Bell 206B, Jet-Ranger III, G-BTFY

AAIB Bulletin No: 12/2003	**Ref: EW/C2003/01/04**	**Category: 2.3**
Aircraft Type and Registration:	Bell 206B, Jet-Ranger III, G-BTFY	
No & Type of Engines:	1 Allison 250-C20 turboshaft engine	
Year of Manufacture:	1974	
Date & Time (UTC):	17 January 2003 at 1536 hrs	
Location:	Cudham, Kent	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Fatal)	Passengers - 1 (Fatal)
Nature of Damage:	Helicopter destroyed	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	45 years	
Commander's Flying Experience:	965 hours (of which 112 hours were on type)	
	Last 90 days - 12+ hours	
	Last 28 days - 3+ hours	
Information Source:	AAIB Field Investigation	

Synopsis

The pilot, a part-time flying instructor, planned to collect the helicopter from Biggin Hill Airport, Kent and fly it to Southend, Essex. The weather for the departure from Biggin Hill was generally poor with low cloud and reduced visibility in rain. The pilot's stated intention was to depart to the north-east, but after initially departing on an easterly track the helicopter turned toward the south. Witnesses in an area about one and a half miles east-south-east of Biggin Hill saw the helicopter disappear from view into cloud and later reappear in a steep descent and strike the ground. Both occupants were killed on impact. An engineering examination of the helicopter revealed no defects that could have caused the accident. The investigation concluded that the accident was probably a result of the pilot's spatial disorientation brought on by inadvertent entry into cloud.

History of the flight

The aircraft had been flown from its base at Southend Airport, Essex to Biggin Hill Airport, Kent on Tuesday 14 January 2003 to undergo defect rectification at a maintenance organisation. The operator, a flying school and Air Operator's Certificate (AOC) holder, was advised that the helicopter would be ready for collection on the afternoon of Friday 17 January 2003. On Thursday 16 January 2003 the flying school's operations staff made arrangements for the pilot to collect the helicopter from Biggin Hill the following afternoon. The helicopter had been booked for an instructional flight and a charter flight on Saturday 18 January 2003, but the operations staff had contingency plans to use other aircraft for these flights if, for any reason, G-BTFY could not be returned to Southend on Friday 17 January 2003. The pilot was advised of these plans by the operations staff.

During the morning on the day of the accident, the pilot flew an instructional flight at Southend. At about 1300 hrs he left the flying school and was driven, with his passenger, to Biggin Hill Airport arriving there at about 1500 hrs. The driver recalled that the weather for most of the route from Southend was unremarkable, but as they arrived at Biggin Hill it was raining and misty. The weather forecast for the return flight to Southend covering the period 1300 hrs to 2200 hrs was: wind 190°/15 kt, visibility greater than 10 km, scattered cloud at 1,500 feet, deteriorating temporarily between 1300 hrs to 1900 hrs to wind 190°/18 kt gusting to 32 kt. Between 1300 hrs and 1600 hrs the cloud cover was expected to increase and become broken at 1,200 feet temporarily deteriorating to broken cloud at 900 feet and 4,000 metres visibility in rain. Sunset was due at 1625 hrs.

The pilot left his passenger and driver in the car while he entered the maintenance organisation's hangar to complete the necessary paperwork. Whilst in the hangar he discussed the prevailing weather conditions with a pilot who worked for a local helicopter company and was advised that the company had cancelled flying for the day because of the poor weather. He was also advised that the best route to depart Biggin Hill in such weather was to the north-east, under or parallel to the approach path to Runway 21, where the ground sloped away toward the Thames valley. The accident pilot replied to the effect that he "would give it a go and come back if necessary". The pilot then left the hangar and returned to the car to collect his passenger. They were then seen to walk, in the rain, to the helicopter which was parked just outside the hangar. The passenger boarded the helicopter and occupied the left front seat whilst the pilot conducted a walkaround check and then boarded the helicopter and was seated in the right front seat.

At 1520 hrs the Biggin Hill Automatic Terminal Information Service (ATIS) frequency gave Runway 21 in use, wind 190°/13 kt, visibility 3,000 metres in rain, cloud scattered at 600 feet, broken at 800 feet, temperature +5°C, dewpoint +4°C, QNH 1009 mb. A message at the end of the ATIS information requested pilots to make their initial call to ATC on the Approach Control RTF frequency of 129.4 MHz.

At 1532 hrs the pilot made his first contact with ATC on frequency 134.8 MHz, the Tower RTF frequency. On being advised to call ATC on 129.4 MHz, the pilot changed frequency requesting to "ROUTE OUT FOR A LOW LEVEL DEPARTURE ROUTING SOUTHEND, ER, ROUTING OUT LOW LEVEL TO THE EAST IF POSSIBLE". ATC subsequently cleared him to hover taxi to "PAD 1", a grass area to the north of Runway 29, and at 1534 hrs the pilot called "READY TO DEPART". ATC cleared him to depart to the "EAST AND NORTH-EAST" which the pilot read back as "CLEARED TO DEPART TO THE NORTH-NORTH-EAST".

Primary radar data obtained from the Heathrow and Gatwick radars, first painted the helicopter just north-east of Runway 29, and then recorded it following an easterly track (see Figure 1) and quickly accelerating to a groundspeed of about 100 kt. About 45 seconds after takeoff the radar data shows the helicopter turned on to a generally south easterly track, and the pilot made the last recorded RTF call requesting the latest QNH. Shortly thereafter the radar records the helicopter turning toward the south. About one and a half kilometres south of Cudham the helicopter turned on to a westerly track, shortly followed by a north-westerly track before finally tracking to the east-north-east. The last recorded radar return is from the vicinity of Horn's Green just south of Cudham and is timed at 1536:44 hrs.

Radar Derived Track G-BTFY, 17 January 2003

Figure 1 Radar derived track and groundspeed

Several witnesses, most of whom described the weather as poor with mist and low cloud in fine rain, saw and heard the helicopter in the last minute of its flight. Witnesses described seeing the helicopter apparently going in and out of cloud and one witness described it as "flying erratically". Most witnesses described the helicopter as making a "thwacking" sound which one witness, who was an experienced helicopter pilot, identified as "blade slap", a well known Bell 206 phenomenon associated with descent and hard manoeuvring. Two witnesses located at a kennels just to the west of Cudham Lane saw the helicopter flying very low on a southerly heading along Cudham Lane. It flew very nearly over their heads and then disappeared from view in cloud and mist to the south. They then heard the helicopter as it seemed to circle their position; one of the witnesses kept her eyes on the point in the clouds from which the sound seemed to be coming. As she followed the noise to the north-west of her position she saw the helicopter reappear in a steep descent. She lost sight of it as it disappeared behind trees, but heard an impact shortly thereafter.

The helicopter struck the ground in the garden of a house. At impact it had been on an easterly heading, banked slightly to the left and in a slightly nose-up attitude. The helicopter broke through a hedge and into an adjacent field where it came to rest and caught fire. Several witnesses attended the scene but were unable to assist the occupants who had been thrown out of the helicopter and showed no signs of life. The pilot of an Air Ambulance helicopter that attended the scene shortly after the accident estimated the cloudbase to be 300 feet agl and the visibility to be in the order of 2,000 metres.

Pilot's flying experience

The pilot's flying log books and licence were in the helicopter and were badly damaged by fire. The flying hours quoted at the beginning of this report are therefore an estimate, but are believed to be accurate within 50 hours for total experience and 5 hours for type experience.

The pilot started helicopter flying training in the USA in the early 1990s. He gained about 80 hours flying experience in the USA but did not complete his US flying licence and returned to the UK where he started a UK Private Pilot's Licence (PPL) (Helicopters) course in 1994. He completed that course in February 1996, and his UK PPL (Helicopters) was issued in March 1996. Over the next two years he increased his flying hours and in 1998 he attained an Assistant Flying Instructor's (AFI) rating. At the time the pilot underwent PPL (Helicopter) training, instrument flying training was not part of the syllabus, and as an AFI he was therefore not permitted to instruct in instrument flying. In March 2000 he applied to upgrade to Flying Instructor (FI) rating, but before he could do so he had to undergo seven hours of ground training and five hours of airborne instrument training which then qualified him to instruct basic instrument flying. He completed this training in April 2000 and his FI rating was issued later that month. There is no record of the pilot having undertaken any instrument flying other than that accomplished during the course required for his upgrade to FI.

In late January 2003, the pilot planned to achieve a long-held ambition and undertake a full time flying course aimed at acquiring a commercial helicopter pilot's licence. Witnesses who encountered the pilot in the days leading up to the accident described his demeanour as bordering on "elation". The student who flew with the instructor on the morning of the accident, thought the instructor was in a particularly buoyant mood and remembers him flying the helicopter in a very spirited fashion.

Medical and pathological information

A post-mortem examination found that both the pilot and his passenger died of multiple injuries. No evidence of any pre-existing disease was found and a toxicological investigation revealed no evidence of any condition which may have caused or contributed to the accident.

Aircraft description

The Bell 206B is a single engined helicopter of conventional layout certified for flight in VFR only. It has a teetering main rotor of comparatively high rotational inertia that is controlled through servo actuators. The aircraft is powered by an Allison 250-C20 gas turboshaft engine mounted on the fuselage roof behind the main rotor transmission. A freewheel unit, mounted on the front of the engine accessory gearbox, delivers power forward to the main transmission and aft to the tail rotor gearbox.

This aircraft was equipped with an optional Paravion cabin bleed air heating system and windscreen demist system. It was also equipped with a Skyforce GPS with a moving map display.

Maintenance history

The aircraft had been reconstructed using an airframe re-imported from abroad and the rotary parts and engine from an aircraft which had an accident that damaged only its airframe (AAIB Bulletin 6/2000, G-JWLS). The completed aircraft received its CAA Certificate of Airworthiness on 30 May 2001, at which time the airframe had logged 18,381 hours.

Three days prior to the accident, on 14 January 2003, the aircraft was flown to Biggin Hill for maintenance work to rectify two reported problems. One was a rain water leak into the rear cabin which was investigated and new seals were ordered to fix that problem. The other was that the main transmission appeared to be using oil at a higher rate than normal while the engine oil level was going up. This problem was diagnosed to have been caused by oil migrating from the freewheel unit into the engine via either the front or rear power output seals in the engine accessory gearbox. The freewheel unit is lubricated by oil from the main transmission in which the case pressure is normally higher than that in the engine accessory gearbox. Therefore, main transmission oil can migrate from the freewheel unit into the engine via the power output seals if there is a problem with the seals. Both power output seals were therefore replaced which involved removing the engine and the freewheel unit. Following this work the engine was tested during a ground run and all engine indications were normal.

During maintenance it was noted that the vertical speed indicator was offset by one half of a needle's width in the negative direction (approximately -100 feet/min) and it was decided to zero the instrument at a later date.

The accident flight was the first flight following maintenance. The maintenance organisation reported that the aircraft had approximately 30 to 40 US gallons of fuel on board. The airframe had logged 18,685 hours and the engine had logged 7,121 hours since last overhaul.

Wreckage and impact examination

The aircraft crashed approximately 2.2 nautical miles south-east of the centre of Biggin Hill Airport. It struck the ground in the back garden of a house near Horns Green south of Cudham at a point where the ground level was approximately 680 feet above mean sea level (amsl).

The main rotor appeared to have clipped a tree branch when the aircraft was 20 feet above the ground and 33 feet horizontally from the main impact mark. This would indicate that the final flight path angle was approximately 30 degrees. Ground marks indicated that the aircraft had struck in a slight nose-up pitch attitude (3° to 8°) with a slight left bank. The point of impact was 10 feet in front of an 8 foot high hedge. The majority of the wreckage broke through the hedge and travelled a further 130 feet on a track of 085°(M) before coming to a rest and catching fire. The characteristics of the wreckage trail were consistent with a forward speed at impact of between 50 and 70 kt. There was no evidence of any appreciable yawing motion at impact.

It was evident that the main rotor had sliced through the top of the hedge (see Figure 2) and there were also slash marks on the ground either side of the hedge where the main rotor had hit. The main rotor mast had broken just below the rotor head and the main rotor blades, still connected to the rotor head, were found resting against a tree 90 feet beyond the main wreckage. The tail rotor and tail rotor gearbox were found 10 feet beyond the main wreckage. One tail rotor blade was damaged but complete and the other tail rotor blade had broken into two pieces. The outboard section of this blade was found 230 feet away from the aircraft initial impact point (ahead of and to the left of the wreckage trail centreline) while the inboard section of the blade was found close to the initial impact point.

Figure 2 Initial impact site (hedge trimmed by main rotor)

The main wreckage included the engine, main transmission, the tail (in three pieces), the instrument panel and other remnants of the cockpit. The engine and main transmission lay inverted with the tail alongside, also inverted. This main wreckage had caught fire and the fire had burnt most of the fuselage structure. All major aircraft components were accounted for and there was no evidence to suggest any pre-impact separations.

After on-site examination the wreckage was removed to the AAIB at Farnborough for more detailed examination.

Powerplant examination

The engine was examined by the AAIB at an approved overhaul facility with an Air Safety Investigator from the engine manufacturer in attendance. The engine was complete but with external heat damage from the post impact fire. One compressor half case had two external punctures resulting from impact damage.

The strip examination revealed that the third stage compressor wheel blades were bent in a direction opposite to that of rotation (see Figure 3). The location of the damaged third stage blades coincided with one of the punctures on the external surface of the compressor case lining. The third stage turbine nozzle displayed rotational scoring and the third and fourth stage turbine wheels showed evidence of blade tip rub 360 degrees around. The combined evidence of these rotational signatures indicated that the engine was operating and producing power at the time of impact.

Figure 3 Compressor wheel with third stage bent blades

Two anomalies were found during the strip examination. The front power output seal, between the engine accessory gearbox and the freewheel unit, was found folded back upon itself in one area (see Figure 4).

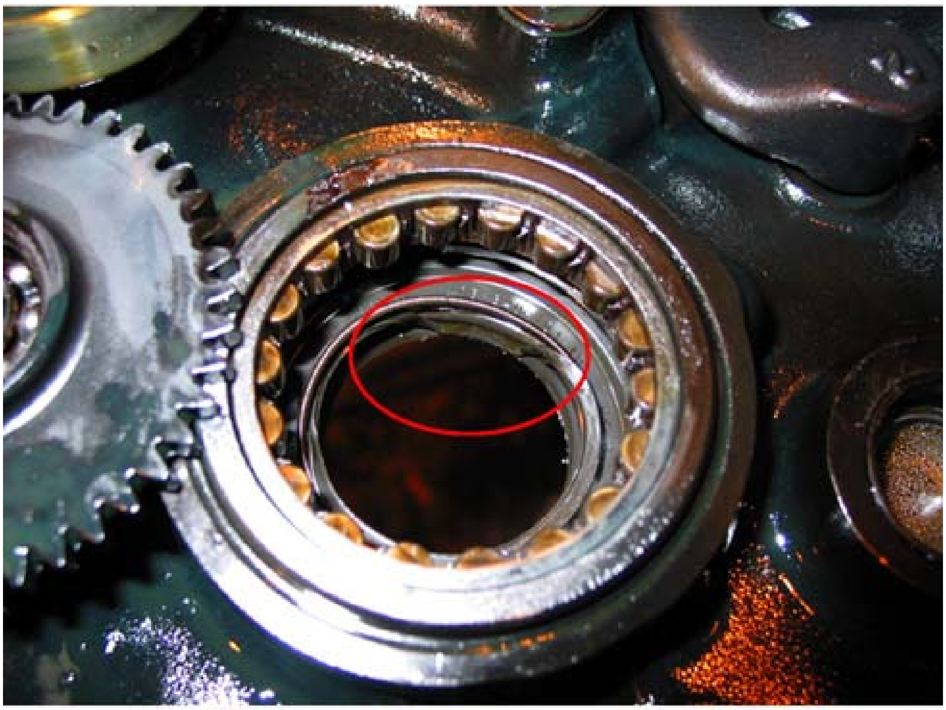

Figure 4 Front power output ssealfolded back upon itself

This is one of the two seals that was replaced during the last maintenance prior to the accident flight. In addition, the inner surfaces of the discharge tubes (which pass air from the compressor to the combustor) and the outer combustion case were unusually coated in oil. The engine manufacturer considered that the presence of this oil was an indication that the engine oil system had been above its maximum total capacity at some point during operation. It appeared most likely that the oil entered through the folded power output seal. The seal is designed to prevent main transmission oil migrating from the freewheel unit into the engine accessory gearbox. However, since main transmission oil and engine oil are of the same type the mixing of the two oils would not have had a damaging effect. Moreover, the additional quantity of oil would not have unduly affected the performance of the engine. The engine manufacturer thought it possible that the engine might have produced some smoke although not necessarily so. The bleed air pickup from the engine compressor was upstream from any oil leakage and therefore any smoke generated inside the engine could not have easily passed into the heated air for the cabin.

It appears that the aircraft left maintenance with the same oil leak problem that it arrived with because the replacement front power output seal had been installed incorrectly. However, this anomaly does not appear to have been a direct factor in the accident as the engine strip examination revealed clear indications that the engine was operating and producing power at impact.

Examination of rotors and rotor drive systems

A strip examination of the main transmission revealed no evidence of a pre-accident failure and the tail rotor gearbox turned freely.

The main rotor blades sustained significant damage and were found resting against a tree 90 feet beyond the main wreckage. The outboard section of one blade (approximately 3 feet long) had fractured and was found lying 12 feet away from the rotor blades. Two large pieces of honeycomb from the trailing edge of the other blade had peeled away. The mast head had separated from the rotor mast following an overload failure in bending and torsion. One of the tailrotor blades had fractured in two places at impact causing the outboard tip to travel a distance of 230 feet. These structural failures in addition to the slash marks in the ground and the trimmed hedge were clear indications that both the main rotor and tail rotor had significant rotational energy at impact.

Flight control system examination

The flight control push-pull tubes were severely damaged during the post impact fire and were fractured in many places. In locations where the flight controls could be checked for continuity no anomalies or disconnects were found. On this aircraft the flight controls on the passenger side can be manually disconnected to prevent accidental flight control inputs. The cyclic and collective sticks unscrew from their attachments and the yaw pedals can be disconnected such that they become footrests. Despite the extensive damage it was possible to determine that the cyclic, collective and pedals on the passenger side were all connected.

Examination of instruments and caution warning panel

The altimeter instrument face had separated from the instrument case and was found lying face up in the grass. The altimeter face indicated an altitude of 50 feet and a pressure setting of 990 mb. The pressure setting was very close to the expected QFE setting for Biggin Hill based on the reported QNH of 1009 mb. The impact elevation was approximately 680 feet amsl - which is 80 feet above the Biggin Hill airport elevation. The indicated reading of 50 feet based on QFE is therefore consistent with the expected reading at impact.

The Direction Gyro Indicator (DGI) was found intact and it was indicating 080°. This is very close to the estimated final track of 085°(M) and therefore it is probable that the DGI was operating and was set correctly at the time of impact.

The aircraft's Attitude Indicator (AI) was badly damaged and was dislodged from the instrument panel. The indicated reading of 90 degrees right bank was not representative of the impact attitude. The instrument was stripped but it could not be determined whether the AI was or was not operating at the time of impact.

No information could be derived from the remaining flight and engine instruments due to either fire damage or lack of conclusive witness marks.

The light bulbs from the caution and warning panel were inspected under a microscope for indications of a stretched filament. None of the bulbs had stretched filaments and therefore it could not be concluded whether any caption was on or off at the moment of impact.

Windscreen misting

Helicopter windscreen misting can be a problem in humid conditions and has been listed as a causal factor in several helicopter accidents (AAIB Bulletin 1/1998, G-FLYR). Misting is most prevalent in humid, cool conditions with significant quantities of water vapour present within the cabin. In the case of this accident the outside air humidity was in the order of 98% and both the pilot and passenger were seen walking in the rain before boarding. In all probability their clothing was therefore damp. In addition, one of the defects that the engineering company had been asked to rectify was water ingress into the rear of the cabin. Several witnesses recall that the rear carpet was damp before it left Southend and further water may have entered the cabin whilst the engineering company were trying to locate the source of the water leak.

The aircraft was equipped with an optional bleed air heater and bleed air demister but it was not possible to determine whether either was selected to ON. The aircraft was also equipped with a ram-air system and two defog blower fans that sent ambient external air and cabin air respectively up the inside of the windscreen to aid in demisting. Pilots experienced on type reported that the bleed air demister was very effective, but the defog blower fans were less so. Conversations with pilots employed by the helicopter operator revealed a lack of knowledge of the bleed air demister, and it was not possible to determine whether the accident pilot was aware of the system or its use.

From a physical examination of the defog blower fans it could not be determined whether they were operating at impact. The recorded radio transmissions from the aircraft to the tower during the accident flight were therefore analysed in an attempt to determine if the frequency signature from the fans was present.

Both defog blower fans were connected to a bench power supply so that their sound could be recorded and analysed at various input voltages. Recordings were made at 24v and 26v DC and the maximum specified operating voltage of 28v DC. A frequency spectral analysis of the bench recordings from one of the fans indicated discrete prominent frequencies of 754, 798 and 841 Hz corresponding to input voltages of 24v, 26v and 28v DC respectively. First, second and third harmonics were also evident. A frequency analysis was then made of the recorded radio transmissions from the aircraft to the tower for periods when the aircraft was on the ground and in the air. A comparison between the ground transmission analysis (12 seconds duration) and the air transmission (4.5 seconds duration) indicated that there was a prominent frequency at 776 Hz in the air that was not present on the ground. This frequency of 776 Hz is consistent with the frequency signature of a defog blower fan operating from a 25v DC supply (which is within the operating DC voltage range of the aircraft).

Terrain and local meteorological effects

Biggin Hill Airport is situated on a plateau within the North Downs and is 600 feet amsl. The local terrain to the south is undulating and intersected by several valleys, but in general the ground slopes upward to the south before dropping away sharply at the North Downs escarpment. To the east the ground also slopes upwards and again is intersected by several valleys. Cudham village is located on the eastern edge of one of these valleys, and the lane that runs through the village to the south slopes gently upwards from 575 feet amsl to about 680 feet amsl at the accident site. On two previous flights to Biggin Hill the accident pilot had approached and departed the airfield from the direction of Sevenoaks which lies about 5 km south east of the accident site in the valley to the south of the North Downs escarpment.

The North Downs escarpment has marked effects on the local weather around Biggin Hill Airport. An AAIB report into a very similar accident near Biggin Hill, also to a Bell 206, in 1989 (AAIB Report 5/1990, G-SHBB,) stated

> *"However, weather conditions in the vicinity of the aerodrome were varied......It is clear that the cloudbase was lower along the ridge of the North Downs and visibility was probably reduced in such conditions. It is a mistake to visualise a cloud base at the reported height as being a horizontal line, and whilst it was reported at 600 feet at the aerodrome, it may well have lowered in tendrils towards the surface of the ridge".*

Flying Regulations

The rules and regulations pertaining to the conduct of the accident flight are contained in several different publications. The *Air Navigation Order* (ANO, CAP 393) outlines the Licence Privileges for the holder of a PPL (Helicopter) and lays down the Rules of the Air which contain the VFR and rules on low flying. The UK Aeronautical Information Publication (AIP) specifies the weather minima for VFR flight, while the Joint Aviation Requirements Flight Crew Licensing and Medical 2 (JAR FCL 2) contains regulations pertaining to helicopter licence holders and flights under IFR. JAR FCL 2 also contains the current training syllabus to obtain a JAR PPL (Helicopter). In addition to these regulations the CAA issues Safety Sense leaflets designed to increase safety awareness and provide practical advice on a number of aviation subjects. Safety Sense 17, *Helicopter Airmanship*, is relevant to this accident.

In the UK, the requirements of JAR FCL 2 were implemented on 1 January 2000. Prior to this date training for a PPL (Helicopter) was subject to a national syllabus and those completing the syllabus were issued with a UK PPL (Helicopters), which was valid for life. Pilots who started training after 1 January 2000 did so in accordance with the JAR FCL 2 syllabus and on completion of training were issued with a JAR PPL (Helicopter), which was valid for five years. The ANO Schedule 8 Part A sets out the Licence Privileges for both the UK PPL (Helicopters) and the JAR PPL (Helicopter). Of particular relevance in the context of this accident are the differences between the two licences with regard to flight in accordance with IFR.

Training in instrument flying was not included in the UK PPL (Helicopters) syllabus and consequently a UK PPL (Helicopters) was normally issued with restrictions that forbade flying by sole reference to instruments or out of sight of the surface. These restrictions could be lifted if the pilot undertook five hours of instrument flying training with a helicopter instructor. The pilot involved in this accident held a UK PPL (Helicopters) and the restrictions referred to above were removed following the instrument training conducted for his FI upgrade.

The use of the UK PPL (Helicopters) is further constrained by Licence Privileges published in Schedule 8 of the ANO. In respect of flight under IFR the ANO states:

> *'He shall not, unless his licence includes an instrument rating (helicopters) fly as pilot in command or co-pilot of such a helicopter flying in Class A, B or C airspace in circumstances which require compliance with Instrument Flight Rules'.*

Anomalously, the ANO places no restriction on the holder of a UK PPL(Helicopters) flying in IMC under IFR in Class D, E, F or G airspace provided the helicopter itself is certified for IFR flight and the above mentioned licence restrictions have been removed by virtue of completing five hours of instrument flying.

Unlike the UK PPL (Helicopters), the JAR PPL (Helicopter) syllabus includes five hours instrument flying training, and the licence is normally issued without the restrictions outlined above. Although the JAR PPL (Helicopter) Licence Privileges make no direct reference to restrictions on the holder flying under IFR, para 2 of the Licence Privileges refers the holder to JAR-FCL para 2.175 which states:

> *'The holder of a pilot licence shall not act in any capacity as a pilot of a helicopter under Instrument Flight Rules (IFR), except as a pilot undergoing skill testing or dual training, unless the holder has an instrument rating appropriate to the category of aircraft issued in accordance with JAR-FCL'.*

In contrast to the UK and JAR PPL (Helicopter) Licence Privileges outlined above, UK and JAR PPL (Aeroplane) Licence Privileges both include the following restriction:

> *'He shall not unless his licence includes an instrument rating (aeroplanes) or an instrument meteorological conditions rating (aeroplanes) fly as pilot in command of such an aeroplane:*
>
> *(i) on a flight outside controlled airspace when the flight visibility is less than 3 Km*
>
> *(ii) on a special VFR flight in a control zone in a flight visibility of less than 10 km except on a route or in an aerodrome traffic zone notified for the purpose of this sub paragraph; or*
>
> *(iii) out of sight of the surface*

Thus PPL (Helicopter) Licence Privileges place no additional restriction on the weather conditions in which a licence holder may fly, over and above those set out in the ANO Rules of the Air and the AIP En-Route section. Both these documents state that for helicopters flying at or below 3,000 feet outside controlled airspace, the helicopter must fly *'...at a speed, which having regard to the visibility is reasonable, and remains clear of cloud and in sight of the surface'*. Thus, in theory at least and provided he/she was in compliance of Rules of the Air paragraph 5 Low Flying, the holder of a PPL (Helicopter) could quite legally fly in the most extreme cloud base or visibility conditions provided he/she remained in sight of the surface and clear of cloud.

Notwithstanding the legal requirements outlined above, the CAA Safety Sense Leaflet 17, *Helicopter Airmanship*, contains sound, practical advice on the operation of helicopters. Para 4.7, En-Route Diversion, provides the following advice on action to be taken if en-route weather starts to deteriorate:

'if the weather gets worse, eg 1,000 feet cloudbase and 3 km visiblity or less turn back, divert or carry out a precautionary landing.

Previous accidents and incidents

In December 2002 the CAA published a special edition General Aviation Safety Information Leaflet (GASIL) on Helicopter Safety. The leaflet presented data, taken from the CAA database, for accidents to helicopters of less than 2,730 kg maximum take-off weight that occurred between 1997 and 2001. The data considered accidents of all causes and included 25 that involved fatalities and serious injuries. Eight of these accidents were assessed as being caused by spatial disorientation.

The investigation made further use of the CAA database to focus on helicopter accidents that occurred in the 10 year period from 1993 to 2003 where poor weather had been among the causal factors. Of these, 19 (involving 24 fatalities and 9 serious injuries) could reasonably be described as a loss of control on encountering bad weather or entering cloud, and 65% had occurred to PPL (Helicopter) holders. The precise weather conditions were not available for all of the accidents, and in any case varied considerably depending on local factors, but of the 19 accidents at least 75% took place in conditions that were below the CAA's recommended *'turn back, divert or carry out a precautionary landing'* conditions of 3 km visibility and 1,000 feet cloudbase.

Independent research[1] based on the CAA database shows that for the period 1980-1999 spatial disorientation was a causal factor in 21% of the total number of fatal light helicopter accidents whilst the equivalent percentage for fatal light fixed wing aircraft accidents was 7%.

Analysis

The short duration of the accident flight tends to indicate that the cause of the accident was induced suddenly. Whilst it is impossible to rule out pilot incapacitation, there is no evidence to support such a possibility. Similarly it is possible that the passenger was flying the helicopter or that the passenger inadvertently interfered with the controls. Whilst neither of these possibilities can be entirely eliminated, the pilot was an experienced instructor and it seems unlikely that he would have allowed his unqualified passenger to fly the helicopter in such poor weather conditions. The pilot was also familiar with flying with students and would therefore have been aware of the potential for interference with the controls by inexperienced occupants. It therefore appears that two main possibilities exist for the cause of this accident: either some serious mechanical failure occurred or there was a loss of control.

Engineering evidence

The evidence from the accident site indicated that the aircraft struck the ground in a slight nose up attitude with a slight left bank at a speed of approximately 50 to 70 kt on a descending flight path angle of 30 degrees (descent rate of 2,500 to 3,500 feet/min). The damage to the main rotor and tail rotor, in addition to the slash marks in the ground and the disturbed hedge, indicated that the blades were rotating at high speed during impact. The aircraft caught fire after breaking through the hedge and the fire burnt most of the fuselage structure and some of the flight control components. No evidence was found of a disconnect in the flight control system and the aircraft's nearly level attitude at impact, with no indication of motion in yaw, would suggest that the aircraft was under some degree of positive control.

The engine examination revealed no major failures and the rotational signatures on the compressor wheel, turbine wheels and turbine nozzle indicated that the engine was operating and producing power at impact. The abnormal amount of oil in the outer combustion case and the discharge tubes may have been a result of the incorrect installation of the power output seal during maintenance. There

[1] Fatal Air Crashes: Directory of UK Civil Aircraft Fatal Accidents 1980-1999 by John Thorpe

may be other explanations for the abnormal oil contamination found but it was considered that this oil would not have unduly affected the performance of the engine.

The Direction Gyro Indicator appeared to be operating at the time of impact as its frozen indication was close to the aircraft's final track. It was not possible to determine whether the Attitude Indicator was operating at the time of impact. The recorded ATC transmission from the pilot indicated that the demisting blower fans were turned on.

In conclusion, no evidence of an aircraft fault was found that could have caused the accident. The possibility of a malfunctioning Attitude Indicator being a contributory factor to the accident could not be ruled out.

The weather

The Bell 206 was not certified for IFR Flight and the pilot was therefore constrained to fly in accordance with the VFR. The weather for the departure from Biggin Hill was below the CAA's recommended minima for en-route diversion but was within current helicopter VFR limits. The fact that the pilot's initial RTF call was on the wrong frequency and that he had to ask for the QNH after becoming airborne casts significant doubt on whether he had listened to the Biggin Hill ATIS. It is therefore possible that the pilot was unaware of the specific weather conditions. However, the main cloudbase over the airfield was around 800 feet agl and having travelled by road along much of the return route to Southend the pilot would have been aware that the weather over the lower ground to the north-east of Biggin Hill was likely to be much better. It is not clear if the pilot was aware of the likely local effects on the weather of the North Downs escarpment, although he had been advised by local pilots to depart to the north-east away from the higher ground to the south and south-east. Given the pilot's apparently buoyant mood and the adequate weather to the north-east, it is perhaps not surprising that he decided to "give it a go and come back if necessary". There is no evidence to indicate that the pilot was under any undue operational pressures to return the aircraft to Southend. However, sunset was approaching, and the pilot's lack of a night flying qualification may have been a factor in his decision to depart.

Radar and witness evidence

The radar data indicates that the initial departure from Biggin Hill went as planned. The general direction was easterly and the fact that the helicopter quickly accelerated to cruise speed suggests that the weather, at least for the first half minute of the departure, was reasonable. However, about 45 seconds into the flight the helicopter turned onto a south-easterly heading and shortly thereafter, was seen near Cudham to be either in or above fragments of low cloud before leaving the area to the south. Since it was the pilot's stated intention to depart to the north-east, the turn on to a south-easterly and then southerly track was probably unplanned and may have been caused by a perception of worse weather to the north-east. The pilot's familiarity with the route in and out of Biggin Hill via Sevenoaks may have been a factor in his decision to turn to the south, and the southerly route would have been the shortest route to significantly lower ground. However, the track along Cudham Lane involved flying over rising ground where the cloudbase was likely to have been lower.

Several witnesses described seeing the helicopter either disappear into cloud or flying in and out of cloud in the area around Horns Green. In the absence of any evidence of a technical malfunction, it therefore seems likely that the pilot inadvertently entered cloud just south of Horns Green and the final manoeuvres captured by the radar were as a result of the pilot's spatial disorientation. The cause of the inadvertent entry into cloud cannot be determined with certainty; however, eyewitness descriptions of the misty, cloudy conditions raise the possibility that the pilot simply lost sight of the ground and flew into cloud. The evidence that the defog blower fans were probably operating in flight points to a possible problem with windscreen misting. A reduction in forward vision caused by windscreen misting could also have been responsible for the pilot flying inadvertently into cloud and may have delayed a realisation that he had emerged from cloud just before the helicopter struck the ground.

Previous accidents and incidents

The CAA's December 2002 GASIL states that in the five years 1997-2001, spatial disorientation was the major cause of light helicopter accidents involving fatalities or serious injuries. This investigation's examination of the CAA database of accidents for the 10 years 1993-2003 has shown that loss of control in bad weather has been a factor in 19 helicopter accidents that resulted in the loss of 24 lives and a number of serious injuries. The majority of these accidents have occurred to pilots holding a PPL (Helicopter) in conditions where the weather has been below the CAA's recommended en-route diversion minima of 1,000 feet cloud base and 3 km visibility. The safety messages to PPL (Helicopter) holders from this accident and those that have preceded it seem clear: inadvertent entry into cloud or mist is a potentially fatal mistake. Inadvertent entry to cloud seems far more likely when the cloud base is below 1,000 feet agl and/or the visibility is less than 3 km.

Flying Regulations

The CAA's Small Helicopter Action Group has been active for the last three years with the aim of reducing the fatal accident rate involving non-public transport helicopters. The Group has taken action on a number of legislative, educational, design and equipment initiatives and there is some indication that there has been an improvement in accident trends, but accidents involving fatalities and serious injuries continue to feature spatial disorientation as a major causal factor.

If the spatial disorientation safety message to pilots holding a PPL (Helicopter) is to be clear and unequivocal, it is important that the legislation, training and education material relating to flight in poor weather conditions is consistent, easily assimilated and clearly presented. This investigation found a number of inconsistencies and anomalies in the regulations which detract from the clarity of the message.

There is inconsistency between the Licence Privileges of a PPL (Aeroplane) and a PPL (Helicopter) in that the holder of a PPL (Aeroplane) is not permitted to fly in visibilities below a prescribed minimum. It could be argued that more liberal weather conditions are justified for VFR helicopter flights by virtue of the helicopters' ability to carry out a precautionary landing almost anywhere. However, this is counterbalanced by the helicopter's inherent unstable flying characteristics, and the problems these create when flying by reference to instruments. Furthermore, in poor visibility, it is often difficult to judge the point where mist becomes cloud. Significantly, the accident statistics show that fatal helicopter accidents are three times as likely to be due to spatial disorientation, when compared to fixed wing fatal accidents.

Safety Recommendations

The PPL (Aeroplane) Licence Privilege limitations provide relatively inexperienced pilots with a yardstick by which to judge the advisability of flying in the weather conditions prevailing. The lack of visibility limitations placed on PPL (Helicopter) holders puts them in the position of having to make judgements on weather conditions which they are unlikely to be sufficiently experienced or trained to make. It is therefore recommended that:

Safety Recommendation 2003-110

The CAA place visibility, and consider placing cloudbase, minima on VFR helicopter cross country flights to be undertaken by PPL (Helicopter) holders.

Furthermore, there is an anomaly in the current legislation relating to the qualifications required by UK PPL (Helicopters) holders to fly in IMC on IFR flights in Class D, E, F, and G airspace. Provided the helicopter is certified for IFR flight, the current legislation does not require the holder of a UK PPL (Helicopters) to have an instrument rating for such flights and in theory he/she could undertake such flights with as little as five hours of instrument flying experience with a flying instructor. This anomaly in the legislation is more theoretical than practical but it is recommended that:

Safety Recommendation 2003-111

The CAA take action to amend the ANO to forbid flying in IMC on IFR flights in Class D, E, F or G airspace by UK PPL (Helicopters) holders unless they hold an instrument rating.

The rules and regulations regarding IFR flight by PPL (Helicopter) holders are complicated, not easily assimilated and there are inconsistencies. It is therefore recommended that:

Safety Recommendation 2003-112

The CAA carry out a review of all regulations, training and educational material, relating to flights by PPL (Helicopter) holders in poor weather conditions, to ensure that they are consistent, easily assimilated and clearly presented.