ACCIDENT

Aircraft Type and Registration:	Bell 206B Jet Ranger III, G-BXLI
No & Type of Engines:	1 Allison 250-C20J turboshaft engine
Category:	2.3
Year of Manufacture:	1989
Date & Time (UTC):	22 January 2005 at 1242 hrs
Location:	Priors Park Wood, 5 nm south of Taunton, Somerset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - 1 (Fatal) Passengers - 3 (Fatal)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	330 hours (of which 220 were on type) Last 90 days - 10 hours Last 28 days - 4 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot had planned to fly with some friends from Staverton Airport, near Gloucester, to a private landing site in the Torbay area but, due to deteriorating weather, landed at Topsham to the south of Exeter Airport. After a period of several hours, the weather had not improved so the pilot decided to return to Staverton. Although on the outbound trip he had routed south via the Bristol Channel and the M5 corridor, an area of low lying terrain, he elected to return to Staverton via Sidmouth, and communicated this to Exeter ATC, advising them that he would be flying at an altitude of 900 ft. As he approached Sidmouth, he then informed Exeter that he was going to go north towards Wellington and Taunton. This route would take the helicopter over the Blackdown Hills, which rise to a height of some 1,000 ft amsl. Witnesses in an area approximately 5 nm south of Taunton generally heard, but did not clearly see, a low flying helicopter and one heard a 'bang'. A subsequent search and rescue effort failed to locate the helicopter, due to very poor weather conditions, and it was found by a dog walker the following morning. All four occupants had received fatal injuries in the accident. No pre-accident defects were found during the wreckage examination.

History of the flight

The pilot had planned to fly two friends and the son of one of those friends in G-BXLI, a Bell 206B helicopter which he part owned, from Staverton Airport, near Gloucester, to a private landing site in the Torbay area of Devon. They then intended to spend the day in the pilot's boat, which he kept at Torquay, before returning to Staverton Airport at about 1800 hrs.

G-BXLI departed from Staverton on the morning of the accident, before the airport had opened[1] and routed south via the Bristol Channel and the M5 corridor at various altitudes. The weather had been good at Staverton, but it began to deteriorate as the helicopter flew towards Torbay. G-BXLI transited through Exeter Airport's overhead at 0923 hrs and, as it continued further south, the pilot decided that the weather was unsuitable for him to carry on to the intended landing site at Torbay. Instead, he elected to land in a playing field at Topsham, a town 3.5 nm to the south-south-west of Exeter Airport. He told Exeter ATC that he was "GOING TO HAVE TO" do so because the cloud was "DOWN TO THE GROUND" to the south of Exeter. ATC advised him that the cloud base at the airfield was scattered at 800 ft above airfield level (aal), broken at 1,500 ft aal and asked the pilot to telephone them after he had landed. G-BXLI landed on the playing field at 0929 hrs and the pilot and his passengers walked into the town in search of a café to await an improvement in the weather.

The pilot made a number of calls on his mobile telephone, to Exeter ATC (as agreed), the local police, the aircraft operating company at Staverton and friends and members of his family, to advise them of the situation. After two and a half hours he decided that, in view of the continuing poor weather to the south, he and his passengers would fly back to Staverton, having established that the weather there remained suitable. Once they had boarded the helicopter and started up, an onlooker noticed the front left seat occupant was wiping the inside of his windscreen. The helicopter took off from the playing field at 1219 hrs and the pilot advised Exeter ATC by radio that he would be routeing via Sidmouth and then on to Gloucester, at an altitude of 900 ft amsl.

At 1226 hrs the pilot informed Exeter ATC that he was "JUST COMING UP TO SIDMOUTH AND I'M GOING TO GO NORTH TOWARDS WELLINGTON AND TAUNTON". GPS data, which was subsequently recovered from the wreckage, revealed that the helicopter approached to within 1.5 nm of Sidmouth before turning north and following the valley of the River Otter towards the Blackdown Hills, and on a line towards Taunton beyond. The co-owner of G-BXLI stated later that it was common for the pilot to route via Dunkeswell when returning to Staverton from Torbay. On this occasion the route took the helicopter 4 nm to the east of Dunkeswell.

At 1240 hrs, the Exeter ATC Approach Controller, who had spent the previous few minutes conducting a Surveillance Radar Approach (SRA) for an inbound scheduled commercial aircraft, tried to contact G-BXLI on the radio but received no reply. At 1245 hrs the controller routinely handed over his duties to a colleague. He informed him of G-BXLI's routeing, the loss of communication with the pilot and a brief secondary radar contact that he had seen in the Taunton area which he thought was the helicopter. The oncoming controller also attempted to make contact with the helicopter, but

Footnote

[1] The pilot, like a number of other operator's, had signed an indemnity agreement with the airport owners, which enabled him to depart from and land at Staverton Airport outside normal operating hours, between sunrise and sunset.

without success[2]. Exeter ATC then called Bristol ATC by telephone to establish whether the pilot had made contact with them as he flew further north but they had heard nothing. Exeter ATC put the same question to Staverton ATC. Again, Staverton had not spoken to G-BXLI but, at this stage, there was no undue concern because, being a private flight, there was no requirement for the pilot to make radio contact with an ATC unit when he was flying outside controlled airspace. Also, Staverton ATC was aware of previous instances when this pilot had flown outside controlled airspace without making contact with an ATC unit. Exeter ATC asked Staverton ATC to call them when they had made contact with the helicopter.

At about 1240 hrs, a member of the public who was standing in a field on top of the Blackdown Hills approximately 600 m to the west of the B3170 road, 5 nm to the south of Taunton, heard a helicopter flying around for approximately four to five minutes. The helicopter sounded "fine"; then he heard a 'bang'. Five minutes later he telephoned the police to report what he had heard. That telephone call was timed at 1247:48 hrs and the caller reported that the helicopter had flown over the residential camp-site where he was standing. The police received no other reports from the public and no further action was taken.

At 1435, Exeter ATC contacted the company at Staverton Airport where G-BXLI was normally accommodated and on whose Air Operators Certificate (AOC) the aircraft was operated. Staff at that company did not know of the aircraft's whereabouts and made calls to the mobile telephones belonging to the aircraft's occupants. Although the 'phones were heard to ring, and one was sent a text message, there was no response.

Footnote

[2] Exeter ATC stated that it was not unusual for the pilot of a private flight to contact another ATC agency without advising them of the change. They remarked that this was sometimes the result of the aircraft's transmissions being masked by hilly terrain if the aircraft was at low altitude.

At 1500 hrs, Staverton ATC made further enquiries as to G-BXLI's whereabouts and, having received no reports of any contact, advised the London Area Control Centre (LACC) at Swanwick of the aircraft's disappearance. In the absence of a flight plan, for which there was no requirement, there was no onus on any ATC unit to initiate overdue action on the aircraft[3].

Staff at LACC commented that they made a number of general enquiries because, often, such reports of loss of contact are resolved satisfactorily. However, at 1610 hrs, the Distress and Diversion (D&D) cell at the London Air Traffic Control Centre (Military) at West Drayton was informed of the disappearance of G-BXLI, by the Civil Supervisor at LACC, and initiated overdue action at 1645 hrs. The D&D cell obtained a radar replay, tried (unsuccessfully) to establish if the whereabouts of the helicopter was known and informed the Aeronautical Rescue Co-ordination Centre (ARCC) at RAF Kinloss. At 1740 hrs, the radar replay was forwarded to ARCC and search and rescue operations (sarops) were launched at 1755 hrs. At 1900 hrs, the SAR helicopter was stood down because of unsuitable weather conditions.

At 1717 hrs, the police, who had been contacted by Staverton ATC at 1554 hrs, initiated a search for the aircraft in the area of the Blackdown Hills where there had earlier been the report of a helicopter and a 'bang'. The search continued in poor weather throughout the night and involved the police, members of the family and friends of the pilot and his passengers, and members of the general public. During the course of the night the rain turned to snow. At 0846 hrs the following morning, a member of the public reported finding the wreckage of a helicopter in a copse adjacent to the B3170, 5 nm

Footnote

[3] When a flight plan is submitted, overdue action is taken if the aircraft has not arrived at its planned destination within 30 minutes of its Estimated Time of Arrival (ETA) and its position is not known.

to the south of Taunton, having been alerted to the helicopter's presence by his two dogs. G-BXLI was severely damaged and the pilot and his three passengers appeared to have received fatal injuries. It was apparent that the predominantly white colour of the compacted wreckage merged with the recently fallen layer of snow and this made it difficult to distinguish, from even a short distance, through the trees and undergrowth. There had been no fire. The aircraft was found at an elevation of 980 ft amsl.

The post mortem reports concluded that the four occupants of G-BXLI died as a result of the injuries they had sustained during the accident.

Witness information

At some time between 1230 hrs and 1300 hrs, a witness standing in the kitchen of her house, 5 nm to the south of Taunton on the south side of the Blackdown Hills and on the east side of a valley adjacent to the B3170 road, heard a helicopter approaching from the south, flying up the valley in a northerly direction. The noise of the helicopter, which sounded very close by, faded and then returned, which prompted her to look out of the window. This witness stated that she briefly saw the tail part of a helicopter through the fog but could not distinguish the colour. The helicopter appeared to be just above and beyond the roof of the property in front of her window, travelling northwards. The roof in question is about 25 ft high. The noise of the helicopter faded again and returned a third time before moving away to the north-west. In commenting on the weather, this witness stated that fog appeared to come "in waves" and that there was drizzle and a high wind at the time.

Between 1230 hrs and 1245 hrs, two other witnesses at a neighbouring farm, some 500 m to the north of the first witness, heard a helicopter manoeuvring, apparently at low speed, very nearby. One of these witnesses, who was standing in the farm's yard, then briefly saw the tail of a helicopter approximately 200 m away over the fields on the east side of his farmhouse. The helicopter was at a height of about 30 ft and the tail, which was whitish in colour, was seen to "whip round" in a clockwise direction. The aircraft appeared to hover for about a minute before flying around to the south of the farm buildings and off in a westerly direction. The other witness, who was inside the farmhouse, had heard an aircraft overhead that sounded like a Chinook helicopter. It moved away to the back of the house, the noise "cut out and cut in again" and then the aircraft returned over the top of the house before moving away. This witness could not see the helicopter when she looked out of a window but also remarked that she was unable to see the fields on the other side of the valley, between 200 and 300 yards away. She estimated that the noise of the helicopter lasted about two and a half to three minutes.

At approximately 1245 hrs, the driver of a small van was travelling south on the B3170 and had just passed the crossroads on the top of the Blackdown Hills at North Down, near the hamlet of Holman Clavel. He was driving alongside a copse, which was on his right, and passing a lay-by on his left when he heard a loud 'whoosh' of helicopter rotor blades above the noise of his car radio and the vehicle's diesel engine. The noise came from the driver's left hand side. He estimated the visibility at 80 to 100 ft, in fog and did not see the aircraft. At about the same time another driver of a car travelling in the same direction on the same stretch of road (probably just in front of or behind the previous vehicle) had a very similar experience. A noise, which she stated was clearly that of a helicopter, flying from left to right above her, was loud enough to make her duck down inside her car. This driver was also unable to see the aircraft.

Three people who were amongst some farmyard buildings, which are situated 300 m to the east of the accident site, heard the sound of a helicopter flying low overhead at about 1230 hrs. The noise lasted about five seconds and towards the end of this period it sounded to one of these ear witnesses as if the helicopter was banking and power was being increased. The noise then ceased and they concluded that the aircraft had flown over the nearby trees and down the north side of the Blackdown Hills. In the very poor visibility and low cloud they, too, did not see the helicopter.

Meteorology

A meterological aftercast showed that, at 1200 hrs on the day of the accident, there was a warm front orientated north-west south-east, lying along a line passing through Chivenor, in north Devon, and Jersey. This front was moving very slowly north-east. Ahead of the front lay a moist, light to moderate, south-easterly flow over the Somerset area with moist, warm air overlaying colder air near the surface. The resultant surface weather included rain and drizzle with low cloud covering some hills in the accident area. The general visibility was between 3,000 and 5,000 m in slight rain and drizzle, reducing to 100 to 1,500 m in moderate rain and drizzle, with accompanying low cloud over the hills. The freezing level was at 2,000 ft amsl and the cloud cover consisted of broken and overcast stratus with a base between 600 and 1,000 ft amsl. Multi-layered cloud probably existed above that up to 20,000 ft amsl. The wind at 1,000 ft amsl was 170º/15 kt and the temperature at that level was approximately +4ºC.

The weather at Staverton Airport, when the aircraft took off, was good. The visibility was in excess of 10 km, the wind was calm, there were a few medium level clouds and the surface temperature was +1ºC. At the same time at Exeter, the visibility was 7,000 m in light drizzle; there was scattered cloud with a base at 800 ft aal and broken cloud at 1,000 ft aal.

For the weather en route, a Terminal Area Forecast (TAF) for Bristol Airport, issued at 0615 hrs, predicted a 30% probability of a temporary change during the period between 0700 hrs and 1600 hrs, when the visibility would reduce to 3,000 m, the cloud base would descend to 500 ft aal and there was the possibility of light rain and snow.

On the morning of the day of the accident, the pilot would not have had access to the meteorological facilities at Staverton Airport before he departed because the airfield was closed. It is not clear what weather forecasts he did obtain, if any, but a number of sources would have been available to him. Exeter Airport operating hours that day were notified as being between 0530 hrs and 2000 hrs, and a TAF, timed at 0752 hrs, was issued for the airfield for the period 0800 hrs to 1600 hrs. It forecast that during that period there was a 30% probability of a temporary change when the visibility would reduce to 2,000 m in rain and drizzle and the cloudbase would be scattered at 200 ft aal and broken at 400 ft aal. The pilot may have contacted ATC at Exeter by landline before he took off from Staverton to request their recent meteorological observations and any forecast, but such calls are not logged. Even if he had not, he would have been able to request that information during the flight from any ATC unit which he was in contact with at the time.

At 1220 hrs, when G-BXLI took off from the playing field at Topsham, an observation at Exeter Airport recorded the visibility as being 5,000 m in light rain and drizzle, with a scattered cloud base at 600 ft aal and broken cloud at 1,000 ft aal. The surface temperature was +7ºC.

Two automatic synoptic observations at Dunkeswell Airfield (elevation 830 ft amsl and 6.5 nm to the south-west of the accident site), taken at 1200 hrs and 1300 hrs respectively, recorded a surface wind of 140º/7 kt, changing to 140º/9 kt, visibility reducing from 1,500 m in rain to 200 m in rain and the cloud base descending from 100 ft aal to ground level. In that hour the surface temperature at Dunkerswell rose from +3.5ºC to +4.2ºC.

The pilot

The pilot started flying in June, 2000, at the age of 50 years, and he gained his Joint Aviation Authorities (JAA) Private Pilot Licence (Helicopter) (PPL(H)) a year later with a rating to fly the Robinson R22 helicopter. In December 2001, he added the rating for the Bell 206 Jet Ranger to his licence. He retained the ratings for both types until June 2004 when his R22 rating lapsed. Of the two types, he had predominantly flown the Bell 206 after July 2001. From June 2003 he flew exclusively in G-BXLI, which he had purchased with a friend a month earlier.

Between January and March 2004 the pilot completed the training for a Night Qualification (Helicopter). This included a minimum of 10 hours dual helicopter instrument instruction, which was in addition to the five hours of instrument flying instruction required during his PPL(H) training. In all he completed 11.6 hours of instrument flying instruction and the qualification entitled him to act as pilot in command of a helicopter at night. However, he had not completed the training for, or been issued with, an instrument rating. His instructor commented that the pilot would find flying in cloud difficult. Without an instrument rating he was not qualified to do so.

The pilot had a current Class Two JAA Medical Certificate, with a limitation that he '*shall have available corrective lenses'*. He was known to have had a pair of spectacles with him on the day of the accident.

The pilot was described by friends and relatives as being a 'larger than life' character for whom landing on the playing field would have been an adventure. However, it was understood that, at the same time, he would have been careful about the safety of others.

Procedures

Rule 5(1)(e) of the Rules of the Air Regulations 1996, as contained in the Air Navigation Order 2000, states that:

> *'an aircraft shall not fly closer than 500 feet to any person, vessel, vehicle or structure'.*

In paragraph (2)(d)(i) of the same rule it states that this restriction:

> *'shall not apply to any aircraft while it is landing or taking-off in accordance with normal aviation practice'.*

The accident flight was being conducted under the Visual Flight Rules (VFR). For helicopters flying at or below 3,000 ft amsl, these rules require the meteorological conditions to be such that the aircraft can remain :

> *'clear of cloud and in sight of the surface'.*

If unable to maintain these Visual Meteorological Conditions (VMC) then the pilot is required to fly according to the Instrument Flight Rules (IFR).

In order to comply with IFR, outside controlled airspace,

> *'an aircraft shall not fly at a height of less than 1000 feet above the highest obstacle within a distance of 5 nautical miles of the aircraft unless:*

(a) it is necessary for the aircraft to do so in order to take off or land;
(b) the aircraft is flying on a route notified for the purposes of this rule;
(c) the aircraft has been otherwise authorised by the competent authority'.

The Joint Aviation Requirements (JAR) Flight Crew Licensing (FCL) requirement JAR–FCL 2.175(a), entitled 'Circumstances in which an IR(H) is required', states that:

'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 (IR) appropriate to the category of aircraft issued in accordance with JAR–FCL'.

The Aircraft Flight Manual states that the:

'engine anti-ice shall be ON for flight in visible moisture in temperature below 4.0ºC (40ºF').

Failure to do so would eventually risk the build up of ice in the engine intake as the temperature dropped further towards and below 0ºC, with consequent reduction in power and, eventually, possible engine failure.

The helicopter was not approved for IFR operations.

ATC procedures

The aircraft was flying outside controlled airspace and the pilot was not required to communicate with ATC. However, he had called Exeter ATC after taking off from the playing field in Topsham for the return flight to Staverton and Exeter ATC provided a Flight Information Service (FIS).

The Manual of Air Traffic Services (MATS) Part 1 states that:

'a FIS is a non-radar service supplied, either separately or in conjunction with other services, for the purposes of supplying information useful for the safe and efficient conduct of flights. Under a FIS the following conditions apply: a) Provision of the service includes information about weather, changes of serviceability of facilities, conditions at aerodromes and any other information pertinent to safety….'. Also, 'the controller may attempt to identify the flight for monitoring and co-ordination purposes only. Such identification does not imply that a radar service is being provided or that the controller will continuously monitor the flight'.

Under a FIS a pilot is responsible for his own navigation and collision avoidance.

Under the heading '*Section 5 Emergency Procedures'*, MATS Part 1 states that:

'a controller may suspect that an aircraft is in an emergency situation when …… radio contact is lost ..... it is overdue at an aerodrome'.

As regards radio failure procedures, MATS 1 states that:

'radio failure procedures shall be adopted when: a) an aircraft is observed to have selected SSR Mode A, code 7600, and the pilot does not respond to ATC communication….'

Regarding 'overdue action', MATS Part1 states that:

'overdue action is not related solely to the filing of a flight plan. If, at any stage of a flight the pilot has

made his intentions clear and subsequently does not arrive or report when expected, controllers should seriously consider taking overdue action.'

Air Traffic Services in the United Kingdom also include an Alerting Service. This is explained in MATS Part1 as being:

'available for all aircraft which are known by the air traffic services to be operating within United Kingdom flight information regions. The responsibility for initiating action normally rests with the air traffic service unit which was last in communication with the aircraft in need of search and rescue aid or which receives the news from an outside source'.

Further:

'approach and aerodrome control units, when they are aware that an aircraft is in need of search and rescue aid, shall immediately:

a) set in motion the local rescue services and emergency organizations…. and/or
b) notify by telephone the watch supervisor at the parent ACC'.

At the ACC 'whenever it is reported from any source that an aircraft within a flight information region is in need of search and rescue aid the area control centre watch supervisor shall initiate emergency action unless it is known that the appropriate rescue organisation has already been alerted.'

In the case where an aircraft is not known to have force landed or crashed the Area Control Centre (ACC) watch supervisor will notify; D&D, ARCC, the appropriate police authority and the aircraft operator. The ARCC controller is responsible for initiating search and rescue action. MATS Part 1 indicates that 90 minutes may elapse from the time when an aircraft was expected at a certain point, and has failed to appear, and a search and rescue operation begins. During that time enquiries will be made to try and establish the whereabouts and safety of the aircraft.

Accident site details

The aircraft had flown into a small copse of trees, coming to rest approximately 50 m west of the B3170 road. The impact track of the aircraft was 300ºM. The road marked the eastern boundary of the copse, with the southern edge some 40 m to the south, beyond which was a level grass field. It was evident that the helicopter initially had struck the upper branches of a tree before striking the ground 28 m further on. The branches were up to 5 cm in diameter and several were found close to the base of the tree, along with most of one tail rotor blade, honeycomb material from the main rotor blades, the broken-off lower portion of the vertical stabiliser and numerous fragments from the cockpit glazing. Some of these were blue-tinted, indicating that they were from the windows in the rear doors.

The height of the truncated tree was around 14 m, which, together with the ground impact position, indicated a flight path angled 26º down relative to the horizontal. The marks on the ground appeared to have been made by the skids and the fuselage underside; together they suggested that the helicopter's attitude at impact had been erect and with the nose high. The skid marks were approximately parallel to the impact track, which indicated that there had been no significant yaw angle. An additional mark, to the rear of those made by the skids, appeared to have been made by the stub of the vertical stabiliser.

After striking the ground, the aircraft had rolled to the left, breaking up as it did so, before coming to rest some 12 to 13 m further on. It was clear that the skids had splayed on impact with the ground, with the downwards momentum of the engine and transmission most probably contributing to the destruction of the cabin. The overall impression given by the disposition of the wreckage was that the helicopter had struck the ground with a high rate of descent coupled with a relatively low forward speed, estimated to have been around 30 to 40 kt. This in turn suggested that the aircraft was already in a descent at the time it struck the top of the tree.

One of the main rotor blades had been all but severed close to its quarter span position, remaining attached by the trailing edge strip. Both main rotor blades had sustained considerable damage to their undersides as a result of striking the tree branches, although there was a lack of heavy leading edge damage.

The mid-section of the tail boom, including the horizontal stabiliser, was found lying approximately 30 m to the north of the main wreckage, ie, to the right of the flight path. It was apparent that it had sustained two main rotor blade strikes. One was on the tail rotor drive shaft cover on top of the boom, with the second being a substantial impact underneath the left horizontal stabiliser[4]. On an intact aircraft, the rotor disc would have to be tilted at an angle of around 20º relative to the axis of the tail boom in order to strike the stabiliser at this point. However, the angle was measured to be around 10º, which led to the conclusion that the strike occurred on the ground as a result of the structural disintegration of the tail boom and fuselage. The near-simultaneous ground contact of the skids, rear fuselage underside and the stub of the vertical stabiliser probably initiated the tail boom failure in two places. The upwards deflection of the central section, relative to the rotors, would have allowed it to be struck by a blade, with the force of the impact throwing it to the right. The rear portion of the tail boom, which included the tail rotor and gearbox, had continued along the ground and had come to rest a few metres to the right of the main wreckage.

A one metre length of the left skid assembly was found close to the separated part of the tail boom and a heavy indentation on it suggested that this too may have been struck by a main rotor blade. It is possible that the piece of the skid broke off on impact and was thrown to the right after being struck by a blade, in a similar manner to the tail boom section. The weakened left skid assembly may have accounted for the aircraft rolling over to the left following impact with the ground.

There was no fire, although a strong smell of fuel was apparent around the main wreckage. The bladder-type fuel tank, which had been located behind and beneath the rear seats, had remained substantially intact apart from one significant hole, through which fuel had escaped into the ground.

Following the on-site assessment, the wreckage was recovered to the AAIB's facilities at Farnborough for a detailed examination.

Detailed examination of the wreckage

Airframe

As noted earlier, the severe disruption to the fuselage structure was attributed to the high descent rate. Further evidence of this was provided by the manner in which the transmission deck had been 'dished' by the mass of the main rotor gearbox. The movement of the gearbox

Footnote

[4] The main rotor on a Bell 206 rotates in an anti-clockwise direction when viewed from above.

had caused failure of some of the flying control linkages between the bellcranks on the front of the gearbox and the hydraulic actuator cradle mounted on the forward part of the deck. It was also apparent that that a flange on the free-wheel unit at the rear of the gearbox had been in violent contact with the isolation mount located immediately below, to the extent that it had machined a groove in it. The resultant damage to the free-wheel assembly had allowed most of the gearbox oil to leak out after the impact. Otherwise, the gearbox was smooth in operation and the oil filter was clear.

Power for the hydraulically boosted flying controls on this type of aircraft is provided by a hydraulic pump, with integral fluid reservoir, mounted on the front of the gearbox. The vertical movement of the gearbox during the ground impact had caused the underside of the pump and its associated pressure transmitter to contact the deck, damaging the transmitter housing. The reservoir was empty, although it was apparent that the fluid had escaped after the accident via a crack in the pressure transmitter housing. The filter element was examined and found to be clear. The pump was intact, as was the drive from the main rotor gearbox.

The flying control linkage was extensively disrupted, especially those components located underneath the floor. However, there was no evidence that any of the failures had occurred prior to impact.

Elsewhere on the airframe, the instrument binnacle was reasonably intact, and the instruments were all at their normal power-off indications. The altimeter subscale was set at 1018 mb, which was the pressure setting passed to the aircraft by Exeter ATC shortly before the accident. The fuel valve ON-OFF switch was found in the OFF position, although it was clear that its associated guard, which prevents inadvertent OFF selection, had received a blow during the impact. However, the motorised valve itself was found to be in the open position. Other switches included the hydraulic power, which was ON and the engine anti-icing valve, which was OFF.

The central warning panel (CWP) caption segments had remained intact and the light bulbs were examined for evidence of stretched filaments[5]. Particular attention was paid to the LOW NR (low rotor rpm) and ENG OUT captions: however no evidence was found of any bulb being illuminated at impact. Whilst this suggested that no technical malfunction had occurred prior to impact, it should be noted that the behaviour of bulb filaments can vary according to the severity of the impact and the bulb manufacturer.

Engine

Prior to removing the engine from the airframe, the accessory gearbox oil filter and magnetic chip detector were examined and found to be clear. The fuel nozzle and its associated screen were also removed and found to be normal in appearance. When removing the nozzle it was observed that the line between the nozzle and a check valve was full of fuel, thus showing that the engine fuel system was primed. There was fuel in the filter bowl and the filter element was clean. The engine had sustained little visible damage, although the power turbine rubbed against its shroud when turned by hand; it was thus not possible to run the engine in a test cell.

The engine anti-ice valve on this type of aircraft is driven by an electric motor. It was observed that the valve was in the OFF position, which agreed with the

Footnote

[5] When bulbs are illuminated, the heated filaments become extremely ductile and an impact can result in extensive filament stretching within the glass envelope. This feature can thus provide evidence that the bulb was lit at impact.

switch position, noted earlier. It was additionally noted that the throttle twist grip was at the 'idle' setting, which agreed with the as-found position of the throttle arm on the engine fuel control unit. However, this apparently corroborative evidence was not considered reliable, as the connecting linkage had been severely disrupted in the impact.

The engine was taken to an overhaul agency and subjected to a strip examination, which was overseen by the AAIB and a representative from the engine manufacturer. No evidence of failure or malfunction was found in any of the components, although there were two noteworthy features. The first was an area of rubbing where the centrifugal compressor wheel had contacted the surface of the compressor diffuser. This was over the twelve o'clock to three o'clock area, when viewed from the front, and most probably occurred when the aircraft rolled over to the left during the ground-slide. The second feature was the presence of solidified aluminium alloy spatter in the turbine section, especially on the third stage nozzle assembly. This was caused by material shaved from the diffuser that had melted as it passed through the combustion section, before solidifying as it contacted the turbine blades and nozzles. This provided evidence that the engine was functioning at impact.

The engine fuel components, comprising the fuel control unit, the power turbine governor and the fuel pump were each subjected to a 'production test' on a dedicated test rig; no faults were found.

Recorded Data and other Recovered Information

Sources

There were several sources of recorded information used for the purpose of this investigation. The aircraft had two GPS receivers fitted, a digital camera was recovered from the wreckage and Burrington radar, some 30 nm to the west of the accident site, had recorded the aircraft's movements. Also, the ATC radio conversations with the helicopter had been recorded, and the appropriate tapes were impounded and replayed.

GPS

The two GPS receivers fitted to the helicopter, a Garmin GPS150 and Skyforce Skymap IIIc, were examined. The GPS150 did not record track information but the Skymap IIIc, although damaged, was successfully downloaded at the manufacturer's facility, using donor parts to replace damaged components. The download yielded flight logs, the last position fix of the unit and a screen shot of the map display at the final fix position. The flight logs covered flights from 10 October 2004 up to the accident flight, and recorded snapshots of GPS latitude, longitude, GPS altitude, ground speed and magnetic track once every 30 seconds. On this type of GPS receiver, flight logs are initiated when the ground speed exceeds 20 kt and terminated when either the aircraft speed drops below 3 kt, power is removed from the unit or the unit can no longer detect a valid position for reasons that include loss of sight of sufficient satellites or disconnection of the antenna.

Figure 1 shows the two GPS tracks recorded on the day of the accident. The first flight of the day departed from Gloucester airport, and the first track point was recorded at 0827 hrs with the helicopter in the air. The flight ended at 0929 hrs at Topsham, south east of Exeter. The second flight, during which the accident occurred, departed Topsham at 1219 hrs. The last flight log point recorded was at 1241:29 hrs just south of Priors Park Wood, approximately 5 nm south of Taunton.

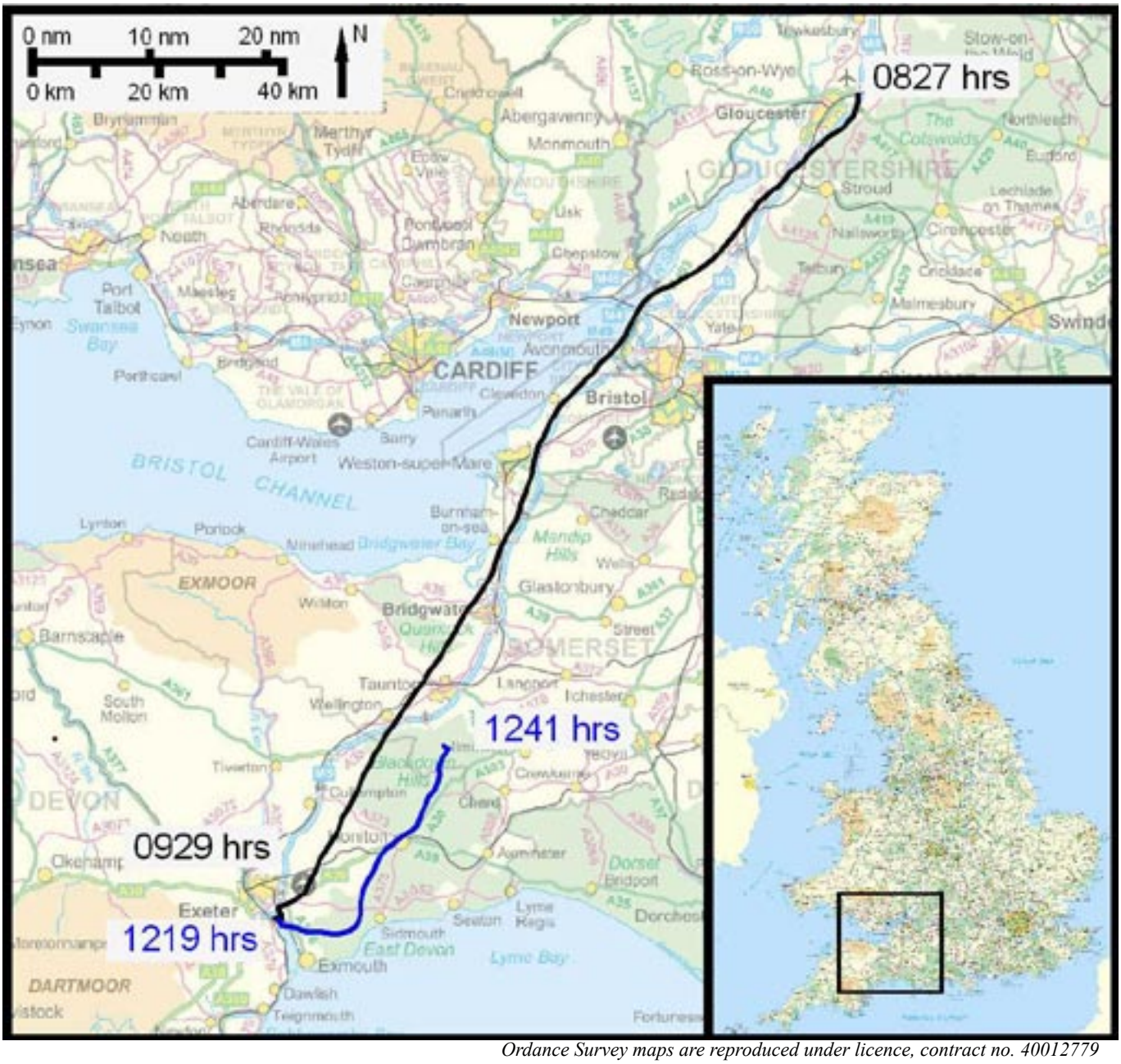

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Figure 1

G-BXLI's flight tracks on the day of the accident

Figure 2 shows the flight path of the accident flight overlaid on a map of the terrain. During this flight, the aircraft initially tracked east and crossed a ridge. The helicopter then flew north-east, following a valley floor at approximately 400 ft agl with an average ground speed of approximately 80 kt. The valley floor elevation increased as the flight progressed. The flight terminated at a location where the valley floor effectively merged with the Blackdown Hills, Figure 3, and this was the last ridge of hills on track before the terrain fell away towards Taunton and the M5 motorway. A minute or so before the flight log terminated, in the vicinity of Moor, Westhay and Walland Farms, the aircraft slowed appreciably, dropped in altitude and significantly changed its heading. The low sample rate of the GPS did not afford more detailed description of the manoeuvring at the end of the flight.

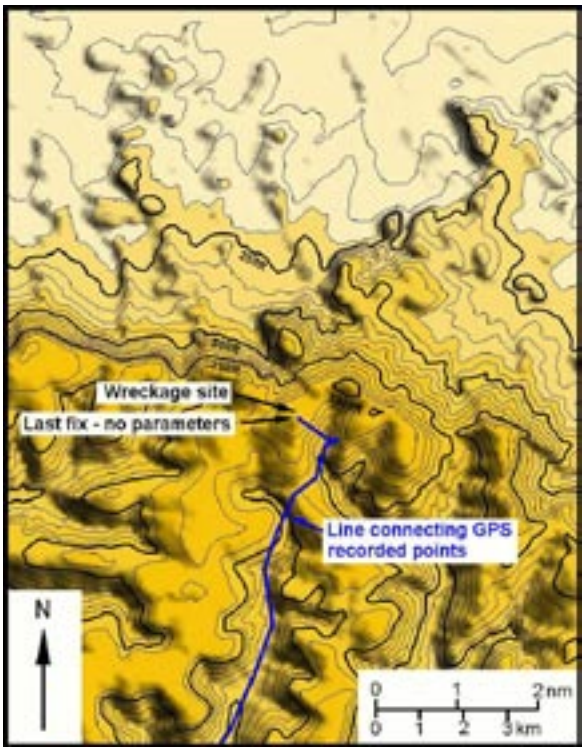

Figure 3

End section of the accident flight in relation to terrain height

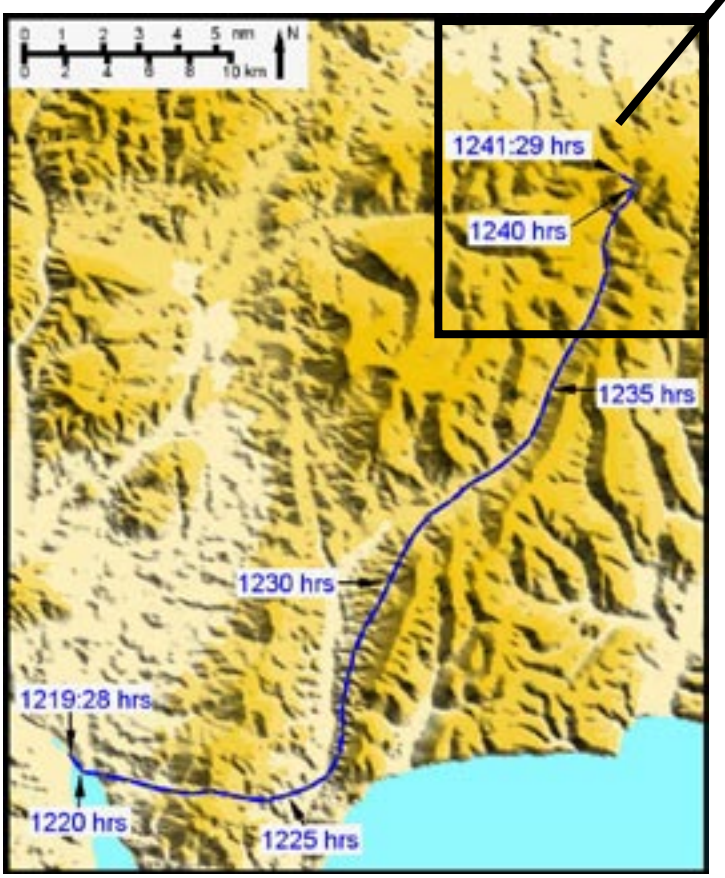

Figure 2

Accident flight track overlaid on a terrain map

The GPS map display was also downloaded and is shown in Figure 4. This represents the map display at the point of the final fix. The colour coding of the display indicates that lower ground was not far to the north-east of the final fix location.

Radar

The aircraft was tracked by Burrington radar, which is located in Devon some 30 nm to the west of the accident site. Due to the low altitude nature of the accident flight, combined with the terrain between the radar head and the aircraft, the radar track consisted of fragmented secondary radar returns with only small parts of the track covered by combined primary and secondary returns. The secondary radar recordings did not include any altitude information. This indicates that the altitude reporting capability (mode C) or the aircraft ATC transponder was not active at the time. Analysis of the limits of line of sight of the radar in the vicinity of the aircraft confirmed that the GPS altitude data, which is prone to larger errors than the GPS lateral position data, was reasonable.

Photographs

A digital camera was recovered from the wreckage which, when its flash card was downloaded, contained photographs taken throughout the day of the accident. Each image had an information 'label' listing, amongst other things, the date and time. Whilst it was clear that the date was correct, it was necessary to assess the accuracy of the clock. This was achieved by examining aerial images taken of known geographic locations en route and comparing the camera times with the accurate GPS times at those locations. The final image was taken from the rear left seat position in the helicopter,

Figure 4

Screen shot of G-BXLI's final GPS fix.

(The 'No Fix Possible' message reflects the fact the antenna is disconnected from the receiver so the location cannot be updated.) The distance between the last fix location and the wreckage was approximately 100 m.

and showed most of the windscreen and some of the instruments. The camera time was 1342 hrs, which was corrected to 1238:00 hrs ± 40 seconds, ie, approximately 4 minutes prior to the time that the helicopter struck the ground. The image showed raindrops on the windscreen but nothing distinguishable through it, other than varying shades of grey. The grey colour was slightly darker towards the bottom of the right hand windscreen. This contrasted with the earlier photographs in which the countryside, where included in the frame, could be seen outside the helicopter.

The image was subjected to an enhancing process and compared with a photograph of the same instrument panel taken on a previous occasion. From this comparison it was possible to discern the following instrument readings:

Airspeed:	70 kt
Barometric altitude:	1,120 ft
Attitude:	10º (approx) right bank, (approx) 1º nose up
Rate of climb:	500 fpm
Heading:	020º

It was also possible to determine that none of the CWP captions were illuminated. The NAV flag was in view on the Horizontal Situation Indicator (HSI), showing that there was no valid VHF omni-directional range (VOR) navigation aid tuned, but the HDG (heading) flag was out of view.

On the overhead panel, the battery and generator switches could be seen to be in the ON positions, and the instrument lights rotary selector was in the OFF position. The navigation lights were selected ON but the pitot heat was OFF and the cabin vent and blower switches appeared to be in the ON position.

The GPS display, which was mounted on top of the instrument binnacle, showed a map on which part of the north Somerset coast could be seen. The definition was insufficient to read any numbers from the display but it was sufficiently clear to compare to the downloaded GPS map display, Figure 3, from the final fix position. It was established that the photograph was taken within 0.25 nm of a position 1.8 nm south and 0.1 nm west of the final GPS fix for the aircraft. This lies on the GPS recorded path, equating to the period between 1237:55 hrs and 1238:25 hrs, ie, three to four minutes before the last recorded 'in air' position. This timing compared well with the other calculation of the timing of the photograph. This final image, together with others, also clearly showed that the front left and rear right seat passengers had their lap and diagonal straps fastened. Those of the remaining occupants were not visible.

Analysis

No evidence was discovered of any technical failure in G-BXLI before it struck the tree in the copse where the wreckage was found.

At about the time of the crash, at 1242 hrs, a helicopter was seen flying around at low level, about 50 ft agl, possibly looking for a suitable place to land. The weather conditions at the time were very poor. These sightings were consistent with the nature and timings of the data that was recovered from the GPS receivers fitted to the aircraft, and radar recordings.

Earlier in the day the pilot had landed the helicopter on a playing field in Topsham, on the north bank of the River Exe, because deteriorating weather conditions had prevented him from continuing south to his planned destination near Torquay. At Exeter Airport, three nautical miles to the north-north-west, the weather was also suitable for a landing and facilities were available for the passengers, the helicopter, flight planning and for obtaining meteorological information. Exeter Airport

would have been the most suitable place in the locality for the helicopter to divert to, as the chosen landing site was an 'uncontrolled' public area. However, the pilot's decision to land at Topsham demonstrated that he was not reluctant to land off airfield due, in this case, to worsening weather conditions. In the event, a safe landing was carried out.

Having made the decision to land, it is not clear why the pilot later continued with the return flight to Staverton Airport in deteriorating weather conditions and, particularly, why he chose a route that took the helicopter over some of the highest terrain between Topsham and Staverton. His decision may have been influenced by his usual practice of flying from Torbay to Staverton via Dunkeswell, which actually lay to the west of the route taken on the accident flight. By contrast, the southbound route they had flown in the morning had notionally followed the M5 motorway over a region of lower lying terrain.

The last photograph taken on the flight, by the passenger who was sat in the left rear seat, shows the GPS display situated on the top of the instrument panel. In contrast with other photographs taken by the same camera on that day's flights, there was no visible countryside in this picture beyond the windscreen, just a general greyness, suggesting that the helicopter was flying either in cloud or in very poor visibility. In such conditions, the GPS display may well have assumed a greater significance than normal, to the pilot, as an aid to navigation.

The pilot had received a limited amount of instrument flying training in the past, consistent with his qualifications as the holder of a PPL(H) and a night rating. He did not hold a rating to fly in Instrument Meteorological Conditions (IMC) and his instructor had commented that the pilot would have had difficulty flying in cloud. Also, the helicopter itself was not approved for IFR operations. During the latter part of the accident flight G-BXLI was flying well below 500 agl and within 500 ft of persons, vehicles and structures; all the evidence suggesting that the aircraft was forced to fly ever closer to the rising ground on his track because of the cloudbase. Even though the aircraft's general drift was northbound, the pilot may, in the later stages of the flight, have been looking for a suitable place to land in the very poor visibility. With the pilot's experience and the relatively low amount of instrument flying training he had received, he would, at best, have found the conditions extremely challenging. The helicopter was last seen at very low level and, following that sighting, it appears that G-BXLI flew up the moderately steep side of the valley in which it had just been manoeuvring. It is considered possible, or even probable, that, as the ground levelled off at the top of the slope, the helicopter continued climbing into the cloud, carried on by its inertia, resulting in the pilot losing all visual cues before he could arrest the rate of climb. This seems to be the time when five witnesses briefly heard a low flying helicopter, but did not see it, in the low cloud and limited visibility. It was immediately after this that the aircraft is believed to have flown into the copse and hit the ground.

The investigation concluded that the helicopter's flight path angle was some 26º down just before it crashed. The combination of the aircraft's estimated forward speed of 30 to 40 kt and this angle, would result in a rate of descent of approximately 1,500 fpm. This suggests that either the pilot was attempting to regain visual contact with the ground or, possibly, that he was aware that the north side of the Blackdown Hills are steep sided and believed that the helicopter was sufficiently far north to be able to descend through cloud to become visual with the ground over lower lying terrain, as indicated in Figure 3.

As the helicopter descended, the pilot would have had little time to react on seeing the rapidly approaching ground. Any action he did take was likely to have reduced a higher rate of descent prior to impact. It was considered that the damage to the underside of the MRBs could have resulted from a rapidly applied aft cyclic pitch setting as the aircraft descended through the trees. Although the lack of leading edge damage could be interpreted as an indication of a low power/ low rotor condition at impact, the lack of any evidence of a stretched filament in the LOW NR warning caption bulb suggested that the rotor speed was not unduly low. It was subsequently observed that the throttle twist grip was at the 'idle' setting, which agreed with the as-found position of the throttle arm on the engine fuel control unit. However, this apparently corroborative evidence was not considered reliable, as the connecting linkage had been severely disrupted in the impact.

The outside air temperature was about +4ºC in the vicinity and at the time of the accident. This is the temperature at which the engine anti-ice system should have been selected on. The switch was subsequently found in the OFF position. However, it is not believed that this was a factor in the accident since, immediately before the accident, the aircraft had sufficient power to perform low speed manoeuvres and climb out of a valley.

The responsibility for initiating alerting action:

> *'normally rests with the air traffic service unit which was last in communication with the aircraft in need of search and rescue aid or which receives the news from an outside source'.*

However, there were a number of understandable reasons why there was a delay in starting this procedure following the accident. The pilot had not submitted a flight plan and had not given an estimated time of arrival other than the original plan to return to Staverton at about 1800 hrs. Under the FIS service that he was receiving from ATC, he was responsible for his own navigation. Although MATS Part 1 states that:

> *'a controller may suspect that an aircraft is in an emergency situation when radio contact is lost .....',*

it is not unknown for aircraft undertaking private flights, as G-BXLI was, to leave a radio frequency without advising ATC. ATC personnel did not have the benefit of knowing that a member of the public had reported hearing a helicopter, and then a bang. Conversely, the police were not aware that Exeter ATC had lost radio contact with G-BXLI or that they had experienced intermittent radar contact with the helicopter, which disappeared at approximately the same time as the bang had been heard. Had each agency been aware of these facts, it is more than likely that a search and rescue operation would have been initiated at that point. Bearing in mind that the helicopter had also landed away from an airfield earlier in the day because of poor weather, it was understandable that the loss of radio contact was followed by general enquiries by ATC, rather than any assumption that it had crashed. In addition, the nature of the terrain where the pilot might have chosen to land could have masked any radio calls from the helicopter advising Exeter ATC of his intentions.

In the event, it was Staverton ATC who alerted LACC following the unanswered calls made to the helicopter occupants' mobile 'phones and the lack of any other contact. One hour and ten minutes after LACC were alerted, the D&D cell at West Drayton was advised and they initiated overdue action a further 35 minutes later. With the benefit of hindsight, it is possible to appreciate

that if the search and rescue action had been started at the time when the one member of the public had reported hearing a bang, and the search had been centred on the position of the last radar contact, then the aircraft might have been found much more quickly

The CAA's General Aviation Safety Sense Leaflet 17c, entitled *Helicopter Airmanship*, contains advice on the meteorological factors to consider when planning a flight. Included is the advice to:

> *'not let 'Get-there/home- itis' influence your judgement. Establish clearly in your mind the current en-route conditions, the forecast and the 'escape route' back to good weather. Take account of the freezing level. Plan a more suitable route if you are likely to fly over high ground which may be cloud covered'.*

Safety Recommendations

The helicopter had originally been issued with a Certificate of Airworthiness in the Transport (Passenger) category by the Civil Aviation Authority, and would have been defined as a Commercial Air Transport (CAT) aircraft. However, at the time of the accident, G-BXLI possessed a valid EASA Certificate of Airworthiness (CoA) in the 'Standard Category', and would be defined under the terms of the UK Air Navigation Order (ANO) as a 'Public transport aircraft'[6]. Even so, it was not in the weight category of helicopter which requires a cockpit voice recorder to be installed.

Although there are no requirements for helicopters such as G-BXLI to carry any equipment for recording flight parameters or cockpit audio information, on this occasion data retrieval from the Skymap IIIc GPS yielded altitude and positional information that would otherwise have been unavailable or less detailed. This enabled an understanding of the last flight, but not the reason for the pilot's decision to return to Staverton on a track which took him over high ground in poor weather conditions. The investigation of this accident would have been enhanced had audio and basic flight parameter recordings been available. Thus, in accidents where there is extensive disruption of the aircraft, it may not be possible to determine the causal factors from wreckage analysis and witness evidence alone. This has proved to be the case in a number of accident investigations, including two recent ones; Hughes 369HS, G-CSPJ (AAIB Bulletin 1/2005), and Cessna 206 G-BGED (AAIB Bulletin 11/2005). In both cases, the reasons for the accident were not established. Before appropriate recording equipment can be developed, however, it is necessary to develop a minimum performance specification. To this end in the report on the accident to G-BGED the AAIB made the following recommendation:

> ***'Safety Recommendation 2005-062***
>
> *It is recommended that the European Aviation Safety Agency [EASA] develop standards for appropriate recording equipment that can be practically implemented on small aircraft.'*

Also, two safety recommendations, 2004-084 and 2004-085, were made as a result of the investigation into the accident to G-CSPJ, and these are reproduced below:

> ***'Safety Recommendation 2004-084***
>
> *The Department for Transport should urge the International Civil Aviation Organisation (ICAO) to promote the safety benefits of fitting, as a minimum, cockpit voice recording equipment*

Footnote

[6] w.e.f. 28 September 2004, UK national CoAs were deemed to be EASA CoAs. The relevant definition of 'Public transport aircraft' was contained in Article 129 of the ANO 2000, which was in force at the time.

to all aircraft operating with a Certificate of Airworthiness in the Commercial Air Transport category, regardless of weight or age.'

'Safety Recommendation 2004-085

The Department for Transport should urge the International Civil Aviation Organisation (ICAO) to promote research into the design and development of inexpensive, lightweight, airborne flight data and voice recording equipment.'

In a letter to the AAIB, dated 14 October 2004, the Department for Transport gave its full support to these recommendations.

With EASA now assuming responsibility for matters of airworthiness within the European Community, the following two recommendations are made:

Safety Recommendation 2005-100

The European Aviation Safety Agency should promote research into the design and development of inexpensive, lightweight, airborne flight data and voice recording equipment.

Safety Recommendation 2005-101

The European Aviation Safety Agency should promote the safety benefits of fitting, as a minimum, cockpit voice recording equipment to all aircraft operated for the purpose of commercial air transport, regardless of weight or age.