

Robinson R22 Beta, G-VFSI

AAIB Bulletin No: 12/2003	Ref: EW/C2002/07/01	Category: 2.3
Aircraft Type and Registration:	Robinson R22 Beta, G-VFSI	
No & Type of Engines:	1 Lycoming O-320-B2C piston engine	
Year of Manufacture:	1991	
Date & Time (UTC):	13 July 2002 at 1703 hrs	
Location:	Hampton Magna, Warwickshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Fatal)	Passengers - 1 (Fatal)
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	24 years	
Commander's Flying Experience:	269 hours (of which 264 were on type)	
	Last 90 days - 50 minutes	
	Last 28 days - 50 minutes	
Information Source:	AAIB Field Investigation	

Synopsis

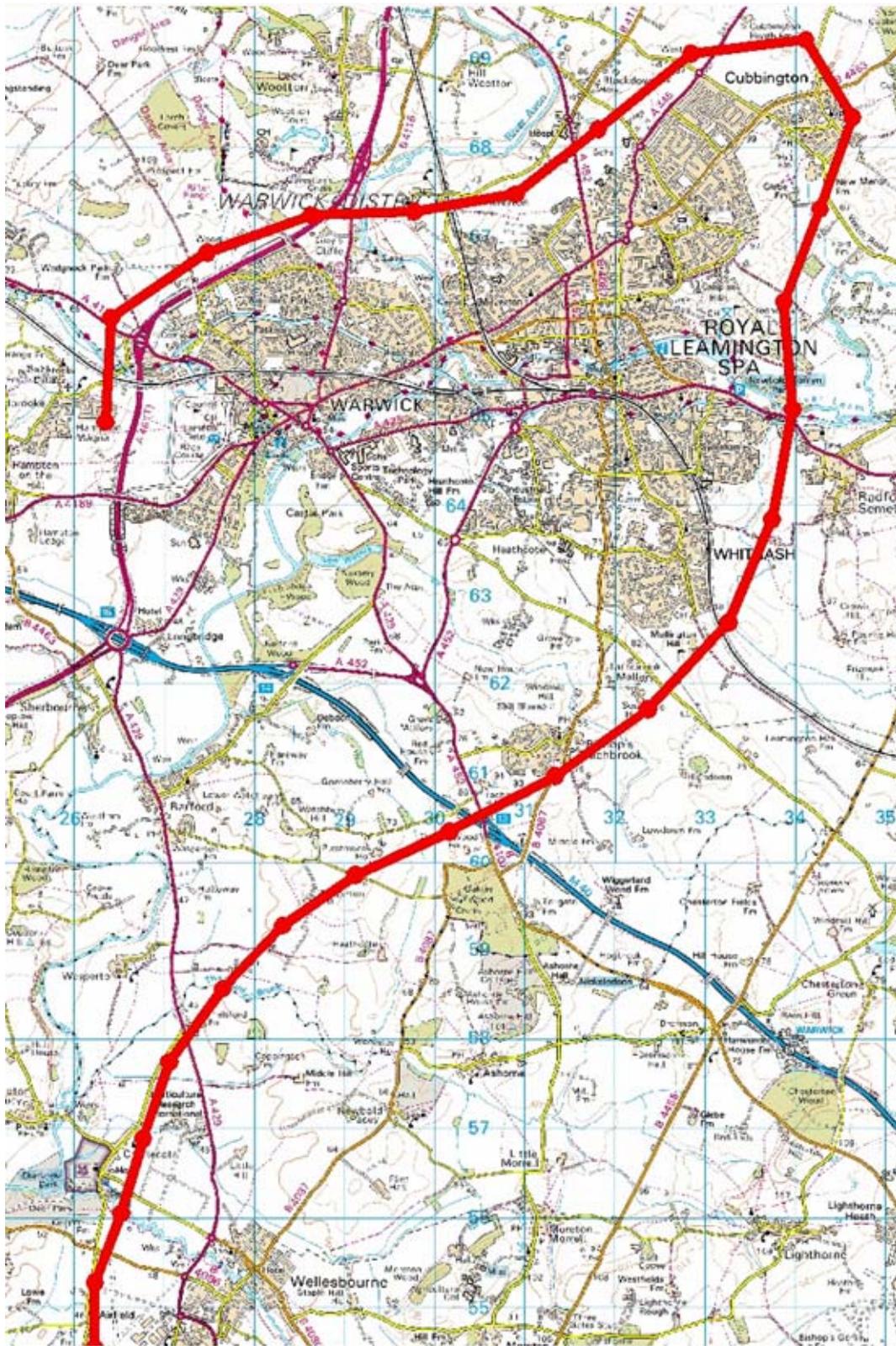
The aircraft was flying in a level attitude in the cruise at approximately 1,500 feet agl and at about 70 kt when it was seen to suffer an in-flight break-up. Evidence suggests that, as a result of mast bumping, the tail cone of the aircraft was struck by the main rotor blades. The Pilot's Operating Handbook states that mast bumping can be caused by abrupt control inputs and, in this case, it is possible that this occurred as the result of an unintentional abrupt input on either the cyclic control or yaw pedals, or both. One Safety Recommendation relating to Safety Notices included in the Pilot's operating handbook, has been made.

History of the Flight

On the day of the accident the pilot arranged to take a friend and his girlfriend's parents for separate flights, in G-VFSI, from Wellesbourne Mountford. Although the weather was good the pilot made a point of obtaining the latest meteorological information before he and his friend embarked on the first uneventful 25 minute flight to Turweston. After a brief stop for light refreshments they returned to Wellesbourne where the pilot met with his girlfriend's parents. Before he re-boarded the helicopter, for a local flight to the north around Royal Leamington Spa (RLS) and Warwick with his girlfriend's mother, it was refuelled with 40.25 litres of fuel. This flight, which lasted 25 minutes, was also uneventful and on their return to Wellesbourne the helicopter was shut down, the mother disembarked and the girlfriend's father seated himself in the front left seat for the next flight. The helicopter was fitted with dual controls for all these flights.

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The helicopter lifted at 1640 hrs and hover taxied for a departure from Runway 36. After takeoff it turned north east to circumnavigate RLS and Warwick in an anticlockwise direction (see Figure 1).



GPS Track of Flight

At 1656 hrs the pilot called Coventry ATC reporting that he was "JUST SOUTH OF LEAMINGTON AT FIFTEEN HUNDRED FEET ON ONE ZERO TWO TWO [QNH]. REQUEST FLIGHT INFORMATION SERVICE. WE'LL BE ROUTING JUST TO THE NORTH OF LEAMINGTON AND THEN RETURNING TO WELLESBOURNE". The call was lucid, concise and relaxed. Coventry ATC acknowledged, advising of a change to the QNH to 1023 mb and confirming a flight information service. At 1700 hrs, with the helicopter now over the northern outskirts of RLS, Coventry ATC advised the pilot of a Cherokee aircraft to the south of his position, which was inbound to Coventry airport. The pilot acknowledged this call but there is no indication that he saw the Cherokee, and the crew in the Cherokee did not recall seeing the helicopter. Subsequent comparison of the two aircraft tracks on a radar recording showed that they passed within one nautical mile of each other, at a similar altitude.

Witnesses in and around the village of Hampton Magna, which lies 400 metres to the north-north-west of where the helicopter finally came to rest, reported seeing it transiting south towards Wellesbourne parallel to and on the west side of the A46 trunk road. One witness on the ground, also an R22 pilot, estimated that it was at 1,500 feet agl and cruising normally at about 70 kt. A number of witnesses stated that the engine sounded normal. As the aircraft passed over the eastern edge of the village two or three loud bangs were heard. These noises were described as being similar to a metal garage door being struck hard. Some witnesses recalled the engine sounding as if it was struggling, 'like a car engine stalling'. The helicopter was then seen to pitch forwards, backwards and forwards again, while also rolling and yawing left and right. Some witnesses reported seeing the aircraft spin anticlockwise once or twice before part of one of the main rotor blades detached. The helicopter then descended uncontrollably, spinning slowly anticlockwise. The other main rotor blade remained attached and stationary, pointing vertically upwards. No noise was heard from the aircraft as it descended. Mid-way through its descent the aircraft's tail rotor, which had stopped, was seen to separate and fall away. Other parts of the aircraft were observed falling after the main structure hit the ground.

There was no record of the pilot making any radio calls after acknowledging the presence of the Cherokee aircraft. Calls from other stations however, were made on the same frequency around the time of the accident and it is possible that these may have blocked any transmission from G-VFSI.

The main part of the helicopter hit the ground on the edge of a field, adjacent to Budbrook North Service Station on the west side of the A46, on a north-westerly heading with little horizontal speed. A number of observers rapidly attended the scene. It was immediately apparent however, that the pilot and his passenger had received fatal injuries in the impact. Although there was evidence of fuel at the site, there was no fire.

Two witnesses reported seeing a jet airliner, above the helicopter, flying north towards Birmingham at the time of the accident. Further investigation revealed that this aircraft, a Boeing 737, was inbound to Birmingham Airport. Comparison of the two aircraft tracks showed that there was no possibility of the wake turbulence from the 737 affecting the R22. Enquiries were also made with the B737 operator to establish if any part of the aircraft had detached in flight. There was no such evidence, nor was there any indication that any object had struck the helicopter whilst in flight.

A post-mortem report revealed no evidence of any medical condition that may have contributed to the accident.

Photographic evidence

The passenger, who had taken a camera with him, took photographs of the countryside during the flight. These were subsequently developed and included pictures taken when the aircraft was west abeam Warwick racecourse. It is estimated that about 10 seconds after the passenger took the last intentional photograph out of the left side window, at 1702:30 hrs, the helicopter was seen to break up in mid-air and fall almost vertically to the ground. The camera shutter subsequently operated three more times. The first of these photographs was blurred but appears to have been taken while the aircraft was still in the air. The last two photographs, although exposed, were subject to virtually no light.

Pilot's background

All of the pilot's flying experience had been gained on helicopters, and all but 4.5 hrs had been accrued on the Robinson R22. He obtained his Private Pilot's Licence (Helicopters and Gyroplanes) in 1996 when he was 18 years old and added the Assistant Flying Instructor's rating for the R22 two years later. This rating had lapsed and he had expressed an interest in renewing it. He had flown for four hours in each of the previous two years before the accident. He was regarded as having an avid enthusiasm for flying, with a mature and diligent approach. Those who had instructed him considered that he was an able and sensible pilot.

Wreckage distribution

The majority of the items of aircraft wreckage fell in an area some 80 metres (north-south) by 200 metres (east-west), although a few items were found 100 metres further away along the A46. The pod of the helicopter containing the cabin and seats, engine, fuel tanks and main rotor mast, with the rotor head still attached, were found at the main impact point. One intact main rotor blade and 1.5 metres of the other blade were attached to the rotor head. The missing outboard portion of blade was found some 60 metres away. The impact marks showed that the main pod had descended almost vertically and that other portions of the airframe and rotors had detached while the aircraft was still in the air. Although both fuel tanks had ruptured and there was no fuel remaining, there were good indications from the distressed vegetation that there had been substantial amounts of fuel onboard at the time of the impact with the ground.

Most of the debris from the cabin, including the shattered plexiglass-type transparency and items from a headset, were found close to the main pod, indicating a main rotor strike on the upper cabin at a late stage. It was established that the headset items were from the headset for the left seat occupant as the headset for the right seat occupant was found intact and still connected in the wreckage. The tail rotor assembly, portions of tailcone structure and portions of tail rotor driveshaft were found more distant and were likely to have been involved in the initiation of the airborne break-up.

Examination of the wreckage

Following the recovery of the wreckage to the AAIB hangar at Farnborough, the tail section was reconstructed and the failures examined in detail, matching the tailcone and driveshaft fractures with the damage to the main rotor blades. This indicated that there had been a total of five strikes on the tailcone and that the fifth strike had finally stopped the rotor. For three of the strikes it was possible to measure the angle the blade was making with the horizontal at the point it struck the tailcone. Each of these angles was at least 10° greater than that achieved by normal blade flapping hinge geometry indicating a distinct downward curvature of the blade at impact.

The engine was stripped and examined at an engine overhaul facility. There were no indications of rotation of the engine or its cooling fan at ground impact consistent with the final main rotor blade strike having stalled the engine. Damage to the engine was due to impact with the ground and there was no evidence of any malfunction within the engine preceding the first main rotor strike.

Examination of the power transmission and the flight controls indicated multiple failures in both systems. The main rotor gearbox had been fractured and the main rotor blade pitch control links had both separated. All the damage, however, was consistent either with the successive main rotor blade strikes on the tailcone in flight or with the further damage which occurred when the aircraft struck the ground. The position of the cockpit controls indicated that, at impact, the carburettor mixture was set at RICH, the carburettor heat was set at COLD and the lateral trim control was in the CRUISE position. Examination of the filaments of various cockpit warning lights indicated that the LOW RPM, ALTERNATOR and OIL bulbs were illuminated at impact (ie the rotor and engine were stationary) and the others (LOW FUEL, TR CHIP, STARTER ON, MR CHIP, MR TEMP, CLUTCH, GOVERNOR OFF and BRAKE) were all off.

The Robinson main rotor system is, essentially, a 'teetering' system but the main rotor head is unusual in design in having both a teetering hinge on the centre line of the rotor shaft and a pair of simple flapping/coning hinges offset some 5 cm. Examination of the rotor head showed that both of the lower 'elephant tusks' had been fractured by their contact with the downward flapping stops on the main rotor shaft and that this had occurred in the impact with the ground. Both of the 'teeter' stops were found in place on the main rotor shaft and they had sustained damage consistent with 'mast bumping' from excessive movement of the teetering main rotor hub. The symmetric pattern of damage showed that this would not have happened in the ground impact and is most likely to have happened at the time of the main rotor strikes on the tailcone.

Helicopter information

The helicopter had been constructed in 1991 and, up to the time of the accident, had accumulated some 2,650 hours. In June 2000 the helicopter had undergone the full factory-approved 2,000 hour

rebuild in the UK and received a newly rebuilt engine. The log books and examination of the aircraft indicated that the periodic maintenance had been performed correctly.

Engineering summary

In summary, the physical examination of the aircraft wreckage indicated that, up to the time of the main rotor strikes on the tailcone, G-VFSI was operating correctly and it was this series of strikes that caused the complete loss of rotor speed and loss of the helicopter.

Meteorological information

An aftercast issued by the Meteorological Office, Bracknell, confirmed that the weather for the flight was good with a slack area of high pressure covering the British Isles. There were a few clouds at 4,500 feet amsl and the visibility was greater than 30 km. The surface wind was variable in direction, but mainly from the north or north-west at 3 to 5 kt. The wind at 1,000 feet was 010°/5 to 10 kt and the wind at 2,000 feet was 020°/5 to 10 kt. Mean Sea level pressure was 1022 mb. The surface temperature was 21°C (Relative Humidity of 38%); at 1,000 feet it was 15°C (Relative Humidity 49%) and at 2,000 feet the temperature was 12.5°C (Relative Humidity 56%).

Flight Recorders

A Skyforce Global Positioning System (GPS) was retrieved from the wreckage. Although the equipment was damaged, it was possible to recover recorded data which made it possible to reconstruct the aircraft's flights on the day of the accident. The data consisted of points defined by date, time, latitude and longitude, aircraft groundspeed, heading and altitude. This data had been recorded every 30 seconds. The last point was recorded at 1702:28 hrs. The data indicated that the aircraft had followed a very similar track on the accident flight to that flown on the previous flight around Warwick and Leamington Spa.

Pilot's Operating Handbook

The Robinson R22 Pilot's Operating Handbook (POH) contains a Note in the Normal Procedures Section, which was issued in accordance with Federal Aviation Administration (FAA) Airworthiness Directive (AD) 95-26-04. The *Note* starts with an introduction that states:

Until the FAA completes its research into the conditions and aircraft characteristics that lead to main rotor blade/fuselage contact accidents, and corrective type design changes and operating limitations are identified, Model R22 pilots are strongly urged to become familiar with the following information and comply with these recommended practices.

There is subsequently a section on mast bumping. It says:

Mast Bumping: Mast bumping may occur with a teetering rotor system when excessive main rotor flapping results from low "G" (load factor below 1.0) or abrupt control input. A low "G" flight condition can result from an abrupt cyclic pushover in forward flight. High forward airspeed, turbulence, and excessive sideslip can accentuate the adverse effects of these control movements. The excessive flapping results in the main rotor hub assembly striking the main rotor mast with subsequent main rotor system separation from the helicopter.

To avoid these conditions, pilots are strongly urged to follow these recommendations:

- (1) Maintain cruise airspeeds between 60 KIAS and less than 0.9 V_{ne}, but no lower than 57 KIAS.*
- (2) Use maximum "power-on" RPM at all times during powered flight.*
- (3) Avoid sideslip during flight. Maintain in-trim flight at all times.*

(4) Avoid large, rapid forward cyclic inputs in forward flight, and abrupt control inputs in turbulence.

In another part of the Normal Procedures Section of the POH, in the *DAILY or PREFLIGHT CHECKS*, there is a *CAUTION* that states:

Removable controls should be removed if the person in left seat is not a rated helicopter pilot.

Due to the confined nature of the R22 cockpit, a passenger in the left seat is in close proximity to the cyclic control, collective control and yaw pedals if dual controls are fitted.

Pilot's Operating Handbook Safety Tips and Notices.

The last section of the POH contains Safety Tips and Notices. Among the Safety Tips is the advice to:

Avoid abrupt control inputs or accelerated manoeuvres, particularly at high speed. These produce high fatigue loads in the dynamic components and could cause a premature and catastrophic failure of a critical component.

The Safety Notices (SNs) have been issued as a result of various accidents and incidents that have occurred. The SNs cover many situations but do not specifically refer to passenger flights. Although the passenger on G-VFSI was using a camera, there was no evidence that the pilot was manoeuvring the helicopter as described in SN-34 (titled *PHOTO FLIGHTS-VERY HIGH RISK*), which envisaged a situation where the speed is decreasing below 30 kt and a rate of descent develops. On the contrary, the helicopter was seen flying straight and level at about 70 kt.

The FAA issued Special Federal Aviation Regulation (SFAR 73) in 1995 to address the special training and experience requirements it was deemed appropriate for the R22 helicopter in the light of accidents in the past. The UK PPL (H) and CPL (H) syllabi cover the requirements in SFAR 73.

Other Investigations

In 1996 the NTSB published a Special Investigation Report on *Robinson Helicopter Company R22 Loss of Main Rotor Control Accidents*. The report covered thirty one R22 accidents between 1981 and 1994, a number of which bore similarities to the accident involving G-VFSI. The NTSB recommended (Recommendation A-96-12) that:

The Federal Aviation Administration, in conjunction with the National Aeronautics and Space Administration, continue the development of the simulator model of lightweight helicopters, using flight tests and whirl tower tests as needed to validate the model, to create a national resource tool for the study of flight control systems and main rotor blade dynamics. If any unusual blade system characteristics are found, ensure that the information and data gathered are disseminated to the appropriate agencies and industry.

The continued development of the simulator model of lightweight helicopters refers to work which the FAA had commissioned the Georgia Institute of Technology to conduct. This simulation study of the R22 was concluded before the mathematical model was thoroughly validated. In 1998 it was agreed between the NTSB and the FAA that further mathematical modelling of lightweight rotor systems would be carried out by NASA as a long-term project.

Analysis

The aircraft was seen to be flying level at approximately 1,500 feet agl and cruising at about 70 kt just before the in-flight break-up. Evidence suggests that, as a result of mast bumping, the tail cone of the aircraft was struck by the main rotor blades. The Pilot's Operating Handbook states that mast bumping can be caused by abrupt control inputs and, in this case, it is possible that this occurred as the result of an unintentional input on either the cyclic control or yaw pedals, or both.

Dual controls were fitted and the passenger in the left seat was not a rated helicopter pilot. This is cautioned against in the Normal Procedures section of the POH. However, it is not covered with the same prominence as advice that is included in the Safety Notices and the caution only states that the dual controls 'should' be removed, as opposed to 'must' be removed. The passenger was using a camera, and a photograph of Warwick racecourse was taken about 10 seconds before the helicopter broke up. The photograph was taken out of the left side of the aircraft and from a confined position in the left seat with the dual controls in close proximity to the passenger. The camera shutter operated a further three times but only the first of these produced a photograph. This photograph was blurred and it appears to have been taken while the aircraft was still in the air. Although it is not possible to say with certainty what initiated the taking of this picture, it is conceivable that the triggering of the shutter mechanism was coincident with an abrupt input to the cyclic control.

A Special Investigation Report published by the NTSB recommended that the FAA and NASA should continue to develop a simulator model of lightweight helicopters to study flight control systems and main rotor blade dynamics. Entries in the POH would appear to indicate that this work has yet to be completed.

The following safety recommendation is made as a result of this investigation:

Safety Recommendation (2003-100)

It is recommended that the Robinson Helicopter Company publish a Safety Notice, for inclusion in the R22 Pilot's Operating Handbook, which stresses the importance of removing the dual controls when the left seat is occupied by a passenger who is not a rated helicopter pilot.