National Transportation Safety Board
Aviation Accident Final Report

Location:	Phoenix, AZ	**Accident Number:**	WPR12FA191
Date & Time:	05/02/2012, 1140 MST	**Registration:**	N380TL
Aircraft:	HUGHES 269C	**Aircraft Damage:**	Substantial
Defining Event:	Sys/Comp malf/fail (non-power)	**Injuries:**	1 Serious, 1 Minor
Flight Conducted Under:	Part 91: General Aviation - Business		

Analysis

When the pilot was about 2 minutes from his destination at an altitude of about 500 feet above ground level, he sensed a vibration through the back of his seat and in the anti-torque pedals. The vibration was followed by a right yaw that the pilot could not correct with a pedal input. As the pilot attempted to maintain level flight, he heard a "metallic clunking" behind him. He looked back and saw what he described as the tail rotor losing rotor speed. The pilot maintained forward flight by countering the right yaw with left cyclic input while he located a cul-de-sac in a residential neighborhood in which to land. The pilot entered an autorotation, and during the descent, the helicopter impacted the roof of a house and an adjacent brick wall. Witnesses reported that the helicopter didn't “sound right,” that the engine was sputtering, and that the engine power appeared to be increasing and decreasing. The helicopter was observed rocking and teetering before nose-diving toward the ground. After the helicopter impacted the ground, the engine continued to run, and the tail rotor continued to spin.

A postaccident investigation revealed that the main transmission pinion had fractured and separated through the threads that retained the aft pinion nut. Because the aft pinion nut maintained the position of the splined sleeve that drove the tail rotor drive shaft, the separation of the pinion allowed the sleeve to wobble as it turned and to move aft, partially disengaging its external splines from the internal splines in the tail rotor drive shaft. The sleeve’s splines began to grind against the drive shaft’s splines, and the resulting material loss on the splines reduced the engagement between the parts to the point where a loss of tail rotor drive occurred. It is likely that enough residual contact between the damaged splines remained to keep the tail rotor spinning (as observed after impact) but was not sufficient to deliver power to the tail rotor.

Examination of the pinion fracture surfaces determined that the pinion failure was due to a fatigue crack that initiated in a thread root and propagated through about 75 percent of the pinion’s cross-section before the remaining material succumbed to overstress conditions. No indication of material deficiencies, such as inclusions, voids, or pits, were found at the crack initiation site. According to the helicopter’s maintenance records, the pinion had been in service for 1,584.4 hours, and on the day before the accident, a 100-hour inspection had been

performed in accordance with the helicopter manufacturer's instructions. These instructions included a procedure for checking the torque of the aft pinion nut, and a co-owner of the helicopter reported that he observed the mechanic perform the torque check. It is likely that the fatigue crack was not large enough to be detected during the inspection and then propagated to the point of failure during the accident flight.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: A loss of tail rotor drive due to a fatigue failure of the main transmission pinion, which resulted in a loss of directional control during cruise flight.

Findings

Aircraft	Main rotor drive - Not specified (Cause) Directional control - Attain/maintain not possible (Cause)
Personnel issues	Aircraft control - Pilot (Cause)

Factual Information

HISTORY OF FLIGHT

On May 2, 2012, about 1140 mountain standard time, a Hughes 269C helicopter, N350TL, sustained substantial damage after colliding with a residential home near Phoenix, Arizona. The helicopter was owned and operated by Canyon State Aero of Mesa, Arizona. The certified commercial pilot sustained serious injuries, and the passenger sustained minor injuries. Visual meteorological conditions prevailed, and no flight plan was filed. The reported photo flight was being operated in accordance with 14 Code of Federal Regulations Part 91, and a flight plan was not filed. The local flight departed Deer Valley Airport (DVT), Phoenix, Arizona, about 1115.

In a telephone conversation with the pilot, as well as in a statement submitted to the National Transportation Safety Board (NTSB) investigator-in-charge (IIC), the pilot reported that after picking up his passenger/photographer, he departed DVT for the construction site the photographer had been hired to photograph. The pilot stated that after taking off he proceeded southwest toward the construction site about 500 feet above ground level (agl) and at an airspeed of between 70 to 75 knots. The pilot stated that about 2 minutes prior to reaching the construction site he detected a vibration in the back of his seat, as well as in the anti-torque pedals. This was followed immediately by a right yaw that was not correctable with pedal input. The pilot opined that he attempted to maintain level flight, then heard a "metallic clunking" sound behind him. He then looked over his left shoulder and thought he observed the tail rotor slowing down. He said he was still maintaining forward flight at about 70 knots and was maintaining his forward track by countering the yaw with left cyclic input. The pilot stated that he picked out a residential area with a cul-de-sac street, and elected to autorotate to the street. He reported that he lowered collective, rolled off the throttle to the idle detent, and made a slight right turn toward the cul-de-sac, maintaining about 55 knots during the autorotation. The helicopter initially impacted the roof of a house and a brick wall that separated the house from the adjoining residence. He said the helicopter came to rest in the backyard of the adjacent house in a slightly nose down, upright attitude. The pilot reported that the main and tail rotor blades were intact, and that in his view this was a mechanical failure rather than a loss of tail rotor effectiveness event. He also stated that [during the descent] the helicopter did not rotate about its vertical axis, that it did not spin, and that it was gusty with respect to the winds.

Local law enforcement provided the IIC with statements of 3 witnesses who observed the accident.

Witness #1, who was located at his residence about 1 block north of the accident site, reported that he heard the helicopter overhead, and that it "didn't sound right." The witness stated that the engine was sputtering and "sounded wrong," and as he watched it, it was "rocking" and "teetering." The witness added that it then lost altitude and nose-dived toward the ground south of his location.

Witness #2 reported that he was in an alley south of the street where the helicopter crash landed, and when he [first] heard the helicopter "it did not sound right." The witness stated that the engine was "sputtering", the rpms were increasing and decreasing, and that the main rotor blade was also increasing and decreasing in speed. The witness opined that the helicopter made a U-turn overhead while losing altitude, and that he lost sight of it due to trees and houses in the area. He then proceeded to the accident site and began turning all switches which

were labeled ON and OFF to the OFF position, but the engine kept running. He also stated that the tail rotor blades were moving very fast.

Witness #3, who was a co-worker of witness #2 and at the same relative location during the initial sighting of the helicopter, reported that he noticed the helicopter turning around and going lower, and that the engine didn't sound right, like it was just barely idling. He stated that the helicopter continued to lose altitude, and it became apparent that it was either going to land or crash. The witness added that after arriving at the accident site the engine continued to run for some time. He added that the tail rotor blades were spinning rapidly.

PERSONNEL INFORMATION

The pilot, age 40, possessed a commercial pilot certificate for rotorcraft-helicopter, and ratings for instrument helicopter and helicopter instructor. The pilot completed his most recent flight review on March 29, 2012. He was issued a second-class Federal Aviation Administration (FAA) airman medical certificate without waivers or limitations dated December 31, 2011.

The pilot reported a total flight time of 1,460 hours, all in helicopters, with 1,030 hours in make and model, 1,410 hours as pilot in command, and 980 hours as pilot in command in make and model. Additionally, the pilot reported having given 950 hours of dual instruction, with 800 hours of dual instruction given in the accident make and model helicopter. The pilot revealed that he had flown a total of 90 hours, 30 hours, and 1 hour in the preceding 90 days, 30 days, and 24 hours respectively.

AIRCRAFT INFORMATION

The accident helicopter was a Hughes Model 269C, serial number 0694C, manufactured in 1978. Its most current airworthiness certificate was issued on April 1, 2009. At the time of the accident the helicopter had accumulated about 1,584 hours total airframe time, with a Hobbs Meter time of 899 hours. The most recent periodic 100-hour/annual inspection was performed on May 1, 2012. The previous periodic inspection encompassed 25-50-100-200-400 hour inspections, which were completed on March 29, 2012, at a total airframe time of 1,481.4 hours, with a Hobbs Meter time of 796.4 hours. The maintenance records revealed that the last annual inspection was completed on May 6, 2011, at a total airframe time of 981.6 hours.

It was revealed during the investigation that during the periodic inspection conducted on May 1, 2012, which was the day prior to the accident, that a 25-50-100 hour inspection had been performed in accordance with the manufacturer's Helicopter Maintenance Instructions (HMI), which included the procedure for checking the proper torque of the aft pinion nut. The co-owner of Canyon State Aero reported to the IIC that he had personally observed the mechanic performed the torque check of the aft pinion nut. The aircraft maintenance logbook revealed no entry for this specific check, nor was one required under Federal Aviation Regulation (FAR) Part 91. Additionally, and while checklist sheets are available to follow and track such checks, they are not required to be completed or maintained under FAR Part 91.

A maintenance logbook entry dated March 9, 2012 at 1,481.4 hours (100 hours prior to the accident) revealed that a replacement H-frame was installed in conjunction with a 100/400-hour inspection. A Sikorsky engineer reported that as a result of this inspection the pinion splines would have been exposed and that a torque check of the aft pinion nut would have been required.

METERORLOGICAL INFORMATION

At 1151, the weather reporting facility at the Phoenix-Sky Harbor International Airport (PHX), Phoenix, Arizona, located about 4 nm south of the accident site, reported wind 140 degrees at 9 knots, visibility 10 miles, few clouds at 20,000 feet, scattered clouds at 25,000 feet, temperature 31 degrees Celsius (C), dew point 1 degree C, and an altimeter setting of 29.83 inches of mercury.

At 1153, the weather reporting facility at the Deer Valley Airport (DVT), Phoenix, Arizona, located about 11 nm north of the accident site, reported wind 170 degrees at 8 knots, gusts to 20 knots, variable 130 degrees to 200 degrees, 10 miles visibility, sky clear, temperature 28 degrees C, dew point -2 degrees C, and an altimeter of 29.85 inches of mercury.

WRECKAGE AND IMPACT INFORMATION

A damage assessment of the helicopter was conducted at the operator's facility on May 24, 2012.

The airframe remained generally intact. The steel main frame tubes were broken, distorted and bent in various locations. The aft cabin wall was distorted aft on the left side. The main rotor mast support tube on the left side of the aircraft exhibited a mid-span compression fold. The aft support tube fractured and was separated at the mast and the tailboom support fitting.

The right landing gear was observed entirely separated from the helicopter. The left side landing gear dampers remained attached to the aircraft, and the strut was attached to the skid tube. Both landing gear skid tubes were fractured at the forward strut attach points. The forward cross beam was fractured near its mid-point, while the aft cross beam was intact but bent down near the right side cluster fitting.

The tailboom was intact but observed separated at the forward bulkhead by a compression fracture. The tailboom tube appeared straight, with minor denting on the top near the forward end. The horizontal stabilizer was intact and remained attached, with minor denting noted. The vertical fin was crushed from contact to the bottom and was bent to the right. The left side support strut was intact with the right side support strut separated forward of mid-span by a folding fracture. Both support tubes exhibited scratches and markings on the bottom, consistent with asphalt shingle material.

Impact damage was consistent with a high vertical velocity wings-level, nose-low impact attitude with the roof of the house, followed by a nose over into the yard and impact with the wall.

All 3 main rotor blades remained attached to the main rotor head and basically intact.

The green dot tail rotor blade was fractured at the outer end of the hub spline. The blade was retained by the tail rotor strap pack and remained connected to the pitch change link. There were fractures and distortion of the fiberglass airfoil inboard of the leading edge abrasion strip, the spar was bent from impact forces on the outboard side, and the aft portion of the tip cap was missing.

The blue dot tail rotor blade was observed intact from the root to the tipcap; the tipcap was intact. There was an area of damage to the airfoil near the inboard end of the abrasion strip. The pitch change link remained attached and appeared straight.

The main rotor head (MRH) was intact and attached to the main drive shaft.

The tail rotor hub (TRH)/tail rotor assembly remained attached to the tail rotor gearbox (TGB)

output shaft. Both pitch change links were observed intact. The swashplate rotated freely and moved in and out on the shaft when activated by the control rod and bellcrank.

The tail rotor gearbox (TGB) remained on the tail boom adapter. The tail rotor drive shaft was rotated, and resulted in rotation of the tail rotor head. This indicated that continuity existed from the drive shaft fracture at the MGB to the TGB output. The chip detector was not examined.

The tail rotor drive shaft (TRDS) was fractured about 6 inches behind the main gear box (MGB) attach spline; a minor torsional indication was observed. The TRDS was bent at the forward tail boom bulkhead with minor indications of rotation. The forward portion of the TRDS was extracted with no tools required and included the aft pinion nut, a portion of the pinion, and the driving spline.

The TRDS appeared intact and straight, back to the TGB attach spline. The aft bump stop was damaged and compressed from impact with the 269A6029 retention nut. Minor wear was observed on the aluminum bumper and the nut.

The main gearbox remained attached to the airframe. When the gearbox input was rotated the MR drive and rotor head turned appropriately. The upper pulley overrunning clutch rotated and engaged appropriately when turned by hand. The input pinion was observed to have been fractured and separated through the threads of the aft thread area. The fractured pinion remained in the aft pinion nut and was secured by a cotter pin. The phenolic spacer was not secured by the cotter pin, was present but out of position, and observed pressed into the pinion's hollow interior just forward of the fracture. The 269A5430 driving spline moved aft in the TRDS far enough to disengage from the internal splines of the TRDS.

The engine was intact and observed to have sustained minimal damage due to impact forces. The engine mounts and engine basket tubing remained attached, however, some visible damage was observed. The lower section of the engine, inclusive of the intake and exhaust manifolds, fuel servo control, throttle linkage, impeller assembly, impeller shroud, and the Bendix gear and housing, experienced minimal visual damage as a result of impact forces to the undercarriage of the helicopter.

A Lycoming Engines representative was present during the examination. Only an external examination of the engine was performed. Due to local law enforcement personnel reporting that the engine remained running at the accident, and secured only after first responders had arrived, a more detailed examination of the engine was not performed by the Lycoming representative.

TESTS AND RESEARCH

Examination of components parts

Under the supervision of the IIC, the following components were shipped to the NTSB Materials Laboratory in Washington, D.C., for examination and analysis by a materials research engineer: the main transmission pinion, the aft pinion nut, a section of the tail rotor drive shaft, the driving spline, the phenolic plug, and the forward bump stop.

Driving Spline and Section of Tail Rotor Drive Shaft

The engineer reported fretting wear scars and material removal were observed on the outer teeth of the driving spline, along with chatter and circumferential gouging on the outer forward

surface. The chatter marks were located where a roller bearing is normally in contact with the driving spline. The engineer's report revealed that the splines exhibited some loss of material; the amount varied from negligible to almost 50 percent of the cross-sectional area, and the largest difference in loss was 180 degrees apart. In contrast, the interior splines of the part were relatively undamaged, and exhibited no appreciable loss of material. Some rubbing was observed on the forward interior of the part mirroring the exterior shape of the pinion.

The engineer further reported that the angle of material removed on the drive spline outer splines mirrored that of the wear and material loss on the mating interior splines of the forward sections of the tail rotor drive shaft. The damage on the interior splines was rotational in nature, but was not as severe as on the driving spline; the material loss was confined to an approximately 90 degree area. The engineer also noted that the forward faces of the splines exhibited some smearing and material loss in a counterclockwise direction, forward looking aft.

Main Transmission Pinion and Aft Pinion Nut

The material research engineer reported that approximately 0.3 inches of the aft portion of the main transmission pinion fractured transversely while fastened inside the aft pinion nut, with the cotter pin still in place.

According to the engineer the exterior of the pinion possesses a series of splines that contact the interior splines of the drive spline. The aft 2 inches of the exterior faces of the splines exhibited a shiny luster indicative of the outer surface having been worn off. The drive faces of the exterior pinion splines showed fretting wear scars and material loss. Upwards of 0.015 inches of material had been removed on the aft most 0.5 inches of the splines on the contact surfaces. Chatter marks were visible on the pinion exterior just forward of where the splines taper off.

The engineer further reported that an examination of the mating fracture surfaces of the pinion revealed a small jog present on the fracture, indicative of torsional failure. The fracture surface was flat, relatively smooth, and perpendicular to the long axis of the part. The surface exhibited fine crack arrest and ratchet marks indicative of progressive cracking. He stated that a closer examination using a scanning electron microscope (SEM) revealed an oxidized surface with a pattern consistent with underlying fatigue striations.

The engineer reported that the pinion fracture surface displayed a variety of ratchet marks, indicative of multiple fatigue crack initiations. The fatigue crack initiated at a thread root, consistent with the area of highest stress concentration on the part. No material deficiencies such as inclusions, pits, or voids were found at the crack initiation site.

The engineer opined that the features of the fracture surface suggest that after initiation, the fatigue crack progressed rotationally, while other cracks initiated ahead of the crack on the outer surface of the pinion in the thread root. Once the crack grew to sufficient size, the remaining cross-section succumbed to overstress. Approximately 0.25 inches of the fracture surface exhibited dimple rupture, indicative of overstress. No indications of other failure mechanisms, such as intergranular cracking, were observed.

The forward faces of the pinion threads were relatively undamaged and showed no indications of contact wear with the adjacent nut. The aft faces of the threads displayed rotational wear to approximately half of the depth of the thread root. The aft thread tips showed indications of fretting wear and minor material loss. No indication of mechanical damage or contact was

found in the valleys of the pinion threads. (Refer to the Material Laboratory Factual Report No. 13-023, which is appended to the docket.)

During the investigation a Sikorsky accident investigator for light helicopters reported that an improper assembly of parts was observed on the accident helicopter. The investigator revealed that the accident helicopter was not in compliance with the maintenance manual instructions in three areas: the phenolic pinion plug 269A5441 was not properly installed, the split bushing 269A5595-001 was missing, and an incorrect longer 269A6030 BSC Spline Adapter was installed on the tail transmission.

Examination of Global Positioning equipment

Under the supervision of the NTSB IIC, the aircraft's Lowrance AIRMAP 2000C Global Positioning System unit was shipped to the NTSB Vehicle Recorder Laboratory in Washington, D.C., for examination and analysis.

The specialist concluded that the recorded points did not conclusively capture the accident flight. As such, it was determined that the information on the device was not pertinent to the investigation. (Refer to the Vehicle Specialist's Factual Report, which is appended to the docket.)

History of Flight

Enroute-cruise	Sys/Comp malf/fail (non-power) (Defining event)
Maneuvering	Loss of control in flight
Autorotation	Collision with terr/obj (non-CFIT)

Pilot Information

Certificate:	Commercial	**Age:**	40
Airplane Rating(s):	None	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	Helicopter	**Toxicology Performed:**	No
Medical Certification:	Class 2 Without Waivers/Limitations	**Last Medical Exam:**	12/31/2011
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	03/29/2012
Flight Time:	1460 hours (Total, all aircraft), 1030 hours (Total, this make and model), 1410 hours (Pilot In Command, all aircraft), 90 hours (Last 90 days, all aircraft), 30 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	HUGHES	**Registration:**	N380TL
Model/Series:	269C UNDESIGNAT	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Normal	**Serial Number:**	680694
Landing Gear Type:	Skid	**Seats:**	2
Date/Type of Last Inspection:	05/01/2012, Annual	**Certified Max Gross Wt.:**	2050 lbs
Time Since Last Inspection:	1 Hours	**Engines:**	1 Reciprocating
Airframe Total Time:	1582 Hours	**Engine Manufacturer:**	Lycoming
ELT:	Installed, not activated	**Engine Model/Series:**	HIO-360-DIA
Registered Owner:	Canyon State Aero	**Rated Power:**	190 hp
Operator:	Canyon State Aero	**Air Carrier Operating Certificate:**	None

Meteorological Information and Flight Plan

Observation Facility, Elevation:	PHX, 1135 ft msl	**Observation Time:**	1153 MST
Distance from Accident Site:	4 Nautical Miles	**Condition of Light:**	Day
Direction from Accident Site:	180°	**Conditions at Accident Site:**	Visual Conditions
Lowest Cloud Condition:	Clear	**Temperature/Dew Point:**	31°C / -1°C
Lowest Ceiling:	None	**Visibility**	10 Miles
Wind Speed/Gusts, Direction:	8 knots, 190°	**Visibility (RVR):**	
Altimeter Setting:	29.83 inches Hg	**Visibility (RVV):**	
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Phoenix, AZ (DVT)	**Type of Flight Plan Filed:**	None
Destination:	Phoenix, AZ (DVT)	**Type of Clearance:**	None
Departure Time:	1115 MST	**Type of Airspace:**	Class G

Wreckage and Impact Information

Crew Injuries:	1 Serious	**Aircraft Damage:**	Substantial
Passenger Injuries:	1 Minor	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Serious, 1 Minor		

Administrative Information

Investigator In Charge (IIC):	Thomas Little	**Adopted Date:**	01/13/2014
Additional Participating Persons:	Jack T Ogle; Federal Aviation Administration; Scottsdale, AZ Mark Platt; Lycoming Engines; Williamsport, PA Steven Gleason; Sikorsky Aircraft Corportation; Horseheads, NY Adroam Booth; The Boeing Company; Mesa, AZ Jan Sandberg; Canyon State Aero LLC; Mesa, AZ		
Publish Date:	06/02/2014		
Investigation Docket:	http://dms.ntsb.gov/pubdms/search/dockList.cfm?mKey=83539		

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