Aviation Investigation Final Report

Location:	Gulf of Mexico, Gulf of Mexico	**Accident Number:**	CEN20FA035
Date & Time:	December 7, 2019, 09:18 Local	**Registration:**	N79LP
Aircraft:	Bell 407	**Aircraft Damage:**	Destroyed
Defining Event:	Powerplant sys/comp malf/fail	**Injuries:**	2 Fatal
Flight Conducted Under:	Part 135: Air taxi & commuter - Non-scheduled		

Analysis

The helicopter was flying over the Gulf of Mexico between two oil platforms. Flight track data showed the helicopter in cruise flight at 700 ft mean sea level (msl) before it gradually descended to 375 ft msl. Just before the data ended, the helicopter entered a left turn, descended to 150 ft msl, and slowed from about 115 knots (kts) groundspeed to about 75 kts groundspeed. The helicopter impacted the water and sank to the sea floor. The main wreckage was eventually located on the sea floor about 350 ft southwest of the last recorded flight track point.

Examination of the engine revealed that the power turbine pinion gear teeth were significantly worn and smeared, which ultimately resulted in the engine's inability to provide power to the rotor system. While the majority of the No. 3 bearing was not recovered, the significant thermal damage and loss of material of the power turbine pinion gear shoulder, to which the No. 3 bearing inner race was installed, indicated that the bearing likely failed first, but the cause of the No. 3 bearing failure could not be determined because the bearing was not recovered. The failure of the No. 3 bearing could result in misalignment of the gear mesh between the power turbine pinion gear and the torquemeter gear, which likely caused the pinion gear teeth to rapidly degrade and/or fracture. The initial failure of the No. 3 bearing would have resulted in the failure of the No. 4 bearing and the power turbine pinion gear. The reasons why damage to the Nos. 3 and 4 bearings and the power turbine pinion gear did not result in an engine chip light or oil filter contamination, leading to a filter bypass indication, could not be determined based on the available evidence.

The blockages observed in the oil delivery tube and oil nozzle were consistent with corrosion, likely due to postaccident saltwater immersion; therefore, whether there were any preexisting anomalies of the oil delivery tube jets and/or the oil nozzle, such as oil coking, could not be determined. However, the remainder of the recovered engine bearings and gears did not show evidence of damage associated with a widespread lubrication issue.

Analysis of the caution and warning panel bulb filaments showed that several annunciator lights were illuminated at the time of impact, consistent with the effects of a loss of engine power due to a failure of the power turbine pinion gear. The main rotor rpm warning light would have illuminated within a second of the loss of engine power as main rotor speed (Nr) decreased, and the hydraulic system and transmission oil pressure annunciator lights would have illuminated once Nr decreased to critical levels. The data downloaded from the helicopter's engine control unit was also consistent with a loss of engine power and subsequent loss of Nr.

While collective pitch was reduced for a few seconds after the loss of engine power, collective pitch was subsequently increased, which led to a quicker decay of Nr. The substantial decrease in Nr would have affected controllability of the helicopter and ultimately resulted in a loss of control. The pilot's cyclic and pedal inputs, as well as the helicopter's attitude and airspeed, at the time of the loss of engine power were not known. Therefore, it could not be determined if the pilot successfully entered autorotation or the reasons why the pilot increased collective control about 3 seconds after the loss of engine power. There was no evidence that the emergency flotation system was deployed. While flight track data for the accident flight was available, the last few data points were discontinuous and could not be reliably matched with the recorded engine data; therefore, it could not be determined if the pilot was in a position to deploy the emergency flotation system following the loss of power.

Probable Cause and Findings

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

A total loss of engine power due to the failure of the engine's Nos. 3 and 4 bearings and the power turbine pinion gear, and subsequent loss of main rotor rpm, which resulted in a loss of control and impact with the water.

Findings

Aircraft	Accessory drives - Failure

Factual Information

History of Flight

Enroute-cruise	Loss of engine power (total)
Enroute-cruise	Powerplant sys/comp malf/fail (Defining event)

On December 7, 2019, at 0918 central standard time, a Bell 407 helicopter, N79LP, was destroyed when it was involved in an accident in the Gulf of Mexico, about 25 nautical miles southeast of Grand Isle, Louisiana. The pilot and passenger were fatally injured. The helicopter was operated as a Title 14 Code of Federal Regulations Part 135 business flight.

In a statement provided by the operator, the helicopter had departed oil platform SP77A about 0834 and was en route to platform WD73, located about 17 nautical miles northwest. The pilot was to conduct pollution control inspections while en route to the destination platform. At 0853, the pilot landed at platform WD109 for additional fuel, but discovered that the fuel nozzle was broken and was unable to refuel. At 0910, the helicopter departed platform WD109 with 1 hour and 20 minutes of fuel reported, 2 persons onboard, and estimated time en route of 20 minutes. The operator tracked the helicopter via Sky Connect Tracker Systems.

Recorded ADS-B data revealed that the helicopter's flight track began at 0912:50 about 1.5 miles west-northwest of platform WD109 at 700 ft mean sea level (msl) and 115 knots groundspeed. The helicopter continued northwest for about 10.5 miles and gradually descended to 375 ft msl. At 0918:10, the helicopter's heading was 292° at a groundspeed of 114 knots and altitude of 375 ft msl. The final recorded point, at 0918:18, showed that the helicopter made a left course deviation to 270°, descended to 150 ft msl, and slowed to 72 knots. Figure 1 shows the platforms, recorded ADS-B flight path, and initial main wreckage location.

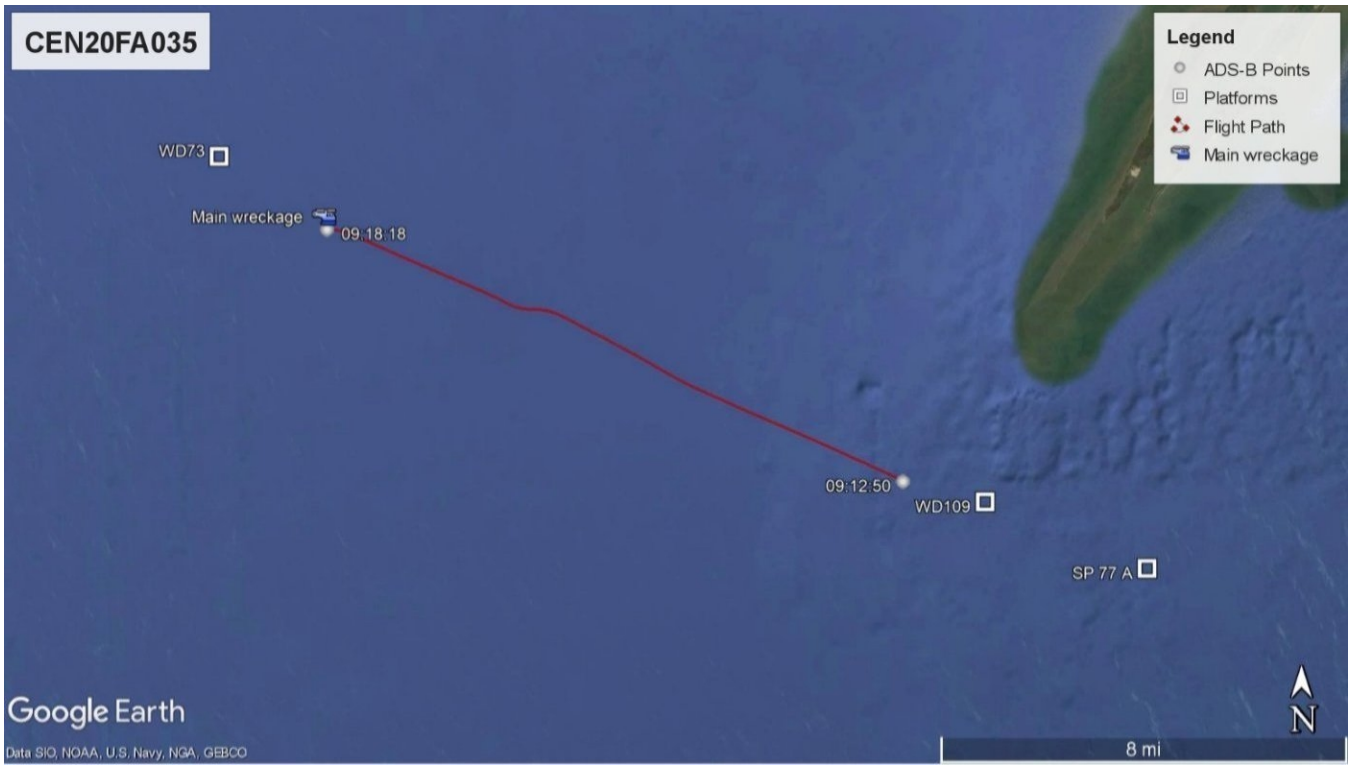

Figure 1 – Main wreckage location, flight track and platforms.

At 0915, the pilot contacted WD73 personnel and reported that he was 10 minutes from the platform. At 1011, when the helicopter had not landed at WD73, platform personnel reported it overdue. An alert notice (ALNOT) was issued at 1121.

The United States Coast Guard recovered several small pieces of the helicopter, including a cargo door, a compressed gas cylinder, and seat cushions. The debris was found near another platform about 25 miles west of where the main wreckage was eventually located.

On December 14, 2019, during a side-scan sonar mission near the last ADS-B point, the sonar hooked onto the left skid tube of the helicopter. The sonar boat pulled the skid tube up to the boat and transferred it to the wreckage recovery company. Pieces of helicopter debris were visible on the sonar images, and divers marked the location for a future recovery. The main wreckage location was about 350 ft southwest of the last ADS-B point and was on the sea floor, about 190 ft underwater. Due to adverse weather in the Gulf of Mexico, the recovery was postponed until December 20, 2019.

On December 16, 2019, a shrimp trawler unintentionally caught the helicopter wreckage in its nets and dragged the wreckage about 3 miles. When the wreckage was noticed to be caught in the net, the trawler stopped, and the wreckage eventually broke loose and sank back to the sea floor. The main wreckage was recovered from the Gulf of Mexico on December 20, 2019, and transported to a recovery facility in Louisiana.

Pilot Information

Certificate:	Commercial	**Age:**	33,Male
Airplane Rating(s):	None	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 1 Without waivers/limitations	**Last FAA Medical Exam:**	April 16, 2019
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	May 13, 2019
Flight Time:	3180 hours (Total, all aircraft), 500 hours (Total, this make and model), 180 hours (Last 90 days, all aircraft), 60 hours (Last 30 days, all aircraft), 6.8 hours (Last 24 hours, all aircraft)		

Passenger Information

Certificate:		**Age:**	27,Male
Airplane Rating(s):		**Seat Occupied:**	Left
Other Aircraft Rating(s):		**Restraint Used:**	
Instrument Rating(s):		**Second Pilot Present:**	No
Instructor Rating(s):		**Toxicology Performed:**	No
Medical Certification:		**Last FAA Medical Exam:**	
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:			

The pilot initially departed Grand Isle, Louisiana, about 0655 on the morning of the accident. He accumulated over 2 hours of flight time and was on the eighth leg of the day when the accident occurred.

Aircraft and Owner/Operator Information

Aircraft Make:	Bell	**Registration:**	N79LP
Model/Series:	407 No Series	**Aircraft Category:**	Helicopter
Year of Manufacture:	1996	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	53027
Landing Gear Type:	Skid	**Seats:**	7
Date/Type of Last Inspection:	May 12, 2019 Continuous airworthiness	**Certified Max Gross Wt.:**	5501 lbs
Time Since Last Inspection:	118.7 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	8500.8 Hrs at time of accident	**Engine Manufacturer:**	Rolls Royce
ELT:	C126 installed, not activated	**Engine Model/Series:**	250-C47
Registered Owner:	Panther Helicopters Inc	**Rated Power:**	650 Horsepower
Operator:	Panther Helicopters Inc	**Operating Certificate(s) Held:**	On-demand air taxi (135)

At the time of the accident, the helicopter had an aircraft total time (ATT) of 8,500.8 hours and an engine total time (ETT) of 7,584.7 hours. The engine was installed on the accident helicopter on November 16, 2016, at an ATT of 6,811.6 hours and ETT of 6,264.6 hours.

A 600-hour/12-month inspection and an engine oil change were last performed on May 12, 2019, at an ATT of 7,786.3 hours (ETT of 6,870.2 hours) as well as on October 21, 2019, at an ATT of 8,382.1 hours (ETT of 7,466.0 hours). According to the operator's director of maintenance, during a typical engine oil change, the combined engine filter assembly (CEFA) oil filter, which filters engine scavenge oil, is inspected for contamination and reinstalled if none is found. A review of the engine and aircraft maintenance records from April 2018 until December 2019 found no entries regarding engine chip indications. During that timeframe, there were two instances of the CEFA oil filter bypass indicator extending, the first on April 24, 2018, at an ATT of 7,180.7 hours (ETT of 6,264.6 hours) and the second on September 25, 2019, at an ATT of 8,286.6 hours (ETT of 7,370.5 hours), neither of which found contamination of the CEFA oil filter. According to the director of maintenance, the CEFA oil filter bypass indicator extending is not a common occurrence but can happen in colder ambient temperatures.

The maintenance records showed that the accident engine was last overhauled in September 2016 at an ETT of 5,894.1 hours. The last overhaul included completion of the 2,000-hour nonintrusive gearbox inspection, a visual inspection primarily aimed at the power turbine pinion and torquemeter gear mesh. No anomalous findings were reported.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:		**Distance from Accident Site:**	
Observation Time:		**Direction from Accident Site:**	
Lowest Cloud Condition:		**Visibility**	7 miles
Lowest Ceiling:	Overcast / 800 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:		**Temperature/Dew Point:**	
Precipitation and Obscuration:			
Departure Point:	Oil Platform WD109, GM	**Type of Flight Plan Filed:**	Company VFR
Destination:	Oil Platform WD73, GM	**Type of Clearance:**	None
Departure Time:		**Type of Airspace:**	Class G

The weather in the area was reported by the operator as wind from 050° at 10 knots, broken clouds at 1,700 ft, no precipitation, and 5 miles visibility in haze. A platform WD73 worker reported the clouds were 800 to 1,000 ft, and 7 to 10 miles visibility with a gray sky.

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	1 Fatal	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 Fatal	**Latitude, Longitude:**	28.926708,-89.671936(est)

The main fuselage was fractured, folded, and twisted in multiple locations, but remained connected via wiring and netting from the shrimp trawler. The forward portion of the tail boom remained connected to the intermediate fuselage but was fractured at the tail boom tube structure. The remainder of the tail boom, including the vertical and horizontal stabilizers, was not recovered. The main rotor gearbox remained attached to the transmission deck. The gearbox housing exhibited extensive corrosion due to saltwater immersion. The main rotor gearbox chip detectors were removed and exhibited extensive corrosion, but no metallic chips

were present. The emergency flotation system was installed under the provisions of Supplemental Type Certificate SR01450LA. All floats were found outside their covers but did not show evidence of inflation and exhibited a vacuum-deflated appearance.

The engine was separated from the airframe but remained partially attached via the wiring harness. The majority of the accessory gearbox housing was consumed by corrosion due to saltwater immersion, and the compressor section was partially separated from the combustion and turbine sections. The airframe-mounted fuel filter remained attached to the airframe and was removed from its mount and disassembled. The fuel filter bowl contained about 0.25 ounces of liquid with a color and odor similar to that of Jet A fuel and the fuel filter was clear of contaminants. The throttle lever was present and indicated about 15 degrees, which corresponded to below idle and beyond the throttle lock-out. The CEFA was impact-separated from the wreckage. The CEFA's oil filter bypass indicator was not extended, which is the position for when the filter is not in bypass mode. Residual oil and fuel, along with salt water, were present in the CEFA, including the filter bowls. The fuel filter element was removed, and no debris was observed. The scavenge oil filter element was removed and metallic debris was found on the filter element and its filter bowl.

Several gears and engine accessories from the accessory gearbox were recovered separated from the engine assembly. The power turbine pinion gear, part of the power turbine-to-pinion (N2) gear train, was found loose in the accessory gearbox and exhibited severe wear and smearing damage on its gear teeth and bearing shoulders. Figure 2 shows a comparison of the accident power turbine pinion gear (left) to an exemplar power turbine pinion gear (right).

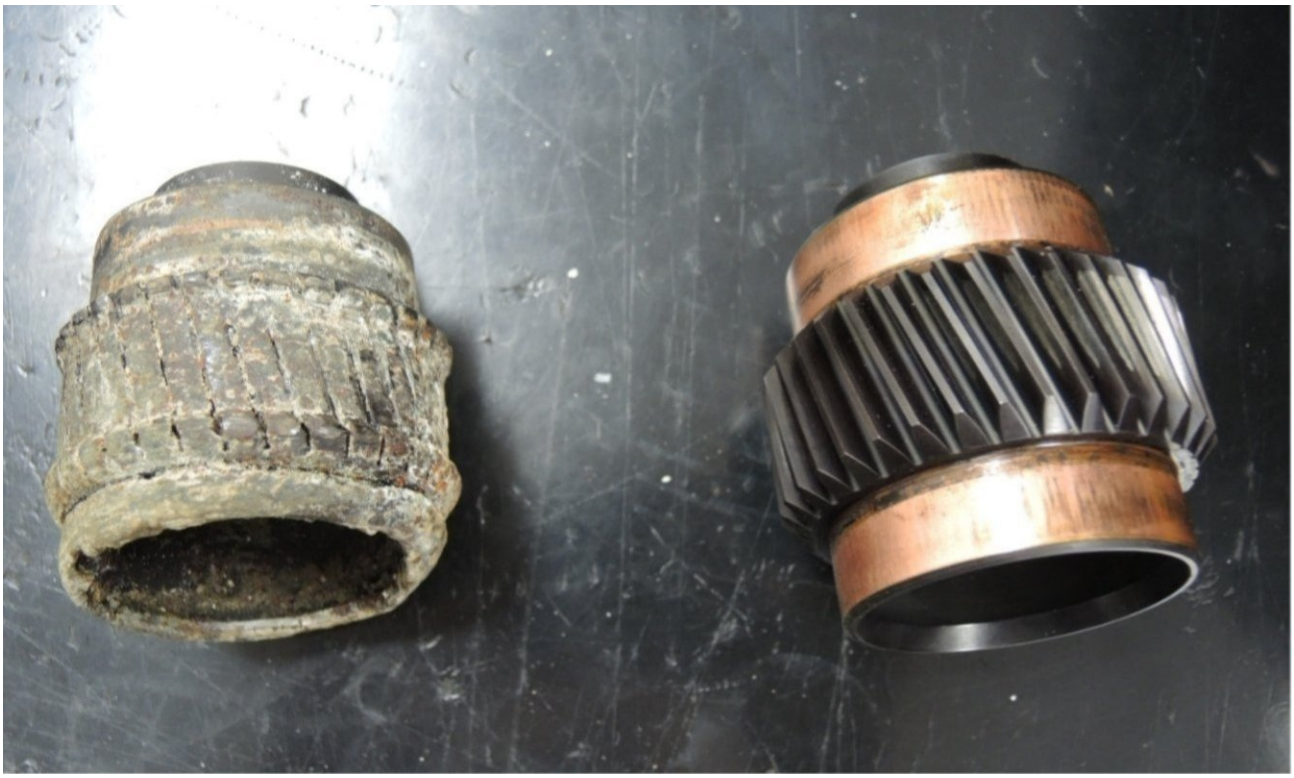

Figure 2 – Accident power turbine pinion gear (left) and an exemplar power turbine pinion gear (right).

The No. 4 roller bearing, normally installed on the aft end of the power turbine pinion gear, was severely worn and its roller elements were found loose in the gearbox cavity, along with the pinion gear. Nine of the twelve roller elements from the No. 4 bearing were recovered. The No. 3 roller bearing outer ring was present and exhibited severe wear. The inner race, roller elements, and bearing cage for the No. 3 bearing were not recovered. The engine was relocated to a specialized engine shop and disassembled. The oil nozzle for the Nos. 4 and 5 bearings remained attached to the gearbox and were corroded but did not exhibit other damage. The No. 5 bearing did not exhibit anomalous wear. Corrosion and mud were observed throughout the accessory gearbox, and additional roller elements from the Nos. 3 or 4 bearings were not found in the remnant mud or within the gearbox. The oil delivery tube for the Nos. 3 and 4 bearings, also known as the "piccolo tube," exhibited severe corrosion.

The following engine components were identified for additional testing and analysis: the No. 4 bearing; the piccolo tube oil nozzle; the oil nozzle for the Nos. 4 and 5 bearings; the housing for the Nos. 3 and 4 bearing; the power takeoff gear; the power turbine pinion gear; the scavenge oil filter and its filter bowl; the pressurized oil filter; the N2 shaft; the No. 2.5 bearing and its support; and an oil sample from the CEFA oil filter.

Medical and Pathological Information

The pilot's body was not recovered during the course of the investigation.

Tests and Research

Metallographic Examination of Gears and Bearings

Rolls-Royce completed a metallographic examination of the retained engine components. The power turbine pinion gear exhibited evidence of fatigue fractures on six consecutive gear teeth. The fatigue fractures originated on the drive side tooth root fillets and exhibited multiple origins. The fatigue fractures progressed toward the coast side (the non-drive and non-contact side) of the gear tooth. No dimensional anomalies were observed at the fracture origins or the gear tooth root surfaces adjacent to the origins. All pinion gear teeth exhibited circumferential rubbing and smearing. The Nos. 3 and 4 bearing journals on the power turbine pinion gear also exhibited circumferential rubbing damage and thermal distress, with the No. 3 bearing journal

showing significant deformation and material loss compared to the No. 4 bearing journal. Analysis of the material composition and core microstructure of the power turbine pinion gear, away from areas of thermal distress, showed that they met drawing requirements. The No. 3 bearing outer ring exhibited material removal on its roller path and circumferential rubbing on the forward shoulder corner. The outer ring's raceway and forward shoulder corner displayed thermal distress. Analysis of the material composition and microstructure of the outer ring, away from areas of thermal distress, showed that they met drawing requirements. The No. 4 bearing outer ring exhibited material removal on its roller path and circumferential rubbing on the aft shoulder corner. Transferred material and roller impressions were observed on the raceway of the inner ring. The inner ring's forward shoulder also exhibited deformation in the forward direction. The inner diameter of the inner ring exhibited circumferential rubbing and transferred material. The outer ring's raceway and forward shoulder corner, the roller diameters, and the inner ring exhibited thermal distress. The recovered rollers all exhibited a circumferential rub step on one end. Analysis of the material composition of the outer ring, inner ring, and rollers met drawing requirements. Microstructure analysis away from the area of thermal distress could only be accomplished on the outer ring and a representative roller. The microstructure for both components met drawing requirements. The No. 2.5 bearing support exhibited circumferential rubbing consistent with contact with the inner diameter of the power turbine pinion gear. The No. 2.5 bearing support was corroded, and its aft face was deformed forward at the 12 o'clock position. The area of deformation on the aft face also showed evidence of circumferential rubbing.

Computed Tomography (CT) Scans of Piccolo Tube and Oil Nozzle

The piccolo tube showed material deposits on the internal passageway walls and all of its oil jets appeared to be blocked. Additionally, material was observed within the oil screen of the remnant gearbox housing material attached to the piccolo tube. The piccolo tube was sectioned in multiple locations to analyze the tube, the remnant gearbox housing material, and deposits within the tube. The oil delivery tube and gearbox housing material were consistent with drawing requirements. The deposits within the oil jets were consistent with byproducts of aluminum (piccolo tube) corrosion and dirt. Additionally, fine metallic particles observed in the deposits were consistent with an iron-based alloy. A representative iron-based alloy particle measured about 0.0008 in. long. Material seen within the oil screen was consistent with byproducts of magnesium (gearbox housing) corrosion. The CT scan of the oil nozzle for the Nos. 4 and 5 bearings showed material deposits on the internal passageway walls and all of the oil jets appeared to be blocked. The oil nozzle was sectioned in multiple locations for further analysis. The oil nozzle material was consistent with drawing requirements. The blockage material was consistent with byproducts of aluminum (oil nozzle) corrosion and dirt. Additionally, fine metallic particles observed within the deposits were consistent with an iron-based alloy, as well as byproducts of magnesium corrosion. A representative iron-based alloy particle was measured to be about 0.0028 in. long.

Caution and Warning Panel

The caution and warning panel was examined by the NTSB Materials Laboratory using a stereomicroscope. Each annunciator light consisted of three bulbs. For several bulbs, the glass globe had a clouded appearance, and the filaments could not be visually examined; these bulbs

were removed from the panel and the individual bulb was x-rayed to examine the filaments. Seven lights exhibited stretched filaments. Table 1 contains excerpts from Bell 407 rotorcraft flight manual applicable to those annunciator lights in which filaments were found stretched.

Annunciator	*Condition*	*Corrective Action*
FADEC FAULT	PMA and/or MGT, Np, or Ng automatic limiting circuit(s) not functional.	Remain in AUTO mode. Land as soon as practical. Applicable maintenance action required prior to next flight.
XMSN OIL PRESS	Transmission oil pressure is below minimum.	Reduce power; verify fault with gauge. Land as soon as possible.
HYD SYSTEM	Hydraulic pressure below limit.	Verify HYD SYS switch position. Accomplish hydraulic system failure procedure.
ENGINE OVSPD	Ng greater than 110% or NP versus TORQUE is above maximum continuous limit (102.1% Np at 100% torque to 108.6% Np at 0% torque)	Adjust throttle and collective as necessary. Determine if engine is controllable; if not, shut down. Maintenance action required before next flight.
ENGINE OUT	Ng less than 55 ± 1% and/or FADEC senses ENGINE OUT	Verify engine condition. Accomplish engine failure procedure.
CYCLIC CENTERING	Cyclic stick is not centered.	Reposition cyclic stick to center position to extinguish CYCLIC CENTERING light.
RPM (with low RPM audio)	Nr below 95%	Reduce collective and ensure throttle is in FLY detent position. Light will extinguish and audio will cease when Nr increases above 95%.

Additional Information

Engine Electronic Control Unit (ECU) Data

The non-volatile memory was successfully recovered from the ECU's interval chips, which included engine fault history, engine history, and engine incident recording data. The recovered data from the maintenance terminal showed multiple faults logged in the fault

history of the primary governor, all of which related to power turbine or rotor functions. Three incidents were logged in the incident recorder: 1) an engine power turbine speed (Np) high exceedance; 2) helicopter rotor speed (Nr) droop; and 3) a Np overspeed.

The ECU data indicated that the engine had performed normally until a sudden overspeed of the power turbine and a steep drop in torque occurred. Nr decreased rapidly and went below 80% within 2.5 seconds of the power turbine overspeed. Immediately after the overspeed occurred, collective position gradually decreased over the next 3 seconds, which slowed the rate of the Nr decay, but not enough to recover Nr. Collective then increased until the end of the ECU data, resulting in an increased rate of Nr decay until its lowest value of 17% at the end of recorded data.

Administrative Information

Investigator In Charge (IIC):	Lindberg, Joshua
Additional Participating Persons:	Keith Kibodeaux ; Federal Aviation Administration; Baton Rouge, LA Jon Michael; Rolls-Royce; Indianapolis, IN Benoit Albert; Bell Helicopter; Hurst, TX Lance Panepinto; Panther Helicopters; Belle Chasse, LA
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