ACCIDENT

Aircraft Type and Registration:	Robinson R22 Beta, G-RIDL
No & Type of Engines:	1 Lycoming O-360-J2A piston engine
Year of Manufacture:	2001
Date & Time (UTC):	15 November 2009 at 1530 hrs
Location:	Pinfold Farm, Macclesfield, Cheshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	476 hours (of which 130 were on type) Last 90 days - 0 hours Last 28 days - 0 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot was undertaking a local flight in his helicopter when witnesses heard an unusual noise and saw the helicopter descend. It crashed in a field, fatally injuring the pilot. Evidence suggests that the pilot may have been attempting a precautionary landing and that the tail of the helicopter contacted the ground, leading to a loss of control. Corrosion was found in the left magneto, which could have caused an increase in engine vibration and noise, and possibly led the pilot to attempt a precautionary landing.

History of the flight

The pilot, who was also the owner of G-RIDL, kept the helicopter outside at a private site located close to Manchester Airport and normally only used it for pleasure flights in the local area. On the afternoon of the accident he decided to undertake such a flight, intending to return after about an hour flying around the Macclesfield area.

There were no witnesses to the pilot preparing the helicopter for flight, but a witness, who had seen the helicopter operating before, watched as the pilot started the engine. He twice saw the helicopter lift off and rise a few feet above the ground before landing again. It then took off and departed normally. He was not aware of anything otherwise unusual regarding the helicopter or its operation.

Manchester ATC recorded the helicopter taking off at

1517 hrs and cleared the pilot to fly to the south-west, to a rural area a few miles to the north of Macclesfield. The helicopter remained flying in this area and at 1519 hrs ATC advised the pilot that another helicopter, G-CKCK, an Enstrom 280FX, was taking off from a nearby site. The pilot of G-RIDL replied that he would descend to 200 ft and later reported that he had the other helicopter in sight. The pilot of G-CKCK did not see G-RIDL.

Shortly before the accident, G-RIDL was seen by witnesses who described it flying at a height of between 500 and 1,000 ft above the ground, with no apparent signs of anything being wrong. The helicopter had been circling near the crash site for a few minutes when one witness heard a noise described as a "bang" or "clatter" and saw the helicopter rock from side to side. He reported that the engine continued to sound as if it was running normally but that the helicopter then slewed to one side so that its nose was pointing to the left of the direction of travel.

Other witnesses saw the helicopter as it descended but, due to the nature of the terrain and surrounding trees, no one saw it strike the ground. Witnesses reported hearing the engine running as the helicopter descended. Other people close to the accident site, who had not seen the helicopter, were alerted to its presence by the noise it was making. One described it as "struggling as if it were under load". There was then a heavy thud and the noise stopped, prompting two people to investigate. They found the helicopter lying on its side in a nearby field, with the pilot having sustained serious injuries. They notified the emergency services who attended the scene but the pilot subsequently died from his injuries.

Air Traffic Control

When Manchester ATC did not receive responses to their calls to G-RIDL they requested the assistance of the pilot of G-CKCK in trying to locate it. The pilot flew over the last known position of G-RIDL, but was unable to locate it. ATC also guided him to the normal landing site for G-RIDL to see whether it had returned. When it could not be found ATC activated their lost aircraft response procedure. This was quickly suspended, however, when they were informed by the emergency services that G-RIDL had crashed.

Weather

Reports from Manchester Airport covering the time of the accident indicated that weather conditions were good, with a light southerly wind and no cloud likely to have affected the flight. The temperature and dew point of 11°C and 8°C, respectively, were conducive to serious carburettor icing.

Recorded data

The helicopter was not equipped with a crash-protected recorder, nor was it required to be.

A GPS receiver capable of recording the helicopter's flight path was recovered from the wreckage. This type of GPS receiver records the track in a memory that is dependent on an internal battery. An attempt to download the data revealed that the battery did not have sufficient charge to maintain the memory; therefore no GPS track data was available.

The flight path of the helicopter was, however, captured by Manchester Airport's radar (Figure 1). The helicopter's transponder was not set to report its altitude, so only its ground track could be assessed.

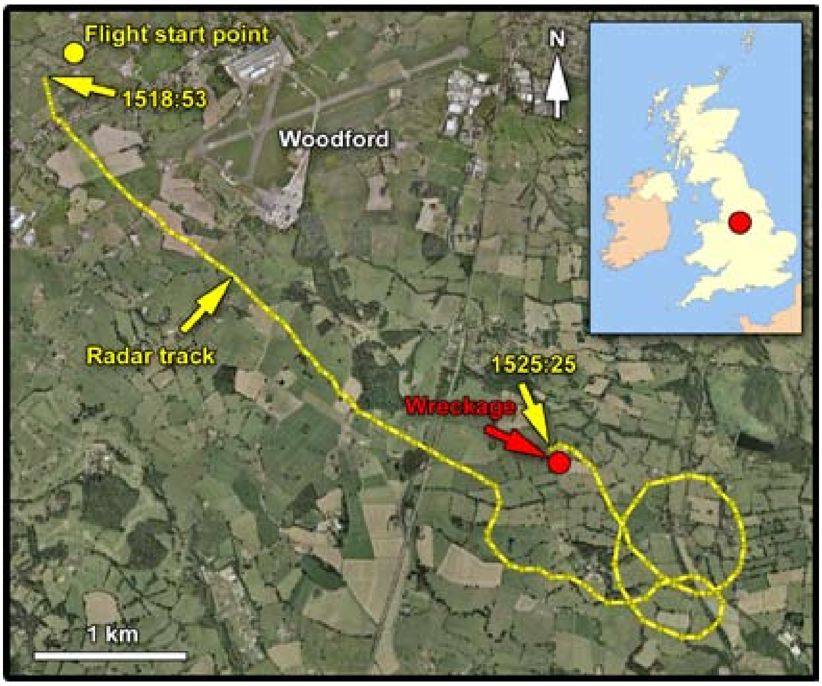

Figure 1

G-RIDL radar track

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Accident site and initial examination

The helicopter struck the ground approximately 50 metres from the north-west corner of a field near the top of an elevated area of ground (Figure 2). The first ground mark consisted of a shallow scrape together with two associated angled slash marks, consistent with the helicopter's tail rotor blades striking the ground whilst rotating. A second ground mark was found three metres beyond the first and contained a portion of the tail rotor gearbox mounting bracket. These markings showed that the helicopter was on a heading of approximately 147°(M)when it first struck the ground. The tail rotor gearbox, including the roots of both tail rotor blades, and the tail assembly of the helicopter had detached and were found close to the second ground mark. The tail rotor blades had failed at approximately 25% of their span; one detached blade section was found 20 metres beyond the first ground mark and the second was recovered from an adjacent field, 115 metres to the left of the first ground mark.

A third ground mark was identified 15 metres beyond the second, which was consistent with the right skid striking the ground. The final ground mark was produced when one of the main rotor blades struck the ground. This had resulted in the fuselage of the helicopter rotating 180° around the rotor head and landing heavily on its right side. The helicopter came to rest in a low-lying, waterlogged area of the field, 53 metres beyond the point of first ground contact. There was no evidence that the helicopter had made contact with any of the trees surrounding the field, or the overhead electricity cables which crossed the field.

Figure 2

Accident site

The impact sequence resulted in the right side of the cockpit being deformed inwards. This also caused deformation of the cockpit bulkhead on the right side and crushing of the right side of the pilot's seat mounting structure. The magneto switch was found in the OFF position but it was later confirmed that the emergency services had turned the key from the BOTH position to the OFF position during their rescue attempt. The carburettor heat selector was also found in the OFF position, although it could not be established whether it had been moved after the accident.

The right skid had failed in bending just behind the forward mounting strut. The rear mounting strut had failed where it attached to the right side of the rear fuselage/engine mounting framework which had also been distorted. Both main rotor blades were intact and showed no leading edge damage. The blades had been bent upwards when they struck the ground during the impact sequence. The tail rotor pitch control rod had also become wrapped around the tail rotor driveshaft.

A significant quantity of fuel was drained from the fuel tanks prior to recovering the helicopter from the field.

Helicopter description

The R22 Beta is a two-seat, single engine helicopter powered by a four-cylinder Lycoming air-cooled engine. The engine is rated at 145 hp at 2,700 rpm.

The rotor system consists of a two-bladed teetering main rotor and a tail rotor driven by a pair of vee-belts. The vee-belts are fitted between a lower pulley mounted on the end of the engine crankshaft and an upper pulley located on the driveshaft of the combined tail rotor and main rotor gearbox (combined gearbox). The belts are tensioned via a clutch system which displaces the upper pulley relative to the engine crankshaft pulley. The clutch assembly consists of an electrically-driven actuator connected to the engine crankshaft and the combined gearbox driveshaft by a pair of bearing assemblies. The upper bearing is fitted with a freewheel unit which allows the rotor system to continue to rotate in the event of an engine failure. When the clutch is engaged via the cockpit-mounted switch the actuator extends, tensioning the belts. A light illuminates on the instrument panel to indicate that the clutch actuator is operating. As the belt tension increases a pair of leaf springs bow outward, operating two microswitches when the correct operating tension is achieved, switching off the actuator motor. The tension in the vee-belts can vary during normal operation and the clutch actuator operates periodically to compensate and maintain the correct belt tension.

Robinson Helicopter Safety Notice SN-2B, dated July 1988, and revised in June 1994, gives information on the clutch warning light. It states that if it flickers, or remains illuminated for longer than usual, it can indicate a belt or bearing failure in the vee-belt drive. It instructs that should this occur whilst airborne the pilot should immediately pull the CLUTCH circuit breaker, select the closest safe landing site and make a normal power-on landing. During the landing the pilot should be prepared to enter autorotation if a failure of the drive system occurs. The CLUTCH circuit breaker on G-RIDL was not found to be pulled when the helicopter was examined.

Ignition system

The engine is fitted with a dual ignition system incorporating two magnetos, each of which supplies high voltage to one of the two spark plugs in each of the four cylinders. Within the magnetos the high-energy electrical power is fed from the coil via its outlet tab to the distributor by a rotating carbon brush. Environmental sealing of the magneto relies on the tight face to face contact of the two magneto case halves and the application of a coat of paint to the assembled unit. The magnetos are turned ON and OFF by a key-operated, five-position, rotary ignition switch mounted on the lower instrument panel. The five switch positions are:

- OFF - Both magnetos off
- R - Right magneto on, left magneto off
- L - Left magneto on, right magneto off
- BOTH - Both magnetos on
- START - Operates the starter motor, both magnetos on

The left magneto was a TCM type S4LSC-200 unit, with part number 10-600614-1 and serial number I180D19E. The right magneto was a TCM type S4LSC-204T unit, with part number 10-600644-201 and serial number I250027E.

Loss of engine power

A loss of engine power in an R22 is evident by a nose-left yaw, change in engine noise and a rapid decay in main rotor rpm. If there is a delay in lowering the collective lever the rotor rpm can decrease to a level where the rotor blades stall. In forward flight the retreating blade will stall before the advancing blade. This will cause the rotor disc to tilt backwards, a phenomenon known as rotor blow-back. With a reducing rotor rpm the helicopter will start to descend and the airflow impinging on the tail surface will cause the helicopter to pitch nose-down. If the pilot moves the cyclic control rearwards to prevent the nose from dropping, then the combination of rotor blow-back and pilot input can cause the main rotor blades to strike the tail cone.

Maintenance history

Examination of the helicopter's maintenance records confirmed that it had been maintained in accordance with the approved maintenance program for the Robinson R22 Beta and was in compliance with all mandatory requirements in force at the time of the accident.

Teledyne Continental Motors (TCM) Service Bulletin 643B provides the maintenance intervals for TCM and Bendix aircraft magnetos and related equipment. SB 643B includes a requirement for the magneto to be inspected every 500 flying hours, which includes inspections of the carbon brush for unusual wear and the outlet tab on the coil for the presence of a depression. The SB also requires that the magneto be overhauled or replaced either at the expiration of five years since the date of manufacture, or four years since the magneto was placed in service, whichever occurs first. The maintenance records for G-RIDL confirmed that both magnetos were removed in July 2009 for overhaul in accordance with SB 643B.

On 6 November 2009, a flying instructor had arranged to use the helicopter, but after starting the engine he observed that the clutch actuator warning light was flickering. He shut down the helicopter and reported the problem to the owner, who replied that this was an ongoing issue. The owner, who had a mechanical engineering background, explained to the instructor that he did not believe the problem was serious. Nevertheless, the instructor provided the owner with a copy of Robinson Helicopter Safety Notice SN-2B, and arrangements had been made for the helicopter to be examined by a maintenance organisation the week commencing 16 November 2009, the week following the accident.

Detailed examination

Analysis of the fuel recovered from the helicopter showed that it conformed to the specification for Avgas and that there were no significant contaminants present. Examination of the rotor head and the cyclic and collective control circuits revealed no evidence of control restriction or pre-impact disconnection. The fracture surfaces of the tail rotor gearbox mounting were consistent with a failure in overload and both tail rotor blades had failed as a result of overload in bending. The tail rotor driveshaft coupling to the tail rotor gearbox had failed in torsional overload and the tail rotor pitch control rod had become wrapped around the tail rotor driveshaft.

Given the reports regarding the flickering rotor clutch light, the rotor drive system was examined in detail. Both rotor drive vee-belts were found to be in good condition with no evidence of wear or deterioration. The tension of both belts was measured and found to be within the limits defined in the Robinson R22 Maintenance Manual and the extension of the clutch actuator was within the expected operating range. In order to test the operation of the clutch actuator, both rotor drive belts were removed and electrical power was applied to the helicopter. With the clutch selected to ENGAGED the clutch light remained illuminated but the clutch motor did not operate. The clutch assembly was removed and damage was found to the outer sleeve of the clutch actuator which was consistent with the actuator being struck by the rearmost, engine-mounted drive belt pulley during the impact sequence. Disassembly of the actuator confirmed that the inner diameter of the outer sleeve had been distorted, jamming the moveable portion of the actuator. The clutch motor was then reconnected to the helicopter wiring loom and electrical power restored. During this test the clutch motor operated intermittently. Examination of the wiring loom confirmed that the insulating sleeve of one cable had been damaged and would, when moved, ‘short out’ against the adjacent structure, causing the clutch motor to stop intermittently. The damage was consistent with having been caused during the impact sequence. When the wire was repaired, the clutch motor operated normally. The upper and lower clutch bearings were disassembled and no evidence of bearing distress or deterioration was noted. The clutch system tension microswitches were tested and found to operate normally.

The engine, serial number L-39266-36A, was removed for a series of operational tests in an instrumented test cell under AAIB supervision. After starting and a warm-up period to confirm that the engine appeared to operate normally, it was accelerated to 1,500 rpm to carry out a functional check of each magneto. The decrease in engine speed was 80 rpm and 76 rpm when operating on the left and right magnetos respectively.

Both magnetos were reselected and the speed of the engine was increased to 1,800 rpm, with no abnormalities identified with the engine’s performance or parameters. After stabilising at 1,800 rpm a second magneto check was carried out, which showed a drop of 271 rpm when operating on the left magneto, compared to a 112 rpm drop when operating on the right. The test was repeated and this time, when operating on the left magneto, the speed drop was 101 rpm.

The engine speed was then increased to 2,700 rpm with both magnetos operating. The engine produced 145.4 hp at this speed, with all of the parameters within the engine manufacturer’s prescribed limits. However, there was an intermittent misfire on the number four cylinder with associated engine vibration. The engine speed was reduced to 1,800 rpm and the test was then repeated using the right magneto only. The engine was able to maintain 2,700 rpm and produced 140 hp without misfiring. Once again the engine speed was decreased to 1,800 rpm and the test repeated using just the left magneto. As the engine speed reached 1,950 rpm the number four cylinder was observed to misfire intermittently and the engine could not be accelerated above 2,300 rpm. The engine was shut down and the magnetos removed for further investigation.

A bench test of both magnetos confirmed that sufficient energy was being produced to generate a spark across a representative air gap. On disassembling the magnetos, no defects were observed in the right magneto; however, when the left magneto was opened, clear evidence of water ingress was found. Examination of the mating faces of the magneto case halves failed to identify the location of water ingress. Removal of the distributor gear revealed evidence of arcing damage to the number four cylinder contactor and the presence of a layer of oxide on the contactor. The copper outlet tab on the magneto coil was coated in a layer of oxide and a depression had formed in the middle of the tab (Figure 3).

Measurement confirmed that the depression had been formed as a result of a loss of material from the tab. The carbon brush in the distributor gear was measured and found to be 10.7 mm long (the minimum permitted length is 9.53 mm), but the surface of the brush that touched the magneto coil tab was pockmarked as if material had been plucked from its surface. The formation of oxide on the conducting surfaces would have resulted in an increase in the electrical resistance and also accelerated the rate of wear of the components. The damage to the number four cylinder contactor confirmed that arcing had occurred between the

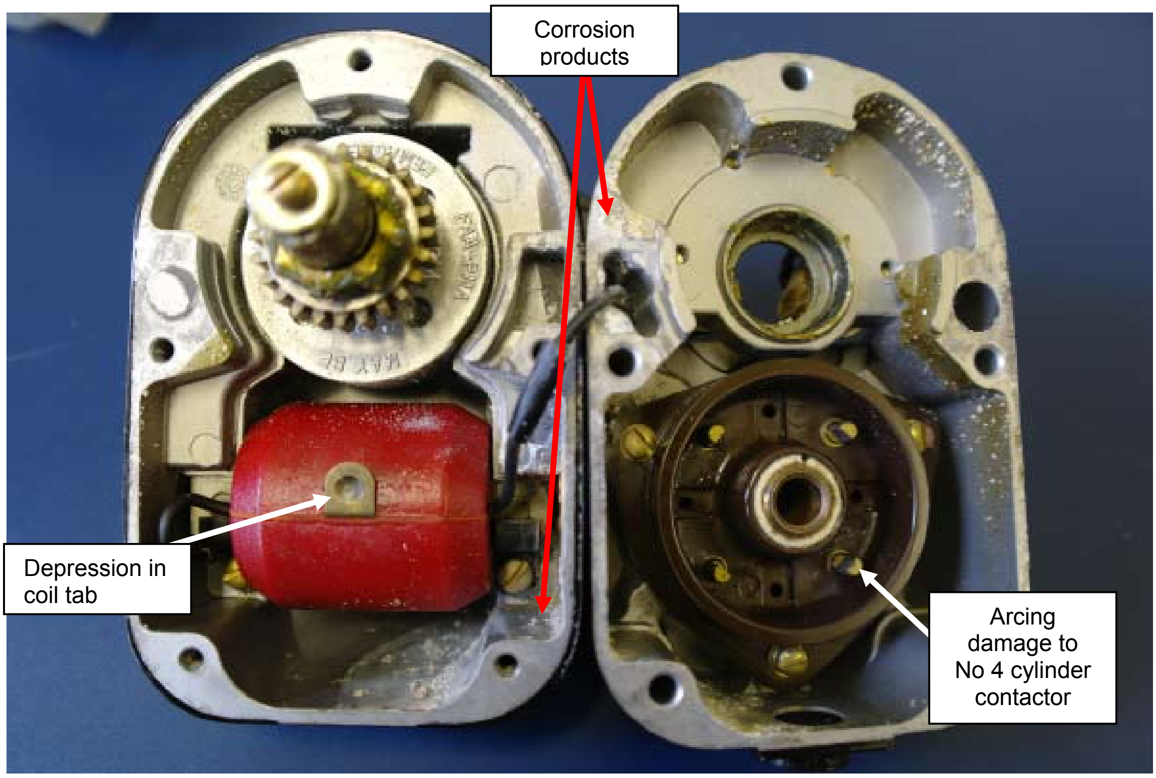

Figure 3

Left magneto showing corrosion and contactor damage

distributor gear and the contactor. Such arcing would have the effect of delaying the generation of a spark from the number four cylinder spark plug connected to the left magneto. This delay would change the speed of combustion within the cylinder resulting in burning fuel passing out of the exhaust valve and an engine misfire.

Previous events

In February 2009 the AAIB investigated a fatal accident to a Robinson R22, registration G-TTHC (AAIB report number EW/C2009/02/04). The investigation identified one of the contributory factors to be the failure of the left magneto due to the failure of the magneto coil tab. Whilst the left magneto fitted to G-RIDL had not failed completely, the abnormalities observed showed significant similarities to the failure mechanism observed on G-TTHC.

Medical aspects

The pilot had a medical history which he had not declared to the CAA and which would have been at least temporarily disqualifying. Post-mortem toxicology tests also revealed that he had been flying whilst taking undeclared medication capable of producing a range of side effects of significance when flying an aircraft.

Analysis

The damage to the helicopter and distribution of the wreckage indicated that the helicopter had first struck the ground in a tail-down attitude, close to the top of a slope in the field, causing the tail rotor blades to fail. The tail-down attitude and the damage to the tail rotor blades indicate that there was sufficient main rotor rpm to maintain pitch control of the helicopter at impact. The failure of the tail rotor blades would have resulted in a loss of directional control of the helicopter in the final stages of the landing, resulting in an accident sequence sufficiently severe to cause fatal injuries to the pilot.

The ground markings indicated that when it struck the ground, the helicopter was travelling on a track of 147º(M), although no accurate estimate of its forward speed could be made. There was no evidence of any pre-impact damage or restriction to the flying controls, nor any evidence of a pre-impact defect within the main rotor drive system.

Tests identified that the engine was capable of generating its maximum rated power despite the number four cylinder misfiring intermittently at high power settings. The misfire, caused by the defect within the left magneto, could have resulted in an increase in engine vibration and noise. The presence of moisture in the magneto would have accelerated the formation of oxides on the electrical contacts within the magneto, resulting in a deterioration in its performance. Whilst the method of moisture ingress could not be identified, the exposure of the helicopter to the elements, whilst parked outside, may have been a contributory factor.

Given the prevailing weather conditions, it is possible that the engine had suffered carburettor icing. The carburettor heat control was found in the OFF position, although it remains possible that this had been moved inadvertently during the rescue attempts. However, witness observations, indications of the powered state of the rotors at impact, and the condition of the left magneto makes it seem more likely that the helicopter was operating normally during most of the flight, but that the problem with the left magneto had then manifested itself to the pilot. A transient loss of engine power could account for the rocking of the helicopter and the yaw to the left observed by one of the witnesses.

The pilot was aware of the issue with the clutch warning light and of Robinson Helicopter Safety Notice SN-2B, with its requirement to carry out a precautionary landing without delay, should a bearing or vee-belt failure be suspected. The investigation revealed no fault with the clutch mechanism, vee-belts or drive bearings, nor could it determine the cause of the flickering warning light. It is considered, however, that the pilot might have incorrectly associated the symptoms of the failing magneto with the clutch warning light issue. Whether or not this is the case, it is believed that the increase in engine vibration and noise due to the deterioration of the left magneto could have caused the pilot to attempt a precautionary landing.

In attempting to land, the pilot was either unaware of the downslope of the field, or was flying at a speed which required a sufficiently large pitch-up to slow down, that the tail struck the ground. This situation might have been exacerbated by the proximity of the electricity pylons ahead. The pilot's lack of recent flying experience, and possible physiological effects due to his medical condition and medication, might also have affected his handling abilities at the time.