ACCIDENT

Aircraft Type and Registration:	Robinson R44 Astro, G-TATY
No & Type of Engines:	1 Lycoming O-540-F1B5 piston engine
Year of Manufacture:	1999
Date & Time (UTC):	16 September 2005 at 0855 hrs
Location:	Near Amersham, Buckinghamshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Severe disruption of fuselage, main and tail rotor blades, cockpit canopy and tail rotor drive shaft
Commander's Licence:	Student Pilot (Helicopters) Private Pilot's Licence (Aeroplanes)
Commander's Age:	59 years
Commander's Flying Experience:	224 hours (of which 31 were on helicopters) Last 90 days - 17 hours Last 28 days - 3 hours
Information Source:	AAIB Field Investigation

Synopsis

The student pilot had departed from Denham airfield on his first solo cross-country exercise. About five minutes after the helicopter had taken off it was seen flying at a low height just to the south of the town of Amersham. Seven members of the public then saw G-TATY perform some energetic manoeuvres before it struck the ground in a nose-down attitude, coming to rest upright. The pilot received serious injuries and the helicopter was seriously damaged. Subsequent investigation found no technical fault with the helicopter that would have contributed to the accident. The weather had been fine but the reported surface wind at the time of the accident exceeded the manufacturer's and operator's limitations for a pilot of this experience. The pilot could not recall any of the events on the flight and it was not possible to conclude what caused the helicopter to descend from the cruise at about 1,500 feet amsl. However, the evidence indicated that the rotational speed of the rotor blades was below the 'power on' limits at the moment G-TATY struck the ground.

History of the flight

The student pilot and an instructor had completed 10 minutes of circuits at Denham Airfield before the instructor disembarked from the helicopter, rotors running, and authorised the student as competent to carry out his first solo navigation exercise in the local area. The planned route for the flight was from Denham, north-west to overhead Westcott disused airfield, a distance of 23 nm, and back to Denham. The pilot had annotated his 1:500,000 chart with a figure of 312º (M), for the required track outbound, and a time of 14 minutes, which equated to a ground speed of 100 kt.

G-TATY took off from Runway 06 at 0849 hrs and turned left for a standard departure via the Maple Cross NDB. This was observed by the flight information service officer (FISO) on duty in the control tower at the airfield. He stated that the pilot sounded normal on the radio and that there was nothing unusual about the departure. After that, the FISO received no further calls from G-TATY and was not advised of any frequency change by the pilot. Before reaching Maple Cross the helicopter turned further left on a track towards Westcott, which took it in the direction of the town of Amersham.

Shortly before 0855 hrs, a member of the public, who was walking her dogs in a field on the southern edge of Amersham, became aware of a "noisy" helicopter approaching from an easterly direction. On looking up she saw a blue helicopter flying towards her at a height which was much lower than normal. She explained that helicopters often flew overhead in that vicinity and that she was used to hearing and seeing them. On this occasion she observed that the helicopter's main rotor blades appeared to be turning more slowly than usual. The helicopter flew past on the far side of a hedge on her right side and then turned left and pitched nose down as it "swung round" through 360º. After that manoeuvre it flew away from her, up a sloping field, and, although the blades appeared to be turning more slowly, seemed to recover some energy. The witness then lost sight of the helicopter. Almost immediately she heard a sound which was a "combination of a crash and a thud". Without delay she called the emergency services on her mobile telephone. That call was timed at 0855:29 hrs.

While remaining on her telephone, the witness moved towards the helicopter, which was about 500 metres away from her. Initially it was hidden by the hedge that was on her right, and the slope of the rising ground beyond, but eventually she was able to see the helicopter near the far side of the field, adjacent to a wood. The rotor blades were stationary but the engine was still running and the only occupant, who was strapped into the front right seat, was moving. While continuing to tell the emergency services what she could see and hear, this lady approached the occupant of the helicopter. He had a visible injury in the area of his throat and was unable to talk, despite apparently trying to. He was also attempting to release his seat belt, without success, so the witness assisted him.

Fifteen minutes after the impact the fire service arrived, switched off the engine and removed the pilot, still conscious, from the helicopter. He had suffered significant head injuries in addition to those to his neck. Shortly after that he was airlifted to hospital by a police air support unit helicopter, which had arrived at the accident site at 0918 hrs.

While the pilot of the police helicopter was on the ground at the accident site, he made G-TATY safe by switching off its master battery switch and alternator switch. The helicopter had been severely damaged in the impact but there was no fire.

The helicopter struck the ground at an elevation of 420 feet amsl.

Other witnesses

As the helicopter was flying to the south of Amersham, an unusual noise prompted six other members of the public to look up at it. The noise was described as sounding like two very loud "choking" noises, a dull "pop" or a few "phuts". Two witnesses stated that the engine sounded as if it was going to cut out and one of those recalled the noise "oscillating up and down". Two of the witnesses, in addition to the lady who was walking her dogs, saw the helicopter turn left and one of those commented that it was banked steeply "as if in a whirlpool". There was agreement between all the witness statements that the helicopter adopted a very steep nose-down pitch attitude and descended rapidly before appearing to regain a level attitude. It then pitched steeply nose down again and turned to the right. At that point most of the witnesses lost sight of the helicopter as it disappeared from view before crashing. However, one witness did see G-TATY strike the ground nose first and fall back, coming to rest in an upright attitude. The aircraft stopped a few metres from the northern edge of Rodger's Wood.

Figure 1

G-TATY, 16 September 2005

The pilot

The pilot had briefly held a Private Pilot's Licence (Flying Machine), with a rating for Group A Landplanes, in 1963. That had lapsed and he qualified for a new Private Pilot's Licence (Aeroplane) in January 2002. He had been the owner of a Scottish Aviation Bulldog from 2002 until June 2005 and held a current rating for single-engine piston ('SEP (Land)') aeroplanes.

In January 2005 he commenced a course of helicopter instruction on the Robinson R44, all but one of the flights being in G-TATY. He had accrued a total of 31 hrs on type, of which 2 hrs 30 mins had been solo. The accident occurred on his first solo cross-country flight.

Following the accident the pilot was unable to remember much of the events of 16 September and none of the accident flight. The head injuries which he had suffered during the accident were considered to have contributed to this memory loss, which bore the usual traits for this condition. He did, however, volunteer to take part in a lengthy cognitive interview with an experienced, qualified practitioner. This technique has been used, with success, to help willing participants recall events which they seem to have forgotten; on this occasion, it did not produce further information.

The pilot was regarded by his most regular instructor as a slow learner but one who handled the helicopter well with the cyclic trim ON. He was considered to be good at controlling the rotor rpm with the governor OFF and good at autorotations. However, hovering was not such a strong point. He was also described as having a tendency to treat the helicopter like a fixed-wing aircraft and was sometimes slow to react to a problem. In addition, the instructor recollected the pilot overriding the governor by gripping the twist grip throttle too tightly "at one time or another". Downwind landings were not a manoeuvre that the instructor encouraged and the pilot recalled receiving very little, if any, instruction on the subject. Therefore he was unfamiliar with the increased power that is required as the helicopter transitions through zero airspeed during such an approach. He was also unfamiliar with the handling requirements in such a manoeuvre, with the potential for the helicopter to enter 'vortex-ring state'[1]. His RTF skills were not considered good.

Aircraft description

The Robinson R44 Astro is a four-seat single-engined helicopter of conventional layout with a maximum gross takeoff weight of 1,089 kg. The primary fuselage structure is constructed of welded steel tubing covered with riveted aluminium skin and is fitted with a skid landing gear. The aircraft is powered by a 6-cylinder Lycoming O-540 piston engine fitted with a carburettor and a carburettor heat system. The engine power output shaft drives a pulley sheave which transmits power to an upper sheave via four rubber 'vee' belts. The belts are tensioned by an electric screwjack clutch actuator which, when activated, raises the upper sheave and automatically sets and maintains the required tension. A freewheel clutch within the upper sheave transmits power forward to the main rotor gearbox and aft to the tail rotor driveshaft. The flying controls are all mechanically operated via push-pull tubes and bellcranks without hydraulic assistance. To ease pilot control forces the cyclic control is fitted with an automatic electric trim system.

The helicopter was equipped with a carburettor heat assist device which, according to the Pilot's Operating Handbook (POH):

> *'correlates application of carburettor heat with changes in collective setting to reduce pilot work load. Lowering collective mechanically adds heat and raising collective reduces heat. Collective input is transmitted through a friction clutch which allows the pilot to override the system and increase or decrease heat as required. A latch is provided at the control knob to lock carburettor heat off when not required. It is recommended that the control knob be unlatched (to activate carb heat assist) whenever OAT* [Outside Air Temperature] *is between 27ºC and -4ºC and the difference between dew point and OAT is less than 11ºC.'*

Aircraft maintenance history

The aircraft was manufactured in July 1999 and the airframe and engine had accumulated 421.2 hours by the time of the accident. The aircraft's last 'STAR' annual inspection was completed on 6 September 2005 at 418.9 hours. There were no recorded defects in the aircraft's technical log.

Meteorology

A meteorological aftercast described the synoptic situation at 0600 hrs on 16 September 2005 as showing high pressure in the central Atlantic which was feeding a moderate north-easterly flow over much of England. At the location of the accident, this gave a visibility of 40 km or more, few clouds at 2,000 feet amsl and a

Footnote

[1] Vortex-ring state, or 'settling with power' is a condition where a helicopter settles into its own downwash. It is characterised by a substantial sink rate and low forward airspeed. The result is an unsteady turbulent flow over a large area of the rotor disk, causing loss of rotor efficiency.

surface wind of 010º/13 kt gusting 20-26 kt. The wind at 1,000 feet agl was calculated to be 030º/25-30 kt and at 2,000 feet agl it was 030º/30 kt.

The Terminal Area Forecast (TAF) for Northolt, which is 4 nm to the south-east of Denham airfield, for the period 0600 hrs to 2300 hrs on 16 September 2005 predicted a surface wind of 350º/10 kt, becoming 010º/15-25 kt between 0700 hrs and 1000 hrs, with visibility greater than 10 km and scattered cloud at 3,000 feet aal. The actual wind at Northolt at 0850 hrs, as recorded on the Aerodrome Meteorological Report (METAR), was 010º/13 kt. At Heathrow, which is 7 nm to the south-south-east of Denham, the surface wind recorded at the same time was 010º/13-26 kt. Respective temperatures and dew points at that time were 12ºC/7ºC (relative humidity (RH) 71.5%) and 13ºC/8ºC (RH 71.6%).

The chart of carburettor induction system icing probability in Safety Sense Leaflet 14 of LASORS[2] indicated that, in these conditions, there was a serious risk of icing at any power setting for a typical light aircraft piston engine without carburettor hot air selected.

A report, which was submitted by the flight information service officer (FISO) on duty at Denham airfield at the time of the accident, recorded the wind as varying in direction between 360º and 010º at a speed of 15-20kt with gusts to 28kt. The cloud was recorded as being broken at 2,000 feet aal.

The regional pressure setting was 1017 mb.

Footnote

[2] LASORS (Licensing Administration Standardisation Operating Requirements Safety) is an annual publication by the CAA containing '*essential licensing requirements and safety information for pilots of all aircraft*'.

Navigation

For a cross-country training flight the operator recommended using a 1:250,000 chart. The planned route to Westcott and back was a typical first solo cross-country exercise and the student pilot recalled that he was advised to remain on the Denham Radio frequency throughout the flight. He would not have been expected to use the GPS.

The pilot had prepared the route on a 1:500,000 aeronautical chart of Southern England and Wales. The outbound and return tracks had been represented by a single line, 8.5 cm in length, drawn in green and annotated 312ºM and 132ºM respectively, with a time of 14 minutes. The distance was 23 nm and this indicated a still air airspeed of 100 KIAS. Radio frequencies for Denham Radio, Northolt Approach, Benson Zone and Brize LARS (Lower Airspace Radar Service) had been handwritten on the chart in red.

Limitations and procedures

The R44 Pilot's Operating Handbook (POH) states:

'The following limitations (1-3) are to be observed unless the pilot manipulating the controls has logged 200 or more flight hours in helicopters, at least 50 of which must be in the RHC Model R44 helicopter, and has completed the awareness training specified in Special Federal Aviation Regulation (SFAR) No. 73, issued February 27, 1995.

1) Flight when surface winds exceed 25 knots, including gusts, is prohibited.

2) Flight when surface wind gust spreads exceed 15 knots is prohibited.

3) Continued flight in moderate, severe, or extreme turbulence is prohibited.'

This was supplemented locally by guidance in the operator's Flying Order Book which stated that solo student pilots should not fly in wind speeds exceeding 15 kt.

The POH Safety Notice SN-25 states:

> *'Carburettor ice is most likely to occur when there is high humidity or visible moisture and air temperature is below 21ºC. ....*
>
> *<u>During Climb or Cruise</u> – Apply carb heat as required to keep CAT (carburettor air temperature) gage [sic] out of yellow arc.'*

The pilot, however, stated that he had considered the carburettor heat, with its 'carburettor heat assist device', as being an essentially automatic system and not something which he would adjust.

The R44 POH normal procedure in the cruise is:

> *'1. Adjust carb heat if required.*
>
> *2. Verify RPM in green arc.*
>
> *3. Set manifold pressure with collective for desired power.*
>
> *4. For aircraft with manual controls, adjust cyclic trim to zero forces.*
>
> *5. Verify gages in green, warning lights out.*
>
> ***CAUTION***
>
> *Inflight leaning with engine mixture control is not recommended. Engine stoppage may result as there is no propeller to keep engine turning should overleaning occur.'*

The pilot stated that it was not his practice to operate the mixture control after the engine was started.

For power failure above 500 feet agl, the POH procedure is;

> *'1. Lower collective immediately to maintain RPM and enter normal autorotation.*
>
> *2. Establish a steady glide at approximately 70 KIAS.*
>
> *3. Adjust collective to keep RPM in green arc or apply full down collective if light weight prevents attaining above 97%.*
>
> *4. Select landing spot and, if altitude permits, maneuver [sic] so landing will be into wind.*
>
> *5. A restart may be attempted at pilot's discretion if sufficient time is available.*
>
> *6. If unable to restart, turn off unnecessary switches and shut off fuel.*
>
> *7. At about 40 feet AGL, begin cyclic flare to reduce rate of descent and forward speed.*
>
> *8. At about 8 feet AGL, apply forward cyclic to level ship and raise collective just before touchdown to cushion landing. Touch down in level attitude with nose straight ahead.'*

The rate of descent of an R44 Astro during a stable autorotation is between 1,600 fpm and 1,800 fpm. The POH states that the configuration for minimum rate of descent during autorotation is:

> *'1. Airspeed approximately 55 KIAS.*
>
> *2. Rotor RPM approximately 90%.*
>
> *3. Rate of descent is about 1,350 feet per minute.'*

G-TATY descended through approximately 1,000 feet before striking the ground, which would have given the pilot up to 45 seconds in which to turn into wind, if employing this power failure procedure.

The POH Safety Notice SN-32, entitled 'HIGH WINDS OR TURBULENCE', states that flying in high winds or turbulence should be avoided but recommends that, if unexpected turbulence is encountered, airspeed be reduced to 60-70 KIAS, overcontrolling be avoided and the governor be left ON.

Accident site examination

The aircraft was resting upright in the field with its nose facing in the direction of 000º(M). Both landing gear skids had collapsed and the forward section of the right skid had fractured. The transparent portions of the cockpit canopy had shattered and there was clear evidence that a main rotor blade had cut through the canopy and struck the instrument panel. The engine rpm instrument was found 50 metres from the main wreckage and had a main rotor blade imprint in its casing. The main rotor blades were relatively undamaged apart from the tips which had been bent rearwards and up as a result of ground impact. The tail boom had partially separated and was bent to the left. The lower vertical tail fin was bent in half and the tail rotor exhibited ground impact damage. One tail rotor blade had separated but was embedded in the ground within 2 metres of the tail rotor gearbox.

All the aircraft components were accounted for and all were found within a 50 metre radius of the main wreckage. There was no evidence that any part of the aircraft had struck a tree in the wooded area a few metres south of the accident site. The damage to the aircraft and the ground witness marks indicated that the aircraft had struck the ground in a nose-low attitude, with a slight right bank, on a heading of approximately 348°(M) with a high vertical descent rate, sufficient to collapse the skids. The aircraft had then translated aft and to the left by 3 metres and yawed to the right before coming to rest.

Detailed wreckage examination

The aircraft wreckage was recovered to the AAIB facility at Farnborough for further detailed examination. The flying control tubes were checked for continuity and the few separations found were consistent with overload failures during impact. The tail rotor driveshaft had failed in torsion overload, consistent with the failure expected as a result of the tail rotor hitting the ground during impact. There were no other failures of the main rotor or tail rotor driveshafts. There was no evidence of a main rotor (MR) gearbox or tail rotor (TR) gearbox failure and both the MR and TR chip detectors were clean.

The attachment lug for the upper sheave of the electric screwjack clutch actuator had failed, which resulted in loss of tension in the 'vee' belts. Metallurgical examination of the lug failure revealed that it was caused by overload, consistent with it having occurred at impact. The clutch actuator motor and microswitches were tested by the aircraft manufacturer and operated satisfactorily. The engine rpm electronic governor control box and the trim control box were also tested by the aircraft manufacturer. Both were found to be slightly outside specification limits but, according to the manufacturer, this would not have been detectable by a pilot.

Both the governor and cyclic trim switches were found in the ON position and the transponder was found set to STANDBY.

Powerplant examination and test

A total of 29 gallons (US) of fuel was recovered from the aircraft's main and auxiliary fuel tanks which have a combined total capacity of 50 gallons (US). There was fuel remaining in the gascolator and carburettor, and the fuel filters in both the gascolator and carburettor were clean. A fuel sample was tested, was found to be free of contamination and complied with the specification requirements for AVGAS 100L.

The engine was still running after the accident so it was decided to test run it rather than carry out a strip examination. The engine was mounted on a dynamometer test rig; it was started and then ran normally after a brief warm-up period. The engine passed a series of tests and produced a maximum corrected power output of 257 bhp at 2,800 rpm. This compared favourably with the engine manufacturer's maximum specified power output of 260 bhp at 2,800 rpm.

Audio recordings of the engine test runs were made at different rpm settings and then compared to the audio recording from the '999' mobile telephone call made by the witness who first arrived at the accident scene. The engine noise was audible during the '999' call while the woman was trying to assist the pilot. When the engine noise from the call was isolated and amplified it most closely matched the recording of the engine test at 2,800 rpm.

The carburettor heat mechanism consists of a sliding valve within the air intake box controlled by a selector knob in the cockpit. The valve position adjusts the mixture of cool and heated air that flows to the carburettor. The valve was found in the full COLD position and this was consistent with the collective position which was full UP and the carburettor heat selector knob which was OFF but unlatched. With the knob unlatched, a lower collective position would have commanded some carburettor heat application.

Cooling fan examination

The engine cooling fan is mounted on a tapered shaft connected to the lower sheave. The fan is secured to the shaft with a 2-inch diameter castellated nut. Eight self-locking nuts, which surround the large fan nut, serve to secure the fan wheel to the fan hub. One of the self-locking nuts was missing and two were only finger tight. There was evidence of heat damage surrounding the nuts and some of the holes had become ovalised as a result of fretting. The fan had slipped on its shaft and was no longer in alignment with the white witness mark on the shaft. The fan wheel was difficult to remove because the hub had partially welded itself to the tapered shaft. The aircraft manufacturer reported that similar occurrences had been seen before and that, if the fan hub becomes loose and moves on the shaft, the friction generated can be sufficient to friction weld the hub and shaft together. This heat also causes the small self-locking nuts to loosen.

No unusual vibrations were noticed by the instructor during the training flight prior to the accident flight. Therefore it is probable that the fan slippage occurred as a result of impact when the engine suddenly became unloaded following the failure of the screwjack clutch actuator.

Caution and warning panel examination

The bulb filaments from the caution and warning lights in the instrument panel were examined for indications of stretch. A stretched filament is an indication that the bulb was 'hot', and was therefore illuminated, when it was subjected to a high force. All the bulb filaments were normal apart from the LOW RPM and CLUTCH lights which both had stretched filaments. The LOW RPM light illuminates when the rotor rpm drops below 97% RPM and the CLUTCH light illuminates when the clutch actuator motor is attempting to tighten the 'vee' belts. These lights were subjected to a high force on two occasions; once when the aircraft struck the ground and then again when the main rotor struck the instrument panel. It was therefore not possible to determine if the lights were on immediately before ground impact or illuminated just after impact, once the rotor blades had slowed and the clutch actuator lug had failed.

Radar and GPS

Radar recordings were obtained for G-TATY and the police helicopter. All the radar contacts for G-TATY were primary. There were no secondary returns; this is probably explained by the aircraft's transponder being found set to STANDBY. The police helicopter gave both primary and secondary radar contacts and the lowest level that the primary contacts were recorded for this helicopter, as indicated by the secondary radar information, was 500 feet on the standard pressure setting of 1013 mb. This equated to an altitude of 620 feet amsl, which was 200 feet higher than the accident site.

Recorded information was retrieved from G-TATY's GPS equipment. The GPS memory was set to record waypoints, and their associated information, every four minutes. However, there was a gap of only one minute and three seconds between the last two points. This could have happened as a result of power being removed and then restored to the GPS at some time after the penultimate waypoint was recorded.

The recorded GPS waypoints are shown in Figure 2.

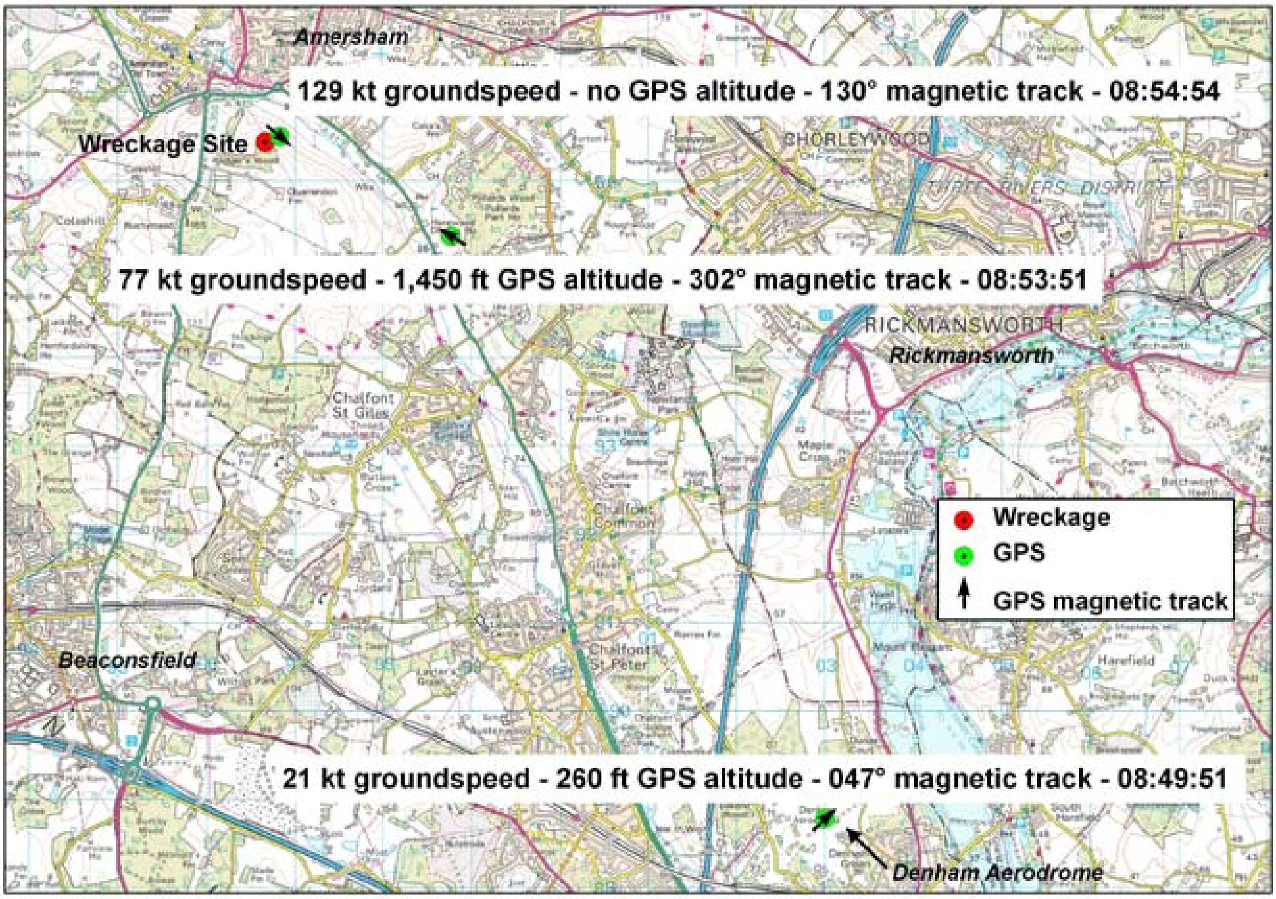

Figure 2

G-TATY recorded waypoints

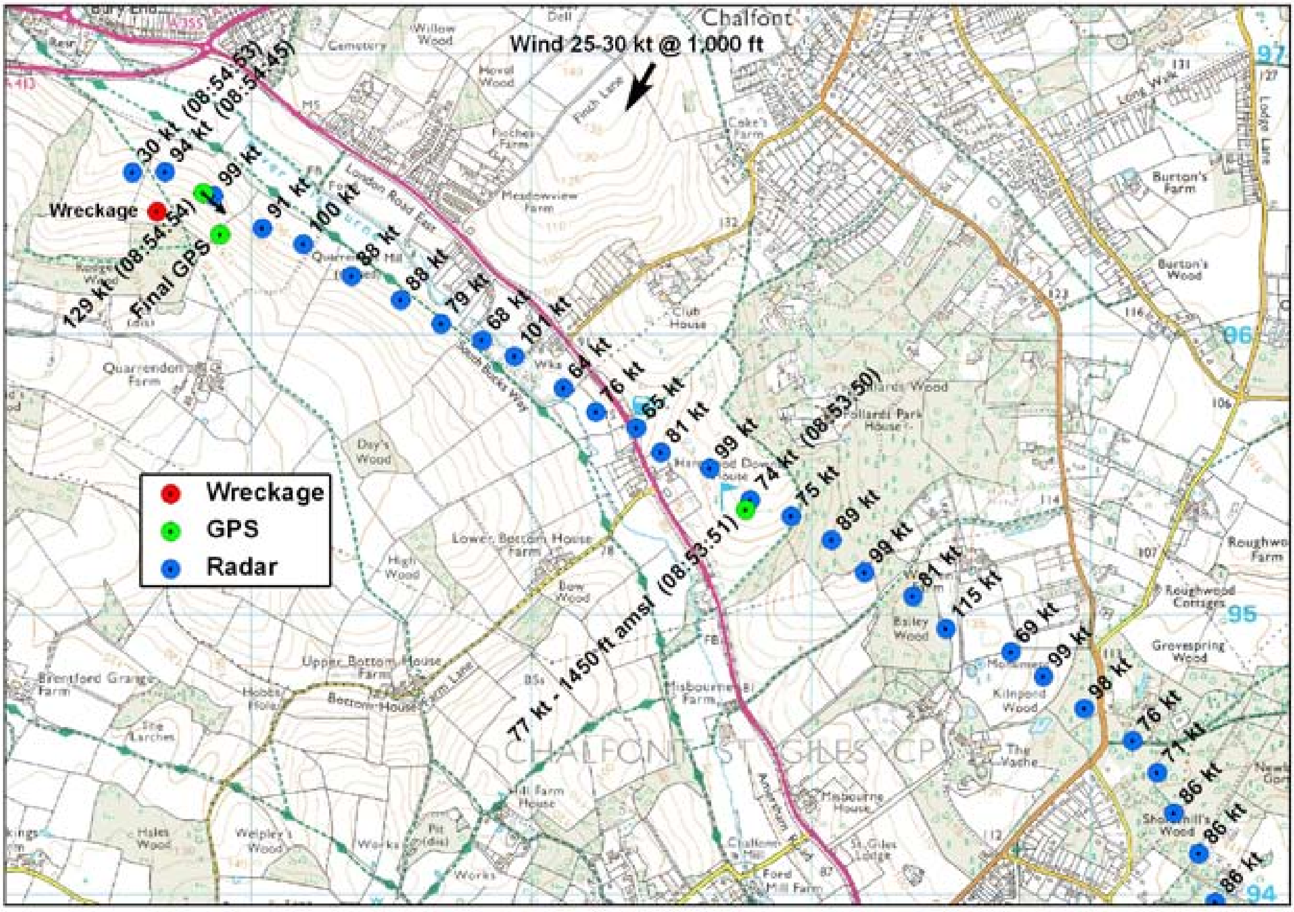

Figure 3

G-TATY radar recordings

However, the helicopter's GPS groundspeed of 129 kt at 0854:54 hrs was considered unreliable because it was not consistent with any of the witness statements, nor was it reflected in the recorded radar data, which is shown in Figure 3.

There was good correlation between the radar and GPS at 0853:51 hrs but less correlation at 0854:54 hrs.

Analysis

From the available evidence, the takeoff was conducted successfully and G-TATY reached a cruising altitude of about 1,500 feet amsl as it turned onto its outbound heading towards Westcott. However, approximately five minutes into the student pilot's first solo cross-country flight the helicopter began to descend.

The GPS and recorded radar information indicated that G-TATY descended from an altitude of 1,450 ft amsl to about 620 ft amsl in the space of 1 minute 2 seconds; an **average** rate of descent of approximately 800 fpm. This was about half the rate of descent expected during a stable autorotation. There was no specific evidence that the helicopter descended throughout that period or that it descended at a uniform rate. Conversely, there was no evidence of G-TATY having descended at a rate that indicated that it had entered autorotation. The average ground speed during that time was 86 kt and, given the wind conditions, G-TATY's airspeed averaged 88 kt. This is reflected in the speeds annotated on the plot of radar recordings in Figure 3 for the same period, which indicate fluctuations about about the mean ground speed. These fluctuations which could have been the result of variations in the positional accuracy of the radar recordings.

The engineering evidence indicated that the helicopter struck the ground in a nose-low attitude with a slight right bank and a high vertical descent rate. The helicopter then translated backwards by approximately 3 metres as a result of pilot input or possibly as a result of the main rotor striking the ground forward of the aircraft. The degree of damage to the main rotor blades indicated that the rotors were probably being driven at low power and were rotating at below normal operating rpm. The subsequent ground impact would have caused the main rotor to slow further and become unstable, consistent with the canopy then being struck. The tail boom, tail rotor driveshaft and tail rotor blade damage were a consequence of the impact. All aircraft parts were accounted for and there was no evidence of pre-impact separation and the detailed examinations did not reveal any technical fault that might have contributed to the accident. The engine was running at high rpm after the accident and engine tests revealed that it was capable of producing full power. The fan wheel fretting was probably a result of the engine suddenly becoming unloaded after impact, and did not contribute to the accident.

Thus, the evidence suggests that the main and tail rotors were turning at less than their optimal speed at the point of impact and what caused the rotor speed to decay was not ascertained during the investigation. The engine was still running when the first witness reached the aircraft and there was no evidence that the engine had stopped in flight and been restarted. The noises which witnesses recalled hearing before the aircraft struck the ground could have come from the engine or been caused by 'blade slap' (which occurs when a rotor blade interacts with the vortex trailing from a preceding blade).

Despite a concerted effort, the pilot was unable to recall any of the events on the flight and his loss of memory bore the normal traits for such a condition following a traumatic accident. However, it seems that he lost control of the helicopter during the manoeuvres which were observed shortly before G-TATY struck the ground. At some point during those manoeuvres the helicopter was flying down wind at slow speed - a situation with which the pilot was unfamiliar. Low rotor speed at this point would have presented the pilot with an extremely challenging situation.

Detailed examination of G-TATY after the accident revealed no faults prior to the helicopter striking the ground. The governor was found in the ON position suggesting that the pilot had not employed the governor failure procedure, although the switch could have been knocked into that position when the helicopter struck the ground.

The surface wind at Denham, as reported by the FISO, was outside the limiting wind speeds stipulated by the operator and by the helicopter manufacturer for a pilot of this experience. The average airspeed (88 kt) established from the radar recordings in Figure 3 did not equate with that recommended for flight in unexpected turbulence. It is not known whether the wind, and any turbulence that existed at higher altitude, affected the pilot's ability to control the aircraft or a temporary fault prompted him to descend and land in a field. However, having departed from Denham airfield only five minutes beforehand, it would have been reasonable to expect the pilot to return there for any problem that did not require an immediate landing. He did not transmit a radio call to advise others that he had a problem and the helicopter did not appear to have entered autorotation in preparation for an engine-off landing. Before the cross-country flight, the pilot had completed 10 minutes of uneventful flying in the circuit at Denham airfield, with an instructor, and had then been authorised to carry out the solo navigation exercise.

Assuming a level attitude, G-TATY probably descended initially as a result of the collective being lowered or a marked reduction in the rotor speed, or both. Had it been the consequence of a forward cyclic input, causing the helicopter to pitch down, there would have been an associated increase in speed, which was not evident. It is not possible to say whether any lowering of the collective was the result of a voluntary or inadvertent pilot input or some other involuntary cause, masked by a distraction.

Being at an early stage in the flight, the pilot may have had cause to consult his prepared chart. One possible explanation for the accident is that the clarity and scale of the information on the map may have absorbed his concentration and distracted him at a time when the problem that caused the helicopter's descent manifested itself. The end result was an uncontrolled impact with the surface. Before this the helicopter had performed some energetic manoeuvres at a low height, a situation from which the student pilot was ill-prepared to recover.

Another possible factor in the accident was carburettor icing. As noted previously, the chart of carburettor induction system icing probability in Safety Sense Leaflet 14 of LASORS indicated a 'serious risk of icing at any power setting' for the weather conditions at the time. This chart is generic and may not be directly applicable to the particular installation on the Robinson R44. However, the pilot was not in the habit of manually applying carburettor heat to keep the carburettor temperature outside the yellow arc on the gauge, as advised in the POH and relied on the 'carburettor heat assist device', which was correlated to collective position. This device does not always provide sufficient heat to keep the temperature out of the yellow arc. Therefore, G-TATY could have suffered a reduction in power during the flight as a result of carburettor ice, with the ice being dislodged as a result of the impact force and thus restoring full power after the accident.

This in-flight loss of power may then have resulted in a reduction in the rotor speed if the pilot had demanded more power than was available by retaining the collective control lever in a raised position, in an attempt to maintain height. Such a loss of power, and 'overpitching' of the rotor blades, would have accounted for the helicopter's descent and the lower than normal rotor speed apparent in the final stages of the flight.