showed that, between 11 and 13 seconds into the video, a large signal level was recorded. The study determined that the large signal level was likely due to the separation of the main rotor from the airframe and was the transient event that significantly changed the spectral characteristics of the engine sound.

Personal Electronic Devices

Two iPhones were found at the accident site were sent to the NTSB's Vehicle Recorder Laboratory in Washington, DC. The laboratory found that the pilot's last incoming phone call was received at 2008:18, about 11 minutes before the accident, and lasted 2 minutes 53 seconds. The pilot's last sent text message was at 2010:20, and his last incoming text message was read at 2010:28. The pilot's cellular phone had navigation and weather applications running in the background, but the contents of those applications could not be decoded. No data pertinent to the accident were found on the passenger's phone.

Previous Related Recommendation

The helicopter was not equipped, and was not required to be equipped, with a flight data recorder or a cockpit voice recorder. The NTSB recommended in June 2020 to international and domestic helicopter manufacturer's, including Robinson Helicopter Company, to install on existing turbine-powered helicopters that are not equipped with a flight data recorder or cockpit voice recorder a means to install a crash-resistant flight recorder system that records cockpit audio and images with a view of the cockpit environment to include as much of the outside view as possible and parametric data per aircraft and installation. Robinson responded that it incorporated a cockpit camera system as standard equipment on all R66 helicopters manufactured beginning in 2021 and offered as a kit for existing helicopters that same year. The camera system was not crash-resistant.

Administrative Information

Investigator In Charge (IIC):	Monville, Timothy
Additional Participating Persons:	William Gossley; FAA/FSDO; Harrisburg, PA David A Gerlach; FAA AVP-100; Washington, DC Thom Webster; Robinson Helicopter Company; Torrance, CA Jack Johnson; Rolls-Royce Corporation; Indianapolis, IN Stephen Joseph; Genesys-Aerosystems; Mineral Wells, TX
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Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=100796

The National Transportation Safety Board (NTSB) is an independent federal agency charged by Congress with investigating every civil aviation accident in the United States and significant events in other modes of transportation—railroad, transit, highway, marine, pipeline, and commercial space. We determine the probable causes of the accidents and events we investigate, and issue safety recommendations aimed at preventing future occurrences. In addition, we conduct transportation safety research studies and offer information and other assistance to family members and survivors for each accident or event we investigate. We also serve as the appellate authority for enforcement actions involving aviation and mariner certificates issued by the Federal Aviation Administration (FAA) and US Coast Guard, and we adjudicate appeals of civil penalty actions taken by the FAA.

The NTSB does not assign fault or blame for an accident or incident; rather, as specified by NTSB regulation, "accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties … and are not conducted for the purpose of determining the rights or liabilities of any person" (Title 49 *Code of Federal Regulations* section 831.4). Assignment of fault or legal liability is not relevant to the NTSB's statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report (Title 49 *United States Code* section 1154(b)). A factual report that may be admissible under 49 *United States Code* section 1154(b) is available here.