ACCIDENT

Aircraft Type and Registration:	Robinson R44 II, Raven II, G-ROTG
No & Type of Engines:	1 Lycoming IO-540-AE1A5 piston engine
Year of Manufacture:	2006
Date & Time (UTC):	24 July 2011 at 1427 hrs
Location:	Marhamchurch, near Bude, Cornwall
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - None
Nature of Damage:	Helicopter destroyed
Commander's Licence:	Private pilot's licence
Commander's Age:	45 years
Commander's Flying Experience:	285[1] hours (of which 221 were on type) Last 90 days - 6 hours Last 28 days - n/k hours
Information Source:	AAIB Field Investigation

Synopsis

While on a flight to visit friends near Padstow, Cornwall, the pilot unintentionally entered IMC, subsequently lost control of the helicopter and, after a very high rate of descent, crashed. There was a post-impact fire and the pilot was fatally injured.

As a result of the investigation some contaminants, that were not contributory to the accident, were found in the helicopter's fuel supply. One Safety Recommendation is made.

History of the flight

The pilot was planning to fly from Aldwick, near Blagdon, 2 nm south of Bristol Airport, where the helicopter was based, to Padstow, Cornwall, to visit friends. He took off at 1320 hrs and the flight progressed uneventfully via Taunton and Okehampton, Devon. En route he was in contact with Bristol Radar and Exeter Radar. At 1358 hrs, when the helicopter was north-east of Okehampton, the pilot was told to 'free call' Newquay Radar. At 1405 hrs he returned to Exeter Radar saying he was unable to contact Newquay. They advised him to contact London Information, which he did at 1407 hrs when 6 nm north-west of Okehampton, Devon.

Footnote

[1] The pilot's experience was calculated using a combination of his logbook and the helicopter's logbook. The last entry made in his logbook was on 13 October 2010. The last entry in the helicopter's logbook was on 19 June 2011.

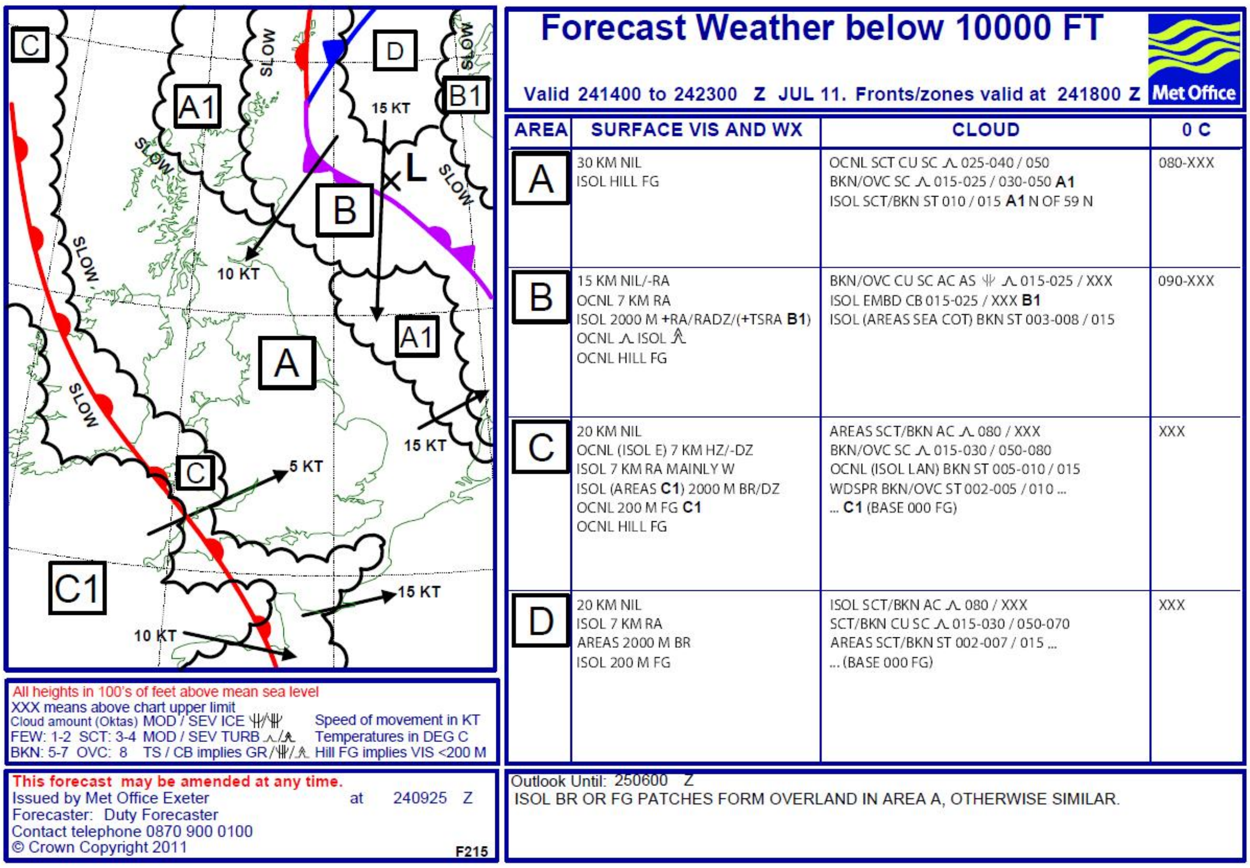
At 1418 hrs, when the helicopter was 24 nm north-west of Newquay Airport, London Information instructed the pilot to 'free call' Newquay Radar, which he acknowledged. Shortly thereafter the helicopter turned through approximately 180º, at about 1º/sec, on to a north-easterly track and started to climb. At 1426 hrs, after establishing contact with Newquay Radar, the pilot requested help from the controller, saying he was "LOST IN CLOUD". The pilot was assigned a transponder code which he read back correctly and selected. He then kept the transmit switch pressed resulting in his microphone remaining live. After about 18 seconds of silence, except for background noise, the pilot was heard talking to himself in an apparently distressed state before the transmission ended.

Radar information indicated that the helicopter then descended rapidly before crashing in a field 2 nm south-south-east of Marhamchurch, near Bude, Devon. The pilot was fatally injured in the impact. There was a post-impact fire.

Weather information

It was not possible to determine what weather forecasts the pilot viewed prior to the accident.

The Met Office forecast form F215, period 1400 hrs to 2300 hrs, is shown in Figure 1 below. It predicted that the weather and visibility likely to be encountered in the area west of Okehampton (areas C and C1 in Figure 1) would be 20 km, occasionally 7 km in haze and light



AREA	SURFACE VIS AND WX	CLOUD	0 C
A	30 KM NIL ISOL HILL FG	OCNL SCT CU SC 025-040 / 050 BKN/OVC SC 015-025 / 030-050 **A1** ISOL SCT/BKN ST 010 / 015 **A1** N OF 59 N	080-XXX
B	15 KM NIL/-RA OCNL 7 KM RA ISOL 2000 M +RA/RADZ/(+TSRA **B1**) OCNL ISOL OCNL HILL FG	BKN/OVC CU SC AC AS 015-025 / XXX ISOL EMBD CB 015-025 / XXX **B1** ISOL (AREAS SEA COT) BKN ST 003-008 / 015	090-XXX
C	20 KM NIL OCNL (ISOL E) 7 KM HZ/-DZ ISOL 7 KM RA MAINLY W ISOL (AREAS **C1**) 2000 M BR/DZ OCNL 200 M FG **C1** OCNL HILL FG	AREAS SCT/BKN AC 080 / XXX BKN/OVC SC 015-030 / 050-080 OCNL (ISOL LAN) BKN ST 005-010 / 015 WDSPR BKN/OVC ST 002-005 / 010 ... ... **C1** (BASE 000 FG)	XXX
D	20 KM NIL ISOL 7 KM RA AREAS 2000 M BR ISOL 200 M FG	ISOL SCT/BKN AC 080 / XXX SCT/BKN CU SC 015-030 / 050-070 AREAS SCT/BKN ST 002-007 / 015 ... ... (BASE 000 FG)	XXX

Outlook Until: 250600 Z
ISOL BR OR FG PATCHES FORM OVERLAND IN AREA A, OTHERWISE SIMILAR.

Figure 1

Met Office Form 215 for 24 July 2011

drizzle with isolated visibility of 7 km in moderate rain to the west of the area. There would be isolated areas where visibility of 2,000 m in mist and drizzle could be expected with occasional 200 m visibility in fog in area C1 and occasional hill fog.

It forecast scattered[2] or broken[3] altocumulus with a base of 8,000 ft amsl. Additionally there was likely to be broken or overcast[4] stratocumulus cloud with a base of 1,500 to 3,000 ft amsl, with occasional (isolated over the land) broken stratus base of 500 to 1,000 ft amsl with widespread broken or overcast stratus base 200 to 500 ft amsl. In C1 there was expected to be extensive hill fog at sea level.

An aftercast for the entire route was obtained from the Met Office. It stated that at the time of takeoff the weather conditions were "good" at Aldwick, with neighbouring Bristol Airport reporting visibility in excess of 10 km, few clouds at 1,800 ft amsl and scattered clouds at 4,500 ft amsl.

There was no indication that, as the flight progressed south-west towards Bridgwater, there would have been any significant deterioration in the weather, with no more than small amounts of cloud at 1,500 to 2,000 ft amsl, beneath a more solid layer at 3,000 to 4,000 ft amsl. Exmoor would probably have given a degree of shelter from the moistening north-westerly flow up until the Tiverton area, about 10 nm north of Exeter, so the Met Office considered that there would not have been much deterioration in cloud base or visibility at this point.

As the pilot headed further west towards Okehampton, there was likely to have been an overcast layer at about 2,000 ft amsl. Locally, the terrain rises to a maximum of 823 ft amsl. Below cloud, the pilot would probably have experienced a visibility of between 3,500 m and 7 km at times as a result of occasional drizzle from thickening cloud layers aloft. Hill fog would also have been present.

For the rest of the route, weather conditions are likely to have deteriorated further with extensive low cloud and poor visibility (2,000 to 5,000 m). A lower cloud base of 300 to 500 ft amsl was more probable in the vicinity of the coast between Boscastle and Bude. Hill fog would also have been an increasing hazard.

The wind in the vicinity of the accident site was from a west to north-westerly direction at 10 to 13 kt at the surface and approximately 25 kt at FL040. Given the stable flow, both wind shear and significant gusts are unlikely to have occurred in the area.

The Air Navigation Order (ANO) states that in Class G airspace, a helicopter flying under VFR at or below 3,000 ft amsl shall remain clear of cloud in sight of the surface[5] and in a flight visibility of at least 1,500 m.

Witness information

The helicopter was heard by witnesses above the accident site approximately one minute before the accident. They then saw the helicopter appear out of the cloud in a "steep" nose down attitude at "high speed". After what was described as a possible attempt to recover from the dive the helicopter crashed into a field.

The witnesses described the weather at the time of the accident as "good visibility" below a cloud base of approximately 500 ft agl.

Footnote

2 Scattered cloud coverage is 3 to 4 oktas of cloud.
3 Broken cloud coverage is 5 to 7 oktas of cloud.
4 Overcast cloud coverage is 8 oktas of cloud.

Footnote

5 'In sight of the surface' means the pilot is able to see sufficient surface features or surface illumination to enable him to maintain the helicopter in a desired attitude without reference to any flight instrument.

Pilot's experience

The pilot conducted his helicopter training in the UK and South Africa (SA). He passed a PPL(H) Licence Skills Test (LST) in SA on 3 September 2007 and was issued an ICAO licence in SA. Training for this did not include any instrument appreciation flying[6].

The pilot undertook additional training in the UK, including 6 hours of instrument appreciation flying as required for the issue of a Joint Airworthiness Authorities (JAA) PPL(H). In the JAA LST the pilot is required to fly a Rate 1 (3º/sec) turn on instruments, through 180º. This is to demonstrate that he can safely turn the helicopter around to regain VMC in the event of encountering a Deteriorating Visual Environment (DVE). He passed the JAA LST on 4 September 2010 and applied to the UK CAA for a JAA PPL (H) on 10 September 2010. This was rejected because his SA LST had expired.

The pilot subsequently renewed his LST in SA on 13 September 2010 but had not informed the CAA at the time of the accident.

Medical information

The pilot held a valid JAA Class 2 medical certificate.

A post-mortem examination was conducted by a consultant aviation pathologist. He concluded that the pilot died of multiple injuries consistent with being involved in a high speed impact. Toxicology tests revealed no signs of drugs or alcohol.

Accident site

The helicopter was completely destroyed in the impact and much of the fuselage was consumed by a post-crash fire.

Footnote

[6] During which flight under instruction is conducted by sole reference to flight instruments.

The helicopter wreckage was located in a field and on the adjacent road, in an area of gently sloping terrain at an elevation of approximately 180 ft.

A ground mark measuring 1.6 m x 2.6 m and 0.25 m deep identified the main impact point where the fuselage had struck the ground. Ground marks corresponding to the vertical stabiliser, tail rotor gearbox, tail rotor guard and rotating tail rotor blades were also evident in this location. Immediately to either side of the impact crater were two long narrow ground marks measuring 2.3 m and 1.3 m which corresponded to the position of the left and right landing skid respectively. The left landing skid ground mark was approximately 9 cm deep and the right, approximately 2 cm deep. Two distinctive curved ground marks 0.16 m and 0.21 m deep, forward and to the left of the main impact crater, were consistent with the rotating main rotor blades striking the ground during the impact sequence.

The landing gear skids and hoops separated at impact and were found broken into a number of sections at either side of the wreckage trail. The horizontal and vertical stabiliser assembly separated from the tail boom at impact and were found adjacent to the initial wreckage trail.

After initial impact the wreckage travelled along the ground in a direction of approximately 087º(M). The majority of the wreckage, including the fuselage, engine tail and boom, was found 23 m from the initial impact point.

The main rotor blades were located just inside the eastern boundary of the field, a distance of 78 m from the impact point. Both blades were still attached to the rotor hub, and damage to the blades was consistent with them having struck the ground while rotating with considerable energy. The main rotor gear box and mast had travelled through the boundary hedge and came to rest in the adjacent road, 88 m from the impact point. Fragments of the main rotor blades were found in various locations around the accident site, ahead and behind the initial impact point at distances up to 78 m.

Ground scorching indicated that a post-crash fire had commenced at the initial impact point, with the helicopter battery, found in the impact crater, a likely ignition source. Both the main and auxiliary fuel tanks were found ruptured and located close to the main wreckage. Much of the fuselage structure forward of the engine had been consumed by the fire. Several days after the accident, a number of areas of stained grass could be seen. Such staining typically occurs from aviation fuel, and the size of the stained areas, together with the extent of the ground scorching and evidence of a significant post-crash fire, are consistent with a substantial amount of fuel being in the fuel tanks at the time of the accident.

Power lines which ran through the field in a direction of 073º(M) and at height of 8 m and offset from the impact point by 21.4 m were undamaged.

From examination of the accident site and wreckage, it was determined that just prior to striking the ground the helicopter was travelling with a very high rate of descent and on an approximate heading of 048º(M) in an approximately nose-level attitude. It was banked slightly to the left, such that the left landing skid was low and possibly with a degree of side-slip to the right. There was no evidence of an in-flight break-up and the main rotor blades were rotating with considerable energy. It was concluded that the main rotor blades struck the ground coincident with the impact, causing the helicopter wreckage to pivot around to 087º(M) and the main rotor gearbox, mast and blades to separate from the helicopter.

Aircraft information

The Robinson R44 Raven II is a four-seat helicopter constructed primarily of metal, powered by a single fuel-injected six-cylinder piston engine and equipped with skid type landing gear. It is certified for VFR operations only. The flight controls are actuated by a conventional system of push-pull rods and bellcranks.

Power is transmitted from the engine to the main rotor gearbox by four rubber 'vee-belts', mounted on two sheaves (pulleys). The lower sheave is bolted directly to the engine output shaft. The 'vee-belts' transmit power from the lower sheave to the upper sheave, which in turn transmits power forward to the main rotor and aft to the tail rotor, via a main rotor and tail rotor gearbox. The transmission is engaged and disengaged by means of a clutch, which is operated by a two-position (ENG/DISENG) guarded switch on the instrument panel.

Two fuel tanks, a main tank (120 litres) and an auxiliary tank (70 litres), are located on either side of the fuselage above the engine.

The helicopter was manufactured in 2006 and the last entry in the technical log, dated 19 June 2011, indicated that at that time it had flown for a total of 581 hours. A review of the helicopter's technical records indicated that it possessed a valid Certificate of Airworthiness and had been maintained in accordance with a CAA approved maintenance programme. The most recent maintenance action was an annual inspection carried out on 28 April, at 570 hours. This included, among other items, a mandatory 100-hour repeat inspection of the main rotor blades. The next maintenance inspection due was a 50-hour check on 27 October 2011, or at 620 hours, whichever occurred sooner.

The technical log had not been updated for a month prior to the accident. Consequently, there was no information available relating to recent defects on the helicopter or maintenance items that were being carried forward or deferred at the time of the accident. The exact airframe hours could not be determined.

Detailed wreckage examination

General

Examination of the wreckage revealed that all damage to the airframe and systems had resulted from the impact with the ground, with no evidence to suggest that the helicopter had not been complete and structurally intact prior to the accident.

Control continuity

The continuity and integrity of the collective, cyclic, tail rotor and throttle control linkages were examined in detail. Whilst there was considerable disruption to these control runs, all appeared to have been intact prior to impact, and all damage was consistent with having been sustained during the impact.

Transmission

There was substantial disruption to the transmission system caused by the impact. The main rotor driveshaft was intact up to the forward flexible coupling, where the main rotor gearbox had detached. The tail rotor driveshaft was intact up to the tail rotor gearbox. The four vee-belts were intact and connected to the upper and lower sheaves. Two distinctive gouge marks measuring 6.5 cm and 8.0 cm on the upper sheave indicated that during the impact it had come into contact with the teeth of the starter ring gear, mounted on the aft end of the engine, just forward of the lower sheave. Metal debris corresponding to the material of the upper sheave was found in the teeth of the starter ring gear. The nature of this damage indicated that the starter ring gear was rotating (and that the engine was delivering power) when this damage occurred.

Rotor Blades

The damage to the main rotor blades was consistent with them having struck the ground while rotating with high energy.

Fuel

Both fuel tanks ruptured during the impact and were subject to significant fire damage so it was not possible to obtain a fuel sample from the fuel tanks. However, small samples of fuel were retrieved from the engine fuel injector and a fuel line which ran between the fuel injector and the fuel distribution spider.

Engine examination

The engine sustained damage as a result of the ground impact, most notably to the lower crank case and the accessories mounted at the forward end of the engine, which had also been subject to fire damage. The engine was removed from the wreckage and examined at the AAIB. There was no evidence of any pre-accident failure.

Light bulb analysis

The light bulbs were removed from both the upper and lower instrument consoles and their filaments analysed to determine whether any warning lights were illuminated at the time of impact[7].

Two of the bulbs had been damaged in the impact and it was not possible to analyse the filaments. Of the remaining

Footnote

7 Light bulb filaments are made from tungsten which is brittle when cold and ductile when hot. If the bulb was off (or cold) then the filament will tend to shatter or break when subjected to substantial impact forces. If the bulb was on (or hot) the filament will stretch.

bulbs, a number of the filaments were found to be intact and the remainder were fractured. None of the filaments examined exhibited evidence of stretching or distortion, as would be expected in the case of a hot (illuminated) filament. It can be concluded that either impact loads were insufficient to cause any of the filaments to stretch, or none of the bulbs were illuminated at the time of the impact. Given the severe nature of the impact, it is more likely that none were illuminated.

Instrument Panel

The clutch switch was found in the DISENG position; however, the sprung guard over the switch was open and broken. It was therefore determined that the switch and the sprung guard were disrupted during the impact sequence.

Fuel

General

Three days prior to the accident the pilot had taken delivery of 3,000 litres of 100 LL Avgas, which is used in the Robinson R44. Witnesses reported that on the day before the accident, the pilot refuelled the helicopter and upon carrying out the fuel drain checks, drained a "significant" amount of water from the fuel tanks. Later that day the helicopter was flown on a local flight with no reported problems.

Condensation can form within aircraft fuel tanks, leading to the presence of water in the fuel. As water and particulate contaminants will sink to the bottom of the fuel tank, it is common practice for fuel samples to be taken from each fuel tank drain and the engine fuel drain prior to flight. The samples are visually inspected by the pilot for colour (100 LL Avgas has a blue tint), water content and the presence of any particulates.

The fuel company which supplied the fuel, takes a sample of the fuel loaded in their delivery trailers prior to dispatch. This is examined visually, for colour, brightness and the presence of sediment or water and a fuel density test is carried out. A Certificate of Quality and Conformity is then produced for the fuel and the sample is retained by the company. The company delivers mixed loads of fuel in the same trailers with aviation jet fuel in some compartments and Avgas in others. If a compartment has previously carried a different grade of fuel, before loading the new fuel it is fully drained and then flushed with some fuel of the type being loaded. Examination of fuel delivery records showed that the compartment from which the pilot's delivery of fuel was made had previously contained Avgas.

Fuel storage

The fuel supply for the helicopter was stored in a static bowser at the pilot's private site. The bowser was a rotationally moulded plastic tank, of the type commonly used for the storage of domestic heating fuel, and was equipped with a diesel dispenser pump. The precise history of the fuel bowser could not be determined and it was not clear whether the bowser had been bought new by the pilot for the specific purpose of storing Avgas, or whether it had previously been used for the storage of any other fuels. Neither the bowser nor the fuel hoses were specifically approved for use in an aviation fuel installation. Aviation fuel industry guidance[8] recommends that aviation fuels should be stored in bunded[9] tanks constructed of carbon steel or stainless steel. In addition, the guidance states that hoses used for dispensing aviation fuel should conform

Footnote

8 Joint Inspection Group publication JIG 4, May 2007 – 'Guidelines for aviation fuel quality control and operating procedures for smaller airports'.

9 A bunded tank is a tank within a tank; the liquid is stored in the inner tank and the outer tank serves to contain any leaks or spills from the inner tank.

to BS EN ISO 825:2011[10] which ensures that they are resistant to degradation by aviation fuels, thereby reducing the risk of contamination.

Fuel Analysis

The fuel samples from the fuel delivery vehicle and the pilot's fuel bowser were tested to determine whether they conformed to the industry standard fuel specification[11] for 100 LL Avgas. There was an insufficient quantity of fuel in the two engine samples taken to complete the full specification test, but all the samples were subject to gas chromatography[12] and infrared spectroscopy[13] techniques to evaluate the presence and extent of any contamination.

The bowser sample did not meet the specification requirements for distillation final boiling point and existent gum. Additionally a small amount of water was found in the bowser and fuel delivery vehicle samples. Both engine samples were wholly comprised of fuel with no evidence of water.

The bowser sample and the two engine samples contained contaminants. One of the contaminants was a phthalate ester, and its presence was consistent with the bowser sample failing the existent gum test. Phthalate esters are used as plasticisers[14] and can be extracted from polymeric materials that are in contact with fuel, such as fuel hoses and plastic storage containers.

Footnotes

[10] BS EN ISO 1825:2011 Rubber hoses and hose assemblies for aircraft ground fuelling and de-fuelling specification. Supersedes BS EN 1361.

[11] Defence Standard 91-90/3 for Aviation Gasoline, produced by the UK MOD Aviation Fuels Committee and endorsed by the CAA.

[12] The gas chromatograph identifies the individual components of a substance by separating them into approximate boiling range order.

[13] The infrared spectrometer analyses the chemical composition of substances by passing infrared energy through the substance.

[14] Substances added to plastics to increase their flexibility, transparency, durability, and longevity.

The other contaminant was consistent with a kerosene-type product, such as aviation jet fuel or domestic heating kerosene. As aviation jet fuel and domestic heating kerosene are very similar in composition, it was not possible to determine more specifically the exact nature of the contaminant. The presence of the kerosene based contamination in the bowser sample, estimated to be 2.8 % by volume, was consistent with the failure of the distillation final boiling point test.

A small quantity of kerosene contamination, approximately 0.2 % by volume, was also identified in the sample from the fuel delivery vehicle. It was not possible to determine whether this was as a naturally occurring component in the Avgas or whether it was due to jet fuel contamination, but the sample contained a higher quantity of kerosene material than two unconnected reference samples of Avgas, with which it was compared.

Regulatory guidance for the storage of aviation fuel in general aviation

The subjects of aircraft fuelling and the management of fuel installations at licensed aerodromes are covered under the provisions of Article 217 of the Air Navigation Order (ANO) 2010 and Civil Aviation Publication (CAP) 748 provides guidance on these subjects. In addition CAP 793 *'Safe Operations at unlicensed aerodromes'* contains the following guidance relating to the storage of aviation fuel.

> *'1 Operators of unlicensed aerodromes who also have the facilities to store and dispense AVGAS 100LL, Jet A1 or MOGAS should be aware of the requirements specified in Article 217 of the ANO 2009*[15]*.*

Footnote

[15] The 2009 version of the ANO was current at the time this edition of CAP 793 was published. The ANO has since been updated.

> *2 The storage and dispensing of AVGAS 100LL and MOGAS from an aerodrome requires the operator or owner of the installation to hold the appropriate Petroleum Licence issued by their local Unitary Authority or branch of the Environment Agency. Fuelling procedures and guidance are contained in CAP 748 Aircraft Fuelling and Fuel Installation Management (available via www.caa.co.uk/cap748).*
>
> *3 While primarily aimed at licensed aerodromes, this guidance is also relevant for fuelling arrangements at unlicensed aerodromes.'*

There is no equivalent published guidance for general aviation pilots regarding the storage of aviation fuel at private airstrips or helicopter sites. The technical aspects of fuel installation construction fall outside of the scope of the CAA guidance but are covered by codes of practice supported by the petroleum industry.

Recorded Information

Introduction

Recorded information was available from two radars located at Burrington, a GPS[16] recovered from the helicopter and ground based radio telephony (RTF) recorders.

The Burrington radar site is located approximately 22 nm to the north-east of the accident site. Each radar recorded information once every eight seconds, with a two second offset between the two radars. When the two radar recordings were combined, the helicopter's position and Mode C[17] pressure altitude were available at increments of two and six seconds respectively. The radar record commenced as the helicopter passed to the south of Bridgwater, Somerset, and ended shortly before the helicopter crashed. The GPS contained a track log of the flight, with GPS-derived position, track, altitude and groundspeed recorded at a nominal rate of once every thirty seconds. The GPS track log commenced as the helicopter departed the pilot's private site, and ended 26 seconds before the final radar point was recorded. There was a close correlation between the radar and GPS information, confirming the accuracy of the radar information. RTF records were available at various stages throughout the flight, including a radio transmission from the pilot shortly before the helicopter crashed.

Interpretation

All altitudes are above mean sea level (amsl) unless stated otherwise.

The first GPS data point was recorded at 1320:56 hrs as the helicopter took off from the pilot's private site (refer to Figure 2 and Figure 3).

Approaching Okehampton, the helicopter momentarily climbed from 1,300 ft to about 1,900 ft (Figure 3 – Point A), whilst also altering track by about 10°, from 253°(M) to 263° (deviating from a direct track to the town of Padstow), but as it passed to the north of Okehampton, it started to descend progressively. When the helicopter was at about 11 nm west of Okehampton it levelled off at about 950 ft (approximately 500 ft

Footnote

[16] Honeywell manufactured Skymap IIIC.

[17] When interrogated by ATC radar, the aircraft transponder transmits the aircrafts pressure altitude, quantised to the nearest 100 ft increment. This data is referred to as Mode C. The pressure altitude is based on the International Standard Atmosphere (ISA) that assumes a barometric pressure of 1013.25 hPa at sea level. The ATC radar system corrects the pressure altitude so that altitude is displayed on the controller's display.

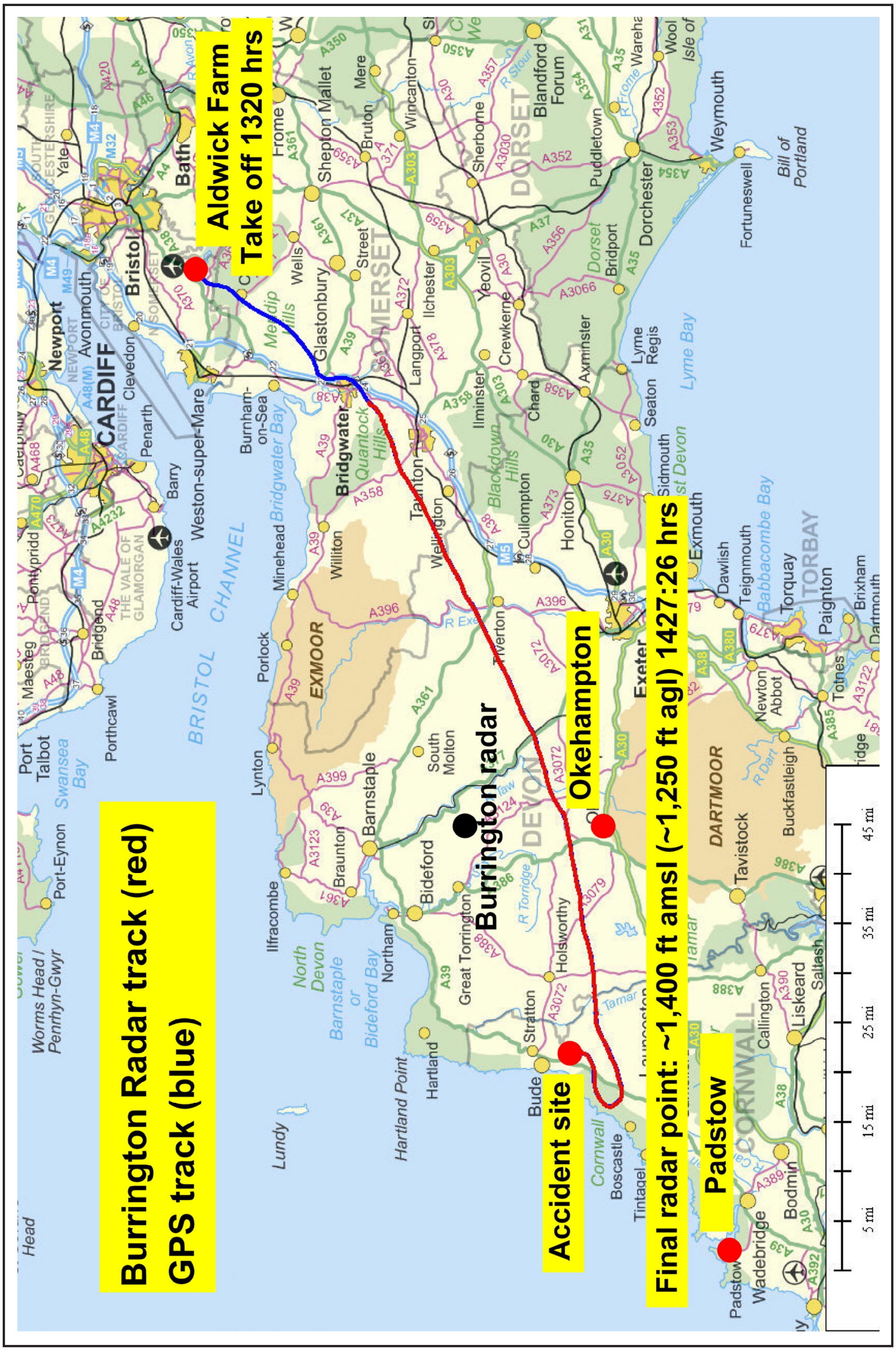


Figure 2

G-ROTG - GPS and Radar flight track

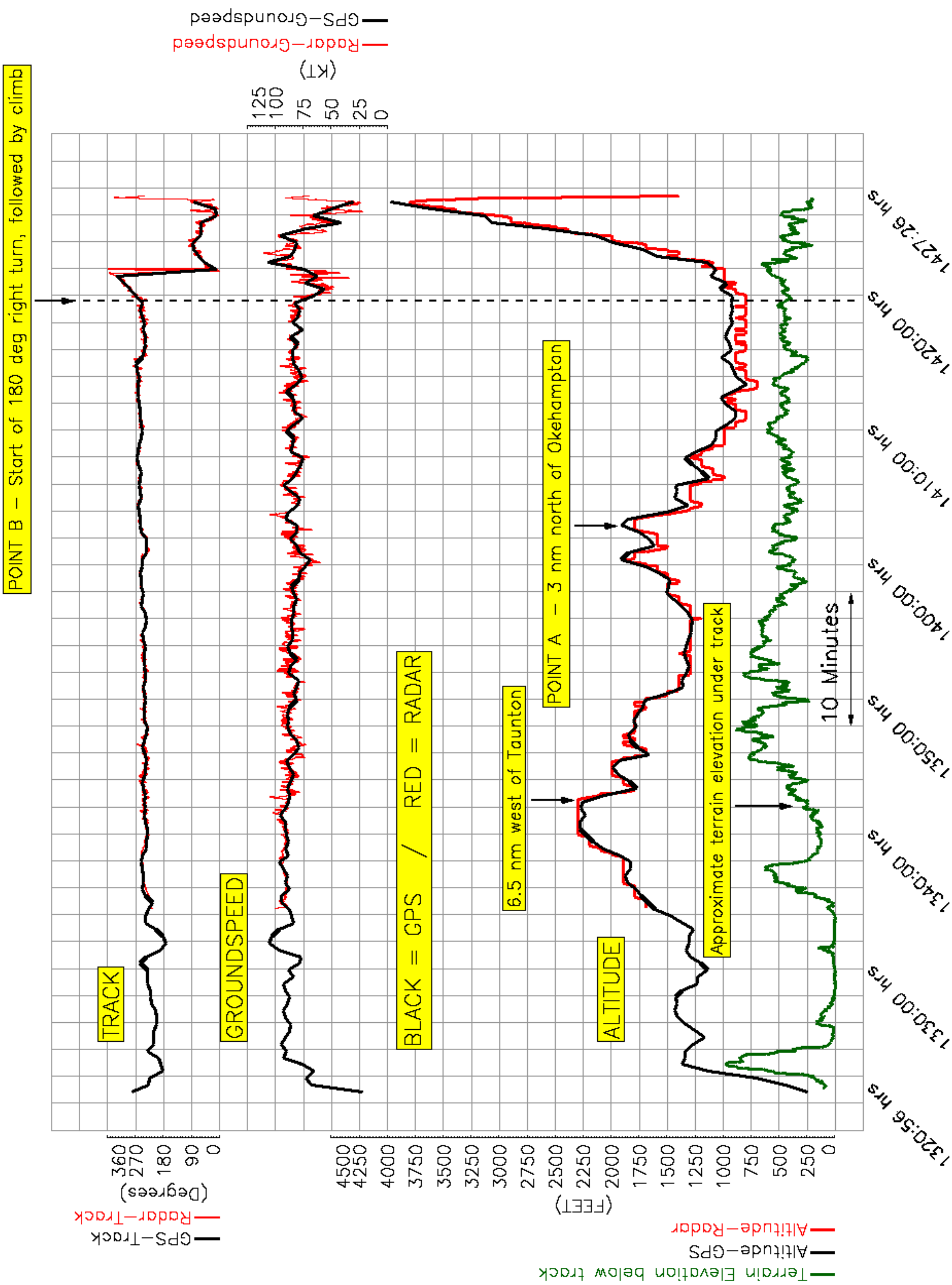


Figure 3

G-ROTG - GPS and Radar altitude profile

agl). At 1415 hrs, the helicopter made a left turn to track 245°, establishing a track towards the north of Padstow by about 9 nm.

At 1418 hrs, the pilot was instructed to 'free call' Newquay Approach, which he acknowledged. The helicopter was 24 nm to the north-east of Newquay, 18 nm to the north-east of Padstow and 6 nm to the south of Bude at the time. At about the same time, the helicopter altered track slightly to 253°. It then continued on track for about a further two minutes, at altitudes of between approximately 800 ft and 1,000 ft, and at heights as low as about 400 ft agl before making a gradual 180° right turn (Figure 3 – Point B) at about 1º/sec. During the turn, the helicopter maintained an altitude of about 1,000 ft (approximately 500 ft agl), but, as the turn was being completed, the helicopter started to climb at about 600 ft/min, although it was not in close proximity to terrain or obstacles that would have required it to climb.

At 1426:20 hrs, about four minutes after having turned back towards the north-east and eight minutes after having being advised to contact Newquay Approach, the pilot established communications with Newquay. Following his initial introductory call, which appeared normal, he advised the approach controller "GOT MYSELF INTO A BIT OF DIFFUCULTY HERE AND AT PRESENTLY THREE THOUSAND TWO HUNDRED FEET….. AND UH GOT LOST IN CLOUD, AM CLIMBING AND UH CAN YOU GIVE ME SOME HELP HERE PLEASE, TANGO GOLF". The controller acknowledged the pilot's request and advised him to select the transponder code (squawk) one seven five zero, to assist in identifying the helicopter on radar. The helicopter continued to climb and four seconds later, at 1426:48 hrs, the pilot acknowledged the squawk code. The helicopter was now at about 3,800 ft on a track of approximately 040º and its groundspeed had reduced to about 30 kt. Based on a westerly to north-westerly wind of 25 kt at FL040, the IAS of the helicopter would have been between approximately 7 kt to 15 kt at this time.

After confirming the squawk code the pilot continued to depress the radio transmit button for the next 36 seconds. During the later stages of the transmission, the pilot was heard to say "WHAT AM I DOING". Shortly afterwards, the helicopter started to descend rapidly. The final radar point was recorded at 1427:26 hrs, which coincided with the end of the pilot's radio transmission. The helicopter was then at about 1,400 ft (1,250 ft agl) and positioned laterally about 130 m south-west of where the initial ground impact occurred. In the following seconds the approach controller and another pilot on the same frequency attempted to provide advice to the pilot, but there was no further radio contact from G-ROTG.

During the final 14 seconds of radar information, the helicopter's altitude reduced from 3,500 ft to 1,400 ft, equating to a mean vertical speed of about 9,000 ft/min. Analysis of the four radar points recorded during this period indicated that the helicopter's vertical speed had been increasing as it descended, with incremental mean vertical speeds of 4,000 ft/min (40 kt), 9,000 ft/min (89 kt) and finally 14,000 ft/min (138 kt). The radar also indicated that the helicopter may have entered a left turn whilst it descended, and its groundspeed may have reached a maximum of about 90 kt, although due to the nominal accuracy of radar this cannot be confirmed.

RTF Analysis

The Robinson R44, Raven II is equipped with a low rotor speed warning system, which includes a warning light on the instrument panel and a horn. If the main rotor rpm drops to 97 % or below, and the collective is not in the fully down position, the horn emits a tone of between 800 Hz and 1,000 Hz and the light illuminates. The amplitude of the tone is such that it is intended to be audible above the normal operating noise of the helicopter when headsets are worn.

The warning horn from G-ROTG was tested and found to operate correctly, generating a tone of just greater than 800 Hz. Frequency spectral analysis of the final RTF transmission did not identify the presence of the warning horn having been activated.

To establish that the sound generated by the low rotor speed warning horn could be recorded as part of a radio transmission, a series of audio tests were conducted using a helicopter of the same type as G-ROTG. The pilot's headset microphone was positioned normally throughout the tests and both verbal and open microphone (non-verbal) radio transmissions were made, simulating the characteristics of the final radio transmission from G-ROTG. Analysis of the ground based RTF recordings established that the sound generated by the low rotor speed warning horn was present during all the tests, which included a simulated loss of engine power during flight.

When a pilot speaks into the headset microphone, background sounds such as those generated by the engine are attenuated due to the noise cancelling design of the microphone. However, during an open microphone transmission, background sounds may be readily recorded. The initial 18 seconds of the final radio transmission consisted of an open microphone transmission. Frequency spectral analysis identified that during this period, sounds were present that corresponded mathematically to the operation of the engine, main rotor gearbox and main rotor. It indicated that the engine was operating at about 2,760 rpm (103 %), with the speed of the main gearbox (which is driven by the engine) and speed of the main rotor being consistent with that of the engine rpm. During the final 18 seconds of the radio transmission, background sounds were masked by the voice of the pilot talking, apparently to himself. During the radio transmission the pilot did not mention a problem with the helicopter's controls or engine.

Evaluation flight

During the investigation a helicopter similar to G-ROTG was flown to assess rates of descent resulting from various combinations of power and indicated airspeed. The results are shown below.

IAS (kt)	Power setting	Average Rate of descent from altimeter (feet/min)
70	IDLE	1,500
130	FULL power	3,000
130	Descent power	4,000

Helicopter accident data analysis 2000-2010

From 2000 to 2010 there were 276 reportable accidents involving small helicopters[18] in the UK and UK registered helicopters in Ireland, of which 27 were fatal. Of these, 16, nearly 60%, were attributed to the pilots encountering DVE.

While helicopters have the ability to slow down, turn around or 'land out', there seems to be reluctance for pilots to make the decision in a timely manner to do either of these. A pilot's ability to make a suitable decision to avoid DVE may decrease as the situation deteriorates and result in the helicopter unintentionally entering IMC.

Footnote

[18] Small helicopters are those of 3,175 kg All Up Mass or less, irrespective of the number or type of engine, or number of seats.

The CAA intends to publish a new AIC to be read in conjunction with AIC 100/2007 (Pink 129), *'Helicopter flight in degraded visual conditions'*, advising helicopter pilots that a precautionary landing in a helicopter is a legitimate exercise and well suited to its capabilities. It will also emphasise that making a precautionary landing should always be considered a viable option, preferable to continuing on into DVE.

Analysis

Engineering

Examination of the accident site and wreckage indicated that the helicopter was structurally intact and functioning normally prior to the accident. The ground marks and presence of undamaged power lines in close proximity to the initial impact point, indicate that the flight trajectory was predominantly vertical at the point of impact. Evidence from the examination of the engine and the transmission components, and in particular the main rotor blade strikes, indicated that the engine was delivering significant power at the time of the accident. Spectral analysis of RTF did not reveal abnormalities.

Fuel

An aircraft engine is designed to operate most efficiently on a specific type of fuel conforming to pre-determined specifications. The use of fuel that deviates from these specifications can reduce operating efficiency and, under some conditions, can cause complete engine failure. Although the investigation determined the presence of contamination in the fuel supply for G-ROTG, there was no evidence that engine operation had been significantly compromised. The investigation concluded that the plasticiser contamination was probably a result of the conditions in which the fuel was stored and dispensed. Neither the bowser nor the dispensing hoses at the pilot's private site were approved for use with aviation fuel.

The investigation was not able to determine the source of the kerosene-based contaminant in the Avgas supply.

Published guidance exists relating to ensuring fuel quality and the provision of adequate fuel storage facilities at licensed and unlicensed aerodromes, but this guidance is aimed at aerodrome operators and fuel suppliers. While the contamination identified in G-ROTG's fuel supply did not influence the outcome of this accident, the investigation identified issues relating to fuel quality and storage. There is no relevant guidance specifically aimed at general aviation pilots operating from private airstrips or helicopter sites. Therefore the following Safety Recommendation is made:

Safety Recommendation 2012-009

It is recommended that the Civil Aviation Authority publish guidance to General Aviation pilots regarding the quality and storage of fuel for use in aircraft.

Conduct of the flight

The forecast and aftercast for the route flown by the helicopter indicated that the weather was likely to have been marginal for flight under VFR west of Okehampton, due to the low cloud and hill fog.

The helicopter's altitude gradually reduced as it progressed west of Okehampton. This is consistent with the pilot trying to stay clear of cloud as cloud base and in-flight visibility reduced.

The helicopter turned through approximately 180º and then started climbing. This was probably an attempt by the pilot to turn around to find better weather conditions, a manoeuvre he would have been required to demonstrated on the JAA PPL(H) LST. This turn was flown at about 1º/sec rather than the 3º/sec required for the LST. This indicated that, while the pilot was doing as he was taught, he was doing so very cautiously. This could be another indication of the poor flight conditions. Initially, the climb may have been inadvertent. Having climbed into a low cloud base during the turn, or if encountering very poor visibility upon rolling out, the pilot may then have decided to continue climbing.

As the helicopter climbed its ground speed decreased from about 105 kt to approximately 55 kt. At about 3,800 ft amsl, immediately before the helicopter started its final high rate of descent, its groundspeed was approximately 30 kt. As the wind at FL040 was predicted to have been from the west to north-west at about 25 kt, the IAS of the helicopter was likely to have been less than 15 kt, which would have made it very difficult to control in VMC or IMC.

Such a situation is likely to require much of a pilot's effort to control the helicopter, leaving insufficient capacity to plan for a safe outcome.

The maximum rate of descent achieved during the descents in the evaluation flight was approximately 4,000 ft/min. The maximum rate of descent recorded by the radar and GPS during the final seconds of the accident flight was approximately 14,000 ft/min. This, together with the pilot's transmission "WHAT AM I DOING", suggests that he had become spatially disorientated and had lost control of the helicopter.

Ground marks at the accident site indicated that the helicopter impacted the ground in an approximately level attitude. This, in addition to witnesses' testimonies, suggests that the pilot may have attempted to regain control of the helicopter upon regaining visual references. However, given the high rate of descent and the small amount of height available below the cloud, it is unlikely that any control inputs at this stage would have arrested the high rate of descent in time to avoid impacting the ground.

Conclusion

The pilot of G-ROTG encountered DVE and subsequently climbed in cloud to nearly 4,000 ft amsl. It is likely that he become spatially disorientated before losing control of the helicopter, which entered a very high rate of descent from which it did not recover. No mechanical fault was found with the helicopter.