Aviation Investigation Final Report

Location:	Moran Junction, Wyoming	**Accident Number:**	WPR12GA106
Date & Time:	February 15, 2012, 13:01 Local	**Registration:**	N407HL
Aircraft:	Bell 407	**Aircraft Damage:**	Substantial
Defining Event:	Loss of control in flight	**Injuries:**	1 Fatal, 2 Serious
Flight Conducted Under:	Public aircraft		

Analysis

The single-main-rotor helicopter was dispatched on a search and rescue (SAR) mission in response to a snowmobile accident in remote, mountainous terrain. The helicopter was on lease to the local sheriff's office, and was being flown by the chief pilot of the company that owned it. Two SAR personnel were passengers. After an initial but fruitless search to locate the snowmobile victim, the helicopter located members of the snowmobile party. After a landing and brief discussion with the snowmobilers, they agreed to lead the helicopter to the accident site on their snowmobiles. The helicopter lifted off to follow the snowmobilers, flying about 100 to 200 feet above the trees. Because the helicopter was faster than the snowmobiles, the pilot stopped several times in a hover to allow the snowmobiles to catch up. During one hover, the pilot experienced a slight left yaw, which he believed he corrected. The helicopter then began to spin rapidly and descended into the trees. The sheriff's office dispatchers used a commercial flight following system to track the helicopter, but system difficulties prevented them from detecting the accident via that system. The injured pilot climbed a nearby hill, and notified the dispatchers of the accident via radio.

The recovered wreckage was examined, and no evidence of any preimpact deficiencies or failures that would have prevented normal operation and continued flight was discovered. Data recovered from the engine control unit indicated that the engine operated normally until the accident, when parameter exceedances and torque spikes, consistent with main rotor blade strikes, were recorded.

The directional control actuator (DCA), which was the hydro-mechanical unit used to control the tail rotor, was removed and sent to the helicopter manufacturer for testing and examination. The DCA passed the functional checks, and no evidence of any anomalies that would have prevented normal operation was detected.

A damaged tree near a trail sign in the search area suggested the possibility that the tail rotor might have struck the tree and been damaged just before the accident. However, examination of the damage to the tree and the tail rotor did not support that hypothesis.

Single-main-rotor helicopters are susceptible to a phenomenon known as "loss of tail rotor effectiveness" (LTE), which can occur at low airspeeds, and is a function of relative wind direction. The loss of control occurred in a hover, but the relative wind direction could not be determined. LTE is more likely at high density altitude and/or gross weight. The accident occurred at a density altitude of about 9,000 feet, and at a weight about 800 pounds below the maximum certificated operating weight. In the accident helicopter, LTE would result in a nose-right spin direction. Both the pilot and surviving passenger recalled that the spin direction was nose left, which is contrary to LTE. However, neither was certain of the spin direction, and a ground witness reported that the spin direction was nose right, consistent with LTE. Examination of the wreckage did not provide conclusive evidence as to the direction of the spin, but did indicate that both the main and tail rotor were rotating under power at the time of impact. Based on the witness observation and the uncertainty of the helicopter occupants about the direction of spin, the high density altitude, and the lack of indications of a tail rotor mechanical failure, it is likely that the loss of control was due to LTE.

Probable Cause and Findings

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

The pilot's failure to maintain yaw control while hovering at high density altitude, which resulted in a loss of tail rotor effectiveness.

Findings

Aircraft	Yaw control - Not attained/maintained
Personnel issues	Incorrect action performance - Pilot

Factual Information

History of Flight

Enroute	Loss of control in flight
Maneuvering-hover	Loss of control in flight (Defining event)

HISTORY OF FLIGHT

On February 15, 2012, about 1301 mountain standard time, a Bell Helicopter model 407, N407HL, was substantially damaged when it impacted trees and terrain in the Bridger Teton National Forest near Moran Junction, Wyoming, during a search and rescue (SAR) mission. The commercial pilot and one SAR crewmember received serious injuries, and the other SAR crewmember received fatal injuries. The public-use flight was operated by the Teton County Sheriff's Office (TCSO). Visual meteorological conditions prevailed, and no Federal Aviation Administration (FAA) flight plan was filed for the flight.

The mission was in response to a reported snowmobile injury accident, in order to transport medical personnel to that scene. Initial attempts to locate that victim, based on trail network and geographic coordinate information, were unsuccessful. The helicopter began a search, and the crew observed two snowmobilers signaling to them in a meadow. The helicopter landed in the meadow, and a SAR member exited and spoke with the snowmobilers. They were from the victim's party, and they agreed to lead the helicopter on their snowmobiles to the accident site. The SAR member re-boarded the helicopter, the helicopter lifted off to follow the snowmobilers, flying about 100 to 200 feet above the trees. Since the helicopter was faster than the snowmobiles, the pilot stopped two or three times in a hover to allow the snowmobiles to catch up. On either the second or third hover, the pilot experienced a slight left yaw, which he believed he corrected. The helicopter then started "spinning rapidly" and descended into the trees. The pilot and the surviving SAR member both believed that the spin direction was nose left, but they were not certain.

The SAR member in the rear seat remained conscious throughout the event, and extricated himself, despite an injured leg. He assisted the other SAR member and the pilot out of the helicopter after they became verbally responsive. The pilot carried a radio to the top of a nearby ridge and requested assistance. Reports varied as to when the first ground personnel who were originally responding to the snowmobile accident arrived at the helicopter, but the first TCSO personnel reached the helicopter about 1622.

PERSONNEL INFORMATION

Federal Aviation Administration (FAA) information indicated that the pilot held multiple certificates and ratings, including a commercial pilot certificate with a rotorcraft-helicopter rating. The pilot reported a total flight experience of about 22,250 hours, including about 4,500 hours in the accident helicopter make and model. His most recent FAA second-class medical certificate was issued in May 2011. He was the chief pilot for Hillsboro Aviation, Hillsboro, Oregon.

AIRCRAFT INFORMATION

According to FAA information, the helicopter was manufactured in 2008 and was equipped with a Rolls Royce 250-C47 series turboshaft engine. The helicopter was registered to Hillsboro Aviation, leased to TCSO, and operated by Hillsboro flight personnel.

At the time of the accident, the helicopter had accumulated a total time in service of 828.6 hours. The operator cited the maximum allowable gross weight of the helicopter as 5,250 pounds, which agreed with the FAA type certificate value when the helicopter was equipped with kit 407-706-020.

METEOROLOGICAL INFORMATION

The 1251 automated weather observation for the departure location, Jackson Hole Airport (JAC), Jackson, Wyoming, located about 25 miles southwest of the accident site, included winds from 090 degrees at 4 knots, visibility 10 miles, few clouds at 4,500 feet, temperature -6 degrees C, dew point -9 degrees C, and an altimeter setting of 29.96 inches of mercury.

Additional relevant meteorological information obtained from a variety of sources, indicated that the entire region, including the accident locale, was dominated by a high pressure region. This resulted in visual meteorological conditions (VMC) conditions, with no or high ceilings, and generally easterly winds of 10 knots or less. The density altitude was calculated to be between 8,500 and 9,300 feet.

WRECKAGE AND IMPACT INFORMATION

Site Information

The accident site was in a partially forested area, with coordinates of 43.726 degrees N, 110.217 degrees W. Site elevation was approximately 9,550 feet above mean sea level (msl). The ground in the immediate vicinity of the wreckage was relatively flat but sloped, the terrain in the general locale of the accident site was uneven, and the overall region was mountainous wilderness. The entire region was snow-covered, and the ground in the immediate vicinity of the wreckage was under deep snow.

Wreckage Overview

The helicopter came to rest on its right side in a stand of evergreen trees approximately 80 -100 feet high. One of those trees bore a diagonal cut, which separated its top, about 50 feet above the ground. The tree had a diameter of approximately 1 foot at that location.

Review of on-scene photographs revealed the following information. The fuselage (cockpit and cabin) was essentially intact, with minimal intrusions into, or compromises of, the occupiable volume. All cabin doors remained attached and operable, but damaged. Of the ten cabin transparencies, only the one for the aft left door was intact.

All four main rotor blades (MRB) were fracture-separated from the rotor mast/hub. The tail boom was fracture-separated into several sections, but damage precluded determination of the spin direction. The empennage, which consisted of the aft vertical fin, tail rotor gearbox, and tail rotor, was fracture-separated from the tail boom. The two tail rotor blades remained attached to the tail rotor hub, which remained attached to the gearbox. The engine remained intact and attached to the airframe. There was no fire.

Wreckage Examination

The wreckage was recovered from the accident site by helicopter on February 24, 2012. Some minor sectioning and/or disassembly of the wreckage was necessary for recovery purposes. The wreckage was examined by investigators and manufacturers' representatives about 1 week after that. Several components or component elements were determined not to have been recovered with the wreckage. These included most afterbody portions of the MRBs, a short tip section of one MRB, and an approximate 30-inch segment of the tail boom (just forward of the tail rotor assembly).

Inspection of the engine exterior did not reveal any obvious signs of damage from impact forces or internal engine failure. The engine mounting structure was intact and properly secured, and no evidence of oil or fuel leaks was observed in the engine bay or surrounding area. The N1 and N2 rotor systems rotated smoothly and quietly by hand, and N1 and N2 gear train continuity was confirmed. There was no impact damage, metal splatter or evidence of rubbing around the power turbine air shrouds. Inspection of the inlet plenum chamber did not reveal any evidence of foreign material or missing hardware. Inspection of the compressor inlet revealed no visible damage or signs of foreign object ingestion. Drive continuity from the engine to the main rotor and tail rotor drive was verified.

The Engine Control Unit (ECU) was visually undamaged. Extraction of the ECU Incident Recorder (IR) data revealed a total of 15 data-points, recorded at 1.2 second intervals. In addition to IR data, eight additional "Snapshot" data lines were recorded in a separate file. Snapshot data is recorded immediately following an engine exceedance. All snapshot data lines were recorded within the final 3 seconds of the accident flight. Examination of ECU IR data recorded during the accident sequence revealed the engine responding normally to control inputs.

Physical examination of the available wreckage did not reveal evidence of any pre-impact deficiencies or failures that would have prevented normal operation and continued flight.

ADDITIONAL INFORMATION

GPS and Flight Information

Two handheld/portable GPS devices were onboard and operational for the entire flight, including the accident. Both were Garmin devices; one was a GPSMap296, and the other was an Aera 500. Both devices were sent to the NTSB Recorders laboratory for data download. Data from the accident flight was successfully recovered from both devices, and the flight tracks from the two devices were congruent.

The departure from Jackson, Wyoming, occurred about 1225. The en route portion of the flight to the search area ended about 1241. The en route groundspeed was about 115 knots, with altitudes ranging from about 8,976 feet MSL to 9,823 feet MSL. Upon entering the search area, the helicopter proceeded southeasterly for about 2 minutes. It then tracked southwesterly, made a 360-degree turn and then proceeded north-northwest until about 1249.

Based on crewmember testimony and geographic information, the northwest-most excursion corresponded to the point in the flight where the crew hovered to read a trail sign in order to obtain orientation/location information. After reading the trail sign, they then headed southeast again. That southeast leg extended about 2.2 miles farther southeast than the prior legs.

About 1254, the helicopter landed and a crewmember exited to speak with uninjured snowmobilers associated with the individual to be rescued. During that ground discussion it was agreed that the snowmobilers would lead the helicopter to the snowmobile victim.

The last segment of the flight, including the accident, occurred between 1300:24 and 1301:53. The groundspeed decreased from about 25 knots to less than 15 knots while at an altitude of about 9,680 feet MSL. The helicopter impacted trees and the ground about 1301:53.

Damaged Tree

The possibility that the TR struck a small tree during the crew's hovering maneuver to read the trail sign was prompted by the finding of a small tree near that sign whose top was observed to be damaged. GPS track data confirmed that the helicopter had transited and loitered near the tree and trail sign. The GPS data did not indicate that the helicopter hovered in the immediate vicinity of the tree. The tree was a few hundred feet away from the sign, and the sign was oriented so that when reading the sign, the sign would be positioned between the reader and the tree. The upper 3-4 feet of the tree was sectioned from the tree by recovery personnel and returned with the helicopter wreckage, and was examined concurrent with the helicopter examination. The broken branch was about 3/4 inch in diameter, and the branch material was soft and flexible. No other branches from the recovered sample were observed to be broken or missing. The aggregate evidence was consistent with the branch not being struck or broken by the helicopter or the TR.

Commercial Tracking Services Company

Guardian Mobility was a private company based in Canada, which provided a variety of aviation services. At the time of the accident, the TCSO and the accident helicopter were equipped for and utilizing the company's "Automatic Flight Following" (AFF) tracking service.

Use of AFF services requires that the aircraft be physically equipped with a GPS-based tracking device, and that the aircraft operator have an active contract with company for the AFF services. Conceptually, the tracking device uploads the current aircraft position, altitude and average speed via satellite every 2 minutes, that information is processed by company software, and then operators can access and monitor that company-provided real-time tracking information via the internet.

According to a TCSO dispatch supervisor, they used the AFF system as a tool to track their aviation resources. Access to the system is installed on a server within the TCSO and available to all dispatchers in the TCSO Communications Center. The tracking system itself is passive with regard to incident or accident notification. The TCSO personnel first have to access and/or log onto the system on their computers, and then they must actively monitor the system display, which depicts certain aircraft parameters.

According to the manager of the Teton Interagency Dispatch Center, AFF does not provide alerts to dispatchers. Aircraft are depicted on the screen in blue if they are active, and in red if they have lost communication. Communication loss could be due to several factors, including operation in a location with poor or no satellite communication, or an incident/accident. The flight follower/dispatcher would not receive an alert, they would have to notice that the aircraft symbol on the screen turned red. Both of the TSCO dispatchers who were monitoring the flight reported that the AFF system did not change the color of the helicopter screen symbol until well after they knew about the accident, despite their repeated

queries of the system; the AFF system was not instrumental in alerting the dispatchers to the loss of the helicopter. Subsequent to the accident, for unspecified reasons, the AFF system was upgraded to a newer version with improved functionality.

Directional Control Actuator (DCA) Test and Examination

The Directional Control Actuator (DCA), which was the hydro-mechanical unit used to control the TR, was removed and sent to Bell Helicopter for testing and examination. The DCA passed the functional checks and no evidence of any anomalies which would have prevented normal operation was detected.

Hover Performance Information

An Allowable Payload chart was found in the helicopter, in a binder identified as a Teton County SAR (TCSAR) medical protocols document. According to TCSAR personnel the chart was developed by the pilot, and was never used by the TCSAR personnel. TCSAR was uncertain as to why the chart was in that binder.

The chart contained two tables, one for "HIGE" (hover in ground effect), and one for "HOGE" (hover out of ground effect). The tables presented the maximum allowable payload (in pounds) as a function of pressure altitude (PA) and ambient temperature. Comparison of the chart with helicopter manufacturer's performance data validated the accuracy of the chart. Calculations using the available information indicated that the departure weight was approximately 4,165 to 4,300 lbs, and the weight at the time of the accident was between 3,965 and 4,100 lbs.

Comparison of known meteorological conditions and the estimated flight weight with the chart performance data indicated that the helicopter was within its hover performance envelope at the time of the accident.

Loss of Tail Rotor Effectiveness (LTE)

FAA Advisory Circular (AC) 90-95, Unanticipated Right Yaw In Helicopters, addressed the topic of loss of tail rotor effectiveness (LTE). The AC stated that LTE has been determined to be a contributing factor in a number of helicopter accidents.

The AC continued with the following text:

LTE is a critical, low-speed aerodynamic flight characteristic which can result in an uncommanded rapid yaw rate which does not subside of its own accord and, if not corrected, can result in the loss of aircraft control. LTE is not related to a maintenance malfunction and may occur in single-main-rotor helicopters at airspeeds less than 30 knots. LTE is not necessarily the result of a control margin deficiency.

Flight operations at low altitude and low airspeed in which the pilot is distracted from the dynamic conditions affecting control of the helicopter are particularly susceptible to the LTE phenomena.

On U.S. manufactured single rotor helicopters [such as the accident helicopter], the main rotor rotates counterclockwise as viewed from above. The torque produced by the main rotor causes the fuselage of the aircraft to rotate in the opposite direction (nose right). The anti-torque system provides thrust which counteracts this torque and provides directional control while hovering

Any maneuver which requires the pilot to operate in a high-power, low-airspeed environment with a left crosswind or tailwind creates an environment where unanticipated right yaw may occur. There is greater susceptibility for LTE in right turns. This is especially true during flight at low airspeed since the pilot may not be able to stop rotation. The helicopter will attempt to yaw to the right. Correct and timely pilot response to an uncommanded right yaw is critical. The yaw is usually correctable if additional left pedal is applied immediately. If the response is incorrect or slow, the yaw rate may rapidly increase to a point where recovery is not possible

The AC also noted that certain factors affect susceptibility to LTE. Relevant to this accident are gross weight, density altitude, and low airspeed. An increase in weight or density altitude will decrease the power margin between the maximum power available and the power required to hover. The pilot should conduct low-level, low-airspeed maneuvers with minimum weight. At airspeeds below translational lift, the tail rotor is required to produce nearly 100 percent of the directional control. If the required amount of tail rotor thrust is not available for any reason, the aircraft will yaw to the right.

Pilot Information

Certificate:	Commercial; Private	**Age:**	62
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	3-point
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	May 5, 2011
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	22500 hours (Total, all aircraft), 4500 hours (Total, this make and model), 35 hours (Last 90 days, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Bell	**Registration:**	N407HL
Model/Series:	407	**Aircraft Category:**	Helicopter
Year of Manufacture:	2008	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	53869
Landing Gear Type:	Skid	**Seats:**	7
Date/Type of Last Inspection:	December 19, 2011 AAIP	**Certified Max Gross Wt.:**	5250 lbs
Time Since Last Inspection:	28 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	829 Hrs at time of accident	**Engine Manufacturer:**	Rolls-Royce
ELT:	C126 installed	**Engine Model/Series:**	250-C47
Registered Owner:	Hillsboro Aviation	**Rated Power:**	650 Horsepower
Operator:	Teton County Sheriffs Office	**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	JAC,7000 ft msl	**Distance from Accident Site:**	25 Nautical Miles
Observation Time:	12:51 Local	**Direction from Accident Site:**	45°
Lowest Cloud Condition:	Few / 4500 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	4 knots / None	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	90°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.95 inches Hg	**Temperature/Dew Point:**	-6°C / -9°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Jackson, WY	**Type of Flight Plan Filed:**	Unknown
Destination:	Jackson, WY	**Type of Clearance:**	None
Departure Time:	12:25 Local	**Type of Airspace:**	

Wreckage and Impact Information

Crew Injuries:	1 Serious	**Aircraft Damage:**	Substantial
Passenger Injuries:	1 Fatal, 1 Serious	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Fatal, 2 Serious	**Latitude, Longitude:**	43.726112,-110.199722(est)

Administrative Information

Investigator In Charge (IIC):	Huhn, Michael
Additional Participating Persons:	Tom Weisner; FAA FSDO; Denver, CO Jon Michael; Rolls Royce; Indianapolis, IN Bill Sarles; Bell Helicopter; Ft Worth, TX
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