Rolls-Royce

Engine Investigation Report

Rolls-Royce Corp.
Model 250-C47B
Engine CAE 848151

Hillsboro Aviation Inc
Togwotee Pass, WY

Jack Johnson
Air Safety Investigations

Accident date: 15 February 2012
Investigation date: 2 March 2012

Background

On 15 February 2012 at 1300 hours local time, a Bell 407, N407HL, operated by Hillsboro Aviation, was substantially damaged during a crash following a loss of control while on a search and rescue mission near Jackson Hole, Wyoming. The pilot and one rescue crewman were injured; another rescue crewman was fatally injured.

The search and rescue mission was in response to a call for assistance by a group of snowmobile riders, one of whom was critically injured (and subsequently died from his injuries). Initial attempts to locate the injured person were unsuccessful, but the helicopter crew eventually spotted the injured snowmobiler's friends in an open field and landed nearby. A rescue crewman exited the helicopter and spoke with the snowmobilers, who agreed to lead the helicopter to their injured friend some distance away.

The rescue crewman boarded the helicopter and the helicopter took off and followed the group of snowmobilers. At several points along the way, the helicopter would have to stop and hover, waiting for the snowmobilers to catch up. According to statements by the snowmobilers, the helicopter would hover 100-200 above the trees. The third time the helicopter stopped to hover, the pilot reports he felt a slight left yaw, which he corrected with pedal inputs. The helicopter then began a rapid spin to the left and descended rapidly into trees and snow-covered terrain.

The rescue crew member in the rear seat extricated himself from the helicopter and assisted the other two crew members from the wreckage. Although both were initially responsive, the second rescue crewmember succumbed to his injuries.

The investigation was conducted under the auspices of the National Transportation Safety Board which requested assistance from the FAA, Rolls-Royce and Bell Helicopter. An examination was held at Beegle's Air Salvage in Greeley, Colorado on 1 March 2012. This report presents the observations made during the investigation.

Aircraft Information

Model	Bell 407
Serial Number	53869
Registration Number	N407HL
Airframe Total Time	812.2 Hours (Hobbs)

Engine Information

Engine Model	Rolls-Royce 250-C47B
Rating:	650 Shaft Horsepower
Serial Number	CAE 848151
Engine Total Hours	986.40 Hours (ECU)
Engine Time Since Overhaul	NEW

Wreckage and Impact Information

The author did not visit the accident site. Numerous photos taken at the accident site were provided by first responders and air salvage personnel.

These photographs show the helicopter lying on its starboard side on heavily forested, steeply sloped terrain. The wreckage is partially buried in deep snow. Broken and chopped tree branches litter the ground immediately surrounding the wreckage. Small pieces of main rotor blade are also shown scattered about the crash site. The tail boom was severed forward of the horizontal stabilizer, but the remains of the tail boom were located immediately adjacent to the wreckage.

The wreckage was recovered to Beegles Aircraft Services, where it was stored until it could be examined by the NTSB, with the assistance of Bell Helicopter and Rolls-Royce.

The following presents the observations made during the examination.

Airframe Examination

The landing skids had been removed by recovery crews.

The forward floor of the cockpit exhibited crushing damage; the remainder of the fuselage exhibited no substantial impact damage.

The main rotor mast was displaced ~5 degrees to port. The main rotor blades had all separated from the mast at the yokes, with the fragmented remains of the yokes all exhibited rotational damage. According to the Bell Helicopter representative, damage to all main rotor blades was consistent with power delivery at impact.

The tail boom was fractured approximately three feet aft of the fuselage. The tail rotor drive output shaft (steel shaft) was intact and remained coupled to the engine and tail rotor drive shaft. The steel shaft exhibited rotational witness marks where the shaft passed through the oil cooler fan bulkhead, suggesting the tail rotor drive was rotating at impact.

The tail rotor blades also exhibited impact damage consistent with power delivery at impact.

The collective was fractured at the base, preventing control continuity verification to the engine.

Engine Examination

The engine was presented for examination installed in the helicopter. 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 within the compartment. 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. Manual rotation was used to confirm continuity of the N1 and N2 gear trains. Drive continuity from the engine to the main rotor and tail rotor drive was verified.

All fuel, lube and pneumatic lines, coupling (“B”) nuts and their associated fittings were checked by hand for security and were found at least finger tight.

The exhaust plenum and visible turbine sections were inspected and found to have no evidence of damage or failure. The exhaust duct exhibited crushing damage, which was attributable to the accident sequence.

The power turbine was then visually examined. The 4th stage turbine blades were smooth to the touch and exhibited no evidence of FOD or thermal degradation. There was no impact damage, metal splatter or evidence of rubbing around the 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.

Engine Maintenance Records

Component	Serial Number	Part Number	TSO	Total Time
Engine	CAE 848151	23063392	NEW	986.40
Gearbox	CAG 48152	23063393	NEW	986.40
Compressor	CAC 45803	23065593	NEW	986.40
Turbine	CAT 45337	23063354	NEW	986.40
HMU	JGALM1273	23078029	NEW	986.40
ECU	JG08ANU1135	23088484	NEW	986.40
Bleed Valve	FF326311	23073353	NEW	986.40
Fuel Nozzle	VN1ATT0334	23077067	NEW	986.40

ECU Data Examination

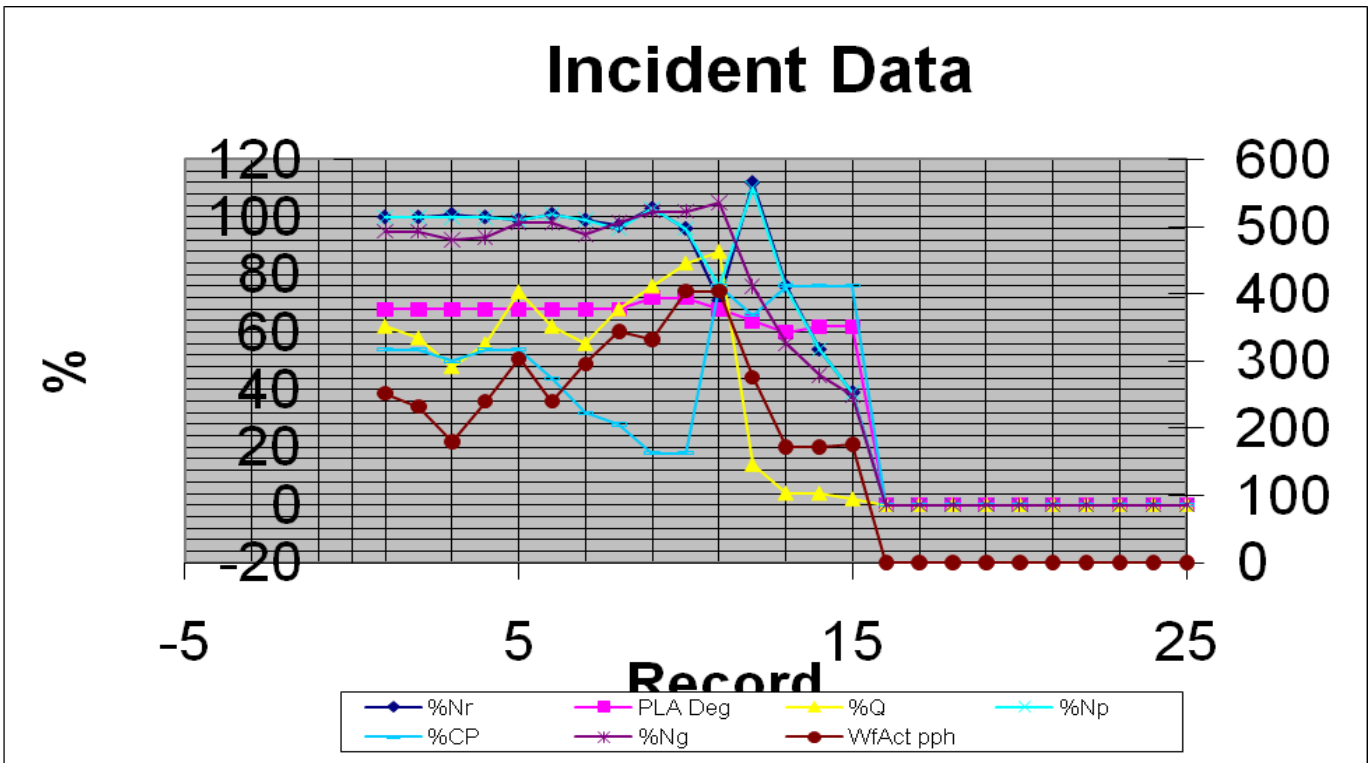
The Engine Control Unit (ECU) was visually examined and found to be undamaged and in suitable condition for a field download of data. Extraction of the ECU IR (Incident Recorder) data was accomplished, revealing to total of 15 data-points, recorded at 1.2 second intervals. In addition to IR data, eight 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 three seconds of the accident flight.

Examination of ECU IR data recorded during the accident sequence revealed the engine responding normally to control inputs.

The ECU’s incident recorder function was triggered at timestamp 986:28:20.232. The first snapshot data is recorded at 986:28:20.544.

The ten data lines recorded prior to the triggering event, indicate the pilot was holding collective at a relatively constant 54%, and then gradually lowered collective to 18% over a period 4.8 seconds. Collective is then suddenly increased and held relatively constant at 76% until power is lost to the ECU.

For clarity, detailed examination of the ECU data is divided into three groups:
Data lines 1-5, 5-10 and 10-15.



Data Lines 1-5:

	HH:MM:SS.mmm	GG Turbine	Main Rotor	MGT	Torque	Power Turbine	Fuel Flow	Ambient Air Pres	Collective Pitch
Record		**Ng**	**Nr**	**Deg**	**%Q**	**Np**	**pph**	**psia**	**%CP**
1	986:28:09.432	95	100	1240	62	100	252	10.17	54
2	986:28:10.632	95	100	1240	58	100	232	10.28	54
3	986:28:11.832	92	101	1160	48	100	180	10.16	50
4	986:28:13.032	93	100	1200	56	100	240	10.36	54
5	986:28:14.232	98	99	1320	74	99	304	10.31	54

Collective Pitch (%CP) is held relatively constant at 54%, with only one adjustment to 50% on data line #3. Pressure altitude fluctuates from 10.17 PSIA to 10.36 PSIA. (The ambient air pressure sensor is used for scheduling fuel flow. It is not a “sensitive altimeter” and is not dampened, thus, even small oscillations in airflow can show what appears to be large oscillations in altitude over a short period of time.) The average PSIA over this period of time is 10.26 PSIA.

On data line #5, both Nr (Main Rotor Speed) and Np (Power Turbine speed) all drop by 1%, while %Q (Engine Torque) increases from 56% to 74%. The nature of this torque increase could not be determined from available evidence, but is most-likely a main rotor blade-strike. The collective pitch does not change at this time, and an anti-torque pedal input alone would be insufficient to cause such a large increase in torque value.

The engine responds to the increase in power demand by increasing fuel flow to 304 PPH (Pounds Per Hour), with corresponding increase in Ng (Gas Generator) speed and MGT (Measured Gas Temperature).

Data Lines 6-10:

	HH:MM:SS.mmm	GG Turbine	Main Rotor	MGT	Torque	Power Turbine	Fuel Flow	Ambient Air Pres	Collective Pitch
Record		**Ng**	**Nr**	**Deg**	**%Q**	**Np**	**pph**	**psia**	**%CP**
6	986:28:15.432	98	101	1340	62	101	240	10.34	44
7	986:28:16.632	94	99	1240	56	99	296	10.33	32
8	986:28:17.832	98	97	1340	68	96	344	10.34	28
9	986:28:19.032	102	103	1480	76	103	332	10.26	18
10	986:28:20.232	102	96	1480	84	96	404	10.34	18

Data line #6 shows the pilot lowering Collective Pitch from 54% to 44%, with a corresponding decrease in fuel flow and torque. The pilot continues lowering collective down to 18% over the next few seconds. During the same period of time torque drops to 56%, but then rises to 84%. Main rotor and power turbine speeds fluctuate between 96% and 103%. The engine responds to the varying power demands by adjusting fuel flow. The average ambient air pressure over this period of time is 10.32 PSIA, an adiabatic difference from the first dataset consistent with a decent of 60 feet.

The large torque fluctuations again suggest a main rotor blade strike.

Data Lines 11-15 (end of data):

	HH:MM:SS.mmm	GG Turbine	Main Rotor	MGT	Torque	Power Turbine	Fuel Flow	Ambient Air Pres	Collective Pitch
Record		**Ng**	**Nr**	**Deg**	**%Q**	**Np**	**pph**	**psia**	**%CP**
11	986:28:21.432	105	71	1620	88	76	404	10.34	76
12	986:28:22.632	76	112	1000	14	110	276	10.37	66
13	986:28:23.832	56	76	500	4	75	172	10.45	76
14	986:28:25.032	45	54	320	4	54	172	10.4	76
15	986:28:26.232	38	39	280	2	39	176	10.4	76
16	00:00:00.000	0	0	0	0	0	0	0	0

Data line #11 indicates the pilot made a large increase in collective pitch, rising from 18% to 76%. This is consistent with typical control inputs immediately prior to ground contact. There is a corresponding increase in torque, gas generator speed and fuel flow, however a large decrease in main rotor RPM. This suggests the main rotor continues to strike solid objects.

Data line #12 shows collective pitch remaining high, but torque dropping to 14% while main rotor increases to 112%. Snapshot data show main rotor speeds peaking at 123%, while all other engine parameters approach minimum values. This data would coincide with the main rotor shedding its blades.

The remaining data lines (13-15) show parameters that are consistent with the helicopter being on the ground. Ambient air pressure remains at a constant 10.40 PSIA, which corresponds to a decent of an additional 80 feet from the time of the first torque spikes. The height of the trees in the immediate surroundings of the crash site was not available at the time this report was written.

Summary of Findings

1. Visual examination of the engine revealed no signs of engine failure or malfunction.

2. Data extracted from the ECU showed the engine responding normally to control inputs prior to and during the accident sequence.