ACCIDENT

Aircraft Type and Registration:	AS350B2 Ecureuil, G-PLMH
No & Type of Engines:	1 Turbomeca Arriel 1D1 turboshaft engine
Year of Manufacture:	1989 (Serial no: 2156)
Date & Time (UTC):	13 June 2018 at 0911 hrs
Location:	Loch Scadavay, North Uist, Western Isles
Type of Flight:	Specialised Operation
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Helicopter destroyed
Commander's Licence:	Airline Transport Pilot's Licence (Helicopters)
Commander's Age:	59 years
Commander's Flying Experience:	9,260 hours (of which 1,892 were on type)[1] Last 90 days - 127 hours Last 28 days - 37 hours
Information Source:	AAIB Field Investigation

Synopsis

Whilst the helicopter was performing an underslung load operation at Loch Scadavay the boat it was carrying became unstable and flew upwards, causing the lifting line to strike the helicopter's tail rotor. The helicopter became uncontrollable and descended rapidly into the loch, fatally injuring the pilot.

The physical characteristics of the boat and the method by which it was carried increased the probability of it becoming unstable.

The helicopter operator has taken a number of safety actions mainly relating to its operational procedures and training. It has also temporarily curtailed the carriage of selected types of unstable or potentially unstable loads.

History of the flight

Background information

The pilot and the task specialist ground[2] (TSG), departed from their home base of Inverness the day before the accident and completed a 'Helicopter External Sling Load Operation' (HESLO)[3] (Figure 1) at Rangehead in South Uist.

Footnote

[1] Hours based on information described later in this report.

[2] TSG - Performs tasks on the ground directly associated with a specialised task. The terms 'groundcrew' and 'ground handler' are used interchangeably in the operator's documentation.

[3] HESLO - helicopter flight for the purpose of transporting external loads by different means. For ease of reference, and for consistency with the operator's Specialised Operation (SPO) manual, this report refers to HESLO as the carriage of underslung loads only.

Figure 1
Example of a HESLO operation

That afternoon, the crew[4] were requested by Operations[5] to perform a second job in North Uist the following day. That job was to transport a boat (Boat 1) for a regular client from Loch Scadavay to Loch Hunder, a distance of around 2 nm (Figure 2). A 'jobsheet'[6] and relevant maps were emailed to the pilot. This included the estimated weight of Boat 1 of 500 kg. During a phone call that evening, the client asked the pilot if a second boat (Boat 2) could be added to the job the following day.

Lifting of Boat 1

The crew stayed overnight locally and the next morning departed from Rangehead in G-PLMH at 0821 hrs, heading for a jetty at Loch Scadavay, 14 nm to the north-east. Whilst en route, the pilot advised ATC that he would be operating two lifts at not above 500 ft, just to the north of the extended centreline of Benbecula Airport Runway 24. They landed at 0829 hrs, shut the helicopter down, and met with the client and other individuals, including two fish farm employees. Boat 1 was already present and Boat 2 was yet to arrive.

The TSG reported that boats were known for being difficult loads. He assessed Boat 1 and discussed with the pilot how to lift it. Of Boat 1's two lifting eyes, they agreed to use the one on its bow in order to achieve a 'vertical' lift, which was the preferred orientation. The lifting eye looked suitable for this.

Footnote

4 Although the helicopter was being operated 'single-crew', for ease of reference, this report refers to the pilot and the TSG as a 'crew'.
5 The operator's Operations department.
6 Document produced by the operator detailing a job using the best information available at the time.

The fish farm employees had to be flown to Loch Hunder first, for them to eventually unhook the transported boat(s) from the helicopter. After receiving a safety brief, they and the pilot departed in G-PLMH at 0845 hrs. Shortly thereafter, the pilot reported to ATC that he was starting the lifting operation. ATC advised that the wind at Benbecula Airport was from 180° at 13 kt, to which the pilot replied "COPIED, FEELS A LOT STRONGER THAN THAT". Three minutes later the helicopter landed adjacent to the jetty at Loch Hunder, where the two employees disembarked.

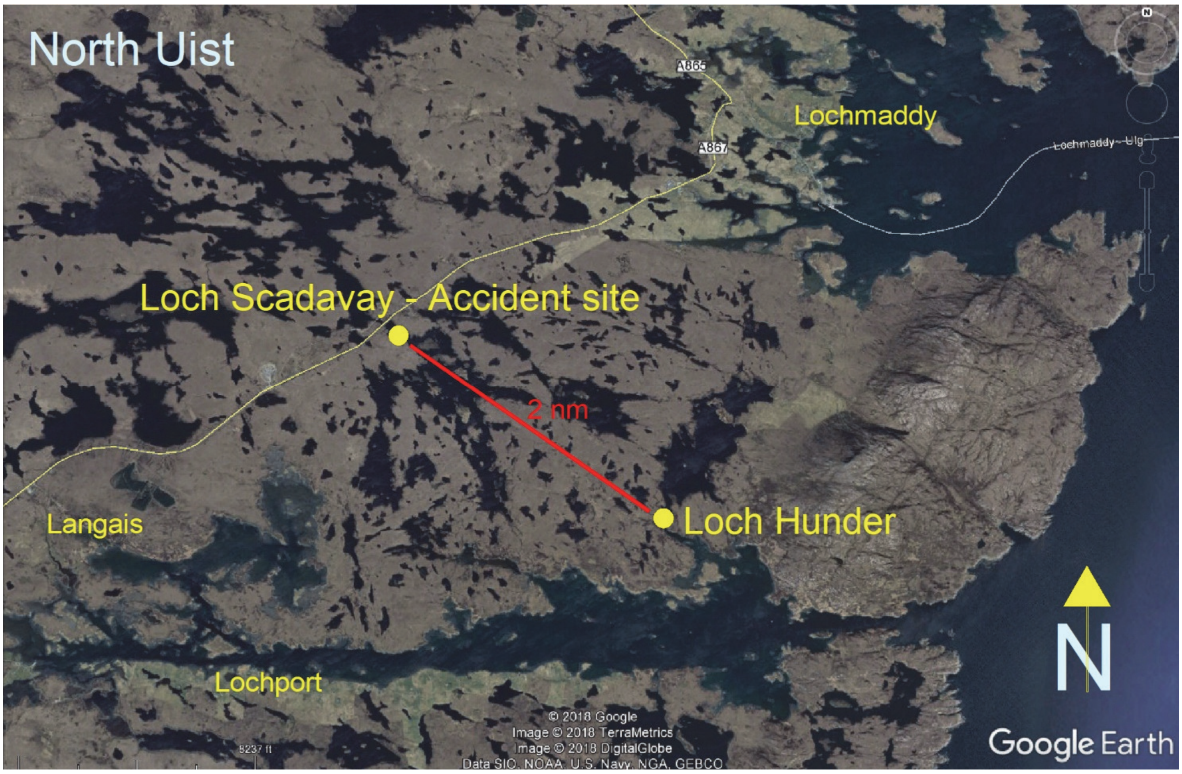

Figure 2

Loch Scadavay (lifting site) and Loch Hunder (drop off site)

The helicopter returned to the lifting site and its rotors stayed running. The TSG, who was in radio contact with the pilot, attached Boat 1 using a 10 m long lifting line. The boat was lifted by the bow in a vertical orientation. The TSG checked the load whilst the helicopter hovered, and transmitted "good lift, OK". Boat 1 was subsequently delivered at 0855 hrs.

Lifting of Boat 2

While the helicopter was away, Boat 2 arrived by trailer. This boat was noticeably smaller and lighter than Boat 1, and the TSG reported that the single lifting eye on its bow did not appear strong enough to support it in a vertical orientation. When the helicopter was returning to Loch Scadavay, the TSG radioed the pilot asking him to shut down the helicopter on arrival, as he wanted to discuss the rigging method and if the pilot was prepared to accept the load. The pilot advised ATC that he was going to land and shut down. When ATC asked when he would be lifting again, the pilot stated: "THEY WANT ME TO DO ANOTHER LIFT BUT I'M NOT CONVINCED IT'S PRACTICAL, SO I'M JUST GOING TO ASSESS IT AND ONCE I KNOW WHETHER I'M going to lift it or not, i'll get back in touch". This was acknowledged by the ATCO. The helicopter landed at Loch Scadavay at 0858 hrs.

The TSG described Boat 2 as "one of those loads" and proposed transporting it on its side, with the strops tied in place with ropes. The TSG recalled the pilot agreeing with the rigging method and making a general comment about boats being challenging. He did not recall the pilot verbalise doubt over lifting it, or a 'go/no go' decision. They agreed on the importance of flying with Boat 2 slowly.

The pilot returned to the helicopter and started the engine. The TSG attached Boat 2 to the helicopter with the 10 m lifting line, hoisting the boat on its side. He asked the pilot to lift slowly so he could check the load. The TSG transmitted "good to go" and the helicopter moved away. Recorded data showed that, at 0910:56 hrs, the helicopter was positioned adjacent to the jetty at Loch Scadavay at an altitude of about 100 ft amsl (70 ft agl). Its groundspeed was 6 kt (Figures 3 and 4). On a course towards Loch Hunder of about 120° T, the helicopter progressively climbed at a rate of 340 ft/min whilst the groundspeed increased at a rate of 1.8 kt/sec. A few seconds later, at 0911:04 hrs, the pilot transmitted to ATC that he was airborne with an underslung load. This was the last radio transmission received from G-PLMH.

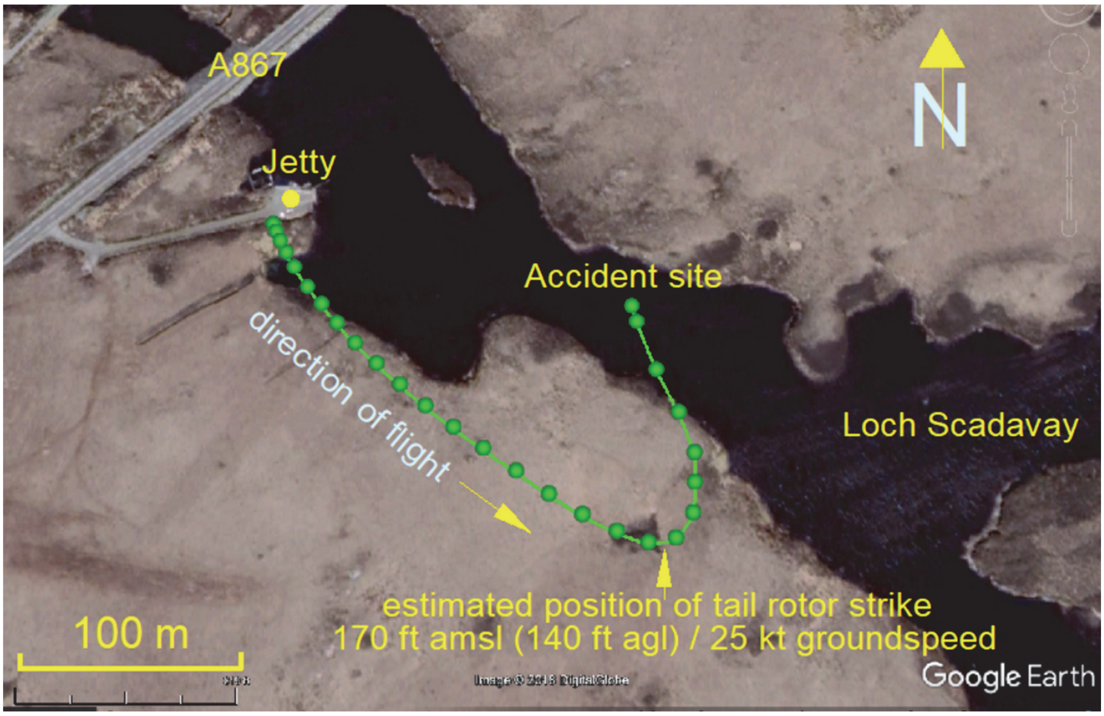

Figure 3

GPS-derived track of accident flight

At 0911:12 hrs, the helicopter had climbed to an altitude of about 180 ft amsl (150 ft agl) and its groundspeed was 36 kt. There were a number of eyewitness accounts of the lifting of Boat 2. These indicated that it started to swing and spin soon after departure. The TSG immediately radioed "slow down, slow down" to the pilot. Although he did not receive a reply from the pilot, it appeared to the TSG that the helicopter slowed down. Recorded data showed that the helicopter's groundspeed reduced to 25 kt, at an altitude of about 170 ft amsl.

Eyewitnesses reported that within seconds of Boat 2 spinning, it lifted in to the air independently of the helicopter, like a "kite". It paused momentarily, then lifted further up and over the tail boom of the helicopter. One witness remarked "[it] all happened really fast".

The helicopter moved erratically and altered track increasingly to the left. It momentarily maintained altitude, before entering a steep nose-first descent towards the loch on a track of about 340°. The helicopter struck the water with a descent rate of about 3,600 ft/min and a groundspeed of 40 kt. It came to rest on its left side, almost fully submerged. The pilot, who was wearing an immersion suit, was fatally injured.

Subsequent inspection of the wreckage revealed that the load and lifting line appeared to have been jettisoned from the helicopter's lifting hook.

Recorded information

Sources of recorded information

Recorded radar information was available from a ground-based site located at St Kilda. This recorded the helicopter's positioning flight from the MoD Rangehead located on South Uist to the pick-up point at Loch Scadavay on North Uist. The helicopter's subsequent flights were not recorded by radar.

The helicopter was fitted with a GPS tracking system[7]. This provided 12 snapshots of GPS-derived position, altitude and groundspeed of the helicopter's movements on the day of the accident; the first data point was recorded at 0820 hrs and the last was recorded at 0858 hrs.

Data was successfully recovered from the pilot's portable tablet computer[8] that was found submerged near the helicopter. This was installed with a flight navigation software application[9] that provided a track log of the accident flight and previous flights, with GPS-derived position, track, altitude and groundspeed recorded at a rate of once per second. Under normal operation, flight recording started when the derived groundspeed was greater than 5 kt and recording stopped when the tablet computer remained stationary for a period of 30 seconds.

RTF recordings of the pilot's communications with ATC at Benbecula Airport were also available.

Footnote

7 http://spidertracks.com
8 Apple-manufactured iPad mini 4 model A1550.
9 Airbox RunwayHD flight navigation software application.

Accident flight

GPS-derived data salient to the accident flight are presented in Figure 4.

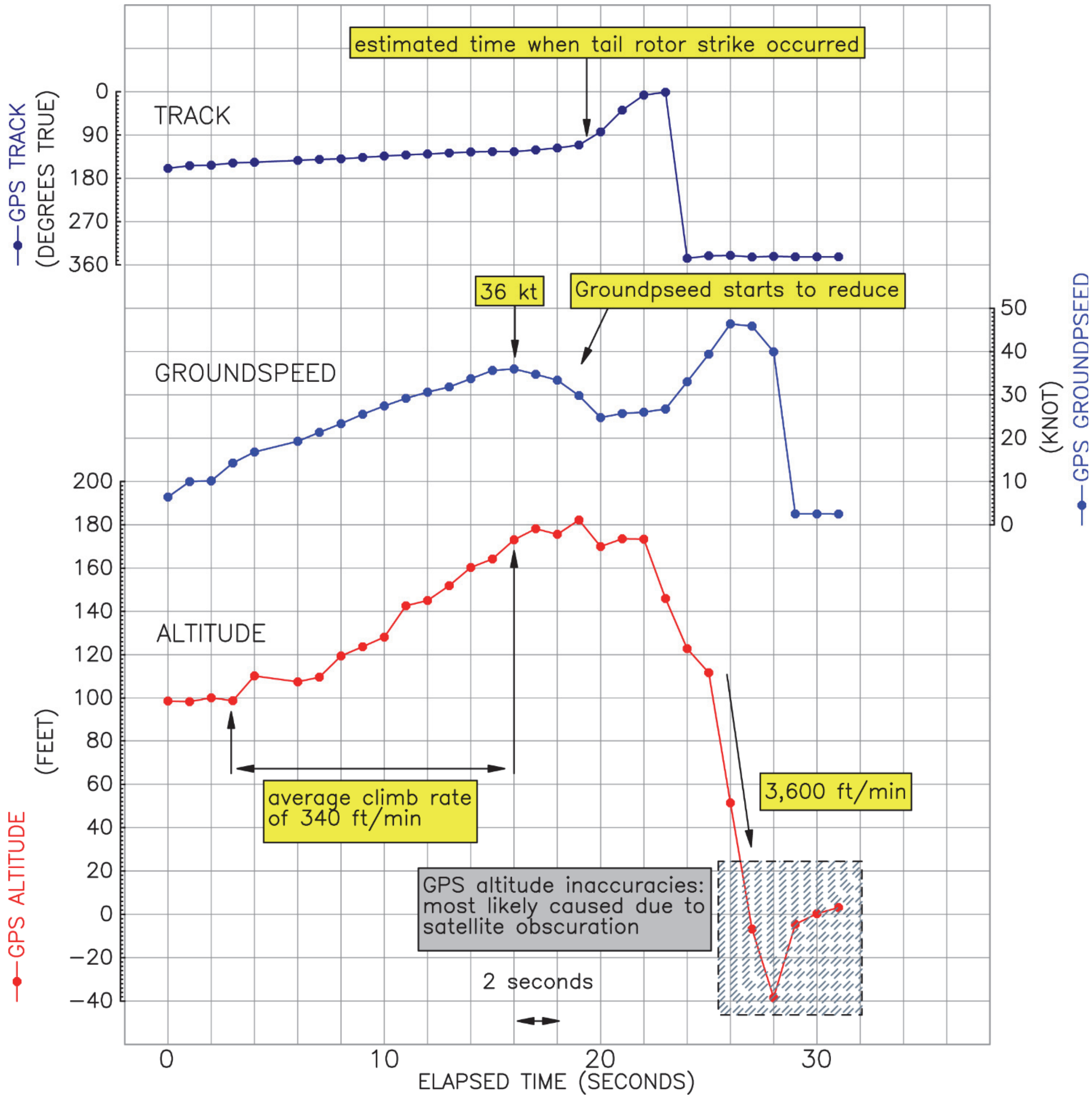

Figure 4

GPS-derived data from the accident flight

Comparison of first and second boat lift

The recorded GPS data for the first boat lift was compared with the accident flight (Figure 5). The first boat lift occurred 20 minutes prior to the accident lift. The track of the helicopter during both flights was almost identical. Therefore, if the wind direction and speed had not altered significantly in the 20-minute period between the two flights, the groundspeed during both flights may be directly compared.

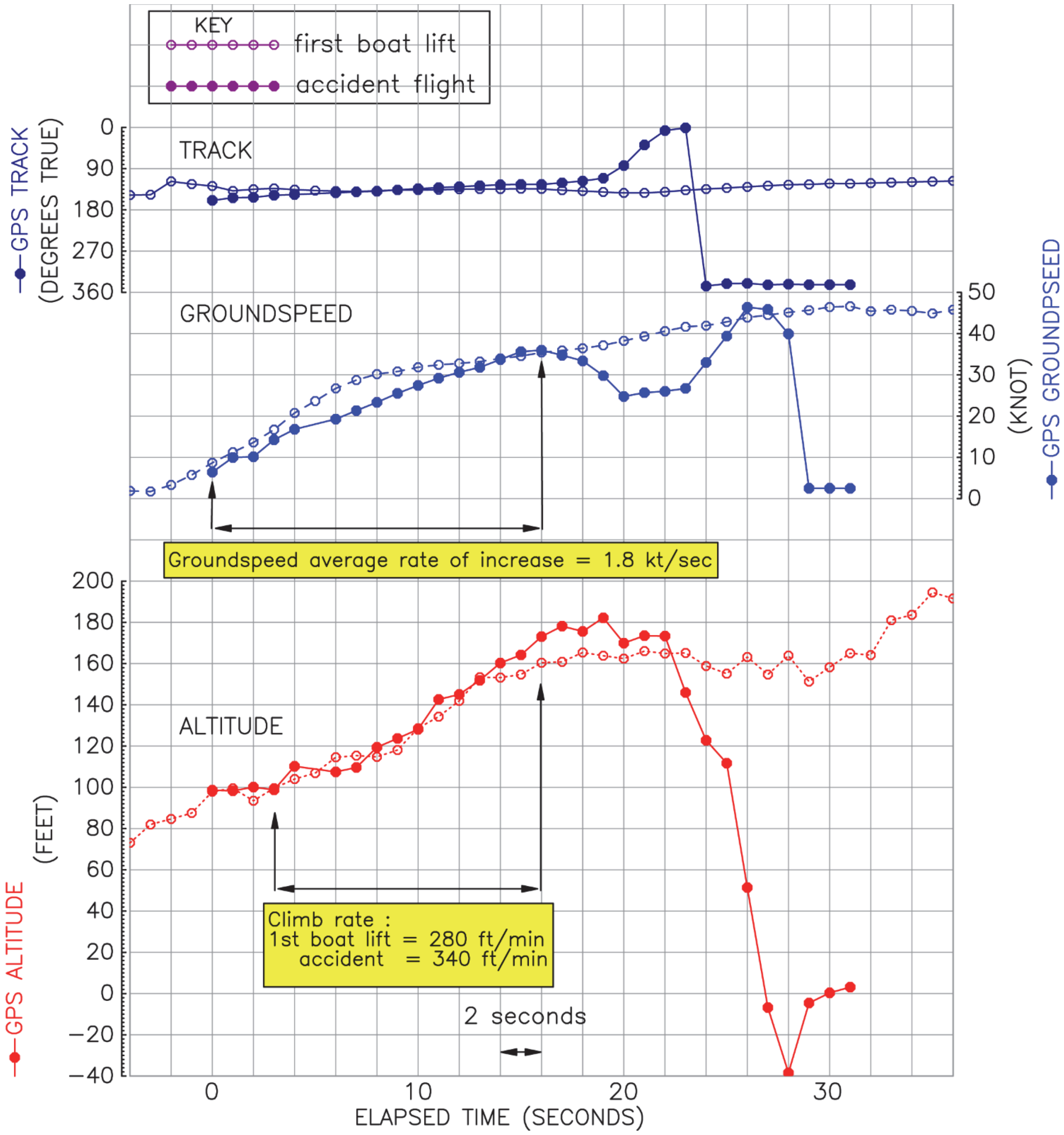

Figure 5

Comparison of GPS data from first boat lift and accident flight

Alignment of the two flights indicates that the helicopter's groundspeed of 6 kt was identical at the time that the helicopter was at 100 ft amsl. Over the next 16 seconds, the groundspeed during both lifts increased to 36 kt, which equates to an average rate of about 1.8 kt/sec. Although the average rate of groundspeed was almost identical up to 36 kt, the initial rate of increase during the first boat lift was not as linear as that of the accident flight, with a slightly higher rate.

As the groundspeed increased to 14 kt, the helicopter started to climb from 100 ft amsl during both lifts. When the groundspeed was at 36 kt, the helicopter had climbed during the first boat lift to about 155 ft and about 170 ft amsl during the accident flight; this equates to an average rate of climb of 280 ft/min and 340 ft/min respectively.

After reaching 36 kt, the groundspeed continued to increase at a rate of just less than 1 kt/sec during the first boat lift. During the accident flight, the groundspeed reduced to 25 kt in 4 seconds.

In summary, the rates of change of groundspeed and altitude during the lifting of both boats were almost identical.

Lifting site

The lifting site was a jetty at Loch Scadavay, which is around 7.5 nm north-east of Benbecula Airport (Figure 6).

Figure 6
Lifting site from the air (circled)

Meteorology

The weather at Benbecula Airport around the time of the accident was reported as:

> At 0850 hrs: wind from 180° at 15 kt, 9,000 m visibility in light rain, scattered cloud at 1,600 ft, broken cloud at 2,500 ft, temperature 11°C, dewpoint 10°C, QNH 1009 hPa.
>
> At 0920 hrs: wind from 180° at 14 kt, 9,000 m visibility in light rain, few clouds at 900 ft, scattered cloud at 1,600 ft, broken cloud at 2,500 ft, temperature 12°C, dewpoint 11°C, QNH 1008 hPa.

The weather was forecast to deteriorate during the day of the accident because 'Storm Hector' would reach the UK the following morning. The TSG said that, because of this, the pilot had brought forward the planned fuel uplift at Benbecula Airport by 30 minutes.

Personnel

Pilot

The pilot held a valid EASA Class 1 medical. He held an EASA ATPL(H) and was appropriately qualified on the AS350, and for the HESLO flying he was undertaking.

The pilot had been flying helicopters professionally since 1986, including military, offshore, and air ambulance. He had flown for the operator previously, but his most recent employment began in September 2016.

According to a document[10] containing the pilot's flying experience prior to joining the operator in 2016, along with the hours he subsequently accrued during his employment, the pilot's total helicopter flight time was around 9,260 hrs. The operator's records suggest the pilot's total AS350 flight time was around 1,890 hrs. Before joining the operator in 2016, the pilot quoted a total of 2,100 hours in underslung loads. The operator reported that he had subsequently performed an estimated 4,072 lifts for them.

Task Specialist Ground

The TSG had worked in helicopter SPOs since 2005. He joined the operator in June 2006, and they described him as being very experienced.

Description of the helicopter

The AS350B2 is a single gas-turbine engine powered helicopter (Figure 7). It is operated by a single pilot and carries up to five passengers. It is fitted with a three-blade main rotor and a two-blade tail rotor; all the rotor blades are of composite construction. The flying controls are hydraulically powered but have manual reversion capability. The main landing gear consists of two fixed skids.

G-PLMH was fitted with an external hook on the underside of the fuselage to enable underslung loads to be carried. An external mirror allowed the pilot to view the underslung load. The external hook was fitted with an emergency release which could be operated readily by the pilot in case the load needed to be jettisoned.

Because the planned operations were over water, the helicopter had manually activated, gas-inflated flotation devices fitted to its skids. A life raft was also carried.

Footnote

[10] The pilot provided a breakdown of his flying experience to the operator before commencing employment there.

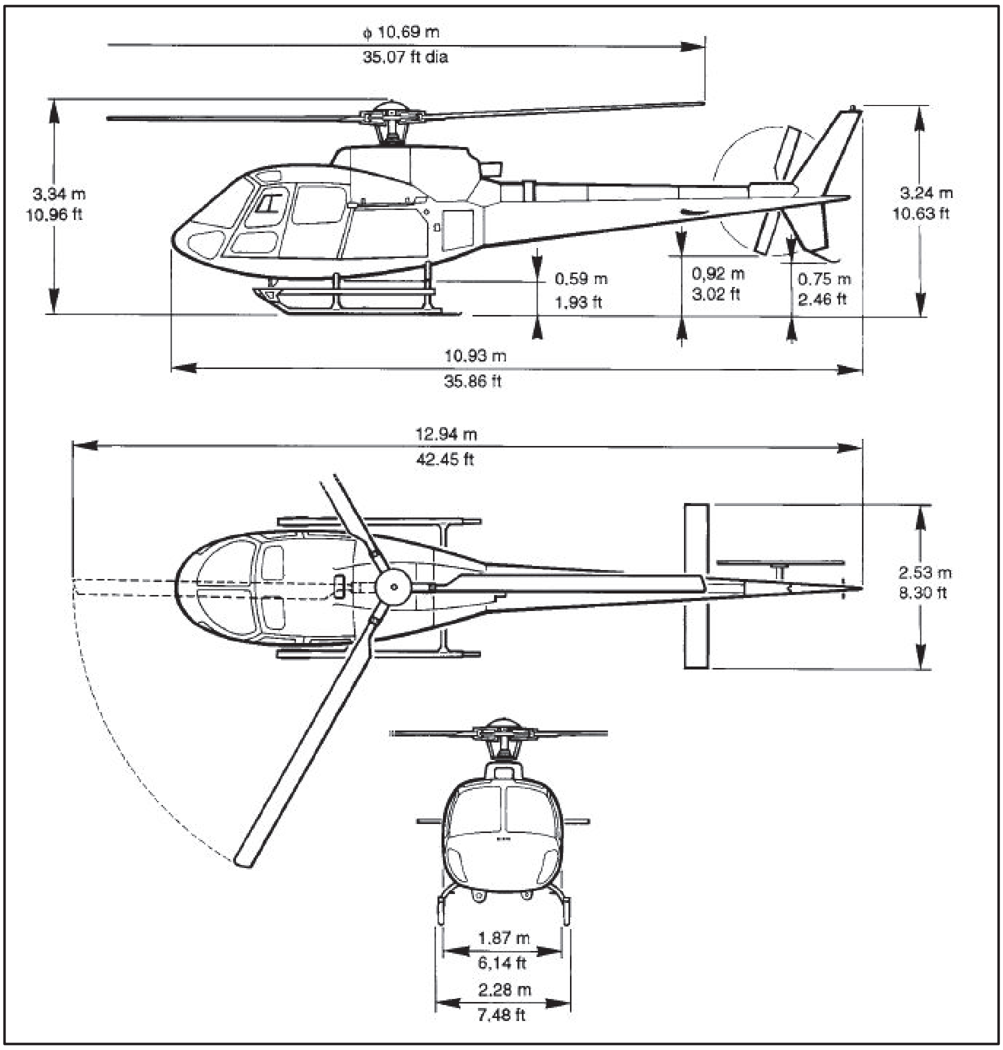

Figure 7

General view and dimensions of helicopter

Maintenance

The helicopter was maintained in accordance with an approved maintenance programme and a review of the maintenance records did not identify any anomalies.

The last scheduled maintenance inspection was a 100-hour inspection, completed on 12 June 2018. The helicopter then flew for approximately 2 hours before the accident flight without any defects being noted; 1.7 hours on 12 June 2018 and approximately 0.3 hours before the accident flight on 13 June 2018.

Lifting equipment and loads

Lifting line

A 10 m long chain was being used to carry the loads. The top end had a swivel joint and an approximately 1 m long rope section built in to act as a shock absorber. The bottom of the chain was fitted with a weight and a guarded hook.

Boat 1

Boat 1 was approximately 4.9 m long, 2.0 m wide and weighed 420 kg. An outboard motor weighing approximately 45 kg was fitted on the transom. It was lifted solely by the attachment on its bow. A similar boat, but without an outboard engine fitted, is shown in Figure 8.

Figure 8

A boat similar to Boat 1 (arrow indicates lifting eye location)

Boat 2

Boat 2 was approximately 4.4 m long, 1.4 m wide and weighed 192 kg. The mooring ring on the bow was not considered by the crew to be strong enough to lift the boat, so the lifting hook was connected to the boat using two strops, at approximately 1/3 of the length in from each end of the boat. These were secured in place by rope to stop them moving on the curved surfaces of the boat's hull (Figure 9). The strops were arranged such that the boat would be carried on its side.

Figure 9

Boat 2 showing arrangement of lifting strops
(cradle added for storage purposes)

Accident site

The helicopter came to rest in Loch Scadavay lying on its left side and mostly submerged (Figure 10). Its life raft had automatically inflated and remained tethered to the wreckage. The manually-operated flotation devices on the helicopter's skids had not been activated. Boat 2 remained connected to the wreckage by the lifting chain and after floating initially, it eventually sank.

Debris, including parts of the tail rotor, cockpit area and parts of the boat were found on the shore to the south-west of the wreckage. Pieces of foam filling from composite panels and the rotor blades were scattered over a wide area by the wind.

Figure 10

General view of wreckage in Loch Scadavay

Initial assessment of the wreckage

An evaluation of the wreckage in-situ was carried out by an expert recovery diver. Images from a helmet-mounted camera were available for viewing by shore-based personnel. The lifting chain was found to be wrapped around the tail boom and horizontal stabilisers (Figure 11). Its upper end had been released from the hook on the underside of the helicopter, and its lower end remained attached to the strops secured to Boat 2.

The pilot's flying helmet[11] was found floating next to the wreckage and was still attached to the helicopter by its audio communication electrical leads.

Footnote

11 The helmet had an integral headset and was plugged in to the helicopter's communications system.

Figure 11
Diver's view of lifting chain wrapped around tail boom, as found

Wreckage recovery

The wreckage was raised using flotation bags and towed close to the shore before being lifted out of the water by crane. A preliminary examination was carried out prior to the wreckage being transported to the AAIB's facilities.

On-site examination of the wreckage

The cockpit area of the helicopter was severely disrupted. The pilot's seat composite structure was torn from the floor mountings on its right side (Figure 12).

Figure 12
Pilot's seat showing damaged mounting

The tail rotor blades showed witness marks along the leading edges from contact with the lifting chain (Figure 13).

Figure 13

Remains of a tail rotor blade showing witness marks from contact with the lifting chain (yellow strop is from the recovery operation)

Detailed wreckage examination

A further examination of the wreckage including the powerplant and its drivetrain, flying control integrity and structure did not reveal any pre-accident anomalies.

Medical and pathological information

A post-mortem examination of the pilot found that he had died because of a severe head injury and drowning. The post-mortem found no other factors that could have contributed to the accident.

Survivability

Flying helmet

In accordance with operator's policy, the pilot had been wearing a flying helmet. After the accident it was found with minor scratches, with no evidence of a significant impact. The chin strap buckle was not secured. The TSG could not recall noticing if the pilot's helmet chin strap had been fastened during the duty.

Pilot's seat

The pilot's seat consisted of a composite structure which was attached to the floor by seat rails. The pilot's harness lap strap was attached to fittings on the floor and the shoulder straps were fitted to the seat structure.

On 25 February 2010, the EASA issued Safety Information Bulletin (SIB) 2010-05, '*Eurocopter AS350 and AS355 helicopters – Improvement of Pilot's and Co-pilot's Seats*'. This SIB informed operators that as a result of accident investigation findings relating to seat attachment failures, the manufacturer had developed seats offering improved safety which were available as an optional modification. The improvements related to improved seat and attachment strength and optional energy-absorption.

The SIB noted that the standard seats complied with the minimum performance standard of the applicable certification basis, but that this modification would enhance occupant's safety.

Since the certification of this helicopter type in 1978, certification standards have increased the requirements for seat strength considerably. Any new type undergoing certification would have to meet the current requirements.

The seats in G-PLMH had not been modified to the improved standard and nor were they required to be.

HESLO information

Specialised Operation

HESLO is considered a 'Specialised Operation' (SPO). Commission Regulation (EU) 965/2012 defines SPO as:

> *'any operation other than commercial air transport where the aircraft is used for specialised activities such as agriculture, construction, photography, surveying, observation and patrol, or aerial advertisement.'*

An operator must hold a declaration[12] to perform SPO operations, and further individual authorisations for SPO activities which are defined as being 'High Risk Commercial Specialised Operations' (HRCSPO)[13]. The accident duty was conducted under the auspices of the operator's single SPO declaration.

HESLO has four categories[14], depending on factors such as the length of the lifting line and complexity of the operation. The lifting of Boats 1 and 2 was being performed under HESLO 1 'Short line' (20 m or less).

CAA CAP 426

The CAA's CAP 426 'Helicopter External Load Operations' contains advice for operators, pilots, and persons supervising the securing and detaching of loads.

Footnote

12 The CAA is the competent authority for SPO in the UK.
13 HRCSPOs typically involve particular risk to third parties on the ground.
14 https://www.easa.europa.eu/sites/default/files/dfu/Annex%20to%20Decision%202017-012-R.pdf [accessed 20 Feb 2019]

Section 5, *'Certificate of Airworthiness Limitations'* states:

> *'In the absence of specific details of loads, it should be assumed that only dense loads with predictable aerodynamic characteristics have been carried. In cases where it is intended to carry loads of irregular shape or low density the advice contained in paragraphs 6.18, 6.19 and 6.20 should be followed to determine the safe flight characteristics.'*

Section 6.17 explains the *'Acceptance of a Load for Flight'*:

> *'The final responsibility for the acceptance of any load for flight rests with the captain of the helicopter concerned. The masses of slung loads are to be made available to the captain before flight to enable accurate flight planning. The total mass of a slung load is always to be determined accurately.'*

Section 6.19 *'Flying Limitations and Load Stability'* contains the following advice:

> *'The weight of the cargo should not be less than 227 kg (500 lb) in total and this in turn should be related to the drag profile of the load. Certain low drag high-density loads with a total cargo weight of less than 227 kg may prove acceptable. The safe carriage of any ultra-low density or ultra-lightweight load will depend upon the speed at which the maximum allowable trail angle is attained and at which any deterioration in load handling characteristics takes place.'*

That section also lists factors which affect the maximum permitted speed at which a load may be flown. These include: *'load motion that can cause unacceptable stresses on the helicopter or interfere with control'* and *'the drag of the load which results in the maximum safe trail angle being reached'*.

Section 6.20 'Load Oscillation' includes the following advice:

> *'Helicopter accidents have been caused by violent oscillations of underslung loads. The problem is complex and not fully understood so it is only possible to give general advice on corrective actions.*
>
> *…Should pilots encounter difficulty in stabilising a load, they should either lower it to the ground or jettison it promptly.*
>
> *…Load oscillations in forward flight result from a combination of the stability characteristics of the load and the forward speed of the helicopter. Loads of low volume and high density do not normally pose a problem, but large volume loads of low density and irregular shape are liable to start oscillating at a certain critical airspeed. The initial acceleration with an underslung load of this nature must, therefore, be made slowly, using extreme caution, in order that a safe approach towards this unknown critical speed is achieved. If the load starts to oscillate, airspeed must be reduced by at least 10% of the speed at which the oscillations began.'*

Manufacturer's information

In 2017, Airbus Helicopters published Safety Information Notice No. 3170-S-00 which contains safety advice on HESLO.

Operator's information

HESLO description

The operator's SPO Manual described HESLO under a series of SOP[15] headings. The 'HESLO General SOP'[16] applied to all HESLO activities. Specialised HESLO activities had additional SOPheadings. As there was no specific SOP for the carriage of boats, the accident duty was performed under the HESLO General SOP.

The SPO Manual described HESLO as being an *'inherently hazardous activity'*.

Training

<u>Pilots</u>

The operator explained that it recruited HESLO pilots from a small worldwide pool, who were already experienced and proficient. Pilots would receive familiarisation training on the operator's culture and procedures, and then undergo flight training on commercial jobs, with a phased introduction to increasingly demanding tasks. The operator indicated that because of the wide variety of working backgrounds of its pilots, it emphasised ingraining its own safety culture.

The operator explained that operators in general are responsible for designing their own HESLO training packages. Part D of its SPO Manual listed the HESLO 1 training syllabus as sets of subjects under section headings. One subject was *'SMS including Risk Assessment and typical hazards and dangers'*. A section entitled *'Different types of load and how to sling'* included the subject *'light loads'*. Furthermore, a section on *'Swinging Loads / Spinning Loads'* listed the subjects *'Unstable loads and their limiting speeds'* and *'Large, light loads can be made to swing by wind gusts'*.

The training related to these subjects was not documented and would take place as a discussion between the instructor and the pilot.

Pilots new to the company would begin by lifting high-density, stable loads and progress to more unstable loads. The HESLO General SOP included guidance on the carriage of fencing and palleting, but not on boats, which were transported by the operator relatively infrequently. There was no documented advice on generic methods for 'unstable or potentially unstable loads' (UoPULs)[17].

Footnote

[15] SOP – Standard Operating Procedures.
[16] Examples of these were 'HESLO SOP Fire Fighting' or 'HESLO SOP Carriage of Live Fish'.
[17] The operator used the term "UoPUL" in the documentation it produced after the accident, which is summarised in the Safety Actions section of this report.

One subject in the HESLO 1 syllabus was *'Training in human factors principles (this will usually be a pilot CRM course)'.* That CRM course was entitled *'Single Pilot CRM / Pilot Decision Making'* and was provided by an external training provider. The operator's policy was for pilots to complete this as a 1-day course immediately after joining the company, and thereafter as half-day recurrent training. The operator stated that, whilst the initial course is valid for 3 years, it held the recurrent training annually. The most recent CRM course which the accident pilot undertook was on 10 November 2017. Some of the content of the CRM training is discussed in a later section of this report.

TSGs

The TSG reported that he had not received specific training on boats, commenting that TSG training tended to be generic because every lift is different.

He indicated that, with the operator's activities being so specialist, the employees themselves tended to be industy experts hence there was limited benefit to using external training providers.

HESLO teamwork

The 'HESLO General SOP' described the HESLO crew composition as being the *'pilot'* – who is *'assisted by Task Specialists Ground, and sometimes by a Task Specialist Air'* (TSA)[18]. It stated:

> *'…It is the pilot's responsibility to assess the suitability of each load for safe carriage in flight. He can be assisted in this duty by a company ground handler but the responsibility remains his. He should be particularly careful of loads on pallets, in fertiliser bags, rigged by polypropylene slings, or which, by virtue of their light weight and large surface area, are likely to be unstable in flight. Pilots should consider the use of nets with such loads.'*

The TSG's *'Function on site'* in the SPO Manual involved the preparing and checking of loads, and the completion of load-related work whilst under the helicopter. TSGs maintain radio contact with pilots when possible, using radio phraseology to assist the pilot in manoeuvring the helicopter, and in the case of an emergency.

The introduction to the *'Ground Handlers Manual'* stated:

> *'Aerial work is very much a team effort; just as a pilot must be expected to have the aircraft and airborne equipment under control, groundcrew should be fully in charge of what is happening on the ground. Groundcrew are the eyes in the back of the pilots head and can often be aware of situations occurring that the pilot is not or cannot be aware of. The groundcrew are, therefore, a very important half of the load lifting team.*

Footnote

[18] Task Specialist Air - performs specialised tasks on board or from the aircraft.

> *The nature of the job is such that each situation is different and will present a different set of problems and hazards. It is therefore impossible to lay down a set of rules to cover every eventuality; indeed what may apply in one circumstance may be entirely inappropriate in another. There are however some general modes of conduct which universally apply and a proper understanding of what is involved in the various operations [the operator] undertakes is necessary for tasks to be completed satisfactorily. The aim is to keep ourselves and the customer happy, safely.'*

The operator described the teamwork between a HESLO pilot and TSG as an "orchestrated sequence of events" and recognised its similarity to a multi-crew[19] operation.

The SPO Manual indicated that TSAs acting as observers on specific jobs were required to undergo formal CRM training, stating:

> *'Crew Resource Management* [CRM] *techniques facilitate effective co-operation between the pilot and observer, which can greatly enhance safety.'*

The TSG training syllabus included the heading *'Human factor principles',* and the Ground Handler's Manual contained a section on *'Interpersonal Communication'*. TSG's did not undergo formal CRM training. However, the operator reported that prior to the accident it had already committed to extending CRM and HF training to TSGs and, further, to all staff obliged to receive training. It intends to bring more of its CRM training 'in-house' and stated that a company-wide understanding of how behaviour, attitude and performance can affect decision making, and therefore safety, is highly desirable.

Operations procedures for load carriage

Job sheet and method statement

In accordance with the operator's procedures, after providing a quote to the client, the Operations team sent a jobsheet to the pilot. This contained the logistical arrangements[20] for lifting Boat 1. Boat 2 was unknown to the operator prior to the accident.

A generic method statement had been created for the client in 2012, applicable to HESLO jobs. It outlined the method of operation in general terms, along with relevant risk assessments[21]. It did not pertain to the technical aspects of lifting underslung loads by helicopter.

The operator stated that unusual aspects of a load would often be picked up at the quotation stage. It defined the maximum weight of an underslung load on the AS350 as 950 kg. It did not specify a minimum weight, but reported that an estimated weight of 200 kg or less

Footnote

19 An aircraft operation that requires at least two pilots.
20 For example, client details, relevant locations, and estimated weight of the load.
21 For example, 'HESLO General', 'Groundhandler General' and 'Refuelling'.

would tend to prompt a discussion about the structural characteristics of a load concerning the speed and distance for transporting it. A member of the Operations team commented that he would flag up such a load to the pilot concerned.

The operator explained the nature of HESLO work meant that clients often asked crews to perform additional lifts 'on the day'. In such cases, a pilot would make a decision based on factors such as the suitability of the load, fuel, and time available. The pilot would then communicate the resulting number of lifts back to the Operations team for invoicing[22]. The operator stated that it would only expect to be told about additional lifts if other jobs or resources might be affected.

Risk assessments

Each HESLO SOP contained applicable generic risk assessments (RAs). For the HESLO General SOP these included a 'HESLO General' RA and additional, more specific RAs, for example, *'Task Specialists Rotors-running'*, *'Slinging over Powerline'* and *'Pallet Loads'*.

The *'Safety Management System (SMS) Risk Assessment Form'* for the HESLO General RA listed applicable hazards, alongside their control measures, with a 'final risk' designated by a 'traffic light' format[23]. One hazard and its control measures were described as follows:

> *'Load strikes Tail Rotor (includes flight with an empty chain) and results in loss of control and crash causing death and injury to occupant(s)'.*
>
> *Training and Checking*
>
> *Adherence to* [Helicopter Flight Manual] *speed limit of 80kts*
>
> *Speed reduction in turbulence*
>
> *Mirror*[24]
>
> *Take particular caution, especially with airspeed, for light and unstable loads'*

That hazard was given a final risk of 5 ('amber'), which is derived from a severity score of 5 ('catastrophic') multiplied by a likelihood score of 1 ('rare'). Amber is defined as

> *'…stop, think. If management available obtain permission OR go ahead if you consider it safe and inform management when you return to base'.*

The operator commented that HESLO mainly operates in the 'amber' band.

Footnote

22 Clients would normally be quoted a price 'per lift'.
23 Red, amber or green, based upon a combination of severity and likelihood.
24 External mirrors are fitted to HESLO helicopters to give pilots a view of underslung loads.

Section 8.13.1 of the SPO Manual, 'Risk Assessments', stated:

> *'In addition, pilots (assisted by Task Specialists) shall make a local informal (unwritten) Risk Assessment of the work to be carried out bearing in mind the environment and circumstances pertaining on that day. For HESLO pilots this local RA is recorded on the… Daily Site Briefing and Risk Assessment form… which is returned to Operations for filing.*

The form would generally be completed at the start of a duty and did not pertain to the loads themselves.

A Daily Site Briefing and RA form for the accident duty was not subsequently located.

Information on unstable load carriage

The operator's HESLO expert indicated that when carrying a UoPUL he would recommend increasing the airspeed incrementally, checking the load in the mirror at each stage, to a limited maximum airspeed. Using an example of some fencing being transported, the control measure was to fly at 40 KIAS, rather than 60 KIAS.

The *'Emergency Procedures'* section of the operator's SPO Manual stated:

> *'If the pilot experiences a serious emergency, engine failure etc., he will… Jettison the load…'*

The TSG estimated that he had assisted with slinging around 12 boats and described them as unpredictable. Vertical lifts were preferred because in a horizontal, 'boating' orientation they might behave like a "wing".

Safety Management System

The operator reported that it designed and promoted its own safety management system (SMS)[25]. This included a 'blog' where all employees could comment and share information on safety related matters. The pilot was reportedly an active participant.

The TSG commented that the operator's safety culture was good, and that reporting was encouraged for all personnel.

Decision making surrounding the carriage of loads

Human factors

The European Helicopter Safety Team (EHEST) produced a training leaflet entitled *'Decision Making for Single Pilot Helicopter Operations',* which stated:

> *'Certain biases are very well known in an operational context, such as the willingness to please a customer or to complete the mission…'*

Footnote

25 SMS – Systematic approach to managing safety, including the necessary organisational structures, accountabilities, policies and procedures.

'Plan continuation bias' is the unconscious cognitive bias to continue with the original plan. It may obscure subtle cues which indicate that underlying conditions and assumptions have changed[26]. EHEST's document suggests that plan continuation bias often occurs in dynamically changing conditions.

EHEST's leaflet also discusses the following:

> *'Heuristics are simple mental rules used to solve problems and make decisions, especially when facing complex problems, incomplete information and time constraints… Studies indicate that pilots often take decisions using a heuristic approach based on past experience instead of thoroughly analysing the situation. With acquiring experience, most of what we do gets 'routinised' and is performed in an automated manner.'*

The document outlines strategies which benefit decision making, including single pilot CRM training, the application of standard operating procedures (SOPs), and the use of decision making aids, explaining:

> *'SOPs… provide pilots with pre-planned responses that manage the risks and break the "chain of events" leading to accidents...'*
>
> *'Decision aids are easy to remember lists intended to support the decision maker... They are particularly beneficial in the case of critical and stressful situations.'*

The FAA cites some example decision making aids[27]:

> *'Pilots can help perceive hazards by using the PAVE checklist of: Pilot, Aircraft, enVironment, and External pressures. They can process hazards by using the CARE checklist of: Consequences, Alternatives, Reality, External factors. Finally, pilots can perform risk management by using the TEAM choice list of: Transfer, Eliminate, Accept, or Mitigate.'*

Information from the operator

The *'Single Pilot CRM / Pilot Decision Making'* course used by the operator included sections on *'Decisions…'* and *'Decision Making Models'*, and included decision making aids, such as *'DECIDE'*, which stands for *'Detect... Estimate… Choose… Identify… Do… Evaluate'*. It suggested that the *'Evaluate'* step helps to avoid plan continuation bias.

The operator reported that it was very familiar with the concept of structured decision making. The 'Training' part of its Operations Manual stated that pilot decision making is assessed as follows:

Footnote

[26] https://www.skybrary.aero/index.php/Continuation_Bias [accessed 1 April 2019]
[27] https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/04_phak_ch2.pdf [accessed May 2019]

> *'…If more time is available, it should be an Analysed decision (ie How much Time is available for the decision? Diagnose what the challenge is. Assess what options are available. Decide which option to implement? Does he Review how the option is progressing to see if it's working as he intended?'*

The accident pilot's training records did not reveal any problems in decision making. Under *'Decision Making'* in his most recent Operator Proficiency Check *'CRM Assessment'* form, the assessor had written *'Very Very professional. A Very comprehensive flight. Excellent TEM'*[28].

The operator indicated that a balance must be struck between pilots 'sharing' their decisions, but also being respected for the decisions they make. An individual pilot's experience and contextual factors 'on the day' mean that decision making varies. On-site crew often cannot contact Operations due to the lack of a mobile phone signal.

Section 8.13.3.6.2 of the SPO Manual stated:

> *'If work cannot be carried out safely even after additional control measures are put in place, or it is not possible to put in place additional control measures, or it is not possible to arrange an alternative safe system of work then the pilot is to inform the client and Operations that the work cannot be carried out.'*

Section 8.3.31 of the SPO Manual stated:

> *'Our pilots understand that the purpose of our flying is to carry out that mission because that's how we stay in business. It's easy to say that "safety comes first" (without thinking about it) but there is a difficult balance to be struck between the attention a pilot pays to safety and the attention he pays to the mission.*
>
> *Perhaps the best way to reach that balance is to have in one's mind the idea that there are two separate functions (safety v mission) and that they are not equal – the mission will occupy a lot of time but failure will have only relatively modest monetary consequences, whereas safety will require action only occasionally but may have very big consequences indeed (also in business terms, if consequent reputational damage is taken into account).'*

The operator believed that the accident crew did as expected by identifying Boat 2 as being potentially unstable and stopping work to discuss it.

Footnote

[28] TEM – Threat Error Management.

Analysis

Engineering

Analysis of the wreckage indicated that the lifting chain had contacted the tail rotor blades, severely damaging them. Because of this damage, the tail rotor would no longer be effective in controlling the torque of the main rotor and would most likely have caused severe vibration. The lifting chain became entangled around the tail boom and stabiliser surfaces despite it being released from the helicopter's lifting hook by the pilot.

The weight of the lifting chain and the attached boat at the end of the tail boom would mean the helicopter was outside of its balance limits and would have become uncontrollable.

Load characteristics

The TSG described boats as known for being difficult loads. Their aerodynamic shape gives them the propensity to behave like a wing.

The CAA advised that load oscillations can result from a combination of the stability characteristics of the load and the forward speed of the helicopter. Loads weighing less than 227 kg should be low drag and high-density. The safe carriage of particularly low-density or lightweight loads depends upon the speed at which the maximum achieved trail angle is attained, and at which any deterioration in load handling characteristics occurs. Therefore, the acceleration of such a load must be made slowly and cautiously.

As boats, both loads were relatively high drag and low-density, but Boat 2 was significantly lighter than Boat 1 and weighed less than the guideline 227 kg. Furthermore, Boat 2 could not be carried in the preferred orientation. Both of these factors meant that the aerodynamic effects would have been greater on Boat 2, hence there was a significantly increased risk of it becoming unstable at a lower airspeed.

The operator stated that when lifting a UoPUL it would advise increasing airspeed incrementally, checking the load in the mirror at each stage, and using an airspeed limit – for example, 40 KIAS, when using a 10 m lifting line. G-PLMH's groundspeed for both boats increased at a similar, linear, rate. Using Benbecula Airport's forecast wind of 180° at 14 kt, the helicopter reached an estimated airspeed of around 57 KIAS with Boat 1, and the accident occurred with Boat 2 at an estimated 43 KIAS. The pilot commented that the wind at his location felt stronger than that reported, therefore the airspeed could have been higher than estimated. The characteristics of Boat 2 and the method in which it was carried created a load which became unstable so suddenly that any precautions taken by the crew were insufficient to prevent the accident.

Although the pilot appeared to have jettisoned Boat 2 from the helicopter, eyewitness accounts of it lifting quickly suggest there was insufficient time for this action to have had an effect.

A company-standard 10 m lifting line was used to lift the boats. It is possible that a longer line would have given the crew more time to react in the event of the load becoming unstable.

Operator's culture, procedures and training

The operator's safety culture was described by the TSG as good. Its SMS included an informal way for crews to share safety related information, and the pilot was reported to be an active participant in this.

The operator's SPO Manual contained specific guidance for some types of loads and operations, and its training syllabus contained subjects relevant to UoPULs. However, there were no formal procedures for the carriage of boats, or for UoPULs in general.

The operator reported that, after the accident, it temporarily curtailed the carriage of boats, caravans and aeroplanes. It has also made significant changes to its operational procedures, which are listed in the Safety actions section of this report.

The safety actions which relate to load characteristics include the addition of guidance to the SPO Manual, the HESLO 1 training syllabus, and the Ground Handler's Manual on: the identification of UoPULs, preparation and acceptance of UoPULs, rigging of UoPULs, and flying techniques for UoPULs. Some of the items discussed are: low-density loads, aerodynamic shape, load orientation, and methods of rigging loads for increased stability. The operator has increased the length of the standard lifting line for UoPULs to 20 m, with a combined airspeed limit of 60 KIAS. Where shorter lifting lines are required, the limit is 40 KIAS and, for some operations, 30 KIAS. Incremental airspeed accelerations of 10 KIAS must be used, continually watching the UoPUL in the mirror. If the status of the load changes at any time, the airspeed must be reduced to below 40 KIAS, and if the line goes slack, the load must be jettisoned.

Decision making

HESLO pilots have ultimate responsibility for the acceptance and carriage of loads.

The operator stated that operators in general design their own HESLO training courses. It normally recruited HESLO pilots already with HESLO expertise and their training consisted of a familiarisation on company procedures, followed by a structured introduction to flying tasks. Due to the varied work experience of its pilots, the operator emphasised ingraining its safety culture. Much of the training content was discussion-based, and was not necessarily documented.

The TSG explained that the operator's staff themselves tend to be the HESLO experts. Further, the operator stated that the variety of the work made it difficult to lay down rules to cover every eventuality. Therefore, pilots made their own decisions on the acceptance of loads based on their experience, and those decisions were generally "respected" by the operator. The Operations' procedures supported pilots' decision making, for example, by flagging up unusual loads, but its information was limited to that available beforehand. Therefore, the single pilot nature of the operation, the variety of the work, and often remoteness of locations, meant that HESLO pilots often made decisions in relative isolation.

For the accident duty, Boat 1 had been processed by Operations, its estimated weight was given to the pilot, and it was available for inspection by both crewmembers before work began. As could sometimes occur, Boat 2 arrived after work had started. It had bypassed the filter of Operations and, despite it looking lighter, the crew may not have been aware of its probable weight. Therefore, much of the decision making for Boat 2 occurred in the dynamic, working, environment, and initially when the pilot was not present.

There was no evidence that the crew were predisposed to accept Boat 2 for flight. The crew had exhibited caution by stopping working to discuss it, in line with the operator's expectations. However, this occurred with the customer and others present, and in deteriorating wind conditions, which the pilot had indicated felt stronger than that reported by ATC. The control measure discussed by the crew was to fly Boat 2 particularly slowly, but the helicopter's eventual flight profile for both boats was almost identical. Therefore, in the dynamic conditions, plan continuation bias may have masked the changes in the underlying conditions and assumptions for Boat 2, for example, the weight and rigging method. Other biases, such as those to satisfy the customer and/or to complete the mission, could have been present.

It is possible that the 'inherently hazardous' nature of HESLO activities can become 'routinised', leading experienced pilots to use a heuristic, and less structured approach to their decision making. The operator was familiar with structured decision making and this was discussed in the 'Single Pilot CRM/Pilot Decision Making' course completed by the pilot. However, given the potentially isolated and complex nature of HESLO decisions, and the possibility for incomplete information and time constraints, additional assistance for pilots in structuring their decisions could be beneficial.

In line with EHEST's advice on SOP's, the written guidance on UoPULs produced by the operator after the accident will provide some *'pre-planned responses to manage risk'*. This could benefit structured decision making, for example, when considering load density, weight and structural characteristics, in combination with rigging method and control measures. This could be particularly beneficial when presented with additional loads on the day.

The operator's new guidance includes the following items: TSGs must alert pilots to UoPULs and they must examine such loads together; adequate time must be allowed for the assessment, rigging, and application of control measures for UoPULs; both pilots and TSGs appreciating the increased time for delivering a UoPUL and managing customer expectations accordingly; and it states *'the company will support any pilot who declines to carry* [a UoPUL] *on the grounds that he is not able to put in place adequate control measures'.*

'Decision Making Aids', like *'DECIDE'* or those described by the FAA, can structure decision making in critical and stressful situations.

The operator has subsequently undertaken to document guidance on decision making. It intends to select a generic decision making aid and endorse its use by pilots, TSGs, operations officers and managers.

CRM

The operator's SPO Manual described TSGs as a 'very important half of the load lifting team', who 'should be fully in charge of what is happening on the ground'. TSGs provide technical assistance in manoeuvring the helicopter, and the operator described the teamwork between them and pilots as an "orchestrated sequence of events". Whilst at the time of the accident TSGs did not receive formal CRM training, the accident TSG was very experienced and, upon inspecting Boat 2, initiated stopping work to discuss it with the pilot.

The operator explained that, whilst CRM training for TSGs was not in place at the time of the accident, it had already undertaken to bring its CRM training more 'in-house' and extend it throughout the organisation. It intends to incorporate its chosen decision making aid in to CRM training. Training for TSGs and pilots could involve practising structuring decisions together, which result in a verbalised 'go/no go' decision and, where applicable, a summary of control measures. CRM training may assist less experienced TSGs to initiate safety related discussions.

Survivability

Pilot's flying helmet

The post-mortem found that the pilot had sustained a severe head injury. He had been wearing a protective flying helmet but there was no evidence of a significant impact on it, and examination revealed that its chin strap had been unfastened at the time of the accident. It is therefore likely that the motion and forces experienced during the accident sequence had dislodged the helmet from the pilot's head and it was no longer protected. It is possible that the pilot forgot to re-fasten his chin strap after vacating the helicopter to discuss Boat 2.

The donning of flying helmets was already mandated by the operator. As a result of this accident, it released a Safety Information notice stating that flying helmets must fit and be properly secured.

Pilot's seat

The pilot's seat structure had failed, compromising the degree of restraint of the pilot in the accident. The seat met the standards required at the time of certification, but standards have improved over time. However, the new standards only apply to helicopters certified at the time they are in force and do not have to be retrospectively applied to previously certified helicopter designs. The manufacturer had made available an improved, stronger seat and its fitment was optional. It had not been fitted on this helicopter and nor was it required to be.

It is not possible to determine in this case what the effect, if any, the stronger seats would have had on the pilot's survivability.

Conclusion

The accident occurred because the helicopter's underslung load became unstable and flew up, striking the helicopter's tail rotor. The helicopter became uncontrollable and descended rapidly into Loch Scadavay.

The load, which was a boat, became unstable because of a combination of its low weight, low-density, and aerodynamic shape, with the linear acceleration of the helicopter to an airspeed above 40 KIAS.

The pilot sustained a severe head injury during the accident. It appeared that his helmet had become dislodged because the chin strap was unfastened.

Safety actions

As a result of this accident, the operator has taken a number of safety actions intended to prevent similar accidents in the future. It has:

- Temporarily curtailed HESLO operations involving the carriage of boats, caravans and aeroplanes.
- Released a Safety Information notice reminding pilots and TSAs that helmets must be worn onboard, which must fit and be properly secured at all times.
- Increased the length of the standard lifting line for UoPULs to 20 m, with an associated airspeed limit of 60 KIAS. Where shorter lifting lines are required, the airspeed limit is 40 KIAS and, for some operations, 30 KIAS.
- Added a section on *'Identification of Unstable or Potentially Unstable Loads (UoUPL)'* to its HESLO 1 pilot training syllabus. This contains sections on low-density loads and aerodynamic shape, and refers to load orientation. It states that *'any change in the status of a load in flight calls for an immediate reduction of speed below 40 KIAS'.*
- Significantly expanded its SPO Manual and Ground Handler's Manual guidance on the preparation and acceptance of loads to emphasise UoPULs. This includes information on low-density loads and aerodynamic shape, and methods of rigging loads to increase their stability, eg cargo nets, and amalgamation.
- Provided guidance in its Ground Handler's Manual which explains that pilots and TSGs should examine UoPULs together. Adequate time must be allowed to assess and rig UoPULs, and to put adequate control measures in place. Customer expectations should be managed accordingly.
- Added a section on flying techniques for UoPUL to its SPO Manual, which includes: accelerate in 10 KIAS increments; continually observing the load in the mirror; if the line goes slack, jettison the load; and states that *'the*

company will support any pilot who declines to carry [a UoPUL] *on the grounds that he is not able to put in place adequate control measures'.*

- Undertaken to continue with its plan to extend its CRM training throughout the organisation and bring more of that training 'in-house'.
- Undertaken to produce written guidance on decision making. Furthermore, to select and endorse a decision making aid company-wide and incorporate it in to CRM training.

Published: 18 July 2019.