Aviation Investigation Final Report

Location:	West Jordan, Utah	**Accident Number:**	WPR21LA320
Date & Time:	August 14, 2021, 10:30 Local	**Registration:**	N226WM
Aircraft:	ROBINSON HELICOPTER R22 BETA	**Aircraft Damage:**	Substantial
Defining Event:	Loss of control in flight	**Injuries:**	1 Serious, 1 None
Flight Conducted Under:	Part 91: General aviation - Instructional		

Analysis

The flight instructor and pilot receiving instruction (pilot), who held a private pilot certificate with an airplane single-engine land rating, departed on a flight to practice pinnacle landings at a location about 20 minutes from their departure airport. When they arrived at their destination, the pilot completed a high reconnaissance of the area before beginning a descent towards his selected landing site. He overshot the approach and entered a steeper approach at an increased descent rate. About 30 ft above the ground, the main rotor started to droop (lose rpm), and the helicopter began to settle as the instructor and the pilot heard the low rotor rpm horn accompanied by an illuminated low rotor rpm light. The student was instructed to lower collective and advance the throttle, which was already in the full-open position. The pilot also erroneously pushed the cyclic forward, which likely exacerbated the main rotor droop and further inhibited a successful recovery at their low altitude. The instructor took control of the helicopter and lowered collective, but the left skid contacted a large rock and the helicopter rolled left and came to rest on its left side.

The instructor suggested that the governor may have been delayed in advancing the throttle when the main rotor speed decreased as this had occurred during practice flights earlier that day. However, during postaccident testing, the governor operated normally with no delay and there was no evidence found of preimpact mechanical anomalies with the governor. Further, the instructor was also aware of this deficiency before they departed on the accident flight and could have easily overridden the governor during the approach phase of the pinnacle landing.

The postaccident examination discovered that the forward vee-belt had likely come apart during the accident flight; the time of the separation could not be determined due to lack of available evidence. The operator had been troubleshooting reported anomalies with the belt tension for several months prior to the accident, and the excess slack likely led to the forward

belt jumping forward during startup and resulted in the destruction of the belt about 20 minutes later. Even if the helicopter was operating with one vee-belt during the approach phase of the pinnacle landing, it should have been able to complete a successful power recovery or make a forced landing on one vee-belt.

The instructor had discussed and flown practice pinnacle approaches with the pilot prior to the accident flight. During the pinnacle approach, the instructor issued the appropriate recovery instructions to the student after the low rotor rpm warnings were observed in the cockpit. However, the pilot chose to apply forward cyclic momentarily contrary to the recovery procedure, which added forward airspeed and further drooped the rotor rpm.

The pilot's application of forward cyclic was likely a negative transfer of learning from his fixed wing flying experience. Although the instructor quickly intervened, the helicopter was descending rapidly at a low altitude and struck the ground before he was able to recover. As the instructor had operational control and responsibility for the safety of the flight, the accident was also the result of his delayed remediation from a low rotor rpm condition at a low altitude.

Probable Cause and Findings

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

The pilot receiving instruction's improper application of forward cyclic in a low rotor rpm condition and the instructor's delayed remediation, which resulted in an impact with terrain.

Findings

Personnel issues	Use of policy/procedure - Student/instructed pilot
Personnel issues	Aircraft control - Instructor/check pilot
Aircraft	(general) - Not serviced/maintained
Aircraft	Airspeed - Incorrect use/operation
Personnel issues	Monitoring other person - Instructor/check pilot

Factual Information

History of Flight

Approach	Loss of control in flight (Defining event)

On August 14, 2021, about 1030 mountain daylight time, a Robinson R-22B, N226WM, was substantially damaged when it was involved in an accident near West Jordan, Utah. The flight instructor was seriously injured and the pilot receiving instruction sustained minor injuries. The helicopter was operated as a Title 14 *Code of Federal Regulations* Part 91 instructional flight.

According to the pilot receiving instruction (pilot), who held a private pilot certificate with an airplane single-engine land rating, the accident flight was his second instructional flight towards his rotorcraft rating. They departed about 0800 on the morning of the accident and performed some basic rotorcraft practice maneuvers. The pilot noted that they received a low rotor rpm indication several times during this practice. At one point they received the indication while in a practice hover and were forced to manually rotate the throttle to add engine power. After about an hour of practice they landed and serviced the helicopter with fuel. They subsequently departed to a nearby practice area to conduct pinnacle approaches.

They arrived at their destination about 20 minutes after departure, and the pilot began to orbit a ridge he selected initially about 500 ft above ground level (agl) then descended to about 300 ft agl. While descending further, the pilot advised his instructor of his selected landing site, which they subsequently overshot. The pilot continued the descent, and when the helicopter reached about 30 ft agl, both the instructor and the pilot heard the low rotor rpm horn sound, which was accompanied by the low rotor rpm light. At this point, the instructor told the pilot to lower the collective and advance the throttle, but the throttle was already in the full-open position.

The pilot then pushed the cyclic forward “to get airspeed,” and the instructor immediately said “no” and took control of the helicopter. The instructor lowered the collective to increase rotor rpm, but the helicopter descended into the ground. The left landing skid contacted a large rock, and the helicopter rolled over and impacted the ground on the left side. According to the instructor there were no preimpact mechanical anomalies with the engine or airframe, except for the governor, that precluded normal operation.

The instructor stated that the accident was the result of main rotor droop (rpm loss) during the pinnacle approach and that the pilot’s decision to push the cyclic forward exacerbated the droop. He surmised that the pilot had employed a high descent rate after they overshot their landing site and that the approach was too steep. The instructor further remarked that the pilot may have been a little overconfident having accumulated about 327 flight hours in fixed-wing aircraft. They had discussed settling with power as they flew the airport traffic pattern prior to

the accident flight; at that time, they discussed main rotor droop, and the instructor demonstrated how the helicopter would settle onto the ground. The instructor and the pilot then completed several simulated pinnacle approaches at the airport before they departed on the accident flight.

According to the instructor, he discovered an issue with the governor on the morning of the accident flight. While doing some pattern work, he noticed that the governor was slightly delayed in advancing the throttle to 104% rpm. He chose to proceed with his instructional flights that day and did not report the issue to the operator. According to the instructor, with the exception of the governor delay, there were no preimpact mechanical anomalies with the engine or airframe, except for the governor, that precluded normal operation.

Postaccident photographs of the helicopter revealed substantial damage to the tailboom.

Engine Examination

The engine was examined, and mechanical continuity was established throughout the rotating group, valve train and accessory section as the crankshaft was rotated manually by hand using the cooling fan. Thumb compression was achieved in the proper firing order at all cylinders. Both magnetos remained attached to their mounting pads and the ignition harness was secured at each magneto. Magneto-to-engine timing was observed at 25° before top dead center of cylinder No. 1.

Engine and Governor Functional Test

The engine was started using procedures from the pilot's operating handbook (POH). After the engine was run at idle power for several minutes, the throttle was advanced to 70% rpm and a magneto check was completed. Throttle was further advanced to 100% rpm for 2 minutes. The governor was then activated and the throttle was reduced to 80% rpm and released at which time the governor automatically engaged and advanced the throttle back to about 102% without any delay. The governor test was repeated, and the same result was achieved. Throttle was then reduced to idle and the engine was shutdown. Engine operation was continuous throughout the engine test, which was unremarkable.

Vee-Belts and Vee-Belt Sheaves

The POH stated that the helicopter was equipped with upper and lower vee-belt sheaves. The lower vee-belt sheave was bolted directly to the engine output shaft and transmits power to the upper sheave through the vee-belts. Power was transferred forward to the main rotor and aft to the tail rotor through the inner shaft of a clutch contained within the hub of the upper sheave. According to the preflight section of the POH, the vee-belts should be inspected for condition during every preflight and the slack should not exceed 1.5 inches.

A postaccident examination of the airframe revealed that the aft vee-belt was dislodged from both the upper and lower sheaves. Rub marks were observed on the lower sheave along the

circumference of the forward face. Most of the forward vee-belt was missing except for a section about 5 inches long that was recovered from the engine compartment. Rub marks were observed at the structural tubes adjacent to the upper sheave with adjacent score marks on the tubes. The friction surfaces of the aft vee-belt and the recovered section of the forward vee-belt were nominal and did not exhibit any irregular wear. The missing section of forward vee-belt was not recovered.

According to the instructor, he performed a preflight inspection of the helicopter before they departed on their first flight. After they refueled the helicopter, he performed a "quick" walkaround inspection and checked the vee-belt tension before they departed. When asked how he inspected the belts, the instructor responded that he does not have any specific criteria, but "checks to see if it's tight." The pilot stated that he did not recall any inspections after the initial preflight inspection. He did not remember if the instructor inspected the vee-belts. The instructor further remarked that he did not remember how quickly the blades began turning after he engaged the clutch, but would have remembered had it taken longer than 5 seconds.

The operator recorded aircraft squawks on a spreadsheet that included a description of each squawk and the action taken. Of the nine total squawks recorded between July 16, 2020, and July 28, 2021, three were related to the vee-belts. An entry about 4 months prior to the accident stated that "it's taking 15-20 seconds each flight today before the blades start turning after clutch is engaged." Accordingly, the down limit switch was adjusted and a subsequent operational check was unremarkable. The next entry, about 3 months before the accident, indicated that the main rotor did not start turning until more than 10 seconds after the clutch was engaged. The issue was noted as "closed" after the belt tension was adjusted. An entry recorded 1 month prior to the accident noted "belts to[o] tight. Spin immediately when engine is started." The main drive belts were subsequently adjusted. No further information related to the resolutions was available.

The helicopter manufacturer offered the following summary of its flight experience in a company helicopter with only one vee-belt installed.

"*We have flown a R22 with just one belt and it sustained flight for about 10 minutes before the belt began to slip a bit (about 2% needle split) and yet still accomplished a power on landing. A likely scenario is that during start-up with excessive slack in the belts, the forward belt jumped one groove forward on the lower sheave, the aft belt remained in its grooves. With the forward belt now misaligned, it effectively becomes shorter, and the actuator applies more tension to the forward/shorter belt, leaving the aft belt tension below the norm. This extra tension along with one vee of the belt folding over the edge of the lower sheave begins to destroy the forward belt and may run this way for 20-30 minutes. Once the forward belt is completely destroyed, the tension on the aft belt is still below the norm and the belt slips, reducing the drive to the rotors. Then the actuator senses the light tension on the aft belt and begins to apply the full tension to the single remaining belt (over a few seconds). Once the full tension is reached, a power on landing is possible.*"

Low Rotor RPM

The FAA Helicopter Flying Handbook (FAA-H-8083-21B) provides a description of low rotor rpm condition stating, in part:

> *…helicopters will not fly below a certain rotor rpm. Safe rotor rpm ranges are marked on the helicopter's tachometer and specified in the RFM [rotorcraft flight manual]. If the pilot allows the rotor rpm to fall below the safe operating range, the helicopter is in a low rpm situation. If the rotor rpm continues to fall, the rotor will eventually stall.*

Low RPM Indication

The POH states that a low rpm light and/or horn indicates that the rotor speed is below 97% rpm. To restore the rotor rpm, the pilot should immediately lower collective, twist the throttle on, and apply aft cyclic (if in forward flight).

Governor Failure

According to the POH, in the event of a governor failure, the pilot should grip the throttle firmly to override the governor and then switch the governor off and complete the flight using manual throttle control.

Robinson Safety Notice SN-29, title "Airplane Pilots High Risk When Flying Helicopters," which was included in the POH, stated, in part:

> *The airplane pilot may fly the helicopter well when doing normal maneuvers under ordinary conditions…But when required to react suddenly under unexpected circumstances, he may revert to his airplane reactions and commit a fatal error.*
>
> *…AND, ABOVE ALL, HE MUST NEVER ABRUPTLY PUSH THE CYCLIC STICK FORWARD.*

Pilot Information

Certificate:	Commercial; Flight instructor; Military	**Age:**	36,Male
Airplane Rating(s):	None	**Seat Occupied:**	Left
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	3-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Helicopter; Instrument helicopter	**Toxicology Performed:**	
Medical Certification:	Class 2 Without waivers/limitations	**Last FAA Medical Exam:**	April 12, 2021
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	August 5, 2021
Flight Time:	1546 hours (Total, all aircraft), 114 hours (Total, this make and model), 1184 hours (Pilot In Command, all aircraft), 112 hours (Last 90 days, all aircraft), 33.7 hours (Last 30 days, all aircraft)		

Student pilot Information

Certificate:		**Age:**	34,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Rear
Other Aircraft Rating(s):	None	**Restraint Used:**	3-point
Instrument Rating(s):	None	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	
Medical Certification:	Class 3	**Last FAA Medical Exam:**	
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:	330 hours (Total, all aircraft), 3 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Make:	ROBINSON HELICOPTER	**Registration:**	N226WM
Model/Series:	R22 BETA	**Aircraft Category:**	Helicopter
Year of Manufacture:	2008	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	4394
Landing Gear Type:	Skid	**Seats:**	2
Date/Type of Last Inspection:	July 7, 2021 100 hour	**Certified Max Gross Wt.:**	1370 lbs
Time Since Last Inspection:	37.2 Hrs	**Engines:**	1 Reciprocating
Airframe Total Time:	2450 Hrs at time of accident	**Engine Manufacturer:**	Lycoming
ELT:	Not installed	**Engine Model/Series:**	O-360-J2A
Registered Owner:	UTAH HELICOPTER LLC	**Rated Power:**	145
Operator:	UTAH HELICOPTER LLC	**Operating Certificate(s) Held:**	Pilot school (141)

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KU42,4603 ft msl	**Distance from Accident Site:**	5 Nautical Miles
Observation Time:	09:55 Local	**Direction from Accident Site:**	110°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.24 inches Hg	**Temperature/Dew Point:**	28°C / 13°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	West Jordan, UT (U42)	**Type of Flight Plan Filed:**	None
Destination:	West Jordan, UT (U42)	**Type of Clearance:**	None
Departure Time:	09:00 Local	**Type of Airspace:**	Class G

Wreckage and Impact Information

Crew Injuries:	1 Serious, 1 None	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:		**Aircraft Explosion:**	None
Total Injuries:	1 Serious, 1 None	**Latitude, Longitude:**	40.649583,-112.10352(est)

Administrative Information

Investigator In Charge (IIC):	Stein, Stephen
Additional Participating Persons:	Thom Webster; Robinson Helicopter Company; Torrance, CA Mark Platt; Lycoming Engines; Williamsport, PA
Original Publish Date:	December 20, 2022
Last Revision Date:	
Investigation Class:	Class 3
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=103702