ACCIDENT

Aircraft Type and Registration:	Piper PA-28R-200 Cherokee Arrow II, G-BKFZ
No & Type of Engines:	1 Lycoming IO-360-C1C piston engine
Year of Manufacture:	1976
Date & Time (UTC):	13 February 2008 at 1535 hrs
Location:	North-eastern edge of Rutland Water, near Empingham, Leicestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	85 years
Commander's Flying Experience:	972 hours (of which 850 were on type) Last 90 days - 2 hours Last 28 days - 0 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft had departed from Spanhoe Airfield to return to its home base, Shacklewell Lodge, 6 nm to the north-east of Spanhoe. The sky was clear after takeoff but there was an area of very low cloud with mist and fog moving in from the east. The aircraft climbed to 1,200 ft above a cloud layer and the pilot contacted RAF Cottesmore to request their cloudbase. The Cottesmore controller reported that the last observation was 'sky clear' with a visibility of 5,000 m in haze. The pilot acknowledged this information but made no further transmissions.

The aircraft crashed in a park on the north-eastern edge of Rutland Water, where it had struck a pair of trees at a speed in excess of 110 kt, whilst in an approximate 20° bank to the left. Witnesses to the accident described the weather at the time as foggy. The reason for the aircraft's descent into foggy conditions could not be clearly established.

History of the flight

Following maintenance at Spanhoe Airfield, the pilot intended to fly the aircraft back to its base at Shacklewell Lodge, just to the east of Rutland Water. He and his wife were aware of fog in the wider area, so he telephoned the engineer at Spanhoe, who told him that the weather there was clear. The pilot and his wife set off by car from their home, some six miles north-east of Shacklewell, to check the weather at the airfield, before continuing to Spanhoe. The pilot's wife was then to drive the car from Spanhoe to Shacklewell to collect her husband after the flight.

After arriving at Spanhoe, the pilot, in discussion with others there spoke about the possibility of poor weather. Consequently, he informed his wife that if he could not land at Shacklewell, he would return to Spanhoe. The pilot fitted his portable Global Positioning System (GPS) receiver to the aircraft, completed his pre-flight checks and prepared for departure, whilst his wife cleaned the aircraft's windscreen. At about 1515 hrs, he boarded the aircraft, started the engine, and taxied for departure.

The aircraft took off from Runway 27 at 1527 hrs, and made a right turn towards the eastern end of Rutland Water.

At about 1529 hrs, the pilot contacted the approach controller at RAF Cottesmore, stating that he was at 1,200 ft, just above a cloud layer; he requested clearance through the Military Aerodrome Traffic Zone (MATZ) at RAF Wittering. The controller informed the pilot that he was receiving a Flight Information Service, that he was cleared through the Wittering MATZ and that he should report on final approach at Shacklewell. A few moments later, the pilot requested the QFE at Wittering. The controller informed the pilot that Wittering was closed, and that the Cottesmore QFE was 1,019 mb[1]. The pilot then asked the controller for the cloud base at Cottesmore, and the controller replied "REPORTED AT ER FIFTEEN HUNDRED WE'VE GOT VISIBILITY OF FIVE THOUSAND METRES IN HAZE CLOUD ER CLEAR SKY CLEAR". The pilot acknowledged this information.

A few moments later, the controller requested the pilot to confirm that he was now on the ground at Shacklewell, but received no reply. Despite repeated attempts by the controller to contact the aircraft, no further transmissions were received. Very soon afterwards, a Police helicopter pilot contacted the controller, stating that he was en-route to a possible aircraft crash at Rutland Water. Almost immediately afterwards, an air ambulance helicopter pilot also contacted the controller with similar information. The controller then suspected that G-BKFZ had crashed.

Although both helicopter pilots made attempts to reach the accident site, by descending at the edge of the fog bank which covered the area, neither was able to penetrate the thick fog.

Witness information

A number of people were walking in the area of Rutland Water at the time of the accident. They described that the earlier clear and sunny weather had been replaced, suddenly, by very foggy conditions[2].

One witness recalled hearing the sound of a light aircraft, stating that it "sounded like the noise a plane would make if it was diving… there were no breaks in the noise, it was constant". Another stated that "one moment the engine noise was fine and then it faltered and then it was fine again as if it was cutting out and starting up again". Other witnesses gave varying accounts of normal engine noise, or engine noise which they believed was indicative of an aircraft in difficulties. Soon after they first heard the aircraft, some witnesses close to the accident site saw an aircraft emerge from the fog, flying low in a shallow descent, collide with trees and break up.

Footnote

1 RAF Cottesmore is approximately 5 nm NNW of Shacklewell Lodge.

2 See 'Meteorological Information'.

The pilot sustained fatal injuries in the impact.

Information concerning the flight from takeoff until witnesses heard and saw the subsequent accident at Rutland Water, consisted of the RTF recordings from RAF Cottesmore and data downloaded from the pilot's GPS receiver.

Pilot's history

The pilot obtained a Private Pilot's Licence (PPL) with a Single-Engine Piston (SEP) rating in 1984, to which he added an Instrument Meteorological Conditions (IMC) rating in 1988. He last revalidated his IMC rating in December 1994, which expired in January 1997, and completed a 'Biennial Test' in October 2007 to revalidate his SEP rating. His log book showed a total of 68 hrs instrument flight, the last such flight being logged in August 2004.

The pilot had been a co-owner of G-BKFZ for many years and flew regularly, touring in Great Britain and Europe. Throughout this time, the aircraft was based at Shacklewell Lodge and the pilot knew the area and its topography well.

Aircraft information

G-BKFZ was a Piper PA-28R-200, Figure 1, an all-metal low-wing aircraft, powered by a Lycoming IO-360-C1C piston engine driving a three-bladed variable-pitch Hartzell propeller. It was of conventional design with mechanical flying controls, retractable tricycle landing gear and with a wingspan of 9.81 m. At the time of the accident, G-BKFZ had accumulated 3,110 hours flying time, with the engine and propeller 977 hours and 1.5 hours respectively.

Figure 1

PA-28R-200, G-BKFZ, with a two-bladed propeller fitted

The PA-28R-200 consumes, on average, about 9 to 10 US-gallons per hour in normal low altitude cruising flight. The pilot's operating handbook (POH) specifies that the speed to be flown, following engine failure, is 100 mph (87 kt).

Fuel

Before its departure, the maintenance engineer at Spanhoe, who had carried out the work on the aircraft, assessed that both tanks were approximately ¼ full, giving a total fuel on board of about 10 USG. This total amount accorded with various records, taking into account fuel that was taken from the aircraft by the engineer for a variety of cleaning tasks during its maintenance. The distribution of fuel between the left and right tanks, however, could not be confirmed from the records.

Meteorology

An aftercast provided by the Met Office stated:

'In summary, the accident appears to have occurred on the boundary between clear skies with haze/mist to the west; and very poor low cloud conditions with mist, fog and hill fog to

the east', and that 'Visibility associated with the low cloud is reported as being in the range 100 M to 2500 M. Visibility associated with cloud free conditions is likely to have ranged from 2500 M to 8 KM'.

The temperature on the ground was around 7°C, 8°C at 2,000 ft, and there was colder air around 1,000 ft where the temperature was 4°C. As these temperatures were all positive, airframe icing was unlikely to have affected the aircraft. The mean sea level pressure in the region at the time of the accident was 1036 mb. The wind at 500 ft was estimated at 060°/11 kt.

The police helicopter pilot gave an account of the conditions he met while attempting to reach the accident site. He stated that "approaching the Manton area[3]… conditions were clear" but that when he flew directly over the accident site, the ground could not be seen. He flew back to the edge of the fog and descended, intending to continue the flight in visual contact with the ground. However, the visibility in the fog was so poor that this was not possible. He commented that the top of the fog was between 500 ft and 700 ft above ground level, and that the fog bank was spreading slowly south-west all the time. The air ambulance helicopter pilot gave a very similar account of his flight and the conditions he encountered, noting too that near the accident site "the fog was completely on the ground with visibility less than 100 metres".

The Met Office provided a high resolution visible cloud satellite image taken at 1530 hrs on the day of the accident, Figure 2. It clearly showed the area of fog across eastern England and the North Sea. The accident site, marked with a red X was between RAF Cottesmore and RAF Wittering.

A hot air balloon passed to the south of Rutland Water about half an hour before the accident. The pilot took a picture of the water which showed, at that time, the accident site was covered by an area of low cloud or fog, but with the boundary between the fog and clearer conditions a short distance to the west.

A private pilot, who lived just north-west of Shacklewell, was at home listening to RTF transmissions using an air-band radio. He later recalled that, shortly after 1500 hrs, the weather changed dramatically, with clear and sunny weather giving way within 15 to 20 min, to dense fog, with a visibility estimated at between 150 m and 200 m. Other witnesses in the area also described the conditions changing from clear with bright sunshine, to dense fog.

Recorded information

The hand-held GPS receiver fitted to the aircraft by the pilot before the flight, was powered throughout the flight and had recorded time, position, groundspeed, heading and GPS altitude, every 30 seconds. This device suffered minor damage during the accident but was successfully downloaded by the AAIB.

The GPS logging function was set up such that position recording for each new flight commenced once the groundspeed exceeded 20 kt. This first recorded position located the aircraft at the eastern end of Spanhoe Runway 27 at 1527:27 hrs. Eight further track points were recorded as illustrated in Figure 3.

Footnote

3 Immediately south of the south-western tip of Rutland Water.

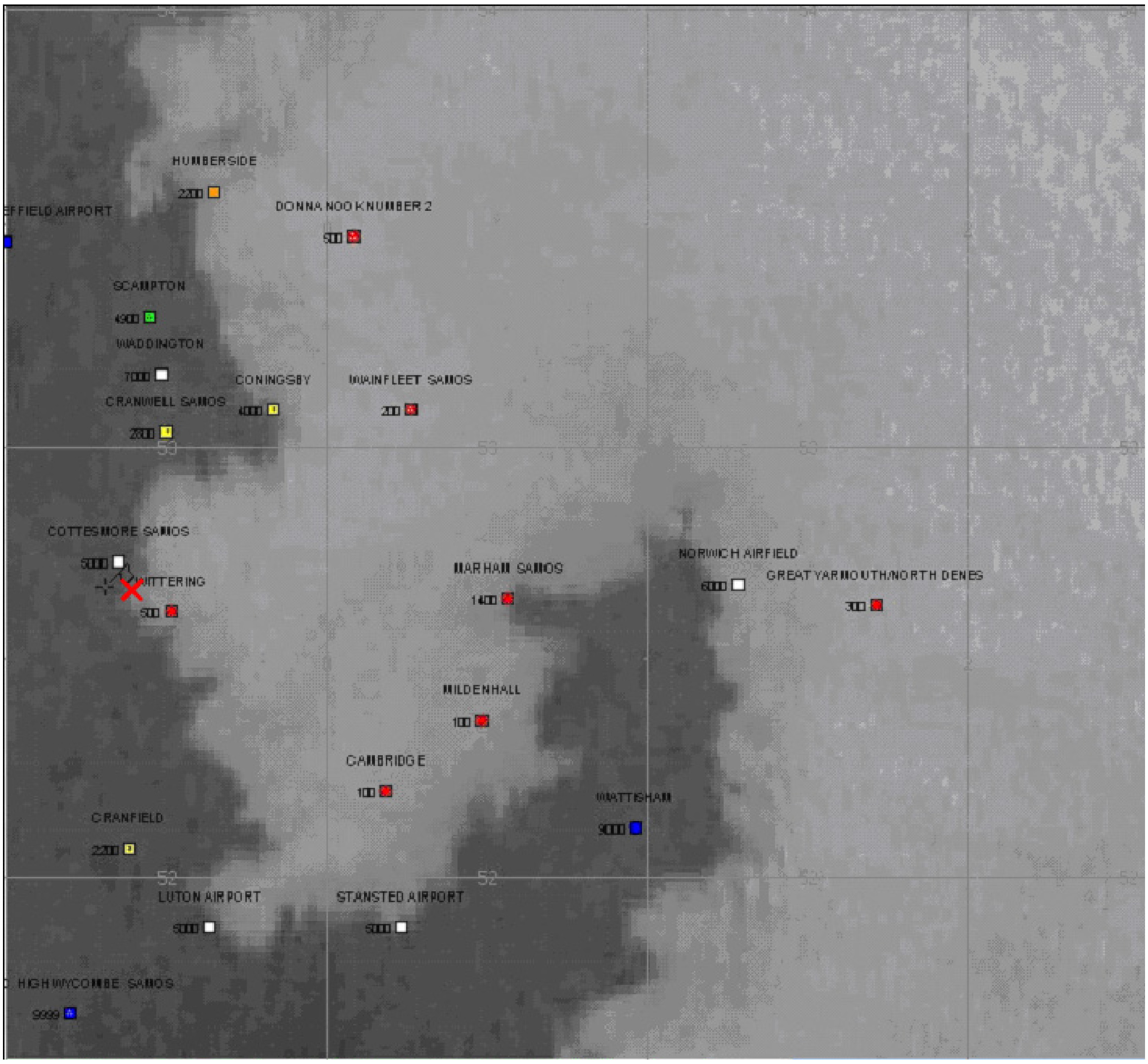


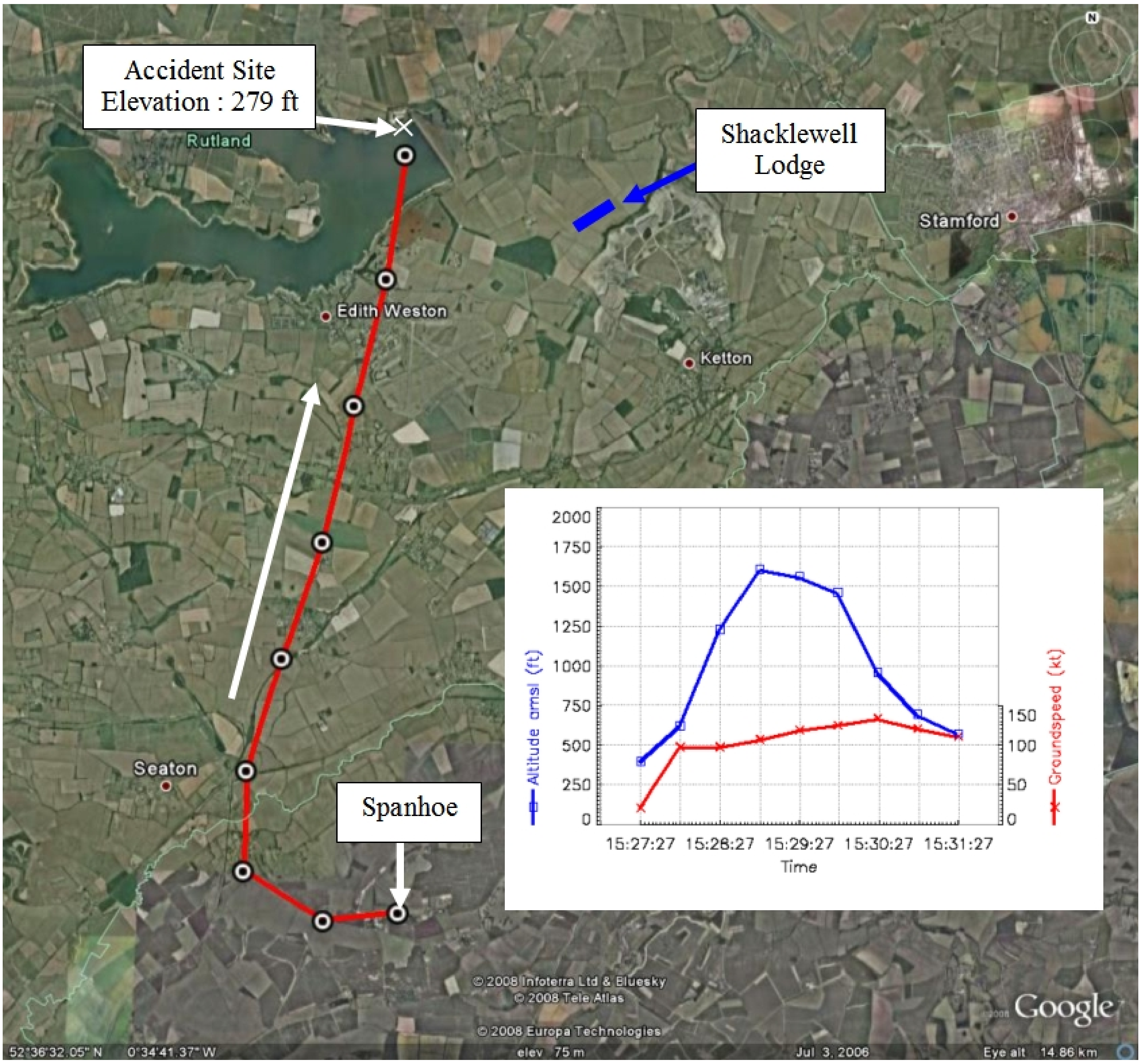
Figure 2

Visible cloud satellite image taken at 1530 hrs on 13 February 2008, five minutes before the accident. The approximate location of the accident site is marked X

The recorded GPS altitude was based on the WGS84 coordinate system. This was converted to altitude above mean sea level (amsl) which showed a GPS altitude at Spanhoe of 394 ft amsl. The eastern end of Spanhoe's Runway 27 is at an elevation of around 344 ft. This suggests that the recorded GPS altitude was in error by around 50 ft at the start of the flight.

GPS altitude can be subject to substantial error and is typically less accurate than altitudes derived by barometric means. This error can arise from a number of sources, including the number of satellites in view of the receiver, satellite orientation and operability, and the GPS approximation of the geodetic model of the earth. The 50 ft inaccuracy at Spanhoe is not unusual and it is likely that all the other recorded GPS altitudes were subject to an error of this magnitude. Horizontal GPS position is usually subject to less error.

After departing Spanhoe, G-BKFZ climbed, turned to the right and headed towards the eastern shore of Rutland Water. The maximum altitude achieved was



(Google Earth ™ mapping service/Infoterra Ltd & Bluesky / Teleatlas / Europa Technologies)

Figure 3

G-BKFZ ground track and altitude from GPS data

1,607 ft amsl, after which a descent commenced of about 150 ft/min which lasted for about one minute. Thereafter, it increased to about 1,000 ft/min. Between the penultimate and final GPS recorded position, the aircraft descended from 696 ft to 572 ft in 31 seconds; a descent rate of 240 ft/min. The total distance covered between these positions was 1 nm, which suggests a descent slope of around 1:50.

The final recorded position of the aircraft was at 1531:27 hrs, at an altitude of 572 ft amsl, at an instantaneous groundspeed of 111 kt and an instantaneous track of 000°. Using the 500 ft aftercast wind of 060° at 11 kt, this represented an airspeed of around 117 kt. This position was approximately 440 m from the accident site where the terrain elevation was 279 ft. Extrapolating from the last GPS point to the accident site gives a final average descent slope of about 1:5 and an approximate final average vertical speed of 2,300 ft/min down. However, it should be emphasised that, due to the inherent inaccuracies associated with GPS altitudes and the 30 second period between data points, the calculated values quoted above for vertical speeds and descent ratios should be treated as very approximate values.

Accident site examination

The accident site was located among trees in a park on the north-eastern edge of Rutland Water and was 279 ft amsl. The aircraft's initial impact was with two trees, 6.6 m apart, whilst in a bank to the left of approximately 20° and about 12 ft above the ground, Figure 4. The impact removed the aircraft's left and right wing outer sections; it continued and struck the ground 15.5 m from the trees whilst on a track of 342°(M). The aircraft's final trajectory from the trees to the ground was calculated at between 10° and 14° below the horizon[4]. After striking the ground, the fuselage bounced and hit another tree head-on, causing the aircraft to break up into multiple sections. The furthest item of wreckage was the battery, which had travelled 127 m from the initial impact point. There were three propeller slash marks at the ground impact point spaced 40 cm apart.

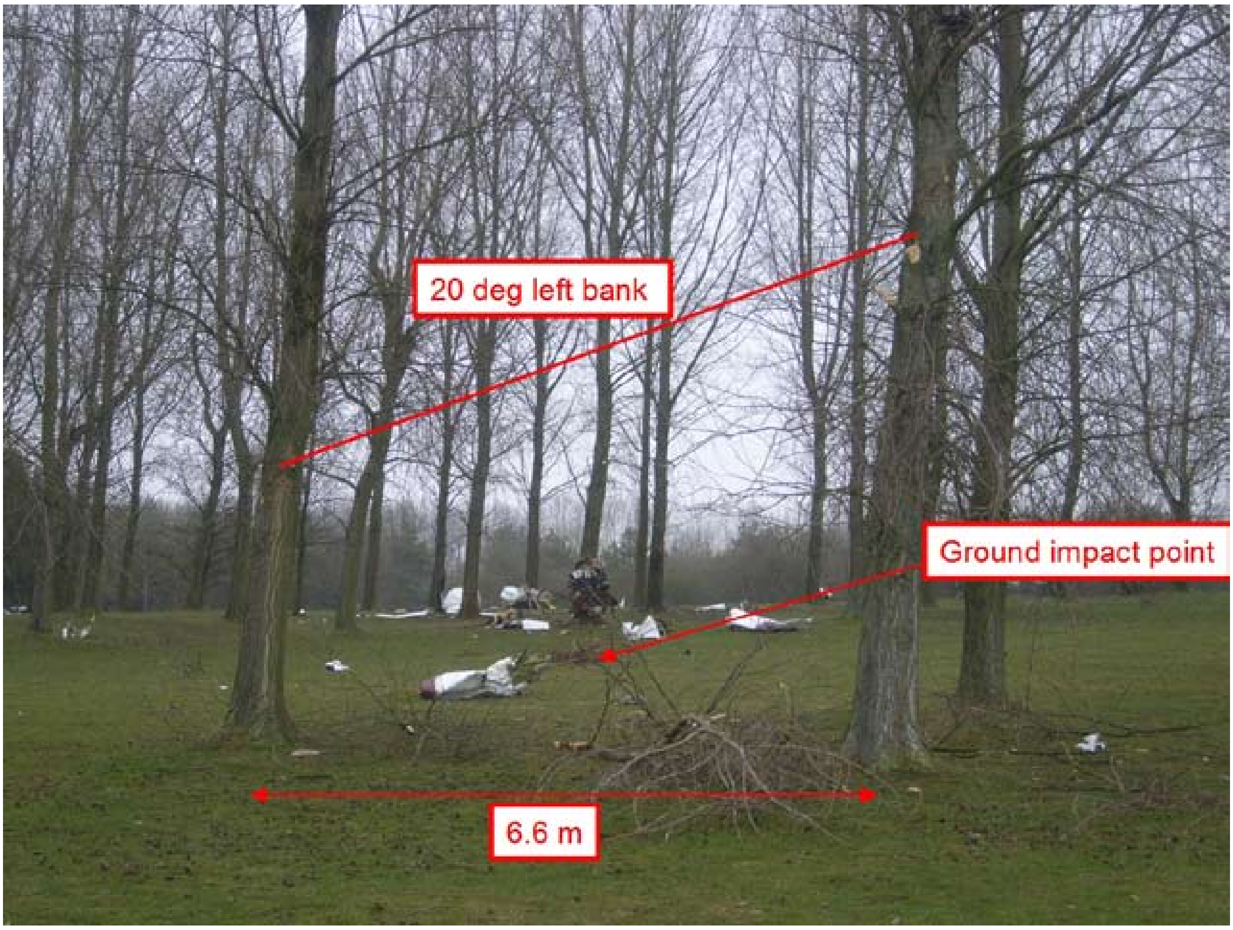


Figure 4

Accident site, viewed in the direction of flight, showing initial impact with trees and ground impact point

Footnote

[4] It was considered unlikely that the tree impact altered the aircraft's trajectory significantly.

Initial wreckage examination

The main and nose landing gear legs were found in their retracted positions. The right inboard wing had separated from the fuselage at the spar join, and the right wing fuel tank had ruptured; only a small amount of fuel was found in this tank. The left inboard wing was attached to the remaining section of centre fuselage, and the lower skin of the wing fuel tank had split; no fuel was found in this tank. Samples of soil from beneath both fuel tanks were tested for contamination by fuel, but the results were inconclusive.

The engine had separated from its mounts and had tumbled along the ground. The three propeller blades had leading edge indentations and chord-wise scratches near their tips.

All the major aircraft structural components were accounted for and no evidence was seen of any pre-impact failures. Following the on-site examination, the aircraft wreckage was recovered to the AAIB's facility at Farnborough for a more detailed examination.

Detailed wreckage examination

Flight controls

The roll controls on this aircraft type consist of two interconnected control wheels that are linked to the ailerons through a series of torque tubes, sprockets, chains, control cables/pulleys and bellcranks. Pitch control is effected by an all-moving stabilator, connected to the control wheels through a series of cables/pulleys and push-pull rods. Numerous separations were present within both of these control systems, but all were attributable to overload failures consistent with the break-up of the airframe. No evidence was seen of any pre-impact disconnection(s). The stabilator trim jack screw was found in a position corresponding to full nose-down trim. However, as the controlling cables had failed in overload, it would be typical that one cable would have failed before the other, causing the screw to be driven to one extreme of its travel. The rudder control cables were connected at both ends but had also failed in overload, consistent with occurring during the airframe break-up. The flap lever was found in the flaps fully down position but the lever had been bent in that direction and did not represent a reliable pre-impact position. No other evidence was found of the position of the flaps at the time of impact.

Instruments

The flight and engine instruments had all suffered damage and many of the instrument faces had separated from their casings. The instrument faces were examined for witness marks of any needle positions at the time of impact; no reliable marks were found. The main altimeter subscale indicated a pressure setting of 1018 mb, the standby altimeter setting was 1024 mb. Both altimeters had suffered impact damage and could not be tested. The Horizontal Situation Indicator (HSI) was intact and indicated 320° with the heading bug set to 040°. The Attitude Indicator's face and casing were damaged, although most internal components were undamaged. The casing that surrounded the gyroscope rotor had evidence of rotational scoring, and the rotor spun up and the instrument self-erected when compressed air was applied to the device.

Some of the warning and indication light bulbs were recovered intact and were examined under a microscope to determine if any lights were illuminated at the time of impact. The bulb for the '*Gear in Transit*' light and the bulb for the gear '*Auto Ext Off*' light both had clear indications of stretched filaments, and were therefore probably illuminated at impact. The bulb filament from the oil low pressure warning light had not stretched and was, therefore, probably off at impact. The bulb filament for the Alternator ('*Alt*') warning light had a minor amount of stretch, but this was insufficient to draw a firm conclusion on its status at impact. The '*Gear Unsafe*' light and the '*Right Gear*' down-and-locked light were determined to have been off at impact. No other bulbs were recovered.

Fuel System

No fuel was recovered from the empty left tank which had split, and a small amount of fuel remaining in the ruptured right tank was lost when the wing was lifted. However, a small sample of fuel was recovered from the engine-driven pump and this was tested and found to conform to the properties of AVGAS 100LL; there was no evidence of contamination. The fuel tank selector was found set to the right tank and the fuel filler cap seals were in satisfactory condition.

The engine-driven fuel pump had split in to two pieces and could not be tested, but the drive pin had not sheared which indicated that the pump had not seized in flight. The electric fuel boost pump was connected to a 14 VDC power source, but did not operate. The pump was separated from the motor and the motor was re-connected to the power source, but it still did not operate. The motor case was opened up, which revealed a warped washer around the bearing and a build-up of dust. There was some friction when rotating the motor by hand but it did not appear excessive. When the motor was re-assembled and connected to the power source, the motor operated normally. No fault could be found that would explain why the motor did not originally operate, as it was considered that the warped washer would not have prevented rotation. The pump had suffered significant impact damage, and although it could be rotated by hand, the motor had insufficient torque to turn it.

The fuel lines from the fuel tanks to the fuel selector were continuous apart from a separation at the right wing-to-body join. In this separated location, where the centre fuselage fuel pipe joined the right wing fuel pipe, it was apparent that a repair had been made, Figure 5. The two plain-ended pipes had been connected with a 12 cm long rubber hose held in place with a single jubilee clip at each end. According to the aircraft manufacturer, this was not an approved method of repair and there should have been a metal threaded union connecting the two pipes in this location. It was determined that the overlap that would have existed between the fuel pipe from the right tank and the rubber hose was approximately 1 cm.

The fuel hose between the engine-driven fuel pump and the fuel injector body had a loose connection at the injector body end but, because both the pump and injector had separated from the engine, the loosening could have occurred during the impact sequence. The fuel hose from the injector body to the fuel manifold had failed in overload. The gascolator had been crushed and was split open; no fuel was present inside.

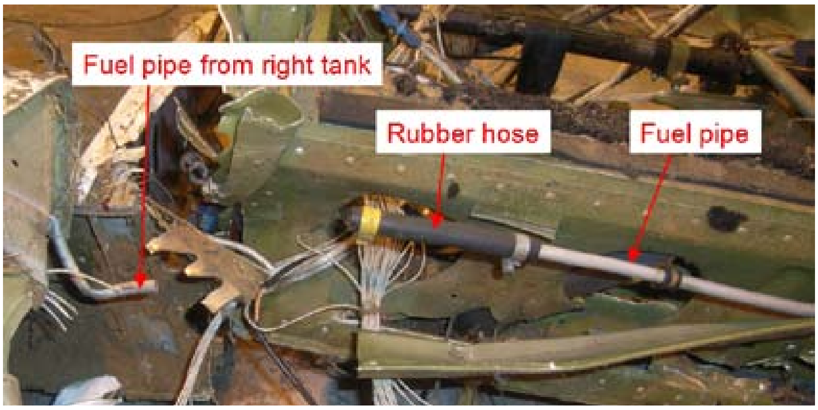


Figure 5

Rubber hose repair to fuel pipe

Other component examinations

The throttle and mixture control levers were close to the full forward position and the propeller lever was in a mid position, but the disruption and damage to the throttle quadrant made these unreliable indications of their pre-impact positions. The magneto switch was set to the RIGHT magneto and the key had broken off. The battery, alternator and the electric fuel boost pump switches were in the ON position. The 'Alternate Air' lever was in the ON position but this was considered an unreliable indication of the pre-impact position. The COM 1 radio was selected ON and was set to 130.2 MHz, the RAF Cottesmore frequency. The combined pitot/static probe had separated from the wing and while the pitot tube hole was plugged with mud and the static port was clear. The pitot-static plumbing system was too severely disrupted to enable any useful determination of its condition prior to the accident, although all damage seen appeared consistent with having occurred during the impact. The electrical wiring from the cockpit area was examined and no evidence was found of any electrical arcing or sooting.

Powerplant examination

The engine and propeller were taken to an approved overhaul facility for strip examination. The engine had suffered significant impact damage, including separation of the No 4 cylinder head from the cylinder barrel. The engine crankcase was disassembled and no internal defects were found.

The left magneto, oil filter, engine-driven fuel pump and propeller governor had all separated from the engine accessory gearbox, and exhibited varying degrees of damage. The fuel injector servo unit had also separated from the engine. The injector and fuel manifold were stripped and all internal components were in satisfactory condition. The engine could be rotated freely by hand, although the damaged No 4 cylinder prevented full rotation. The engine had been sufficiently lubricated and there was no evidence of any pre-impact mechanical failure or evidence of overheating. The spark plugs were in satisfactory condition, apart from the lower No 2 plug, which was coated in oil, and the upper No 4 plug, which had disintegrated at impact. The right magneto was still attached but its retaining nuts were loose but as their washers had evidence of torque having been applied, it was possible that the nuts loosened as a result of impact forces. The engine timing was checked and was found to be correct within the range of movement of the loose right magneto. Both magnetos were rig tested and operated normally. The oil filters were clean and the oil scavenge pump was in satisfactory condition. The vacuum pump rotated freely and an internal examination revealed that the rotor and vanes were intact. The propeller governor could be rotated, although it was stiff as a result of impact damage. The alternator could not be tested due to its impact damage.

The propeller hub was disassembled, which revealed that all three blade pitch-links had sheared in overload. The piston rod was slightly bent and the pre-load plates did not exhibit any witness marks that could be used to determine the blade angles at impact. There was sufficient grease within the hub and no evidence of any pre-impact failure. All three propeller blades were bent aft from the shank to the tip. Propeller blades No 2 and No 3 were also twisted towards low pitch. This evidence, coupled with leading edge indentations and chord-wise scratches on all three blades, indicated that the propeller had significant rotational energy at impact.

Additional information

Since the propeller was a variable-pitch constant-speed unit, evidence of rotational energy in itself did not indicate that the engine was producing power. At high airspeed, such a propeller may be turning at relatively high speed, but at relatively low, or no, power. The spacing between the three propeller slash marks found in the ground was 40 cm and this was used to determine a relationship between the propeller's rotational speed and the aircraft's groundspeed. This relationship for a selection of groundspeeds is shown in Table 1.

V_{GS} (kt)	RPM
80	2062
90	2320
100	2578
110	2835
120	3093

Table 1

Relationship between groundspeed (V_{GS}) in kt, and propeller speed (RPM) for 40 cm spacing between propeller slash marks for a 3-bladed propeller

As no pre-impact defects were found with the propeller governor, and the propeller speed is limited to 2,700 rpm, the aircraft was therefore unlikely to have had a groundspeed at ground impact above, approximately, 105 kt. The degree of disintegration and the spread of the wreckage following ground impact, were consistent with speed of at least 80 kt when the aircraft struck the ground, so it is probable that the propeller speed was between 2,000 rpm and 2,700 rpm. A rotational speed above 2,000 rpm is also considered consistent with the damage sustained by the propeller blades. However, a flight conducted with a similar aircraft has shown that a propeller speed of 2,000 rpm to 2,200 rpm can be achieved at 110 kt to 120 kt in a descent with idle power. Therefore, it was not possible from the propeller speed evidence alone to establish that the engine was producing more than idle power.

Maintenance history

On 28 December 2007, the pilot flew G-BKFZ from Shacklewell to Spanhoe for its annual maintenance check. The aircraft's Certificate of Airworthiness was due to expire on 3 January 2008 and the aircraft required a Star Annual check before the CAA could issue a new EASA non-expiring Certificate of Airworthiness (CoA) and the accompanying Airworthiness Review Certificate (ARC).

The maintenance for the Star Annual check was carried out under the supervision of a Licensed Aircraft Engineer (LAE), at Spanhoe. In addition to the normal inspections, the two magnetos were removed for a 500 hour inspection, and re-installed, and a new propeller was fitted. The landing gear hydraulic hoses, two fuel hoses and two oil hoses were also replaced. A special inspection for cracks of the stabilator balance weight arm, required by an EASA Airworthiness Directive, was also carried out, but no cracks were found. As part of a previous Annual inspection, the two altimeters had been checked for accuracy. The maintenance worksheet recorded that the main altimeter indicated 0 ft and 500 ft at reference pressure altitudes of 0 ft and 500 ft respectively, while the standby altimeter indicated 10 ft and 480 ft. This was within acceptable limits.

Approximately two or three gallons of fuel were removed from the aircraft by the engineer to clean the engine. Additionally, fuel from the aircraft was also used to verify the flow rate through the new fuel hoses.

The aircraft's 50 hour/6 month maintenance checks were carried out by the pilot in accordance with the applicable Light Aircraft Maintenance Schedule (LAMS), the last such check being on 11 September 2007.

The British Civil Air Regulations (BCAR) state in Section A:

> *'A Star Inspection and the coincident annual inspection shall be carried out at the premises of an organisation approved in accordance with BCAR Chapter A8-15…'*

A maintenance organisation that is approved in accordance with BCAR Chapter A8-15 is identified as a M3 organisation, but the organisation at Spanhoe was not so approved. The LAE at Spanhoe stated that he thought that the maintenance work for the Star Inspection could be carried out at a non-M3 organisation, on condition that the final check was carried out, and paperwork signed off, at an M3 approved organisation.However, this is incorrect as this inspection must be carried out at the premises of an approved organisation. The engineer completed the Annual check and signed it off in the aircraft logbooks on 31 January 2008 and, sometime between 5 and 7 February 2008, he flew G-BKFZ to a M3 approved organisation at Seething. Here, the Chief Engineer of this organisation carried out a physical audit of the aircraft and completed the appropriate paperwork to apply for the new EASA Standard CoA and ARC; both were issued on 13 February 2008.

Sometime between 7 February 2008 and the accident date, 13 February 2008, the engineer from Spanhoe flew G-BKFZ back to Spanhoe. The Star Annual maintenance check included an inspection of all the fuel pipes and fuel hoses in the aircraft, and should have revealed the presence of the non-approved fuel pipe repair in the right wing to fuselage join area. However, the engineer at Spanhoe stated that he thought the rubber hose had been installed as an anti-chafing device and did not realise that there would normally be a union in this position.

The airframe logbooks, dating back to 1994, contained no entries for a fuel pipe repair. The Service Bulletins and Airworthiness Directives with their relevant compliance due dates were recorded in the pink sheets of G-BKFZ's engine logbook, but these had not been recorded in the airframe logbook following the aircraft's Annual Inspection.

Altimetry and terrain

Shortly before the accident, the pilot had requested the Wittering QFE from the approach controller at RAF Cottesmore; the similarity between the elevations of RAF Wittering and Shacklewell, together with their proximity, meant that the RAF Wittering QFE would have served as a workable QFE for Shacklewell Lodge. In fact, the controller passed the Cottesmore QFE, as RAF Wittering was closed. RAF Cottesmore's elevation is 461 ft and RAF Wittering's, 273 ft.

The aircraft's main altimeter was found set to a pressure datum of 1018 mb, only 1 mb displaced from the Cottesmore QFE passed to the pilot by ATC; however, this discrepancy is not considered significant and may have resulted from the impact or slight imprecision in adjusting the subscale. The pressure datum of the standby altimeter was found set to 1024 mb and, as this was consistent with the QFE at Spanhoe, it seems likely that the altimeter had been set to zero before departure.

Post-mortem examination

A post-mortem examination of the pilot was carried out by a specialist aviation pathologist. He found no sign of pre-existing medical condition which might have contributed to the accident. There was some evidence to indicate that the pilot had been holding the controls at the time of impact.

Analysis

GS data

The last four GPS data points indicate a progressive reduction in the aircraft's rate of descent, which began at approximately 1,000 ft/min at an altitude of around 1,450 ft. For a minute prior to this, the aircraft had been in a gentle descent of around 150 ft/min, having achieved a maximum altitude of 1,607 ft, and at which time the pilot was above cloud and communicating with RAF Cottesmore. If the top of the cloud/fog layer was between 500 ft and 700 ft at that time, as reported later by the police helicopter, then the aircraft would have entered the cloud/fog whilst descending at approximately 500 ft/min and with a groundspeed of around 130 kt.

The last two GPS points indicated that the aircraft travelled a distance of 1 nm in 31 seconds while descending only about 125 ft; this represents an approximate rate of descent of 240 ft/min and a very shallow average descent of around 50:1. This would not be achievable in this type of aircraft without some engine power, even taking into account the slight reduction in airspeed at this time.

From the analysis of the accident site and the spread of the wreckage, the aircraft's speed was estimated to have been in excess of 110 kt when it struck the trees. The aircraft's final trajectory from tree impact to ground impact was 10° to 14° below the horizon which represents a descent rate of between 1,900 ft/min and 2,700 ft/min at an airspeed of 110 kt. These values were broadly consistent with the final 2,300 ft/min descent rate extrapolated from the last GPS data point, although this value must be treated as approximate due to the inherent inaccuracies with GPS derived height data. Despite these inaccuracies, the combined data suggests that a marked increase in the rate of decent of the aircraft occurred shortly before it struck the trees.

Engineering aspects

The landing gear was established to have been retracted at impact so it is possible that the 'Gear in Transit' light was activated as a result of the inboard right wing separation severing the wires to the right gear microswitches. The 'AUTO EXT OFF' light illuminates when the automatic gear extension system is disabled; and it is not uncommon for pilots to disable this system for flight. The significant conclusion from these two bulbs having been illuminated is that electrical power was available on the aircraft at the time of impact.

There was no evidence of any pre-impact structural failure or a pre-impact problem with the flight controls. As far as could be determined, the vacuum pump and Attitude Indicator were functioning correctly prior to impact and, therefore, artificial attitude reference should have been available to the pilot.

The engine examination revealed no evidence of pre-existing defect or failure. The loose right magneto was probably caused by impact forces but, should it have been loose prior to impact, it would have caused rough running which could have been resolved quickly by the pilot isolating this magneto by selecting the magneto key to LEFT. This was found set to RIGHT, which would suggest that the right magneto was operating correctly; however, the key had broken off during the impact so it was possible that impact forces could have moved the key to the RIGHT position.

It could not be established from the accident site whether there had been sufficient fuel onboard the aircraft prior to impact for continued flight; however, fuel was recovered from the engine-driven pump which indicated that fuel was probably being delivered to the engine at the time of impact. The examination and test of the electric fuel boost pump proved inconclusive, but the engine-driven pump alone would have been sufficient to provide adequate fuel flow under normal conditions. The fuel selector was set to the right tank and it was within the fuel line from the right tank that the non-approved rubber hose repair had been carried out. The fuel pipe was found separated from the hose and, although it was not possible to establish conclusively when this occurred, it was considered unlikely to have occurred before the impact, as the fuel pipes would have been secured to the airframe and not likely to pull apart. Also, there was evidence that the pipe from the wing had been inserted by at least 1 cm into the hose, and both screw clamps were not judged to have been loose. However, had the pipe separated, or had been close to separating from the hose in flight then, either a loss of fuel flow or entrained air could have resulted in partial or a complete loss of power. Apart from this possibility, no other evidence was found during the engineering investigation that could be considered a causal factor in the accident.

Operations aspects

Shortly before the accident, the pilot reported to the approach controller at RAF Cottesmore that he was flying at 1,200 ft just above a cloud layer. Data from the Met Office indicated that the aircraft must have been flying close to the boundary between clear skies with haze/mist to the west, and very poor visibility and low cloud conditions, with mist, fog and hill fog, to the east. A few moments later, the aircraft descended into the cloud which was continious to ground level, and crashed into trees before striking the ground.

With the proximity to relatively clear air, where an emergency or precautionary forced landing could have been attempted, three possible reasons for the aircraft to descend in to cloud are listed below, and are considered in turn:

- the pilot intended the aircraft to descend
- the pilot did not intend the aircraft to descend but lost control of the aircraft
- the pilot did not intend the aircraft to descend but the aircraft was no longer capable of sustaining level flight.

Intentional descent

Although the pilot did not hold a current IMC or Instrument Rating, and was therefore not qualified to fly in cloud, the fact that he had logged instrument flight time after his IMC rating had expired, may indicate that he had confidence in his ability to control the aircraft by sole reference to instruments. The pilot was aware, prior to flight, that foggy conditions were expected. He had received the RAF Cottesmore weather report which indicated 5,000 metres visibility and a clear sky; this might have influenced him to think that he was flying above a layer of cloud rather than a layer of fog and indeed, his radio transmission mentioned 'cloud' rather than fog. He may, then, have considered that flight below the cloud would be possible.

If it was the pilot's intention to descend through the 'cloud' in order to locate his destination visually and land, it would be logical and practical for the aircraft's path to have turned towards the destination at some point, as the pilot had a GPS receiver with him capable of showing the necessary route. However, the aircraft's track was essentially straight and towards the eastern end of Rutland Water and it could equally well be that his intention was to descend to a low height over an area free from obstructions, or that he only intended to maintain control of the aircraft in a straight line when in IMC , possibly hoping to become visual with the ground in time to divert to Shackwell lodge.

However, as he descended into the 'cloud', he would have seen his altimeter read closer and closer to zero, and then pass through reading zero very soon before impact. The forward speed and the significant rate of descent just prior to impact, gear and flaps up, would not be consistent with the normal actions of a pilot who knew that his aircraft was close to the ground with the ability to climb back to a safe height. Therefore, it is considered unlikely that the pilot deliberately descended to a dangerously low height in fog. His initial intention may have been to get below the 'cloud' layer, and complete the journey in sight of the ground, but he did not appreciate the high rate of descent until it was too late to recover.

Loss of control

Loss of control, resulting from, for example, incapacitation, distraction or spatial disorientation, often result in the aircraft entering a spiral dive. The relatively large time intervals between the positions recorded by the pilot's GPS unit, make determination of the aircraft's precise track impossible, but small deviations from a straight path may have been present between data points. However, the last seven position data points are essentially in a straight line, and it is therefore considered improbable that any significant deviations from a straight descending path occurred, and hence that the aircraft was not out of control whilst in cloud. Should a loss of control have occurred above the cloud, which forced the aircraft to descend in to the cloud, then it would not seem reasonable for the aircraft to have continued to descend essentially in a straight line until it crashed, rather than crashing sooner, or recovering to controlled flight above cloud. The fact that the aircraft struck the trees in a reasonably upright attitude also suggests that it was under control at the moment of impact. This view is supported by the findings of the post-mortem examination which identified that the pilot was probably handling the controls at the moment of impact.

The pilot previously held an IMC rating, and must have demonstrated his ability to fly on instruments in order to obtain and renew that rating. The aircraft was equipped with adequate instrumentation to permit flight in IMC, and the engineering examination identified as far as possible that this equipment was serviceable, and that electrical power was available. Again, the fact that the pilot had logged some instrument flight time after his IMC rating had expired, may indicate that he had a measure of confidence in his ability to control the aircraft by sole reference to instruments, even though he had flown for only two hours in the last 90 days, and could not be considered to be current at flying on instruments.

The post-mortem examination did not identify any medical cause for the accident, in terms of incapacitation. If anything, it indicated against this to some extent. However, the possibility that the pilot suffered some sort of brief incapacitating event, which prevented his controlling the aircraft for a very short time, cannot be ruled out.

A distraction, requiring a significant element of the pilot's attention, remains a possibility. Concentrating on some task, he might have kept the aircraft under control, without being able to assess his position (particularly in terms of his altitude) and make precise corrections to achieve his desired flight path. The most likely cause of distraction is considered be an unidentified technical malfunction of some kind.

It could be argued that the absence of an emergency communication to ATC might indicate that the pilot did not recognise the gravity of his situation. However, communications with ATC often assumes a lower priority to a pilot than resolving a difficulty and, therefore, the absence of communication is not considered significant.

It is concluded that it was unlikely the pilot lost control of the aircraft prior to the accident.

Aircraft malfunction

The analysis of the wreckage concluded that a major failure or malfunction of the aircraft structure and systems was unlikely to have occurred.

The aircraft departed with a small quantity of fuel on board, apparently sufficient to complete the flight but offering an endurance of, at most, one hour. Depending upon the distribution of the fuel, it is possible that one fuel tank may have run dry, causing the engine to falter or stop. Although not considered likely, the possibility that a separation of the fuel hose from the right wing pipe could have been a factor in the accident could not be dismissed entirely. In this event, the pilot would have found it necessary to select the other tank and restart the engine. The 'as found' positions of the fuel pump switch and magneto switch are consistent with attempts being made to deal with an engine problem. The pilot's flying experience may have enabled him to diagnose a problem accurately and, perhaps, attempt to resolve it. Some witnesses spoke of hearing the engine running, whilst others spoke of hearing abnormal engine sounds. It is therefore unclear whether he had actually suffered an engine problem.

Faced with a loss or significant reduction of engine power, the pilot would have had no option but to descend in order to maintain flying speed. In this circumstance, it might be expected that he would have turned the aircraft towards the clearer air, in the hope of flying out of the fog before reaching the ground, unless he was focussed on trying to resolve a problem. Equally, it is possible that he may have considered heading for Rutland Water to land/ditch in an area without obstructions. The impact speed, estimated at in excess of 110 kt, mitigates against this unless, as previously stated, he was focussed on trying to resolve a problem. Another possibility was that, having descended into the fog, the pilot may have only been able to cope with maintaining control of the aircraft in a straight line as a result of his lack of currency when flying solely on instruments.

In conclusion, it is considered that the pilot may have been forced to descend in to the fog, possibly due to a loss of engine power.

Conclusions

The aircraft crashed as a result of hitting trees in foggy conditions. The reason for the aircraft's descent in to the fog could not be clearly established, but various possibilities were identified.