Robinson R22 Beta, G-BUIW

AAIB Bulletin No: 11/98 Ref: EW/C98/3/1 Category: 2.3

Aircraft Type and Registration:	Robinson R22 Beta, G-BUIW
No & Type of Engines:	1 Lycoming O-320-B2C piston engine
Year of Manufacture:	1992
Date & Time (UTC):	9 March 1998 at 1136 hrs
Location:	Amport, Andover, Hants
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:	39 years
Commander's Flying Experience:	75 hours (all of which were on type) Last 90 days - 2 hours Last 28 days - None
Information Source:	AAIB Field Investigation

History of flight

The pilot started the PPL course at Thruxton in January 1997 and passed the GFT on 5 December 1997. He flew 40 minutes dual on 12 December and 40 minutes solo on 19 January. His PPL was issued on 27 January 1998. He had planned to fly on several occasions since then but poor weather had frustrated his intention. On the morning of 9 March, the weather was suitable and the pilot booked a helicopter on a Self Fly Hire basis. The pilot was outside the company's 30 day currency requirement and would normally have been given a check flight by a qualified instructor. This would have entailed flying a visual circuit and normal powered landing. The Chief Pilot elected to waive this requirement, however, he did give the pilot a comprehensive brief.

The aircraft had been in the hangar over the previous night and was refuelled to full in the morning. It is believed that the pilot intended to fly from Thruxton Airfield to an area to the north west of Andover before returning to the airfield for some circuit flying practice. Radio transmissions were not recorded, however, the AFISO recalled that, at 1130 hrs, the helicopter, callsign Findon 33, requested a radio check and airfield instructions for a "local flight" with 1 person on board. The helicopter hover taxied from the hangar area on the north west of the airfield, across active Runway 25, to the helicopter square to the south. It was seen in the hover over the square for a short time before it departed on runway heading and turned left. It is standard practice for the transit to be flown at 1,000 feet amsl.

Several witnesses in the villages of Amport and Monxton saw the helicopter shortly before impact. In general they observed that the engine appeared to stop, some reporting spluttering or misfiring. The helicopter descended with the main rotor turning slowly or stopped during the latter stage, with the blades bent upwards. The fuselage appeared to be rotating or turning slowly probably in a clockwise direction.

One witness, an experienced pilot with a BCPL/IR, reported that the helicopter passed over his house and garden. When first seen, it was flying normally at what he estimated was 800 feet agl and 80 kt. He looked away but his attention was drawn to it again when the engine noise stopped suddenly; he likened it to what he had heard on many occasions, when at an airfield where simulated power failure training in R22 helicopters was in progress. When he looked up the helicopter was about 300 feet agl, turning relatively slowly in a clockwise direction with the main rotor stopped and the blades "folded". He recalled a "snapshot" view of it pointing directly towards him shortly before it disappeared from view and struck the ground; he was about 1/3 nm south of the accident sight. He then made an emergency call to the police, the first they received, which was logged at 1136 hrs.

A 1 to 2 second transmission was heard on the Thruxton radio frequency which, at the time, the AFISO thought was from an aircraft stall warning device. The R22 has a low rotor RPM warning horn, which could sound similar to a stall warning horn over the radio and, with the benefit of hindsight, he thought it was possible this was what he heard. Very shortly afterwards a PA 38 Tomahawk called finals and its landing time was logged as 1137 hrs.

Meteorology

Over the period of the accident flight the surface wind at Thruxton was 180° to 200°/8 to 12 kt, the visibility was >10 km and the QNH was 1026 mb. The temperature/dew point was +7°/-5°C. In these conditions only light carburettor icing would be experienced in the cruise, however, the company Chief Pilot observed that he had to use more carburettor heat than he had expected when he flew an R22 to the accident site shortly after it had happened.

Engineering investigation

The helicopter had remained upright and had descended vertically into a ploughed field on the crest of a hill. Neither the tail or the main rotor blades showed any tip damage arising from the impact, and the main rotor blades had pronounced upward bending, usually associated with loss of rotor RPM. The main rotor blades had not struck the tail boom, which had failed at the riveted joints under inertial forces. The rotor blade tip weights were intact and there was no evidence of a bird strike.

Examination of the helicopter at the AAIB facility at Farnborough showed that the underside, including the fuel system and the carburettor and engine induction system were too badly damaged to be tested. However, the guillotine type carburettor hot air selector valve was in the **COLD** position. The lack of rotational damage marks on the engine cooling fan and shroud indicated that the engine had not been running before the accident.

The helicopter was fitted with the latest standard of fuel tank vent pipes, which included a crossfeed pipe connecting the venting systems of both tanks. None of the pipes showed any evidence of having been kinked.

The helicopter was fitted with an engine governor; this was tested by the manufacturer, in the presence of a representative of the United States National Transportation Safety Board. The governor controller was found to be within calibration limits, and the motor proved to be functional. The governor controller takes engine speed information from tachometer points located in the right hand magneto. Dirt on these points can cause 'noise' in the signal to the governor controller which can be interpreted as an excessive RPM signal, and cause a reduction in RPM. The tachometer points on G-BUIW were in good condition.

Initial engine compression checks revealed that two cylinders had low compression, so the engine was taken to an overhaul facility for further strip and testing, where differential pressure testing confirmed the lack of compression on Nos 1 and 3 cylinders. Subsequent examination showed that the lack of compression on the No 3 cylinder came from the inlet valve and that the most probable cause was that a particle of loose carbon had lodged under the valve during the impact. The three rings on the No 1 piston had their gaps aligned, causing a loss of compression whilst cold; there was no evidence of hot gases blowing past the piston. The gaps were within the allowable tolerances, and the effect when hot, and at high speed, was assessed as being small.

The deposits coating the piston crowns and plugs showed that the engine had been running with a very weak mixture, and with a temperature gradient associated with the cooling fan, from back to front. These conditions are typical of this installation. There were no sticking valves. The operation of the engine mixture control has, in the past, been known to cause a weak cut to the engine. The mixture control had a removable plastic guard which fitted round the knob on the centre console and was only to be removed to shut down the engine; this collar was found on the cockpit floor. The mixture control cable had pulled out of the carburettor during the impact, however, the ball bearing locking device on the cockpit end of the cable functioned satisfactorily. There was no evidence to indicate that the mixture control had been operated and had caused the engine to stop.

Seven out of the eight plugs were satisfactory, the remaining plug having been damaged in the accident. One magneto was tested and produced strong sparks, the other magneto was too badly deformed to allow testing.

The helicopter instrumentation contained a cluster of warning lights; examination of the filament of the low rotor RPM warning light (which should have been illuminated before the accident) showed that the filament was intact, indicating that the impact had not been sufficient to cause permanent damage to any other light bulb filaments which might have been illuminated. The sensors of those warning lights likely to initiate a forced or precautionary landing were examined, and the magnetic chip detector fitted to the main rotor gear box (MRGB) was found to be heavily contaminated with metallic particles, forming an annulus around the edge of the detector. The debris, as found, did not form an electrical bridge across the detector.

The helicopter had had a factory overhaul 254 hours before the accident; this included a replacement MRGB. The UK helicopter distributor informed the AAIB that it was normal to have a MRGB chip detector light illuminate at around 10 hours after such a replacement. This had not occurred on G-BUIW, and the maintenance schedule did not call for the magnetic chip detector to be checked until the 500 hour inspection.

The MRGB chip detector was mounted vertically at the bottom of the gearbox, with the sensor at the centre of a hemispherical dome on the upper end. It would have been possible for the debris found on the chip detector to have been distributed more uniformly across the detector before the accident, and for the warning light to have been on. The high 'g' forces during the impact could then have displaced the debris downwards, away from the centre of the dome, destroying the electrical continuity across the detector.

Medical and pathology

The pilot held a current Class 3 Medical Certificate, which was issued on 2 May 1997 and was valid until 31 May 1999. Post mortem examination revealed no evidence of pre-existing disease which would have contributed to the accident, however, cannabis was discovered in the urine and blood and its identity was confirmed by Mass Spectrometry. The levels indicated were indicative of recent ingestion although probably not on the day of the accident. Although the immediate effects of the ingestion of cannabis would result in a decrement in piloting performance, it has not yet been possible to quantify the longer term effects. Work is continuing on this aspect. Death was instantaneous and was caused by severe multiple injuries.

Emergency procedures and training

In the event of a power failure above 500 feet agl, the normal procedure is to lower the collective lever immediately to maintain rotor RPM and to enter autorotation. The helicopter should be established in a steady glide at 65 kt, which would give a maximum glide range of about 0.75 nm per 1,000 feet.

Should a red warning light illuminate, the advice is to select the nearest safe landing area and make a normal landing as soon as practical.

In any powered aircraft, a pilot undergoing training or subsequent refresher/check flights will be expected to demonstrate his/her ability to respond correctly to the total failure of a power unit. Although briefed that this will occur at some point in the flight, the simulated failure is normally given without warning, in order to test the pilot's ability first to detect and identify the failure and then to respond to it with the correct actions.

Robinson Safety Notice SN-27, revised June 1994, is titled SURPRISE THROTTLE CHOPS CAN BE DEADLY advises flying instructors how they should give a student a simulated power failure. It states:

"Never truly surprise the student. Tell him you are going to give him a simulated power failure a few minutes before, and when you roll off the throttle, loudly announce "power failure"."

The instructor is also advised to plan to initiate recovery within one second, regardless of the student's reaction.

Pilot reaction time

Manufacturer's Safety Notice SN-10, revised in June 1994, is titled FATAL ACCIDENTS CAUSED BY LOW ROTOR RPM ROTOR STALL. It states, in part:

"A primary cause of fatal accidents in light helicopters is the failure to maintain rotor RPM. To avoid this, every pilot must have his reflexes conditioned so he will instantly add throttle and lower collective to maintain RPM in an emergency."

and:

"No matter what causes the low rotor RPM, the pilot must first roll on throttle and lower the collective simultaneously to recover RPM before investigating the problem. It must be a conditioned reflex. In forward flight, applying aft cyclic to bleed off airspeed will also help recover lost RPM."

The Robinson R22 helicopter has a low inertia main rotor, even at the current standard which is fitted with tip weights. Information supplied by the manufacturer defined the mechanical energy contained within the helicopter in terms of horsepower-seconds (1 pint of AVGAS would supply 7,500 HP-secs):

KINETIC ENERGY

	Forward Speed		Rotor RPM
90 kt	800 HP-secs	104%	100 HP-secs
60 kt	340 HP-secs		
30 kt	90 HP-secs		

POTENTIAL ENERGY

500 feet	1,100 HP-secs
1,000 feet	2,200 HP-secs

In flight at 90 kt, 500 ft agl, the R22 needs 90 HP to maintain airspeed and altitude. If, in the event of an engine failure, the pilot maintains forward cyclic and up collective, the rotor rpm will reduce to an irrecoverable value in 1.1 seconds. In the climb at 60 kt, rate of climb 1,000 fpm, the total power required is 103 HP, the time would reduce to less than 1 second.

Certification aspects

AAIB Accident Report EW/C92/2/4 reported on the accident to Robinson R22M, G-BPPC at Oldham. The report discussed the problem of pilots failing to react in a timely manner in order to maintain minimum rotor RPM and the certification aspects associated with this. It also considered previous similar accidents and accident statistics related to the R22. The report was passed to the CAA in April 1992. The following recommendation was made:

'92-26': Existing certification criteria in relation to pilot intervention times following loss of power should be re-appraised when formulating JAR 27. Revised requirements should be based upon results of current research into pilot intervention time. The relevancy of the guidance material contained in the existing appendix to BCAR Section G2-8 should also be considered for inclusion in future requirements.'

The Authority accepted this recommendation and informed the AAIB that two items of research related to the recommendation were currently in progress. The first of these was a study being conducted by the RAF Institute of Aviation Medicine (later to become DERA Centre for Human Sciences), on behalf of the Authority, into likely pilot reaction times to a variety of cues resulting from failure. This work was to cover a number of different failures, including engine failure. The second was research work on the specific topic of rotor RPM loss and associated warning. This was to be carried out by Westland Helicopters Ltd and the aim was to indentify the most appropriate method of warning the pilot of low rotor RPM conditions.

The Authority hoped that the research would be completed in the 1993/94 financial year. It was pointed out that this would be too late for the results to be taken into account in the formulating of the initial issue of JAR 27, which was expected to be published early in 1993. When the research was complete it was to form the basis for formulation of any proposals for the amendment of JAR 27 if necessary. The relevance of the guidance material in the appendix to BCAR G2-8 was to be considered at the same time.

The final report on the research, conducted by the Centre for Human Sciences on 'Pilot Intervention Times in Helicopter Emergencies' was completed in March 1998. It quantified detection and response times for a range of emergencies, including total power failure, measured during routine training sorties in Chinook, S61N and Super Puma simulators.

The report concluded that: "If a failure to recover rate of 10% is acceptable, a safe regulatory approach would allow up to 1 second detection time and 2 seconds total reaction times for failures likely to be immediately evident in a control variable at the focus of the pilot's attention (eg AFCS runaways in the hover). Up to 3 seconds detection time should be allowed for failures likely to be less immediately obvious (eg total power failure and tail rotor drive failure in the aircraft represented in these trials). Total reaction times of about 6 seconds should be expected, assuming no distraction. The broad similarity of results for collective response across aircraft types and emergencies suggested these results may be treated with some confidence." The report will be published in the near future as a CAA paper under the same title.

The research undertaken for the Authority by GKN Westland Helicopters Ltd, to investigate methods of reducing rotor RPM loss following engine failure, has already been published as CAA Paper 95009, "Enhanced Warning and Intervention Strategies for the Protection of Rotor Speed Following Power Failure".

The results from these projects are contributing to ongoing discussions within JAA and FAA for proposed amendment to the rotorcraft airworthiness requirements JAR/FAR Parts 27 and 29. These discussions are taking place within the rotorcraft Performance and Handling Qualities Harmonisation Working Group which consists of authorities and industry representatives. It was formed to consider a specific list of flight related requirement issues and agree a harmonised set of proposed changes to the existing requirements and associated material. Intervention Time is one of the last agenda items and the group should be ready to report the outcome of it's discussions in the form of a Notice of Proposed Amendment within the next twelve months.

Consequently, the final outcome is yet to be determined and the UK represents only one input within the group. However, the results of this UK research clearly support the CAA recommendation for an increase in the pilot intervention time following power failure currently required in JAR 27/29.