## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | Schweizer 269C-1, G-LINX |
| **No & Type of Engines:** | 1 Lycoming HIO-360-G1A piston engine |
| **Year of Manufacture:** | 2006 |
| **Date & Time (UTC):** | 22 September 2009 at 1103 hrs |
| **Location:** | East bank of River Wyre, near Stalmine, Lancashire |
| **Type of Flight:** | Training |
| **Persons on Board:** | Crew - 1 Passengers - 1 |
| **Injuries:** | Crew - 1 (Fatal) Passengers - 1 (Fatal) |
| **Nature of Damage:** | Aircraft destroyed |
| **Commander's Licence:** | Commercial Pilot's Licence |
| **Commander's Age:** | 38 years |
| **Commander's Flying Experience:** | 1,524 hours (of which 894 were on type)<br>Last 90 days - 59 hours<br>Last 28 days - 12 hours |
| **Information Source:** | AAIB Field Investigation |


### Synopsis

The helicopter, which was on a training flight, suffered an in-flight emergency and subsequently crashed, fatally injuring both occupants. Examination of the wreckage revealed that the main rotor was turning at low speed on impact, but the reason for this could not be established. The investigation concluded that the most likely cause of the accident was a loss of control during an attempted forced landing downwind. The helicopter was being flown at 400 ft immediately prior to the emergency, which would have reduced the probability of a successful outcome.

One Safety Recommendation is made as a result of this investigation.


### History of the flight

The helicopter took off from Blackpool Airport at 1042 hrs with a student and instructor aboard. The purpose of the flight was not recorded but the student had flown with the instructor on several previous occasions in the course of his training for a Private Pilot's Licence (PPL). The helicopter departed to the west before turning north to follow the Blackpool coastline and climbed to approximately 1,400 ft. On passing Bispham, about 2 nm north of Blackpool Tower, it turned towards the town of Knott End-on-Sea.

A witness in Blackpool reported that, shortly before 1100 hrs, he saw a helicopter similar in appearance to G-LINX flying inland to the north of the town at a height of approximately 1,500 ft. He stated that the helicopter appeared to emit five or six “puffs of black smoke”, then flew on without further incident until out of his view. There were no other reports of this event.

At 1050 hrs, the helicopter crossed the coast at Knott End-on-Sea and commenced a descending left turn onto a westerly heading. A witness in Knott End watched as it operated above the sands approximately 1 nm north of the coast, manoeuvring for several minutes as though in a right hand circuit. He saw it twice climb to a height of a few hundred feet before descending again to a height consistent with having either landed or entered a low-level hover. At 1100 hrs, the helicopter flew south towards the mouth of the River Wyre, initially at about 200 ft, before climbing to approximately 400 ft as it passed south-west of Knott End, behind buildings and out of view of the witness. It then continued along the east bank of the river.

At 1102:23 hrs the Blackpool Approach controller (APC) received a MAYDAY transmission, later identified as spoken by the instructor, which included the aircraft call sign, its approximate location and the word “FAILURE”. The APC acknowledged the call and requested further details. He received a further transmission from the helicopter at 1102:31 hrs, consisting mainly of background noise, which did not contain any verbal clarification of the nature of the emergency.

At 1104 hrs, after several unsuccessful attempts to contact the helicopter, the APC initiated emergency procedures. Several agencies joined the search for G-LINX, which was located by a police air support helicopter at 1152 hrs. Both occupants of G-LINX had received fatal injuries.

**Meteorological information**

When issuing taxi instructions to G-LINX at 1037 hrs, the aerodrome controller reported that the wind was from 270° at 15 kt, gusting to 26 kt. Meteorological conditions reported at Blackpool Airport at 1050 hrs included: surface wind from 260° at 20 kt, visibility of 10 km or more and scattered cloud with a base at 2,000 ft. The air temperature was 16°C and dew point 11°C. A further report at 1120 hrs indicated that conditions had not changed significantly.

**Recorded Information**

*Accident protected flight data recorders*

G-LINX was not equipped with an accident-protected data or voice recorder, nor was it required to be.

*Radar information*

Recorded radar information was available from two radar sites, located at Great Dunn Fell and St Annes. St Annes radar is located approximately 8 nm south of the accident site and Great Dunn Fell approximately 50 nm to the north-east. Primary and secondary radar information was recorded approximately once every four seconds by the radar at St Annes and approximately once every eight seconds by the radar at Great Dunn Fell. Both radars recorded G-LINX manoeuvring in the vicinity of Knott End-on-Sea before tracking south to follow the River Wyre. About 1.5 nm south of Knott End, 1.2 nm west of the village of Stalmine, it altered track towards the east and descended, disappearing from radar shortly thereafter. The final radar positions were within 45 metres of the accident site. Figure 1 shows the helicopter’s radar track.

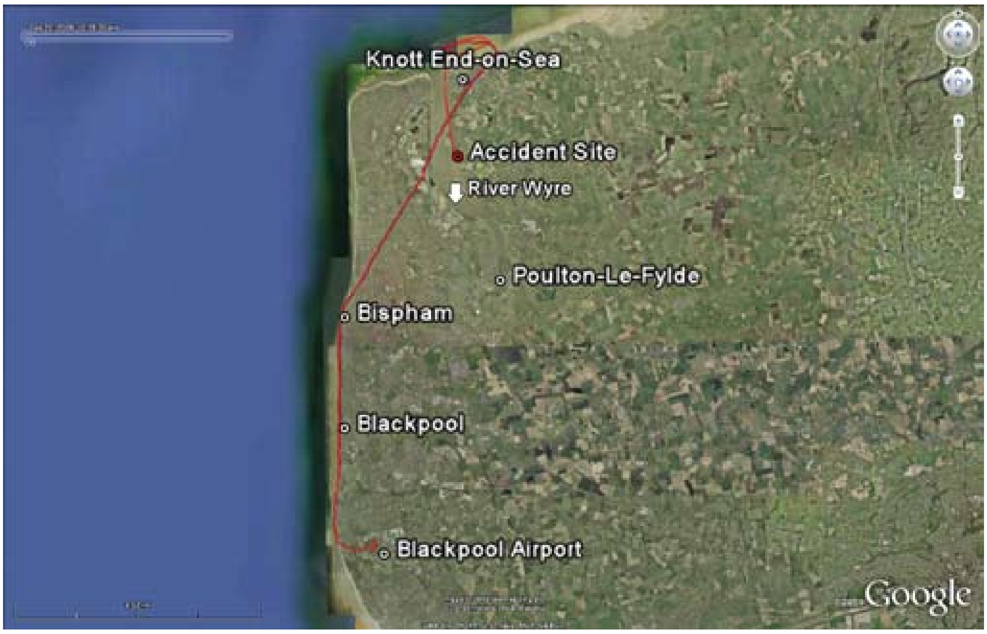


**Figure 1**

G-LINX –Radar track

Transponder[1] Mode A and Mode C information was available for most of the flight. Analysis of the departure from Blackpool Airport indicated that the transponder altitude was within approximately +/- 50 ft of the aircraft's actual altitude.

The helicopter was also equipped with a Garmin GNS 430 combined GPS, navigation and VHF communications unit. The final GPS position recovered from the unit coincided with the accident site, indicating that the unit was electrically powered at the time of impact. The VHF communication frequency was tuned to the Blackpool Approach frequency, with Blackpool Tower set as the standby frequency. No GPS routes had been activated and the unit did not record the helicopter's GPS track.

*Interpretation*

All altitudes are above mean sea level unless stated otherwise.

During the flight along the Blackpool coastline, the average ground speed was 65 kt, and from Bispham to Knott End it was 80 kt. Allowing for the winds as reported at Blackpool Airport, the average airspeed during the flight from Blackpool Airport to Knott End would have been approximately 70 kt, which is consistent with normal operation of the helicopter.

At 1050 hrs, the helicopter approached the coastline near Knott End. From a height of about 1,400 ft it made a descending left turn onto a westerly track, heading into wind. Its descent stabilised at about 975 ft/min +/- 75 ft/min at an average ground speed of 35 kt. About 0.5 nm north of the coastline, above an area of sand exposed at low tide, the helicopter descended to a height consistent with either touching down or flying at low level. During the next eight minutes, it

**Footnote**

[1] When interrogated by ATC radar, the transponder transmits data which can be decoded by ATC radar to display specific information on the aircraft, including a four-digit identity code and its altitude, on the radar screen. Pressure altitude is based upon the International Standard Atmosphere (ISA), which assumes a barometric pressure of 1013.25 millibars at sea level. Mode C (altitude) information transmitted by the transponder is quantized to the nearest 100 ft increment.

flew in a predominantly right-hand circuit direction, at heights not above about 400 ft. During this period the helicopter climbed and descended twice (Figures 2 and 3). Both descents occurred whilst heading into wind. During the first descent, the average descent rate was 1,570 ft/min +/- 786 ft/min and the second was 1,570 ft/min +/- 524 ft/min. The average ground speeds during both descents were similar, at about 35 kt, giving an airspeed of approximately 50 to 55 kt in the prevailing conditions.

At 1100:25 hrs, G-LINX routed to the south, tracking along the east bank of the River Wyre. Initially flying at about 200 ft, it then climbed to about 400 ft as it passed to the south-west of Knott End. Approximately one third of a mile from the accident position there was a momentary 100 ft increase in transponder altitude, indicating that G-LINX was at about 430 ft. The ground speed remained stable at about 60 kt after departing the area near Knott End (Figures 4, 5 and 6).

At 1102:23 hrs, the instructor transmitted a MAYDAY on the Blackpool Approach frequency. At that moment the helicopter was at a height of approximately[2] 280 ft +/- 50 ft, and its average ground speed had reduced from 60 kt to 45 kt. During the next 13 seconds, its ground speed stabilised at about 30 kt and the helicopter altered track to the east and descended. It was then approximately 0.5 nm east of the west (upwind) bank of the River Wyre. The final radar point, recorded at 1102:36 hrs, indicated the helicopter was at a height of about 180 ft +/- 50 ft. The average descent rate during the final nine seconds of data was 1,311 ft/min +/- 656 ft/min.


**Figure 2**

G-LINX - Flight in the vicinity of Knott End-on-Sea

**Footnote**

[2] The nominal alignment error between the radar and RTF information was +/- one second.

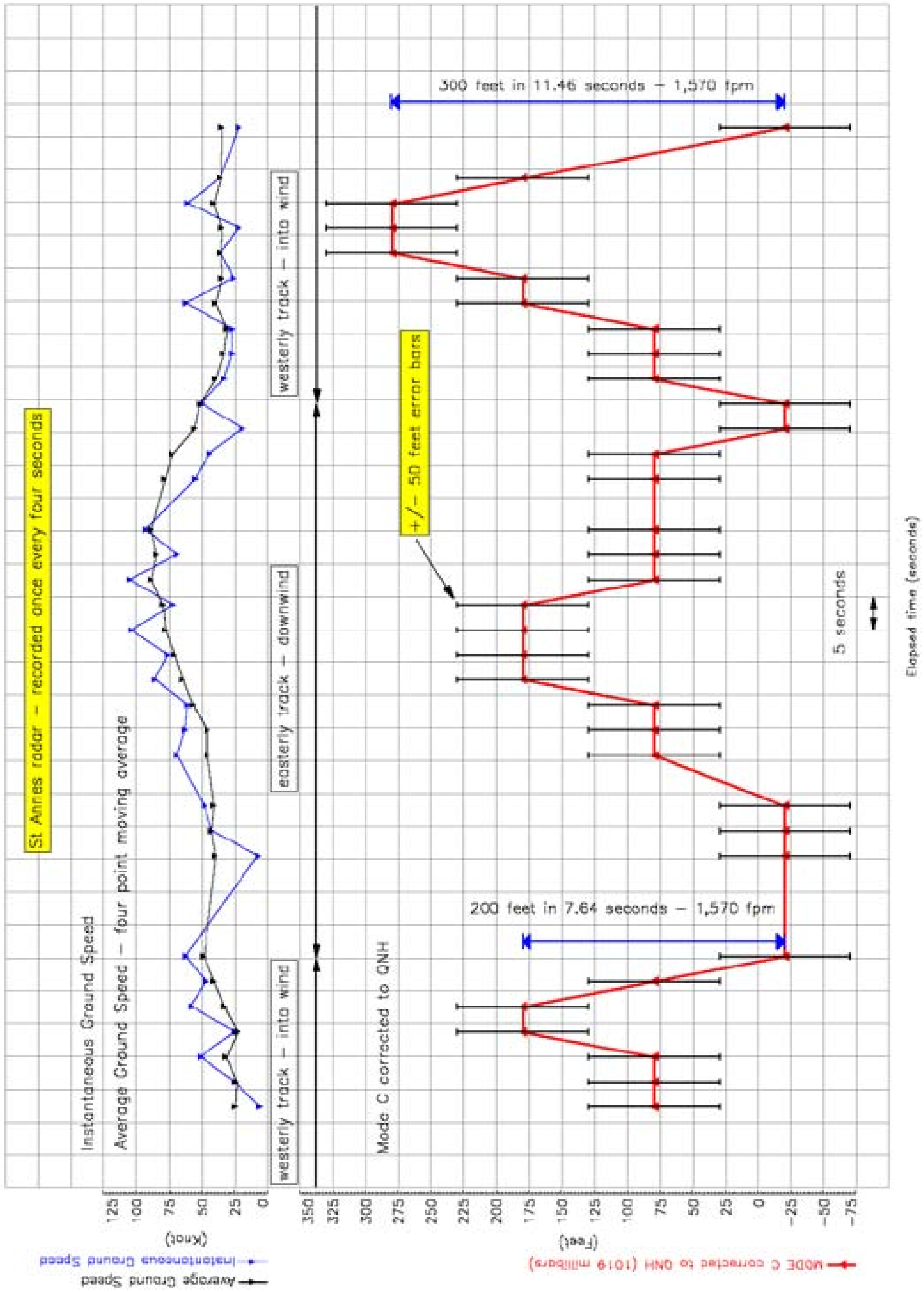


**Figure 3**

G-LINX - Flight in the vicinity of Knott End-on-Sea


**Figure 4**

G-LINX - Flight from Knott End-on-Sea

*Radio Telephony (RTF)*

Five radio transmissions from G-LINX were recorded on the Blackpool Radar frequency. Three were made in short succession at 1042 hrs, as the aircraft climbed through 780 ft on departure from Blackpool Airport. The final two transmissions were made 20 minutes later, at 1102:23 hrs and 1102:31 hrs. The first of these was a MAYDAY, followed by an open microphone transmission. Both lasted about three and a half seconds and were separated by an ATC acknowledgement lasting four and a half seconds. During the MAYDAY transmission, the instructor is believed to have said "FAILURE", but it could not be determined if he was referring to a component or system on the aircraft. A family member who assisted with interpretation of the transmission commented that the instructor sounded calm and that his voice held no sense of panic during the MAYDAY call.

Frequency spectral analysis of the first three radio transmissions identified the presence of sounds generated by the rotation of the main rotor gearbox and the main rotor. Sounds generated by the operation of the engine could not be identified. However, mathematical correlation with the rotational speed of the main rotor gearbox, which is driven by the engine, indicated that the engine was operating at about 2,515 rpm at the time of the radio transmissions.

Analysis of the MAYDAY call identified that during the final second of the transmission, the rotational speed of the main rotor gearbox was reducing. This reduction equated to a main rotor speed of approximately

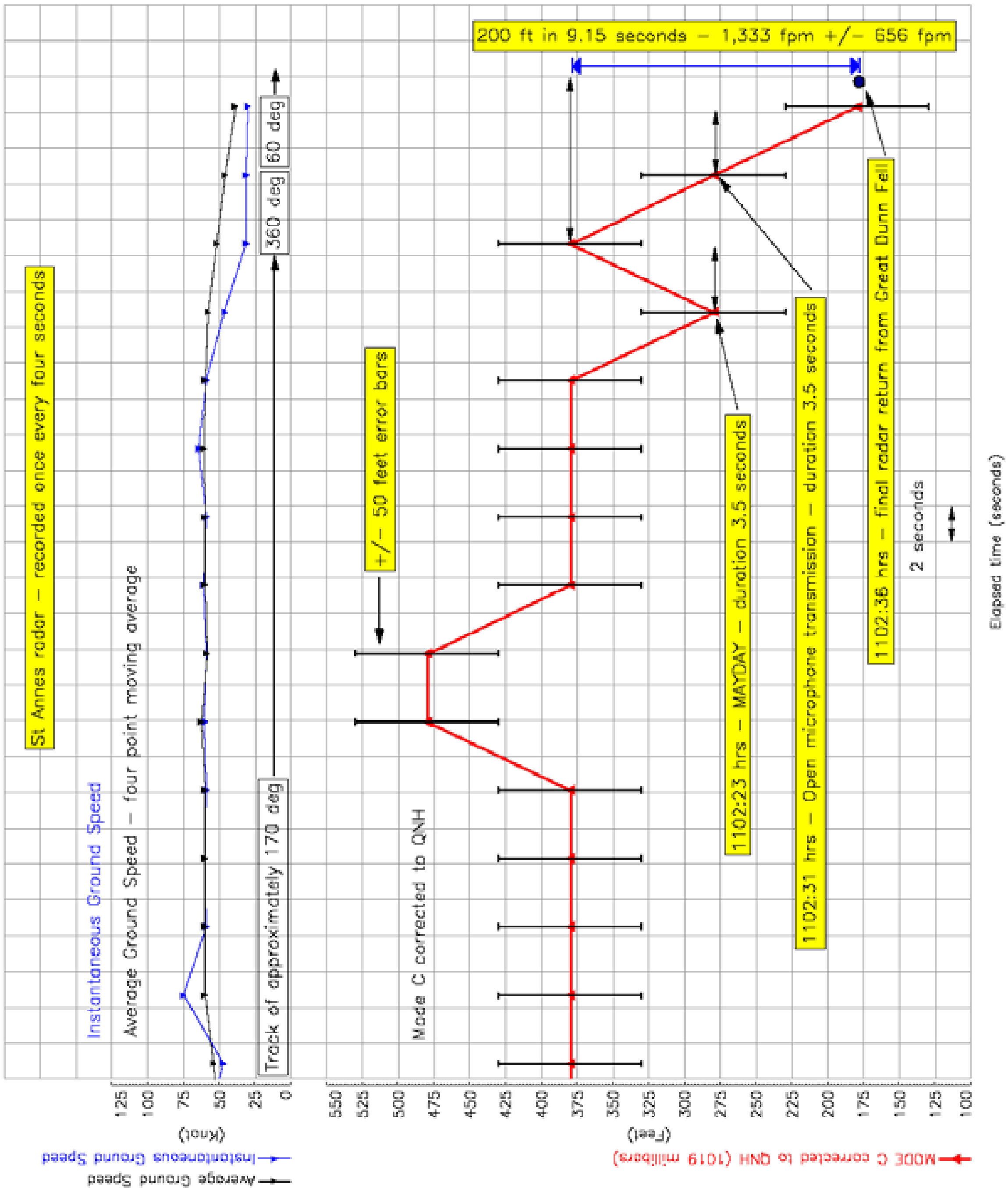


**Figure 5**

G-LINX - Flight from Knott End-on-Sea

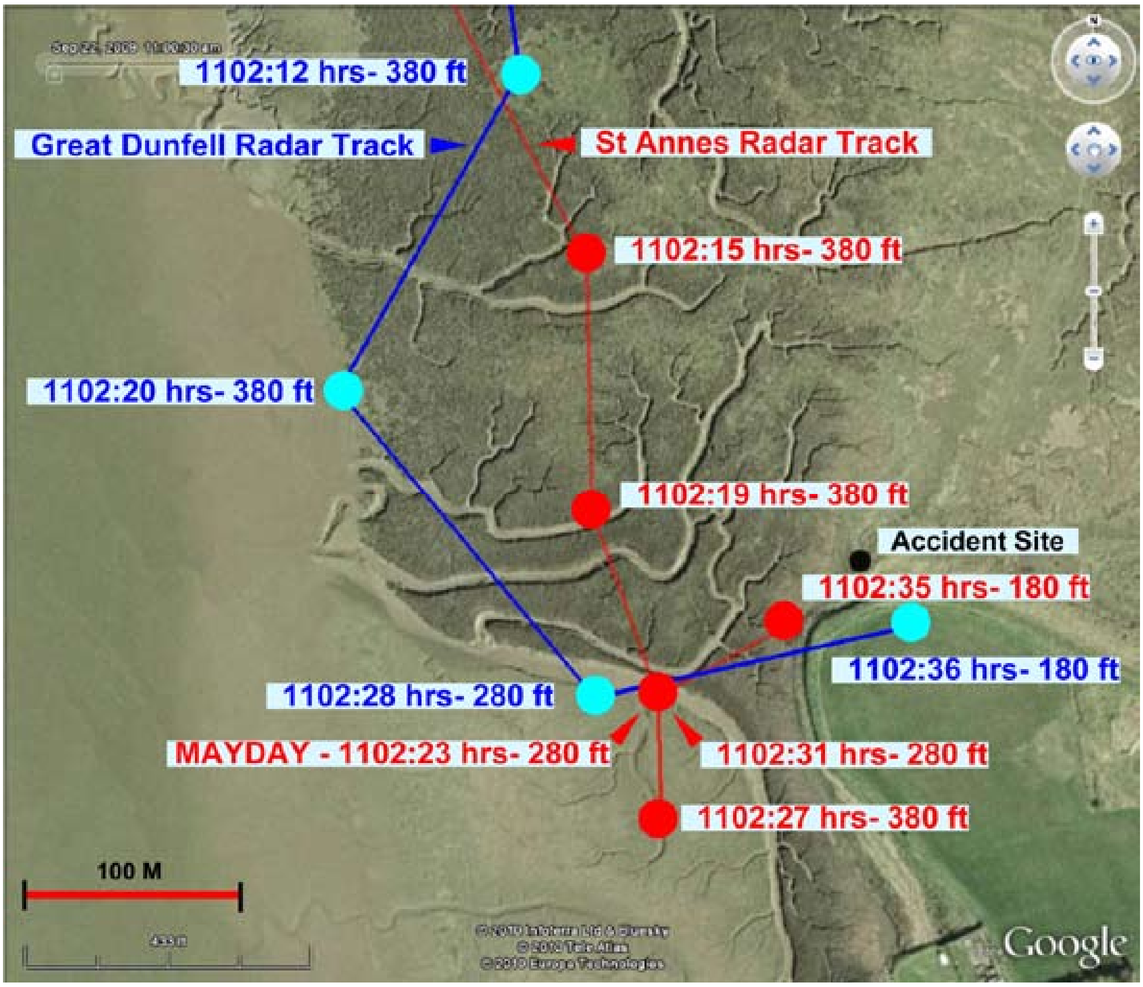


**Figure 6**

G-LINX – Final radar positions

445 rpm, reducing to 438 rpm. As with the first three transmissions, engine-related sounds could not be identified.

During the final open-microphone transmission, a steady 3,063 Hz tone was recorded; this was determined to be the main rotor low speed audible warning. The helicopter manufacturer stated that no other systems would produce an audible tone of similar frequency. This tone was not present in the four previous transmissions. The tone was recorded throughout the duration of the final transmission, and was of sufficient amplitude to be heard above the background noise.

During the later stages of the final transmission, a rhythmic pulsing sound was identified. Although the source of the sound could not be established, had the sound originated from the rotation of the main rotor blades, it would be indicative of a main rotor speed of about 340 rpm, some 50 rpm below the activation point of the main rotor low speed warning system.

*RTF tests at Blackpool Airport*

A series of audio tests were conducted at Blackpool Airport using a helicopter of the same type, and having the same model of headsets and VHF communication equipment as G-LINX. It was established that whilst in the cruise, at engine speeds of about 2,600 rpm and above, sounds generated by the operation of the engine could be recorded by the RTF system at Blackpool Airport. At an engine speed of 2,530 rpm, (similar to that at the time of the first three radio transmissions from G-LINX) sounds generated by the engine could not be detected in the recording. Two practice autorotations were also carried out, with the engine speed set to about 1,500 rpm. Analysis of the recordings could not detect any sounds generated by the engine.

*Previous flights*

The instructor flew G-LINX on 14 occasions between 23 July 2009 and 20 September 2009. Radar data indicated that six of the flights had been circuits flown within the Blackpool aerodrome traffic zone and eight were local flights, departing and returning to Blackpool Airport. All but one of the local flights operated to the north of Blackpool Airport. Transponder Mode A information was available for all the flights, but only four - all local - contained Mode C altitude information: two flights on 23 July 2009, one flight on 24 July 2009 and one flight on 20 September 2009.

Each of the four flights containing Mode C altitude information included descents consistent with carrying out practice autorotations. During the flights on 23 July 2009 and 24 July 2009, the helicopter descended from 1,500 ft to about 500 ft before climbing. On the 20 September 2009, the practice autorotation continued to a landing or low-level hover above a field. Radar information indicates that G-LINX then tracked slowly across the field for about two minutes, before climbing to 1,600 ft. The field itself was situated near to the east bank of the River Wyre, just over 0.5 nm south of the accident location.

The four flights for which altitude information was available provided no evidence of G-LINX having been flown consistently at heights similar to those during the latter stages of the accident flight, except during takeoff, landing or the aforementioned practice autorotations.

**Medical and pathological information**

A post-mortem examination, conducted by an aviation pathologist, revealed that both occupants had died immediately of severe injuries sustained in the accident. There was no evidence of pre-existing medical conditions that could have caused or contributed to the accident and toxicology revealed no evidence of drugs or alcohol.

**Autorotation**

Autorotation in helicopters is said to occur when the main rotor is turned by the action of airflow rather than engine power and is the means by which a helicopter can be landed safely in the event of an engine failure[3]. The rate of descent in an autorotation is affected by forward airspeed. In the Schweizer 269C-1 it is relatively high at zero airspeed, reducing to a minimum at approximately 50 to 60 kt and increasing again as airspeed increases. The speed specified by a manufacturer for conducting the manoeuvre is usually chosen to give the best combination of minimum rate of descent and most shallow glide angle. Accordingly, the absolute minimum rate of descent may be achieved at a slightly slower airspeed than that specified but any further decrease in airspeed will result in an increased rate of descent.

When landing, the rotational energy stored in the main rotor is converted into thrust to decrease the

**Footnote**

[3] U.S Department of transportation, *'Rotor Flying Handbook'*, 2000, p.30.

rate of descent and achieve a soft landing. More energy is required to decrease a high rate of descent. Consequently, descents at very low or very high airspeeds are more critical than those performed at the airspeed giving the minimum rate of descent, because the rotor may have insufficient stored energy to reduce the resulting high rate of descent before landing.

The stabilised rate of descent in a typical practice autorotation is between approximately 1,500 and 2,000 ft/min. The average rate for the whole manoeuvre from initiation in level flight to recovery is lower depending on the duration of the manoeuvre, because it includes a period at the start of the manoeuvre during which the rate of descent increases from approximately zero.

*Effects of controls*

Collective

Lowering the collective lever reduces the pitch of all the main rotor blades. Following an engine failure this will result in a descent and an upward flow of air that can produce sufficient thrust to maintain main rotor rpm for autorotation. Conversely, raising the lever increases the pitch of all the main rotor blades. To a certain extent this will increase the lift of the main rotor but in the absence of engine power will also result in a reduction of main rotor rpm. It is therefore important not to raise the lever to such an extent that the rpm falls below the normal operating range until a safe landing is assured. Given sufficient height it may be possible to increase rpm by lowering the collective again but this will result in an increased rate of descent.

Cyclic

The cyclic control changes the pitch of each main rotor blade according to its position in the rotor cycle and, all else being equal, results in the rotor disc tilting in the direction of the control input. Forward movement of the cyclic control will, in the absence of other influences, tend to tilt the disc forwards, resulting in the nose of the aircraft pitching down and an increase in forward airspeed. Likewise, aft movement of the cyclic will tend to raise the nose and reduce forward airspeed. During an autorotation a descent of several hundred feet may be required before a forward cyclic input will result in a significant increase in airspeed.

*Procedures*

The Pilot's Flight Manual contains *'emergency and malfunction procedures'*. The first five items of the procedure entitled *'Engine failure – altitude above 450 feet'* are as follows:

*'1. Lower collective pitch.*

*2. Enter normal autorotation.*

*3. Establish a steady glide of 52 kt (60 mph) IAS approximately.*

*4. At an altitude[4] of approximately 50 feet, initiate a flare.*

*5. At approximately 10 feet, coordinate collective pitch with forward movement of cyclic stick to level aircraft and cushion landing. Make ground contact with aircraft level.'*

The procedure entitled *'Engine failure – altitude above 7 feet and below 450 feet'* states:

*'In the event of power failure during takeoff, lower the collective pitch (altitude permitting), in order to maintain rotor speed. The amount*

**Footnote**

4 Strictly, the word "altitude" indicates height above sea level, but in this context is understood to mean height above ground level.

> *and duration of collective reduction depends upon the height above ground at which the engine failure occurs. As the ground is approached, use aft cyclic and collective as needed to decrease forward speed and vertical velocity.'*

*Training*

The requirements for the licensing of helicopter pilots are set out in the Joint Aviation Requirements Flight crew licensing (Helicopter), known as JAR-FCL 2. Appendix 1 to JAR-FCL 2.125 – *'PPL(H) training course – Summary'* states that the PPL(H) flight instruction syllabus shall cover, among other items, emergency procedures, basic autorotations and simulated engine failure.

Appendix 1 to JAR-FCL 2.320D – *'Flight Instructor rating (Helicopter) (FI(H)) course'* states the following course objective:

> *'The aim of the FI(H) course is to train helicopter licence holders to the level of proficiency necessary for the issue of a FI(H) rating and, for that purpose, to:*
>
> *a. refresh and bring up to date the technical knowledge of the student instructor;*
>
> *b. train the student instructor to teach the ground subjects and air exercises;*
>
> *c. ensure that the student instructor's flying is of a sufficiently high standard; and*
>
> *d. teach the student instructor the principles of basic instruction and to apply them at the PPL level.'*

The United Kingdom CAA no longer produces formal guidance on the conduct of this training but conventions remain based on the withdrawn document Civil Aviation Publication (CAP) 421 – *'Basic flying instructor (helicopter) handbook'*, which previously served this purpose. In particular, instructors are usually taught that when conducting a practice autorotation or engine-off landing the aircraft should be positioned into wind at the correct speed no lower than 300 ft agl.

During the investigation the AAIB consulted several instructors, the CAA Flight Operations Inspectorate and Staff Flight Examiners. All commented that, whilst a successful downwind landing is possible in favourable circumstances, it is always preferable to land into wind, especially in the event of engine failure. To do so requires sufficient height to reposition the helicopter if it is not already heading into wind and the existence of suitable terrain in the landing direction. If forced to land downwind a pilot would be presented with an unfamiliar situation and might be tempted to reduce the high apparent ground speed by applying aft cyclic control. This could result in an airspeed below that for minimum rate of descent.

The instructor who operated the registered facility from which the flight originated commented that when flying along the River Wyre he would do so approximately half a mile east of the high tide line to allow sufficient space for a dry landing into wind in the event of an engine failure. In common with the other instructors consulted, he stated that a practice autorotation would not normally be initiated below 1,500 ft. To do so would limit its training value by providing insufficient opportunity to explore the manoeuvre, whilst reducing the margin for correcting errors.

When conducting a practice autorotation the normal procedure is to lower the collective lever fully whilst closing the throttle progressively to avoid excessive engine speed. It is not necessary to close the throttle abruptly but instructors commented that students sometimes did so and that on occasion this had resulted in the engine stopping.

**Organisational information**

In the UK, training for the issue of a PPL is conducted at Registered Training Facilities (RF). RFs are required to register with the CAA and to certify that they comply with certain required conditions but no approval is required. No inspections are carried out, no training or operations manuals are required and it is not necessary for the RF to maintain formal training records, although some choose to do so. Registration remains valid until either the CAA is informed that PPL training is to cease or the CAA establishes that training is not being carried out safely or is not in compliance with JAR-FCL5. The AAIB explored the potential disadvantages of this system and made recommendations intended to improve oversight in its report of the accident on 26 January 2008 to Gazelle helicopter YU-HEW6.

The RF from which the accident flight originated did not have training or operating manuals and did not maintain formal training records for each of its students. Consequently it was not possible to determine the minimum height at which its instructors were expected to operate the aircraft in cruising flight or when initiating practice autorotations.

**Footnote**

5 Joint Aviation Requirements – flight crew licensing.
6 Published in the AAIB Bulletin 11/2009.

**Aircraft information**

G-LINX (Figure 7) was type certified as a 'Model 269C-1', but its commercial designation was 'Schweizer 300CBi'. The helicopter type is a development of the Hughes 300C. G-LINX was manufactured in 2006 and the airframe and engine had accumulated 307 hours at the time of the accident. The helicopter was powered by a fuel-injected Lycoming HIO-360-G1A piston engine which drove the main rotor gearbox and tail rotor driveshaft via a belt-drive transmission assembly. It had a three-bladed, fully articulated, main rotor and a two-bladed tail rotor. The helicopter's flight controls were mechanically actuated via a series of tubular push-pull rods and cables, without any hydraulic assistance. The helicopter was fitted with two seats and dual flying controls and had a maximum takeoff weight of 794 kg.


**Figure 7**

Accident aircraft, G-LINX

*(photo courtesy CAA website G-INFO)*

The helicopter was equipped with the optional AES/STAR system (Automatic Engagement System/Startup RPM Limiter/Rotor Low RPM Warning Installation). The low rotor rpm warning part of this system includes a red light on the instrument panel and a horn. If the rotor rpm drops below the minimum normal operating range of 442 rpm (equivalent to 2,530 engine rpm when the engine is engaged to the rotor) the red light flashes and the horn emits a pulsing tone at 2,900 ± 500 Hz. If the rotor rpm drops below 390 rpm (the minimum safe autorotation rpm) the red light indicates steady ON and the horn emits a steady 2,900 ± 500 Hz tone.

**Maintenance history**

The helicopter was maintained by an EASA Part-145 approved maintenance organisation. Its last annual maintenance inspection was completed on 21 July 2009 when the helicopter had accumulated 289 flight hours (18 hours prior to the accident). The annual inspection included work on the main rotor and tail rotor drive systems and was, therefore, followed by an air test. The helicopter's last maintenance input before the accident was a main rotor mast torque check on 11 September 2009 at 305 flight hours. There were no open deferred defects recorded in the technical log. There were no entries in any of the maintenance worksheets of an adjustment having been made to the engine's idle rpm setting or idle mixture setting.

**Accident site and initial wreckage examination**

The helicopter had struck the ground on the eastern bank of the River Wyre, 1.2 nm west of Stalmine. It was located in a grassy area of soft ground that sometimes floods at high tide. On the day of the accident the high tide occurred at 1320 hrs (UTC) at which time the river came to within a few metres of the wreckage but did not reach it. The evidence at the accident site indicated that the helicopter had hit the ground with a high vertical speed and a very low foward speed, on a heading of approximiately 173°(M). There was a very limited spread of wreckage, mostly consisting of broken pieces of perspex, in the direction of 107°(M) (Figure 8), which indicated that the helicopter had some sideways travel to the left at the time of impact. The furthest piece of wreckage, a piece of perspex, was located 16 m east of the main wreckage. The left skid had broken, the right skid had splayed outwards and both seat pans had been crushed, indicating that the helicopter had not initially struck the ground on its left side, but that it had rolled onto its left side after impact in a moderate left bank.

The three main rotor blades were intact with no damage to their leading edges, trailing edges or tips, indicating that they had little rotational energy at impact. One rotor blade was bent upwards, one was bent downwards, and the third had multiple bends and wrinkles from impact with the ground. Chordwise mud splatter on the tips of the blades indicated that some rotation was present at impact. The tail rotor gearbox had remained attached to the tail boom and both tail rotor blades were attached to the gearbox. One tail rotor blade was undamaged, and the other, which was buried, had a damaged tip. The


**Figure 8**

Accident site - parts of the cabin structure have been removed and the green tarpaulin was placed on the ground after the accident horizontal stabiliser was undamaged. The tail boom had bent and split about 70 cm forward of the tail rotor gearbox, and the tail rotor driveshaft had sheared at the same location, although it did not exhibit evidence of a high-energy torsional failure. The eight transmission drive-belts were intact, although they had lost their tension as a result of failure of the H-frame supporting the upper and lower pulleys.

**Detailed wreckage examination**

*Flying controls*

The cable control between the tail rotor and the pedals was continuous. The cyclic pitch and roll, and collective controls to the main rotor head were continuous apart from some control rod overload failures beneath the cockpit floor.

*Rotary drive components*

The main rotor gearbox was driven by the engine through a transmission assembly consisting of a lower pulley attached to the engine driveshaft and an upper pulley attached to the main rotor gearbox input drive shaft (Figure 9). The lower pulley directed power to the upper pulley through a set of eight drive-belts. An 'idler' pulley, running against the belts, and actuated electrically by the pilot, operated as a clutch to engage the upper pulley after engine start. The tail rotor driveshaft was driven directly by the upper pulley. The upper pulley incorporated an over-running clutch (freewheel unit) to permit the main rotor to autorotate without back-driving the belts or engine, in the event of an engine failure. Examination of the main rotor head, main rotor driveshaft, main rotor gearbox, upper pulley, tail rotor driveshaft and tail rotor gearbox revealed that they were all free to rotate. The over-running clutch was also found to be operational. The lower pulley was connected to the engine driveshaft, and once the driveshaft was disconnected the lower pulley rotated freely on its bearing. The eight belts were intact and in good condition, but tension had been lost as a result of overload failure of the H-frame between the upper and lower pulleys. Failure of this H-frame was consistent with the high vertical loads experienced at impact. The linear actuator which drove the 'idler' pulley was measured to be in the fully retracted position, corresponding to full belt tension having been applied. The main rotor gearbox and tail rotor gearbox chip detectors were found to be clean.

*Fuel system*

The single fuel tank (32.5 USG usable capacity) on the aircraft was found to be intact and contained 11.7 USG of fuel. Fuel samples taken from the fuel tank and the fuel lines were tested and found to conform with

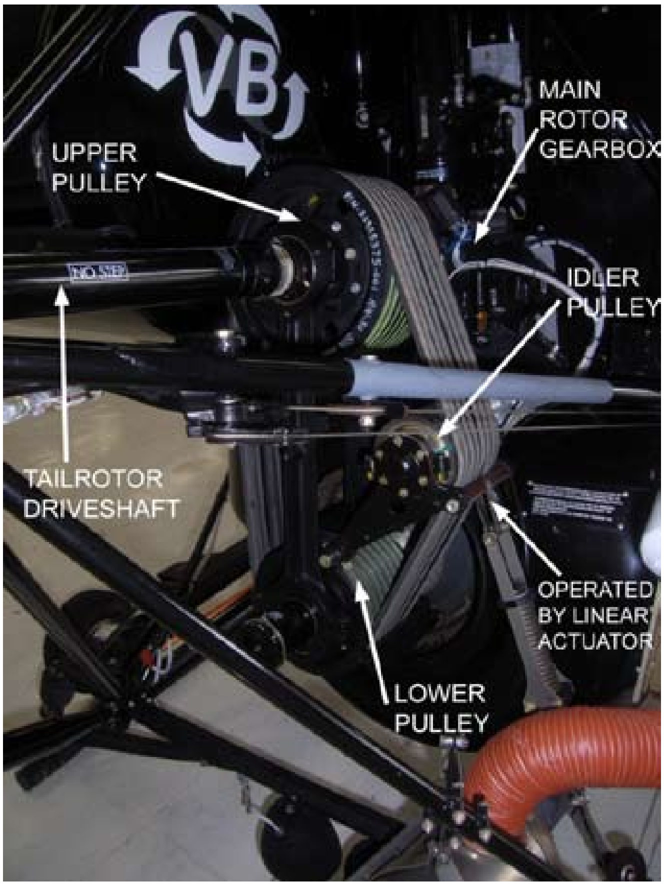


**Figure 9**

Schweizer 269C-1 transmission assembly

the properties of Avgas 100LL with no evidence of contamination. The fuel tank breather tube was clear. The pilot-controllable fuel shutoff valve, located near the outlet of the fuel tank, was found in the ON position. The fuel lines were continuous between the fuel tank and the engine apart from a separation at the outlet of the fuel strainer. The hose between the outlet of the fuel strainer and the engine-driven fuel pump had separated at the strainer fitting end, but this appeared to be the result of impact damage to the fitting. Residual fuel was found throughout the system, including in the fuel strainer, the engine-driven fuel pump and the fuel injector servo. The electric fuel boost pump motor was tested with a 24 VDC power supply and operated normally, and the pump was stripped with no defects found. The engine-driven fuel pump was also stripped with no defects found.

*Instruments and switches*

The lower portion of the instrument panel was severely disrupted which rendered the position of unguarded switches unreliable. The guarded clutch switch was in the normal ENGAGE position. The magneto switch was in the BOTH position but the key had broken off. The fuel mixture control lever was found in the normal 'full rich' position, but bent almost 90°. There were no witness marks on the faces of the flight or engine instruments that might have given an indication of a pre-impact reading. The altimeter was found set to a QNH of 1019 mb. The filaments from the warning and caution bulbs were examined for indications of stretch that might indicate a hot/illuminated bulb at impact, but none of the filaments had stretched or broken.

*Air intake*

The engine air intake duct, at the front of the helicopter beneath the cockpit floor, was crushed. The intake duct was cut open and the air filter was found to be clear with no evidence of obstructions within the intake system.

**Engine examination**

The throttle and mixture controls to the fuel injector servo on the engine were continuous apart from some overload failures within the throttle linkages. The engine was removed from the aircraft for a strip examination. The engine had suffered some impact damage to its exhaust pipes and intake manifold pipes, which were attached to the base of the engine, but the engine was otherwise intact. When the spark plugs were removed the engine could be rotated freely by turning the fan attached to the crankshaft. A complete teardown of the engine cylinders and crankcase did not reveal any mechanical failures or defects, or any evidence of heat distress. All the cylinder bores, pistons and piston rings were in good condition, although oil had collected inside cylinder No 1 and No 3 (the left side of the engine[7]), probably due to the engine's orientation at the accident site. The spark plugs were in good condition apart from oil deposits on the lower plugs from cylinders No 1 and No 3. The components of the oil scavenge pump were in good condition and the oil filter was clear.

The fuel injector lines were all connected and free of internal obstructions, and a flow test of the fuel injector nozzles found them to be operating within specification. The engine-driven fuel pump was intact and ejected some fuel during removal. The fuel injector servo was bench tested after cleaning its venturi assembly which had ingested some mud. The fuel injector servo passed the flowmeter limit specifications, except for the fuel

**Footnote**

[7] Compared to a fixed wing aircraft with a tractor-propeller configuration, the engine on the Schweizer 269C-1 is mounted backwards, so the No 1 and No 3 cylinders are on the aircraft's left side.

flow measurement with 0 lb/hr airflow and the mixture control set to RICH. During this test a fuel flow rate of 32.25 lb/hr was observed, while the specification range was 23.0 lb/hr minimum to 31.0 lb/hr maximum.

Both the left and right magnetos were securely attached to the accessory gearbox with no witness marks indicating slippage. The magnetos were removed and bench tested. The left magneto passed the specification test which required it to produce a consistent steady spark at 255 rpm[8]. At speeds above this it also operated normally. The right magneto failed the specification test. At 255 rpm the right magneto barely produced a single spark; at 500 rpm it produced sparks at all four points but firing erratically; at 750 rpm it was still missing some sparks on occasions; at 1,000 rpm it produced near steady sparks; and at 1,500 rpm and above it produced consistent steady sparks. The right magneto was opened up which revealed that the contact points were worn more than normal, and the position at which the contact points opened was 7° out. The contact points were replaced with a used set and rigged correctly. The right magneto was then retested and it produced a consistent steady spark at 255 rpm and above. At a later date, the original contact points were reinstalled in the magneto and set to their as found position. The magneto was then installed on a different Lycoming IO-360 engine which was mounted to a dynamometer testbed. The magneto installed in the 'left' position was a new magneto. The engine was warmed and then operated at varying engine rpms while operating on both magnetos, the left magneto only and the right magneto only. The engine operated normally at 700 rpm and above while selected to the left, right or both magnetos. At 500 rpm and 600 rpm, the engine ran continuously but roughly on the left magneto only. At 500 rpm and 600 rpm, the engine ran down and stopped when on the right magneto only. The idle stop was set to 500 rpm as this was an engine intended for a fixed-wing aircraft. The engine fitted to G-LINX would have had its idle-stop originally set to a minimum of 1,400 rpm with the rotor disengaged.

**Footnote**

[8] In this installation magneto rpm is equivalent to engine rpm.

**Adjustment of engine idle rpm and idle mixture**

The Schweizer 269C-1 Pilot's Flight Manual (Revision 24 October 2002) contains a procedure in section 4.14 entitled '*Pilot's Check of Idle Mixture, Idle Speed, and (Helicopters with Fuel Injected Engine – HIO-360-G1A) Fuel Boost Pump*'. The procedure states that:

> *'this check of idle mixture and idle speed shall be accomplished at the end of the last flight each day, prior to engine shutdown.'*

The idle mixture check involves rapidly rotating the throttle to the closed (normal idle stop, not override) position, and then smoothly moving the mixture control towards the IDLE CUTOFF position and noting the engine rpm, before moving the mixture back to FULL RICH before the engine stops. The engine rpm should rise between 25 and 100 rpm, before dropping during this check. If the rpm rise is not within these limits then the idle mixture setting needs to be adjusted by maintenance personnel.

The idle mixture procedure is followed by the idle speed check. During this check the throttle is rapidly rotated closed to the full override position, and the rpm should be checked that it does not drop below 1,400 rpm. A second check involving rapidly rotating the throttle to the normal idle stop should produce an engine rpm no greater than 1,600 rpm. If the engine idle speed is not within these required limits then it needs to be adjusted by maintenance personnel.

The checklist found in G-LINX did not contain either of the above checks as part of the post-flight engine shutdown checks. However, in its pre-takeoff '*After Engagement*' section, a check similar to the idle speed check was included which stated:

> *'Lower lever – close throttle. Observe needle split and check ground idle rpm (1400 +/- 100 rpm).'*

The checklist did not make it clear whether the throttle should be closed to the normal idle stop or the override position. The checklist also permitted a ground idle rpm of 1,300 rpm, whereas the Pilot's Flight Manual specified a minimum of 1,400 rpm.

Discussions with six different Schweizer 269C-1 flight instructors from different training organisations in the UK revealed that only one of them was aware of the idle mixture check. They all carried out some variation of the idle speed check as part of their pre-takeoff checks, although some just checked for a needle split and that the engine did not stop, but did not check for a specific rpm. The aircraft manufacturer stated that it was important to carry out the idle speed check and idle mixture check because if either the idle speed or idle mixture were set incorrectly, it could lead to engine stoppage in flight if idle were selected. The manufacturer also stated that it was important to perform the idle speed check at the end of the flight, rather than only prior to flight, because the engine response was different when the engine was at normal operating temperature.

*Post-maintenance engine ground runs*

G-LINX was maintained in accordance with the Light Aircraft Maintenance Schedule (LAMS), which later became the Light Aircraft Maintenance Programme (LAMP). Both LAMS and LAMP required that an engine ground run be carried out after every 50-hour, 150-hour, or annual check. The only LAMS/LAMP requirements for the engine ground run were that the powerplant, liquid, air and gas systems be checked for leaks, and that the instruments, systems and services be checked for operation, and that following the ground run a check of cowling, panel and door security was carried out. There was no specific requirement to check engine idle speed or idle mixture setting. The Schweizer 269C-1 maintenance manual did not specify such a check either, unless the settings had been adjusted. The maintenance organisation that maintained G-LINX had carried out engine ground runs in accordance with LAMS/LAMP, and no check of the idle speed or idle mixture setting was carried out. The maintenance organisation employed pilots to perform the engine ground runs, and these pilots were not aware of the idle mixture setting check or the pre-shutdown idle speed check in the Pilot's Flight Manual, and therefore had not performed them. The maintenance organisation that had previously maintained G-LINX had completed an 'engine run record' after some of its maintenance checks. These included an entry for '*Slow Running RPM*' (although not defined) and for '*ERPM Rise at Mixture Check*'. The last engine run record was completed on 11 April 2007 and noted a '*Slow Running RPM*' of 1,430 rpm and a '*ERPM Rise at Mixture Check*' of 50 rpm. Assuming the '*Slow Running RPM'* check was done with the throttle in the override position and the needles split, then these figures were within the specification limits in the Pilot's Flight Manual.

## Analysis

*Engineering issues*

The evidence at the accident site was consistent with the aircraft having struck the ground with a high vertical speed, travelling sideways to the left with little or no forward speed. The aircraft's attitude at impact was probably slightly nose-up with some left bank. The minimal damage to the main rotor and tail rotor blades indicated that the rotors probably had insufficient rotational energy to sustain flight. This evidence was consistent with the presence of the steady low rpm warning tone in the pilot's final radio transmission, which indicated that the rotor rpm was below a safe speed for autorotation. There was no evidence of a pre-impact failure to any of the rotary drive components, so an engine problem or stoppage was suspected as a factor in the loss of rotor rpm. A witness who may have observed G-LINX shortly before 1100 hrs reported seeing puffs of black smoke from a helicopter. Black smoke from an exhaust can result from incomplete combustion of the fuel. However, apart from a weak right magneto and a slightly out-of-tolerance fuel injector servo, no anomalies with the engine powerplant system could be found. At the normal minimum engine idle rpm of 1,400, the problem with the right magneto's contacts would not have been apparent and therefore was probably not a factor in affecting the engine's operation. Even if the engine idle rpm had been set 200 rpm below the 1,400 rpm minimum, the right magneto would probably still not have affected the engine's operation.

The slightly rich setting of the fuel injector servo might have contributed to a rich cut if the throttle was rapidly reduced to idle, but the idle mixture setting would normally have been adjusted by the aircraft manufacturer after installing and ground-running the engine; this idle mixture setting is adjusted by turning a thumbwheel which shortens or lengthens the idle mixture link and could compensate for an over-rich setting internal to the fuel injector servo. There were no entries in any of the maintenance worksheets of an adjustment having been made to the engine's idle rpm setting or idle mixture setting post aircraft construction. So the possibility existed that the settings had drifted outside the required limits, and this could have caused an engine stoppage if idle had been selected in flight. There was no requirement for the maintenance organisation to check the idle speed or idle mixture settings during the post-maintenance engine ground run, but according to the Pilot's Flight Manual, pilots should have been performing this check at the end of the last flight of the day. Among the Schweizer piloting community in the UK the awareness of these procedures appeared to be low. Therefore the following Safety Recommendation is made:

**Safety Recommendation 2010-089**

It is recommended that the Civil Aviation Authority highlight to owners and operators of Schweizer 269C-1 helicopters the importance of performing the idle speed and idle mixture checks in section 4.14 of the Pilot's Flight Manual.

*Operational issues*

With the exception of the single report of black puffs of smoke emanating from the helicopter as it flew north from Blackpool, the flight appears to have proceeded unremarkably until the helicopter descended over the sands north of Knott End. Radar resolution was insufficient to determine the exact nature of the manoeuvres north of Knott End, but indicated average rates of descent that are typically achieved during practice autorotations. From that point until the end of the flight there is no record of the helicopter having climbed above 500 ft, although there were no reported cloud or airspace restrictions that would have prevented it from doing so.

After these manoeuvres the helicopter turned south to follow the east bank of the River Wyre at approximately 400 ft. There were no indications of flight control or other difficulties until the MAYDAY call shortly before the final descent. Transmission of the MAYDAY indicates that the instructor had identified an emergency situation and, although it was not possible to determine what this was, the MAYDAY itself was delivered in a voice that, according to family members, sounded calm and held no sense of panic. Analysis of the final transmission, however, suggests that the helicopter was by then no longer in controlled flight.

The engineering investigation found that a loss of power might occur if the throttle was rapidly reduced to idle, such as might occur if it was closed too abruptly at the start of a practice autorotation. If the manoeuvres north of Knott End seen by the witness and recorded on radar were practice autorotations then they appear to have been completed without incident. The instructor had previously used the area in which the accident took place to conduct practice autorotations. It is therefore possible that immediately prior to the accident one of the occupants of G-LINX initiated a practice autorotation. If this involved abrupt closure of the throttle then this might have caused the engine to lose power. This would have been cause for the instructor to transmit a MAYDAY and attempt a forced landing and is a possible mechanism for the helicopter entering its final descent. However, there is no record of the instructor having conducted practice autorotations from heights of 500 ft or less on previous flights and there is no obvious training value in doing so. There is therefore no reason to presume that this is what happened.

Having identified an actual emergency, particularly if he believed the engine had failed, the instructor would probably have initiated an intentional autorotation in order to land under control. However, at the time of the MAYDAY, the location of the helicopter was such that he would have been constrained to complete a forced landing either downwind or into the river. There would have been insufficient height to reposition the helicopter with enough dry land ahead to complete the manoeuvre into wind. At a height of approximately 400 ft the instructor would have had very little time in which to make a decision, but the location of the wreckage suggests that he attempted a landing downwind.

Information provided by the manufacturer and experienced pilots indicates that a landing downwind without power is likely to be difficult to accomplish safely. A pilot faced with this situation might try to reduce the apparent high ground speed by applying aft cyclic control, which could result in an airspeed below that for minimum rate of descent. There might then be insufficient energy stored in the rotor to reduce the resulting high rate of descent, such that the impact would not be survivable. Having elected to land downwind, normal control could be maintained by maintaining the correct airspeed throughout the descent and allowing the helicopter to touch down with high forward ground speed. However, the outcome would then depend on how smooth and level the terrain was over which the aircraft would then slide to a halt.

Whatever caused the instructor to make a forced landing, the location of the helicopter at low level over the downwind river bank limited the options for a successful outcome. Operation of the helicopter at greater height, further downwind of the river bank, would have provided more opportunity to complete an autorotation into wind and onto land.

**Conclusion**

The pilot responded to an emergency situation, apparently associated with a loss of power, the cause of which the investigation was unable to identify. The subsequent manoeuvres, initiated from a height of approximately 400 ft, were accompanied by a loss of rotor rpm and did not result in a safe landing. Operating the helicopter at greater height and in a position from which an into-wind landing could have been accomplished would have increased the opportunities for a safe outcome.