ACCIDENT

Aircraft Type and Registration:	AS355F2 Twin Squirrel, G-SEWP
No & Type of Engines:	2 Allison 250-C20F turboshaft engines
Constructor's Serial No:	5480
Year of Manufacture:	1991
Date & Time (UTC):	28 October 2010 at 0950 hrs
Location:	31 nm south of Belfast Aldergrove Airport, Northern Ireland
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - 1 (Minor) Passengers - 3 (Minor)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Commercial Pilot's Licence (Helicopter)
Commander's Age:	42 years
Commander's Flying Experience:	2,045 hours (of which 185 were on type) Last 90 days - 47 hours Last 28 days - 21 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot lost control of the helicopter whilst manoeuvring at low speed to approach a hilltop landing site in quite strong wind conditions. It descended rapidly with increasing forward ground speed, before striking the ground short of the point of intended landing and passing through a substantial stone wall. The helicopter was destroyed but the occupants suffered only minor injuries. The investigation determined that an error of judgement or perception led the pilot to attempt a downwind approach. A combination of human factors was thought to have contributed to the accident.

History of the flight

The helicopter was engaged on a task for the Police Service of Northern Ireland (PSNI), ferrying personnel and equipment to and from the site of a helicopter accident which had occurred 5 days earlier, on 23 October 2010. The site was in the Mourne Mountains, near to the top of the 626 m (2,054 ft) amsl Shanlieve hill. A PSNI control point, from where passengers embarked for the ferry flights, had been established in a valley about 3 km from the site.

G-SEWP had been similarly tasked the day before, completing seven round trips. The same pilot operated the task, but with a different observer than on the day of

the accident. Cloud affected the hilltop on occasions and the first three flights terminated at an alternative landing site lower down the hill.

On the day of the accident, the pilot and observer commenced their pre-flight duties at 0700 hrs at their Aldergrove base. A 'check A' was made on the helicopter and the fuel state was confirmed at 65% (about 475 litres). A weather report showed that a warm front was forecast to cross the area, giving rise to cloud on the hilltops. It was thought that a workable period should be available prior to the weather front's passage at about lunchtime, and possibly afterwards as well. Surface winds were expected to be about 10 kt at the surface, and about 20 kt on the hilltops, generally from the south-west.

The helicopter departed Aldergrove at 0744 hrs and flew to the accident area, where the pilot carried out a weather check. Cloud was affecting the hilltops and the helicopter circled the area without overflying the primary landing site near the summit. The helicopter then landed and shut down adjacent to the police control point.

A plan for the morning's task was agreed and passengers were briefed accordingly. It was decided that 'rotors running' turn-rounds would be made, with the observer escorting passengers to and from the helicopter. The observer normally occupied the front left seat in the helicopter, but for mass and balance purposes he occupied the rear right seat for the ferry flights. This also allowed better monitoring and supervision of the passengers. While the pilot and observer wore safety helmets, only headsets were available to the passengers.

The first flight could not be made to the hilltop because of cloud, so the passengers were disembarked at the alternative landing site. However, the next four flights were able to reach the primary landing site, situated a few metres from the summit of the hill, near to a substantial stone wall and a little way upslope from the earlier accident area.

The accident occurred on the last planned ferry flight of the morning. It appeared that the summit was affected by cloud so the pilot initially routed towards the alternative landing site. However, it then became apparent that the summit was clear of cloud, so the pilot continued towards it.

The four previous approaches had been made from the north-east, approximately into wind. Whilst at the summit on the previous flight the pilot thought that the wind had backed and reduced in strength. On the accident flight, because of the possible drop-off at the alternative site, the helicopter approached the hilltop from a westerly direction. It overflew the landing site and started a right turn back towards it (Figure 1).

The pilot's recollection was that he had completed at least a full orbit and was approaching the landing site substantially into wind, although this time on a more south or south-easterly track. With the landing site in view ahead, and whilst making his final approach at about 40 kt IAS, the pilot sensed a sudden loss of airspeed and lift, which he regarded as being due to windshear. The helicopter began to sink rapidly, accompanied by some instability in yaw. The pilot checked forward with the cyclic control in an attempt to gain airspeed and fly out of the situation. The helicopter continued to sink as the pilot raised the collective lever to apply power.

With the helicopter descending rapidly and now with significant forward speed, the pilot flared the helicopter just before it struck the ground. He recalled that it struck the ground a short distance before the intended landing site. The occupants sensed that the rear of the helicopter

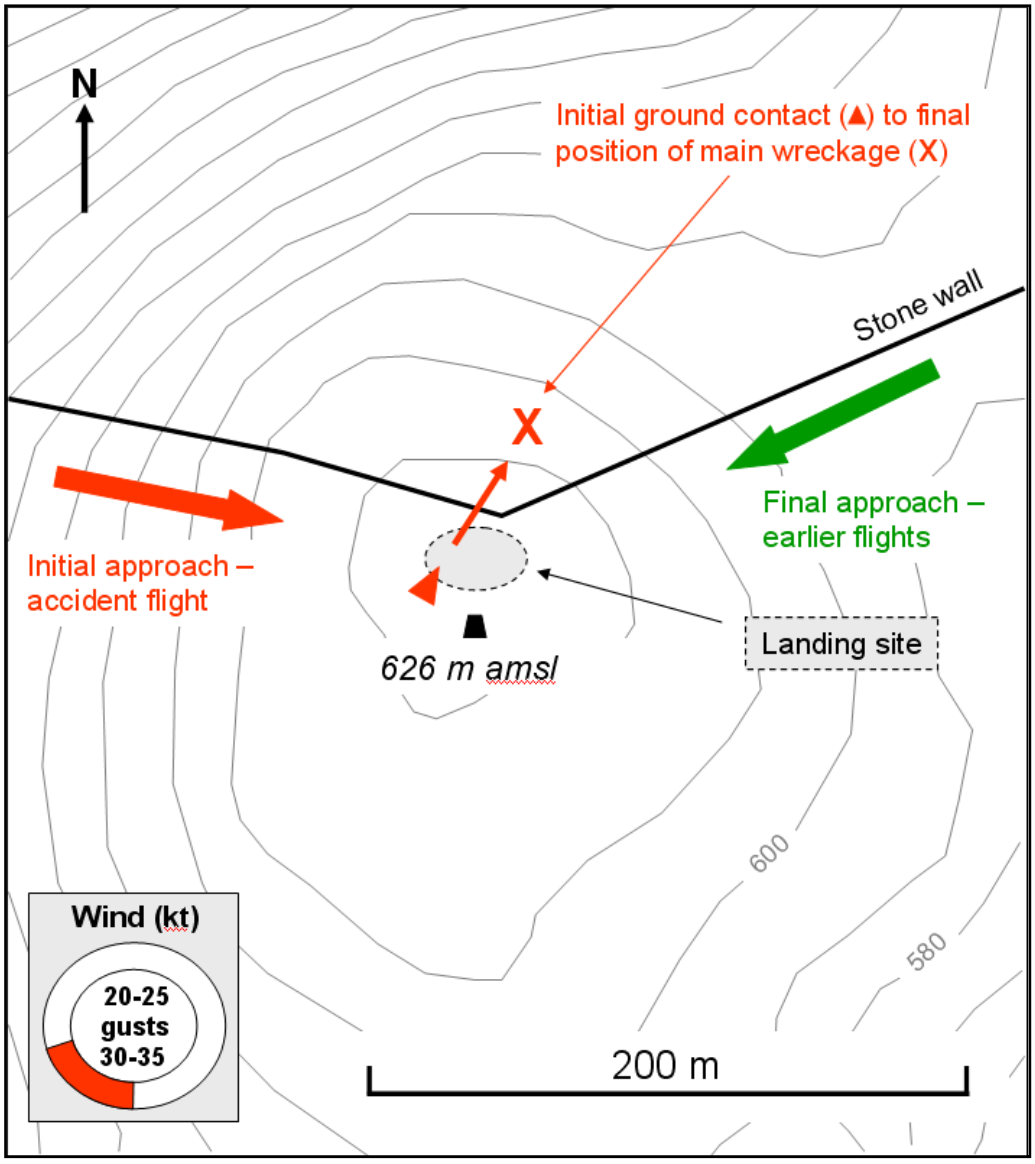

Figure 1

Sketch of accident location

struck the ground first, followed by the main cabin, in a substantial (though essentially upright) impact. The helicopter bounced and continued forward as it started to break up. It passed through the upper portion of the stone wall and came to rest some 36 m beyond.

The pilot and observer extricated themselves from the largely inverted wreckage of the main cabin. The observer then assisted the first of the passengers out, who had been seated in the left middle of the four-place rear seat. The second passenger, who had been seated in the left-most rear seat, was the most severely injured, suffering cuts and bruises which included a laceration of his scalp. He was also helped from the wreckage by the observer.

The survivors were taken to a tent being used by recovery teams working on the original accident site, where they were given first aid. The weather worsened soon after the accident, which initially prevented

further airborne access to the scene, so a rescue effort was launched on foot by mountain rescue personnel and paramedics. After some time, an RAF Sea King rescue helicopter was able to get to the scene and airlifted the survivors off the hillside. Paramedics arrived with the mountain rescue teams at about the same time as the rescue helicopter.

Accident site information

The helicopter struck approximately level ground in an erect attitude. The softness of the ground, the remoteness of the site and the adverse weather during the subsequent investigation limited the extent of the assessment of the ground markings which could be made.

The general condition of the helicopter, however, suggested a reasonably low rate of descent at initial ground contact. Absence of any earth deposits on the tail-skid (despite the soft peaty soil of the area) indicated no excessively nose-up attitude at initial ground contact. Rapid upset of the aircraft from the level attitude (as a consequence of forward motion with the skids in contact with a soft peaty surface) appeared to have resulted in the main rotor blades experiencing a sequence of ground contacts as they continued to rotate. This caused progressive multiple blade failures, rotation of the helicopter about the main rotor axis and separation of the aft end of the tail-boom. In addition the tail-rotor gearbox separated from the structure soon after initial ground contact. Upset of the helicopter appeared to have caused downward failure of the forward ends of the skids leading to consequent bending failure of those sections of skid between the forward and aft supports. Total destruction of the main blades occurred during the process of translation between the impact point and the final resting place of the fuselage.

The effect of main rotor blade contacts appears to have propelled the helicopter in a generally northerly direction, passing through the top of a dry stone wall, for a total distance from initial impact of approximately 80 metres. The helicopter came to rest in an approximately inverted position with the main rotor mast still attached and the tail-boom separated.

Passenger and eyewitness accounts

The observer and two passengers gave their accounts of the accident. Like the pilot, they recalled flying over the landing site from a westerly direction before turning right. However, unlike the pilot, all three described the helicopter turning through only about 270° before it started descending rapidly, either just after rolling level or as it was in the process of doing so. All three described the wall which the helicopter would eventually strike as being directly ahead and running across their path as the helicopter made its sudden descent.

The observer realised that the helicopter was approximately downwind when it started descending, and thought it had been caught by a strong gust of wind. One passenger clearly recalled hearing the pilot comment "it's into the wind" just before the final descent started, about coincident with a sudden bank to the right. The same passenger became aware of an intermittent warning tone[1] sounding in the cabin, which had not been present before the final descent started and was not present once the helicopter had come to rest.

A police officer working with the recovery teams at the earlier accident site described the helicopter's approaches earlier in the day as being from the north-east, with it touching down in a west or south-westerly direction. On

Footnote

[1] An intermittent warning horn sounds to indicate that the main rotor rpm is above 410 RPM. Maximum speed is 425 rpm (*AS355 F2 Flight Manual*)

the last flight, he became aware of the helicopter turning to the right before seeing what he described as a sudden yaw, probably to the right, followed by a sharp descent. The helicopter then went out of sight behind the wall (the witness was part way down the slope) before seeing it come physically through the wall, banked to its left.

Other eyewitnesses saw parts of the accident sequence, although none had a clear view because of their position further down the slope. Most described some form of rolling or yawing motion before the helicopter descended out of sight. Passengers and witnesses described the sound of the engines increasing just prior to impact.

Subsequent examination

The wreckage was salvaged using a heavy-lift helicopter and road vehicles. More detailed examination then took place of the powerplant, systems and flying controls.

Engines

Examination of the engines revealed no evidence of any failure. The intake areas of both engines showed similar evidence of ingestion of wet peat consistent with both units still running after the helicopter had become inverted and the external intake grills were partly buried or immediately adjacent to the peat surface. The liners of both compressors were similarly scored resulting from forceful rotation of the gas generators after soil ingestion; this indicated similar rotational conditions of each engine during the period of ingestion, some seconds after initial ground contact.

Boroscope inspection of both turbine areas indicated that they were in a serviceable condition. Hand rotation of each LP turbine resulted in corresponding rotational movement of the main rotor confirming the integrity of the drive from each engine to the rotor.

Flying Controls

The mechanical controls were disconnected from the servos and examined/functioned (as appropriate) from the cyclic and collective controls through to the servo inputs. No evidence was found of any failure or restriction that was not consistent with the effects of impact or structural distortion arising from the series of impacts.

The three main rotor servos were removed complete with their external flexible pipe systems (other than those piping areas where one system's piping was routed through the bell-housing above the main rotor gearbox). Each system was functionally tested at working pressure on a hydraulic pressure rig. Effectively identical movement rates were recorded for each end of each of the double servos (a total of six functions were being tested). In each case smooth operation occurred as a result of hand deflection of the input levers. No evidence of leakage was observed.

The tail rotor servo was similarly tested and responded in a similar way.

Hydraulic pumps

Both hydraulic pumps were removed for testing. The input splines were observed to be intact on both units. Strip examination confirmed that both pumps were in sound internal condition and thus fully capable of normal operation.

Survival aspects

The standard rear seat harness arrangement was lap straps for each seat. However, for operations with doors removed, the outermost seats on each side had been fitted with shoulder harnesses. While the observer was wearing the shoulder harness as well as the lap strap,

the passenger in the left outer seat wore only the lap strap. The passenger in the centre left seat had only the lap strap available.

In its final position, the overturned helicopter was prevented from becoming completely inverted by support from the main rotor mast, being inclined in such a way that the front right seat (pilot's) occupant volume was only partly intruded. The back of this seat was distorted in a forward direction consistent with the final ground impact. The bulk of the glass-reinforced plastic shell and transparent panelling of the cabin section was destroyed, leaving only a small section of the right-hand side roof in place, the remainder of the occupied volume no longer being enclosed. The overhead control panel and quadrant area was totally disrupted although it remained attached.

The metal floor structure was distorted with impact damage concentrated at the forward left side but the bulk of the floor remained relatively intact. Although the front left seat survived in a damaged state, the whole of the left front seat occupant volume was totally intruded. This left seat was unoccupied during the accident flight. The rear cabin bulkhead remained intact and provided head protection for the rear seat occupants.

Pilot information

The pilot gained a Commercial Pilot's Licence in 2005 and underwent AS355 type rating training in 2006. He subsequently gained a Flight Instructor rating, and from 2007 worked as an instructor and charter pilot on R22 and B206 helicopters. Following a period of line and role training in early 2010, he started work with the helicopter operator in April 2010 as a full time freelance pilot, flying G-SEWP on charter to the PSNI. The pilot had completed all the helicopter and role training required by the operator.

The pilot arrived in Northern Ireland from England two days before the accident, for the start of a five day period of duty. Immediately beforehand, he had suffered a family bereavement. He did not report this to his company and considered on the day that he was fit for flying duty. However, when the pilot subsequently informed the AAIB of the fact, he thought it possible that it may have been a contributory factor in the accident.

Helicopter performance

A post-accident mass and balance calculation produced an estimated mass at the time of the accident of 2,281 kg. Maximum permissible mass was 2,540 kg. Longitudinal centre of gravity was calculated at 3.31 m aft of datum: a moderately forward position, within permissible limits.

Meteorological information

A report on the forecast and actual weather conditions was prepared by the Met Office. There was an area of low pressure centred to the west of Ireland, with an approaching warm front which lay approximately across the accident area by 1200 hrs. Thus, at the time of the accident, the area lay in a west to south-westerly airflow, with an approximate gradient (or 2,000 ft) wind from 230° at 30 to 35 kt. Surface analysis charts and airfield weather reports were not wholly representative of weather in the Mourne Mountains, but clearly showed the approaching warm front. The Belfast Aldergrove forecast showed temporary periods of rain from 0900 hrs, with broken cloud at 1,200 ft agl, implying a high possibility of hill fog on the mountains.

Wind speeds at airfields in the area were 10 to 11 kt, with no gusts reported. The winds at the accident site would probably have been significantly stronger and closer to the gradient wind speed: 20 to 25 kt with gusts of 30 to 35 kt. There were indications of mountain wave

activity in the area, with predicted vertical velocities of 200 to 300 feet per minute, which may have caused turbulence effects such as sudden gusts.

Information from the crew and passengers generally concurred with the Met Office report, although no turbulence was experienced. However, the pilot's assessment of a change of wind direction was not supported by the Met Office report.

Vortex ring state

Vortex ring state (VRS) is a phenomenon that occurs when the main rotor tip vortices are recycled into the induced airflow (Aeronautical Information Circular (AIC) 020/2010)[2]. VRS is normally experienced at low airspeeds and significant rates of descent, which result in an airflow in opposition to the induced airflow. The effect is to produce severe instability of the airflow around the rotor disc with subsequent aerodynamic inefficiencies and loss of rotor thrust.

In general terms VRS becomes a possibility when airspeed is below about 30 kt, with a rate of decent greater than 300 ft/min and with power applied. At the incipient stage, there is an increase in vibration and buffet, small amplitude twitches in roll and yaw, and instability in all axes. In the established stage, VRS is characterised by a very rapid build-up in the rate of descent, reduced effectiveness of cyclic inputs and the inability of applied collective to reduce the rate of descent – it may in fact increase it. A fully developed VRS may occur with very little advance warning to the pilot. With respect to the AS355, it is reported that VRS becomes a possibility when airspeed is below 20 kt with a rate of descent greater than 1,000 ft/min.

Footnote

[2] For a full description of VRS see also: W J Wagtendonk (1996) *Principles of Helicopter Flight.*

AIC 020/2010 states the following (original emphasis):

> *'At typical helicopter operating heights, particularly during photographic or surveillance tasks or during steep or vertical approaches, the conditions referred to* [above] *must be avoided since lack of height will make recovery from the condition uncertain ... Pilots should therefore always maintain airspeed when turning or descending* ***and especially when downwind*** *in high wind conditions.'*

Helicopter operator

The helicopter operator provided G-SEWP in support of the PSNI. The operator's operations manual stated that the helicopter was to be operated solely in accordance with the company's Air Operator's Certificate (AOC) and that certain alleviations from conditions of the Air Navigation Order that would be available to the PSNI under the terms of its own Police AOC were not applicable to G-SEWP. The provision of the helicopter to the PSNI had been the subject of discussion between the operator and the CAA, who were satisfied with the arrangements. The operations manual stressed that no special approval had been granted to do anything other than normal AOC public transport operations. The task G-SEWP was engaged on at the time of the accident fell within this category.

Human factors

The death of a close family member has been found to lead to higher levels of stress than any other experience with the exception of the death of a spouse or partner. Such stress will be likely to cause loss of concentration and performance (Green R.G., Muir H., James M., Gradwell D., Green R.L., (1991) *Human Factors for Pilots*).

When the pilot's bereavement became known after the accident, the operator undertook to emphasise to all its pilots the critical importance of informing the company of any personal issues that may affect their ability to fly safely and efficiently. Furthermore, the operator arranged with the provider of its Crew Resource Management training for this accident to be highlighted during recurrent training, stressing the importance of the fit-to-fly decision in single pilot operations.

Recorded information

Positional information for the helicopter during much of the accident flight was recorded by the Belfast secondary surveillance radar (SSR) (every five seconds) and by a Skyforce Skymap IIIC GPS unit (every 30 seconds) installed in the helicopter. Radar contacts were made once the helicopter had climbed above 1,300 ft amsl but the first recorded point (0947:05 hrs) was on the GPS at 844 ft amsl (about 300 ft agl) with it just to the north-west of the takeoff field. The last GPS recorded point was at 0949:35 hrs with the helicopter at 2,250 ft amsl (196 ft agl) over the landing zone (ie summit of Shanlieve) with a groundspeed of 35 kt. Radar was available until 0949:51 hrs (ie 17 more seconds but only four returns). These additional returns show the helicopter manoeuvring in the vicinity of the landing zone.

Analysis

The helicopter was being operated within the applicable aircraft limits. It was engaged on a task permitted by the operating company's AOC and within the capabilities of the pilot, who had completed all applicable training to the required standard.

The engines, transmission and flying controls appear to have been operating correctly at the time of the accident. The impact took place at a low descent rate with some horizontal motion present. Continuous rotation of the rotor after initial ground contact and overturning caused the helicopter to be driven along the ground for a considerable distance during which the cabin enclosure was destroyed. The severest damage was inflicted to the forward left side of the cabin. The occupant volume at that location was judged to be almost certainly un-survivable; fortuitously, the seat was unoccupied. The final resting attitude of the helicopter protected the occupants seated in other positions from major injury.

The pilot confirmed that he had begun his final approach to the landing site, so his comment about being into wind, which was heard and reported by one of the passengers, was presumably his assessment of the situation. However, physical evidence from the accident site and the accounts of the observer, passengers and witnesses indicate that the helicopter was substantially downwind when it got into difficulty.

As the pilot would have been flying with reference to ground features, it is likely that the helicopter encountered a loss of lift as it turned right to a downwind position, with airspeed having to reduce to maintain groundspeed. This may at first have been masked, as the need to commence a steeper descent than expected (as the helicopter was downwind) would have required a large reduction in power – which was probably the reason the high rotor RPM warning horn sounded. In this condition, the helicopter would not have been susceptible to VRS, but it is possible that the application of power to arrest the rate of descent precipitated VRS, the onset of which may have been sudden because of the rapidly changing situation.

The pilot's recovery actions were correct but, because the helicopter was actually travelling largely downwind, a considerable increase in forward speed would have been required, together with more height than was

available, to fly out of the situation. In the meantime the helicopter would remain in 'dead' air, yet with an increasing groundspeed.

It could not be established with certainty why the pilot believed he was starting the approach into wind. Previous approaches had been made from a different direction, and the pilot had intended to refine his approach and landing direction anyway due to a perceived change in wind direction. Visual references on the hilltop would have been limited, with the only prominent feature being the stone wall, which itself changed direction in the vicinity of the landing site.
With poor weather in the area and a further deterioration imminent (it occurred just after the accident) visual references were probably further reduced. The weather may also have introduced an element of time pressure to complete the last planned flight of the morning. A change of plan, reduced visual references and deteriorating weather may all have contributed to the accident.

The task to be carried out on the day of the accident, although demanding, was within the capabilities of the pilot. However, although the effects on an individual of a recent family bereavement cannot be measured, it is considered that this was probably the most significant contributory factor in the cause of the accident.