Robinson R22 Beta, G-BNUZ

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Aircraft Type and Registration:	Robinson R22 Beta, G-BNUZ	
No & Type of Engines:	1 Lycoming O-320-B2C piston engine	
Year of Manufacture:	1987	
Date & Time (UTC):	2 December 2000 at 1526 hrs	
Location:	Biggin, North Yorkshire	
Type of Flight:	Private	
Persons on Board:	Crew - One	Passengers - One
Injuries:	Crew - One (fatal)	Passengers - One (fatal)
Nature of Damage:	Helicopter destroyed	
Commander's Licence:	Private Pilot's Licence (Helicopters)	
Commander's Age:	52 years	
Commander's Flying Experience:	66 hours (all on type)	
	Last 90 days - 4 hours	
	Last 28 days - 1 hour	
Information Source:	AAIB Field Investigation	

History the flight

The pilot gained his Private Pilot's Licence in April 2000. Since the issue of the licence, the pilot had flown on 15 occasions, including the accident flight. On the day of the accident, the intention was to conduct a local flight from the helicopter's operating base at Sherburn-in-Elmet airfield, taking along a family member as a passenger.

On the morning of the accident, the helicopter was booked to operate several training sorties. A normal Daily Inspection was carried out by the flying school's Operations Manager with no abnormalities being apparent. The helicopter was refuelled with 52 litres of fuel at 0935 hrs. Two dual training flights were then undertaken by one of the school's Qualified Flying Instructors (QFI), who was acting as duty supervisory instructor for the day. No abnormalities were noted during these flights. The helicopter was then again refuelled with 53 litres of fuel.

An Assistant Flying Instructor (AFI) then operated the helicopter on a student training flight in the airfield circuit area. At the completion of this sortie, the AFI reported verbally to the QFI that the helicopter had suffered from an unusually rapid drop in engine rpm on throttle closure prior to flight. It was also reported that more collective lever angle than usual was needed to achieve lift off to the hover and that, in flight, the Oil Temperature appeared slightly higher than normal, although still within normal operating limits. An intermittent intercom system was also reported. Subsequent consideration of the ambient conditions suggested that the apparently sluggish engine response may have been due to the subtle onset of carburettor icing conditions as the helicopter was being run up on the grass prior to flight.

In order to assess the helicopter's condition, the QFI flew it (with the Operations Manager as a passenger) on a short flight to a location just outside Sherburn-in-Elmet airfield. He then operated a return flight to the airfield. During each of these two short flights, which were preceded by a number of rapid throttle reductions to idle power, no abnormalities were noted by the QFI and no entries were made in the aircraft's Technical Log to indicate any abnormalities.

While this assessment was taking place, the pilot and passenger involved in the accident had arrived at the flying school for their allotted booking. The pilot held a discussion with the owner of the flying school during which it was established that the pilot intended to carry out a local area flight. The pilot was briefed to go and carry out a pre-flight check on the helicopter.

The pilot was subsequently seen to be conducting an external pre-flight check on G-BNUZ, but did not complete any pre-flight paperwork or the Technical Log prior to departure on the accident flight and was therefore not briefed on the earlier comments made about the helicopter's performance.

The airfield at Sherburn-in-Elmet has no formal Air Traffic Control facility, so aircraft take-off and landing times are not officially recorded. There was thus no accurate record of the departure time of G-BNUZ. However, shortly after take-off, the pilot contacted Church Fenton Approach control at 1440:51 hrs and indicated that the helicopter was airborne from Sherburn and intended to route to the south of the airfield to the southern training area. The pilot was familiar with this area from his training course. The next contact with the helicopter was at 1506 when the pilot reported his position at Thorne, heading 110°. The helicopter was given a transponder code of 4540 which was received on radar at 1507.14.

There were then no further transmissions from the helicopter until 1520 hrs. During the intervening period, replay of the radar data indicated that the helicopter flew a generally northerly easterly, then north westerly track, with two distinct wide orbits until 1520:32 hrs. The pilot then called Church Fenton to request MATZ penetration from the southern training area, in order to return to the airfield. This clearance was immediately issued, not above 1,500 feet on the Church Fenton QFE of 1002 mb. The pilot was requested to call again when he had visual contact with Sherburn airfield. The next transmission from G-BNUZ was at 1521:23 when the pilot indicated that he had Sherburn in sight. The Church Fenton controller then released the helicopter to call Sherburn and to Squawk Standby. There was no reply to this transmission from G-BNUZ. There were no indications from the transmissions of any problem with the helicopter. No witnesses could be found who could indicate whether the aircraft contacted Sherburn radio prior to joining the circuit.

The radar plot had ceased at 1521:26 hrs and no further (primary) radar data was available. At the time of the last transmission, the helicopter was at a position just to the north of Junction 34 of the M62 Motorway, some 10 km south south-east of Sherburn. Analysis of the radar data showed that the average cruising speed was about 85 to 90 kt, which reduced to around 55 kt during the two wide orbits. The normal operating limit speed (VNO) was 92 kt. The accident occurred close to the village of Biggin, some 3 km from the landing area, while the helicopter was tracking southwest, essentially on a direct approach to the airfield at 1526 hrs.

Some local residents in the village of Biggin noted that the helicopter was flying towards the airfield in a south westerly direction, at a height estimated to be around 500 to 600 feet. With such helicopter traffic being commonplace in this location, little attention was paid to the passage of the helicopter initially. There was then a 'metallic bang' followed by the sound of the engine 'faltering'. Immediately after this, parts were seen to fall from the helicopter and it pitched down and began to descend steeply, one witness describing how the tail boom had creased and the rotor blades could be clearly seen rotating very slowly. The helicopter hit the ground with a 'loud thud', at which time the emergency services were summoned by telephone. Another eyewitness described the engine sound as 'popping or banging' prior to the helicopter descending behind some trees from that witness's viewpoint.

Given the refuelling and flight history on the day, endurance calculations estimated that some 20 to 25 litres of fuel would have been on board the helicopter at the time of the accident.

An aftercast from the Met Office indicated that, at the time of the accident, there was an area of low pressure centred over the north west of the United Kingdom with a fresh south westerly airstream covering the North Yorkshire area. The visibility was around 30 km with 1 okta cumulus cloud, base 2,000 feet amsl and 5 okta stratocumulus, base 4,000 feet. The QNH was 1004 mb. The surface wind was from 210°T at 12 kt, temperature +9°C, dew point +5°C, relative humidity 77%. At 1,000 feet, the wind was from 220°T at 30 kt, temperature +6°C, dew point +3°C, relative humidity 81%. At 2,000 feet, the wind was from 230°T at 35 kt, temperature +4°C, dew point +2°C, relative humidity 88%.

With these values of relative humidity and temperatures, there was a serious risk of the onset of carburettor icing at any power setting, according to the CAA General Aviation Safety Sense leaflet Number 14A, Piston Engine Icing.

Examination of the wreckage

The helicopter lay in a field close to a hedgerow and a minor road. All the major components were present on the accident site, although it was clear that there had been some degree of in-flight structural disruption. The machine had fallen vertically to the ground in a right-skid-low attitude with little or no forward speed. The left seat occupant had still been in his seat but the pilot had been thrown clear by a few metres: the impact was clearly non-survivable.

The main rotor blades had suffered major damage due to ground contact, but not characteristic of having had significant RPM at impact. There were some signs of contact with the airframe in-flight (paint smears) but again this did not appear to have occurred at high rotational speed. It was also evident that the tailboom had struck the ground roughly at right-angles to its normal orientation relative to the fuselage and was therefore stuck in the ground vertically, with the tail rotor driveshaft buried in the earth by about 0.5m. The tail surfaces and the tail rotor gearbox were found close-by. Analysis showed that the tailboom had suffered a low-energy rotor strike about 0.5m aft of the fuselage attachments which had crippled but not separated it. Subsequent ground impact by the (bent) tail rotor driveshaft had failed the tail rotor gearbox/empennage support casting and popped these items off the end of the boom.

Pieces of the right windscreen and part of the right door frame were located in a line stretching back along the aircraft's flightpath over a distance of roughly 400 metres. This again indicated a low-energy airborne 'slap' on the front right side of the canopy by the main rotor.

In the cockpit area, it was noted that the magneto switch was selected to 'Left', the carburettor heat control knob appeared to be in 'Cold' and the mixture control in 'Rich'. It was also noted that both plastic hand-grips had pulled from the cyclic control column and were loose in the wreckage. The wreckage was recovered and transported to the AAIB hangar for further investigation.

Subsequent examination

The helicopter was examined by AAIB and a representative of the manufacturer. The main rotor gearbox and rotor mast were strip-inspected, with particular attention being paid to the freewheel clutch. All items were found to be in good, pre-accident, condition. The flying control rods and linkages, although having suffered considerable impact damage, did not show any evidence of pre-impact anomalies.

The engine oil sump had been ruptured by ground impact and the carburettor crushed beyond meaningful examination. The remains of the air filter box showed that the carburettor heat slider was trapped in the 'full-hot' position. This was at variance with the 'as-found' position of the control knob in the cockpit, but it was considered that the slider, by virtue of its position and orientation, was the more reliable indication of carburettor heat selection than the knob, which must have moved during impact. There were no signs of rotation of the engine or transmission at impact. The engine was strip-inspected under AAIB supervision at an overhaul agency and found to be in good condition internally, commensurate with its low running time from new. Both magnetos were bench-tested and found to be serviceable.

An attempt was made to examine filaments from the various cockpit warning lights for signs of hot-stretching, indicative of being illuminated at impact. Unfortunately, those associated with the engine, notably the governor de-coupled warning, were broken and beyond examination. However, the 'Low Rotor RPM' warning light had survived sufficiently intact for its filament to show clear evidence of hot stretching.

As mentioned above, both the plastic handgrips had detached from the cyclic control yoke at impact. Discussion with the manufacturer suggested that, because they are adhered to the metal, this could be taken as evidence that both occupants may have been gripping the yoke upon ground impact, as it was unlikely that the grips would fall-off on their own. The grips were tested for fingerprints but none were found.

Analysis

During this investigation, no mechanical defects were found which could have accounted for an engine failure or any loss of main rotor control.

From examination of the meteorological data, there was a strong probability that G-BNUZ would have experienced a degree of carburettor icing, especially during the descent from around 2,000 feet to circuit height. The onset of carburettor icing is very subtle and can go unnoticed until a very late stage.

On most light aircraft piston engines, with fixed pitch propellers, the first sign of ice build up can be identified from a loss of rpm for a fixed throttle position, followed by the onset of 'rough running'. These two symptoms are normally sufficient to alert the pilot to the presence of carburettor icing and allow sufficient time for the application of carburettor heat to clear the ice build up. Initially, on application of carburettor heat, the rough running can become worse as the ice melts, before recovery to normal running. Typically, up to 30 seconds may be required to restore normal running.

The Robinson R22 series is fitted with an electronic rpm governor system, which automatically modulates the throttle (and the pilot's throttle twist grip) in response to rpm changes. Should carburettor icing conditions be encountered, the rpm loss that would naturally occur is compensated for by the governor system. Thus, if the pilot does not detect the movement of the throttle twist grip, he would be unaware of the rpm trend. One of the main cues to the presence of carburettor icing has thus been removed. The governor system would continue to compensate for the potential rpm loss, until such time that the rough running occurred, probably once full throttle had been applied. By this stage, the ice build up would be well developed and the likelihood of a complete engine failure therefore increased.

In general, carbureted piston engined helicopters are more susceptible to carburettor icing because they operate at derated power, where the carburettor's throttle butterfly valve does not operate in the fully open position at full power. Thus, there is always a more restricted venturi in this type of engine/carburettor combination, such that relatively smaller amounts of ice build up are required to adversely affect the running of the engine.

G-BNUZ was fitted with a Carburettor Temperature Gauge, marked with a yellow 'caution' range (between +5°C and -15°C) to indicate the temperature band in which there was an increased risk of carburettor icing. Operating advice from the helicopter manufacturer indicated that operation of the Carburettor Heat was required in order to keep the Carburettor Temperature above the yellow arc, for hover, takeoff, climb or cruise. For descent or autorotation practice, the advice was to ignore the temperature gauge and apply FULL Carburettor Heat. Anecdotal evidence from a number of pilots of other aircraft indicated that this type of temperature gauge cannot always be relied upon to give an accurate indication of the likely risk, possibly because of the poor positioning of the temperature sensor in relation to the area where ice is most likely to form. Some pilots have the practice of cross checking the temperature indication with the Outside Air Temperature gauge prior to engine start before flight, in order to check the calibration at one known point. It was not possible to check the gauge accuracy in G-BNUZ due to impact damage.

The pilot's most recent flying experience, prior to the day of the accident, had been on another Robinson R22 helicopter, registration G-IIFR. That helicopter was a model R22 Beta II, which was fitted with a 'Carburettor Heat Assist' system. Such a system has a linkage between the collective lever and the carburettor heat control, such that carburettor heat is automatically applied whenever the collective lever is lowered, such as when initiating a descent. However, good airmanship and practice normally dictates the application of carburettor heat some 30 seconds before initiating a descent, to allow time for any ice build up to be dissipated prior to throttle reduction. A manual override facility is provided for this purpose. The 'Carburettor Heat Assist' system was not fitted to G-BNUZ.

The Robinson R22 series is fitted with a light weight, low inertia rotor system, such that in the event of an engine failure in flight, the pilot must immediately and fully lower the collective lever in order to enter an autorotative descent. Should there be a delay of more than 1 to 2 seconds in this action, the main rotor rpm will have decayed to such an extent that autorotation is no longer possible. Under these conditions, experience from previous accidents has shown that the main rotor blades can become unstable and contact the canopy and/or tailboom, causing the loss of the helicopter.

Sunset at this location occurred at about 1548 hrs. With the helicopter on a south westerly track heading towards the airfield, it is likely that the pilot would have experienced reduced forward visibility as a result of glare from the low sun. It may also have impaired his vision of the cockpit instrumentation. This, coupled with the naturally higher workload and concentration required by a pilot joining the circuit to land, could readily account for the onset of carburettor icing going unnoticed until engine failure occurred at the low power settings used for descent.