Final report AO-2016-006: Eurocopter AS350-B2, ZK-HYY, Collision with terrain during scenic flight
Mount Sale, near Arrowtown, 12 September 2016

Final Report

Aviation Inquiry AO-2016-006:

Eurocopter AS350-B2, ZK-HYY

Collision with terrain during scenic flight

Mount Sale, near Arrowtown

12 September 2016

Approved for publication: February 2018

Transport Accident Investigation Commission

About the Transport Accident Investigation Commission

The Transport Accident Investigation Commission (Commission) is a standing commission of inquiry and an independent Crown entity responsible for inquiring into maritime, aviation and rail accidents and incidents for New Zealand, and co-ordinating and co-operating with other accident investigation organisations overseas. The principal purpose of its inquiries is to determine the circumstances and causes of the occurrences with a view to avoiding similar occurrences in the future. Its purpose is not to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. The Commission carries out its purpose by informing members of the transport sector and the public, both domestically and internationally, of the lessons that can be learnt from transport accidents and incidents.

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Citations and referencing

Information derived from interviews during the Commission's inquiry into the occurrence is not cited in this final report. Documents that would normally be accessible to industry participants only and not discoverable under the Official Information Act 1982 have been referenced as footnotes only. Other documents referred to during the Commission's inquiry that are publicly available are cited.

Photographs, diagrams and pictures

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Terminology (Adopted from the Intergovernmental Panel on Climate Change)	Likelihood of the occurrence/outcome	Equivalent terms
Virtually certain	> 99% probability of occurrence	Almost certain
Very likely	> 90% probability	Highly likely, very probable
Likely	> 66% probability	Probable
About as likely as not	33% to 66% probability	More or less likely
Unlikely	< 33% probability	Improbable
Very unlikely	< 10% probability	Highly unlikely
Exceptionally unlikely	< 1% probability	

Eurocopter AS350-B2, ZK-HYY

(Courtesy of K Gosper)

Source: mapsof.net

Location of accident

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Abbreviations

BEA	Bureau d'Enquetês et d'Analyses (France)
CAA	Civil Aviation Authority
Commission	Transport Accident Investigation Commission
ELT	emergency locator transmitter
ft	feet
kg	kilogram(s)
km	kilometre(s)
kts	knots
m	metre(s)

Glossary

collective lever	a flight control that changes the pitch of the main rotor blades collectively, therefore altering the total lift provided by the main rotor
line pilot	a pilot who flies routine flights, but does not train or check other pilots
translational lift	improved rotor efficiency resulting from directional flight. For a main rotor this occurs at about 16-24 knots

Data summary

Aircraft particulars

Aircraft registration:	ZK-HYY
Type and serial number:	Eurocopter[1] AS350-B2, 3886
Number and type of engines:	one Turbomeca Arriel 1D1
Year of manufacture:	2004
Operator:	The Helicopter Line
Type of flight:	commercial charter (scenic)
Persons on board:	six

Crew details

Pilot's licence:	commercial pilot licence (helicopter)
Pilot's age:	31
Pilot's total flying experience:	2,701 flight hours (1,246 hours on type)

Date and time	12 September 2016, 1447[2]
Location	Mount Sale, Otago, northeast of Arrowtown
	latitude: 44°55.0´south
	longitude: 168°53.8´ east
Injuries	one minor
Damage	substantial

[1] On 2 January 2014, the Eurocopter Group, previously Aérospatiale, was renamed Airbus Helicopters.
[2] Times in this report are in New Zealand Standard Time (Coordinated Universal Time +12 hours) and expressed in the 24-hour format.

1. Executive summary

1.1. On Monday 12 September 2016, the weather in the Queenstown area was fine and clear with a moderate westerly wind. The Helicopter Line was using several AS350-B2 (Squirrel) helicopters for tourist flights in the area.

1.2. One of the flights was to take five passengers for a snow-landing experience on Mount Vanguard, north of Queenstown. Soon after take-off the pilot saw that the weather had deteriorated in that direction, so he changed the destination to Mount Sale, northeast of Arrowtown.

1.3. The pilot approached the intended landing site, at an elevation of approximately 1,500 metres, from the north. He said that the approach proceeded normally until the final stage, when the rate of descent suddenly increased, so he increased the power to go around. Although the helicopter responded to the pilot's control inputs, it struck the ground hard with the landing gear and the main rotor blades, and came to rest on its left side.

1.4. One of the passengers suffered a minor injury to his knee. The helicopter was substantially damaged.

1.5. The Transport Accident Investigation Commission (Commission) found that the helicopter weight and balance were within limits, the engine was delivering high power and the helicopter was operating normally. The pilot had the required training and experience for the flight.

1.6. The Commission found that the landing approach was made with a tailwind when the pilot was expecting a crosswind. The pilot made a relatively fast, low and close approach to the landing site. This technique might not give pilots enough time to confirm the actual wind before landing, nor does it ensure that their intended escape routes remain useable throughout the approach.

1.7. The Commission identified a safety issue in that the operator had had four serious landing accidents in three years. While there were some similarities in the circumstances, the factors for most of these accidents were not determined conclusively by the Commission's inquiries or by the operator's internal investigations.

1.8. Therefore the Commission made a recommendation that the chief executive of The Helicopter Line, in consultation with the New Zealand Civil Aviation Authority, review The Helicopter Line's safety management system audit process to ensure that its safety policy, safety assurance, risk management, and promotion of safety are sound.

1.9. Key lessons arising from this inquiry were:

- human factors can have both positive and negative effects on situational awareness. It is important for pilots to remain vigilant for changes in environmental conditions.
- the loss of the emergency locator transmitter antenna during the break-up sequence demonstrated once again that an alternative means of independent, real-time flight following would be beneficial in respect of search and rescue[3]. It is prudent to use a flight-following service or facility where possible.

[3] The unreliability of emergency locator transmitters is well documented; see Commission report AO-2011-003 with associated safety recommendation 006/14.

2. Conduct of the inquiry

2.1. On the afternoon of Monday 12 September 2016, the Police notified the Transport Accident Investigation Commission (Commission) of the accident. The Commission opened an inquiry under section 13(1)(b) of the Transport Accident Investigation Commission Act 1990 and appointed an investigator in charge.

2.2. On 13 September 2016 the Commission notified the Bureau d'Enquetês et d'Analyses (BEA) of France, the State of Manufacture for the helicopter and the engine. In accordance with Annex 13 to the Convention on International Civil Aviation, France appointed a BEA investigator as its Accredited Representative to participate in the investigation.

2.3. Three investigators from the Commission arrived in Queenstown on the afternoon of 13 September 2016 and conducted interviews with some of the passengers who were about to leave the area. The investigators carried out a site and wreckage examination on 14 September 2016. The wreckage was removed later that day and taken to a secure location.

2.4. In the following two days interviews were conducted with the pilot, the remaining passengers and the first responders to the accident. Photographs and video recordings taken prior to and after the accident were obtained.

2.5. The maintenance records for the helicopter were obtained and the engine was given an initial technical inspection by the Safron/Turbomeca field representative in New Zealand.

2.6. Between 8 November and 11 November 2016 the investigation team interviewed senior managers and other staff of the operator.

2.7. Airways New Zealand provided air traffic control surveillance data that showed the track of the helicopter during the accident flight.

2.8. On 15 December 2017 the Commission approved the circulation of the draft report to interested persons for comment.

2.9. On 21 February 2018 the Commission approved the final report for publication.

3. Factual information

3.1. Narrative

3.1.1. On the afternoon of Monday 12 September 2016, five tourists arrived at The Helicopter Line's (the operator's) Queenstown base for a local helicopter sightseeing flight that included a snow landing. The pilot allocated to the flight read the weather briefing material before going to start the helicopter.

3.1.2. A staff member conducted the safety briefing for the passengers. A safety poster written in Simplified Chinese was presented to the Mandarin-speaking passengers. Each passenger was weighed and their weight was recorded. The staff member showed the passengers to the helicopter, seating four of them in the rear seats and one in the dual front seat. The staff member checked that the passengers' seat belts were secure before closing the cabin door.

3.1.3. At 1437 the pilot was cleared by Queenstown air traffic control to depart to the north towards Mount Vanguard, the intended destination. Shortly after take-off the pilot could see that the weather towards Mount Vanguard was "a bit messy", so he changed the destination to Mount Sale to the northeast of Arrowtown and advised Queenstown air traffic control (see Figure 1). En route the pilot estimated that the wind was from the west to southwest.

3.1.4. The pilot stated that after flying over Arrowtown he could see indications of a westerly wind. He flew at about 5,000 feet (ft) towards Mount Sale, intending to approach the landing area, which was an area of flat ground at 1,546 metres (m) (5,070 ft) and 1.7 kilometres (km) west of the summit, from the north.

3.1.5. The pilot stated that he made a "normal" approach to the ridgeline and landing area (see Figure 2). There was no turbulence and he estimated there was a crosswind from the west at about 10-15 knots (kts). Some of the passengers said that they thought the helicopter was not going to land because of the high (ground) speed as they got closer to the landing area.

Figure 1
Flight track to Mount Sale from Queenstown (source: Airways New Zealand surveillance data)

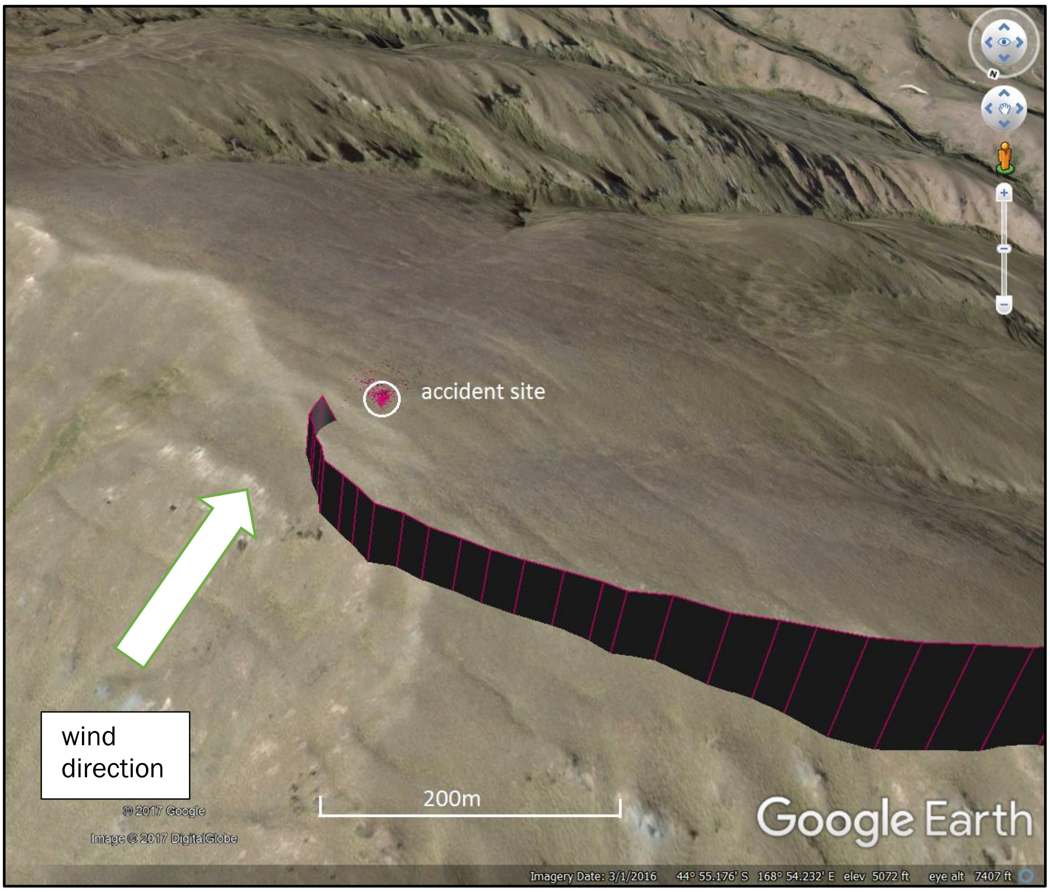

Figure 2
Final approach flight path (source: Airways New Zealand surveillance data)

3.1.6. At a point that the pilot estimated was slightly less than 50 m from, and 20 ft above, his intended landing site, the helicopter experienced what he described as an "excessive sink". The pilot said that the sink occurred before he started to increase the power in order to reduce the rate of descent for the landing.

3.1.7. According to the pilot, he decided to go around rather than land. He immediately raised the collective lever[4] and applied right pedal and forward right cyclic input. He stated that the helicopter responded correctly to his control inputs and he noticed at this time that the indicated engine power[5] was at the upper limit.

3.1.8. However, the nose of the right skid hit the ground at a speed estimated by the pilot to be about 20 kts. This was followed by the helicopter bouncing and rolling onto its left side.

3.1.9. The engine continued to drive the main rotors while the helicopter was on its side, until the pilot used the fuel shut-off lever to shut down the engine. This took about 30 seconds.

3.1.10. After the passengers had got out of the helicopter the pilot found that the front seat passenger had suffered a deep laceration to his knee. The pilot used his mobile phone to advise the operator's Queenstown base of the accident.

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[4] The flight control that changes the pitch of the main rotor blades collectively, therefore altering the total lift provided by the main rotor.
[5] The primary power reference for the turbine engine was the Ng gauge that indicated the speed (in revolutions per minute) of the gas producer spool.

3.1.11. The operator directed several of its helicopters to the crash site to give assistance. All of the occupants of the helicopter were taken to Queenstown within an hour of the accident.

3.1.12. The accident occurred at about 1447, in daylight.

3.2. Site and wreckage examination

3.2.1. The accident occurred on a north-facing slope west of the summit of Mount Sale, a peak 1,700 m (5,576 ft) high, 5 km northeast of Arrowtown. The landing area was on a slightly sloping section of the ridgeline (see Figure 3). The operator used the landing area often, but did not have a dedicated wind marker placed there. At the time there was a light covering of snow on the tussock grass.

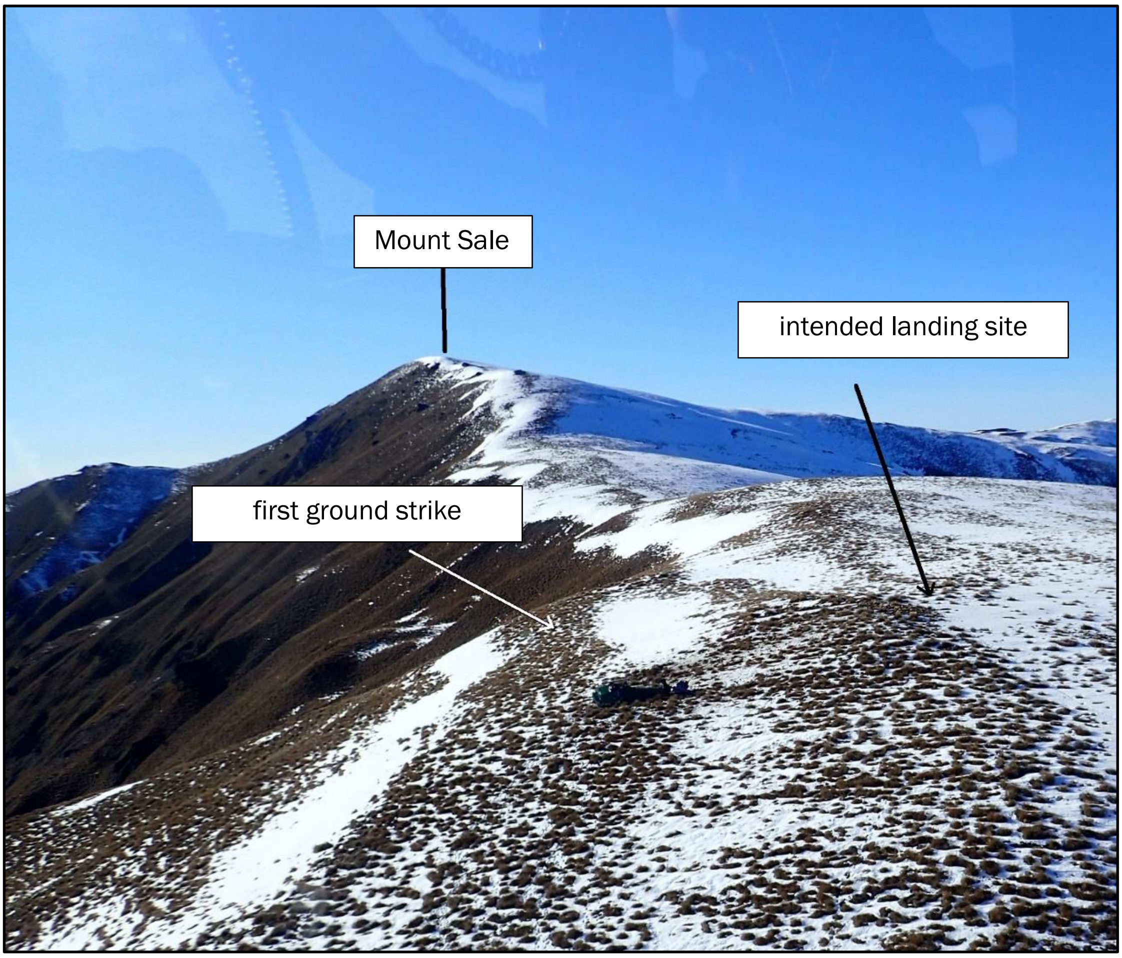

Figure 3
Mount Sale ridgeline and accident site

3.2.2. The right skid penetrated the snow and made contact with the ground while the helicopter was moving forward, at a point about 35 m to the north of the intended landing point. Shortly afterwards the main rotors struck the ground, which caused the helicopter to reverse direction.

3.2.3. The helicopter rolled left through 90 degrees and came to rest on its left side, approximately 20 m from the initial ground strike and 30 m from the intended landing point.

3.2.4. The fuselage structure remained largely intact, but the upper-forward cabin structure, windscreen and centre pillar were struck by the main rotor blades and portions of these parts were thrown some distance from the helicopter (see Figure 4).

Figure 4
Helicopter wreckage

3.2.5. All three main rotor blades were destroyed and the arms of the Starflex main rotor head separated. All three pitch change links failed during the break-up of the main rotor (see Figure 5). Pieces of the main rotor blades and main rotor head assembly were found some distance from the helicopter.

3.2.6. The left and right aft lift struts on the main rotor gearbox failed and the supporting airframe structure on the main rotor transmission deck was deformed.

3.2.7. Due to the 'bouncing' of the helicopter during the accident sequence, the underside of the engine casing contacted the tail rotor drive shaft shroud at its forward end. The shroud, in turn, contacted the tail rotor drive shaft, leaving witness marks around its circumference.

3.2.8. The tail rotor blades and lower vertical stabiliser did not strike the ground during the impact sequence, although the tail boom deformed on its underside aft of the forward frame where it attached to the centre fuselage.

3.2.9. The collective lever was found in the fully raised position, which corresponded with the pilot's report of demanding high power before the helicopter hit the ground.

3.2.10. The fuel tank did not rupture and its contents did not leak.

3.2.11. A close visual inspection of the helicopter at the accident site confirmed the pre-accident integrity of the flight control linkages and cables between the pilot's controls and the main and tail rotors.

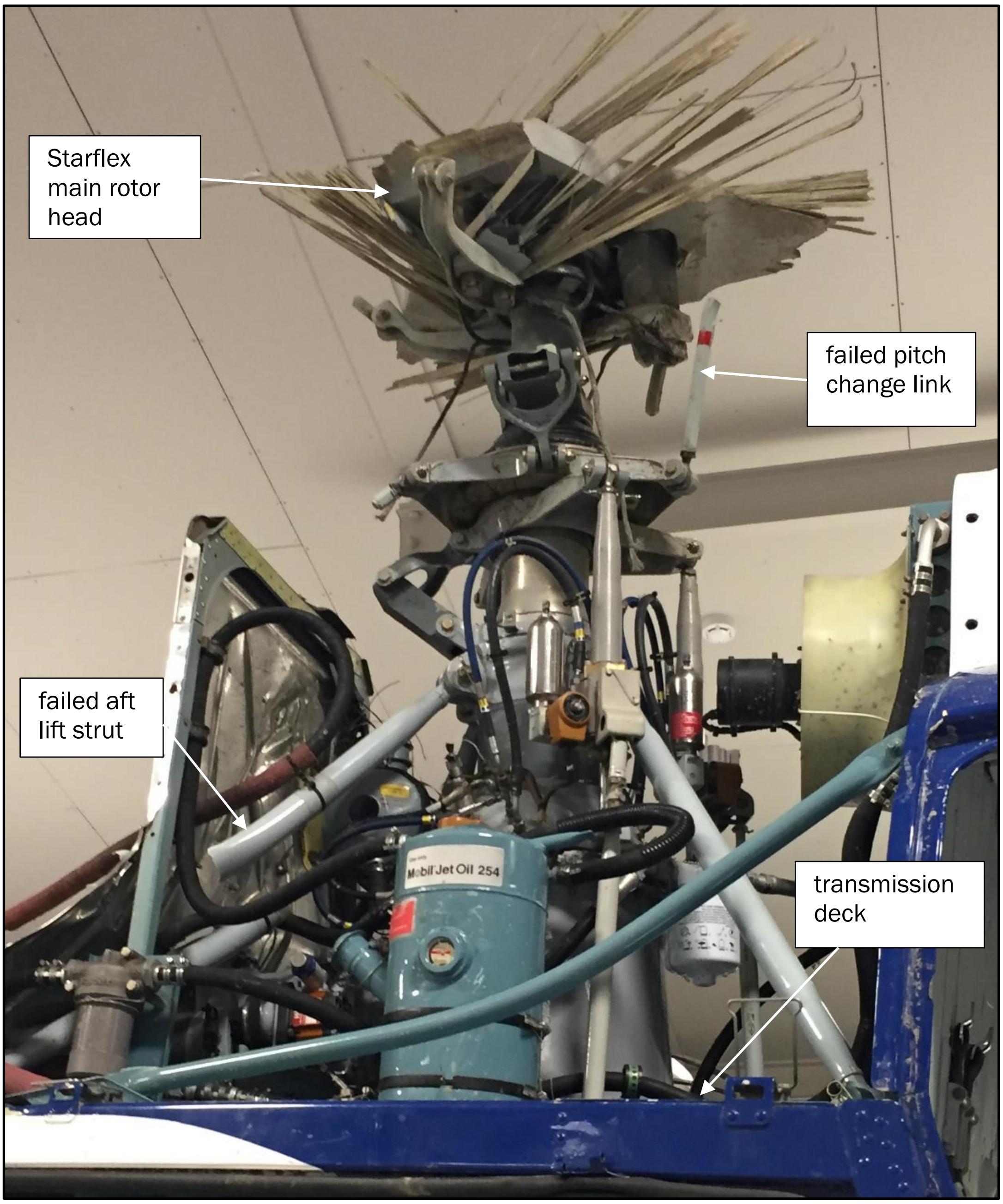

Figure 5
Main rotor gearbox with main rotor head damage due to rotation under high power

3.2.12. An audible tone was heard from the emergency locator transmitter (ELT) at the accident site, indicating that the ELT had been triggered. It was switched off at the remote switch on the pilot's instrument panel.

3.2.13. The items in the baggage locker were weighed. They included camera equipment, survival equipment and five small bags of ballast, weighing in total 44 kilograms (kg).

3.2.14. The wreckage was taken to a maintenance facility where it was further disassembled. No pre-accident technical anomalies were found.

Engine investigation

3.2.15. The engine was inspected visually by the engine manufacturer's technical agent in New Zealand. A borescope was used to examine internal components. The compressor and turbine stages were viewed from the engine inlet and exhaust, and through the ignitor plug aperture. No anomalies were found during this inspection.

3.3. Personnel information

3.3.1. The pilot had completed his helicopter training in New Zealand in 2007 and obtained his commercial pilot licence (helicopter) that year. He had then commenced employment as a pilot in Auckland. He had obtained a B-category instructor rating in 2010.

3.3.2. In December 2013 he had joined the operator as a full-time line pilot[6] at the Mount Cook base. He had gained an internal Category 1 authorisation on 8 September 2014, which enabled him to fly unsupervised as pilot in command[7]. He had transferred to the Queenstown base in May 2015 and completed his Queenstown area familiarisation training in the following four months.

3.3.3. At the time of the accident the pilot had flown 2,701 hours on helicopters, including 1,246 hours on the AS350.

3.3.4. His most recent annual operational competency assessment check flight had been conducted on 17 January 2016, the day after he had passed the associated theory examination.

3.3.5. In addition to that check, the training manager had conducted training in the following aspects:

- approaches
- vertical descent speeds and forward airspeeds
- finishing approaches to a zero-speed landing and to a 6 ft hover
- staying out of the height-velocity curve[8]
- conditions conducive to encountering vortex ring state[9].

3.3.6. This additional training had been properly recorded by the operator. The training manager explained that the specific training had been given to two pilots, either of whom might have been a pilot who was reported by other pilots to have been flying slow and steep approaches. According to the training manager, "The [accident] pilot did not exhibit any problem areas during this training session".

3.3.7. The pilot's most recent 180-day competency check, which included a mountain-flying refresher, had been carried out on 23 August 2016.

3.3.8. The operator had had no reports of any problems with the pilot's flying and he was seen by his mentors as an average and dependable pilot.

3.3.9. The pilot held a Class 1 medical certificate with no restrictions or endorsements. It was valid until 17 April 2017 for single pilot air operations carrying passengers. He said that on the day of the accident he was not fatigued or suffering any sickness. He had had two

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[6] A line pilot flies routine flights, but does not train or check other pilots.
[7] The pilot had held a B-category authorisation under the previous scheme, and with similar privileges, since January 2014.
[8] A chart depicting the area of the flight envelope, specific to the type of helicopter, in which it is less safe to operate.
[9] A state in which the helicopter descends in its own downwash.

rostered days off and three annual leave days during the preceding week, and had flown 1.7 hours and 1.85 hours respectively in the two days before the accident. He stated that he had had plenty of rest during those days and had been sleeping well.

3.3.10. The operator's procedures required that after an accident pilots were to give blood and urine samples that were to be tested for the presence of any performance-impairing substances. This test was carried out and the results were negative.

3.4. Aircraft information

3.4.1. ZK-HYY was a Eurocopter AS350-B2 helicopter, serial number 3886, manufactured in November 2004. It had been imported into New Zealand from the United States in April 2014.

3.4.2. On 23 May 2014 the helicopter had been issued with an airworthiness certificate in the Standard category and placed on the operator's Operations Specifications. At the time of the accident the helicopter had flown 3,855.3 hours.

3.4.3. The engine, serial number 19003, had entered service in April 2005. It had accrued a total of 3,334 hours.

3.4.4. The helicopter had seven seats, including the pilot's seat. The pilot was seated on the right side and on this flight one passenger was on the left side of the dual front passenger seat. The front seats had four-point harnesses, consisting of a lap belt and one inertia reel for the two shoulder straps.

3.4.5. There were four rear seats situated side by side in the cabin. Three-point harnesses were provided for each seat, with standard aircraft-style buckles with lifting latches.

3.4.6. The helicopter had a maximum certified take-off weight of 2,250 kg. At this weight the allowable centre of gravity range was 3.210 m to 3.425 m aft of datum[10].

3.4.7. At take-off the helicopter weighed 2,075 kg and the centre of gravity was within the limits.

3.5. Meteorological information

3.5.1. On the day of the accident a large anticyclone covered the Tasman Sea, with a ridge of high pressure extending over the South Island. The area forecast predicted wind from the northwest at 10 kts, increasing to 20 kts at 5,000 ft. The freezing level was forecast to be 7,000 ft and the temperature at 5,000 ft to be plus two degrees. The forecast visibility was 30 km, reducing to 6,000 m in rain. The main cloud was areas of broken cumulus at 3,000 ft with tops at 6,000 ft, mainly in the west. Rain was expected to develop from late morning.

3.5.2. The pilot said that during the flight he detected a tailwind from the west to southwest and, closer to Mount Sale, he saw the tussock blown by a westerly wind.

3.5.3. A video taken by the pilot on the ridgeline close to the accident site soon after the accident captured indications of a moderate wind from a northerly direction. He also stated that, while standing at the scene, he noticed that the wind was from the north.

3.5.4. Pilots who flew to the accident site in response to the pilot's emergency call said that the wind in the Queenstown basin was from the southwest, but at about Lake Hayes there was an apparent wind shift to the north. These pilots stated that when they arrived at the accident site, approximately 30 minutes after the accident, there was a northeasterly wind of 15-20 kts.

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[10] Datum is a reference point, line or plane from which measurements are taken. The position of the helicopter's datum may vary between different helicopter types.

3.5.5. At the time of the accident the Cardrona ski field mountain ridgeline weather station, 7 km to the north of the accident site, recorded a northerly wind at 15 km per hour (8 kts) gusting to 28.5 km per hour (15 kts). This data showed the wind consistently from the north throughout the day.

3.6. Organisational and management information

3.6.1. The operator had been established in 1986 from the amalgamation of three separate companies. This had resulted in the operator becoming one of the largest helicopter operators in New Zealand, with extensive alpine flying experience in the South Island.

3.6.2. The operator held a Part 119 air operator certificate, issued by the Civil Aviation Authority (CAA), which allowed it to conduct Part 135 domestic helicopter operations involving passenger transport and commercial work, including to remote areas.

3.6.3. Queenstown was the main centre of operations. Outlying stations were Glentanner in Aoraki/Mount Cook National Park, Franz Josef Glacier and Fox Glacier. Pilot training and competency, and quality assurance requirements were managed from the Queenstown centre. 'Lead pilots' were appointed for each station, with the outlying stations visited regularly by the operations manager and the chief pilot.

3.6.4. A fleet of 24 AS350 helicopters was available for use by the operator. The AS350 helicopter was considered by the operator to be the most suitable for the types of operation it flew in the mountains.

3.6.5. The CAA carried out a five-yearly re-certification audit of the operator prior to renewing the Part 119 air operator certificate on 23 September 2013. No adverse findings were recorded. Several positive comments had been recorded in the audit report, including that the organisation's "high levels of operational safety" were being maintained by senior staff, and some had been made on the quality of its internal procedures. The CAA auditors further commented that a review of the CAA database had found no significant safety issues or trends that would have indicated systemic problems. The CAA had routinely audited elements of The Helicopter Line's operation, with no major concerns identified.

3.6.6. Since the re-certification the operator had had three helicopter accidents:

- on 28 October 2013 a collision had occurred between two of its helicopters on a snowfield. One stationary helicopter on the ground had been struck by a helicopter about to land. The pilot of the airborne helicopter had received serious injuries[11]
- on 9 January 2014 a helicopter that was moving sideways when it touched down on the Richardson Glacier had rolled onto its side. There had been no injuries[12]
- on 16 August 2014 a helicopter taking a heli-ski group to Mount Alta had struck the terrain and rolled 300 m down a slope[13]. After this accident the operator had carried out an internal review of the management, supervision and training structure. This had resulted in a management reorganisation, including a new position of training manager and changed responsibilities and personnel.

3.6.7. Records obtained by the Commission showed that the CAA had conducted a further risk assessment of the operator after the 9 January 2014 accident. The assessment had been completed on 30 May 2014. A supplementary entry had been added after the 16 August 2014 accident on Mount Alta that showed the CAA had assessed the operator as having a

[11] Commission inquiry AO-2013-010, Aérospatiale AS350B2 'Squirrel', ZK-IMJ, collision with parked helicopter, near Mount Tyndall, Otago, 28 October 2013.
[12] CAA incident report 14/52, AS350BA ZK-HKR, Richardson Glacier, 9 January 2014.
[13] Commission inquiry AO-2014-005, Eurocopter AS350-B2 helicopter (ZK-HYO) collision with terrain during heli skiing flight Mount Alta, near Mount Aspiring National Park 16 August 2014.

"medium risk potential". The 'Risk Profile' generated as part of the CAA's assessment had put the operator in "the lowest of the CAA risk assessment bands for this document type".

3.7. Additional information

3.7.1. Civil Aviation Rules Part 61, Pilot Licences and Ratings, Subpart E Commercial Pilot Licences prescribed that, to be eligible for a commercial pilot licence, a person must have a written examination credit, or an approved equivalent, that covered the subject of human factors[14,15].

3.7.2. CAA Advisory Circular AC61-5, Pilot Licences and Commercial Ratings – Commercial Pilot Licence, Appendix III, provided the syllabus for the human factors written examination. The aviation psychology section of the matrix included elements such as information processing, situational awareness, and judgement and decision-making. Additionally, Appendix VI – Helicopter Basic Mountain Flying Training Syllabus (Theory Component) in the Advisory Circular outlined the objectives for the situational awareness training and approaches to unprepared sites.

3.7.3. The operator's exposition contained the following in section 4.4 Training Program [sic]:

> Scope – The organisation places an emphasis on recurrent training as an important part of its safety programme. Such training will be directed towards the maintenance of a high level of flight safety and piloting competence through effective and professional programmes that recognize the importance of human factors, risk management and pilot judgment training in pursuit of a zero accident rate.

3.7.4. Questions related to human factors appeared in the operator's annual Operational Competency Assessment written examination for pilots. However, the operator had not undertaken any recent specific human factors training for its pilots.

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[14] Rule 61.203 (a)(6)(vii).

[15] Human factors developed from a realisation that it was human rather than mechanical failures that accounted for 70% of incidents and accidents. Often considered synonymous with crew resource management, it is, however, much broader in both its knowledge base and scope, gathering information about human abilities and limitations and applying it to tools, machines, systems, tasks, jobs and environments (CAA 2016).

4. Analysis

4.1. Introduction

4.1.1. The accident occurred on the pilot's fourth flight that day in the helicopter. He was experienced in mountain flying, had been employed by the operator for four years, and was known as a capable and competent pilot. He was appropriately qualified and authorised, in good health and well rested.

4.1.2. The intended landing site was at an elevation of 1,546 m and had been used by the pilot on many occasions. The site was not considered challenging as it had clear approaches from all directions. The weather conditions were suitable for the flight.

4.1.3. The following analysis explains the circumstances leading up to the accident, and why the go-around was unsuccessful. Some important considerations for mountain flying are reinforced.

4.2. What happened

4.2.1. Surveillance data showed that the pilot was less than about 100 ft above the landing site when he commenced a right turn back towards the ridgeline. The turn was tightened as the helicopter lined up for the final approach, which was flown perpendicular to the ridgeline and heading south.

4.2.2. The reported sink occurred in the late stage of the landing approach. The pilot immediately applied power and attempted to go around, but although the helicopter responded correctly to his control inputs, he was unable to prevent it striking the ground.

4.3. Why it happened

4.3.1. The pilot made the final approach to the south, expecting a westerly crosswind. His own observation of the wind immediately after the accident, the recollections of the rescue pilots, and the recorded data from the Cardrona ski field confirmed that the wind was from the north. Therefore it was very likely that the landing approach was made downwind and the final turn was tightened because the northerly wind was blowing the helicopter closer to the landing site.

4.3.2. It is usually preferable to land a helicopter into wind. For a given airspeed, the ground speed is slower, translational lift[16] is maintained for a lower ground speed, and the power requirement to terminate the approach is reduced. Directional stability is also enhanced by the 'weathervane' effect of the vertical stabiliser. These factors help to reduce the workload for the pilot.

4.3.3. A pilot compensates for the reduction in translational lift as a helicopter slows down by increasing the main rotor blade pitch, at least until the helicopter enters ground effect[17]. If the reduction in translational lift is not countered by a thrust increase, the helicopter will descend or an existing descent rate will increase.

4.3.4. When a helicopter slows towards a hover after a downwind approach, zero airspeed occurs while the helicopter is still moving forward. A landing downwind may be acceptable and safe, provided its pilot is prepared for the necessary handling adjustments.

[16] The improved rotor efficiency resulting from directional flight. For the main rotor, this occurs at about 16-24 kts.
[17] A helicopter is 'in ground effect' when the downwash from the main rotor strikes the surface, stopping the downward wash and generating an increase in pressure, effectively a cushion of air that reduces the power required to maintain position.

4.3.5. A pilot reduces helicopter speed by moving the cyclic stick in the opposite direction to the helicopter's travel. When applied in forward flight, this action is called 'flaring'. By tilting the main rotor disc away from the direction of travel, a component of total rotor thrust slows the helicopter.

4.3.6. The pilot was familiar with the landing site and therefore did not fly a reconnaissance pattern prior to committing to an approach. Approaching from the west, as he did, was preferable to approaching from the east. It allowed a lower cruise altitude for a given terrain clearance and, being seated on the right side, he had an unobstructed view during the turn to final approach.

4.3.7. However, the track was flown upwind of the landing site (whether the wind had been from the west or from the north), which resulted in the turn to the final approach heading having to be tight. As the turn progressed, and with the wind very likely from the north, the helicopter was blown closer to the landing site. The ground speed would have been higher than for an approach into wind, and the pilot would have had to reduce speed much earlier than he had anticipated.

4.3.8. Being closer to the landing site, a marked flare and associated power reduction would have been required. However, being downwind, the airspeed would have reduced to below that for translational lift before the ground speed was brought under control. It is very likely that the pilot did not observe the airspeed reduction, and that the consequent loss of translational lift without a compensatory increase in power led to the sink.

4.4. The unsuccessful go-around

4.4.1. The pilot responded quickly to the sink and attempted to go around by increasing the power and turning right, away from the higher terrain. However, the helicopter was approaching over rising terrain and at a similar altitude to the landing site, as well as being too close for the pilot's corrective actions to be effective.

4.4.2. A longer, descending final approach, offset from rather than perpendicular to the ridgeline, would have been preferable to the fast, low and close approach that was flown. The former gives a pilot more time to confirm the wind direction and helicopter performance. If a tailwind is recognised, speed and power corrections can be made earlier and smaller, and a go-around can be initiated from a safer height along the planned escape route.

4.5. Other operational factors

Helicopter performance

4.5.1. The helicopter weight at take-off was estimated to have been 175 kg below the maximum allowable weight. The centre of gravity was within limits. The pilot said he had had no controllability issues.

4.5.2. Performance charts showed that the helicopter had more than enough power available to approach, hover and land at Mount Sale, and was capable of achieving an 'out-of-ground-effect'[18] hover at the altitude of the landing site. Helicopter performance was not a factor in the accident.

Engine performance

4.5.3. The pilot said that there was no power loss or engine performance problem. Neither he nor the passengers reported seeing, or hearing, any warning that would have indicated low engine RPM (revolutions per minute) or low rotor RPM. The damage to the main rotor blades and main rotor head was consistent with the rotor having had high energy when the blades struck the ground. The main rotor continued to be driven by the engine when it came

[18] A hover at such a height that the surface has no effect on the downwash.

to rest. It is evident that the helicopter's engine was producing high power at the time of the accident.

Vortex ring state

4.5.4. Despite the pilot demanding full power, a safe recovery was not achieved in the height available. Therefore the investigation considered whether the helicopter might have entered vortex ring state.

4.5.5. Airbus has previously advised, during another Commission inquiry[19], that an AS350 Squirrel needs to have a rate of descent in the order of 900 ft per minute and forward airspeed less than 20 kts to be within the vortex ring state domain. The final turn and approach were relatively shallow, implying a low rate of descent. A harsh flare of, say, 30 degrees nose up performed at 20 kts could have resulted in an upflow through the rotor of 1,000 ft per minute. However, that is not the same as descending in the rotor downwash at that rate, because the increase in rotor thrust generated by the flare must be countered by the pilot reducing the collective pitch, thereby reducing the induced downwash. Without the power input, a vortex ring state will not occur.

4.5.6. When a helicopter is established in vortex ring state, an increase in power increases the main rotor downwash energy and causes the helicopter to descend more quickly. If the helicopter had encountered vortex ring state, it would very likely have struck the ground with much more vertical energy than was evident at the site.

4.5.7. The pilot had been trained to recognise the handling symptoms of vortex ring state and said that these did not occur. The helicopter responded correctly to flight control inputs and to the demanded power increase. Therefore it was very unlikely that the helicopter had entered vortex ring state.

4.6. Human factors

4.6.1. The investigation did not identify any mechanical defect or helicopter performance factor that contributed to the accident. The outcome was a result of decisions made by the pilot. His mistake in assessing the wind direction reflected a reality of flying in mountainous terrain, where the wind direction and strength vary as much as the terrain. Hence the need for pilots to plan their flights carefully, be vigilant, and operate conservatively when approaching unprepared landing sites.

4.6.2. A knowledge and demonstration of the human factors that support operations in the mountains are part of the CAA-approved helicopter pilot training syllabi at all licence levels. Although the operator's pilots had the correct training and qualifications, the operator arranged additional human factors training for them following this accident. Topics covered included helicopter stabilised approaches, decision-making, vigilance and situational awareness.

[19] Commission inquiry AO-2014-005, Eurocopter AS350-B2 helicopter (ZK-HYO) collision with terrain during heli skiing flight Mount Alta, near Mount Aspiring National Park 16 August 2014.

Findings

1. The helicopter had no mechanical or controllability defect, or performance limitation, that might have contributed to the accident.
2. The final approach to land was very likely made downwind, whereas the pilot was expecting a crosswind.
3. The pilot flew the approach at a relatively high speed, low and close to the landing site. This technique resulted in a tight turn to a short final approach, which did not allow him time to confirm the anticipated wind.
4. The reported sink very likely occurred when the helicopter's airspeed decreased below that for translational lift, but while the ground speed was still unexpectedly high.
5. The low and close turn to the final approach, flown perpendicular to the ridgeline, negated the intended escape route and prevented a successful go-around.

4.7. The operator

Safety issue – The operator had had four serious landing accidents in three years. While there were some similarities in the circumstances, the factors for most of these accidents were not determined conclusively by the Commission's inquiries or by the operator's internal investigations.

4.7.1. The investigation conducted a general review of the operator's training standards and associated record-keeping, reporting standards and organisational culture. This review included interviews with senior personnel.

4.7.2. The pilot said that line pilots were not under pressure to complete flights, and it was evident that the organisational culture reflected this.

4.7.3. Changes had been made to organisational systems and policy as a result of previous accidents. Actions were taken by the operator to improve operational standards as a result of its internal investigation into this accident.

4.7.4. The additional training carried out for two pilots, either of whom might have been a pilot seen conducting slow, steep approaches, demonstrated that the operator had a system of internal incident reporting and took appropriate action in response to reports in order to improve operational standards.

4.7.5. The operator stated that it required its pilots to make "constant attitude approaches" to landing sites. Final approach checks included the rate of descent, airspeed vs ground speed comparison, having a planned escape route, having a landing commitment point, and undertaking a power check. Pilots' compliance with this requirement was checked during routine operational competency assessments.

4.7.6. Although each pilot was checked as being capable of conducting constant attitude approaches, the company exposition did not specify that requirement. This accident, like other recent landing accidents of the operator, suggested that its pilots might not be completing the final approach checks as expected. The inherent flexibility of helicopter operations, which generally allowed pilots considerable discretion over the conduct of their flights, needed to be constrained in the case of air transport operations.

4.7.7. In spite of the operator having had consecutive satisfactory CAA audits and enjoying a good reputation within the aviation industry, it has now had four serious accidents in three years, including this accident. Not all of the factors contributing to these accidents were able to be determined conclusively by the Commission's inquiries or by the operator's internal investigations.

4.7.8. Therefore the Commission is recommending that the chief executive of The Helicopter Line, in consultation with the CAA, review The Helicopter Line's safety management system audit process to ensure that its safety policy, safety assurance, risk management and the promotion of safety are sound.

Findings

6. On the accident flight the pilot did not conform with the operator's stated principle of conducting constant attitude approaches.

7. In spite of many consecutive satisfactory CAA audits and a generally high reputation, the operator had had four significant landing accidents in three years, for which the factors were not determined conclusively.

4.8. Emergency response

4.8.1. The operator's flight-following system at the Queenstown base recorded the departure of the helicopter at 1437, for the amended destination of Mount Sale. The helicopter was the only one of the operator's helicopters away from base at the time of the accident.

4.8.2. Pilots were expected to call the base by radio when they landed at their destinations. The flight-following system would initiate an alert if a destination call were missed or if a helicopter were overdue at the time of its expected return to the base.

4.8.3. At 1447, after the pilot had supervised the egress of the passengers from the wreckage, he called the base on his mobile phone. This initiated the operator's emergency response plan. The first of the operator's helicopters arrived at Mount Sale at 1515.

4.8.4. The helicopter was fitted with a 406-megahertz ELT that was activated by the impact, as designed. However, the roof-mounted antenna had disconnected from its coaxial cable in the crash and separated from the helicopter.

4.8.5. At 2245 on 12 September 2016, eight hours after the accident, the first of three ELT transmissions was detected by the global search and rescue satellite system. Two more transmissions were detected the next day. The delays in receiving the intermittent detections were almost certainly due to the disconnection of the antenna during the crash.

4.8.6. Had the pilot (or a passenger) been unable to report the accident, the damaged ELT would have delayed a search until the operator's emergency response plan was activated, 30 minutes after the last contact. The unsatisfactory crash performance of ELTs has been noted in many previous accident reports of the Commission and the CAA. The International Civil Aviation Organization and the Federal Aviation Administration of the United States have ongoing research aimed at improving the performance and reliability of ELTs.

4.8.7. The Commission is monitoring this matter by way of a Watchlist item: 'Technologies to track and locate'[20].

4.8.8. The helicopter was equipped with a GPS-based tracking system. However, transmissions from that system were only sent at take-off and landing, and the unit was not designed to survive a crash.

[20] https://taic.org.nz/watchlist/technologies-track-and-locate

4.8.9. The pilot's change of destination after his departure from Queenstown is a reminder of the importance of pilots advising their flight-following services of any change to their flight plans. This issue was a key lesson identified during a previous inquiry by the Commission[21].

Finding

8. The failure of the emergency locator transmitter to alert the search and rescue network had the potential to adversely affect survivability.

[21] Commission inquiry AO-2013-010, Aerospatiale AS350B2 'Squirrel', ZK-IMJ, collision with parked helicopter, near Mount Tyndall, Otago, 28 October 2013.

5. Findings

5.1. The helicopter had no mechanical or controllability defect, or performance limitation, that might have contributed to the accident.

5.2. The final approach to land was very likely made downwind, whereas the pilot was expecting a crosswind.

5.3. The pilot flew the approach at a relatively high speed, low and close to the landing site. This technique resulted in a tight turn to a short final approach, which did not allow him time to confirm the anticipated wind.

5.4. The reported sink very likely occurred when the helicopter's airspeed decreased below that for translational lift, but while the ground speed was still unexpectedly high.

5.5. The low and close turn to the final approach, flown perpendicular to the ridgeline, negated the intended escape route and prevented a successful go-around.

5.6. On the accident flight the pilot did not conform with the operator's stated principle of conducting constant attitude approaches.

5.7. In spite of many consecutive satisfactory CAA audits and a generally high reputation, the operator had had four significant landing accidents in three years, for which the factors were not determined conclusively.

5.8. The failure of the emergency locator transmitter to alert the search and rescue network had the potential to adversely affect survivability.

6. Safety actions

General

6.1. The Commission classifies safety actions by two types:

(a) safety actions taken by the regulator or an operator to address safety issues identified by the Commission during an inquiry that would otherwise result in the Commission issuing a recommendation

(b) safety actions taken by the regulator or an operator to address other safety issues that would not normally result in the Commission issuing a recommendation.

Safety actions addressing safety issues identified during an inquiry

6.2. On 16 January 2017 The Helicopter Line advised that online human factors training had been recently undertaken for operational personnel. Further training was facilitated in early 2017 by an external consultant, who developed and delivered a programme tailored to the operation.

Safety actions addressing other safety issues

6.3. None identified.

7. Recommendations

General

7.1. In a previous report on an accident involving this operator[22], the Commission commented that New Zealand's helicopter accident rate is higher than that of other aviation sectors. There has been public criticism of how helicopters are operated in New Zealand, including a culture of operating outside the manufacturers' published and placarded 'never exceed' limitations. Should this situation exist, there is a possibility that such a culture has become normalised. The core safety issue would therefore lie within the wider helicopter sector, with flow-on effects to individual operators' safety systems.

On 21 February 2018, the Commission recommended that the Director of Civil Aviation include the safety issue of helicopter operational culture in the CAA's current 'sector risk profile' review. (004/18)

7.1.1. On 2 March 2018, Civil Aviation Authority replied:

> The Director accepts the recommendation and notes that operational culture is already identified as a risk in the Small Aircraft (including helicopters) Sector Risk Profile work currently nearing completion. The timing, content and ownership of risk treatments is developed at the end of the process so cannot be advised at this time.

7.2. In spite of the operator having had consecutive satisfactory CAA audits and enjoying a good reputation within the aviation industry, it has now had four serious accidents in three years, including this accident. Not all of the factors contributing to these accidents were able to be determined conclusively by the Commission's inquiries or by the operator's internal investigations.

On 21 February 2018, the Commission recommended that the Chief Executive of The Helicopter Line, in consultation with the CAA, review The Helicopter Line's safety management system audit process to ensure that its safety policy, safety assurance, risk management and promotion of safety are sound. (005/18)

7.2.1. On 13 March 2018, the chief executive of The Helicopter Line replied, in part:

> Regarding the recommendation to review THL's safety management system I confirm The Helicopter Line (THL) has opened discussion on this matter with CAA and is already implementing this review. I will now provide an update on current changes and timelines to complete a range of improvements.
>
> THL and CAA have agreed that the 2018 THL re-entry audit and (likely) 2019 Safety Management Systems (SMS) certification will be the best opportunities to progress the reviews referred to. This notwithstanding, THL has decided to implement some SMS elements in advance of its SMS certification.
>
> Sector Risk Profiling has identified safety culture as a factor to be addressed by CAA and the industry. THL is fully engaged on this project and attended recent seminars on the project. CAA has agreed to provide learnings and information to THL resulting from this project.

[22] Commission inquiry AO-2014-005 Eurocopter AS350-B2 helicopter (ZK-HYO) collision with terrain during heli skiing flight Mount Alta, near Mount Aspiring National Park 16 August 2014.

8. Key lessons

8.1. Human factors can have both positive and negative effects on situational awareness. It is important for pilots to remain vigilant for changes in environmental conditions.

8.2. The loss of the ELT antenna during the break-up sequence demonstrated once again that an alternative means of independent, real-time flight following would be beneficial in respect of search and rescue[23]. It is prudent to use a flight-following service or facility where possible.

[23] The unreliability of ELTs is well documented; see Commission report AO-2011-003 with associated safety recommendation 006/14.

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