Accidents Investigation Branch

Department of Transport

Report on the accident to British Airways Sikorsky S-61N, G-BEON in the sea near St Mary's aerodrome, Isles of Scilly on 16 July 1983

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Department of Transport
Accidents Investigation Branch
Royal Aircraft Establishment
Farnborough
Hants GU14 6TD

30 January 1985

The Rt Honourable Nicholas Ridley
Secretary of State for Transport

Sir,

I have the honour to submit the report by Mr D A Cooper an Inspector of Accidents, on the circumstances of the accident to British Airways Sikorsky S 61N, G–BEON in the sea near St Mary's aerodrome, Isles of Scilly on 16 July 1983.

I have the honour to be
Sir
Your obedient Servant

G C Wilkinson
Chief Inspector of Accidents

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Accidents Investigation Branch

Aircraft Accident Report No. 8/84
(EW/C840)

Operator:		British Airways Helicopters Ltd
Aircraft:	*Type:*	Sikorsky S–61
	Model:	N
	Nationality:	United Kingdom
	Registration:	G–BEON
Place of Accident:		In the sea near St Mary's aerodrome, Isles of Scilly Latitude: 49° 55.4′ North Longitude: 006° 14.9′ West
Date and Time:		16 July 1983 at about 1135 hrs All times in this report are GMT

Synopsis

The accident was reported to the Accidents Investigation Branch (AIB) by the British Airways Air Safety Branch at 1245 hrs on 16 July 1983, and the investigation commenced the same day.

G–BEON was on a scheduled service from Penzance to the Isles of Scilly, and was being operated in accordance with the Visual Flight Rules (VFR). Whilst it was on the approach to St Mary's aerodrome the helicopter gradually descended from its intended height of 250 feet without either pilot being aware of this, and flew into the water.

Nineteen of the 23 passengers, and 1 of the 3 crew members lost their lives. St Mary's lifeboat attended the scene and picked up the 6 survivors.

The report concludes that the accident was caused by the commander not observing and correcting an unintentional descent before the helicopter collided with the surface, whilst he was attempting to fly at 250 feet by external visual reference only in conditions of poor and deceptive visibility over a calm sea. Contributory factors were: inadequate flight instrument monitoring; a combination of VFR weather minima which were unsuited to visual flight and insufficiently detailed company operating procedures; and the lack of an audio height warning equipment.

Eight safety recommendations are made.

1. Factual Information

1.1 History of the flight

G–BEON (ON) was operating a scheduled passenger flight from Penzance Heliport to St Mary's aerodrome, Isles of Scilly, when the accident occurred (see map at appendix 1). ON had been scheduled to depart at 0815 hrs, and the crew of two pilots and a cabin attendant reported for briefing at about 0730 hrs. Both pilots were qualified S–61 captains, and one of them was nominated as the commander and handling pilot. Two aircraft had been due to fly to the Isles of Scilly on the morning of 16 July – ON and another S–61, G–BDDA (DA), which had been originally scheduled to take-off at 0750 hrs.

Poor visibility prevented either aircraft from departing until DA took off at 1046 hrs on a VFR flight to St Mary's; it landed without incident at 1106 hrs. Since there was a possibility of the weather deteriorating, the commander of ON decided that he would conduct the flight either wholly VFR or not at all. He therefore awaited confirmation that DA had landed at St Mary's. By then the weather being reported by St Mary's was 1,200 metres visibility and a cloud cover of 3/8 at 500 feet. This was better than the laid down minima for day VFR operations, which were 900 metres and 200 feet cloud ceiling. ON took off at approximately 1110 hrs, carrying 23 passengers and sufficient fuel to allow a diversion to Royal Air Force St Mawgan should a deterioration of the weather make that necessary.

Following the normal procedure, ON climbed en-route to an altitude of 2,000 feet on the Scillies regional pressure setting (regional QNH) of 1014, and cruised at an indicated airspeed (IAS) of 110 kt along a prescribed track which was marked on the Decca flight log. In the vicinity of the Longships lighthouse visibility was assessed as well in excess of half to three quarters of a mile in haze, and the crew saw DA passing below at 1,500 feet on its way back to Penzance. The crew stated that around this time DA passed them a report of the weather conditions at St Mary's as half to three quarters of a mile visibility at 300 feet. However, the crew of DA do not recall speaking to ON at any time, and the source of this message remains unidentified. The commander believed that the term "300 feet" referred to the cloud base but did not discuss the report with the co-pilot, who understood that it referred to the height at which the visibility had been observed. With a 300 foot cloud base over St Mary's aerodrome in mind, the commander decided to descend to 500 feet so as to be better able to assess the prospects of making a satisfactory approach and landing.

At 1126:30 hrs ON reported being at 18 miles range from St Mary's, and that a descent to 500 feet was being carried out. During the descent the crew carried out successively the descent checks, the initial approach checks, and the landing checks – except that the radar was left on to provide mapping information, and the cabin attendant had yet to make his report. The landing gear was down (resulting in the 'gear up below 250 feet' warning horn circuit being disarmed). Both pressure altimeters were set to the St Mary's aerodrome surface pressure (QFE) of 1010, thus displaying the height above the aerodrome.

ON levelled off at a height of 500 feet on the radio altimeter (radio height) on a track of 259°M, which was maintained for the rest of the flight. The co-pilot then cross-checked the barometric and radio altimeters and, at 1130 hrs, reported to St Mary's that ON had passed the mid-point and was level at 500 feet. The crew stated that they continued to have visual contact with the surface, that they saw no cloud or fog (at or below their level), but that thick haze resulted in restricted forward visibility with no discernable horizon, and that there was a flat calm sea. Relying on their experience, the weather forecast, and the report by DA, they were confident that the forward visibility was in excess of the company's prescribed minimum of 900 metres.

Approximately 6nm from the coast the commander commenced a descent to 250 feet radio height in anticipation of low cloud at St Mary's, and to provide himself with a better sight of the texture of the sea surface. 250 feet was the minimum en-route height permitted by the BAH Operations Manual for flight over the sea in daylight 'contact' conditions, provided that the forward visibility was no less than 900 metres.

During the descent the commander continued to fly primarily by external visual reference, but also monitoring the flight instruments. The co-pilot, who was monitoring his own flight instruments, had set the altitude warning bug on his radio altimeter at 300 feet and at that height he warned the commander that the aircraft was nearing the desired 250 feet. Both pilots stated that having levelled at that height they cross-checked that both radio altimeter indicators showed a height of 250 feet, that the two pressure altimeters showed about 134 feet, and that the helicopter was stabilised in level flight at about 110 knots. The commander stated that his radio altimeter bug was set at 200 feet, but the co-pilot was unsure of the height at which his bug was then positioned.

The commander stated that whilst at 250 feet he was "principally looking outside" the helicopter but was at the same time monitoring his flight instruments, concentrating on the attitude indicator, the radio altimeter and the airspeed indicator.

The co-pilot, being satisfied that there was adequate visual reference and having assured himself that the commander was flying visually, concentrated his attention on the radar and the Decca to ensure accurate navigation. From the moment when ON was 3 to 3½ nm from the land ahead (54 to 72 seconds before impact at an average ground speed of 100 kt) the co-pilot was entirely engaged in operating the radar set so that he could call out ranges to the commander every half mile, and so he was no longer monitoring the flight instruments. The co-pilot stated that because of the position of the radar display he had to bend to his right, put his face within one foot of it, and shield the tube with one hand from sunlight, in order to see the picture satisfactorily. He added that the set when selected to the 5 mile range setting, as was the case, provided no range markers to assist judgement of distance and needed constant adjustment. Apart from measuring distance ahead he also had to keep a watch for ships, as these had to be avoided by at least 500 feet.

At 1132:00 hrs ON reported "ABOUT SIX MILES TO RUN TO ST MARY'S"; and at 1133:15 hrs "JUST UNDER FIVE MILES", and was told by St Mary's to report approaching 2 miles. At 1134:45 hrs ON reported, "COMING DOWN TO 2 MILES" and was told by St Mary's "CONTINUE THE APPROACH RUNWAY 28, SURFACE WINDS 300 DEGREES AT 5 KNOTS QFE 1010". At 1135:00 hrs St Mary's transmitted "OSCAR NOVEMBER IS CLEAR TO LAND 300 DEGREES AT 5 KNOTS". This message was not acknowledged by ON, and no further transmission was received from the helicopter.

At some undetermined point in this sequence of events the commander told the co-pilot that he was going to reduce speed to about 90 knots. The commander stated that he then lowered the collective pitch lever and used the beeper trim to trim nose-up to reduce speed at constant height. He did not refer to the torque meter, but from experience judged that torque was reduced from the cruise setting of about 60% to about 48%. The commander stated that while he was checking the radio altimeter, which was reading about 250 feet with no warning light evident, his attention was drawn to the vertical gyro indicator (VGI) by the momentary appearance of its attitude failure (ATT) orange coloured flag. The indications appeared normal and the commander, believing that the weather would be much better from this point onwards, reverted to external visual reference in an attempt to establish a horizon and to sight the islands ahead. However, he was unable to discern either a horizon or a landfall. He has stated that if he had not seen the land by the time the helicopter was 1 nm from the coast he would have prepared to overshoot.

The commander also stated that during the period he was looking outside he was still slowing the helicopter down by further lowering the collective pitch lever and trimming nose-up. The helicopter then unexpectedly struck the water in a straight and level attitude. The commander could not recall the airspeed at impact but considered that it might have been below 90 kt. The co-pilot stated that when ON was 1½ nm from the coast he told the commander (who also recalled this). He then decided to look up, expecting to see the coastline and with a view to cross checking with the Decca flight log. As he moved his head to do so the helicopter struck the sea.

The co-pilot stated that the impact position was on the Decca track of 259° M to St Mary's airfield and approximately on Decca lane Green 38, ie about 2 nm from the airfield and 1½ nm from the coast (see appendix 2). It is estimated that the accident occurred at about 1135 hrs. Neither the commander nor the co-pilot had been aware of any descent below 250 feet.

The crew reported that, apart from the momentary appearance of the VGI 'ATT' flag noticed only by the commander, the aircraft had appeared to be completely serviceable throughout the flight.

A passenger stated that towards the end of the flight the cabin attendant had walked forward to the flight deck and then returned to a position near the airstair door where his folding seat was positioned, but might not have had time to sit down and fasten his seat belt before the impact occurred. This passenger, and another, reported that the cabin attendant told them separately that the helicopter was flying at 100 feet as he passed them. Neither the commander nor the co-pilot could recall the cabin attendant approaching the flight deck at this stage of the flight.

During the impact both sponsons broke off together with the inflatable flotation gear, water entered the cockpit forcibly, and the aircraft's hull was disrupted in such a way as to cause water to burst open the two freight-bay hatches in the floor. The fuselage rolled over, filled with water, and quickly sank. Only four of the passengers and the two pilots survived. Nineteen passengers and the cabin attendant lost their lives. The six survivors were picked up by the St Mary's lifeboat at approximately 1225 hrs.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1	19	–
Serious	1	1	–
Minor/none	1	3	

1.3 Damage to aircraft

The helicopter was destroyed as a result of the impact.

1.4 Other damage

There was no other damage.

1.5 Personnel information

1.5.1 *Commander:* Male, aged 37 years

Operational experience:

In 1975-6, whilst in the United States, the commander gained FAA commercial licences for both rotary and fixed wing aircraft. In May 1977 he was granted a Commercial Pilot's Licence (Helicopters), and in August joined British Airways Helicopters (BAH) as a co-pilot on S–61N helicopters at Sumburgh in the Shetland Islands. In November 1979 he was promoted to Captain and remained at Sumburgh until November 1982 when he was posted to Aberdeen. He was based at Aberdeen at the time of the accident, although he had been detached at various times to Bergen, Beccles and Penzance. His experience of the Penzance–Isles of Scilly schedule was 2 detachments and on the second, which began on 9 July 1983, he had flown 28 sectors prior to the accident, having flown approximately 35 sectors on the first.

Licence:	Airline Transport Pilot's Licence (Helicopters). Valid until 22 May 1988 and endorsed for Bell 206 and Sikorsky S–61N as pilot in command. Private Pilot's Licence for Group A Land Planes and Self Launching Motor Gliders; permanent validity.
Instrument Rating:	Renewed 30 November 1982
Competency checks:	Last base check: 5 May 1983
	Last line check: 8 February 1983
	Last survival check: 8 February 1983
	Last dinghy drill: 23 October 1981
Medical certificate:	Last medical: 14 February 1983, Class I, no limitations
Total pilot hours:	3,970
Total helicopter hours:	3,506
Total S–61N hours:	2,820
Total in last 28 days:	69 hours 25 minutes

Total in last 7 days:	15 hours 05 minutes
Rest period prior to reporting for duty:	14 hours 30 minutes

1.5.2 *Co-Pilot:* Male, aged 30 years

Operational experience:

In 1974 the co-pilot graduated from the College of Air Training, Hamble, with a Commercial Pilot's Licence (Aeroplanes) and, in the absence of pilot vacancies, was seconded to temporary ground duties with British Airways. In 1976 he attended the Oxford Air Training School on a helicopter course, and gained a CPL (Helicopters) in August 1976. In September 1976 he was posted to Sumburgh, Shetland Islands, as a co-pilot on S–61N helicopters. In October 1977 he was posted to Beccles, Suffolk, as an aircraft commander on the Sikorsky S–58T. In January 1979 he returned to Sumburgh as a co-pilot on the S–61N. In July 1979 he was promoted to Captain and remained at Sumburgh as an aircraft commander until January 1982. He then returned to Beccles, initially on Sikorsky S–76 helicopters and then, from June 1983 until the time of the accident, on the S–61N. During these postings he had been detached on duty to Teesside, Aberdeen, Gatwick and Penzance. His experience of the Penzance–Isles of Scilly schedule was 2 detachments; on the first he flew 42 sectors and on the second, which began on 5 July 1983, he had flown 68 sectors prior to the accident.

Licence:	Airline Transport Pilot's Licence (Helicopters). Valid until 13 December 1988 and endorsed for Enstrom F28A, Sikorsky S–61N, S–58T, and S–76A, as pilot in command.	
	Commercial Pilot's Licence (Aeroplanes) Groups A and B.	
Instrument rating:	Renewed 24 June 1983	
Competency checks:	Last base check:	24 June 1983
	Last line check:	24 June 1983
	Last survival check:	24 June 1983
	Last dinghy drill:	27 November 1981
Medical certificate:	Last medical: 2 March 1983, Class 1, no limitations.	
Total pilot hours:	3,737	
Total helicopter hours:	3,350	
Hours on S–61N:	2,280	
Total in last 28 days:	31 hours	

Total in last 7 days:	18 hours 25 minutes
Rest period prior to reporting for duty:	14 hours

1.5.3 Of the 63 Penzance–Scilly sectors flown by the commander and the 110 by the co-pilot, they had flown 10 together as a crew. They had also flown as a crew on 6 other occasions.

1.5.4

Cabin attendant:	Male, aged 22 years	
Competency checks:	Last training:	28 March 1983
	Last survival check:	28 March 1983
	Last dinghy drill:	15 March 1983
Rest period prior to reporting for duty:	14 hours 15 minutes	

1.6 Aircraft information

1.6.1 Sikorsky S–61N G–BEON had been in service with British Airways Helicopters since 1977. It was normally based at Aberdeen and was configured for offshore oil support operations, fitted with 24 passenger seats. ON had been positioned at Penzance since 24 June 1983 and at the time of the accident was being employed to back-up the 32 seat Sikorsky S–61NM dedicated to the Penzance–Isles of Scilly service.

1.6.2 *Main particulars*

Manufacturer:	The Sikorsky Division of United Technologies, USA
Aircraft type:	S–61N
Date of manufacture:	1977
Manufacturer's Serial No:	61770
Registered Owner:	British Airways Board
Certificate of Airworthiness:	UK Transport Category (Passenger) renewed by the Civil Aviation Authority (CAA) on 3 July 1983 and valid until 2 July 1984
Total airframe hours:	7,904 hours, of which 49 had been flown since the issue of the last C of A
Engines:	Two General Electric CT58-140-1
Total engine hours since overhaul:	No 1 engine 896 hours, No 2 engine 1,647 hours

1.6.3 *Weight and balance data*

Maximum permitted take-off weight:	19,650 lb
Actual take-off weight:	19,627 lb
Estimated weight at accident:	19,177 lb
Permitted centre of gravity range:	258 inches to 276 inches aft of datum
Estimated C of G at accident:	265 inches aft of datum
Type of fuel:	Jet A–1 (Avtur)
Total fuel at take-off:	2,000 lb
Fuel at impact (estimated)	1,550 lb

1.6.4 *Flying controls*

The S–61N has conventional dual flying controls incorporating two hydraulic systems. The aircraft was equipped with a three axis automatic flight control system (AFCS) able to maintain a selected attitude and heading, but not a height or an airspeed. In this system the No 1 (co-pilot's) vertical gyro is the attitude sensor for the pitch and roll channels, and the compass system for the yaw channel. A four-way switch on each cyclic stick permits trimming at a controlled rate in both pitch and roll (beeper trim), and a trim release switch on each cyclic stick allows rapid manual re-positioning of the stick. The authority of the AFCS system is 10% in roll, 7½% in pitch, and 5% in yaw. The system can be over-ridden by normal forces applied to the controls by the pilot, and it can be switched off by operating a switch on either cyclic stick.

1.6.5 *Vertical Gyro Indicators and Standby Horizon Indicator (see appendix 3)*

G–BEON was equipped with two Sperry HZ444 Flight Director Indicators, in this installation referred to as Vertical Gyro Indicators (VGI). One of these instruments was mounted centrally in each pilot's instrument panel. Each instrument was supplied with pitch and roll signals from the vertical gyro on the corresponding side of the aircraft, the indicator in the No 1 (co-pilot's) position using the same gyro as supplied the signals to the AFCS system. No flight director signals are available in the BAH S–61 installation, so the instruments simply supply pitch and roll attitude information to the crew. During normal operation the flight director command bars, and the failure flag (marked FD), disappear from the faces of the instruments and only reappear when power supplies are interrupted.

Each VGI also has an orange coloured attitude (marked ATT) mode failure warning flag which, when pertinent, appears on the periphery of the instrument face. Failure of the attitude mode in either indicator will produce an 'ATT' flag, which is discrete to the instrument displaying it and indicates one of the following:

(a) Power failure to its vertical gyro

(b) Power failure or lack of attitude information to the instrument

(c) Lack of co-ordination between the signal from the vertical gyro and the visual horizon information being displayed on the instrument.

It has, however, been observed by S–61 pilots that the 'ATT' flag can also momentarily appear during flight.

An R C Allen Standby Horizon Indicator was fitted on the centre instrument panel between the two pilots. This instrument works independently of either of the VGIs or vertical gyros, and therefore can provide attitude reference in the event of failure of either or both of those instrument systems.

1.6.6 *The radio altimeter*

G–BEON was equipped with a Sperry AA–200 series Radio Altimeter System. This comprised one RT–220 transmit/receive unit of the short pulse modulation type working on a nominal frequency of 4300 MHz, and two RA–215 indicator instruments. The transmitter/receiver was mounted in the electronics compartment under the cockpit floor and one instrument was on each pilot's instrument panel. The RA–215 instrument has a circular scale from 0 to 2,500 feet which is expanded below 500 feet. A pointer indicates absolute height within this range to a stated displayed accuracy of ± 5 feet between 0 and 100 feet, ± 3 per cent between 100 and 500 feet, and ± 7 per cent between 500 and 2,500 feet. Altitude trip points are provided at 50, 250, 400 and 1,200 feet; only the 250 feet point was employed in the BAH fleet – to supply the undercarriage audio warning system.

Each RA–215 indicator has its own moveable decision height bug. Whenever the actual height is at or below the height set a small amber light on the top right of the instrument is illuminated. There is no associated audio warning. By setting the decision height bug below zero height the pilot can prevent nuisance lighting of the warning lamp. A warning flag appears if a system failure is detected. Pressing a test button on the instrument causes the pointer to show 100 feet, illuminates the decision height light and brings the warning flag into view. The BAH Operations Manual contained no instructions on the use of the decision height warning system and there was no standard practice in use by pilots.

The possibility was considered of the effects of a failure occurring in the radio altimeter system such that during a descent the instrument needle is caused to remain stationary while simultaneously the decision height warning light is prevented from operating as decision height is passed. Error in the pointer indication due to simple mechanical sticking within either instrument will not prevent the operation of the corresponding warning light during descent when the aircraft passes the decision height selected on the individual instrument. This feature results from the use of circuitry within each instrument to drive the pointer which is independent of the circuitry which triggers the warning light.

The single transmit/receive unit supplies signals to both instrument pointers and both warning light circuits. An erroneous signal output from the unit could therefore produce inaccurate operation of both pointers and both decision height warning lights. Such inaccuracy would not be detectable by cross-referencing between the warning light and the corresponding pointer, or indeed by cross-referencing between No 1 and No 2 radio altimeter instruments. However, a failure which causes the output signal to remain at a fixed figure comparable with that occurring shortly before the failure is very rare. Such a failure would be necessary to produce the effect of a sticking pointer combined with a failure of the warning light to function. Failures within the transmit–receive unit or in the antennae connections almost invariably cause a sudden and considerable change in output signal and hence in pointer indication.

ON's commander gave evidence that in his selected seat position the radio altimeter indicator was partially obscured by the top of the cyclic stick. This caused him to move his head each time he wanted to see the right hand side of the indicator, which included the height scale below 500 feet and the decision height warning light. Tests were carried out, and it was established that the seats have sufficient range of adjustment to enable a pilot to ensure a clear view of the instrument. However, it was evident that some pilots selected a different seat position because of other factors.

1.6.7 *Warning light system*

The S–61N has three warning light panels, positioned on the console between the pilots. Each panel contains warning captions which separately illuminate to warn of a failure, unsafe condition, or operating state of its associated component or system. A master caution light, located on the glare shield above the instrument panel, lights up concurrently with the captions. The crew did not observe any warning caption illuminate during the flight.

1.6.8 *Undercarriage audio warning system*

ON was equipped with an undercarriage audio warning system which uses the radio altimeter as a sensor, taking a feed from the 250 feet trip point. It sounds a pulsating note if the aircraft descends below 250 feet with the wheels up with the system operative. A Test/On/Off switch allows the system to be tested on the ground and to be switched off for low level flight. The switch is normally kept on throughout the flight.

1.6.9 *Underwater acoustic beacon*

ON was equipped with a Dukane model B15F 210 B underwater acoustic beacon, with an operating frequency of 37.5 KHz and a pulse rate of 1 per second. It was mounted on the main gearbox support frame on the starboard side of the helicopter.

1.6.10 *Maintenance information*

1.6.10.1 *Recent maintenance history*

Separate Certificates of Maintenance (C of M) were issued for different maintenance procedures. A C of M for Electrics, Instruments and AFCS was issued on 6 July 1983; a C of M for Airframe and Engines was issued following completion of a check 1 on 8 July 1983; a Radio C of M was issued on 26 May 1983; and a Compass C of M was issued on 6 July 1983. All were valid at the time of the accident.

1.6.10.2 *Technical Log*

No carried forward defects were recorded in the Technical Log. The only significant entries were as follows:

(1) On 12 May 1983 at 7,898:05 hours: "Rad altimeter suddenly went to zero and undercarriage warning sounded whilst aircraft was still at 1,200 feet AGL. Switching it on/off put it right." and "Rad alt incorrect self-test operation". These were followed by: "Rad alt T/R changed and test satisfactory".

A check was carried out to establish the status of the transmit/receive unit removed on that date. It has been confirmed by the overhaul agents that the unit was found to be defective and was repaired. There are no further technical log entries relating to radio altimeter problems on the aircraft between then and the time of the accident.

(2) On 21 June 1983 at 7,867:35 hours: "AFCS occasionally drops out (X3 today) however it will engage again," and "Co-pilot's vertical gyro replaced P/No 121672-01-17 S/No off 287 S/No 0000627 HEL 02202S".

The vertical gyro replaced in this position was undamaged by the accident and was found to perform within specification when tested.

(3) On 8 June 1983 at 7,819:00 hours: "Pilot's and co-pilot's ASI's replaced, found time expired".

1.7 Meteorological information

1.7.1 A verbal forecast was passed over the telephone to the operations centre at Penzance by the Plymouth Meteorological Office. This was then written out in longhand and photo-copied for the crew. It was as follows:

"Valid 0700 – 1230 hrs:

Moist slack air mass becoming more unstable

Wind:	Surface – 5,000 ft. Variable 10 Knots
Cloud:	8/8 Stratus, surface to 200 feet
Visibility:	1-4 Km. Below 500 metres in fog and less than 100 metres locally. Fogbanks dense at times with outbreaks of thundery rain.
Fog warning:	Valid 0700-1700 hrs: Sea fog is expected in our area today and tonight, reducing visibility to less than 200 metres at times".

1.7.2 Actual meteorological conditions recorded at St Mary's aerodrome and passed to Penzance were:

Time (hrs)	Wind	Visibility	Cloud Cover	QNH
0930	300°/2 kt	1,200 metres, mist	3/8 at 500 ft, 7/8 at 1,200 ft	1014
1030	300°/2 kt	1,200 metres, mist	3/8 at 500 ft, 7/8 at 1,200 ft	1014
1130	300°/5 kt	2,200 metres, mist	3/8 at 500 ft, 7/8 at 1,200 ft	1014
1230	310°/5 kt	2,200 metres, mist	3/8 at 500 ft, 7/8 at 1,200 ft	1014

1.7.3 *Conditions observed by DA*

11.04 hrs: At 400 feet on the approach to St Mary's DA was in visual contact with the sea surface and sighted the coast at ½ to ¾ miles range. The weather was basically as had been reported by St Mary's, but patches of sea fog were sighted approximately ½ mile south of the aerodrome.

11.16 hrs: Whilst climbing out of St Mary's on the return flight, DA entered cloud between 400 and 500 feet before passing over the coastline.

11.55 hrs: Returning to St Mary's on its second flight at a range of 3 miles from St Mary's and at 400 feet, DA found the weather to be: no cloud, hazy, estimated visibility 1 mile above extensive sea fog. The aerodrome was sighted over the top of the fog which ended at the coastline but seemed to surround the island.

12.06 hrs: During a low level radar search for ON, DA established the height of fog as 150 to 200 feet. There was then extensive fog to the east, north-east and south of the islands.

At 1107 hrs, when DA was on the ground at St Mary's, an inbound Twin Otter requested the weather encountered by DA during its approach and this was given as "300 feet and ½ mile". This conversation was recorded on the St Mary's ATC tape. The commander of DA does not recall having later passed this information to ON when they passed at the Longships (or at any other time), nor do the recordings of the St Mary's ATC tape show it. However, the crew of ON clearly remember receiving this meteorological report although the source remains unidentified. It is possible that this information was passed on the (unrecorded) Penzance frequency of 118.1 MHz either by DA to Penzance or by Penzance and received by ON, but the discrepancy in this evidence could not be resolved.

1.7.4 The sun's position at St Mary's at 1135 hrs was: elevation 59.6°, azimuth 155.0°.

The sea temperature was 18° C.

1.8 Aids to navigation

The route Penzance to St Mary's was served by two independent radio aids. These were a Decca chain, and the Land's End co-located VHF omni-directional radio range (VOR) and distance measuring equipment (DME). These were all operating and serviceable throughout the flight.

The aircraft was equipped with a Decca Mk 19 navigator, providing a flight display head situated at the top of the centre instrument panel. A VOR indicator was positioned on each pilot's instrument panel, and an automatic direction finding system (ADF) and DME were also fitted.

The Decca equipment may be used in one of two ways on the route between Penzance and St Mary's. Firstly, it may be used as a general navigational aid without having been precisely checked by flying over a fixed datum. Secondly, it may be used to carry out a Decca approach cloud break procedure, but only if it has been checked while flying directly overhead the fixed datum of the Land's End

VOR (LND). The Decca flight log chart had three procedural tracks marked for the route. The northernmost of the three tracks passed directly over LND, and only if this track was selected could the Decca equipment be used for the approach cloud break procedure. G–BEON's flight was a VFR one along the middle of the three tracks marked on the Decca flight log chart, and so the Decca equipment could only be used as a navigational aid.

The BAH Operations Manual contained details of the Decca approach cloud break procedure for St Mary's aerodrome. The procedure commenced at 2,000 feet on the regional QNH overhead LND. The procedural track of 249°M was marked on the Decca flight log chart, and in the vicinity of the accident was nearly co-incident with the marked Decca track of 259° flown by ON. The procedure called for a descent to be commenced 20 nm from LND to an obstacle clearance limit (OCL) of 200 feet on the Scilly QFE (316 feet above mean sea level) at a range of 25 nm from LND (3.6 nm from St Mary's aerodrome). The associated minimum visibility was 900 metres, reducing to 600 metres if the mapping radar was serviceable. While this procedure was not relevant to ON's flight, the minimum visibility permitted is the subject of comment in para 2.7.2.

The aircraft was also equipped with an Ekco E290M weather/mapping radar, the display and the control unit being positioned on the centre console.

1.9 Communications

The Penzance Heliport frequency 118.1 MHz was not recorded. It was used by ON from departure until 1114 hrs when contact was made with St Mary's aerodrome Air Traffic Control (ATC) on the tower frequency of 123.15 MHz, which is used along the route between the Longships lighthouse and St Mary's. This frequency was recorded and a transcript is at appendix 4. G–BEON's co-pilot carried out the air-ground communications throughout the flight. The air traffic control officer (ATCO) on duty at St Mary's at the time of the accident stated that the time injection unit is accurate to ± 1 minute only.

1.10 Aerodrome information

St Mary's aerodrome, Isles of Scilly, is situated on the south east coast of the island at latitude 49° 54.8′ North and longitude 006° 17.5′ West, and is 116 ft above sea level. There are three available runways, 10/28, 15/33 and 18/36. Runway 28 was in use at the time of the accident. There were no radio beacons or radar at St Mary's aerodrome.

1.11 Flight recorders

G–BEON was not equipped with either a flight data recorder or a cockpit voice recorder, nor were these required to be fitted.

1.12 Wreckage and impact information

1.12.1 Wreckage recovery

The MV Seaforth Clansman sailed from Falmouth for the crash area at 1704 hrs on 16 July 1983. She was fully manned with a Royal Navy saturation diving team and her lifting capacity was more than adequate for the task. She arrived on station at 2210 hrs and began searching the location in which the survivors had been rescued and which had been marked by two 'dan-buoys'.

AIB Inspectors joined the ship at sea by helicopter as soon as the fog cleared on the morning of 17 July, taking Dukane acoustic detectors with them. The ship was at that time searching the area using sonar and underwater television. By 1000 hrs a search was started using the acoustic detector. Weak signals were detected almost immediately 500 metres south of the ship, but they faded after about 30 minutes and during this time no logical or high confidence bearings could be obtained.

The search team then decided that the signals received were either the result of unusual acoustic propagation conditions, or that the helicopter still retained some bouyancy and the strong tide was moving it along the sea bottom. As two acoustic detectors were available, one was deployed by a diver at a depth of 20 metres and the other from the more normal position just below the surface. By this method it was hoped to overcome the reduction in detection range if a surface thermal layer existed. No detections were obtained in the area where previous signals had been received so the four quadrants within half a mile from the ship were searched, again without success. The search area was then expanded to the north of the ship and contact was gained at 1800 hrs. By 1830 hrs an accurate fix on the acoustic beacon had been obtained and the ship was established in a 'four point moor' over the datum by 0130 hrs on 18 July. The strength of the tide did not allow diving until 0500 hrs.

The fuselage of the S–61 was found by a diver at 2110 hrs and the ship was moved into a position to raise the wreckage, which was lifted onto the deck at 1200 hrs on 19 July. (See photograph at appendix 5.)

1.12.2 Examination of the wreckage

An extensive and detailed examination of the wreckage was carried out at the AIB facility at Farnborough. Particular attention was paid to the power plants, flying controls, and flight instruments.

All the evidence indicated that the aircraft was structurally and mechanically complete at the time of the impact, that the engines were capable of delivering power to the rotor system, and that the flying control system was capable of controlling the aircraft.

The general state of the electrical components and many of the instruments, however, prevented any positive conclusion from being drawn as to their pre-crash serviceability. Nonetheless no evidence of pre-impact failure was found in any of these components.

There was little doubt from the wreckage examination that the aircraft struck the water in a nearly level attitude, at a low rate of descent, and on a heading of about 265°M.

1.13 Medical and pathological information

1.13.1 Post-mortem examinations

Seventeen bodies were found in the fuselage and a post-mortem examination was carried out on each. The bodies of the cabin attendant and two adult passengers were not recovered.

The post-mortem examinations revealed that all the passengers died from drowning, and that although no fractures or incapacitating injuries had been sustained during the impact it was possible that a number could have been concussed or at least dazed. It was the opinion of the pathologist that no pre-existing disease restricted the ability of any of the passengers to escape. Only three of the 17 bodies examined showed evidence of lap strap bruising or abrasions.

1.13.2 The pilots

As part of the accident investigation each of the pilots underwent an examination by a consultant in neurology, carried out under the auspices of the CAA Medical Department. These examinations included an electro-encephalogram. The consultant reported that nothing abnormal was found. Following a review of their medical histories the CAA Medical Department reported that in their opinion both pilots were fully fit at the time of the accident, and that nothing had been discovered that would appear to have any medical bearing on the cause of the accident.

1.14 Fire

There was no fire.

1.15 Survival aspects

1.15.1 The impact, evacuation, and survival in the water

Details of ON's emergency exits, liferafts, and seat positions are shown at appendices 6 and 7. At the moment of its initial impact with the water the helicopter appears to have been slightly nose-down and banked slightly to port, flying at an airspeed probably between 80 and 100 knots, and at a low rate of descent. Both the pilots and all the passengers were seated and strapped in, but it could not be established whether the cabin attendant was seated or was standing near his seat. Seat positions were not allocated to passengers, and it was not possible to establish the position of most of the passengers. However it was established that the two adult surviving passengers had been in the double seat in row 6, and the child survivors in the single seats in rows 2 and 5 respectively.

The impact forces caused the sponsons to detach, and destroyed the aircraft hull below floor level for most of its length. The two access hatches from the cabin to the underfloor freight bays were displaced, leaving the cabin open to the sea at these points. Six of the helicopter's eight double passenger seats became detached from the airframe. The helicopter quickly rolled over, filled with water, and sank before all but four passengers (two women and two children) and the two pilots could escape. Only one of the survivors managed to take a lifejacket out of the aircraft, but lost it before it could be removed from its case and inflated.

The evidence of the survivors indicated that each escaped as follows: the commander through his emergency exit window, the co-pilot and one child out of the forward freight bay hatch and hole in the fuselage floor, another child out of the rear freight bay hatch and hole, and the remaining two passengers out of the airstairs door on the starboard side. Having seen the helicopter sink, the two pilots collected the other four survivors together and, using suitcases as flotation aids, kept themselves and two of the four passengers afloat until rescued by the St Mary's lifeboat at approximately 1225 hrs. The surviving passengers highly commended the actions of the two pilots in sustaining them in the water until rescue could be effected.

1.15.2 *The rescue*

As nearly as could be established, the accident occurred at 1135 hrs. At 1144 hrs after making several attempts to contact G–BEON, the ATCO at St Mary's aerodrome alerted the Rescue Co-ordination Centre (RCC) at Plymouth. At 1144 hrs London Air Traffic Control Centre (LATCC) were notified, and shortly afterwards the Police, the Fire Service and BAH helicopter 'DA' were informed. At 1145 hrs the RCC requested that the St Mary's lifeboat be launched, and by 1206 hrs it was making all possible speed (18 knots) towards the suspected crash area.

At 1146 hrs, the RCC informed Royal Naval Air Station Culdrose that the S–61 was overdue and asked them to "Bring helos to immediate readiness". Two helicopters were available for search and rescue (SAR) tasks at Culdrose, a Wessex (callsign 'Rescue 77') and a Sea King (callsign 'Rescue 80'). The Wessex was already preparing to take off to carry out an exercise at St Michael's Mount, and was airborne at 1155 hrs. At about 1158 hrs, following the receipt of a scramble and tasking message for the Wessex, Culdrose diverted it to attend the accident. The Sea King, on 90 minute readiness for such emergencies, was alerted at 1200 hrs and took off from RNAS Culdrose at 1240 hrs.

Rescue 77 set course for St Mary's at 1,000 feet amsl and descended en-route to 500 feet to remain visual with the surface. On nearing the Isles of Scilly, fog banks were seen below and visibility was 1 to 2 km. Having received no precise information about the position or nature of the accident, the captain landed at St Mary's at 1223 hrs for a briefing. On the ground ATC provided all the available details, and Rescue 77 took off at 1230 hrs to search the north and east sectors of the coast at 200 feet. At approximately 1235 hrs the crew, having heard the lifeboat say they were picking up survivors, returned to St Mary's aerodrome. Having acquired a definite datum position for the accident from the lifeboat, Rescue 77 then flew at 100 feet to the area. Arriving at the specified position, it performed a 180° turn during which the pilot became disorientated due to poor visibility in fog. He therefore levelled the aircraft, climbed above the fog and returned to land again at St Mary's aerodrome. Rescue 77 then acted as a radio relay station between Culdrose and Rescue 80, which had an unserviceable high frequency radio.

Meanwhile, at approximately 1225 hrs, the St Mary's lifeboat arrived in the area of the accident, which was initially identified by the smell of aviation kerosene. With the assistance of its inflatable tender, the crew picked up six survivors and began the search for others. At 1300 hrs, Rescue 80 arrived overhead the datum area but the lifeboat was in a patch of dense fog which necessitated the use of flares and radio to guide the helicopter to the exact spot. The two sponsons from the S–61 were then sighted by Rescue 80 and a diver was dropped between them. A medical attendant and a crewman were then winched down to the lifeboat to give assistance, and Rescue 80 took control of the air operation.

At 1327 hrs, the lifeboat set course for St Mary's harbour with the six survivors. The vessel 'Flying Cloud' remained with the Deputy Lifeboat Launching Authority aboard as the 'on scene commander' of the small vessels which arrived in the area in response to a 'Mayday Relay' message broadcast by Lands End Radio on all maritime distress frequencies.

A short time later, at 1335 hrs, Rescue 80 requested that Rescue 77 should position his diver on board one of the fishing vessels and thence return to St Mary's to pick up one of the survivors and take her to hospital at Truro, before returning to base. At 1525 hrs Rescue 80, which was getting low on fuel, winched up the divers and left the scene. It subsequently also returned to base, arriving there at 1620 hrs.

1.15.3 *Co-ordination and control of the rescue operation*

Examination of the various logs at RCC Plymouth, the Maritime Rescue Co-ordination Centre (MRCC) Falmouth, and RNAS Culdrose revealed that, although the physical and electronic means of communication were readily available, there were times during the incident when understanding broke down between the RCC and Culdrose. When the RCC asked Culdrose to "Bring helos to immediate readiness" at 1146 hrs, the RCC meant that the readiness of both the Wessex and the Sea King helicopters should be reduced to the minimum possible without actually getting airborne. Culdrose did not recognise reductions in readiness from the standard 15 mins for the Wessex and 90 mins for the Sea King, and so the Sea King was not brought to a higher state of readiness. Culdrose did not interpret the message from the RCC to mean that there was a high probability of an aircraft accident involving 26 persons and that both Wessex and Sea King helicopters were likely to be required for a rescue operation. Their understanding of the message was that the S–61 was overdue at St Mary's and that the Wessex might possibly be required. Since the Wessex was already starting up to exercise with the Penlee lifeboat and no scramble message had yet been passed by the RCC, the Wessex crew were not told of the possibility of an SAR operation but were allowed to continue with their exercise. In the event this resulted in little or no delay as the Wessex was airborne at 1155 hrs and was diverted to the Scillies at about 1158 hrs.

When the Wessex scramble and tasking messages were received at Culdrose operations they realized that the lack of navigation equipment in the Wessex would make it extremely difficult for the crew to carry out a search in the very poor visibility obtaining, and so at 1200 hrs they called out the Sea King crew. The Sea King is superior in SAR capability compared with the Wessex in that it has an area navigation equipment, radar, an automatic flight control system with a hover capability, and can carry many more survivors. The Sea King became airborne at 1240 hrs, a fast reaction by the crew, and well within the 90 mins readiness stipulated. However, some 14 minutes had been lost because of the misunderstanding between the RCC and RNAS Culdrose.

By 1255 hrs another Sea King was available although there was no formal requirement to provide a second such aircraft.

1.15.4 *Safety equipment*

The aircraft carried the following safety equipment:

2 x 19 seat liferafts (RFD 18U MK 1)

1 lifejacket at each of the 24 seats (RFD 102 MK 2BA)

1 lifejacket per crew member (3), equipped with personal locator beacons (PLB). (RFD 5DC with BE375 PLB's)

1 emergency position indicating radio beacon (EPIRB) (BE 369 stowed alongside the emergency rear door).

G–BEON was on temporary detachment to Penzance from its usual base at Aberdeen and was equipped for operation in the offshore oil support role. Because of this the passenger lifejackets were of the constant wear type which are designed so that they can be tied around the waist before take-off, if desired. On the Penzance–Scillies service this was judged impractical and so one lifejacket was placed at each passenger seat for donning if an emergency arose, as is normal practice on ordinary passenger flights.

1.15.5 *Homing capability*

The lifejackets provided for the commander and the cabin attendant each contained a PLB set to the civil distress frequency of 121.5 MHz; the co-pilot's lifejacket contained a beacon set to the military distress frequency of 243 MHz; the EPIRB was capable of operation on both 121.5 and 243 MHz. In the event none of these survival radio beacons was available to the survivors because the pilots were unable to lay their hands on their lifejackets (which were stowed under their respective seats) or on the EPIRB.

The RN Wessex and Sea King helicopters used in the SAR operation carried homing equipment operating on 243 MHz but not on 121.5 MHz. Thus even if all members of ON's crew had been wearing their lifejackets it was only the co-pilot's beacon that could have provided a homing capability, and he might well not have escaped. Whilst all UK dedicated SAR aircraft are capable of homing on 243 MHz, the only ones that can home on 121.5 MHz are RAF Sea Kings, none of which were deployed during this operation.

The St Mary's lifeboat carried no equipment capable of homing onto transmissions on either 121.5 or 243 MHz, but the Royal National Lifeboat Institution (RNLI) are equipping lifeboats with equipment to home on 121.5 MHz.

1.15.6 *Cabin seats*

ON was equipped with seats for 24 passengers, and one fold-up seat for the cabin attendant. Those along the port wall were all single seats, those along the starboard wall double seats. Thus an aisle was formed on the left of the cabin centreline. All the seats were recovered with the exception of the cabin attendant's seat. Unlike some other public transport helicopters and most fixed-wing airliners whose seats are anchored only to the floor, these seats were mounted at their inboard ends to the floor, their outboard ends being fastened to the fuselage wall. This arrangement defined the position of each seat row, as the floor and wall fittings were not of the continuous rail type.

All seat belt buckles on the passenger seats were fitted to the left hand seat belt, with the exception of the single seat at row 9 which was fitted on the right. AIB report 10/82, on an accident to a Bell 212 helicopter, recommended that the handing of seat safety belts be standardised to avoid the possibility of confusion as to the opening direction of the buckle.

The cabin attendant's seat was not recovered but examination of its mounting showed that it had failed in a forward direction, all but one of its attachment screws remaining in the floor structure. Fragments of the structure had remained around the screw heads, indicating that the seat had pivoted about its forward feet as the screw heads tore through the material of the rear structure. Tests carried out on a deceleration track at the RAF Institute of Aviation Medicine resulted in a similar failure mode at a longitudinal deceleration of 6.5g when an identical seat was tested carrying a 170 lb dummy. Details were passed to the CAA, with the suggestion that the strength of this seat be reviewed.

Examination of the passenger seats revealed that whereas none of the single seats had become completely detached, six double seats had separated from the fuselage as a result of the impact. The separated seats contained examples of both types of seat fitted to the helicopter (the Burns Aero Seat Co Inc Type 650–2–39 and the Aerosmith HC 25C/D–1). Appendices 8 and 9 refer.

These separations were associated with the seat foot and the wall fittings, and were not a function of the type of seat. Seat rows 3, 5 and 6 had characteristics consistent with having initially suffered release of their floor attachments, and seat rows 9 and 10 appeared to have suffered initial release of their attachments to the fuselage walls. Seat row 4 had suffered a complex failure leaving both the forward and the aft legs still attached to the floor.

Examination of the seat floor attachments in the aircraft showed that the starboard double rows at positions 3, 5 and 6 had floor attachment stud fittings (part number unknown) on their rear legs which relied on a locking collar alone to hold the moving tongues in engagement with the corresponding floor mounted fittings. The rear legs of seat rows 4, 9 and 10 had a different, though compatible, design of floor attachment fitting (part number 33115). This incorporated a positive locking plunger to secure the collar, and hence the locking tongues, in the fully closed position. Examination of the locking fittings of the first type, both in this aircraft and in others, showed that disengagement could occur if the locking collars were moved upwards, which could be done with minimal force. Those of the second type, however, could not be released without first disengaging the locking plungers.

Examination of the fuselage side attachments of the seats indicated that those securing double rows 3, 5 and 6 had the single protruding bolt tails on the wall fittings positioned forward of the seat attachment spigots. These bolt tails appear to have prevented the seat fittings on double rows 3, 5 and 6 from sliding forward out of engagement with the fixed rails. Seat rows 9 and 10 had such bolt tails positioned aft of the spigots. This appears to have permitted forward sliding disengagements to take place from the rails once the attachment spigot locating plates had released from their engagement position in the rails.

During the accident investigation deceleration tests were also conducted on several S–61 passenger dual seats of the two types with which ON was equipped, carrying two 170 lb dummies. The results indicated that the seat structures, when securely attached to the test vehicle, could withstand longitudinal decelerations of about 12g before failure occurred. Details of the results of the investigation and tests were passed to the CAA.

As BCAR's only require helicopter passenger seats to be able to withstand the loads generated by a longitudinal deceleration of only 4g in crash landing conditions, it is considered that these requirements should be reviewed.

1.15.7 *Emergency exits*

All the exits on the helicopter were examined during the investigation. The designated emergency exits were: a jettisonable window at each of the pilot's positions, a removable window at seat row 5 port and starboard, the forward starboard side sliding cargo door, the port rear emergency door, and the normal airstair door. All the exits were found to be marked in accordance with the relevant requirements.

Both crew emergency windows became detached during or subsequent to the accident, due to structural deformation of the cockpit structure. Neither jettison handle had apparently been operated.

The two escape hatches at row 5 position were fitted with frangible plastic panels covering the operating mechanism. Neither had been broken. The top of the starboard hatch was found to be displaced outwards by approximately 25 mm, but this did not prevent a satisfactory test jettison of the hatch. Subsequent examination revealed distortion to its top engagement tongues, a distortion that would have occurred if a relatively low pressure had been applied across the inside face of the hatch. The port hatch also operated satisfactorily when tested.

Some difficulty was experienced in opening the cargo door when checking its operation. However, deformation of the fuselage structure along its lower edge had affected part of the mechanism which allows the door to move outboard before sliding rearwards. This damage was entirely attributable to impact forces.

The port rear emergency door was found to be securely locked to the airframe, both inside and outside manual operation handles being in the 'door locked' position. The external handle wire locking was intact. When tested by operation of the interior handle the door functioned satisfactorily. The liferaft lanyard was correctly attached to the airframe. This door can be electrically unlocked by operation of a switch to the side of the pilot's overhead panel, but the system had not been actuated. Electrical power for the system is taken from the emergency battery (essential DC Bus) which is mounted in the nose bay, but this area of structure had suffered gross disruption during the impact which would have precluded electrical actuation of the door. The violence of the in-rushing water had, in fact, prevented the co-pilot operating the actuating switch.

The normal entry/exit airstair door was found closed. Operation of the door, which is hinged about its lower edge, was found to be satisfactory when tested. Some evidence of wear was evident in the latching mechanism, but this was judged to be typical of an in-service door when compared with several other helicopters examined.

1.15.8 Passenger briefing

On the Penzance – Scilly Islands route the passenger briefing was normally given by the cabin attendant over the cabin address system shortly before take-off. Passengers were asked to read the safety leaflet provided, and to note the emergency procedures and the position of the emergency exits. No demonstration or briefing on the use of lifejackets was normally given. It was not possible to establish exactly what briefing was given on the accident flight but there was no reason to believe that it was other than the standard briefing.

Following the accident a number of passengers who use this service regularly wrote to say that they had experienced great difficulty in understanding the cabin attendant's safety briefing owing to the poor audibility of the cabin address system when the helicopter's engines and rotors were turning. This was brought to the notice of the CAA.

1.16 Tests and research

1.16.1 S–61 performance

Computer simulations were carried out by Sikorsky Aircraft and at the Royal Aircraft Establishment, Farnborough (RAE) into various aspects of the performance of the S–61. Based on this work a summary of the approximate performance of an S–61 under the loading and atmospheric conditions of the accident flight is as follows:

Power required for level flight at 110 kt:	58% torque Associated pitch attitude –2.2°
Power required for level flight at 90 kt:	50% torque Associated pitch attitude –1.0°
Minimum power speed:	72 knots. 47.5% torque

When torque was decreased from a level flight condition at 90 kt but with pitch attitude being maintained at –1.0° the following results were obtained:

Torque (%)	Time to lose 250 feet (secs)	Final rate of descent (fpm)
44	113	210
40	66	231
37	33	397

When pitch attitude was decreased from the 90 knot level flight condition but with torque being maintained at 50% the following results were obtained:

Pitch Attitude (°)	Time to lose 250 feet (secs)	Final rate of descent (fpm)
–2	74	234
–2.5	51	335

Finally, tests were carried out to explore the effect of small reductions in both pitch attitude and power below that required to maintain level flight. The simulations were again commenced with the aircraft in level flight at 250 feet and 90 knots, and the results were as follows:

Pitch Attitude (°)	Torque (%)	Time to lose 250 feet (secs)	Final rate of descent (fpm)
–2	44	46	342
–2	40	35	457
–2.5	44	40	404
–2.5	40	33	477

1.16.2 *Effect of cabin attendant's movement*

Sikorsky Aircraft carried out a computer simulation to determine the effect on fuselage pitch attitude and helicopter rate of climb or descent that would be produced if a weight of 170 lbs (representing a cabin attendant) was moved between the airstair door and the cockpit entrance, assuming no pilot intervention. The start condition was that the helicopter was in trim at an airspeed of 90 knots under the loading and atmospheric conditions of the accident flight. Two cases were considered and the results were reported as follows:

> "Case 1 represents the S–61N aircraft response when a 170 lb load is moved from the rear passenger door to the entrance of the cockpit. This distance is approximately 19.2 feet. The net impact on the aircraft CG for this change in loading is a 2 inch forward shift and is assumed to occur over a 10 second period. Equivalent translation rate of the load is 2 ft/sec. The automatic stabilization equipment (ASE) is on, and represents the only corrective action, ie, no retrimming of the cockpit controls.
>
> The aircraft simulation model response initially consists of a nose-down pitch attitude change of approximately 1.5 degrees. This results in a shallow descent of approximately 150 ft/minute. If the load remains at the forward location, the aircraft pitch attitude stabilizes about 1.0 degrees below its initial trim. Altitude loss after 60 seconds from the initial movement of the load is approximately 135 feet with a concurrent descent rate of 120 ft/minute.
>
> In Case 2, the load is returned to the passenger door immediately after reaching the cockpit entrance. The response for this case is initially the same as Case 1, but in the long term, the aircraft returns to a level flight condition with a net loss in altitude of approximately 20 feet."

1.17 Additional information

1.17.1 *The Visual Flight Rules and company operating minima*

Pilots of helicopters making VFR flights outside controlled airspace in visual contact with the surface must conform with Rule of the Air 23 (a) (iii) which reads as follows:

> "A helicopter flying outside controlled airspace at or below 3,000 feet above mean sea level shall remain clear of cloud and in sight of the surface, or at least 1 nautical mile horizontally and 1,000 feet vertically away from cloud and in a flight visibility of at least 3 nautical miles."

The BAH Operations Manual, drawn up within this rule, permitted VFR flight over sea by day down to a minimum height of 250 feet, in a minimum cloud ceiling of 300 feet, and a forward visibility of not less than 900 metres. Other UK helicopter operators had similar limits for S–61 aircraft.

In November 1981 the British Airline Pilots Association (BALPA) to which most BAH pilots including the commander and co-pilot of ON belonged, wrote to the CAA concerning Rule 23 (a) (iii). The letter expressed BALPA's serious doubts as to whether it was possible to guarantee adequate visual reference for a helicopter flight without reliance on instruments in a visibility of less than one nautical mile, especially over an unbroken surface with no reference points such as snow or a smooth expanse of water. BALPA proposed that changes be made to Rule 23 to bring helicopters in line with fixed wing aircraft, so that the minimum visibility permitted in VFR flight would be one nautical mile. Following discussions between the CAA, BALPA, and other interested parties, the CAA, although not accepting that the appropriate minimum visibility was one nautical mile, decided to review the minima for helicopters. The CAA were also of the opinion that whilst an amendment to Rule 23 was not an appropriate method of implementing any change considered necessary, action could be effected by amending the operating minima in company operations manuals.

By March 1983 proposals had been drawn up for CAA internal discussion. These were to the effect that for flights up to 50 nautical miles present minima should be allowed to stand, but be reinforced by provisions that operating indicated airspeed should allow a forward visibility of 60 seconds to a single-pilot crew and 30 seconds to a two-pilot crew. The pilot should also be able to assess attitude by external reference. The proposals for longer flights were more restrictive, requiring a 600 feet ceiling and 10 km visibility by day, and a 1,200 feet ceiling and 10 km visibility by night. These proposals were being considered when the accident to G–BEON occurred.

1.17.2 *The Operations Manual*

Relevant extracts from the BAH Operations Manual are at appendix 10.

1.17.3 *Visual flight in poor visibility*

Both pilots were interviewed by the Head of Flight Skills Section of the Royal Air Force Institute of Aviation Medicine. He provided an assessment of the problems pilots face when flying by external visual reference in poor visibility over the sea, with particular reference to this accident. Extracts from his report are as follows:

> "The pilot who is attempting to fly reasonably close to the surface of the earth by visual reference to that surface, must control both height and attitude. The visual cues which a pilot may use to accomplish these goals are several. To maintain control of attitude it is clear that use may be made of the horizon if it is visible. In more restricted visibility, it is possible that information derived from the visual range of the haze can be used to provide the same type of information as the horizon, but such information almost certainly provides a weak and potentially illusory cue. A more powerful cue to attitude perception is provided by the gradients and movement of surface texture on the retina. As long as a surface is textured in a reasonably uniform way, judgements may be made of the angle at which the surface is being observed even if the texture

is unfamiliar and of unknown element size. Thus, the absence of surface texture (ie the glassy sea) at the time of this accident would effectively have presented the visual perception of orientation, and the vestibular system cannot be relied upon to detect rates of attitude change (ie small angle accelerations) or to detect the resultant, perhaps quite large, changes of attitude.

There can be no doubt that this pilot (ON's commander) would have been placed extremely poorly to perceive the attitude of the aircraft, and it is quite conceivable that large attitude changes could have occurred which would, to him have been indetectable both from a visual and vestibular point of view. Even if this pilot had failed to appreciate an attitude change, one might suppose that he should have detected the reduction in height as he approached the surface of the sea. In this respect, the horizon is of little consequence as no height information may be derived from it, visual height judgements predominantly being influenced by two factors. The first and more important is the retinal size (or visual angle) of objects and texture of known actual size on the surface. The second is the rate at which objects and texture on the surface pass the observer (their relative angular velocity) and this variable is affected by both height and speed."

". . . It is recognised that the analysis above of the cues used in height judgement is simplified and it is quite possible that the use of surface texture will interact in a complex manner with visual range in the judgement of height and descent rate. Furthermore, even if texture is present, illusory phenomena can occur leading to erroneous judgements if the real element size in the texture is unknown to the observer.

To summarize though, it can be said that the perception of attitude may be achieved using the horizon and surface texture as cues. Height perception however, does not depend on the horizon, does require surface texture and what is more, requires the observer to be aware of the real size of the texture . . . Because of this, the pilot flying by limited external cues would ideally be provided with information from the radio altimeter as close to the forward cockpit transparency as possible. Regrettably, the radio altimeter in this aircraft is located in a far from ideal location, requiring not only a large head and eye movement to transfer the gaze from it to the outside world, but it is also partially obscured behind the control column."

1.18 New investigation techniques

None.

2. Analysis

2.1 The nature of the accident

Neither of the pilots was able to describe how the accident occurred because up to the moment of impact each was under the impression that the helicopter was at 250 feet. However, their evidence as to the serviceable condition of the helicopter at the start of the flight and its behaviour during it, taken together with the evidence derived from the engineering investigation, leads to the conclusion that G–BEON was mechanically serviceable, with both engines operating, and was fully controllable up to the moment that it struck the sea in a substantially straight and level attitude on its intended track and heading. This accident therefore falls into the category of a collision with the water in controlled flight. It was not in any sense a ditching.

2.2 The VGI

Various conceivable subtle failures or malfunctions which might have led directly or indirectly to an unnoticed loss of height were examined, but the only one for which there was any evidence at all was the possibility of an error in the No 2 VGI system. The only evidence for this was the commander's report of a momentary appearance of his VGI 'ATT' flag whilst he was checking the height on his radio altimeter. The commander noticed nothing else unusual about the VGI, but did not then compare it with the standby horizon or the co-pilot's indicator. In fact his reaction was to look outside the cockpit to seek a reference on the approaching coastline, and he did not again refer to his VGI (or any other instruments) during the rest of the flight. Thus any VGI malfunction at this time could not have misled him. The reason why the helicopter lost 250 feet unnoticed by the pilots must, therefore, be sought in the areas of their performance and in operational factors.

2.3 The weather encountered

Before ON took off the commander had received a satisfactory weather report from St Mary's, and he knew that DA had landed after a VFR flight. He was therefore justified in his decision that the weather was suitable for his own flight to be a VFR one.

During the course of the flight both pilots were in no doubt that VFR conditions prevailed. Although the identity of the station which transmitted the report of the weather at St Mary's received by ON when near the Longships could not be established, the report was in fact the weather that DA had encountered – a visibility of ½ to ¾ nm when at 300 feet radio height.

ON's crew stated that towards the end of the flight they were flying at 250 feet radio height, in visual contact with a flat calm sea, with no horizon discernable, in haze but with a forward visibility they were confident exceeded the minimum permissible of 900 metres. They were supported in this assessment by the report they believe came from DA. The best independent evidence of the weather in the accident area at the time of the accident is that of the crew of DA. Although it is apparent that patches of shallow sea fog appeared in the area soon after the accident, it is concluded that during the last stages of ON's flight the crew were in visual contact with the sea and in a flight visibility of over 900 metres, and possibly as much as ¾ nm (1,200 metres). ON was, therefore, being operated in conformity with the instructions in the BAH Operations Manual on weather minima for daytime VFR flight over the sea.

The evidence concerning the weather encountered towards the end of the flight indicates that not only were conditions such as to make the assessment of attitude and height by external visual reference difficult, but that nonetheless they were also capable of causing a pilot to be deceived into believing that adequate cues were available for the safe control of a helicopter's flight path – at least for short periods of time.

2.4 Operating height

The apparent conflict of evidence between the statements of the two pilots that the final stage of the flight was being conducted at 250 feet radio height, and that of the two passengers who stated that shortly before the impact the cabin attendant had said the helicopter was flying at 100 feet deserves examination. Several explanations were considered, namely: the helicopter was being flown level at 100 feet and not at 250 feet; the passengers misheard what the cabin attendant said; the cabin attendant misread the radio altimeter; the cabin attendant read the height from one of the barometric altimeters which are much more obvious than the radio altimeters to a person standing at the cockpit entrance, and at 250 feet radio height would have indicated about 134 feet QFE; finally that the cabin attendant had in fact seen a height of about 100 feet indicated on the radio altimeter as the helicopter was descending without realising that it was not level. In view of the fact that the crew's evidence is direct and that of the passengers' hearsay, and as there would have been no advantage to be gained by intentionally flying lower than 250 feet but rather the opposite, it is concluded that immediately prior to the final loss of height which resulted in the impact the crew intended to fly at 250 feet radio height, ie in accordance with the minimum en-route height for daytime VFR flight over the sea laid down in the BAH Operations Manual.

2.5 The cause of the unintentional descent

The effect of the cabin attendant's movement forwards to the cockpit entrance and then rearwards to his seat was examined as a possible cause of an undemanded rate of descent. It was discounted because of the small effect it would have had on the helicopter's performance, even in the absence of pilot intervention.

On the other hand the evidence is that just before the commander directed his attention from his radio altimeter to his VGI, and thence outside the cockpit, he had reduced power to decrease airspeed. He had made a further power reduction later whilst looking ahead, and had also been adjusting the helicopter's attitude by trimming nose-up with a view to maintaining height as airspeed decreased. There is no firm evidence regarding the time that elapsed from the start of the descent from 250 feet to the impact. However the loss of height must have been gradual because the pilots' non-visual senses were not alerted. It is likely, therefore, that the commander made neither large changes in power nor large changes in attitude, and this accords with his evidence.

The computer simulation of the S–61's performance indicates that for variation of torque or pitch attitude alone, a relatively large error from the figure appropriate to level flight at 90 knots would be required to produce a loss of 250 feet in a credible time scale, but that a relatively small error of both together could do so in about 40 seconds. Decelerating a helicopter at constant height demands close co-ordination of power and attitude. The accurate control required would be difficult to achieve in the external visual conditions that pertained without reference to the flight instruments.

Once the commander had transferred his attention from the VGI to continue flying by external visual reference he was expecting to sight land shortly and to find improved weather in the vicinity of the airfield. He clearly did not realise that the external visual cues were insufficient for what he was attempting without any further check of the flight instruments. If the helicopter had been in stabilised level flight when the commander last looked out and power had remained unaltered, it is likely that little height change would have taken place. But in fact power and attitude were being altered to decrease airspeed, and unless control was perfectly co-ordinated an unwanted change of height was likely. Thus it seems probable that whilst looking out ahead the commander had insufficient visual cues to realise that an imperfect co-ordination of the cyclic and collective pitch controls had resulted in a power and attitude combination which had given rise to a gradual but continuous loss of height.

2.6 Contributory factors

2.6.1 Flight instrument monitoring

One of the principal reasons for having a co-pilot in public transport aircraft over 12,500 lbs weight is so that safety may be enhanced by the non-handling pilot being able to monitor the flight path, especially when the aircraft is at low level. As a general principle of good airmanship, the co-pilot should monitor the instruments throughout the flight and the commander should ensure that this is done.

The BAH Operations Manual (Vol 5 para 4.1.3.1, Allocation of Duties S–61N, Normal Operations) specifically required the co-pilot to monitor the instruments during the 'final approach' phase of flight, but monitoring of the instruments was not mentioned under the 'descent and initial approach' phase. These instructions were applicable to both VFR and IFR approaches; for a VFR approach such as that conducted by ON, there was no clear definition of the point at which the initial approach ended and the final approach began. Whereas the commander considered the helicopter was on the initial approach at the time of the accident, the co-pilot believed that it had been on the final approach.

As the helicopter approached land at 250 feet the co-pilot, being satisfied that there was adequate visual reference and having confirmed with the commander that he was flying visually, concentrated on his navigation and radio communication duties. He considered that the range from the coast was of particular importance because, if the helicopter were to reach a point one mile from land without it being visible, he would have to warn the commander to prepare to carry out an overshoot procedure. Because of this, and because he was constantly adjusting the radar set and had to shield the screen from glare, the co-pilot concentrated solely on obtaining radar ranges and on radio communication to the exclusion of flight instrument monitoring for about the last minute of the flight – a period which probably included the entire time of the helicopter's descent from 250 feet to the water.

Nevertheless, monitoring of the flight instruments was of vital importance in the potentially deceptive meteorological conditions obtaining, the Decca flight log was operating satisfactorily, the helicopter was on track, and the range to the land ahead was closing at a known rate. Because of these factors, and not withstanding his navigational and communications duties, the co-pilot could and should have paid some attention to the flight instruments during the last minute or so of the flight.

2.6.2 The weather minima

The flight was conducted in accordance with the rules for VFR flight and the BAH Operations Manual minima and procedures. The BALPA argument (first put to the

CAA 20 months before the accident) that the weather minima relevant to VFR 'contact' flight were unsatisfactory led to a review by the CAA, but proposed changes were still under consideration when the accident occurred. Although the flight was conducted in accordance with the minima contained in the Operations Manual the poor external visual cues during the approach phase meant that adequate control of the helicopter's flight path could not be maintained purely through external visual reference, although such reference was essential for collision avoidance and to make a safe landfall.

The weather minima applicable to this flight are most appropriately considered in the context of the BAH operating procedures, and in the light of the lessons long learned from the operation of fixed wing aircraft concerning the value of continuous (as opposed to intermittent) instrument monitoring during the visual phase of landing approaches in poor visibility. It is considered that the operating procedures left too much to the individual commander's and co-pilot's discretion as regards flight instrument monitoring when flying VFR at low level in poor visibility, as compared with a formally structured method of arranging the crew duties such that the flight instruments would be continuously monitored by one pilot in such conditions e.g. the concept of the monitored approach. The practice of operating the S–61 (a helicopter which had neither an auto-pilot, nor a height hold facility on its AFCS system) in VFR flight over water, at 250 feet in visibilities down to 900 metres, without a company operating procedure capable of ensuring that the flight instruments would be continuously monitored, was one which eroded safety margins to the extent that it allowed catastrophe to be the consequence of human error of a kind already well known in aviation. This practice was thus a major contributory factor.

As a result of a review of operating procedures undertaken after the accident BAH introduced revised operating procedures concerning two-pilot operations. They included the statement that "if, overwater, the cloud base is less than 550 feet or there is no discernable horizon the handling pilot is to fly the aircraft by reference to instruments only, whilst the non-handling pilot maintains the look-out and monitors the instruments paying particular attention to altitude and airspeed".

2.6.3 *The radio altimeter*

Thirdly there is the question of the adequacy of the height alert system incorporated in ON's radio altimeter. At the time of the accident the BAH Operations Manual contained no instructions on the use of the radio altimeter height alert system, but one was issued after the accident. However, the commander had set his radio altimeter bug at 200 feet after levelling at 250 feet, although it is not known to what position the bug on the co-pilot's instrument was set.

Nevertheless the height alert system is unlikely to attract the attention of a pilot not looking at the instrument panel, because the radio altimeters are mounted low on the panel and the warning light is small. It is surprising that following the action taken a decade ago to require the larger public transport aircraft to be equipped with a ground proximity warning system, no action had been taken to apply this important safety lesson to helicopters. Had even the simplest audio alert system, such as one operated simultaneously with a radio altimeter decision height warning light, been in use in ON it could have alerted the crew in ample time for them to arrest the helicopter's descent safely. Such systems are reliable and have been available for many years. The lack of an audio height alert system capable of warning pilots even if they are not looking at their flight instruments is therefore judged to have been a contributory factor in this accident.

It is ironic that ON was equipped with an audio alert system which would operate at 250 feet if the landing gear was still up. If the landing gear had been left up until the aerodrome was in sight, and the final approach made, say, at 300 feet, then the crew would have had an audio height alert system. But the equipment was not intended to be used in this manner and pilots were not trained or instructed to do so, although in the past some Penzance based pilots had so used it when circumstances warranted.

At the time of the accident radio altimeters were not mandatory equipment for helicopters operating offshore. A recommendation that radio altimeters incorporating audio as well as visual decision height warning be fitted to all such helicopters was made in AIB reports 4/83 and 2/84, and to the CAA in the early stage of this investigation. Although such equipment is considered a vital contribution to the prevention of further accidents following an inadvertent loss of height and should therefore be introduced quickly, in the longer term a more elaborate system should be considered. The report of the Helicopter Airworthiness Review Panel (HARP) of the Airworthiness Requirements Board, published in March 1984, stated that "ground proximity warning systems (GPWS) suitable for helicopters seem highly desirable and should be developed and used". This view is supported.

Given the importance of the radio altimeter in offshore helicopter operations it is suggested that consideration be given to re-locating the S–61N's radio altimeter indicators to significantly reduce the head and eye movement needed to transfer the gaze between them and the outside world, and to ensure that they are fully visible to a pilot whatever his seat position. In the longer term the solution to the problem of assessing height when flying VFR at low level over water probably resides in providing a display of height in the pilot's head-up visual field.

2.7 Other operational matters

2.7.1 *Crew workload*

The circumstances of this accident contain indications of an unsatisfactory workload on both the commander and the co-pilot. Although it is one which has long been carried by helicopter crews it is now being alleviated in new types of machine by the introduction of autopilots, and by improvements in navigation and radar equipment. Such developments should be encouraged for reasons of safety. Moreover retrospective modification of older helicopter types such as the S61N should also be encouraged, perhaps by applying higher operating minima to helicopters with inferior equipment.

2.7.2 *Landing minima at St Mary's airfield*

During the investigation it was noted that whereas the BAH minimum visibility for overwater flight was 900 metres, the day time landing minimum runway visual range (RVR) at St Mary's was 600 metres for S–61's whose mapping radar was serviceable. There were no instructions concerning at what point the 900 metres minima ended and the 600 metres limit began. It is thus conceivable, even likely, that a crew being passed an RVR that was anywhere between 600 and 900 metres might continue an approach over the sea in a visibility less than 900 metres as the assessment of visibility over water in such conditions is extremely difficult. As there is no instrument approach procedure to St Mary's airfield it is suggested that the CAA consider whether the minimum RVR for day landings should be not less than that laid down for overwater VFR flight at low level.

2.7.3 *Altimeter pressure settings*

The crew acted normally in carrying out the landing checks when they did, and in setting both barometric altimeters to the St Mary's QFE at that time. In the case of this level approach over the sea to an airfield above sea level such an action produces the condition whereby the helicopter's height is supposed to be controlled at 250 feet above the sea but the barometric altimeters indicate 134 feet. In such circumstances it would not be surprising if pilots gave the radio altimeter their prime attention, even to the extent of ignoring the barometric altimeters during the final approach. One danger of this practice is that a failure of the radio altimeter which resulted in a credible but incorrect indication might not be detected. It should be considered whether safety would be enhanced if one or both barometric altimeters were to be set to QNH until the coast was crossed or the airfield was in sight.

2.7.4 *Flight data recorders*

This accident serves to underline the continued need for large transport helicopters to be fitted with flight data recorders (FDR). Whilst such helicopters are now required to have a cockpit voice recorder the urgent requirement for the introduction of a helicopter FDR is in no way diminished.

2.8 Survival aspects

2.8.1 *Lifejackets and liferafts*

The bodies of the cabin attendant and two adult passengers were not recovered, and the possibility remains that they managed to escape from the aircraft. The six persons that were rescued were extremely fortunate to survive, and credit is due to the two pilots who helped to keep their passengers afloat and maintained their will to survive.

ON, being an Aberdeen based helicopter on temporary detachment to Penzance, was equipped with constant wear type lifejackets. However, in accordance with standard practice on the Penzance – Isles of Scilly service, these were not tied around the waists of the passengers as is the practice on flights to offshore oil installations. Similarly none of the crew was wearing a lifejacket. The fact that no flotation aid was available to the six survivors emphasises the value to both crew and passengers of having a lifejacket on in the event of a helicopter flooding quickly after an accident on water.

As a result of previous accidents the automatic deployment of at least one of a helicopter's liferafts has been considered in the past, and a design exists for modifying the S–61's rear door accordingly. Whilst there could be objections to a simple inertia operated system which might release the liferaft before the fuselage and rotors had come to rest, it might be possible to incorporate an appropriate delay in such a mechanism. Alternatively it might be feasible to employ a switch activated by water pressure so that as a last resort the raft would be released if the helicopter sinks. Had an automatic system capable of operating despite the disruption of the aircraft's electrical supplies been fitted to ON it is probable that the liferaft, which was found fully serviceable during the accident investigation, would have been available to the survivors.

2.8.2 *Search and rescue*

Apart from flotation aspects another severe handicap incurred by the survivors in the water was that the helicopter sank together with the dual frequency BE369 beacon and the BE375 PLB's carried in the lifejackets of the three crew members. This accident again illustrates the value of equipping helicopters which operate offshore with a survival radio beacon which is automatically deployed by immersion in water or by impact forces. Recommendations to this effect were made in AIB reports 10/82, 4/83, and 2/84.

This accident also illustrates the value to be gained following an accident in which a helicopter fills rapidly with water after impact if crew members wore their PLB equipped lifejackets on every flight. If this had been standard practice at the time of this accident a radio location device would have been available despite the loss of the BE369 beacon, and this should normally have ensured a speedy rescue even in the very poor visibility pertaining on the day. In the event, had the crew been wearing their lifejackets, the two rescue helicopters deployed could have homed onto only the co-pilots PLB as neither had the capability to home on the civil distress frequency of 121.5 MHz, on which the PLB's of the captain and cabin attendant were designed to operate. This is a severe limitation on the capability of the SAR organisation to effect a speedy location of survivors and subsequent rescue. A recommendation that all SAR helicopters should have the capability of homing onto emergency beacon transmissions was made in AIB report 8/78. Additionally the St Mary's lifeboat was not equipped with a homing capability on either 121.5 MHz or 243 MHz. The RNLI are presently fitting their lifeboats with equipment capable of homing on 121.5 MHz.

A further shortcoming in the rescue operation was due to the misunderstanding between the RCC and RNAS Culdrose which resulted in Culdrose not interpreting the earlier information from the RCC as meaning that there was a high probability of an S–61 accident involving 26 persons. This resulted in an inadequate response to the accident in that, although the Wessex was despatched, the Sea King was initially not brought to a higher state of readiness. Furthermore, the Wessex was not equipped with any form of fixing aid and, although the crew demonstrated considerable skill in navigating their machine by dead reckoning, the effectiveness of their search was considerably limited by navigational inaccuracy. This coupled with the poor visibility made it unlikely that the Wessex was in any position to effect a rescue even if the precise location of the survivors had been known. On the other hand the Sea King is capable of hovering automatically and this, together with its radar and superior load carrying capability, would have made it an effective SAR vehicle had it arrived at an early stage. In the event, it had not taken off by the time the survivors had been rescued by the St Mary's lifeboat, whose crew had with great skill located them in fog.

Although co-ordination between the RCC and RNAS Culdrose left much to be desired on this occasion the lack of location devices available to the few survivors made it doubtful whether this had any effect on the rescue operation. When the shortcomings became apparent during the AIB investigation both the RCC and RNAS Culdrose took immediate steps to ensure that there would be no recurrence of the problem.

Representations have been made by the AIB to the Department of Transport, who are responsible for SAR involving civil aircraft, to review the capability, equipment and response times of the SAR helicopters in the South West, and to examine the overall UK SAR capability with regard to civil air accidents.

3. Conclusions

(a) Findings

(i) G–BEON had been maintained in accordance with an approved maintenance schedule, its Certificate of Airworthiness was valid, and it was fully serviceable throughout the flight.

(ii) The crew were properly licensed and sufficiently experienced.

(iii) The helicopter was correctly loaded and carried ample fuel.

(iv) The commander was justified in planning a VFR flight and the weather throughout the flight was above the minima laid down in the BAH Operations Manual, which were similar to those of other operators.

(v) When the helicopter was nearing land on its approach to St Mary's aerodrome it was initially flying at 250 feet in a flight visibility in excess of 900 metres. With no natural horizon discernable, but believing he had adequate visual reference, the commander was alternating his scan between the flight instruments and the external scene.

(vi) At about the time that the commander reduced power so as to decrease airspeed he altered his scan pattern, and thereafter flew entirely by external visual reference.

(vii) The helicopter's loss of height probably occurred because the commander did not correctly co-ordinate power and attitude to maintain level flight as speed decreased.

(viii) Because of the inadequate external visual cues and his lack of reference to the flight instruments the commander did not notice that the helicopter was descending before it struck the water.

(ix) The co-pilot did not notice the loss of height because his attention was fully directed to operating the radar and in communicating with St Mary's for about the last minute of the flight.

(x) The helicopter's radio altimeter decision height alert system was incapable of warning a pilot who was not looking at the flight instruments, and there was no procedure in the Operations Manual for use of the system.

(xi) The BAH operating procedures did not require the flight instruments to be continuously monitored by one pilot when flying over water at low level in poor visual conditions.

(xii) Following the evacuation of the helicopter, the commander and co-pilot acted with courage and determination in assisting the passengers to survive until rescue arrived.

(xiii) Untoward features of the search and rescue operation were an initial lack of co-ordination between the Rescue Co-ordination Centre and RNAS Culdrose, and the original despatch of a rescue helicopter which did not have the capability to operate in fog.

(xiv) Although the helicopters and lifeboat deployed did not have the capability of homing onto emergency radio beacons transmitting on the civil aeronautical distress frequency of 121.5 MHz, this had no effect on the rescue operation because ON's crew were unable to take any beacons with them on evacuation.

(xv) The timely despatch of the St Mary's lifeboat and the skill exhibited by its crew were crucial factors in the rescue of the six survivors, who were floating without lifejackets and in fog.

(b) Cause

The accident was caused by the commander not observing and correcting an unintentional descent before the helicopter collided with the surface, whilst he was attempting to fly at 250 feet by external visual reference only in conditions of poor and deceptive visibility over a calm sea. Contributory factors were: inadequate flight instrument monitoring; a combination of VFR weather minima which were unsuited to visual flight and insufficiently detailed company operating procedures; and the lack of an audio height warning equipment.

4. Safety Recommendations

It is recommended that:

4.1 The weather minima for helicopter VFR 'contact' flight, and the associated crew instrument monitoring procedures, should be reviewed.

4.2 Radio altimeters incorporating audio as well as visual decision height warning be fitted to all helicopters operating offshore as a matter of urgency.

4.3 In the longer term, consideration be given to the development of a ground proximity warning system for helicopter use.

4.4 The practicability of moving the S–61N's radio altimeter indicators to a position clear of the cyclic stick, and nearer the pilot's head-up field of vision, should be examined.

4.5 Public transport helicopters be fitted with a survival radio beacon which is automatically deployed on immersion in water or by impact forces.

4.6 Consideration be given to requiring pilots of public transport helicopters operating offshore to wear lifejackets incorporating dual frequency (121.5 and 243 MHz) personal locator beacons.

4.7 The use of QFE by BAH helicopters on low level approaches to St Mary's aerodrome prior to crossing the coast, and the minimum RVR of 600 metres, be reviewed.

4.8 The requirements concerning the strength of helicopter passenger and cabin attendant seats be reviewed.

D A Cooper
Inspector of Accidents
Accidents Investigation Branch
Department of Transport

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