Aircraft Type and Registration:	1) Robinson R22 Beta, G-LIDS 2) Hybred 44XLR, G-MTJP
No & Type of Engines:	1) 1 Lycoming O-360-J2A piston engine 2) 1 Rotax 447 piston engine
Year of Manufacture:	1) 1998 2) 1987
Date & Time (UTC):	6 July 2004 at 1154 hrs
Location:	Overhead Welham Green, Hertfordshire
Type of Flight:	1) Training 2) Private
Persons on Board:	1) Crew - 2 Passengers - 0 2) Crew - 1 Passengers - 1
Injuries:	1) Crew - 1 (Serious) Passengers - N/A 2) Crew - 1 (Fatal) Passengers - 1 (Fatal)
Nature of Damage:	1) Damage to cabin, transparencies and main rotor blades 2) Aircraft destroyed
Commander's Licence:	1) Airline Transport Pilot's Licence 2) Private Pilot's Licence
Commander's Age:	1) 45 years 2) 45 years
Commander's Flying Experience:	1) 13,940 hours (of which 580 were on type) Last 90 days - 233 hours (6 on type) Last 28 days - 72 hours (5 on type) 2) 77 hours (all on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	AAIB Field Investigation

Synopsis

A Robinson R22 helicopter departed Elstree Aerodrome with an instructor who was the aircraft commander and a student who was receiving a trial lesson. A microlight aircraft with a pilot and his friend were carrying out a local private flight returning from Hunsdon to Plaistow Farm near St Albans. Both aircraft were operating under VFR in good VMC when they collided at about

1,200 feet above Welham Green. The microlight suffered severe structural damage and descended out of control into a wooded area, fatally injuring both persons on board. The helicopter instructor received a serious injury to his left foot and despite some structural damage to the helicopter, he was able to perform a successful emergency landing in a crop field. Both occupants of the helicopter survived the accident.

History of the Flight

Background

The microlight pilot and his passenger had met at Plaistow Farm, a private grass operating site, to carry out a flight to Hunsdon, a disused airfield to the north of Harlow. Following a short stop for coffee they would then return to Plaistow. Both persons were suitably dressed for the flight with one piece flying suits, gloves and protective helmets equipped with communications headsets. The aircraft, of which the pilot owned a half share, was already rigged and following some pre-flight activity they departed for Hunsdon.

There was no requirement to 'book in or out' at either location and therefore no accurate record of the departure or arrival times was available. Witnesses recalled that the aircraft departed Plaistow Farm at about 1000 hrs arriving at Hunsdon at about 1100 hrs.

The pilot of the Robinson R22 was an experienced helicopter instructor and professional helicopter pilot whose full-time occupation was flying large transport aircraft as a co-pilot for an airline. It was his second full day of instructing in recent weeks, following a two year period during which he had given occasional flying instruction but had focussed mainly on his professional flying activities.

The instructor arrived at Elstree at about 0930 hrs and met his student at 1015 hrs to conduct the trial lesson, which comprised one hour of ground briefing and a one-hour flight. Because the weather was good the instructor decided to conduct the briefing at the helicopter rather than in the classroom and he fully involved the student in all aspects of the pre-flight checks of weather, NOTAMS and refuelling. Having explained the use and effects of the flight controls, the instructor carried out a comprehensive safety briefing covering the seat harness, normal and emergency procedures, positive hand-over of control and the need for 'lookout' with the clock code method of indicating the position of other aircraft. The flight was to be conducted with the student occupying the right seat.

Following engine start the pilot booked out with the aerodrome information service and departed Elstree at 1114 hrs to the north-west climbing to 1,000 feet. The anti collision light was switched on but the navigation lights and landing light were switched off. During the next 40 minutes, the instructor carried out a series of exercises which involved turning, increasing and reducing speed, climbing and descending with the student handling the controls when appropriate.

Having completed their break, the pilot and passenger of the microlight departed Hunsdon at about 1130 hrs from Runway 03 climbing through circuit height of 500 feet before departing to the south.

The collision

Both aircraft were being operated VFR in good VMC at about 1,200 feet on the QNH. The radar data recorded from the Stansted radar head, showed the microlight was generally tracking 245°T at a ground speed of 65 kt. This was confirmed by a number of witnesses just prior to the collision who saw the aircraft holding a constant heading in a level attitude and maintaining what appeared to be a constant height. The radar tracks are overlaid on the map included at Figure 1. The slightly oscillatory nature of the aircraft tracks, particularly the microlight track, results from the limitations of the radar recording.

The instructor of the R22 had just completed a high hover at about 1,800-2,000 feet and had transitioned into forward flight. In order to demonstrate the effect of increasing airspeed on rotor RPM, the aircraft was turned to the right halfway between Hatfield and Potters Bar onto a track of 100°T. The engine governor was switched 'OFF' in order to permit the rotor RPM to rise ungoverned as airspeed increased. The instructor made a visual scan of the area ahead and below before gently descending the aircraft and increasing airspeed from 55 to 85 KIAS. The rotor RPM began to rise as expected and he pointed this out to the student before levelling the aircraft at about 1,200 feet. The student was looking to his left across the cabin with his attention on the RPM gauge and the instructor, when out of his right peripheral vision he detected the microlight. At the same instant the instructor noticed the microlight through the left front transparency, slightly below and filling approximately 60% of his windscreen. Having perceived that the microlight was moving from left to right, he immediately applied full left cyclic in an attempt to avoid it but as he did so the two aircraft collided.

The helicopter pitched nose down and the instructor felt an impact to his left foot; the noise level increased markedly as the windshield disintegrated and the left door was torn off. Realising he still had control, the instructor transmitted a 'MAYDAY' call to Elstree and reversed his left turn whilst entering autorotation. Ahead was a large crop field into which he commenced an emergency descent. Having confirmed the student was not injured he continued the approach for an engine-off landing. As he flared to reduce airspeed he realised that the engine was still driving the rotors and so he closed the throttle before cushioning the touch-down with the collective pitch lever, making a safe, short, run-on landing. On the ground he confirmed on his radio that Elstree had received his transmissions and he tried to shut down the engine using the mixture control but this still allowed the engine to idle. Consequently the ignition key was used to stop the engine.

The student was sent to a nearby farm to ensure that the helicopter's location passed by radio was accurate and another company helicopter landed near the damaged aircraft to render assistance. The emergency services were quickly on the scene and the instructor was evacuated to hospital.

Engineering information

Accident site details

The microlight aircraft had come down in a small area of dense woodland that lay between the back gardens of a row of houses and a road. It was evident that the collision had occurred approximately 250 metres to the east because this was where much of the debris that had been released in the air was centred. Debris was scattered in the woods, on the road and at the uncultivated edge of an oilseed rape field to the south of the road. This mostly consisted of fragments of transparency from the helicopter cabin and door, together with pieces of the left-hand door frame. The only microlight wreckage found in this area consisted of three pieces of aluminium tubing that were subsequently found to be from the outboard right wing leading edge; these had been struck by the helicopter's main rotor. Approximately 100 metres to the east of the microlight main wreckage, the outermost portion of the right wing, some 1 metre in length, was found lodged in tree branches. Pieces of wooden propeller blade were found at the western extremity of the wreckage trail. One of these had fibres embedded in it that came from the sailcloth-covered wing of the microlight.

The microlight had struck the ground nose-first at the base of some trees, having brought down a number of light branches on top of itself. The 'trike' was lying on its left side and was separated from the wing due to the failure of the 'mono-pole' structural member.

The helicopter had landed approximately 1 km to the east of the collision area. The entire left side of the cockpit transparency was missing, together with the left door apart from a small section of the door frame that included the hinge.

After an on-site examination the microlight wreckage and the helicopter's main rotor blades were recovered to the AAIB's facility at Farnborough for a more detailed examination. The helicopter was released to the operator to await repair assessment, but was also examined in detail. It is likely that not all the scattered debris was recovered due to the difficulty of searching the standing rape crop and the undergrowth within the wooded area.

Detailed examination of the wreckage

Helicopter

The cabin windshield of an R22 helicopter extends downwards to a few inches above the floor. Below this level, the 'chin' area of the fuselage structure is covered with a glassfibre skin. This had been distorted as a result of the aerial collision, and the surface was imprinted with a dark purple dye that was the colour of the microlight sailcloth. (The microlight manufacturer stated that the sailcloth colour was black, although a degree of fading had occurred over time.) The impact damage extended from the landing light bezel on the nose of the helicopter round to the left almost as far as the door cut-out, and was centred on the approximate 10 o'clock position. Higher up, the mid-section of the front of the doorframe had been deflected rearwards. The fuselage skin and its supporting structure had been pushed rearwards to the extent that it limited the travel of the left seat pilot's left yaw pedal. This damage also accounted for the injury to the instructor's left foot.

The main rotor blades had sustained minor damage close to the tips, with associated distortion on the leading edge of one of them. One blade also had a chord-wise smear approximately 1 metre inboard, and a few fibres from the microlight wing fabric covering were found on a blade tip.

There was no obvious evidence of collision damage on any other part of the helicopter.

Microlight

All the damage to the 'trike' had occurred during the impacts with the trees and the ground. The mid-air collision had involved only the wing upper surface, although evidence of the aerial contact had become confused with marks subsequently made by the trees.

A section of inboard left wing leading-edge tube approximately 1.4 metres long had broken off and was found lying within the wing. The tubing had suffered bending overload failures at each end, with the inboard failure located 0.15 metres from the nose. There was an indentation in the tube approximately 0.5 metres from the nose which was probably made whilst airborne by one of the helicopter skids. Although this would have affected the aerodynamic characteristics of the wing, its basic structural integrity had been maintained by the cross-tube which had remained intact. A chordwise tear was apparent in the wing upper surface, which could have been made by one end of the broken leading edge tube, or perhaps by the helicopter skid. It was clear that the tear had occurred in the air however, as the individual fibres of the fabric around the tear had become teased out due to the effect of the airflow during the descent. Similar tears were apparent around the right wing tip and on the underside of the inner right wing where it had been contacted by the propeller. Although a number of additional tears were noted, their clean edges suggested they had occurred as a result of ground impact forces. The series of tears on the right tip area had been made by the helicopter's main rotor blades; these blade strikes progressed in a forward direction before severing the leading edge tube in two places. The fractures in the tube were tears rather than clean cuts, and it was not possible to derive a relative angle of the rotor disc to the wing. At least four blade strikes were evident. (Note: at 100% rotor RPM, there would be around 17 blade passes per second.)

The only obvious signs of contact with the helicopter on the wing fabric were a faint chordwise smear on the left wing upper surface, approximately 1.5 metres left of the centreline and another mark some 0.7 metres to the right of the centreline. None of the wires attached between the top of the king post and various locations on the wing upper surface had been broken. However the wire attached to the outboard left leading edge had suffered abrasion damage to its protective plastic sheath at a point approximately 1.7 metres from the king post. This had probably been caused by the same helicopter skid that broke the leading edge tube. None of the battens (which are inserted into chordwise pockets in the wing fabric, and which give the wing its aerodynamic profile) had been broken.

Collision parameters

The sum total of the evidence led to a 'best fit' of the parts of each aircraft that came into contact in the air, which in turn suggested that the R22 was banked approximately 30° to the left, relative to the microlight, on a relative heading of around 135°. This is represented graphically in Figure 2 where it can be seen that the helicopter's left skid would contact the left inboard leading edge of the microlight wing, with the right skid remaining clear of the left wing rigging wires. From this position, the helicopter's nose would go on to brush the wing upper surface, with the main rotor cutting into the right tip. It was not clear how all but one of the upper surface wing wires escaped being damaged, although the effect of the impact on the leading edge may have resulted in an instantaneous loss of tension, causing them to droop out of the way.

It must be stressed however that the illustration is a 'best fit' approximation and the relative attitude of the ensemble to the horizon is not known.

Meteorological information

The synoptic situation at 1200 hrs on the day of the accident showed a slack area of high pressure over Southern and Eastern England. The high was centred over the southern North Sea, with a central pressure of 1,024 mb. There were small amounts of cloud over the area with 3/8 to 4/8 of cumulus reported at Stansted, London City and Northolt Airports. Visibility was 30 km with 3/8 to 4/8 cumulus at 4,800 feet. The wind at 2,000 feet was variable in direction at 5 kt and the air temperature at that height was +14°C.

The METAR for Stansted at the time of the accident was: EGSS 061150Z VRB03KT 9999 SCT045 21/08 Q1022. Witnesses described bright sunshine being present at the time of the collision; from records for that time of day the sunlight was from an azimuth of 180° at an elevation of 61°.

Communications

The R22 instructor was using the aerodrome frequency at Elstree to maintain his flight watch. The microlight had been using a dedicated frequency of 129.825 MHz at both Plaistow Farm and Hunsdon.

Other information

The colour schemes for both aircraft were relevant to the accident in addition to their small size, speed and profiles.

The CAA's General Aviation Safety Sense leaflet 13A, '*Collision Avoidance*', provides comprehensive guidance on maintaining an effective visual scan in the visual flight environment, sometimes referred to as the 'see and avoid' method. There are distinct limitations with the human eye which, although it can accept light rays through an arc of nearly 200°, only through approximately 10-15° can it focus on and classify an object. Although movement can be detected on the periphery of vision, the brain cannot identify what is happening there. In addition, glare from the sun makes aircraft hard to see and looking into the sun is uncomfortable.

Motion or contrast is needed to attract the eyes' attention but with slow moving aircraft on a collision course there is little or no relative movement. An aircraft on an unwavering collision course will remain in a seemingly stationary position without appearing to move or grow in size for a relatively long time and then suddenly, it will bloom into a huge mass almost filling up one of the windows. This is known as the 'blossom effect'. Contrast of aircraft colour against background will also allow the object to be seen. High contrast such as a black object against a white background would have high conspicuity whereas a dark object against a dark background would have poor contrast and would be difficult to see. It would be said to have low conspicuity. Seeing an aircraft against a background cluttered with buildings, woods, shadows and a patchwork of fields could be difficult if it tended to blend into the background. The use of landing lights and strobe lights can improve the conspicuity of an aircraft.

Size and profile of the aircraft also affect conspicuity, particularly the distance at which an aircraft is first detected. Given the aggregate of times required for a pilot to perceive an aircraft, realise that it is on a collision course, make a control input, for the input to take effect, and for the aircraft to manoeuvre, it is vital that the aircraft is seen some distance away. This distance is also a function of closing speed.

Medical information

A post mortem examination of the microlight pilot and passenger revealed that they had both died from multiple injuries as a result of the ground impact. No evidence was found of any disease, alcohol, drugs or any toxic substance which could have caused or contributed to the accident. The commander and student of the R22 helicopter provided blood samples to the police. These were analysed for alcohol and drugs but no trace of either was found. Neither pilot had any medical limitations in their licence nor any requirement for corrective lenses for their vision.

Analysis

When the R22 rolled out of its gentle right turn at about 1,500 feet the aircraft were approximately 1 nm apart and some 30 seconds from the collision. From that moment onwards they were heading towards each other with nearly constant relative bearings of 085°/265° creating virtually a 'head-on' collision. There was no obstruction of any significance between the two aircraft to prevent them seeing each other.

According to eye witness evidence, the sun was shining at the time of the accident with the scattered cloud well above the two aircraft. On the ground, the rural patchwork of fields and woods was supplemented by deep shadows cast by ground structures, buildings and clouds. This visual scene tends to 'camouflage' any dark coloured aircraft when viewed from above, particularly if the aircraft's apparent movement relative to the ground is slow.

The R22 instructor had visually cleared the area ahead and below the helicopter prior to descending for the acceleration exercise and he did not see the microlight. During the descent he continued to look out ahead and below the helicopter with an occasional scan of the rotor RPM gauge to confirm that the rotor speed was increasing, which it was. Having levelled off, the instructor began to review the exercise with the student discussing the behaviour of the rotor whilst pointing to the instrument. The sudden appearance of the microlight was consistent with the 'blossom effect' described earlier. The dark coloured wing and fuselage of the microlight with its small profile would effectively have been a stationary object to the occupants of the R22. When set against the background of shadows and dark areas of woodland as the helicopter descended, the microlight would have had no discernible contrast or movement for the helicopter instructor or his student to detect.

Equally, the white colour of the R22 against the cloud combined with the small size and profile of the helicopter in bright sunshine would also have meant that it too had low conspicuity. The anti-collision beacon would not have been easily visible in the bright light. Moreover, because the helicopter was ahead and mainly above the microlight, the beacon, mounted on the upper surface midway aft along the tail boom, was probably obscured from the view of the microlight occupants by the helicopter's cabin. It is not known where the pilot and passenger of the microlight were looking shortly before the collision but the helicopter was not approaching directly out of the sun. The microlight pilot was wearing sun-glasses which would have assisted in reducing glare.

The two pilots were using different radio frequencies and neither was receiving a radar or information service that could warn them of the proximity of the other aircraft.

Conclusions

The collision occurred because those onboard the two aircraft did not see each other and take timely avoiding action. Contributory factors were the small size and profile of the two aircraft and the lack of movement or conspicuity against their respective backgrounds. Detection in these visual conditions was challenging for the human eye. The aircraft were also on different radio frequencies and so had no common service to alert either of the pilots to the presence of the other aircraft.

Safety Recommendation 2005-006

It is recommended that the Civil Aviation Authority should initiate further studies into ways of improving the conspicuity of gliders and light aircraft, to include visual and electronic surveillance means, and require the adoption of measures that are likely to be cost-effective in improving conspicuity.

Safety Recommendation 2005-008

It is recommended that the Civil Aviation Authority should promote international co-operation and action to improve the conspicuity of gliders and light aircraft through visual and electronic methods.

The same safety recommendations will be made in the report on the mid-air collision between two gliders on the 26 April 2004 approximately 2 km west of Lasham airfield, (EW/C2004/04/03) which is likely to be published in Bulletin 5/2005.

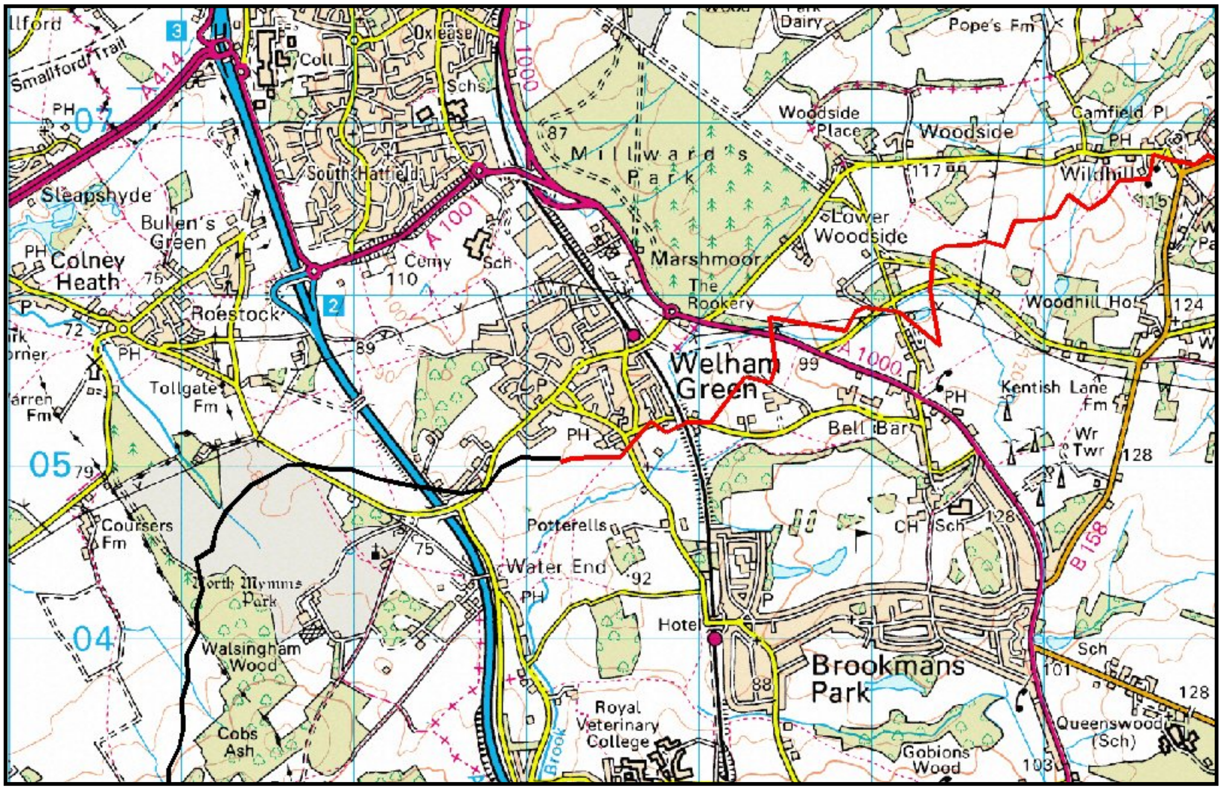

Figure 1 - Radar tracks of microlight G-MTJP (in red) and helicopter G-LIDS (in black)

Figure 2 - Representation of the two aircraft immediately prior to impact