ACCIDENT

Aircraft Type and Registration:	Agusta Bell 206B Jet Ranger II, G-SUEX
No & Type of Engines:	1 Allison 250-C20B turboshaft engine
Year of Manufacture:	1978 (Serial no: 8567)
Date & Time (UTC):	16 September 2014 at 1241 hrs
Location:	Flamborough Head, Yorkshire
Type of Flight:	Public Transport (Helicopter)
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Fatal) Passengers - 1 (Fatal)
Nature of Damage:	Destroyed
Commander's Licence:	Commercial Pilot's Licence (Helicopter)
Commander's Age:	58 years
Commander's Flying Experience:	Estimated 4,000 hours (of which n/k were on type) Last 90 days - n/k hours Last 28 days - n/k hours
Information Source:	AAIB Field Investigation

Synopsis

The helicopter was on a transit flight, at low level, on the seaward side of cliffs near Flamborough Head, Yorkshire. Loss of power from the single engine probably led the pilot to attempt an autorotation to the cliff top. This was unsuccessful and having lost rotor rpm the helicopter struck the surface of the sea at the base of the cliffs. Both the pilot and his passenger were fatally injured.

Background

The helicopter was based in the south of England but had operated a series of flights in locations across Scotland during the weekend. It was scheduled to depart from its temporary base at Bankhead Farm, near Edinburgh, and position back to the company's base at Manston on Monday, 15 September 2014. However, the weather was not suitable for the flight and the pilot delayed his departure.

History of the flight

On Tuesday, 16 September the weather near Edinburgh had improved and the pilot, accompanied by a friend, departed with the intention of initially flying to Humberside Airport to refuel. The pilot was in the front right seat and his passenger occupied the front left seat.

The helicopter initially routed overland and reached the east coast about 20 nm north of Newcastle upon Tyne. It then proceeded south along the coast. Radar data, combined with eyewitness accounts, suggested that the helicopter's track varied from being over the land to being over the sea. The evidence indicated that, during this stage of the helicopter's transit, it operated at times at less than 100 ft above sea level.

At about 1130 hrs, the helicopter landed in a field near Boggle Hole car park, near Robin Hood's Bay, Yorkshire. The landowner, having heard the helicopter, located it at about 1150 hrs. He described the weather as thick fog, with visibility about 50 m. He reported that he offered the crew accommodation or a lift to a nearby train station but his offers were not taken up, so he left to continue with other activities and did not see the helicopter when it departed.

Prior to landing, the pilot had been in radio contact with Durham Tees Valley ATC and, after landing, he phoned them to confirm that he had landed. At 1137 hrs, the pilot phoned Humberside Airport, 50 nm to the south, to confirm their weather and check that, when he was able to depart, he could continue to use the assigned transponder code. On the phone recording the pilot advised the ATCO that he estimated he would be on the ground for up to an hour. The ATCO told the pilot that Humberside's cloudbase was broken at 700 ft and overcast at 1,100 ft. He said the weather was due to improve in the next 30 minutes, with the cloudbase lifting to 1,800 ft and the visibility increasing to 9 km.

It was reported that, while on the ground the pilot also telephoned a member of staff at his company. This call was not recorded. The staff member later recalled the pilot telling him that he had tried to route around bad weather, by heading offshore, but that he had encountered further bad weather and had returned inland. He also recalled the pilot saying that he was due to carry out his Operator's Proficiency Check (OPC) that afternoon. He informed the staff member that, in order to conduct his OPC, he would route to Biggin Hill Airport after Humberside.

No further relevant messages were received by the company or air traffic service providers to advise them that the helicopter was departing from the field landing site.

Subsequently, a witness in a house 100 m from the top of the cliff at Hunmanby Gap, about 17.5 nm south of Robin Hood's Bay, saw the helicopter flying along the coast and estimated that it was no more than 60 ft above the foreshore. He described there being a heavy sea fog, with visibility on the shore between 800 m and 1.2 km.

Eyewitnesses to the final minutes of the helicopter's flight were located along the coastline either on or in the vicinity of Flamborough Head Golf Course. They reported that visibility was in the order of 5 km, with the coastline clearly visible. The witnesses reported that the helicopter was operating offshore, a short distance from the cliff top. One witness on the cliff path, just north-west of the eventual accident site, stated they could see directly through the passenger cabin windows and out the other side of the helicopter, suggesting that it was level with or just above the top of the approximately 200 ft high cliff.

One set of witnesses stated that as the helicopter passed them it appeared to turn slightly left, away from the cliff, as if to route round a headland. It then turned abruptly to the right, back towards the cliff, before descending steeply and passing out of sight below the top of the cliff.

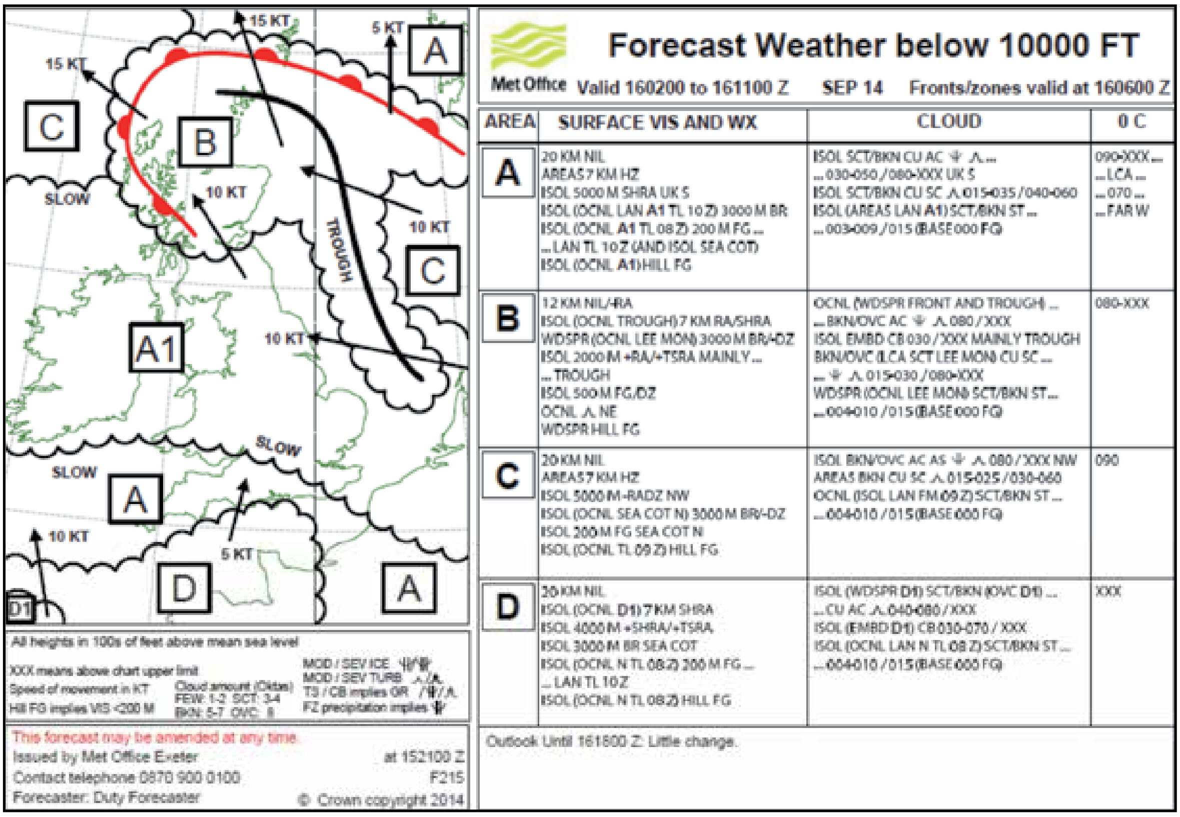
The witnesses realised the helicopter had crashed and contacted the emergency services. An RAF SAR helicopter, which was on a training flight nearby, was dispatched to the scene, arriving within minutes.

The pilot and passenger in G-SUEX were fatally injured in the accident.

Weather

The UK Met Office provided an aftercast for the day of the accident.

The Metform F215 (see Figure 1) for 16 September 2014, issued at 0300 hrs and valid from 0800 hrs to 1700 hrs, included the following forecast for area A1: generally 20 km visibility, with areas of haze reducing visibility to 7 km; isolated (occasional over land) mist until 1000 hrs with visibility of 3 km; isolated fog with 200 m visibility, clearing over land by 0900 hrs but remaining over the sea and coastline throughout the time of the flight; isolated (occasional until 1100 hrs) hill fog. The cloud was forecast as: isolated, scattered or broken cumulus or stratocumulus, with bases 1,500 ft to 3,500 ft and tops 4,000 ft to 6,000 ft; isolated, but in areas over the land, scattered or broken stratus with bases 300 ft to 900 ft and tops at 1,500 ft, with the cloudbase at the surface in fog.



AREA	SURFACE VIS AND WX	CLOUD	0 C
A	20 KM NIL AREAS 7 KM HZ ISOL 5000 M SHRA UK S ISOL (OCNL LAN A1 TL 10 Z) 3000 M BR ISOL (OCNL A1 TL 08 Z) 200 M FG ... ... LAN TL 10 Z (AND ISOL SEA COT) ISOL (OCNL A1) HILL FG	ISOL SCT/BKN CU AC Λ ... ... 030-050 / 080-XXX UK S ISOL SCT/BKN CU SC Λ 015-035 / 040-060 ISOL (AREAS LAN A1) SCT/BKN ST ... ... 003-009 / 015 (BASE 000 FG)	090-XXX ... ... LCA ... ... 070 ... ... FAR W
B	12 KM NIL/-RA ISOL (OCNL TROUGH) 7 KM RA/SHRA WDSPR (OCNL LEE MON) 3000 M BR/-DZ ISOL 2000 M +RA/+TSRA MAINLY ... ... TROUGH ISOL 500 M FG/DZ OCNL Λ NE WDSPR HILL FG	OCNL (WDSPR FRONT AND TROUGH) ... ... BKN/OVC AC Λ 080 / XXX ISOL EMBD CB 030 / XXX MAINLY TROUGH BKN/OVC (LCA SCT LEE MON) CU SC ... ... Λ 015-030 / 080-XXX WDSPR (OCNL LEE MON) SCT/BKN ST ... ... 004-010 / 015 (BASE 000 FG)	080-XXX
C	20 KM NIL AREAS 7 KM HZ ISOL 5000 M -RADZ NW ISOL (OCNL SEA COT N) 3000 M BR/-DZ ISOL 200 M FG SEA COT N ISOL (OCNL TL 09 Z) HILL FG	ISOL BKN/OVC AC AS Λ 080 / XXX NW AREAS BKN CU SC Λ 015-025 / 030-060 OCNL (ISOL LAN FM 09 Z) SCT/BKN ST ... ... 004-010 / 015 (BASE 000 FG)	090
D	20 KM NIL ISOL (OCNL D1) 7 KM SHRA ISOL 4000 M +SHRA/+TSRA ISOL 3000 M BR SEA COT ISOL (OCNL N TL 08 Z) 200 M FG ... ... LAN TL 10 Z ISOL (OCNL N TL 08 Z) HILL FG	ISOL (WDSPR D1) SCT/BKN (OVC D1) ... ... CU AC Λ 040-080 / XXX ISOL (EMBD D1) CB 030-070 / XXX ISOL (OCNL LAN N TL 08 Z) SCT/BKN ST ... ... 004-010 / 015 (BASE 000 FG)	XXX

Outlook Until 161800 Z: Little change.

Figure 1

Metform 215, the flight was within zone A1

Departure

At the approximate time of departure from the temporary base at Bankhead Farm, the nearest airport, Edinburgh Airport, reported light winds, visibility above 10 km and 1 to 2 oktas of cloud at 800 ft, with scattered cloud at 2,100 ft.

Weather at Flamborough Head

The SAR Sea King helicopter, based at RAF Leconfield, was on exercise approximately 7 nm south of the accident site when the emergency services were alerted to the accident. The helicopter immediately routed towards the site and the commander later provided an assessment of the weather conditions in the area.

He reported that they had been operating with a cloudbase of 700 ft to 800 ft above mean sea level (amsl), though he described conditions below the cloud as "goldfish bowl like[1]". As they descended, approaching the accident site, the visibility improved to about 9 km at 200 ft amsl. The wind was from 080° at less than 5 kt.

Recorded data

GNSS (Global Navigation Satellite System) receivers

Two GNSS receivers were recovered from the wreckage but no track data for the accident flight was recorded.

Radar

Radar data was recovered from Edinburgh, Newcastle and Durham Tees Valley Airports, together with various elements of the NATS operated en-route system. For significant portions of the flights on 16 September, no radar contact was made with G-SUEX due to line-of-sight limitations when the helicopter was below radar coverage. An overview of the recorded track is at Figure 2

The helicopter was initially detected by Edinburgh's Primary Surveillance Radar (PSR) and the Secondary Surveillance Radar (SSR) feed from NATS Lowther Hill radar. The helicopter's transponder was reporting altitude via Mode C, which has an accuracy of ±50 ft. This was converted to altitude, amsl, using the appropriate QNH. There was radar contact between 0938 hrs and 0959 hrs, during which the helicopter operated at an average calculated ground speed of 100 kt and at an altitude of between 800 ft and 1,300 ft amsl.

G-SUEX was next detected by Newcastle Airport radar, between 1021 hrs and 1051 hrs (see Figures 2 and 3). At 1025 hrs the helicopter was at 1,000 ft amsl. Then, over the next seven minutes, it descended to below 200 ft amsl. Between 1032 hrs and 1051 hrs the helicopter's reported altitude varied between 130 ft amsl and 30 ft amsl and the groundspeed was 100 kt ±10 kt.

Footnote

[1] 'Goldfish bowl like' is a common aviation term to describe conditions where the visibility at the surface is fair but with increasing altitude the horizon becomes increasingly hazy and indistinct.

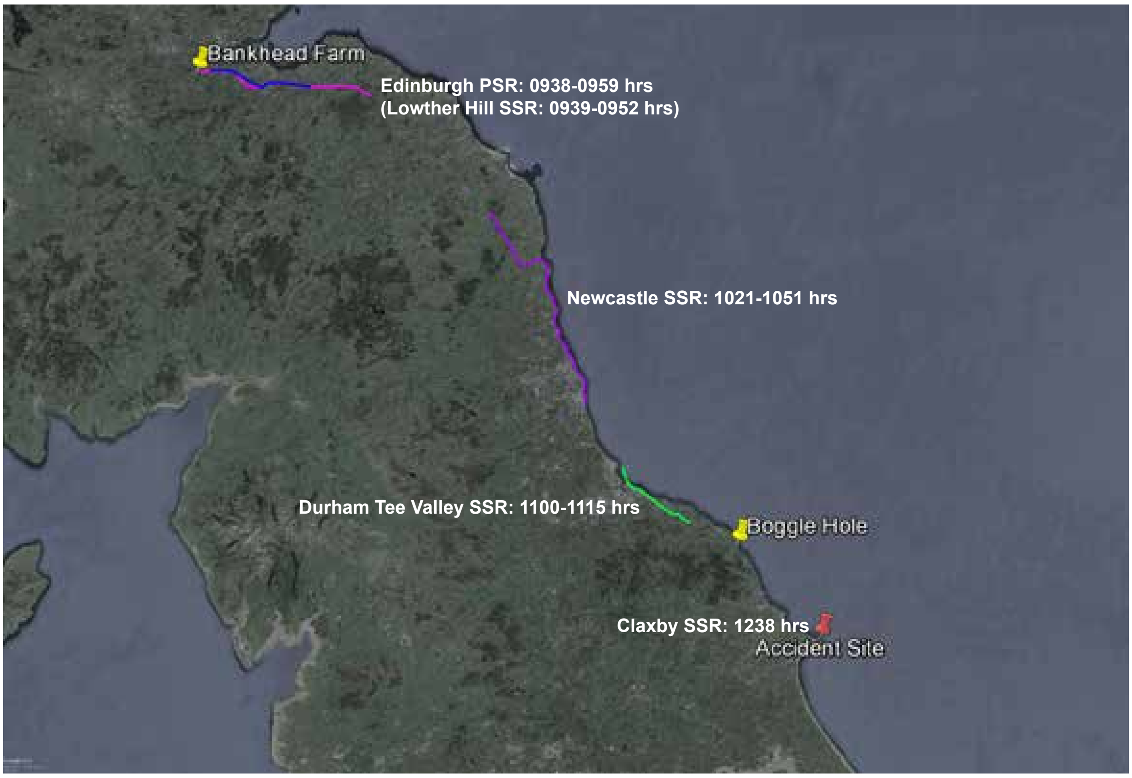


Figure 2

Overview of radar recorded tracks

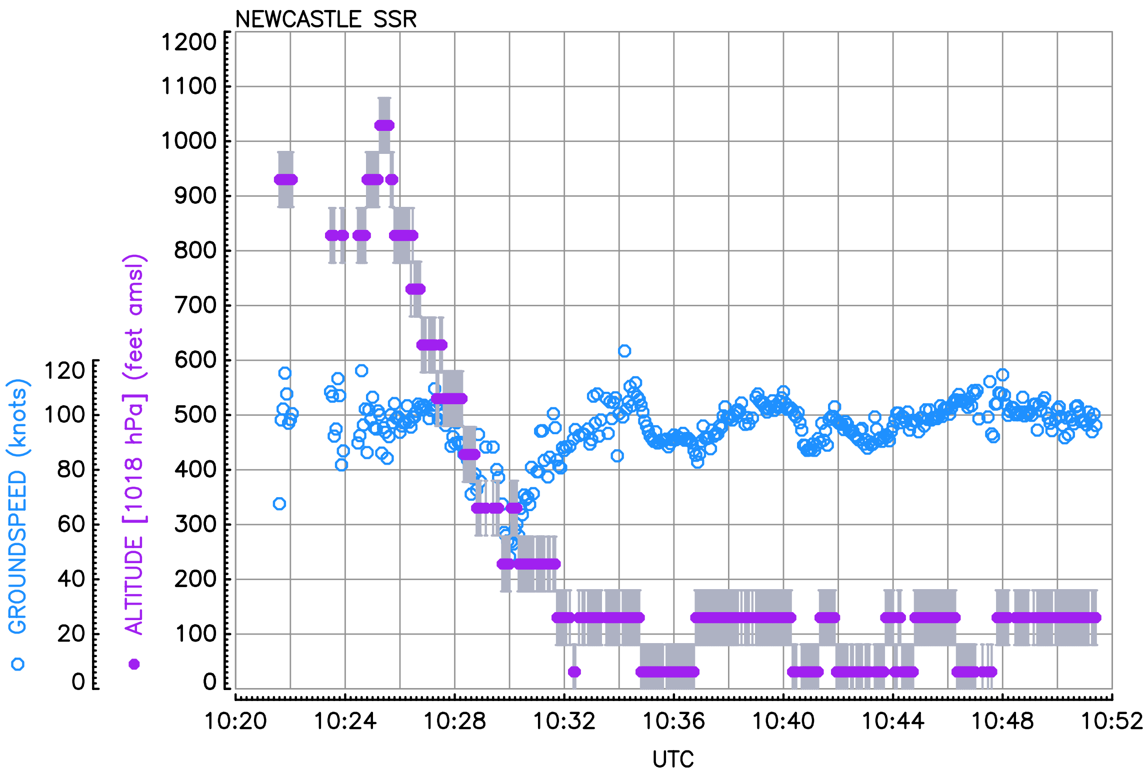


Figure 3

Mode C altitudes and calculated groundspeed from Newcastle Airport radar (±50 ft error bars, indicating Mode C accuracy, are shown)

As the helicopter passed Durham Tees Valley Airport, it was detected by the Great Dun Fell SSR between 1100 hrs and 1115 hrs. There was significant variation in altitude and speed, with the helicopter initially being between 400 ft amsl and 200 ft amsl, before, between 1102 hrs and 1106 hrs, climbing to 1,600 ft amsl and then descending back to 600 ft amsl by 1107 hrs. There was no radar contact between 1110 hrs and 1113:30 hrs. This was co-incident with the pilot telling the Teeside Radar controller that he intended to descend to low level and look at something on the ground.

The final two contacts were from the Claxby SSR (Figure 4) at 1238:17 hrs and 1238:25 hrs, when the helicopter was within 800 m of the accident site. The reported Mode C altitude, corrected for QNH, was 200 ft amsl for both contacts and the groundspeed was calculated to be about 90 kt. However, as this was based on just two points, whose positional accuracy is unknown, it is approximate.

Figure 4

Claxby SSR contacts near the accident site

Audio recording

A witness, who was approximately 800 m to the south of the accident site, had inadvertently activated the video recording feature on their camera while it was in their pocket. It was subsequently possible to isolate the audio of the helicopter's rotor system from the recording and conduct frequency analysis (Figure 5). Of note, no loud, sharp noises, such as bangs, were found on the audio. Also, the higher frequencies generated by the engine were beyond the frequency range of the audio recording.

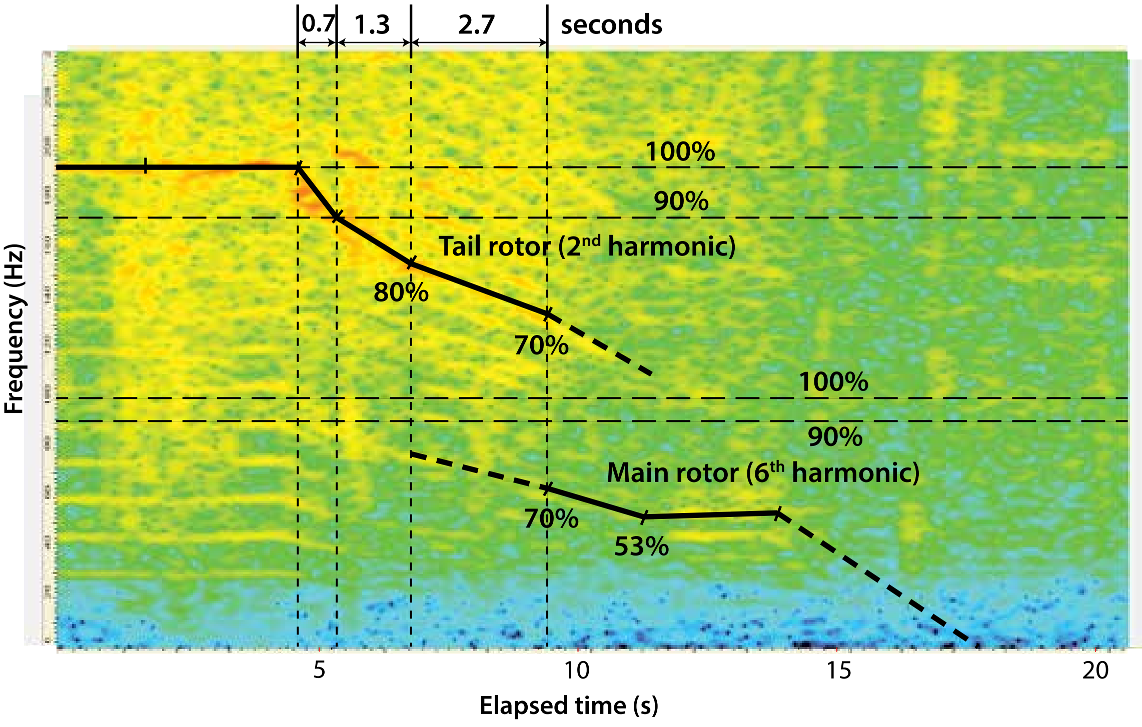


Figure 5

Frequency analysis of witness audio recording showing main and tail rotor rpm decay

Manufacturer's flight mechanics analysis

Details of the helicopter's flight path, its estimated weight and the frequency analysis chart were provided to the airframe manufacturer, who compared the recorded main rotor (MR) rpm decay with an analytical model of the helicopter. They concluded:

> *'The analysis shows that the recording of MR RPM decay is not compatible with a typical autorotation manoeuvre, while there is better correlation with a piloting technique intended to maintain altitude.'*

The analysis then compared two alternative piloting techniques that could be used to maintain altitude, following a loss of power. The model that most closely matched the recorded data considered that the pilot used both collective and cyclic control inputs to use the energy in the rotor system. Using this technique, the helicopter would travel approximately level for 180 m in a straight line, before the main rotor rpm would decay to below 70%. Once below 70% rpm, the helicopter would descend on a virtually ballistic trajectory, with only marginal control and no possibility of successfully flaring the helicopter to reduce the rate of descent. It was not possible to model turns, however it was considered that any turns would reduce the available energy and thus distance travelled.

Helicopter description

The Augusta Bell 206B is a five-seat, light utility helicopter powered by a single, turboshaft gas turbine engine, which drives a two-blade main rotor and a tail rotor via the main gearbox. A freewheel device is fitted between the engine and the main gearbox to allow the rotors to continue turning in the event of an engine failure. A self-generating dual tachometer on the instrument panel displays both the rotor and power turbine rpm to the pilot. A low rotor rpm warning, which is tested as part of the pilot's pre-flight checks, provides a visual and audible warning should the rotor rpm decay below 90% of its normal value. The helicopter was not equipped with emergency flotation equipment.

The design requirements for light single-engine helicopters include the requirement for them to be safely controllable and manoeuvrable in both powered and unpowered flight and the transition between the two, even if the transition is sudden. This is to allow a safe landing to be made in the event of an engine failure.

The manufacturer's flight manual includes the following procedure regarding rotor rpm in the event of an engine failure:

> *'Collective pitch – Adjust as required to maintain rotor RPM, 90% to 107%.'*

It also advises that ground contact should be made before the main rotor rpm decreases below 70%.

Pilot

The pilot worked part-time for the operator and was the company's Chief Pilot. He was the CAA accepted post-holder for both Flight Operations and Flight Crew Training[2]. He, therefore, controlled the content of the operator's Operations Manuals. In addition, he was reported to conduct freelance flying and training for other operators.

The pilot held a B206 type rating, valid until 31 May 2015. In addition, he held valid type ratings for the Robinson R22 and R44, a valid Type Rating Examiner's certificate for the B206 and a flight instructor's rating.

The pilot's logbook was not recovered from the accident site, the pilot's home or the operator's offices. However, a digital scan of a single page of the pilot's logbook, recorded as part of a routine audit by the operator in May 2014, was provided to the investigation. His total experience was approximately 4,000 hrs. It was not possible to calculate his B206 flight time, though it was considered to be a significant proportion of his total time. Digital scans of flight logs from the weekend's activities showed that the pilot had operated 17 hrs in 29 flights between Friday and Sunday.

The pilot held an EU class one medical, valid for single pilot operations until 23 November 2014.

Footnote

[2] Certain management roles within an Air Operator's Certificate holder are required to be approved by the relevant National Aviation Authority. Within the UK these roles are generically referred to as post-holders.

A previous flight

On 1 September 2014, the pilot had conducted a similar positioning flight in G-SUEX. Following that flight he filed a Mandatory Occurrence Report (MOR) to the CAA, stating that he had conducted a precautionary landing in a field near Rugby as the weather had prevented him routing round radio towers and wind turbines.

In his internal company safety report, into the landing, the pilot stated his proposed preventative actions included:

> *'(1) Never to allow the task to drive me into flying unsafely and (3) never to fly when cloud less than 600' AGL.'*

Medical

Post-mortem examinations were conducted by a pathologist, and a specialist aviation pathologist interpreted the findings for the AAIB. He reported that both occupants exhibited similar fatal injuries indicative of vertical decelerations in excess of 80 g. The pathologist commented that:

> *'The relative lack of severe injuries to the head, limbs and other vital organs suggests that the occupants' harnesses and other crashworthy aspects of the helicopter have afforded them significant protection, but the crash forces of the impact were outside the range of human tolerance.'*

He concluded that:

> *'In summary no medical factors have been identified which could be implicated in the cause of the accident.'*

Procedures

Operator's Operations Manual

The operator's manuals required that transit flights would normally not be flown below 1,500 ft unless operating under specific instructions from ATC, still with the proviso that *'in the event of an engine failure, the aircraft can land safely.'* The manuals allowed a minimum cloud base of 600 ft and in-flight visibility of 800 m *'…for short periods, during daylight when in sight of land.'*

The manuals also required that pilots should not commence flights unless the forecasts indicated that the route could be flown in compliance with the company rules.

In addition, they stated that flights would not be conducted:

> *'…beyond autorotative distance from land unless the aircraft is fitted with an emergency flotation equipment and all persons on board have access to life-jackets.'*

Air Navigation Order

The Air Navigation Order, in force at the time of this flight, defines a flight as public transport if it is operated by an air transport undertaking and passengers are carried, even if gratuitously.

Rule 5 of the Rules of the Air, commonly referred to as the low flying rule, includes the requirement that:

> *'Except with the written permission of the CAA, an aircraft shall not be flown closer than 500 feet to any person, vessel, vehicle or structure.'*

The European Helicopter Safety Team (EHST) *Helicopter Airmanship* leaflet states:

> *'Weather*
>
> *Ensure you get an aviation weather forecast from an authorised source, heed what it says, (decodes are available on the internet) and make a carefully reasoned GO/NO GO decision. Do not let self induced or passenger pressure influence your judgement. The necessity to get home (Homeitis) has been a frequent casual course of accidents. Establish clearly in your mind the en-route conditions, the forecast, and possible diversions in case of deteriorating weather. Have a planned detour route if you are likely to fly over high ground which may be cloud covered.'*

CAA Safety Sense Leaflet 17, *Helicopter Airmanship,* states:

> *'If you fly a single-engined helicopter and your proposed route takes you over a congested area, forest, lake etc. where a forced landing due to engine failure or unexpected bad weather could be hazardous to yourself or those on the ground, plan a different route where a forced landing would be safe.'*

Accident site and wreckage recovery

The accident site was located in the inter-tidal zone at the base of a gully in the cliffs at Flamborough Head. A photograph taken shortly after the accident showed the helicopter lying on its left side, partly submerged in the sea (Figure 6). It had sustained damage from the impact but appeared whole. The tide was ebbing and the emergency services were able to recover the deceased occupants at low tide. A significant quantity of jet fuel was reported in the sea around the wreckage.

The cliff face above the accident site was largely undercut and the top edge of the cliff was unstable, making access difficult (Figure 7). The wreckage was initially accessible for a short period either side of low tide, by abseiling down the cliff to an adjacent beach and walking around an outcrop. An assessment of the wreckage was made and photographs were taken but no attempt at recovery was made, due to the incoming tide. It was evident that, due to the action of the waves, the wreckage had been moved and was broken into smaller pieces. When the weather and sea conditions became less favourable, this route was no longer available.

Figure 6

Showing helicopter lying at the base of the cliffs shortly after the accident
(Courtesy Trevor Norton)

Figure 7

General view of the accident site

Specialists were able to access the accident site by boat and once the wreckage had been loaded into bags, it was lifted to the cliff top. The AAIB deployed its Un-manned Aerial System (UAS) to provide a real time view over the cliff, which proved most useful in assisting the recovery operation.

There was only one witness mark on the cliff, approximately 30 cm above the beach level, which appeared to be a main rotor blade strike. There was no evidence of the helicopter having made any other contact with the cliff.

As the wreckage was brought to the cliff top, it was initially inspected and protected from the effects of contact with sea water, before being transported to the AAIB facilities at Farnborough.

Examination of the airframe wreckage

The wreckage was inspected in the hangar at the AAIB facilities in Farnborough, with the assistance of technical representatives from the airframe and engine manufacturers.

The airframe had suffered severe damage and fragmentation, due to the action of the waves, whilst it was lying in the inter-tidal zone before recovery. Many of the magnesium alloy based parts had corroded significantly due to their immersion in sea water.

Deformation to the lower parts of the fuselage indicated that the helicopter had sustained a high vertical impact load, initially with the surface of the water but also when the skids contacted boulders on the sea bed. Based on witness reports, it was estimated that the water was between 0.5 m and 1 m deep.

The damage to the main rotors, the drive train, its couplings and mountings suggested that there was low energy in them (low rotor rpm) at the time of impact. The freewheel device between the engine and gearbox operated normally.

The remote oil reservoir and oil cooler fan were severely damaged and sea water was found in the scavenge oil filter, as the oil lines had been broken by wave action. The fuel filter smelt of fuel but also contained sea water, due to the broken fuel lines. The remainder of the fuel system was compromised and no meaningful conclusions could be drawn.

A warning panel consisting of a number of warning captions was fitted to the instrument panel. These included warnings for engine failure and low rotor rpm. The engine failure warning illuminates if the engine gas generator rpm drops below its normal operating speed. The low rotor rpm illuminates if the rotor rpm decays below 90%. The filament associated with the low rotor rpm caption was not recovered.

An analysis of each recovered filament was undertaken to determine if any showed signs of being illuminated. None of the filaments examined showed any signs of the characteristic plastic deformation associated with an impact whilst illuminated.

The inspection did not identify any pre-accident anomalies with the airframe, its controls or drive train. Dual controls were found fitted to the left seat position.

Examination of the engine

The engine consists of a gas generator assembly, which includes both axial and centrifugal compressor stages, a combustion section and an axial flow turbine section connected to the compressor. The remaining hot gases then pass through an axial flow power turbine assembly which, through the power output gear, provides the power output to the main rotor gearbox via a freewheel device (Figure 8).

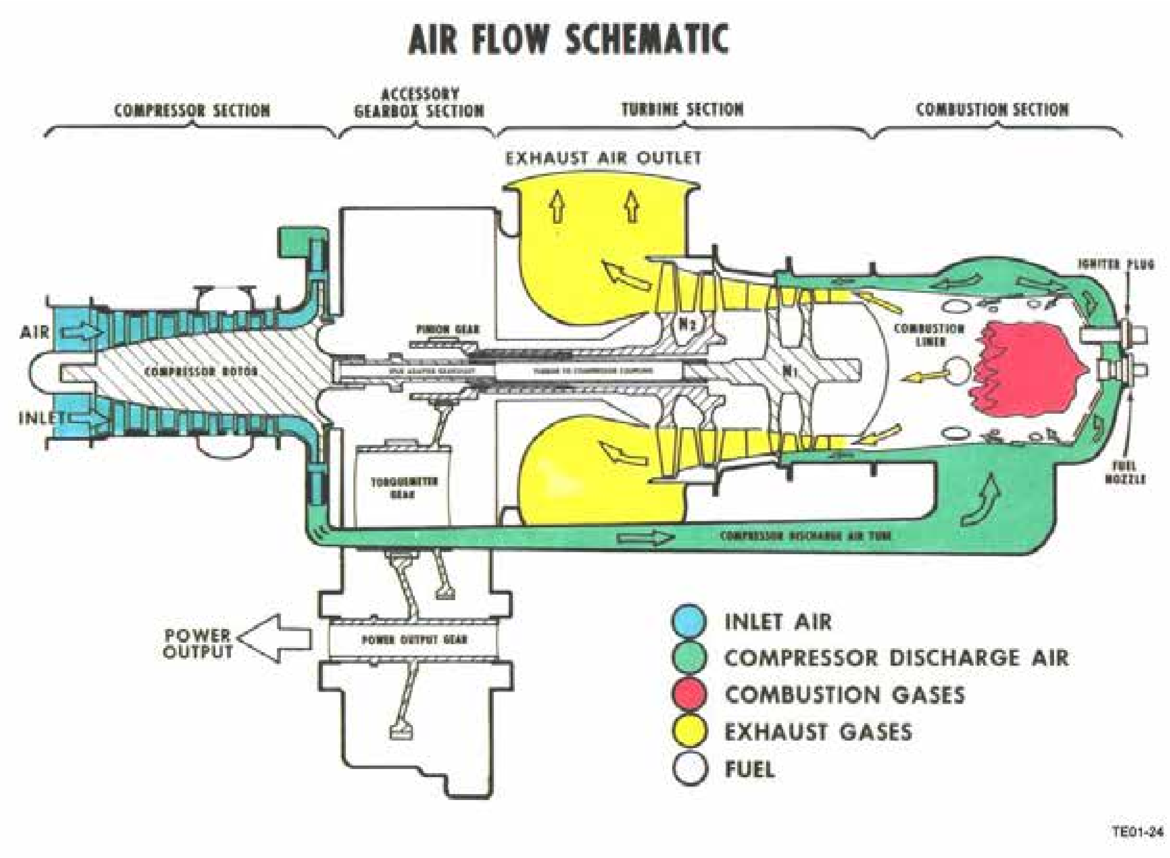


Figure 8

General arrangement of engine

The engine assembly was taken to an approved maintenance organisation with specialist experience in this type of engine. A full disassembly inspection was carried out, with the technical representatives of the engine and airframe manufacturer in attendance.

The compressor assembly was dismantled and found to be in good condition, apart from some impact damage to a few blades at the front of the compressor which was determined to be a result of the accident. Chopped seaweed was found throughout the compressor air passages. The seaweed found on the beach was in long strips, and finely chopped seaweed material was found inside the engine. This suggested that the gas generator part of the engine had been rotating at the time of the accident. However, it was not possible to determine the engine's speed at that moment.

The oil pump appeared to be in good condition and no blockages were found within the internal oil passages. The pressure filter was not obstructed and oil appeared to have been present throughout the lubrication system. The magnetic chip detectors had collected debris but it was not possible to draw any conclusions due to the large quantities of corrosion products resulting from the immersion in sea water.

The engine fuel control unit and governor were disassembled and examined. They were found to be in a satisfactory condition with no pre-accident defects. Several of the pneumatic air lines were dented but their connection fittings were all secure.

When the turbine assembly was dismantled, the No 5 and No 8 bearings (Figure 9) were found to have suffered severe thermal distress (see Figure 10). The No 6 and No 7 bearings had also suffered damage. The No 5 bearing and No 8 bearings are ball bearings and provide axial and radial location for the turbine assembly. Damage to the turbine rotors and adjacent components indicated they had come into contact with each other.

The engine, including the failed and damaged bearings, was returned to the engine manufacturer for detailed evaluation.

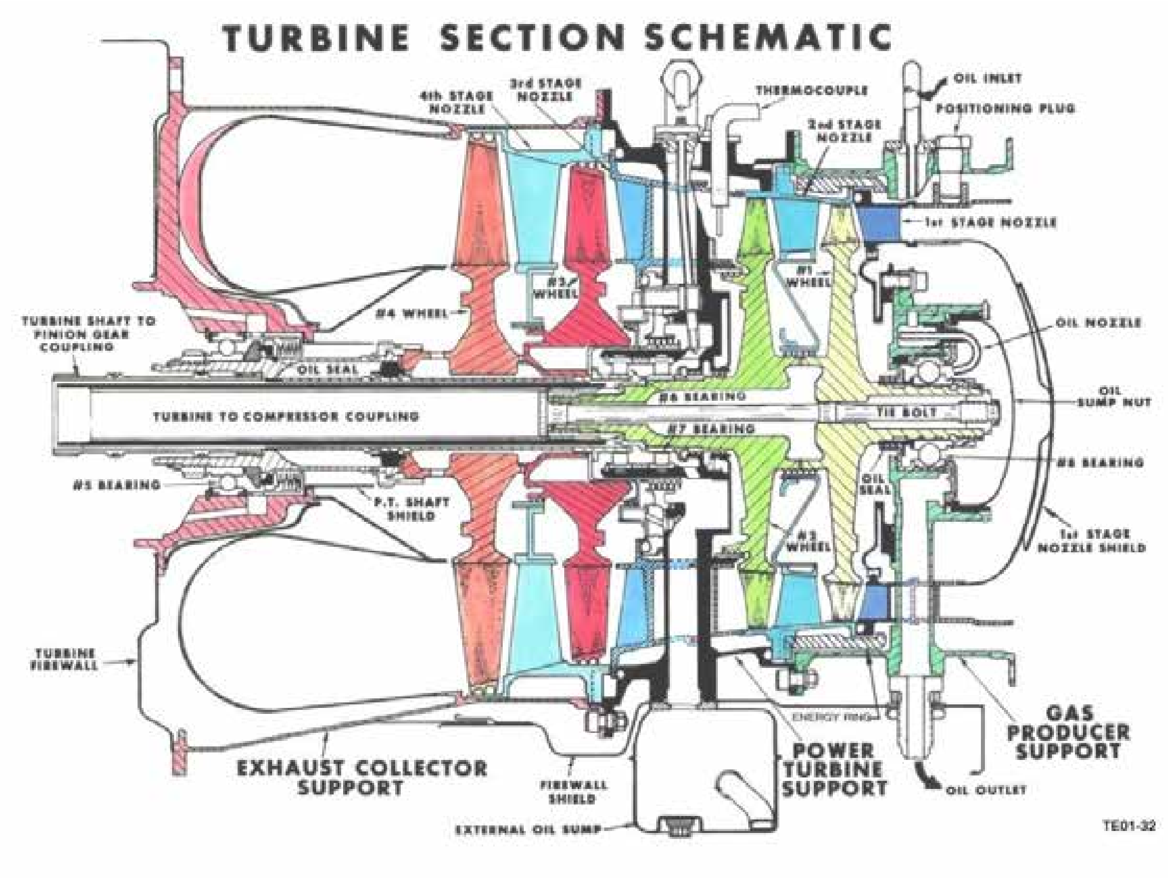


Figure 9

General arrangement of turbine assembly and bearings

Figure 10

Example of bearing damage, in this case No 5 bearing

The No 5 and No 8 turbine thrust bearings exhibited severe thermal distress which had led to the bearings ceasing to position the turbine rotors axially and radially. The No 6 bearing also exhibited damage which indicated it had ceased to position the power turbine rotor radially.

The No 8 bearing exhibited an approximately 0.75 inch long circumferential fatigue crack in the outer ring, originating at the corner of the key slot, which did not extend into the bearing raceway. This was typical of a crack caused by the outer raceway trying to rotate against its key due to friction within the bearing. The bearing was comprised of the material types specified by the engineering drawing but it was not possible to determine the original hardness or microstructure of the part due to the severe thermal distress.

The engine manufacturer concluded:

> *'The primary failed component was unable to be identified due to the advanced stage of distress to many of the turbine bearings, as well as the engine's exposure to seawater.'*

Maintenance records

The helicopter was being maintained to an approved maintenance programme and had a valid airworthiness review certificate (ARC). The last scheduled maintenance was a 100-hour inspection, which was carried out on 12 September, 2014. In addition to the routine items, a number of minor defects were rectified. Since then, the helicopter had flown for approximately 17 hours on 29 flights.

The engine turbine assembly had been overhauled in November 2011 and had been fitted with new bearings (No 5 to No 8), which had been manufactured under a Parts Manufacturer Approval (PMA) issued by the FAA. During the build process, the PMA No 8 bearing was replaced with an original equipment manufacturer (OEM) supplied part, for an unspecified reason. The overhauled turbine assembly was released from the overhaul organisation in September 2012.

Whilst the use of PMA parts is acceptable, the authorised Release Certificate did not note that PMA parts had been fitted, as required by EASA Decision 2007/003/C. The overhauled turbine assembly was fitted to the engine on 19 September 2013 and the helicopter had subsequently operated for approximately 370 hours. The turbine bearings do not have a defined life, but instead they are inspected at each turbine overhaul for condition and replaced if required.

Analysis

The pilot held the appropriate licences and ratings to operate the flight; he was experienced, current and familiar with the task and route. The helicopter had been maintained to the required standards and there were no known defects before the flight.

On the day of the accident, the weather near Edinburgh was suitable for both departure and en-route flight, within the constraints laid down by the company's operations manual. However, the forecast contained within the F215 chart, for the portion of the flight towards the east coast of England, was less favourable. The evidence indicated that, after 1032 hrs, the helicopter was being operated, for extended periods, below 600 ft agl and in some cases below 100 ft agl, in weather conditions which appeared to be below the limits contained within the operations manual.

Flight at low level would have mitigated, to some extent, the risk of inadvertent entry into a degraded visual environment but, in doing so, it exposed the helicopter to other risks. Specifically, it was probably flown into positions from which a safe autorotation and landing could not be assured, following a loss of power.

As on a previous occasion, the pilot interrupted the flight by landing in a field due to poor weather conditions. After about 50 minutes on the ground, during which he discussed the weather with Humberside Airport and called his company, the helicopter departed the field, which was near Robin Hood's Bay.

As the helicopter approached Flamborough Head, about 24 nm south of Robin Hood's Bay, it seems to have entered an area of improved weather. The SAR helicopter commander subsequently reported good visibility near the surface, deteriorating with altitude towards a cloudbase at about 800 ft.

The final radar recordings and eyewitness accounts, shortly before the helicopter suffered a loss of power, indicated that it was transiting on the offshore side of the cliff top at a height that varied from level to slightly above the top of the cliff. This suggested that the pilot was probably endeavouring to maintain good visual conditions, by flying at low level, while remaining compliant with Rule 5 of the Rules of the Air, by being laterally clear of people on the cliff top path.

The loss of engine power was due to the failure of bearings supporting the turbine assembly. However, the wreckage of the helicopter was severely damaged by wave action and its immersion in sea water. Due to this damage and the thermal distress suffered by the failed turbine bearings, it was not possible to determine the cause of the bearing failure. No pre-accident anomalies with the airframe, its controls or drive train were found.

The degradation of the power turbine assembly removed drive from the rotor system. The gas generator part of the engine was still rotating and, therefore, the engine-out warning tone and caption may not have activated. This may have increased the pilot's response time to the loss of power. However, the helicopter would have reacted to the change in torque, possibly explaining the slight turn to the left described by some of the eyewitnesses, and this could have alerted the pilot. The helicopter was then seen to turn towards the cliff, before descending below cliff top height and out of sight of the witnesses.

The audio analysis showed a significant and sustained reduction in the rotor rpm, inconsistent with entry into normal autorotation[3]. The single strike mark near the foot of the cliff and the nature of the damage to the rotor drive train were indicative of very low energy in the rotor system at impact. Also, the injuries identified at the post-mortem examination were consistent with a vertical impact of greater than 80 g, suggesting an unarrested descent.

The evidence suggests that the pilot probably attempted to land at the top of the cliff. The helicopter was not fitted with flotation equipment and the company's Operations Manual stated that, in such circumstances, the helicopter should not be flown beyond autorotative distance of land. On this occasion, minimal height loss would have been required to reach the top of the cliff. However, there was insufficient energy within the rotor system to achieve this. The loss of rotor rpm then prevented a reduction in the rate of descent as the helicopter approached the surface, at the bottom of the cliff.

Conclusion

The helicopter was transiting at low level along a section of coastline dominated by cliffs. It was not equipped with flotation equipment, was offshore and either level with or slightly above the cliff top. A loss of engine power occurred due to the failure of bearings within the turbine assembly, the cause of which could not be determined. When the loss of engine power occurred, the helicopter was not in a position from which it could land safely. The pilot probably attempted to land on the top of the cliff but there was insufficient energy within the rotor system to achieve this. The helicopter then descended rapidly and struck the surface of the sea, fatally injuring the pilot and his passenger.

Bulletin correction

This report included a graphical display of the main and tail rotor rpm decay, based on the frequency analysis of the witness audio recording (see Figure 5 on page 55). Figure 5 was incorrectly labelled. Reference to the tail rotor should have been to the main rotor, and vice versa. The time axis labels and harmonic references were also incorrect. However, the supporting text, analysis and conclusions were unaffected by these labelling errors.

The graphic was amended online on 29 January 2016 and a correction was placed in the March 3/2016 Bulletin.

Footnote

[3] Had the helicopter successfully entered autorotation, the rotor rpm could have been maintained between 90% and 107% until a short distance above the surface, when a flare manoeuvre and application of collective pitch to the main rotor system could have cushioned the touchdown, while rapidly slowing the rotor rpm.