AIRCRAFT ACCIDENT REPORT 1/2016

Air Accidents Investigation Branch

Report on the accident to AS332 L2 Super Puma helicopter, G-WNSB on approach to Sumburgh Airport on 23 August 2013

AIRCRAFT ACCIDENT REPORT 1/2016

Air Accidents Investigation Branch

Report on the accident to AS332 L2 Super Puma helicopter, G-WNSB on approach to Sumburgh Airport on 23 August 2013

This investigation has been conducted in accordance with
Annex 13 to the ICAO Convention on International Civil Aviation,
EU Regulation No 996/2010 and
The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996.

The sole objective of the investigation of an accident or incident under these Regulations is the prevention of future accidents and incidents. It is not the purpose of such an investigation to apportion blame or liability.

Accordingly, it is inappropriate that AAIB reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

Published 15 March 2016

Printed in the United Kingdom for the Air Accidents Investigation Branch

Department for Transport
Air Accidents Investigation Branch
Farnborough House
Berkshire Copse Road
Aldershot
Hampshire GU11 2HH

February 2016

The Right Honourable Patrick McLoughlin
Secretary of State for Transport

Dear Secretary of State

I have the honour to submit the report on the circumstances of the accident to AS332 L2 Super Puma helicopter, registration G-WNSB, on approach to Sumburgh Airport on 23 August 2013.

Yours sincerely

Keith Conradi
Chief Inspector of Air Accidents

Contents

Appendices

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

°C	degrees Centigrade
°M	degrees magnetic
AAIB	Air Accidents Investigation Branch
aal	above airfield level
ADELT	Automatically Deployable Emergency Locator Transmitter
AFCAU	Automatic Flight Control Auxiliary Unit
AFCP	Automatic Flight Control Panel
AFCS	Automatic Flight Control System
AFCS	Automatic Flight Control System
AFM	Aircraft Flight Manual
agl	above ground level
AIP	Aeronautical Information Publication
ALS	Approach Lighting System
AMC	Acceptable Means of Compliance
AMM	Aircraft Maintenance Manual
amsl	above mean sea level
ARCC	Aeronautical Rescue Co-ordination Centre
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATIS	Automatic Terminal Information Service
ATSA	Air Traffic Services Assistant
AVAD	Automatic Voice Alerting Device
BEA	Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile
BOSIET	Basic Offshore Safety Induction and Emergency Training
BRU	Beacon Release Unit
CAA	Civil Aviation Authority
CAM	Cockpit Area Microphone
CAP	Civil Aviation Publication
CFIT	Controlled Flight Into Terrain
CFM	Complementary Flight Manual
CPI	Crash Position Indicator
CPR	Cardiopulmonary resuscitation
CWP	Central Warning Panel
DCU	Display Control Unit
DGAC	Direction Générale de l'Aviation Civile
DME	Distance Measuring Equipment
DOC	Designated Operational Coverage
EASA	European Aviation Safety Agency
EBS	Emergency Breathing System
ELT	Emergency Locator Transmitter
ESE	Emergency and Survival Equipment
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FATO	Final Approach and Takeoff Area
FCOM	Flight Crew Operating Manual
FDC	Flight Data System
FDM	Flight Data Monitoring
FMS	Flight Management System
FOET	Further Offshore Emergency Training
fpm	feet per minute
FRC	Fast Rescue Craft
FSF	Flight Safety Foundation
FSI	Flying Staff Instruction
ft	feet
g	acceleration due to gravity
GPS	Global Positioning System
HEMS	Helicopter Emergency Medical Service
HFDM	Helicopter Flight Data Monitoring
HOSS	Helicopter Offshore Safety and Survivability
hPa	hectopascal
HSI	Horizontal Situation Indicator
HTAWS	Helicopter Terrain Awareness Warning System
HUET	Helicopter Underwater Escape Training

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT - cont

IFDS	Integrated Flight Display System
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
JAA	Joint Aviation Authorities
JHWG	Joint Harmonisation Working Group
kg	kilogram
kHz	kilohertz
KIAS	Indicated airspeed in kt
km	kilometre
kt	knot
LPC	Licence Proficiency Check
m	metre
MAP	Missed Approach Point
MDA	Minimum Descent Altitude
METAR	Meteorological Aerodrome Report
MHz	Megahertz
min	minute
MRCC	Maritime Rescue Coordination Centre
NAA	National Aviation Authority
NAMRL	Naval Aerospace Medical Research Laboratory
NDB	Non-Directional Beacon
nm	nautical mile
NMD	Navigation and Mission Display
NTSB	National Transportation Safety Board
NVM	non-volatile memory
OHSAG	Offshore Helicopter Safety Action Group
OM	Operations Manual
OPC	Operator Proficiency Check
OPITO	Offshore Petroleum Industry Training Organisation
OTWG	Operations and Training Working Group
PF	Pilot Flying
PFD	Primary Flight Display
PLB	Personal Locator Beacon
PNF	Pilot Not Flying
PSU	Pressure Sensor Unit
QAR	Quick Access Recorder
RFFS	Rescue and Fire Fighting Service
RFM	Rotorcraft Flight Manual
RMT	Rulemaking Task
RTF	Radio Telephony
SAR	Search and Rescue
SB	Service Bulletin
SMD	Smart Multifunction Displays
SMS	Safety Management System
TAF	Terminal Area Forecast
TAWS	Terrain Awareness Warning System
TSO	Technical Standard Order
UK	United Kingdom
UTC	Co-ordinated Universal Time
V/S	Vertical Speed
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omni-Range
Vy	optimum climbing speed
WIDDCWG	Water Impact, Ditching Design and Crashworthiness Working Group

Air Accidents Investigation Branch

Aircraft Accident Report No: 1/2016 (EW/C2013/08/03)

Registered Owner and Operator	CHC Scotia Ltd
Aircraft Type	Eurocopter AS332 L2 Super Puma helicopter
Nationality	British
Registration	G-WNSB
Place of Accident	Approximately 1.7 nm west of Sumburgh Airport, Shetland Islands
Date and Time	23 August 2013, at 1717 hrs (Times in this report are UTC unless stated otherwise)

Introduction

The accident was reported by the helicopter operator at approximately 1756 hrs on the day of the accident.

In exercise of his powers, the Chief Inspector of Air Accidents ordered an investigation into the accident be carried out in accordance with the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996. The sole objective of the investigation of an accident or incident under these Regulations is the prevention of accidents and incidents. It shall not be the purpose of such an investigation to apportion blame or liability.

The AAIB despatched teams of investigators and support staff to Aberdeen and the Shetland Islands early the following morning, to commence the investigation.

In accordance with the provisions of ICAO Annex 13, France (the State of aircraft design and manufacture) appointed an Accredited Representative from the BEA[1], assisted by Advisers from the helicopter and engine manufacturers. Advisers from the European Aviation Safety Agency (EASA) and the UK Civil Aviation Authority (CAA) also participated in the investigation.

1 Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (the French equivalent of the AAIB).

Summary

At 1717 hrs UTC on 23 August 2013, an AS332 L2 Super Puma helicopter with sixteen passengers and two crew on board crashed in the sea during the approach to land at Sumburgh Airport. Four of the passengers did not survive.

The purpose of the flight was to transport the passengers, who were employees of the UK offshore oil and gas industry, to Aberdeen. On the accident flight, the helicopter had departed the Borgsten Dolphin semi-submersible drilling platform in the North Sea, to route to Sumburgh Airport for a refuelling stop. It then planned to continue to Aberdeen Airport.

The commander was the Pilot Flying (PF) on the accident sector. The weather conditions were such that the final approach to Runway 09 at Sumburgh Airport was flown in cloud, requiring the approach to be made by sole reference to the helicopter's instruments, in accordance with the Standard Operating Procedure (SOP) set out in the operator's Operating Manual (OM). The approach was flown with the autopilot in 3-axes with Vertical Speed (V/S) mode, which required the commander to operate the collective pitch control manually to control the helicopter's airspeed. The co-pilot was responsible for monitoring the helicopter's vertical flightpath against the published approach vertical profile and for seeking the external visual references necessary to continue with the approach and landing. The procedures permitted the helicopter to descend to a height of 300 ft, the Minimum Descent Altitude (MDA) for the approach, at which point a level-off was required if visual references had not yet been acquired.

Although the approach vertical profile was maintained initially, insufficient collective pitch control input was applied by the commander to maintain the approach profile and the target approach airspeed of 80 kt. This resulted in insufficient engine power being provided and the helicopter's airspeed reduced continuously during the final approach. Control of the flightpath was lost and the helicopter continued to descend below the MDA. During the latter stages of the approach the helicopter's airspeed had decreased below 35 kt and a high rate of descent had developed.

The decreasing airspeed went unnoticed by the pilots until a very late stage, when the helicopter was in a critically low energy state. The commander's attempt to recover the situation was unsuccessful and the helicopter struck the surface of the sea approximately 1.7[2] nm west of Sumburgh Airport. It rapidly filled with water and rolled inverted, but was kept afloat by the flotation bags which had deployed.

Search and Rescue (SAR) assets were dispatched to assist and the survivors were rescued by the Sumburgh-based SAR helicopters that attended the scene.

2 AAIB Special Bulletin S7/2013 detailed that the helicopter struck the surface of the sea approximately 1.5 nm west of Sumburgh Airport. This position has been further refined.

The investigation identified the following causal factors in the accident:

- The helicopter's flight instruments were not monitored effectively during the latter stages of the non-precision instrument approach. This allowed the helicopter to enter a critically low energy state, from which recovery was not possible.

- Visual references had not been acquired by the Minimum Descent Altitude (MDA) and no effective action was taken to level the helicopter, as required by the operator's procedure for an instrument approach.

The following contributory factors were identified:

- The operator's SOP for this type of approach was not clearly defined and the pilots had not developed a shared, unambiguous understanding of how the approach was to be flown.

- The operator's SOPs at the time did not optimise the use of the helicopter's automated systems during a Non-Precision Approach.

- The decision to fly a 3-axes with V/S mode, decelerating approach in marginal weather conditions did not make optimum use of the helicopter's automated systems and required closer monitoring of the instruments by the crew.

- Despite the poorer than forecast weather conditions at Sumburgh Airport, the commander had not altered his expectation of being able to land from a Non-Precision Approach.

AAIB Special Bulletins S6/2013 and S7/2013, published on 5 September 2013 and 18 October 2013 respectively, provided initial information on the circumstances of the accident. Special Bulletin S1/2014, published on 23 January 2014, highlighted a safety concern relating to pre-flight safety briefings given to passengers, on the functionality of emergency equipment provided to them for UK North Sea offshore helicopter flights.

The AAIB investigation found similarities between this accident and previous accidents resulting from ineffective monitoring of the flight instruments by the flight crew.

Following this accident, the operator of G-WNSB and the Civil Aviation Authority (CAA) took safety actions intended to prevent similar accidents in future and to increase the level of safety of UK offshore helicopter operations in the North Sea.

During the investigation a number of additional safety concerns were identified. In addition to the Safety Recommendations issued in the aforementioned Special Bulletins, this final report contains further Safety Recommendations concerned with the certification of rotorcraft, Helicopter Flight Data Monitoring and offshore helicopter survivability.

1 Factual information

1.1 History of the flight

1.1.1 Background

The helicopter was operating a commercial passenger transport flight on charter to an oil and gas exploration and production company. The flight was scheduled to depart from Aberdeen Airport at 1330 hrs, using the callsign 'Helibus 23R'. The first destination (Figure 1) was the Alwyn North platform located in the North Sea, 248 nm north-east of Aberdeen. The next destination was the Borgsten Dolphin semi-submersible drilling rig, 11 nm to the south of the Alwyn North. The helicopter was then scheduled to return to Aberdeen.

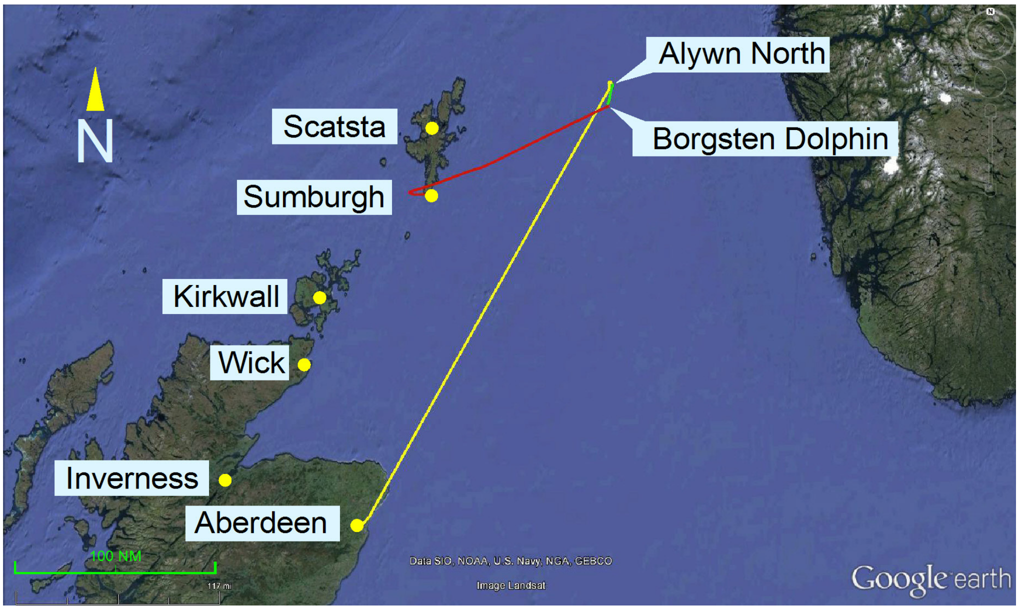


Figure 1

G-WNSB flight tracks (accident sector in red)

The passengers, who all worked in the offshore oil and gas industry, were equipped with survival suits and had undertaken the required safety training in their use. Pre-departure safety briefings were given at the point of boarding.

1.1.2 Pre-flight planning

Both crew members arrived before the required reporting time of 1230 hrs. It was usual, during the planning stage, for the charterer to be given two, or sometimes three, possible flight plan options. One plan would indicate the payload available for a direct flight to the destination but, if this was too restrictive, alternative plans would be provided, where possible, offering a higher payload but requiring an intermediate refuelling stop.

On this occasion the helicopter commander had originally prepared two flight plans for the charterer: a direct route and an outbound route via Sumburgh. The en route weather conditions were forecast to be favourable. However, when the co-pilot checked the updated weather information in the planning office he noticed that the conditions at Sumburgh had deteriorated, with a lowering cloud base. He advised the commander and, as a result, only the direct flight plan option was provided to the charterer.

In the flight planning office the commander met up with another company pilot who had just returned from an offshore flight. The pilot, who had worn a survival suit for the flight, told them that it had been uncomfortably hot. As a result, the commander suggested to the co-pilot that they need not wear survival suits, and he agreed.

1.1.3 First two sectors

The helicopter departed Aberdeen at 1344 hrs and landed on the Alwyn North platform at 1525 hrs. The co-pilot was the Pilot Flying (PF). There were five passengers on board bound for the Alwyn North, and ten for the Borgsten Dolphin. While en route to the Alwyn North, the crew were advised that there was an additional passenger for the return sector from the Borgsten Dolphin. The commander reviewed the available load and calculated that, with the additional passenger, it would no longer be possible to fly directly back to Aberdeen. He checked the weather forecasts, the flight times and fuel required for a return flight via Sumburgh and decided to accept the request.

After landing on the Alwyn North, all the passengers were disembarked and the helicopter was refuelled. The ground crew also provided the flight crew with a weather information pack. The ten passengers bound for the Borgsten Dolphin then boarded the helicopter again, together with an additional five who were returning to Aberdeen.

The helicopter departed the Alwyn North at 1548 hrs, with the commander now as PF. After the short flight to the Borgsten Dolphin, the helicopter landed at 1557 hrs. During the flight the crew commented that the weather pack did not include the latest report for Scatsta Airport (33 nm to the north of Sumburgh) and had a brief discussion about obtaining an update from the Borgsten Dolphin. However, there was no evidence that this was acted upon. After landing the commander remained on board throughout the turnaround, which was carried out with the rotors running. Ten passengers disembarked and an additional eleven passengers boarded.

The passengers were given a safety briefing by the commander before departure for the sector to Sumburgh.

1.1.4 Accident sector

The helicopter lifted off from the Borgsten Dolphin at 1612 hrs, with 16 passengers on board and a fuel load of 1,480 kg. The commander continued as the PF. During the climb the co-pilot established two-way radio contact with Brent Radar and the helicopter was cleared to climb to 2,000 ft amsl and proceed on a direct track to Sumburgh.

For the climb, the autopilot[1] was engaged in 3-axes[2] with V/S mode and the ALT.A mode was utilised. The autopilot remained coupled for the rest of the flight, in either the 3-axes, or 4-axes, modes.

During the climb the commander noticed a problem with the collective pitch (flying control) lever. He had attempted to set the engine torque at 65% by raising the collective pitch lever, but on releasing the lever it lowered, reducing the engine torque by approximately 5%. He commented to the co-pilot that the problem appeared to be intermittent. On levelling at 2,000 ft, he again noticed the problem and described it as “sticking”. He asked the co-pilot to try exercising his collective trim release trigger switch[3] a couple of times and this appeared to resolve the problem. The commander also made a small adjustment to the collective lever friction setting; however, the problem occurred on two further occasions, the last of which was at 1709 hrs, just prior to intercepting the localizer course[4] for the approach to Sumburgh.

The cruise checklist was completed at 2,000 ft, whilst en route. The crew calculated that, allowing for two approaches at Sumburgh, there would be approximately 900 kg of fuel remaining for a diversion to Scatsta.

At 1625 hrs both pilots listened to the Automatic Terminal Information Service (ATIS) broadcast for Sumburgh, which included the following information: Information ‘W’, time 1620 hrs, Runway 09, surface wind from 150° at 18 kt, visibility 4,000 m in haze, scattered cloud at 300 ft and broken cloud at 500 ft. The pilots commented that the conditions were close to their landing minima. They discussed the approach they would need to make; this was the Localiser Distance Measuring Equipment (DME) for Runway 09 (RWY09 LOC DME), with an MDA of 300 ft and a required visibility of 1,000 m.

At 1627 hrs and 73 nm from Sumburgh Airport, the helicopter was handed over to Sumburgh Radar. At 1647 hrs, Air Traffic Control (ATC) advised the crew

1 A description of the autopilot system and associated modes is included at Appendix A.
2 3-axes mode provides pitch, roll and yaw axis stabilisation; 4-axes mode provides automatic collective pitch control, in addition.
3 See Section 1.6.3.5 for more information.
4 Guidance towards the runway extended centreline, in this case 085°M, offset two degrees south of the runway centreline.

that the weather conditions at Sumburgh were now: visibility 2,800 m, few cloud at 200 ft and broken cloud at 300 ft.

The crew discussed the deteriorating conditions and the commander briefed for the RWY09 LOC DME approach (Figure 2). He would fly the approach and hand over control to the co-pilot for the landing once visual references had been established. The briefing was for the approach to be flown to maintain a constant descent angle, matching the SUB DME[5] range/height profile published on the approach chart.[6] A descent rate of 500 fpm would be selected, with a speed of 80 kt during the latter stages. The Automatic Voice Alerting Device (AVAD)[7] bugs were set to the MDA of 300 ft, in accordance with the SOP. After two approaches, if a landing was not possible, a briefing and diversion to Scatsta would be carried out.

As the helicopter approached the east coast of Shetland, ATC issued a clearance to climb to 2,500 ft. The crew listened to the 1650 hrs Sumburgh ATIS Information ‘X’. The surface wind was now from 150° at 12 kt, visibility 2,800 m in mist, few cloud at 200 ft and broken cloud at 300 ft. The commander commented that it would still be possible to see something at 300 ft. The helicopter routed across the island, to the north of the airport, before being issued a descent clearance to 2,100 feet. The descent was managed with the autopilot in the 4-axes mode with the IAS mode engaged. Approaching 2,250 ft altitude, the IAS mode was disengaged, returning the autopilot to 3-axes with V/S mode, with the pilot manually controlling airspeed via the collective pitch lever. Shortly thereafter, the helicopter levelled at 2,100 ft, on a radar heading towards the localiser course.

Final approach

The entire final approach phase was conducted in cloud. The APP[8] mode was armed and, at 7.3 nm DME SUB, the localiser was captured. The commander advised that he was reducing the airspeed, which was 120 kt, and the engine torque reduced to 51%. The helicopter turned onto the final approach course and, at 6.4 nm DME SUB, descent was initiated in accordance with the procedure. The commander selected a descent rate of 500 fpm using V/S mode and reduced the engine torque to 41%. ALT.A mode was not armed. The helicopter’s vertical descent profile for the final approach is shown in Figure 3.

ATC transferred the helicopter to the Sumburgh Tower frequency and the co-pilot established two-way contact. The co-pilot, cross-checking the helicopter’s

5 Range from ‘SUB’ navigation aid which reads zero at the Runway 09 threshold.
6 The range and heights were to be called out by the co-pilot during the final approach.
7 The AVAD provides an aural warning to flight crew when the helicopter reaches a height preselected by the crew, and at a fixed height of 100 ft.
8 APP mode is selected on the Automatic Flight Control Panel to enable localiser capture.

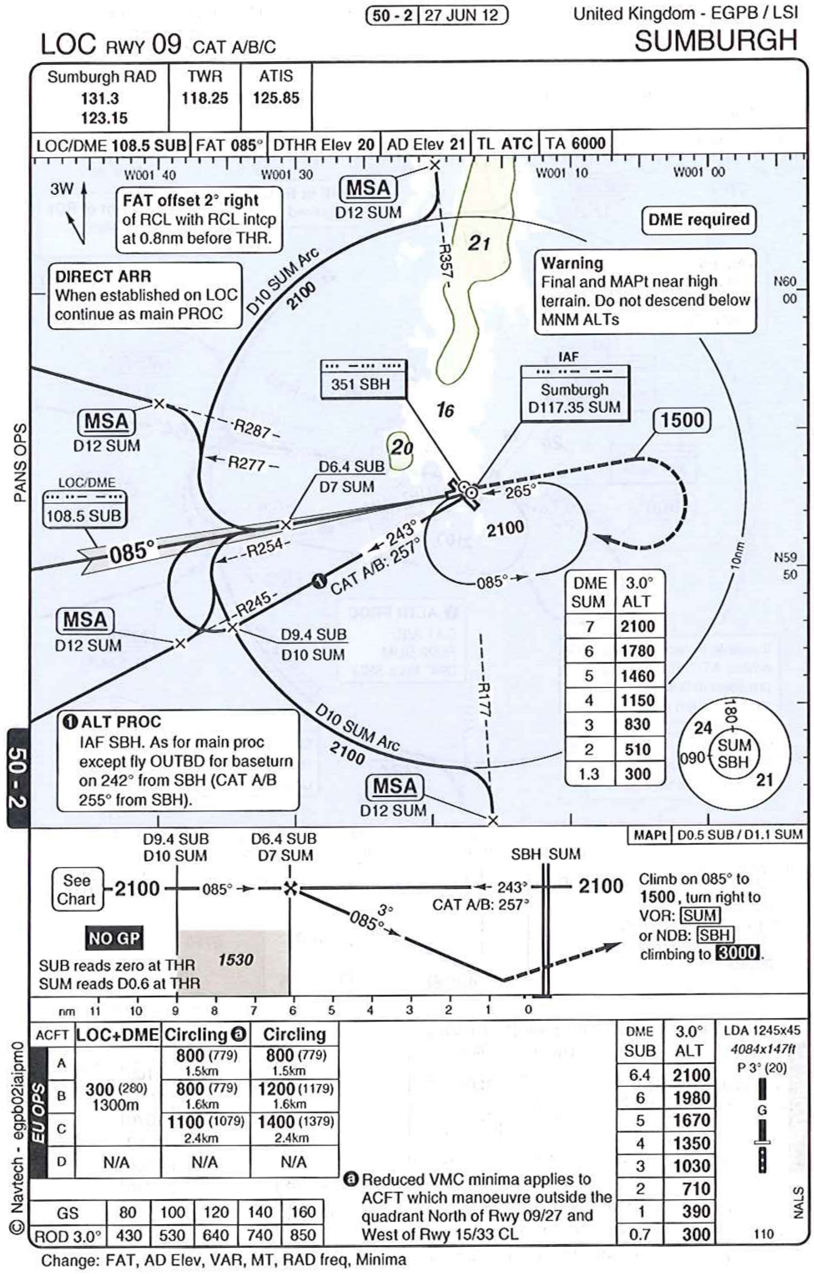


Figure 2

Sumburgh Runway 09 Localiser DME Approach Chart altitude against the published profile, announced at 5 nm that the height was 1,670 ft (on profile); at 4 nm he announced that they were at 1,350 ft (on profile). The commander stated that he was going to reduce the rate of descent and at the same time a reduction in engine torque to about 22% was recorded.

The tower controller requested the range of the helicopter and the co-pilot responded that they were at 4 nm. He then advised the commander that at 3 nm they should be at 1,030 ft. At 1715 hrs, the helicopter was cleared to land, with ATC reporting the wind from 150° at 14 kt, gusting 24 kt. The co-pilot acknowledged. Shortly thereafter, the commander reduced the collective pitch and the engine torque stabilised at about 18%. The airspeed was now reducing at a rate of about 1 kt/sec.

The co-pilot announced the crosscheck at 3 nm as 1,000 ft (30 ft low on the profile) and advised that at 2 nm they should be 710 ft. He then advised that they were 500 ft above the minima (MDA 300 ft), which the commander acknowledged.

At 2.4 nm DME SUB and 710 ft, the co-pilot advised that the profile was good at 2 nm. The commander noted that the airspeed was now at the briefed approach speed of 80 kt and increased the engine torque to about 24%. He also made a comment which suggested he was intending to maintain that speed. Over the next 36 seconds, unobserved by either pilot, the airspeed reduced steadily, to a minimum value of less than 30 kt. During this period there was no change in the collective pitch lever position and therefore no increase in engine power to prevent the airspeed from decreasing.

At 2.15 nm DME SUB the co-pilot advised that at a range of 1 nm the height should be 390 ft and the commander made a reference to reducing the rate of descent. The co-pilot called one hundred feet above minima; the commander acknowledged, but there was no change in the collective pitch input. Sumburgh ATC transmitted a wind update, advising it was from 150° at 13 kt, gusting 24 kt.

A few seconds later, at 300 ft, the four warning tones of AVAD 'CHECK HEIGHT' callout occurred, which the commander acknowledged verbally. The airspeed was now about 40 kt and the rate of descent approximately 600 fpm.

Shortly thereafter the co-pilot drew the commander's attention to the airspeed, which was now about 35 kt and the helicopter was now descending at 1,000 fpm. The commander acknowledged the co-pilot and began to increase the collective pitch. At this point there was a second AVAD 'CHECK HEIGHT' warning.

The commander increased the collective pitch initially to about 63% engine torque. He then made an exclamation and raised the collective pitch lever further, resulting in a maximum value of 120% engine torque. The rate of descent was now 1,800 fpm and he was not able to prevent the helicopter from impacting the water.[9]

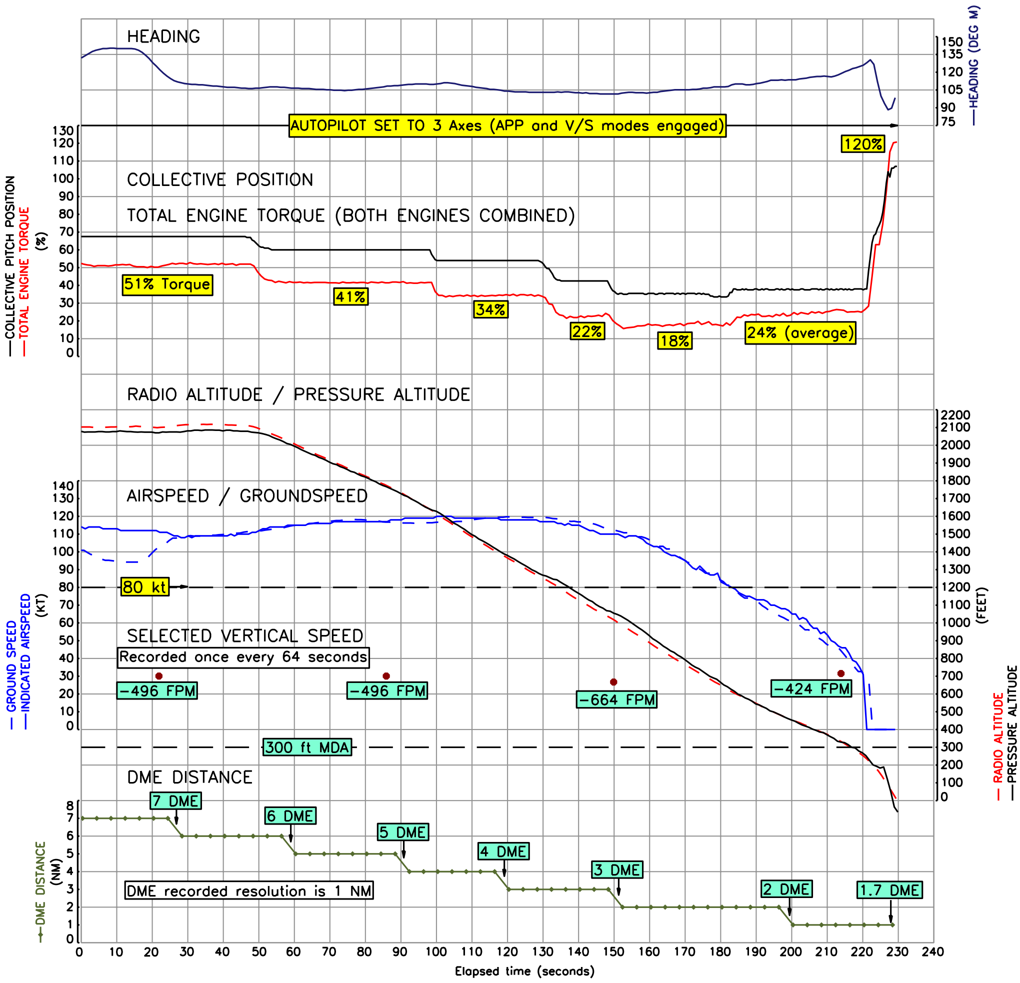


Figure 3

G-WNSB final approach vertical profile

The co-pilot, seeing the surface of the sea approaching, reached down across the centre pedestal and armed the Emergency Flotation System. As he did so the helicopter impacted the water and he was thrown forwards. He struck his head against the instrument panel, but he remained conscious.

9 At some point before impact the crew saw the surface of the sea.

Post-impact

Following impact with the water, the helicopter rolled upside down and rapidly filled with water but remained afloat, inverted on the surface, supported by the floats which had inflated automatically. Twelve passengers and two crew members escaped from the helicopter and survived the accident. There were four fatalities: two passengers did not escape from the upturned fuselage, one passenger was found by the coastguard helicopter, lifeless, floating on the surface and one passenger, who had successfully escaped, subsequently died in one of the liferafts.

1.2 Injuries to persons

Injuries*	Crew	Passengers	Others
Fatal		4	
Serious	1	3	
Minor/None	1	9	

* Injuries are categorised according to ICAO Annex 13 definition.

1.3 Damage to aircraft

As the helicopter had drifted onto the rocky shoreline following the accident, the extent of the damage caused by the impact with the water was difficult to assess from the recovered wreckage. However, a number of other sources of evidence were available, including images of the floating fuselage taken prior to it reaching the coastline. Evidence was also available from survivor statements and the distribution of the wreckage along the coast. Images of the helicopter taken while it was floating inverted showed that it appeared to be largely intact and relatively undamaged; however, the tail section aft of the rear baggage compartment was missing. The main rotor and tail rotor blades were significantly damaged, consistent with high energy contact with the water. Two of the main rotor blades had broken off at the blade root, which remained attached to the rotor head. The remaining blades had detached at their mounting hinge. Statements from the passengers and crew also indicated that most of the windows on the left side of the cabin had been removed by the force of the impact with the water.

Significant additional damage occurred to the helicopter due to repeated contact with the rocks as it drifted onto the shoreline. This resulted in the remaining fuselage breaking into two main sections, failing circumferentially at the forward end of the main cabin doors. It also caused damage to the engines, main rotor head and gearbox, all of which had broken away from the fuselage, along with the right sponson.

1.4 Other damage

There was no other damage.

1.5 Personnel information

1.5.1 Commander

Age:	51 years	
Licence:	Airline Transport Pilot's Licence	
Licence expiry date:	23 January 2017	
Helicopter Ratings:	AS332 / AS332L2 / EC225LP	
Operator Proficiency Check:	Valid to 31 November 2013	
Licence Proficiency Check:	Valid to 31 May 2014	
Line Check:	Valid to 31 December 2013	
Medical certificate:	Valid to 7 June 2014	
Annual Emergency and Survival Equipment Check:	Valid to 31 January 2014	
Triennial Emergency and Survival Equipment Check:	Valid to 30 April 2015	
HUET:	Valid to 30 April 2016	
Crew Resource Management:	Valid to 31 July 2014	
Flying Experience:	Total all types:	10,504 hours
	Total on type:	1,894 hours
	Last 90 days:	152 hours
	Last 28 days:	47 hours
	Last 24 hours:	4 hours
Previous rest period:	16 hrs 5 minutes	

The commander was on day five of a twelve-day roster pattern. The day following the accident was scheduled to be a single day off.

1.5.2 Co-pilot

Age:	40 years
Licence:	Commercial Pilot's Licence
Licence expiry date:	18 October 2014
Helicopter Ratings:	AS332L2 / EC225 LP / AS355 / EC135/B206 / R44
Operator Proficiency Check:	Valid to 28 February 2014
Licence Proficiency Check:	Valid to 28 February 2014
Line Check:	Valid to 28 February 2014
Medical certificate:	Valid to 17 December 2013
Annual Emergency and Survival Equipment Check:	Valid to 31 July 2014

Triennial Emergency and Survival Equipment Check:	Valid to 31 July 2015	
HUET:	Valid to 31 July 2016	
Crew Resource Management:	Valid to 31 August 2013	
Flying Experience:	Total all types:	3,060 hours
	Total on type:	427 hours
	Last 90 days:	132 hours
	Last 28 days:	71 hours
	Last 24 hours:	4 hours
Previous rest period:	16 hours 15 minutes	

The co-pilot was on day four of his roster pattern, he was scheduled next for three days off. He was given a change of duty on the evening prior to the accident flight; the original flight was of shorter duration.

1.5.3 Crew background, training, experience and duty time

The two pilots had flown together as a crew on several occasions in the preceding six months, the most recent being on 21 June 2013.

The maximum allowable flying duty period for each crew member was 12 hours, with a maximum flying time of 8 hours. At the time of the accident they had completed 4 hours 47 minutes of flying duty.

1.5.3.1 Commander

The commander had been employed by the operator for 16 years as a pilot on operations in support of the oil and gas industry. In May 2010 he undertook differences training to transition from the AS332 to the AS332 L2; the training was completed on 3 June 2010. At the time of the accident he had been flying the AS332 L2 for 3 years. He had operated into Sumburgh Airport on many previous occasions; the most recent was on 31 July 2013. There were no points of note in the commander's flight simulator training records.

1.5.3.2 Co-pilot

The co-pilot joined the operator in July 2012. His previous flying experience was in single engine, single crew helicopters, in which he had also worked as a flying instructor. His training for North Sea operations was carried out by the operator. He completed a Multi-Crew Conversion (MCC) and Crew Resource Management (CRM) training course on 7 August 2012.

On 9 August 2012, he started his training on the EC225 helicopter. His training records included comments which suggested he was experiencing some difficulties on the course, with managing the workload and becoming overloaded at times. On 23 August 2012 he was assessed as ready for the Licence Skills Test (LST); a comment was included in this training report which suggested he could be hesitant to act when required. The LST was completed successfully on 27 August 2012.

Line flying training started on 6 September 2012 and steady progress was reported. The final training flight on the EC225 was on 12 October 2012 and the report indicated that further training was still required. In late October 2012 the UK offshore EC225 fleet temporarily ceased flying operations, as a result of two accidents[10] and therefore the co-pilot's line training on the EC225 was not completed. In December 2012 he started a differences course of training for the AS332 L2 helicopter. Training reports indicated good progress and the final line check was completed on 27 February 2013. It was recorded in the co-pilot's flying logbook that, on 18 June 2013, he acted as PNF for a LOC DME approach to Runway 09 at Sumburgh.

On 10 to 11 June 2013, the co-pilot carried out eight hours of *'Return to Service'* training in the EC225 flight simulator. He did not fly the EC225 at this time, but continued flying the AS332 L2.

The co-pilot stated after the accident that he did not consider that he had received training on the specific duties of the Pilot Not Flying (PNF) in respect of how to monitor the progress of an approach, or of how to monitor the other pilot during an instrument approach. Additionally, he considered that he had not received guidance as to when, as PNF, he should look outside during an approach to acquire the visual references required for landing.

1.5.4 Training and checking

1.5.4.1 Simulator training

Pilot Operator Proficiency Checks were conducted twice a year, usually at a simulator facility located at Aberdeen and contracted to the operator. Mandatory items were covered either annually or, on a rotational basis over a three-year cycle. The mandatory items included non-precision onshore approaches, both with and without the use of the autopilot higher-order modes[11]. The programme did not include training in instrument scan techniques and it was not a requirement.

10 AAIB Aircraft Accident Report No: 2/2014.
11 Autopilot higher-order modes, also commonly referred to as 'upper modes', enable acquisition and/or hold of one or more pilot selected set parameters.

1.5.4.2 Sea survival training

Pilots operating helicopters offshore in support of the oil and gas industry carry out Emergency and Survival Equipment (ESE) training and testing. This comprises three elements which involve theoretical classroom tuition, practical demonstration and testing. This is to ensure that flight crew members have the proper level of knowledge and expertise to exit the helicopter, utilise the on-board safety equipment and survive in the hostile offshore environment.

The three elements are:

- An initial Sea Survival course which includes: exiting the Helicopter Underwater Escape Training (HUET) cabin simulator both on the surface and submerged in the upright and inverted attitudes; boarding the liferaft; use of the life jacket and the other offshore survival equipment. This is followed every three years by a refresher session during which pilots must demonstrate their ability to escape from a submerged HUET cabin simulator, in both the normal upright and inverted attitudes.

- A requirement every three years for pilots to demonstrate an ability to operate the emergency exits fitted to the specific type of helicopter that they fly.

- An annual requirement for pilots to carry out dangerous goods, first aid and safety equipment training in the classroom. They also revise and demonstrate their ability to carry out basic firefighting.

The co-pilot's initial Sea Survival training was conducted at a facility in Aberdeen on 31 July 2012. The commander's three-year refresher training was conducted at the same facility on 18 February 2013.

1.5.5 Flight crew interviews

When interviewed by the AAIB, neither pilot was able to explain exactly what had happened during the latter stages of the approach to Sumburgh, nor why it had happened.

The commander stated he had no recollection of events between the time the helicopter passed 4 DME and just before impact, when he caught sight of the sea surface and attempted a recovery. He stated that it had been his intention to carry out up to two approaches at Sumburgh and then decide on where to divert.

The co-pilot provided information to the investigation on the day following the accident and during subsequent interviews. He had a good recollection of most events, but did not have a complete picture of what had occurred during the latter stages of the approach. He stated, at interview, that he had been relying on the commander's greater experience and had therefore not challenged his comments during the approach briefing.

The co-pilot stated that he had accepted the helicopter's deviation below the published vertical profile during the latter stages of the approach because this was allowed and he had seen other approaches flown in this way. He commented that during the final approach he had noticed the commander looking up at some stage, perhaps seeking external visual reference.

1.5.6 Air Traffic Control personnel

An Air Traffic Controller (ATCO) and an Air Traffic Services Assistants (ATSA) were on duty in the Sumburgh Airport tower at the time of the accident. Both of them were experienced and familiar with local operations. The ATCO had undertaken the required annual Training in Unusual Circumstances and Aircraft Emergencies (TRUCE).

1.6 Aircraft information

1.6.1 General

Manufacturer:	Eurocopter
Type:	AS332 L2 Super Puma
Powerplants:	2 Turbomeca Makila 1A2 turboshaft engines
Manufacturer's serial number:	2582
Year of manufacture:	2002
Total airframe hours:	13,749:44 hrs
Total airframe cycles:	16,243 cycles
Registered owner:	CHC Scotia Ltd
Certificate of Registration:	18 April 2013
Certificate of Airworthiness:	Issued by the CAA on 9 May 2013
Airworthiness Review Certificate:	Expiry 9 May 2014

1.6.2 Aircraft description

The AS332 L2 variant of the Super Puma helicopter was granted a type design certificate by the French national airworthiness authority, the DGAC, in June 1991. Responsibility for the type was subsequently transferred to the European Aviation Safety Agency (EASA). The AS332 L2 is a large twin engine transport helicopter, developed as a derivative product of earlier AS332 models. The fuselage is 16.5 m long, 3.4 m wide and 5 m high. The diameter of the four-bladed main rotor is 16.2 m. It is certified for a maximum seating capacity of 25, though the accident helicopter was configured with 19 passenger seats and two pilot seats. The aircraft has a maximum takeoff mass of 9,300 kg. Performance at 8,000 kg gross weight gives a maximum cruise speed of 153 kt and a maximum rate of climb (at 70 kt) of 1,732 fpm.

G-WNSB was manufactured in 2002. It was originally registered on the Norwegian register as LN-OHI, for passenger transport use in the Norwegian North Sea operation. In 2011 it was transferred to the Cayman Islands register as VP-CHB and operated in a split passenger/SAR role in the Falkland Islands. In April 2013, it was imported onto the UK register as G-WNSB for use as a passenger transport helicopter in the UK North Sea operation[12]. The last recorded flight hours total for the airframe was 13,749 hrs, of which 12,908 hrs were accrued as LN-OHI operating in the Norwegian North Sea area.

1.6.3 Integrated Flight and Display System (IFDS)

The IFDS is an early example of the 'glass cockpit' instrument panel, which replaced traditional individual gauges and dials. The system integrates the computer processing of operating parameters with the pilot displays and auto flight control. To give redundancy it is split into two identical half-systems, one for each pilot, which provides independent cross-monitoring and allows both displays to be fed by the same half-system in the event of a failure. Each half-system subsystem comprises three further subsystems which are:

- Flight Data System - The raw data from aircraft sensors (pressure, temperature attitude, etc) is fed to the Flight Data Computer (FDC) that processes and delivers it to the other sub-systems for use.

- Automatic Flight Control System (AFCS) - Uses the data provided by the FDC to provide automatic flight, when the higher-order modes are selected by the pilot.

- Smart Multifunction Displays (SMD) - Two of these screens display flight and mission data for each pilot.

1.6.3.1 Smart Multifunction Display

The display subsystem has two identical and independent subsystems, which allow reconfiguration in the event of failure. Each consists of a display screen and a Display Control Unit (DCU) with symbol generation function. Apart

12 The aircraft was owned by the same parent operating company since delivery from the manufacturer.

from displaying data to the pilot, the SMDs are also used to concentrate data from the radio navigation sensors, monitor the whole system, manage system reconfiguration, store non-volatile memory (NVM) fault codes for problems within both half-systems and facilitate maintenance through ground self-test routines.

Figure 4

Smart Multifunction Displays[13]

1.6.3.2 Primary Flight Display (PFD)

The PFD, depicted on the right of Figure 4, provides basic flight parameters, autopilot status and ILS indicators on a single screen. The AFCS status indicator is displayed at the top of the PFD screen. The status is permanently indicated, and is dependent upon the autopilot modes engaged. Modes are colour-coded to reflect their status. A higher-order engaged mode appears on the top line, coloured green, with a fixed frame displayed for ten seconds after a change of state. A higher-order armed mode, coloured blue, is displayed on the line below.

Further detail on the airspeed and vertical speed displays are provided in Appendix B.

1.6.3.3 Navigation and Mission Display (NMD)

The NMD, depicted on the left of Figure 4, presents the relevant parameters from specific navigation instruments in a single screen and can be selected to display either a conventional Horizontal Situation Indicator (HSI) compass rose or a forward looking sector mode. The NMD image also displays a radio altimeter indicator (right side), collective pitch indicator and First Limit

13 Shown as depicted in the Complementary Flight Manual.

Indicator (left side). It also displays system reconfiguration and failure warning messages. Groundspeed, from a pilot-selected source, is numerically displayed on the upper left of the display.

1.6.3.4 Automatic Flight Control System (AFCS)

The AFCS consists of two computers, each of which control a half servo valve of the autopilot hydraulic unit on each of the four axes, in basic stabilization and higher-order modes. The second computer also controls an electric trim actuator on each axis. The basic stabilization functions provide attitude control of the helicopter and allow fly-through manual override control. The higher-order modes enable acquisition and/or hold of one or more pilot-selectable parameters. A description of the system and its associated components is provided to flight crew in the manufacturer's Complementary Flight Manual (CFM).

The autopilot can be operated in a number of different modes. When coupled in 3-axes with V/S mode on the cyclic pitch axis, the AFCS will attempt to maintain the selected V/S by adjusting the helicopter pitch attitude, regardless of the airspeed, to the limit of its control authority. (By comparison, the EC225 helicopter, when coupled in 3-axes with V/S mode selected, and the speed decays below 65 kt IAS, the collective pitch will automatically engage on the 4^{th} axis to prevent further airspeed decay.)

The autopilot can be coupled in 3-axes mode with IAS mode engaged on the cyclic pitch axis, in which case the selected IAS will be maintained and the pilot adjusts the vertical speed using the collective pitch lever.

The autopilot is controlled via the Automatic Flight Control Panel (AFCP) (Figure 5), the autopilot control buttons on the cyclic and collective grips (Figure 6) and the Automatic Flight Control Auxiliary Unit (AFCAU).

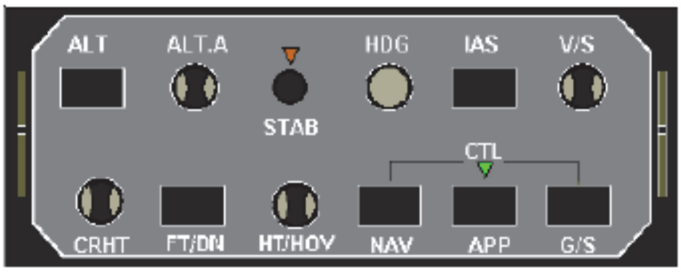
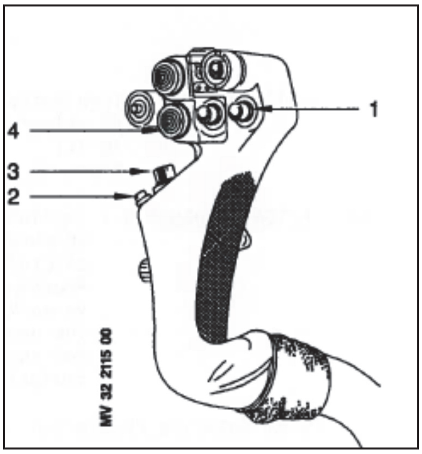


Figure 5

Automatic Flight Control Panel (AFCP)



3.4.1 Cyclic Stick (Fig. 27)

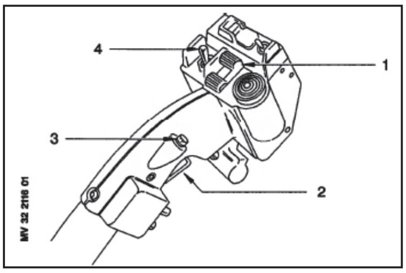
(1) AFCS Pushbutton Function : AP Disengagement.

Utilization : Press to disengage AFCS basic stabilization modes.
Note : Same as STAB pushbutton on AFCP.

(2) Higher-Order Mode Pushbutton Function : Disengage all higher-order modes.

(3) TRIM REL Pushbutton Function : Release trim loads on cyclic axes.

(4) 4-Way TRIM Switch Function : Cyclic axes beep trim control (spring return to center).



3.4.2 Collective Lever (Fig. 28)

(1) TRIM Switch Function : Collective axis beep trim control (spring return).

(2) TRIM REL Trigger Switch Function : Release trim loads on collective axis.

Note : In addition to releasing the trim loads :
- The TRIM REL trigger switch inhibits the FLY-UP function (Autopilot Safety mode).
- In TRANS DOWN mode, any actuation on the trigger for 3 seconds will shift the mode to HT/HOVER (optional modes).

(3) G/A Pushbutton Function : Activates GO-AROUND and TRANS UP modes.

Note : - Engages IAS hold mode on pitch axis and V/S mode on collective axis, for GO-AROUND mode,
- Upward transition from hover on pitch axis and collective pitch channel, for TRANS UP mode.

(4) AP HYD Toggle Switch Function : Cuts off AP hydraulic power.

2.2 Autopilot Subsystem

The autopilot subsystem comprises :

- An Automatic Flight Control System (AFCS) computer,

- An Automatic Flight Control Panel (AFCP),

- Trim actuators and servo-valves on all four axes.

The autopilot subsystem ensures three primary functions :

- Autopilot : basic and higher-order stabilization modes

. IAS
. ALT and ALT.A
. V/S
. CR.HT
. G/S
. HDG
. APP
. LOC
. NAV
. GO AROUND
. F/TDN (optional)
. HT/HOV (optional)
. T.UP (optional)

Figure 6

Autopilot subsystem and stabilisation modes

1.6.3.5 Electrical trim actuators

Trim principle on the cyclic and collective axes

The trim system allows the pilot to set the controls in a specific position, removing the need to apply a constant input force, which can become fatiguing over long periods. It also allows the pilot to release the control safely to perform other tasks. The electrical trim is controlled by the pilot from the cyclic/collective controls or automatically by the AFCS computers.

Two position sensors (Figure 7) report the angular position of the collective control lever. When selected ON, an electromagnetic clutch holds the lever in position until the collective trim release trigger (Figure 8) (or button on the cyclic) is pressed. Releasing the trigger following a movement of the control reactivates the clutch and maintains the lever in the new position. The trim can also be released using a switch on the AFCAU. The lever can still be moved without releasing the trim by pilot input on the control lever; however, once the input force is removed, the collective lever will move back to the previously trimmed position.

The cyclic has a four-way switch which allows the trim to be adjusted in small increments; a similar two-way switch provides this function on the collective.

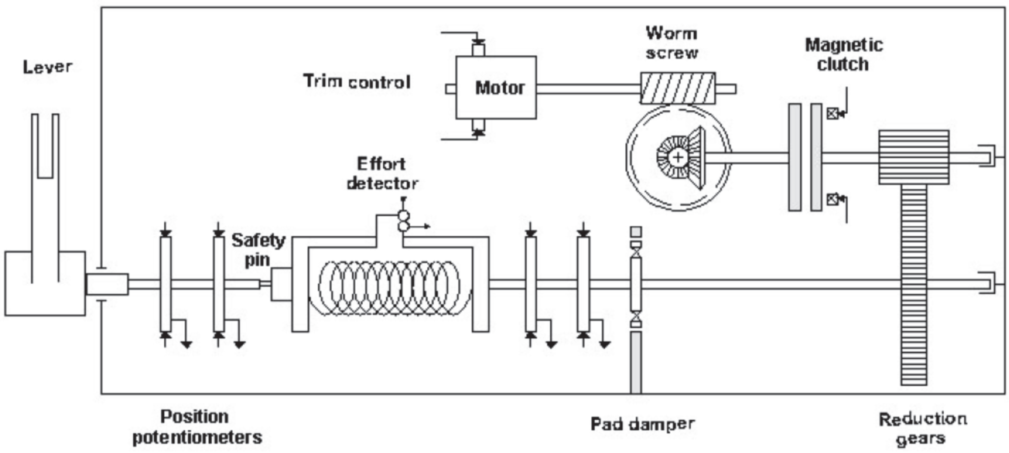


Figure 7

Electrical trim control

Collective trim
release trigger

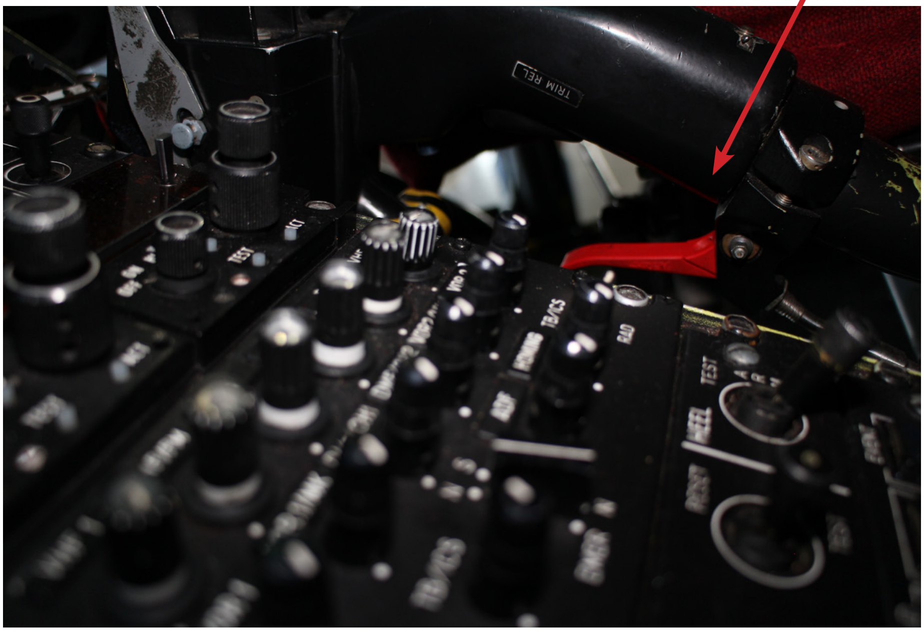


Figure 8

Collective trim release trigger

1.6.4 IFDS system test

The IFDS system has a maintenance test mode, which allows the system to be tested on the ground, and a pre-flight test mode, which ensures the system is ready for operation. It also stores maintenance codes for failures which occur both pre-flight and in-flight. These are normally accessed through a maintenance menu page. Faults are listed by flight sector and record the system in which the fault occurred, a code to identify the fault type, along with the time the fault started and the time it cleared.

1.6.5 Helicopter emergency equipment

1.6.5.1 Crash Position Indicator (CPI)

The helicopter was fitted with an externally-mounted, deployable Type 15-503-134 CPI system. The CPI is a type of Automatically Deployable Emergency Locator Transmitter (ADELT), which is a primary radio location aid designed to activate automatically in the event of an accident so that the helicopter and its occupants can be located quickly. G-WNSB was initially equipped with a Type 113 CPI at manufacture, but this was retrospectively modified to a Type 15-503-134 standard CPI system.

1.6.5.1.1 CPI system description

The CPI system normally consists of a radio beacon, a beacon release unit (BRU), a system interface unit (SIU), a cockpit control panel, a water-activated switch and an aircraft identification unit with an integrated g-switch. This modification standard also included a beacon deployment control (BDC) unit adjacent to the BRU. The BDC provides and controls the power supplies for automatic activation and release of the beacon should the CPI system wiring be severed. The aircraft identification unit contains NVM which, in the event of a deployment, records a code identifying the reason why the beacon deployment has been triggered. The CPI beacon is externally mounted on the left side of the tail boom, immediately aft of the main cabin and the helicopter transport joint.

1.6.5.2 Liferafts

The AS332 L2 is equipped with two double-sided Survitec/RFD Type 18R MK3 inflatable liferafts. Each has a deployable canopy and capacity for 18 occupants, with a nominal overload capacity of 27. They are mounted, together with their inflation systems, in the forward sections of the helicopter's sponsons, on either side of the fuselage.

The liferafts can be deployed by any one of three methods:

- Operation of a D-ring, positioned near the top of the bulkhead behind each flight crew position, which deploys and inflates the liferaft on the corresponding side of the helicopter.
- Operation of deployment handles, positioned externally in recesses on each side of the helicopter just aft of each cabin door, which deploys and initiates inflation of the liferaft on that side of the helicopter.
- Removing either liferaft cover from its sponson and pulling the inflation D-ring inside.

Following an accident to a Norwegian-registered AS332 L1 Super Puma in 1997, concern was raised about the ability of survivors to deploy the liferafts from a fuselage that was floating inverted. A modification was designed by the maintenance provider for the operator involved, to install additional D-ring handles on the underside of each sponson which deployed the liferaft on the corresponding side. The modification was approved by the Norwegian CAA and certified as an optional modification. The Norwegian oil and gas industry subsequently adopted the modification as a minimum standard for helicopters used to service their installations, and all AS332 helicopters working in the Norwegian offshore sector had this modification installed.

The modification was not used by operators in the UK sector. However, as G-WNSB was originally flown by the Norwegian subsidiary of the operator, the modification had been installed and had not been removed. The Norwegian CAA had 'grandfather rights' for all modifications approved by them prior to joining EASA as an associate member. No additional modification paperwork was therefore required to operate the aircraft with the modification in place in another EASA member state, such as the UK. As a consequence, although the original temporary Flight Manual revision for the modification was still present, the aircraft applicability referred to the original Norwegian registrations, not G-WNSB. UK pilots were therefore not informed of the presence of the additional handles on the aircraft.

The additional deployment handles were non-standard for UK sector helicopters, so they were not included in the passenger pre-flight safety video. The passengers were therefore not aware of their existence.

The co-pilot reported that he was aware they were fitted, but only as a result of an informal conversation with another pilot who worked as an instructor for all the operator's subsidiary companies, including the one based in Norway.

The main features of the liferaft are shown in Figure 9. A rescue pack is attached to each liferaft by a bridle/rescue pack line. The pack contains a number of items, including flares, water, anti-seasickness tablets, an '*Immediate Action*' survival leaflet, an aircrew survival flip-card and a Survival Emergency Locator Beacon. The mooring lines are attached to the helicopter by weak link connections which automatically release if the helicopter sinks.

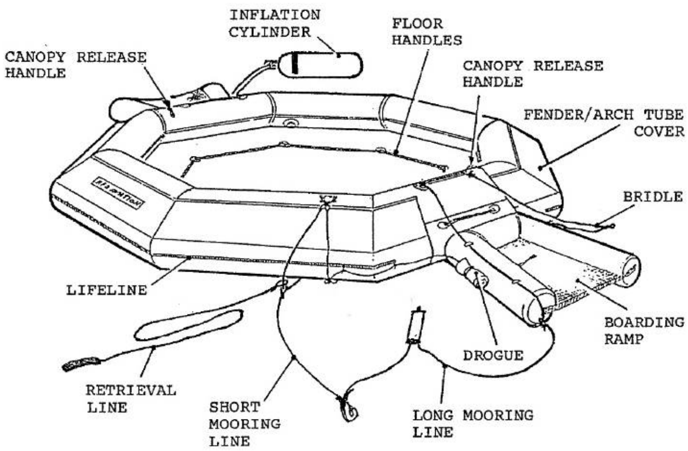


Figure 9

Type 18R MK3 liferaft showing the various lines

1.6.5.3 Aircraft exits

The passenger cabin is fitted with two large main passenger doors, one on each side of the fuselage, approximately midway along the length of the cabin. Normal access for embarkation and disembarkation of passengers is through the left main door, but both doors are available for emergency use.

For normal operation, the doors initially move outboard from their closed positions in their apertures. They then slide forward, on rails along the outside of the cabin, towards the fully open position. In this position they fit closely alongside the cabin outer skin, covering two cabin windows, one of which is an emergency exit, thereby denying their use in an emergency[14].

The cabin doors can be jettisoned during an emergency evacuation. To achieve this, a D-ring jettison handle is located in a recess on the cabin wall beneath a transparent cover, behind the first row of seats adjacent to the door (Figure 10). The D-ring is pulled to release the hinge pins from their attachments; the door must then be pushed out and drops away under gravity. External jettison handles are positioned in a recess forward of each door aperture below the window.

The helicopter cockpit has two hinged exit doors, one on either side of the fuselage. The doors are jettisoned in an emergency evacuation by operating an external or internal jettison handle located on the forward frame of the door aperture; this releases the door's hinge pins. Once the jettison handle has been operated, the doors must be manually pushed to separate them from the helicopter.

The helicopter is fitted with four large windows and eight smaller windows, distributed symmetrically along the sides of the cabin. The larger windows are at the forward and aft ends of the cabin, with the smaller windows located in-between. Two of these windows form part of the main cabin door. The large windows are designated emergency exits, but all of the windows can be removed to allow egress. This is achieved by pulling on one of two release tabs (one internal, one external) that release the seal keys holding in place the rubber seal around the Plexiglas panel. A protective cover must first be removed to access the internal tab. When either of the seal keys is released, the window can be pushed out.

14 Although the window exits are covered when the door is slid open, the remaining emergency exit meets the regulatory requirements on the minimum number of emergency exits.

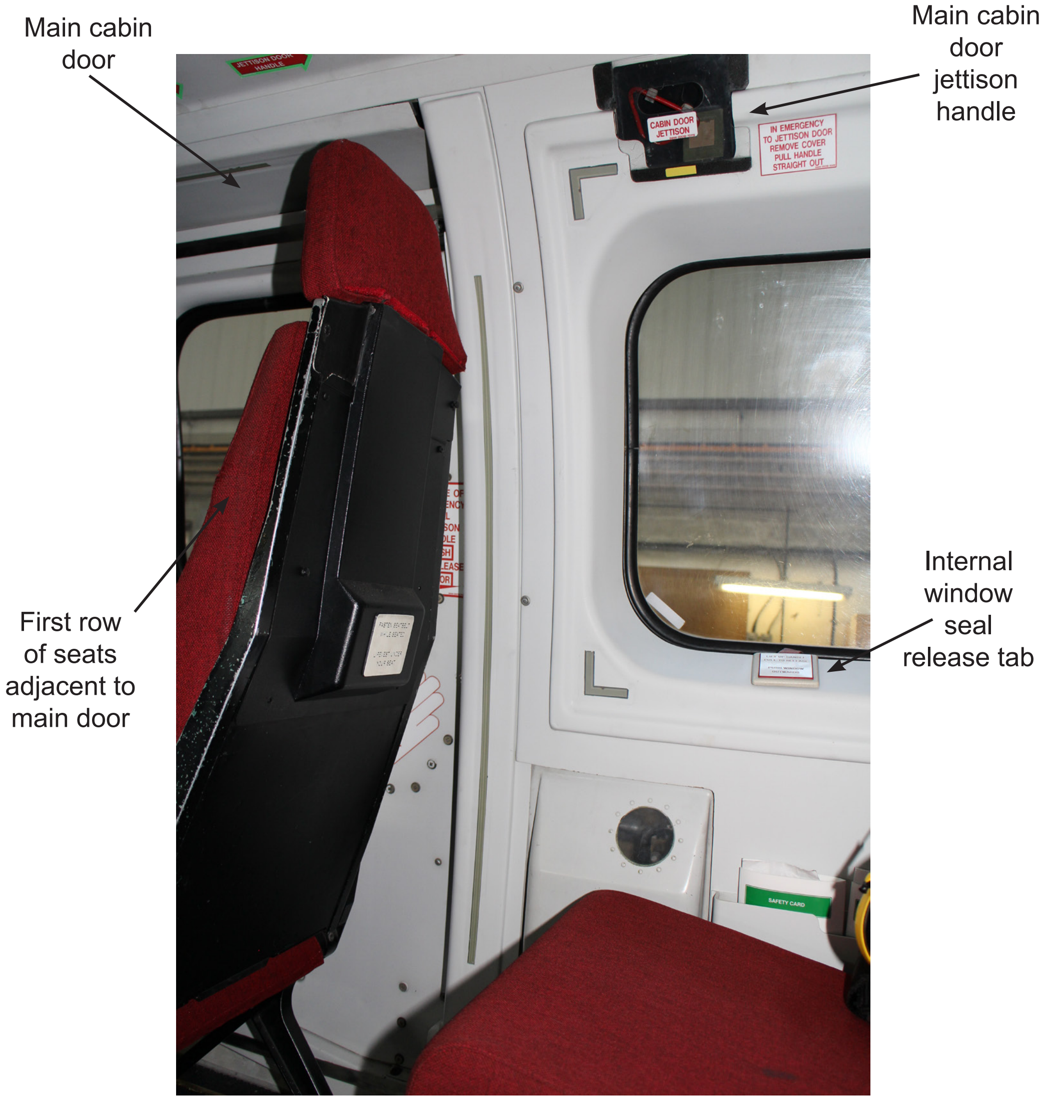


Figure 10

Main door internal jettison handle position

1.6.5.4 Flotation equipment

The helicopter was equipped with an Emergency Flotation System consisting of four cylindrical float bags. The stowed float bags are externally mounted, one attached on either side of the helicopter's nose and one attached on the outer edge of each sponson. When deployed, the four floats are inflated by compressed helium contained in three bottles. The system must be armed by selecting a switch on the centre console. Once armed, inflation is initiated automatically following water immersion, or manually, by pressing a button on the collective control or on the centre console.

1.6.6 Maintenance information

1.6.6.1 Deferred defects

The helicopter had one open deferred defect for an unserviceable fuel booster pump. This was not relevant to the accident.

1.6.6.2 Maintenance history

Review of the maintenance records for G-WNSB from the preceding months highlighted a number of defect entries relating to problems with the IFDS. The majority of these reported failures of either AFCS 1 or 2 were addressed by replacing the appropriate AFCS computer. After a number of computer changes, a fault was traced to the AFCS arm/disarm switch on the AFCAU panel, which was replaced. On 12 July 2013, FDC 1 and 2 were reported as having failed in-flight. The fault could not be replicated on the ground, so the defect was cleared following a recalibration. The final defect report occurred on 19 August 2013, when AFCS 1 failed in flight. The two AFCS computers were interchanged for evaluation, but no additional failures were reported prior to the accident flight.

1.6.7 AS 332 L2 IFR operating limitations

IFR OPERATING LIMITATIONS

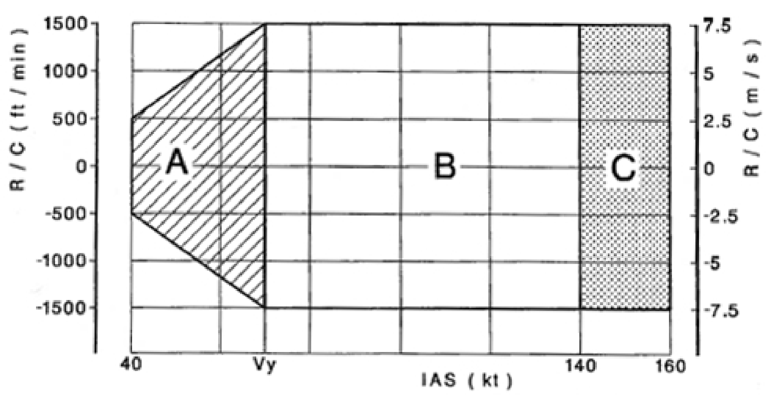


Figure 5

(A + B + C) = Complete IFR flight envelope

CAUTION 1 : ZONE (A) IS AUTHORIZED PROVIDED THAT THE IAS HIGHER ORDER MODE IS ENGAGED.

Figure 11

Instrument Flight Rules (IFR) flight envelope

The minimum operating airspeed for flight under Instrument Flight Rules (IFR) without the IAS higher-order mode engaged is Vy, 70 KIAS. With IAS mode engaged the helicopter may operate in Zone A, where the minimum permitted airspeed is 40 KIAS (Figure 11).

1.7 Meteorological information

1.7.1 Synoptic situation

Shetland was situated in an area of strong east to south-easterly airflow, with a trough line to the east and north-east and a cold front lying across the western side of Scotland.

1.7.2 Sumburgh forecasts

Terminal Area Forecasts (TAFs) provided by the Met Office were available to the crew, but it was not established which issue time of TAFs were on the helicopter at the start of the final sector.

The forecast issued at 1100 hrs indicated strong south-easterly surface winds at Sumburgh, a broken cloud base of 1,000 ft with temporary deteriorations to 600 ft. Visibility was forecast to be generally 10 km with possible deteriorations to 4,000 m in mist. Three amended TAFs were issued before the next scheduled TAF at 1700 hrs. These were at 1120 hrs, 1355 hrs and 1452 hrs and indicated that there could be periods of reduced visibility, down to 4,000 m, and a lower cloud base, down to 400 ft.

1.7.3 Aftercast

The Met Office provided an aftercast in which the available meteorological data was reviewed. The summary of their findings was:

> *‘Shetland and the Oil Rigs to the east were in a strong southeasterly surface flow, and the observations (including marine observations) show that surface winds were generally southeasterly with average mean speeds around 20 KT. The 1720 UTC Sumburgh METAR reported a wind of 140 degrees at 17 KT. The Lerwick radiosonde ascent showed that wind direction was consistent with height at 1200 UTC, but that winds increased with height, reaching speeds of around 40 KT at approximately 2000 ft. This is consistent with the estimated gradient wind taken from the surface pressure chart in Figure 9.*

> *The analysis of satellite images, surface METARs, observations and the Lerwick 1200 UTC ascent has shown that there was a good deal of low cloud and mist in the vicinity of Shetland, and this had been forecast in the TAFs and the F215 chart. The 1720 UTC Sumburgh METAR was reporting a visibility of 2800 M in mist, with a scattered layer of stratus at 200 ft, and a broken layer at 300 ft.*
>
> *Visibility and cloud base conditions were more favourable near the oil rigs to the east of Shetland, as they were in an area of mainly clear skies.'*

The Met Office also provided comment on the reasons why the original forecast may not have well reflected the actual conditions. They stated that predicting changing cloud base conditions was challenging, as the area was data-sparse in terms of observations. The Met Office uses models and satellite pictures as a basis for forecasts. Satellite pictures showed some high cloud which reduced the effectiveness of satellite imagery to see the extent of low cloud in the area.

1.7.4 Sumburgh actual weather reports

Meteorological Aerodrome Report

METARs for Sumburgh Airport were issued every 30 minutes. The reports showed weather conditions deteriorated after 1420 hrs, with a lowering cloud base and reducing visibility. The last report before the time of the accident, issued at 1650 hrs was: visibility 2,800 m, few cloud at 200 ft, broken cloud at 300 ft, temperature 15°C, dew point 14°C and pressure 1014 hPa.

Locally recorded weather data

The Met Register log for Sumburgh Airport showed that, sometime between 1120 hrs and 1150 hrs, there had been a deterioration in the weather conditions from a 700 ft cloud ceiling to a 400 ft cloud ceiling.

1.7.5 Automatic Terminal Information Service (ATIS)

The crew listened to two different ATIS broadcasts on the flight to Sumburgh:

- Information 'W' at time 1620 hrs reported: Runway 09, surface wind 150° at 18 kt, visibility 4,000 m haze, scattered cloud at 300 ft, broken cloud at 500 ft, temperature 15°C, dew point 14°C and pressure 1014 hPa.

- Information ‘X’, issued at 1650 hrs reported: surface wind from 150° at 12 kt, visibility 2,800 m in mist, few cloud at 200 ft, broken cloud at 300 ft, temperature 15°C, dew point 14°C and pressure 1014 hPa.

1.7.6 Other airports in the region

Scatsta

The planned alternate airport for the flight was Scatsta (EGPM). The forecast conditions there were similar to those at Sumburgh and there was a similar deterioration in the actual weather. At 1620 hrs the visibility was 5,000 m with broken cloud at 700 ft, temperature 16°C, dew point 15°C and pressure 1012 hPa. By 1720 hrs the visibility had reduced to 4,700 m and the cloud was overcast at 300 ft.

Kirkwall

The weather at Kirkwall Airport, (EGPA), 74 nm to the south, at 1720 hrs was surface wind from 190° at 13 kt, visibility 1,500 m in mist with fog in the vicinity, broken cloud at 100 ft and broken cloud at 200 ft.

Wick

The weather at Wick Airport, (EGPC), 102 nm to the south-south-west, at 1720 hrs was surface wind from 160° at 7 kt, visibility 7,000 m and few cloud at 4,500 ft.

1.7.7 Departure airport

The weather conditions at Aberdeen Airport, (EGPD), at the time of departure were: surface wind from 140° at 8 kt, visibility 7,000 m, few cloud at 1,300 ft. There was a temporary deterioration for several hours during the early afternoon, but by 1720 hrs the conditions had improved to: surface wind from 170° at 12 kt, visibility in excess of 10 km and scattered cloud at 1,300 ft.

1.7.8 Sea surface conditions

The sea state was reported as ‘slight to moderate’ by one of the helicopters attending the accident scene. The sea surface temperature was 13°C.

1.8 Aids to navigation

1.8.1 Ground-based navigation aids

Sumburgh Airport is equipped with an Instrument Landing System (ILS) transmitting on frequency 108.500 MHz, identification code 'SUB', which is used for the Runway 09 Localiser DME instrument approach. There is a note in the United Kingdom Aeronautical Information Publication (UK AIP) to ignore any glidepath indications observed. The localiser is offset 2.2° to the south and intercepts the extended runway centreline 1,400 m from the Runway 09 threshold. The Distance Measuring Equipment (DME) 'SUB' is frequency paired with the ILS 'SUB' and indicates zero range at the runway threshold. The applicable approach minima for G-WNSB for this approach were: 300 ft amsl and 1,000 m visibility.

A Very High Frequency Omni-Range VOR/DME 'SUM', frequency 117.35 MHz, is located on the airfield; this DME reads 0.6 nm at the threshold of Runway 09. There is a non-directional beacon (NDB) transmitting on 351.0 kHz identification code 'SBH' located on the airfield.

Runway 27 is equipped with a Category 1 ILS approach facility, the decision height for which is 270 ft amsl.

1.8.2 Helicopter navigation aids

The helicopter was equipped with a Flight Management System (FMS) for area navigation using Global Positioning System (GPS) data. The other on-board navigation systems consisted of one ADF receiver and two VOR/ILS receivers.

1.9 Communications

Records of radio transmissions between the helicopter and Sumburgh ATC were available from the ATC recording media. Radio transmissions were also recorded on the Combined Cockpit Voice and Flight Data Recorder (CVFDR).

Sumburgh Radar, frequency 131.30 MHz, provides radar services for offshore sectors and for approach radar. The services are provided by an Air Traffic Services Unit located at Aberdeen.

Sumburgh Tower operates on frequency 118.25 MHz, with a Designated Operational Coverage (DOC) of 30 nm/10,000 ft. The emergency frequency, 121.50 MHz, is also monitored in the tower.

There is no radar relay facility in the tower for the controller to monitor the location of aircraft. It is normal procedure for the tower controller to request a range check from an inbound aircraft at 4 nm. The controller then has to ensure that the roadway crossing the Runway 09 undershoot is closed, before issuing a landing clearance for Runway 09/27. This is achieved by means of two-way telephone communication with an operator, located adjacent to the road crossing, who is responsible for closing the barriers and then notifying ATC.

1.10 Aerodrome information

1.10.1 Sumburgh Airport

Sumburgh Airport (EGPB) is a coastal airport located at the southern tip of Shetland. The main instrument runway is orientated 09/27 and the approach path at each end is over the sea. The UK AIP Sumburgh aerodrome chart is included at Appendix C.

The threshold of Runway 09 is 135 m from the sea and is at an elevation of 20 ft amsl. Runway 09 is equipped with 110 m of high intensity approach lighting, comprising one flush inset crossbar plus four double flush inset lamps. A public road crosses the Runway 09 undershoot immediately before the painted threshold. The road is closed by staffed barriers prior to any arrivals or departures on Runways 09/27.

1.10.2 Alternate airport, Scatsta

Scatsta Airport (EGPM), the designated alternate airport for the flight, is located on Shetland, 33 nm to the north of Sumburgh Airport. It has a single runway orientated 06/24. Runway 24 has two available instrument approaches: a Surveillance Radar Approach (SRA) with an applicable MDA of 550 ft, and a Non-Directional Beacon (NDB) approach with an applicable MDA of 740 ft.

1.10.3 Other airports in the region

Kirkwall Airport (EGPA) is located 74 nm to the south-west of Sumburgh Airport. It is equipped with ILS approaches for Runway 09 and Runway 27.

Wick Airport (EGPC) is located 102 nm to the south-south-west of Sumburgh Airport. It has a single runway orientated 13/31. Runway 13 and Runway 31 are each equipped with a VOR/DME approach procedure.

Aberdeen Airport is located 163 nm to the south of Sumburgh Airport. The main instrument runway is orientated 16/34; each direction is equipped with an ILS approach. There had not been any scheduled non-availability periods for the ILS since runway extension work was undertaken in 2011.

Inverness Airport (EGPE) is located 165 nm to the south-south-west of Sumburgh Airport.

1.11 Flight recorders

1.11.1 Introduction

The helicopter was equipped with a CVFDR[15] which recorded the most recent 78 hours of flight data and two hours of audio into a crash-protected solid state memory. A complete data and audio record of the accident flight was available, with the audio record commencing as the helicopter approached the Alwyn North platform to land. The flight data and audio records ended when the helicopter struck the surface of the sea. The CVFDR is located in the tail boom and begins recording whenever the aircraft battery is selected on. It is stopped automatically if the helicopter lands on water, by the activation of an immersion switch located in the right sponson, or if an acceleration of 6 g or greater is sensed by an inertia switch.

The CVFDR audio record consists of the commander and co-pilot communications, radio transmissions and passenger announcements recorded into two channels, and ambient sound from a cockpit area microphone (CAM) recorded to a third channel. A transcript of the CVFDR accident flight is provided in Appendix D. Non-operational conversations during the flight are omitted.

Salient parameters from the CVFDR include: indicated airspeed, collective pitch position, engine torques, pitch and roll attitude, pressure altitude, radio altitude, DME distance and the status and selected modes of the AFCS. The selected vertical speed and ALT.A parameters were recorded on the CVFDR once every 64 seconds. The indicated airspeed parameter was recorded once every second and to a resolution[16] of 1 kt; engine torques were recorded once per second and collective pitch position was recorded twice per second. DME distance was recorded to a resolution of 1 nm.

The helicopter was also equipped with a Quick Access Recorder (QAR), installed in the aft baggage bay. This recorded the same parametric data as the CVFDR onto a removable media card that was used to support the operator's Flight Data Monitoring (FDM) programme (see Section 1.17.6 of this report). Neither the QAR nor the media card were recovered.

1.11.2 Additional sources of recorded information

Additional sources of information included: primary and secondary radar data from Sumburgh and ground-based radio telephony (RTF) recordings of communications between the crew and controllers during the flight. The radar record ended shortly before the helicopter struck the surface of the sea.

15 Curtiss-Wright Controls Avionics & Electronics manufactured Multi Purpose Flight Recorder (MPFR), part number D51615-102-641, serial number 254012-005.
16 The smallest change in a parameter.

1.11.3 Approach to Alwyn North platform

The crew became visual with the Alwyn North platform at a range of about 3 nm. The co-pilot was Pilot Flying (PF) and he positioned the helicopter onto a downwind leg with the autopilot set to 3-axes with Heading (HDG) and Altitude (ALT) modes engaged. As the helicopter turned onto the final approach course at about 1.7 nm from the platform, the collective pitch was lowered and the airspeed gradually started to reduce from 100 kt.

As the airspeed reduced to about 70 kt, the commander advised the co-pilot, who responded by increasing the collective pitch. With the helicopter at about 600 ft the airspeed continued to reduce to a minimum of 62 kt, before increasing. The co-pilot and commander then had a brief conversation regarding the approach airspeed, with the co-pilot stating "THE CAPTAIN THE OTHER DAY WAS EH REALLY WANTING IT RIGHT BACK BUT VY'S PROBABLY GOOD AT THIS POINT ISN'T IT". The commander responded by stating that he would fly this part of the approach at "VY PLUS TEN" (Vy = 70 kt). The approach continued to an uneventful landing.

1.11.4 Accident sector

Figure 12 is a time series plot of salient parameters during the latter stage of the approach to Sumburgh. The following paragraphs provide supplementary parametric information to that contained in Section 1.1 History of the flight. Figure 13 provides a time series plot of the vertical descent path with the CVFDR transcript incorporated.

All times are referenced to UTC (local time was UTC+1 hour). Altitudes are above mean sea level (amsl), unless the height of the helicopter is defined by its radio altimeter (RA). Engine torque is referenced as the combined torque value of both engines.

At 3 nm DME the helicopter was at 1,050 ft, 20 ft above the vertical profile, and its airspeed was 110 kt. The selected vertical speed was 664 fpm. Shortly after, at 1715 hrs, the helicopter was cleared to land. The collective pitch was reduced and engine torque stabilised at about 18% (Figure 12, Point A), with airspeed reducing gradually at a rate of about 1 kt/sec.

At 630 ft the airspeed had reduced to 80 kt, at which point there was an increase in collective pitch (Figure 12, Point B), with engine torque increasing from 18 to about 24%. The airspeed continued to reduce gradually at a rate of just less than 1 kt/sec.

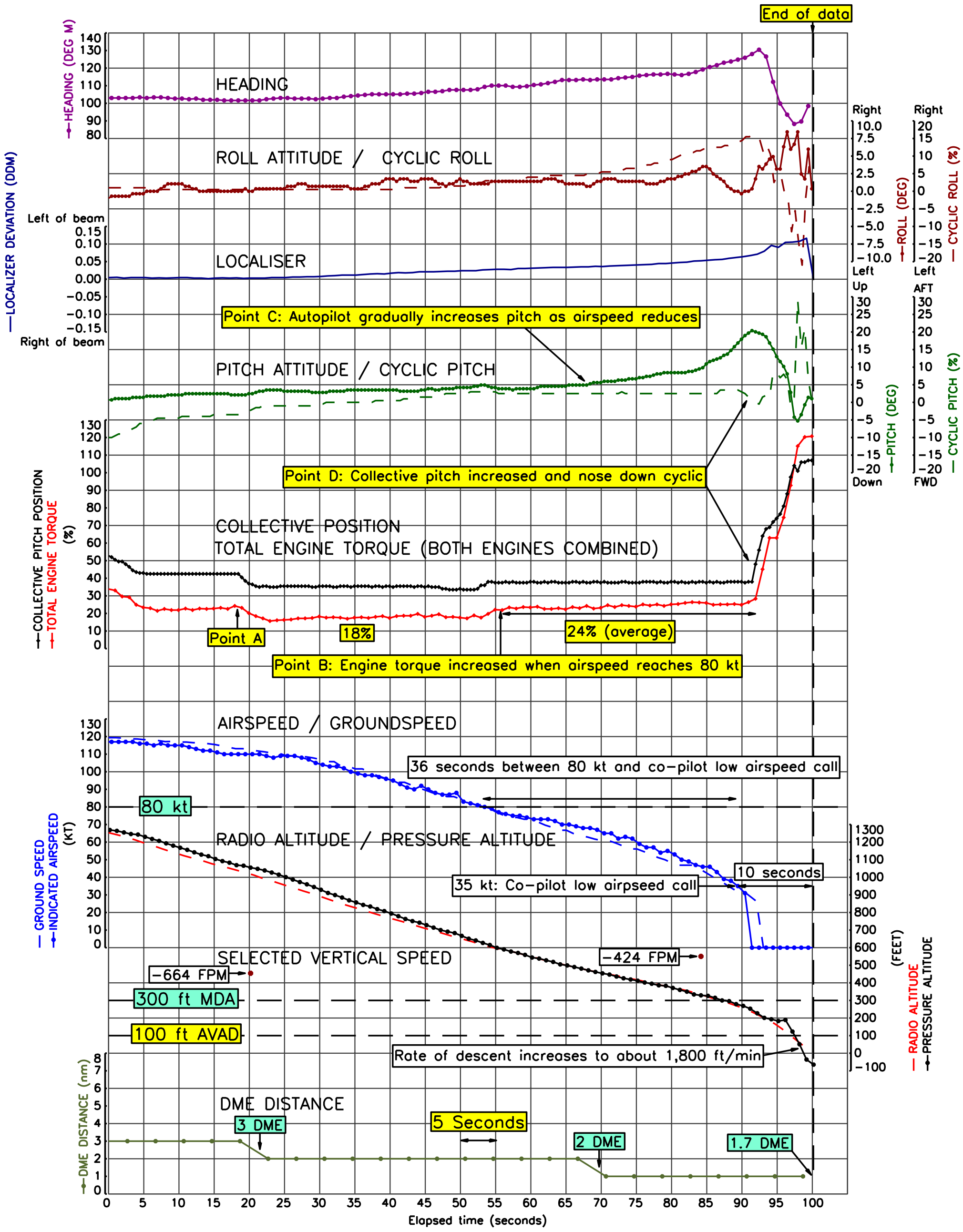


Figure 12

G-WNSB vertical descent path, engine torque and airspeed from 1,200 ft

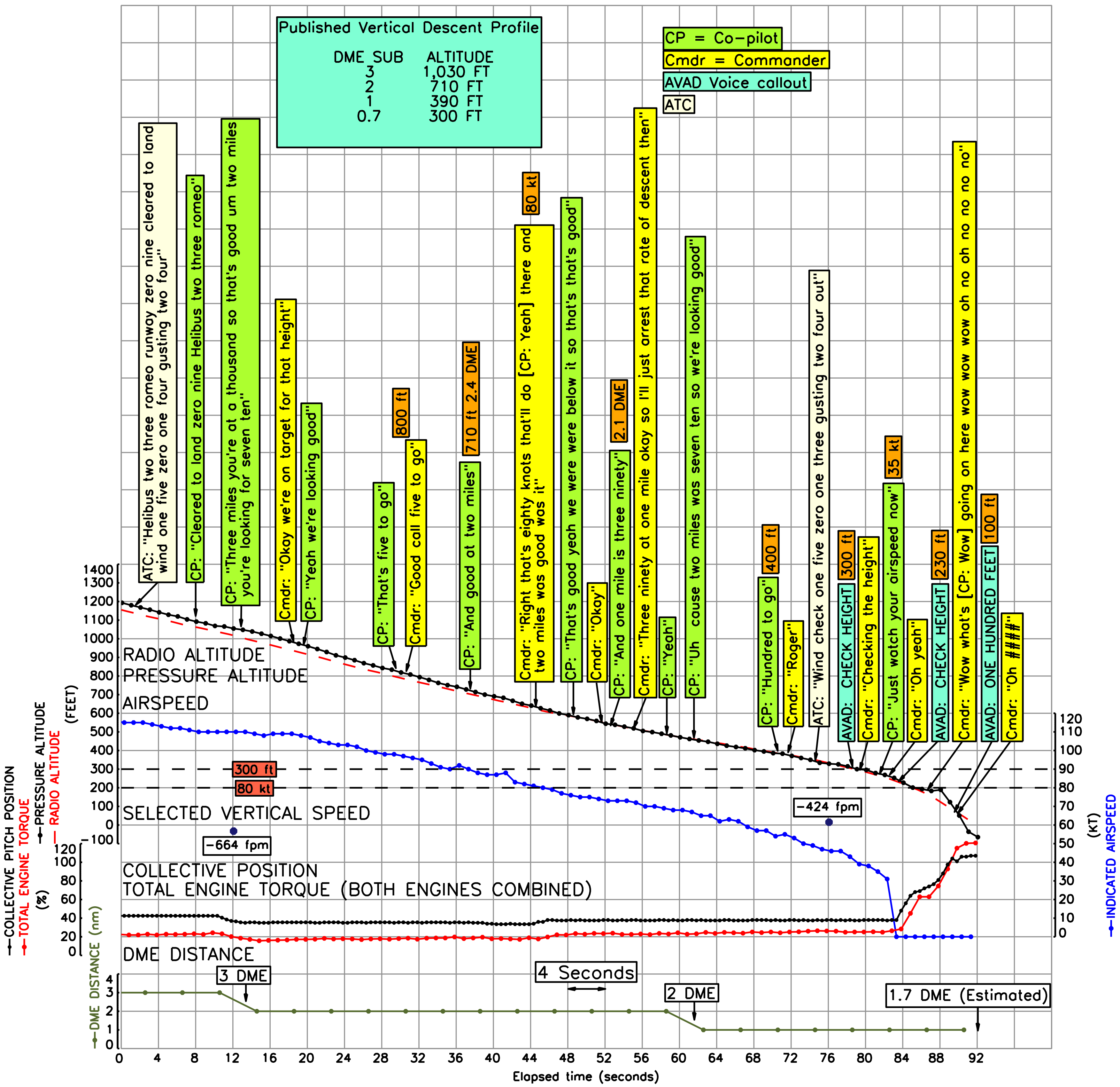


Figure 13

CVFDR record from 1,200 ft

Intentionally left blank

As the airspeed reduced, the autopilot gradually started to increase the nose-up pitch attitude (Figure 12, Point C), to maintain a calculated vertical speed of about 550 fpm. At 2 nm DME the helicopter was at 460 ft, (250 ft below the published vertical descent profile) and the airspeed was 67 kt. The airspeed started to reduce more rapidly, with the rate of decay increasing to about 1.3 kt/sec.

As the helicopter descended to 340 ft, the selected vertical speed was recorded at 424 fpm. A few seconds later, at 300 ft, the AVAD 'CHECK HEIGHT' callout occurred; the airspeed was now about 40 kt, but there was no increase in collective pitch to prevent the airspeed from decreasing further. Two seconds later, at a height of about 260 ft RA and an airspeed of 35 kt, the co-pilot alerted the commander to the low airspeed. The helicopter's pitch attitude was now 20° nose-up and its rate of descent had increased rapidly to about 1,000 fpm. The commander responded almost immediately, increasing the collective pitch and moving the cyclic forward (Figure 12, Point D). This was coincident with a second 'CHECK HEIGHT' callout. The helicopter continued to descend and at a height of about 230 ft RA the airspeed reduced to less than 30 kt[17].

The engines responded to the change in collective pitch position, with engine torque increasing at a rate of about 14% per second. However, the descent rate continued to increase whilst the helicopter first yawed quickly to the left at up to 19°/sec, and then back to the right at up to 14°/sec, whilst also rolling to 8° right bank, with the nose progressively pitching down.

As the helicopter descended to 100 ft, the AVAD 'ONE HUNDRED FEET' audio alert sounded. At the same time the cyclic stick was moved aft and the helicopter started to pitch up. The engine torque was now at a maximum of 120%. The helicopter impacted the surface of the sea approximately 1.7 nm from the threshold of Runway 09 (Figure 14), yawing to the right and rolling towards a level attitude from about 6° right bank and with the nose about 1.4° up. The time was 1717 hrs. The peak recorded normal acceleration at impact was about 5.5 g.

17 When the indicated airspeed is less than 30 kt, it is not recorded on the CVFDR.

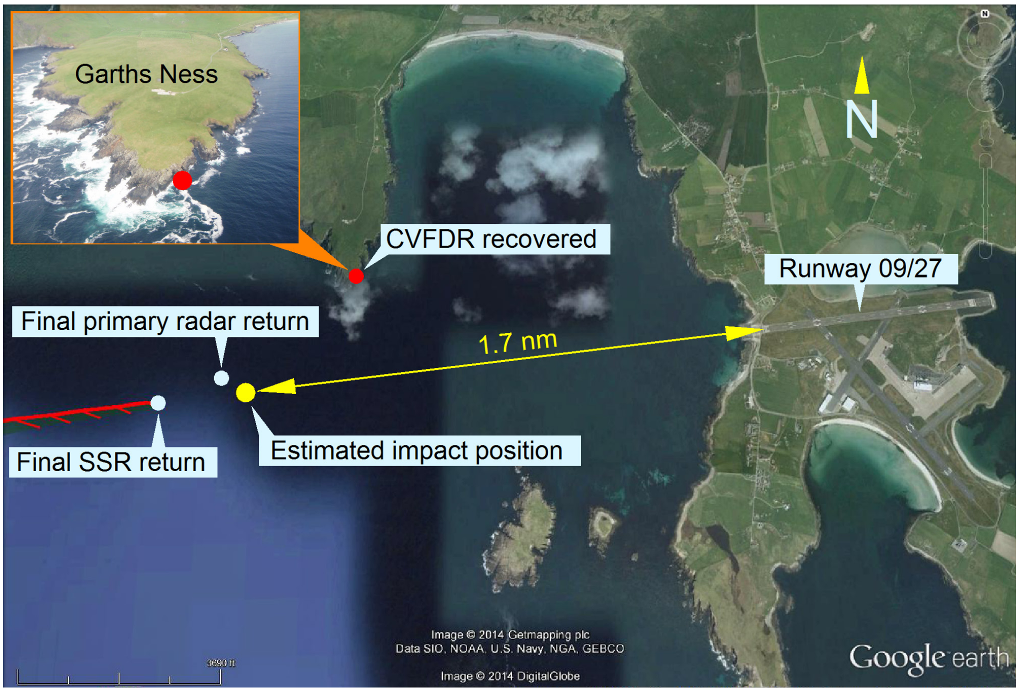


Figure 14

G-WNSB estimated impact position

1.11.5 Commander's reference to speed and CVFDR parameter validity

During the approach the commander and co-pilot set the navigation source selection on their Data Control Unit (DCU)'s to the V/L2 and V/L1 positions. In this configuration, groundspeed displayed on the NMD's is derived from the helicopter's slant range to the DME transponder. Groundspeed recorded on the CVFDR is acquired from the navigation computer; the selection which determines the source of this information is not a recorded parameter but it is likely to have been GPS. The helicopter's flight path during the final approach meant that the difference between a ground track and slant range derived groundspeed would have been no more than about 1 kt.

When the descent started at 6.4 nm DME, the commander stated "THAT'S NINETY EIGHT KNOTS AND POWER COMING OFF". At this time the recorded airspeed on the CVFDR was 110 kt and recorded groundspeed was 111 kt. Later during the approach, when the helicopter was at about 3.8 nm DME, the commander had further stated that the groundspeed was 113 kt. The groundspeed parameter recorded on the CVFDR at this time was 119 kt.

Analysis of radar data, which provides an independent verification source of the helicopter's groundspeed during the approach, in conjunction with derived wind data, confirmed that at 6.4 nm DME both the groundspeed and airspeed were consistent with the data recorded on the CVFDR. Further, when the helicopter was at 3.8 nm DME, the radar-derived groundspeed was also consistent with the CVFDR record of 119 kt.

Later during the approach, at about 2.3 nm DME, when the commander stated "RIGHT THAT'S EIGHTY KNOTS, THAT'LL DO THERE", the CVFDR record was consistent with a recorded value of 80 kt. Also, shortly before impact with the sea, the co-pilot had brought to the attention of the commander that the airspeed was low, which was consistent with the low airspeed value recorded on the CVFDR.

Analysis of the 78-hour CVFDR record further identified no evidence of a fault with the operation of the flight recording system or recorded parameters. Additional information regarding how the validity of parameters is tested and identified by the flight recording system is provided in Appendix E.

1.12 Wreckage and impact information

1.12.1 General

Following the initial impact with the water, the flotation bags deployed sufficiently to keep the inverted fuselage on the surface. However, evidence from the CPI, witness photographs and the final location of the tail section confirmed that it detached from the fuselage during the initial impact. Data from the CVFDR showed that the main and tail rotor blades were still rotating with high energy at impact and would therefore have been significantly damaged by contact with the water; this was supported by their 'as found' condition.

In the hours following the accident the floating wreckage (Figure 15) drifted north-east towards the tip of Garth's Ness headland, to the west of Sumburgh Airport. Repeated contact with the rocks on the headland resulted in the forward and rear fuselage sections detaching. Each engine also separated from the fuselage, along with the gearbox and rotor mast/head. Only the rear section of fuselage stayed afloat, supported by the single flotation bag that remained undamaged.

The remnants of the forward fuselage section were found lodged in crevices in the rock at the base of the cliffs. A combination of the prevailing current, wave refraction around the headland and the nature of the rocks forming the cliffs, resulted in the wreckage becoming caught in the surf break zone along the south-east side of the tip of the headland. This had the combined effect of causing extensive damage to the wreckage, but also created very difficult and potentially dangerous conditions for wreckage recovery. Despite attempts to use a Remotely Operated underwater Vehicle (ROV) from the salvage ship, items of wreckage could only be recovered in a period of relatively calm weather and sea conditions, during short duration dives by a team of inshore divers utilising lift bags. As such, the recovery of wreckage from the forward section of the fuselage was limited.

The items of interest which were recovered included: the tail section, containing the CVFDR (found further south at the tip of the headland), two SMD screens containing stored fault code data, both engines and the main gearbox and rotor head. A number of smaller items, such as sections of rotor blade and the right sponson, were washed up onto the coast at low tide and were collected from the shore.

Figure 15

G-WNSB wreckage contacting coastline

1.12.2 Initial wreckage examination

The recovered items of wreckage were transported to the AAIB's facilities for examination. The CVFDR data showed that the engines were producing power and both rotors were operating at normal speed at impact. This was confirmed by an external inspection of the engines, which had suffered impact damage only. The main gearbox and rotor shaft were also inspected internally using the inspection port in the bottom of the gearbox. Whilst there was significant corrosion present from contact with seawater, no anomalies were identified.

1.12.3 Recovered fault code data

The NVM chips contained within the recovered SMD screens were extracted and the data recovered with the assistance of the BEA and the helicopter manufacturer in France. Data was recovered from three sectors where fault codes were recorded. A table of recovered fault codes is contained in Appendix F.

The manufacturer confirmed that the fault data relating to sector 3042 was from the accident flight. The OCC_TIME column referred to the time when the fault first appeared from electrical power-up of the helicopter system at the start of the flight. The 'DIS_TIME' column referred to the time when the fault cleared. The zeros in this column for the last four faults show that they were present at the time when power to the system was lost during the impact.

The manufacturer stated that the fault codes which were present at the end of the flight were similar to those seen in previous accidents and related to the way in which the flight control system of the helicopter failed as it struck the water. As such, they were not indicative of any pre-existing fault that may have been causal to the accident.

1.12.4 Review of helicopter performance

Review of the relevant parameters recorded by the CVFDR showed that the helicopter responded normally to the control inputs being made by the crew during the flight. No failure or warning captions were recorded as being active prior to impact. The collective trim actuators were also confirmed to be operating normally and the autopilot monitoring the system did not trigger any fault discreet.

The helicopter manufacturer took the recorded data from the 30-minute period of flight leading up to the impact with the sea and compared it with their standard performance model. This confirmed that G-WNSB's performance matched the model. It also identified that during the attempted recovery action taken by the pilot prior to impact, the performance was consistent with the aircraft having entered into Vortex Ring State[18] (VRS). VRS occurs when the rotor disc of the helicopter descends through its own rotor tip vortices, causing recirculation of the turbulent air. This leads to sections of the rotor blades stalling in an unpredictable manner and results in an overall loss of lift from the rotor and erratic handling of the helicopter. Based on the CVFDR data for the accident, the manufacturer estimated a loss of 30 to 45% of the normal lift generated by the main rotor during the last 8 seconds before impact.

18 Also known as 'settling with power'.

1.13 Medical and pathological information

1.13.1 Deceased

Autopsies were performed on the four deceased passengers by a local forensic pathologist at the request of the Procurator Fiscal.

The passengers are identified in this section by their alphabetical letter shown in Figure 16 in Section 1.15.2. The following information includes material provided by the RAF Aviation Pathologist who provided expert assistance to the AAIB investigation.

Passenger K was recovered from the passenger cabin, still secured in their seat. The post-mortem report indicates that a head injury was sustained, which seemed likely to have rendered the passenger unconscious. The injuries were predominantly to the left side of the head and it was not clear how these had occurred. Other pathological evidence was consistent with drowning; the seat harness had not been released, most likely as a result of the head injury.

Passenger H was recovered from the sea. The pathological evidence was consistent with drowning. There were other injuries, which included a head injury, but none were particularly severe. Given that this passenger appears to have released their harness, escaped from the helicopter and inflated their life jacket, it seems unlikely that the head injury had an incapacitating effect.

Passenger E's body was recovered from the water after the fuselage of the helicopter had broken open due to the wave action and contact with the shore. Evidence from the Emergency Breathing System (EBS) indicates that the mouthpiece had been removed from the pouch and the valve opened in an apparent attempt to use the device. Whilst there were some minor injuries, the evidence showed that the passenger had drowned whilst still in the cabin of the helicopter.

Passenger I was able to escape from the helicopter and was assisted by other survivors onto the inverted fuselage of the helicopter and then into the liferaft. Whilst in the liferaft, the passenger was seen to be showing symptoms of chest pain and then apparently stopped breathing. Others in the liferaft attempted cardiopulmonary resuscitation (CPR), but this was unsuccessful. Further attempts at resuscitation after the passenger was winched into the rescue helicopter were also unsuccessful. The post-mortem identified evidence of significant pre-existing heart disease which, from the witness accounts and the absence of serious injuries, indicate that the passenger had died of heart disease.

Toxicology was performed on all four deceased passengers. None exhibited any evidence of volatile hydrocarbons or exposure to carbon monoxide. No alcohol was detected in any of the deceased.

1.13.2 Survivors

During the accident one of the crew and one of the surviving passengers sustained spinal fractures. Overall, the pattern and magnitude of injuries to the occupants was consistent with a relatively low speed impact with water.

In summary, of the 18 occupants of the helicopter, 14 survived; a small number of these sustained spinal injuries in the accident, but these did not prevent them from escaping from the helicopter.

1.14 Fire

There was no fire.

1.15 Survival aspects

1.15.1 General

During the final stages of the approach, the helicopter was in cloud and those passengers looking out of the windows were unable to see the land or the sea. As the helicopter emerged beneath the cloud, the commander attempted to climb the helicopter and the co-pilot armed the helicopter's flotation equipment. The rolling and pitching motion of the helicopter, combined with the descent towards the sea, caused alarm amongst the passengers, with some adopting the brace position. The passengers received no warning of the impact from the flight crew.

The helicopter had rolled to the right and was rolling back to the left when it struck the sea. On impact, the helicopter immediately rolled over to the left and the flight deck and passenger cabin filled with water. The water immersion switch activated on contact with the water and the floats inflated. Neither pilot had time to take a breath before they found themselves upside down and with no visual references. The co-pilot, who had been leaning forward at impact, received a head injury. The commander suffered a serious back injury as a result of the impact.

Some of the passengers could see that they were about to hit the sea, but the impact and speed with which the helicopter rolled over and filled with water resulted in only a few being able to take a breath before becoming submerged. Most survivors had difficulty with the poor visibility under the water and although a few initially attempted to use their EBS, they were unable to locate the cover for the mouthpiece and so concentrated on escaping from the cabin instead.

1.15.2 Aircraft evacuation

Figure 16 shows the passenger seating positions and evacuation exits used. A brief summary of all the occupants' seating positions, together with the survivors' recollections of their escape and exits used, is provided at Appendix G.

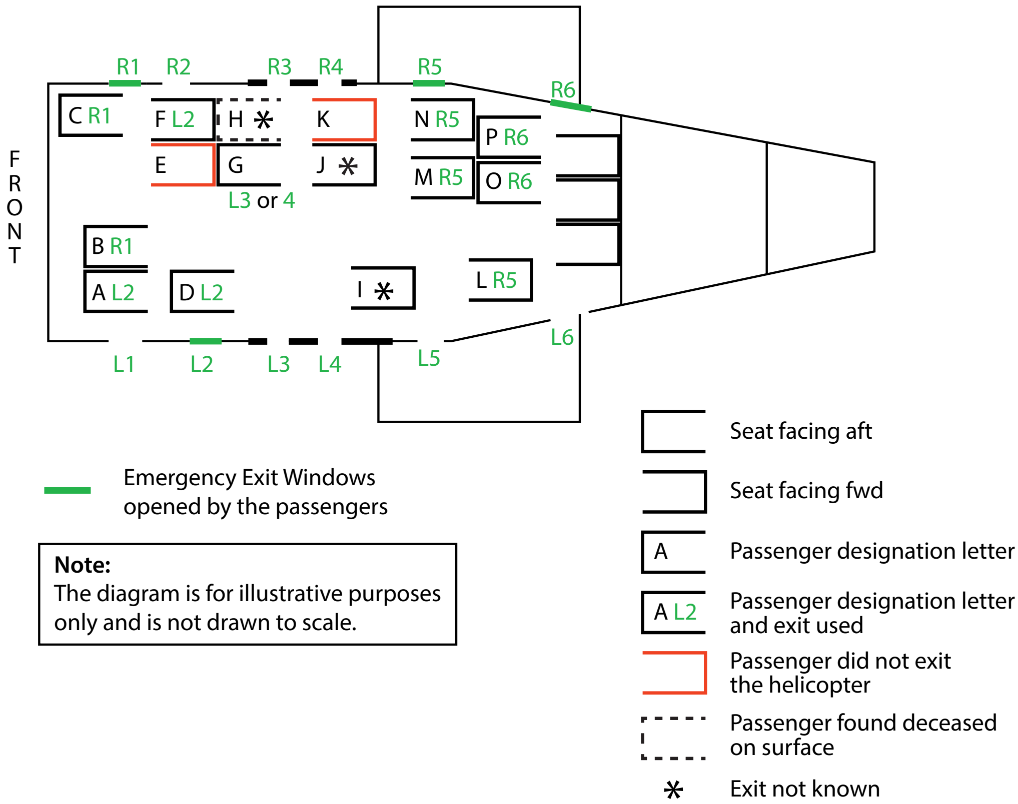


Figure 16

Passenger seating positions and evacuation diagram

Comparison of the survivors' recollections highlighted some common issues that either aided or hindered their escape from the helicopter:

- The rate the cabin filled with water after impact and the speed of the rollover meant that many were unable to take a breath. Some were able to take a breath prior to becoming submerged, and others who attempted to take a breath inhaled water. A number of passengers were able to reach pockets of air trapped in the cabin, allowing them to take a breath.

- Some passengers had relatively little difficulty seeing underwater, but others could not see very well and felt their way towards an exit.

- Four windows were known to have been removed by the survivors whilst underwater. Some passengers who had removed window panes reported experiencing difficulty pushing out the panes due to the amount of force necessary, and in some cases more than one attempt was required, delaying their exit from the submerged cabin. Neither of the main cabin doors was opened or released during the evacuation. Those passengers who had not opened a window either followed those who had, or managed to locate an escape window and exit the cabin.

- Neither pilot could locate the emergency jettison handle for their respective door and were forced to use the normal door handle.

1.15.3 Events following the evacuation

As the survivors surfaced on both sides of the upturned helicopter, they reported that the sea was covered in fuel and debris. The co-pilot was able to climb onto the upturned fuselage and release the liferaft from the right sponson (now located on the left side) by pulling the D-ring located on the bottom of the sponson. He stated that the raft was slow to come out of the housing, so he pulled it free, which allowed it to inflate normally. He and a passenger were able to assist the commander, who had an incapacitating back injury and some other survivors onto the upturned fuselage and then into the liferaft. The co-pilot then deployed the second liferaft using the D-ring, again pulling the raft from the sponson as it was slow to inflate. Ten survivors were now in the first liferaft. The co-pilot recalled that the painter lines were excessively tangled so, given the concern that the helicopter might sink, both lines were cut, allowing the raft to float free from the wreckage. The co-pilot and a passenger left the liferaft and swam to the second liferaft, which was now fully inflated, with the intention of manoeuvring it to the five passengers in the water, but they were unable to reach them.

In the first liferaft, one passenger was seen to be having difficulty in breathing. Other passengers removed his life jacket and commenced CPR, which they continued for some time, but this was not successful.

Five passengers in the water became separated from the helicopter and liferaft and remained in the water until rescued. All reported that they had inflated their life jackets, but had problems locating the buddy lines and became separated from each other. Some stated they had difficulty reaching their gloves and spray hoods once the life jackets had inflated.

None of the survivors mentioned feeling cold initially, or suffering cold shock when first submerged in the water. One of the survivors who remained in the water and whose suit filled with water stated that he did feel cold as time passed.

Of the three fatalities caused by drowning, one did not release their seat harness and was still secured in their seat when the wreckage was recovered.[19] A second person released their seat harness but did not escape from the cabin. Their body was released when the helicopter fuselage broke apart. There was some evidence to suggest that the third person escaped from the cabin, but subsequently drowned.

1.15.4 Search and Rescue

1.15.4.1 Notification

The final transmission from G-WNSB to ATC was at 17:15:59 hrs, when the co-pilot acknowledged the clearance to land. At 17:17:28 hrs, an 8-second burst of undistinguishable RTF noise was recorded. At 17:18:10 hrs, a 15-second ELT transmission was recorded on 121.50 MHz. This transmission was followed by several other less distinct and intermittent ELT transmissions over the next few minutes. The ELT transmissions were heard, but not recognised at first, by the Sumburgh tower controller.

At 17:20:10 hrs, the tower controller tried to contact the helicopter, but received no response. He made a second attempt and then contacted the radar controller, by telephone, to see if the helicopter could be seen on the radar screen. The radar controller advised that they could not see it and tried to contact the helicopter directly, but without success. At 17:22:09 hrs, after a short discussion between the two controllers concerning the ELT signal, the tower controller called the Sumburgh RFFS and advised them of a possible missing helicopter.

At 17:23 hrs, with the realisation that the helicopter should by now have landed and concerned about the ELT noise, the tower controller sounded the emergency alarm. Within a minute, the airport fire vehicles and rescue boat reported manned. The tower controller then contacted and advised the other emergency agencies.

19 The seat belt was function tested and found to be fully serviceable.

1.15.4.2 Rescue co-ordination

Airborne and surface rescue assets were deployed to the accident location to search for the helicopter and rescue survivors.

At 1724 hrs, the Air Traffic Services Assistant (ATSA), following the Sumburgh Airport Emergency Orders, telephoned the Police Scotland Command and Control Centre at Inverness[20] to notify them of an aircraft accident. This process took several minutes, delaying the ATSA from carrying out other necessary actions. At 17:27 hrs, the tower controller telephoned one of the Sumburgh-based SAR helicopter operators directly and advised them of a possible aircraft accident at sea.

By 1731 hrs, the Command and Control Centre at Inverness had established contact with the Maritime Rescue Coordination Centre (MRCC), Shetland, and it was confirmed that a rescue helicopter would be launched. At this point, the first SAR helicopter was already being readied to deploy, in response to the tower controller's notification. A second Sumburgh-based SAR helicopter was tasked at 1735 hrs.

The first SAR helicopter tasked was the first to arrive on the scene, at 1740 hrs, 23 minutes after the accident occurred. This helicopter recovered four persons from the sea and flew them to Sumburgh Airport, before returning to the scene. All the survivors were rescued by the SAR helicopters. Five were winched up directly from the water and the other nine from the two liferafts.

The crew of the second SAR helicopter at the scene commented on the difficulty they experienced in seeing the other helicopter in the prevailing conditions. The first helicopter had a red and white colour scheme and the second had a black and yellow colour scheme.

1.15.4.3 Sumburgh Airport Fast Rescue Craft (FRC)

ICAO Annex 14 and UK Civil Aviation Publication (CAP) 168 (Aerodrome Licensing) require airport operators to make arrangements for the rescue of survivors of aircraft accidents that occur on airport approach and departure paths. Although Annex 14 does not define a specific distance, CAP 168 states that the area within 1,000 m of a runway threshold should be assessed.

Sumburgh Airport Rescue and Fire Fighting Service (RFFS) has an 8.6 m rigid inflatable FRC, equipped to operate within the areas of sea near the runway thresholds of Runways 09/27. The FRC has to be towed on its trailer to the launch site by a suitable vehicle.

20 A transcript of the telephone call is included at Appendix J.

The FRC was deployed to assist in the search and rescue effort. During the deployment, difficulties in launching the FRC from the Runway 09 slipway were encountered which, although having no bearing in this accident, could have been significant in different circumstances. In the event, the accident location was beyond 1,000 m from the runway threshold and therefore the Sumburgh FRC was not the designated primary responder. The search and rescue was provided by the SAR helicopters, which were deployed successfully.

Rescue response time

There is no specified rescue response time in CAP 168; however, in order to be effective, a rescue has to occur within the time frame that a person can survive in the environment from which they require rescuing. The majority of Sumburgh Airport's passengers travel on fixed wing aircraft and therefore do not wear survival suits. The passengers on G-WNSB were wearing survival suits, but the crew were not.

The AAIB investigation determined that the slipway near the Runway 09 threshold was both shorter and narrower than optimum. The narrowness of the slipway required the launch vehicle to be connected to a safety winch, adding a six minute delay. Furthermore, an airport safety survey, conducted in 2010, indicated that the slipway could be used typically in only 11% of tidal conditions.

The nearest alternate launch site was located on a soft, sand beach to the south of the airport. This site was identified for responding to incidents on Helicopter Runway 06/24. The Runway 09 threshold was a 4 nm sea transit from this launch site.

The FRC could not be launched from the slipway near the Runway 09 threshold in response to this accident due to the unfavourable tidal conditions that prevailed. An attempt was made to use the alternate launch site, but the FRC became bogged down in the soft sand and had to be recovered. The FRC was launched from the Runway 27 slipway, requiring a 6 nm open sea transit around the peninsula to the accident location. It arrived at the accident location 58 minutes after the accident. Two of the three FRC crew members sustained injuries due to the difficult sea conditions encountered during the transit.

This accident has highlighted that, in the majority of tidal conditions, the FRC may not be able to respond to aircraft accidents in the sea on the western side of Sumburgh Airport within the available survival time. This safety issue was highlighted in AAIB Special Bulletin S7/2013, published in October 2013, and which contained the following Safety Recommendations:

Safety Recommendation 2013-021

It is recommended that the operator of Sumburgh Airport, Highlands & Islands Airports Limited, provides a water rescue capability, suitable for all tidal conditions, for the area of sea to the west of Sumburgh, appropriate to the hazard and risk, for times when the weather conditions and sea state are conducive to such rescue operations.

Safety action

In response to this Safety Recommendation, Highlands & Islands Airports Limited took action to modify the Runway 09 slipway to allow a water rescue capability to be provided in all tidal conditions, subject to weather conditions.

Safety Recommendation 2013-022

It is recommended that the Civil Aviation Authority (CAA) review the risks associated with the current water rescue provision for the area of sea to the west of Sumburgh Airport and take appropriate action.

This Safety Recommendation was accepted by the CAA, who carried out a review and liaised with Highlands and Islands Airports Limited to ensure they had in place plans to mitigate the associated risks. The CAA also visited Sumburgh Airport to view the water rescue facilities and requested that the airport provide an action plan for the provision of a '*fit for purpose*' slipway at Toabsgeo launch site, or an alternate launch site(s) to the west of the airport.

1.15.5 Passenger safety and sea survival training

Passengers travelling in helicopters operating in support of the offshore oil and gas industry receive specific safety and sea survival training. They are trained to escape from a helicopter in the event of it entering water, in the use of personal survival aids and in how to inflate and enter a liferaft.

The Offshore Petroleum Industry Training Organisation (OPITO) has its origins in the late 1970s and has developed safety training standards which include the Safety and Sea Survival training.

The Basic Offshore Safety Induction and Emergency Training (BOSIET) course lasts three days and is valid for four years. The course is a combination of classroom and practical training and includes the following items: an offshore overview, offshore hazards, safe working procedures, helicopter safety procedures, Helicopter Underwater Escape Training (HUET), Emergency Breathing System exercises, sea survival, liferaft training, lifeboat training as a passenger, first aid/hypothermia, firefighting and self-rescue. Protective helmets are required to be worn for the HUET practical training.

Within the four-year validity period, a passenger has to attend a Further Offshore Emergency Training (FOET) course, successful completion of which re-validates the qualification for a further four years. Some leeway is permitted to exceed the four years by up to three months in special cases, with the written support of the person's employer. The course lasts one day and is a revision of the content of the BOSIET course, with practical sea survival exercises in the pool involving HUET escape and liferaft drills.

Successful completion of the initial and recurrent training is recorded on an internationally-accessible central register and Vantage training registration system. When a passenger checks in for their flight, the Vantage card issued to them contains their training status. It is a simple method of ensuring no passenger is carried without a current safety and sea survival qualification.

1.15.6 Personal safety equipment

1.15.6.1 Survival suits

The oil and gas industry has determined that all passengers travelling offshore by helicopter in the UK sector of the North Sea must wear a survival suit, regardless of water temperature. These are dry suits, which are designed to seal around the body from the neck down and wrist upwards, to prevent ingress of water and keep the wearer's clothing dry in the event of submersion. This significantly extends survival time in the water by reducing body heat loss and increases the chance of a successful rescue following an emergency evacuation. To facilitate donning of the suit there is a large diagonal opening across the chest from the right shoulder to the opposite hip. Once in the suit, this opening is sealed by a waterproof zip, which must be fully closed and locked in place for the suit to be watertight. The manufacturer advised that because the suits are designed to prevent rapid heat loss when submerged in cold water, under normal conditions they can become hot and uncomfortable to wear, leading some passengers to open the zip to provide ventilation.

The suits come in a range of body sizes with the neck and wrist seal size selected using standard anatomical relationships. In order for the seals to function properly they must seal tightly against the skin, which can feel uncomfortable. Passengers are fitted by trained personnel from the suit manufacturer for the correct suit size prior to their first flight. However, these personnel can only recommend a size, with the passenger ultimately choosing a suit which they consider to be the best fit and most comfortable. This selected size is recorded against their personal details and on their Vantage card. For each flight offshore, prior to boarding the helicopter, passengers are issued with a suit of their recorded size and instructed how to don it correctly. They then retain the suit whilst offshore for reuse during their return flight. The suits are checked for fit prior to the passengers leaving the airport terminal or offshore rig. Onshore this is done by personnel from the manufacturer. Offshore, the role is delegated to a rig worker as a secondary duty. The suit issued for each flight is tracked against the passenger's name by the manufacturer using the suit's unique serial number.

Pilots are issued with specialist flight crew survival suits, which they retain as personal issue kit. However, the regulations allow pilots the choice whether to wear them for flight in daylight hours, whenever the sea temperature is +10°C or more and the estimated survival time in the water exceeds time to rescue. Both pilots had chosen not to wear survival suits. The pilots were equipped with a crew lifejacket which did not include an Emergency Breathing System (EBS).

1.15.6.2 Passenger Emergency Breathing System (EBS) and lifejacket

All the passengers were issued with and were wearing a Lifejacket Air Pocket Plus (LAP Plus) at the time of the accident. This combines a single bladder, compressed air inflated lifejacket with an integrated hybrid rebreather EBS. The lifejacket is activated by pulling the inflation toggle, which releases compressed gas into the jacket bladder. The rebreather is attached to the jacket, but consists of a separate bladder and air supply, with an attached hose, mouthpiece and nose clip. When the EBS is submerged in water, a small supply of air is automatically released into the bladder. This provides an initial source of air for the wearer to breathe, but if possible this should be supplemented by the wearer expelling a deep breath into the EBS air bladder via the mouthpiece. Passengers are trained in the event of a planned ditching to prepare the EBS for use prior to touching down and to add the breath before becoming submerged. In the event of an unplanned ditching or water impact, the wearer may be submerged without having prepared the EBS for use. The jackets are a standard fit and are not tracked against the individual wearer.

Interviews with the survivors of this accident identified that they were unaware that the hybrid LAP Plus jacket had an automatically released air supply. They believed that the EBS would only be of assistance if they inflated it manually with an expelled breath. Given the speed at which the fuselage inverted, most of the passengers were unable to take a breath before becoming submerged; as such they elected not to use the EBS during the evacuation. This safety issue was highlighted in AAIB Special Bulletin S1/2014, published on 23 January 2014.

UK operators in the North Sea took safety action to amend the pre-flight safety briefing video for passengers, to include information on the automatic air supply feature.

Research has identified that in about 60% of all water impacts, the helicopter inverted or sank either immediately or after a short delay[21]. Capsize often occurs before evacuation of all the occupants can be completed. As a result of this, EBS were developed to allow helicopter occupants to breathe underwater for a short period of time. The benefit of the EBS it that it bridges the gap between the maximum breath-hold time of an occupant and the time required to complete an underwater escape, thereby increasing the chances of survival for the occupant. An EBS was not required to be worn under EASA or CAA regulations, nor was there a national or internationally-accepted Technical Standard Order (TSO) for their design. The CAA published CAP 1034 in May 2013, which provided a proposed technical standard and separated EBS into Category A and B devices, based on their capacity to be used either without or with prior warning; ie water impact or ditching scenarios. This is primarily characterised by the ability to purge the mouthpiece underwater and the time taken to deploy the device.

As a result of the safety actions introduced by CAP 1145[22], the industry has developed and introduced into operation a Category A compliant EBS and the associated training required to operate it. This uses a compressed air supply which provides the user with approximately 120 seconds of air, dependent on the user's rate of breathing. The gas supply is attached to a hose and regulator, with an integrated nose clip.

CAA Safety Directive SD-2015/001 contains an Operational Directive which requires all offshore passengers to be equipped with EBS from 1 January 2015 and from 1 April 2016 all occupants, including flight crew, will be required to have an EBS.

1.15.7 G-WNSB safety equipment

1.15.7.1 Liferafts

An inspection of the liferafts found that one had suffered some damage to the fabric; however the extent of the damage when compared to the survivors' testimonies suggested it was likely this had occurred after the occupants had been rescued but prior to, or during, recovery of the rafts from the rocks along the cliff edge.

21 Rice and Greer, 1973; Hayes, 1991; Brooks, 1989; Clifford, 1996.
22 CAP 1145: '*Civil Aviation Authority - Safety review of offshore public transport helicopter operations in support of the exploitation of oil and gas*' (See Section 1.15.8.5).

1.15.7.2 Crash Position Indicator (CPI) activation and operation

The wiring for the CPI system was severed when the tail boom of the helicopter detached on impact with the water. This triggered the CPI release mechanism and the CPI was successfully deployed and began to transmit. The transmitted location data was received by the UK ARCC at RAF Kinloss. The close proximity of the impact point to the coast and the airport to the impact point meant that the Search and Rescue helicopters were quickly on scene and able to identify the floating wreckage and liferafts and the CPI data was therefore not required.

1.15.8 Aviation regulation relating to survivability

1.15.8.1 Current Large Rotorcraft regulatory requirements

Ditching

The large rotorcraft ditching requirements are contained in EASA Certification Standard (CS) 29.801. There is no requirement associated with water impact. This requirement is taken directly from CS 25, which specifies the design regulations for fixed wing large passenger aircraft. There is no specific reference relating to the increased likelihood of a rotorcraft to roll inverted due to the high centre of gravity created by the location of the rotor head, gearbox and engines.

Emergency exits

The requirements for emergency exits are covered by CS 29.805, 29.807, 29.809, 29.811 and 29.813. These requirements are, in the main, transposed directly from CS 25. No account is taken of variations in the anatomical distribution of offshore workers versus the general population, or the requirement for offshore passengers to wear several layers of clothing under a survival suit and lifejacket. The regulations only address exits which are designated emergency exits, when specifying minimum sizes. Exits are classified Type I through to Type IV, with I being the largest and IV the smallest. A helicopter carrying up to 19 passengers only requires one Type III exit or two Type IV exits per side. The remaining push-out escape windows along the fuselage are not mandatory and there is no minimum size limitation.

Evacuation

The regulation relating to emergency evacuation is CS 29.803. The associated cabin layout requirements in terms of seat pitch and access to emergency exits are covered by CS 29.813 and 29.815. Again, these are predominately the same as the CS 25 requirements. As such, the minimum evacuation time requirement of 90 seconds is only applicable to helicopters with seating capacities over 44, where there are 10 or more passengers to an exit, there is no main aisle or the exits are blocked by temporary seating. The 90-second evacuation requirement for fixed wing aircraft only relates to evacuations on land.

1.15.8.2 Current helicopter operational regulatory requirements

The operational requirements relating to occupant and helicopter safety equipment are contained within Commission Regulation (EU) No. 965/2012 and specifically Annex IV, Subpart D, Section 2, CAT.IDE.H.275 through 310. These regulations relate to provision of lifejackets, survival suits, liferafts, ELTs and life-saving equipment.

1.15.8.3 Civil Aviation Authority (CAA) historical activity

In 1982 the CAA initiated a major review of helicopter certification standards. A joint industry/CAA group was formed to conduct the review known as the Helicopter Airworthiness Review Panel (HARP). Their report was published in 1984 and became CAP 461. One of the key aspects in the report was a requirement for helicopters to have adequate buoyancy, stability, a practical means of escape and effective liferaft equipment. Three relevant safety recommendations were made to address specific issues.

- Recommendation 1 related to consideration of human factors issues resulting in catastrophic accidents
- Recommendation 9 addressed certification requirements relating to ditching
- Recommendation 10 related to stability of helicopters following ditching

A number of further studies were commissioned by the CAA into helicopter survivability.

A Review of Helicopter Offshore Safety and Survivability (RHOSS) was published as CAP 641 in 1995. This introduced a 'top down' principle to safety where improvements were targeted at firstly trying to reduce the need for underwater evacuation by keeping the helicopter upright after impact, then progressively addressing the issues associated with the higher level targets not being achieved, for example evacuation from an inverted cabin underwater. It addressed each phase of the flight from passenger pre-flight training, through survival equipment issue to ditching, water impact and subsequent escape and survival.

Seventeen recommendations were made in the final report; most of which related to the need to address issues of helicopter flotation post-impact, facilitation of evacuation including cabin layout, emergency exit operation and personal survival equipment.

After this point, updating of aviation regulations became the responsibility of the Joint Aviation Authorities (JAA), which was a cross-Europe organisation, but within which the CAA played a major role.

In 2003 the CAA, on behalf of the JAA Helicopter Offshore Safety and Survivability (HOSS) group, published a study on the use of EBS. This study reviewed the various benefits and hazards of the available systems, but concluded there was no strong evidence either to mandate or ban the use of EBS or select one EBS system above the others. However, it did recommend that a Technical Standard Order (TSO) should be created to ensure that any EBS used by operators met a minimum standard.

In 2005, the CAA paper *'Summary Report on Helicopter Ditching and Crashworthiness Research (2005/06)'* was published. This summarised research work undertaken in the previous 12 years relating to helicopter stability and buoyancy following ditching or water impact. It reiterated many of the conclusions drawn by previous reports, whilst adding further supporting data relating to water impact crashworthiness. It advocated similar solutions such as high-level flotation devices to prevent inversion and submersion of the helicopter (side-floating concept). Supporting reports from HOSS and the Water Impact, Ditching Design and Crashworthiness Working Group (WIDDCWG), reporting to the JAA/FAA Joint Harmonisation Working Group (JHWG), were included as appendices to the paper. These contained multiple recommendations and proposed rule changes relating to helicopter stability and survivability following ditching or water impact.

1.15.8.4 European Aviation Safety Agency (EASA) activity

In 2003, the European Aviation Safety Agency was created and began to take over responsibility for aviation regulation within European member states. Whilst introduction of the rule changes proposed by HOSS were initially listed on EASA's 2005 to 2007 rulemaking plan, this was delayed by a further study on helicopter ditching and crashworthiness.

From 2006, a number of additional reviews took place under the responsibility of both the International and European Helicopter Safety Teams. By 2011, a top ten list of future rulemaking initiatives had been created.

RMT.120

In 2012, following the ditching seminar of 2011, EASA formally raised a Rulemaking Task (RMT.120) to review and introduce some of the initiatives and recommendations which had been raised by the various studies over the years. The group responsible for this review within EASA were given Terms of Reference (ToR) to develop amendments to CS 27 and 29, which delivered the objective below:

> *'This task is aimed at enhancing post ditching and water impact standards that could significantly enhance occupant escape and survivability. It will, in part, consider the recommendations arising from early work performed by the JAA Water Impact, Ditching Design and Crashworthiness Working Group (WIDDCWG) and the Helicopter Offshore Safety and Survival (HOSS) working group.'*

The timescale has slipped from the original ToR, which targeted delivery of the amended regulations by quarter three of 2015. At the time of writing, the current schedule for this task targets a Notice of Proposed Amendment (NPA) by the end of 2015, followed by the required consultation period, potentially leading to a regulation change in late 2016. Although still under review, the RMT group is also likely to comment on a number of other issues in its report, including passenger training and personal survival equipment. However, only the issues which can be dealt with by changes to the Certification Standards will be addressed by the NPA. These include, amongst others:

- Provision and operation of an automatic Emergency Flotation System;
- Realistic sea-keeping performance demonstration and limits;
- Number, size and operability of emergency exits;
- Liferaft and ELT carriage and operation.

EASA has also approached various standards organisations with the intention of creating a European Technical Standard Order (ETSO) for the design and certification of EBS, using CAA CAP 1034 as a basis.

The NPA is currently targeted at new helicopter designs only. A second NPA will be required to address retrospective action on helicopters already in service.

RMT.409

In June 2013, the EASA issued NPA 2013-10 following work done by the RMT.409 working group. This proposed the introduction of an additional subpart to EU 965/2012 dealing with offshore helicopter operations. This included helicopter operating requirements such as the proposed mandatory introduction of vibration health monitoring and a Helicopter Terrain Awareness Warning System (HTAWS). It also included a number of survivability requirements such as: flight crew and passenger survival suit use, requirements for emergency exits, EBS, lifejackets, liferafts and emergency cabin lighting. Following the consultation process, Comment Response Document (CRD) 2013-10 was published, which included a response to the CAA's CAP 1145. It stated that the safety actions relating to arming of flotation systems and use of Category A EBS would be adopted into the RMT; however the other actions relating to sea state limitations and maximum passenger sizes for emergency exit classifications were rejected. The introduction of side-floating capability and flotation stability certification requirements were deferred to RMT.120.

EASA.2007.C16

EASA commissioned a study into helicopter ditching and crashworthiness, which resulted in a report published in 2007. The work was subcontracted to Eurocopter[23] and had a specific scope to study the technical feasibility of introducing a side-floating capability in the event of helicopter capsize following ditching or water impact. It was also tasked with assessing the feasibility of retrofitting this equipment to the Eurocopter products, the EC225 Super Puma and AS355 Twin Squirrel. The conclusions documented in the report broadly supported those from the CAA studies previously carried out with the assistance of Westland helicopters and other independent contractors. It demonstrated a significant and appreciable benefit to survivability from high-level flotation devices to achieve a side-floating capability, versus a fully inverted fuselage.

Safety Action Project on Offshore Helicopter Safety in North Sea

This project was launched in November 2014, primarily aimed at coordinating the EASA response to the recommendations contained in the CAA's CAP 1145 report.

Amongst other actions, the safety project created an Offshore Subgroup of the Helicopter Accident Data Coding and Analysis Group (HADCAG) to perform a review of offshore accidents and serious incidents in EASA member states between 2009 and 2013.

23 Now called Airbus Helicopters.

1.15.8.5 CAA Safety Review (CAP 1145)

In response to this and a number of other recent helicopter accidents in the North Sea, the CAA launched a wide-ranging safety review of public transport helicopter operations in support of the exploitation of oil and gas. The culminating report was published as CAP 1145, on 20 February 2014. Chapter 9 of the report covered ditching and water impact survivability. The review identified four key issues:

- The sea-keeping performance required of ditching helicopters is inadequate;
- The certification requirements do not address water impacts, leading to inadequate post-crash operability of Emergency Flotation Systems;
- The time required to escape from a flooded and usually inverted helicopter cabin will exceed the ability of at least some of the occupants to hold their breath;
- There are no regulatory restrictions on operations over sea conditions where a reasonable prospect of safe rescue cannot be assured.

The report made a number of recommendations to EASA and the CAA introduced changes to North Sea operations by virtue of its own regulatory powers.

The safety actions introduced by the CAA were:

> The prohibition of helicopter operations over sea states exceeding six or the certificated ditching performance of the helicopter.
>
> The requirement for operators' procedures to be amended to ensure emergency flotation equipment is armed for all overwater departures and arrivals.
>
> The prohibition of the use of passenger seats not immediately adjacent to push-out window exits, unless a Category A EBS has been provided to the passenger, or the helicopter has been modified to ensure side-floating rather than inversion.
>
> With effect from 1 April 2015, the prohibition of operators from carrying passengers on offshore flights, whose body size is incompatible with window emergency exit size for the helicopter.

With effect from 1 April 2016, the prohibition of offshore operations unless all occupants wear a Category A EBS, unless the helicopter is modified to ensure side-floating.

The CAA recommendations stated:

- That all offshore operators should adopt without delay key issues relating to helicopter design, personal survival equipment and liferafts from the NPA resulting from RMT.120;
- That RMT.120 should include a requirement to make safety and survivability training mandatory for offshore passengers;
- That the Offshore Petroleum Industry Training Organisation (OPITO) should review and enhance its safety and survivability training standards relating to the fidelity and frequency of training.

In May 2014, Safety Directive SD-2014/001 was issued by the CAA. This formalised the safety actions relating to sea state limitations and the exit window seat use only limitation using the Operational Directive powers granted under Article 15 of the ANO. Safety Directives were subsequently issued to include the passenger size limitations and mandatory use of a Category A EBS.

1.15.9 Industry initiatives on survivability

Following a number of helicopter accidents which have resulted in loss of life of offshore workers in the North Sea, the oil and gas industry has voluntarily introduced a number of safety initiatives over the last 30 years of operation. Amongst others, these have included:

- Mandatory wearing of survival suits for all passengers;
- Provision of integrated hybrid rebreather EBS;
- Automatic helicopter float deployment systems;
- Mandatory offshore safety and survivability training.

1.16 Tests and research

1.16.1 Human performance

Two independent studies were commissioned by the AAIB, in order to explore the human performance aspects of this accident. The studies utilised different methodological approaches, but the conclusions were broadly similar. The focus was on the procedures and methods used for conducting the approach and on the reasons why the pilots had a period of inattention to their flight instruments.

1.16.1.1 Independent Human Factors Specialist Report A

This report (Appendix H) identified the key period in the approach as being when the airspeed reduced below 80 kt and the helicopter started to pitch up at an accelerating rate. That these events were not perceived by the crew suggested that there was period of time when the flight instruments were not monitored. The report noted that any explanation for this must to some degree be speculative, because neither pilot had a useful recollection of the period.

The conclusions identified two causes of the accident. One was the dynamic nature of the approach profile and the other was a period of inattention to the flight instruments for some 30 to 40 seconds before impact.

The report also identified the 'crucial' role of the PF (the commander) in maintaining close attention to the flight instruments. The report surmises that the reason this did not happen was as a result of a firm expectation on the part of the commander that visual references would be obtained. His attention to the instruments was especially important because the operating procedures required the PNF (the co-pilot) to look outside in order to acquire visual references. The PNF, tasked with dividing his attention between external and internal references, was subject to a high workload.

It was noted that, had a stable speed and descent rate been established at an early stage of the approach, the exposure to the risk of such a period of inattention would have been reduced, because the flight path should have remained relatively stable.

1.16.1.2 Independent Human Factors Specialist Report B

This report (Appendix I) specified the investigation methodology in a matrix format. The structural and procedural aspects leading up to the accident were examined, as well as possible limitations in monitoring and hazard recognition. Background factors common to all flight crew were considered, together with more specific factors pertinent to this particular operation. Some risks inherent within the operation were identified leading to a number of conclusions and recommendations.

The report highlighted that the use of subjective terms in the operator's OM could lead to a variety of interpretations and an associated lack of standardisation during the flight. The inability of the FDM programme to detect a number of operational risks and to monitor compliance with SOPs could have contributed to this.

The potential for a high workload for the PNF during a Non-Precision Approach was identified as an outcome of the task requirements and the layout of information on the approach chart.

Monitoring limitations and the inability of the crew to detect changes to the vertical descent profile were discussed. The two factors combined could contribute to key information being missed. Firstly, poor instrument scan techniques could have developed unnoticed as a result of a lack of instrument scan training. Secondly, the presentation of information on the PFD may not have been optimal. Recommendations made as a result included a proposed review of training in instrument scan techniques, together with research into the presentation of information on instrument displays.

Weaknesses in some operating practices were also observed. One was the crew's use of phraseology that differed from that specified in the operator's SOPs, thereby reducing the effectiveness of the PNF in the task of monitoring and supporting the PF. Another was the limited consideration given to diverting to an alternate airfield in the deteriorating weather conditions.

Finally, the report noted that the CHECK HEIGHT minima automated call was ineffective in preventing a descent below minima and recommended that interpretation of and response to such alerts be researched and mitigations put in place where necessary.

1.16.2 Survival equipment testing

The survival suits, crew lifejackets and lifejackets/EBS worn by all the passengers, including the deceased, were retained by Police Scotland and passed to the AAIB for examination. An initial assessment of all of the equipment was performed at the AAIB's facility, with the assistance of the manufacturer. Where available, comments relating to the wearer's experiences during the evacuation and rescue, recorded during their interviews, were compared to the 'as found' condition of the equipment. Where the suits were reported to have leaked, or problems were encountered with the lifejacket, an attempt was made to identify possible causes. Subsequently, a number of the suits and all of the lifejackets were taken for additional testing at the manufacturer's facility.

In summary, five passengers reported water ingress into their suits to some degree. One passenger reported that his suit filled with so much water that the SAR helicopter crew had to cut the suit open to drain it, prior to him being winched into the rescue helicopter. This necessary damage precluded subsequent testing of the suit. The remaining four suits were subjected to an inflation test and inspected for leaks. Some evidence of very minor pinhole leaks was found, but nothing that would account for entry of noticeable amounts of water. The suits from the four fatalities were also inspected. Two had significant damage, likely to have been caused during impact with the water, or in subsequent attempts to evacuate the helicopter. One other had a small amount of damage to the neck seal, which may have resulted in a small but insignificant leak.

The lifejackets and EBS were also subject to a range of manufacturer's tests to determine serviceability. There was no record of which life jacket had been issued to a particular passenger and therefore it was not possible to link the test results to the passenger statements. The exceptions were the three passengers who did not successfully escape from the helicopter, where Police evidence tags did allow identification of the wearer.

Seventeen lifejackets were recovered; the missing one was a crew lifejacket, likely to have been that worn by the co-pilot. Of these, all but three had been inflated by deliberate activation of the gas bottle. Subsequent manual inflation of the remaining three confirmed they inflated correctly, although a small leak was detected in one of these. Of the jackets inflated during the accident, five failed the manufacturer's post-overhaul serviceability test; however, all but two of these were for minor leaks which would not have reduced their effectiveness as a buoyancy aid in the short term. The air bladders of the remaining two jackets were compromised in a manner consistent with damage sustained during the impact or the evacuation and rescue. One of these damaged jackets was worn by a passenger who had drowned.

The 16 passenger lifejackets were fitted with hybrid rebreather EBS. All but one of these were found in the stowed position on their respective lifejackets. The air supply had been successfully released into the air bladder by the hydrostatic valve on all of the EBS worn by passengers during the accident. The deployed EBS was attached to a lifejacket which had not been inflated. The mouthpiece valve on this EBS had been moved to the open position, however damage was found in the air bladder, sufficient to result in loss of air or entry of water into the EBS.

1.16.3 Terrain Awareness Warning System (TAWS)

1.16.3.1 Background

In the 1970's, accidents involving aircraft inadvertently flying into terrain or obstacles due to a crew's loss of situational awareness became known as Controlled Flight into Terrain (CFIT). The Ground Proximity Warning System (GPWS) was developed for fixed wing aircraft, to alert crews if the aircraft's rate of descent when near to the ground, or terrain closure rate, were hazardous. Additional modes were subsequently added to provide: automatic height call-outs during the approach and alerts if the aircraft was not in the correct landing configuration, descending below the ILS glideslope and at high bank angles when near to the ground.

A technological limitation of the GPWS system was that it could not look ahead of the aircraft's flight path to determine if terrain or obstacles posed a hazard, due to the use of the downward-pointing radio altimeter sensor used to measure the aircraft height above terrain. This meant that under some circumstances, such as when approaching steeply rising terrain, alerts could occur too late to prevent an accident.

Technological advancements in the late 1990's enabled the development of the Enhanced Ground Proximity Warning System (EGPWS)[24], which added a look-ahead function to the existing GPWS 'classic' warning modes. This uses a digital terrain and obstacle database, in conjunction with aircraft position and flight path information. Other manufacturers have since developed similar systems. The generic name of TAWS has been internationally adopted.

Since 2003, the EASA has required a TAWS to be equipped to fixed wing aircraft with a maximum certificated takeoff mass in excess of 5,700 kg, or a maximum approved passenger seating configuration of more than nine.

Neither the CAA nor the EASA currently require helicopters to be equipped with TAWS. In August 2014, the EASA published Comment-Response Document (CRD) 2013-10, that proposed the fitment of a TAWS to helicopters used in Commercial Air Transport (CAT) offshore operations with a maximum certificated take-off mass (MCTOM) of more than 3,175 kg, or a maximum operational passenger seating configuration (MOPSC) of more than nine, and first issued with an individual Certificate of Airworthiness after 31 December 2018. The proposal was ratified in May 2015 by the EASA, resulting in a regulatory requirement. In the USA, the FAA has required the fitment of a TAWS to Helicopter Emergency Medical Service (HEMS) helicopters no later than April 2017.

24 EGPWS is a proprietary name used by Honeywell Aerospace for its TAWS system.

Although not currently required by regulation, several helicopter types, already operating in support of the UK oil and gas industry, are equipped with a TAWS. This includes the Airbus Helicopters EC225. The EC225 TAWS consists of a Honeywell Aerospace manufactured MkXXII EGPWS, which incorporates the AVAD crew selectable and fixed height audio callout function. The installation is certified by the EASA, and meets the criteria laid down in document RTCA/DO-309, entitled '*The Minimum Operational Performance Standards (MOPS) for Helicopter Terrain Awareness and Warning System (HTAWS) Airborne Equipment'.*

1.16.3.2 Helicopter TAWS (HTAWS) development

The transition of TAWS from fixed wing aircraft to helicopters has provided a number of technical challenges, due to the operational flexibility of helicopters and the environment in which they frequently operate.

Following the accident to G-REDU in 2009, the AAIB made three Safety Recommendations[25] to the EASA relating to HTAWS performance. A project, managed by the CAA on behalf of the Helicopter Safety Research Management Committee (HSRMC)[26], was established to refine TAWS alert envelopes for offshore operations so they more closely reflect helicopter operations, reduce nuisance alerts, develop new warning modes and determine the optimal means of providing warnings to crews.

The project analysed flight data from previous accidents, in conjunction with approximately 3,000 routine flights from two helicopter types operated in support of the UK oil and gas industry. The project identified a number of performance improvements to the existing Mode 1, 2, 3, 4 and 6 alert envelopes, as well as the creation of a new Mode 3B[27] alert. The interim results were made available to operators and manufacturers in 2012. The final report is anticipated to be published in 2017.

1.16.3.3 TAWS performance simulation for accident approach

G-WNSB was not equipped with a TAWS, nor was there any requirement for it to be fitted. A laboratory simulation was performed by Honeywell Aerospace using a MkXXII EGPWS[28] with parametric input data derived from the G-WNSB CVFDR accident record to establish if a TAWS alert would have been generated during the accident approach.

25 2011-061, 2011-062 and 2011-063. The EASA responded in 2013 to 2011-061 advising that it was waiting for the final report on the HSRMC project.
26 The HSRMC comprises, amongst others, key representatives from the European aviation authorities, the offshore oil and gas industry, UK offshore helicopter operators and helicopter manufacturers.
27 Loss of airspeed after takeoff.
28 In addition to providing TAWS alert modes, the crew selectable height alert was set at 300 ft and the automatic voice callout was set to 100 ft, as per the AVAD settings at the time of the accident.

The results of the simulation were that: at a height of 179 ft, about 5.7 seconds before G-WNSB struck the surface of the sea, a Mode 1 'SINK RATE SINK RATE' audio alert would have been generated. Figure 17 provides details of the EGPWS Mode 1 envelope used to trigger the alert and Figure 18 is a time series plot of when the alert would have occurred relative to other alerts and impact with the sea.

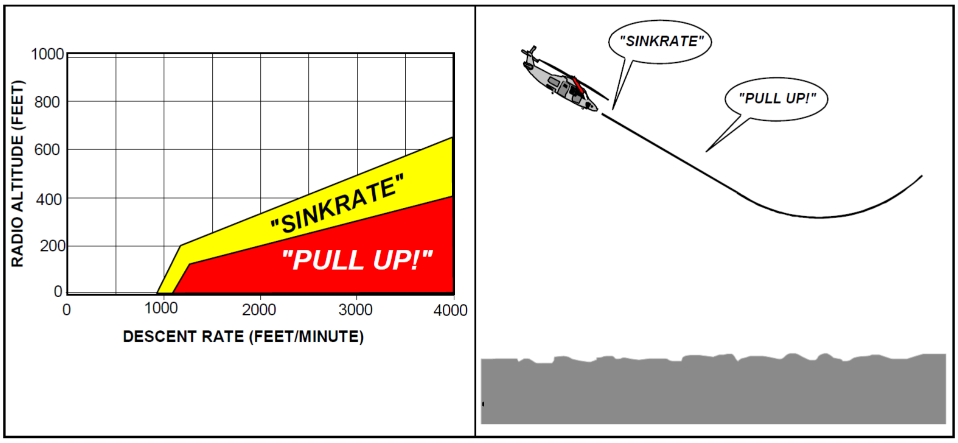


Figure 17

EGPWS Mode 1 Alert envelope

1.16.3.4 Ongoing development of HTAWS

The accident flight data from G-WNSB and modified alert envelopes were analysed in conjunction with the CAA to establish if the alert time of 5.7 seconds, demonstrated during the laboratory simulation, could be improved upon. The HSRMC revised Mode 1 envelope was found to improve the alerting time to just greater than 8 seconds (when the helicopter was at a height of about 230 ft) before the helicopter struck the sea (Figure 19).

In June 2014, the CAA initiated the second phase of the HSRMC project, intended to establish the optimal means of presenting HTAWS auditory and visual alerts to crew. The project also continued to further analyse the accident data from G-WNSB with the aim of identifying whether a new alert mode could be developed to improve on the results demonstrated by the revised Mode 1 alert envelope.

The project had previously analysed data from the EC225 and the Sikorsky S76A+, which had been selected to provide as broad a spectrum of offshore operations as possible. The project found that although technological and operational differences existed between the helicopters, generic alert envelopes could be successfully established. Therefore, the EC225 dataset (consisting of about 800 flights) was considered to provide a suitable alternative to the AS332 L2 for the purposes of evaluating new alert modes.

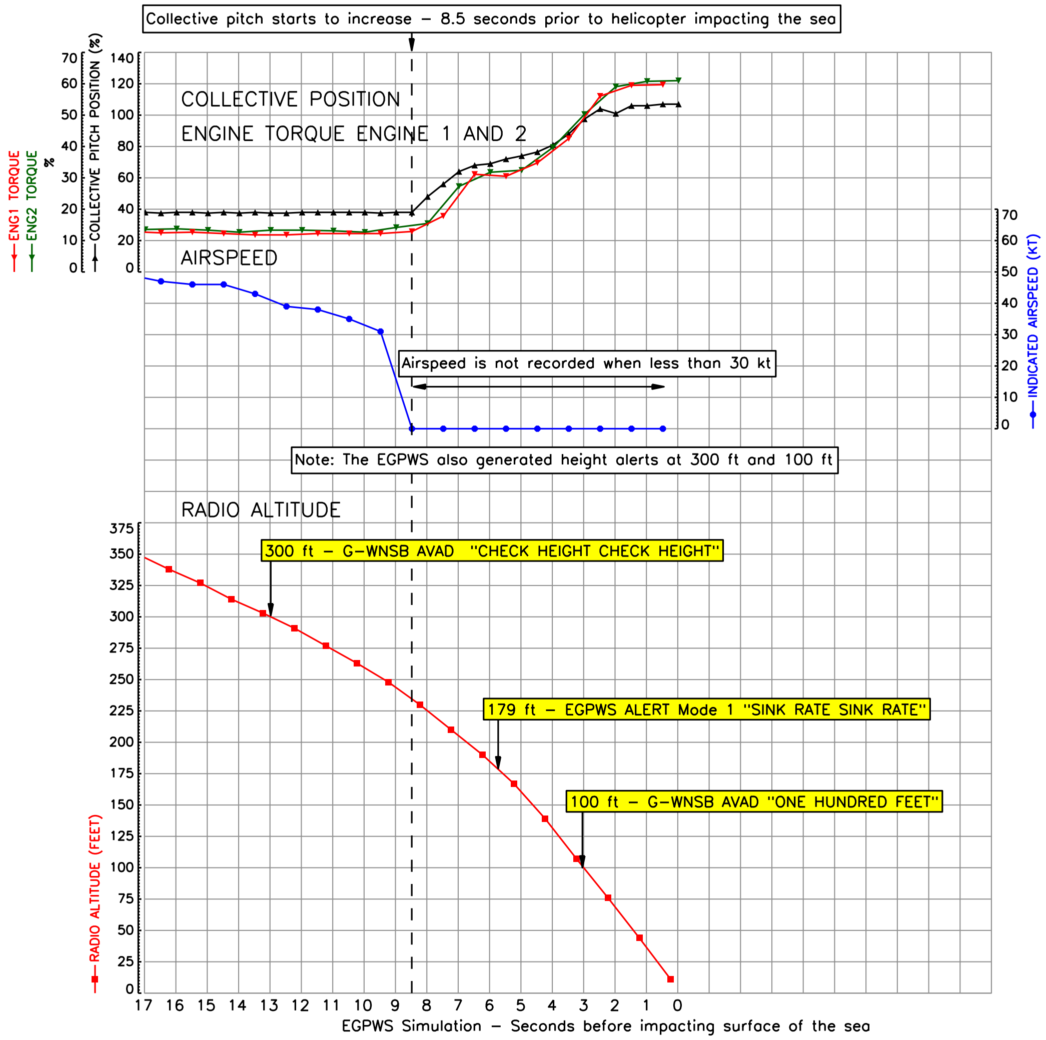


Figure 18

EGPWS Simulation with Mode 1 alert triggered at 179 ft

Initial research focused on the relationship between engine torque and airspeed during the latter stages of an approach. Two envelopes were created to reflect the statistical measures of 1% and 0.1% percentile, which were then compared against the accident approach of G-WNSB. The 1% and 0.1% envelopes were exceeded 11.5 and 10.5 seconds respectively before the helicopter struck the sea (Figure 19). At 11.5 seconds G-WNSB's airspeed was 38 kt and it was at a height of 280 ft. At 10.5 seconds its airspeed was 34 kt and the height was 265 ft.

The project also analysed other parametric relationships, including collective pitch position and airspeed, to determine if the alerting time could be further improved upon. It was found that the warning based on engine torque and airspeed continued to provide the greatest alerting time for the accident approach profile.

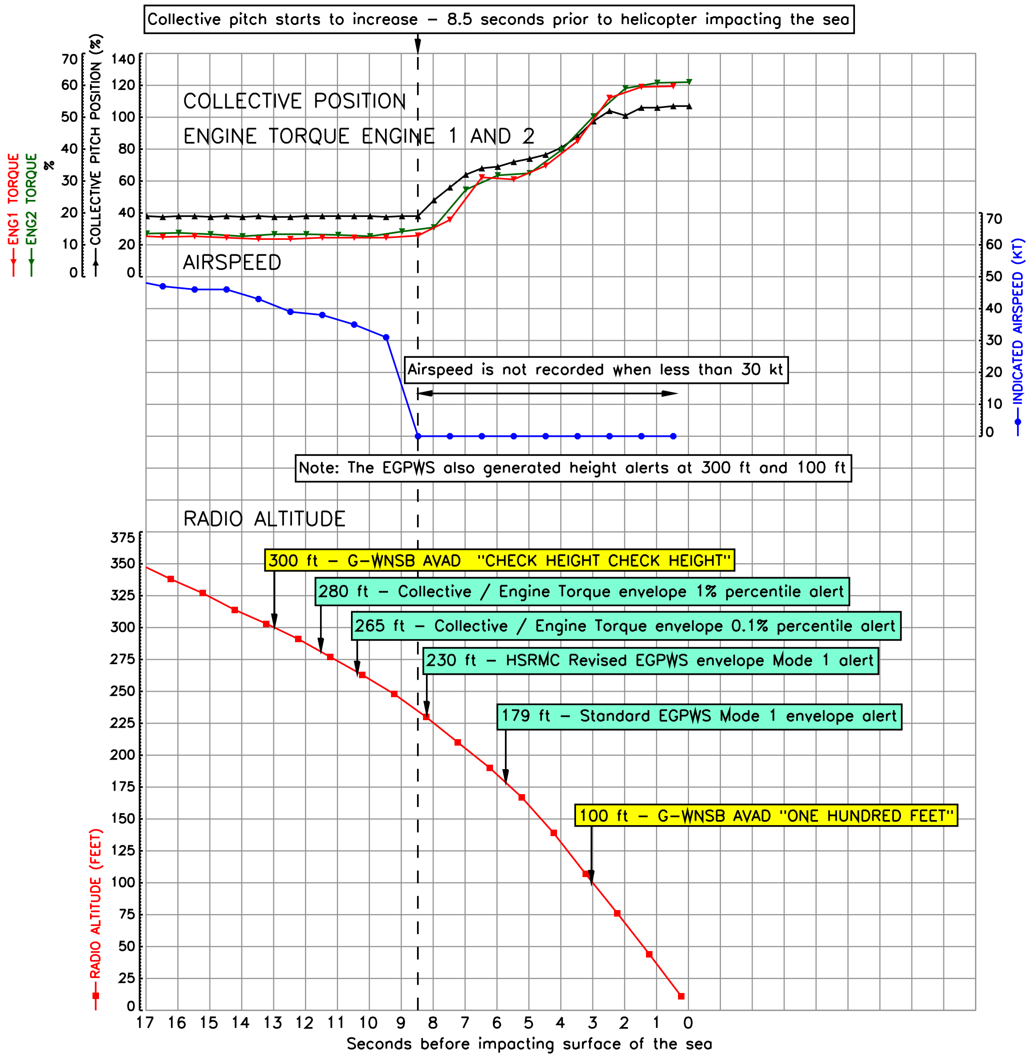


Figure 19

Alert activation times of EGPWS developmental envelope, revised Mode 1 envelope and current Mode 1 envelope

1.16.4 Helicopter Low Airspeed Warning Device

The EASA issued three requests for tender (one in 2008 and two in 2012) for a project to demonstrate the feasibility and safety benefit of a device capable of indicating low airspeed in helicopters. This could be used to provide a warning to avoid entering a vortex ring state (VRS), or to avoid losing tail rotor effectiveness. Several tenders were received in 2008, but none passed the selection process and no submissions were received in 2012. The EASA were in the process of drafting a further tender, but prior to its release, several manufacturers reported on the development of low airspeed sensors for helicopters. In December 2014, Airbus Helicopters completed initial flight tests of one such system, and indicated that low airspeed systems may be incorporated into their future helicopter designs.

1.16.5 Fuel status

The fuel state of the helicopter for the period leading up to the time of the accident was examined. Fuel quantity was not a recorded parameter, so references to fuel by the pilots were used to estimate the fuel quantity on board (Table 1). The estimated endurance remaining at the time of the accident was 112 minutes, sufficient for the helicopter to fly to either Kirkwall or Wick with adequate reserves, but not sufficient to fly to Aberdeen or Inverness (Table 2).

Time UTC	Fuel on board (kg)
1611	1,480
1615	1,440
1617	1,406
1701	1,100
1717	903 (by calculation)

Table 1

G-WNSB estimated fuel quantities on board

Airport	Distance (nm)	Time** (min)	Estimated fuel burn (kg)
Scatsta	33	12	100
Kirkwall	74	45	375
Wick	102	58	480
Inverness	165	97	810
Aberdeen	163	99	825

** Wind used for calculation 170° at 40 kt.

Table 2

Approximate fuel requirements for alternate airports

1.17 Organisational and management information

1.17.1 United Kingdom oil and gas industry

The accident flight was conducted by the operator on charter to one of the larger oil and gas operators in the UK sector of the North Sea.

The helicopter operator held an Air Operator Certificate to conduct helicopter flights onshore and offshore in support of the oil and gas industry. The transfer of personnel to and from the offshore installations is a vital link for the industry and the majority of personnel travel in helicopters. There is frequently a demand for helicopters to operate to their maximum payload.

1.17.2 Operation of the helicopter

1.17.2.1 Oversight of flight operations

Oversight of the operator is by the UK CAA. The operator set out in their Operations Manual (OM) the procedures for the operation of their aircraft in accordance with the requirements of JAR OPS 3[29], unless modified by national regulations. A copy of the OM is provided to the UK CAA and any proposed changes are required to be submitted for acceptance. For short notice changes the operator issued Flying Staff Instructions (FSIs), which were circulated to the flight crews and copies sent to the CAA for retrospective acceptance.

1.17.2.2 Fatigue management

The operator did not have, and was not required to have, a fatigue management system. Rostering was in accordance with the requirements of CAP 371 '*The Avoidance of Fatigue in Aircrews*' guidelines. Flight crews were able to opt for one of several different fixed pattern rosters. The crew of G-WNSB had been operating for 4 hours and 47 minutes at the time of the accident.

1.17.2.3 Flight planning

The OM included the following information about the weather requirements for a destination airport:

> *'The appropriate weather reports or forecasts, or any combination thereof must normally indicate that, during a period commencing one hour before and ending one hour after ETA at the destination heliport, the weather conditions will be at or above the following:*

29 JAR OPS 3 was extant at the time of the accident, but has since been replaced by EU Ops.

> *b. Non-precision approach:*
>
> *i. RVR / Visibility at or above the approach minimum,*
> *ii. Cloud ceiling at or above the approach MDH/MDA.'*

For an alternate airport the planning weather requirements were enhanced:

> *'The appropriate weather reports or forecasts, or any combination thereof must indicate that, during a period commencing one hour before and ending one hour after ETA at the destination alternate, the weather conditions will be at or above the applicable planning minima for the expected approach as follows:*
>
> *a. Cloud ceiling: DH/MDH + 200 ft,*
>
> *b. RVR/visibility: Minimum for the approach + 400 m.'*

1.17.2.4 Standard Operating Procedures (SOPs)

The operator published Standard Operating Procedures (SOPs) in its OM. These included information about the required and recommended levels of automation to be used during flight, and requirements for conducting onshore Non-Precision Approaches. Specific guidance was not provided in respect of the role of the PF concerning the need to monitor the flight instruments throughout an instrument approach.

At the time of the accident the OM required the Emergency Flotation System to be armed only for offshore approaches.

The OM also included a structure for and the phraseology to be used for standard and monitoring calls made in flight and during approaches. It also specified the stabilised approach criteria which, if not met, required a go-around.

References were also made to the use of ALT.A mode; one of which used the word '*shall*' (no discretion allowed) and the other the word '*should*' (implying discretion):

> *'Crews shall use ALT.A whenever climbing or descending to any altitude or flight level and both pilots shall crosscheck that the correct settings have been made. ALT.A should be set at MDA + 50 feet for Non-Precision Approaches.'*

The operator stated that the intent of the OM was that ALT.A must be set for all Non-Precision Approaches.

1.17.2.5 Non-Precision Approach

The purpose of an instrument approach is to enable a safe descent under instrument meteorological conditions (IMC) to a point from which a landing may be made visually. A Non-Precision Approach aid provides lateral guidance only, in this case the localiser. Information to control the vertical flight path is provided on the approach chart as a pilot-interpreted table of height and distance information.

The method of flying a Non-Precision Approach was not specified in the OM, but a representative from the operator's training department advised that pilots were trained to use a constant descent angle technique. This method, as taught, required the PNF to monitor the DME distance and cross-check the helicopter's altitude with the corresponding altitude tabulated on the chart. The next required altitude and distance were then called out.

The OM recommended that the ALT.A mode should be set to 50 ft above MDA. If the required visual reference has not been obtained at 50 ft above MDA, the rate of descent should be moderated, and the helicopter levelled at MDA. This should then be maintained to the Missed Approach Point (MAP), from where, if there is still no visual contact, a go-around should be flown.

The OM stated that a Non-Precision Approach should be flown with the autopilot coupled, either in 3-axes or 4-axes modes. The procedure for a Non-Precision Approach, flown in specific conditions of reduced cloud base and visibility, defined as *'marginal conditions'*[30], required the PF to fly the approach until the PNF had the required visual reference to complete the landing. The PNF was required to monitor the approach and look outside to acquire the visual references.

The required visual references for a Non-Precision Approach were:

'A pilot shall not continue an approach below Minimum Descent Altitude (MDA)/ Minimum Descent Height (MDH) unless at least one of the following visual references for the intended runway is distinctly visible to, and identifiable by the pilot:

a. Elements of the approach light system,

b. The threshold, or its markings, lights or identification lights,

c. The visual approach slope indicator(s),

d. The touchdown zone, zone markings or zone lights,

e. FATO/runway edge lights.'

30 Cloud base less than 200 ft above DA/MDA and/or RVR less than 400 m more than published minimum.

1.17.2.6 Actions at minima

At the MDA the OM required the PNF to announce "MDA, Level OFF" and "xx (DME) To Run"; the distance to the MAP. On reaching the MAP the OM procedure was provided:

> *'At the MAPt, PF calls "Decide"*
>
> *PNF responds with one of the following calls:*
>
> *"Go Around"*
>
> *"Visual Look Up"*[31]
>
> *"Visual I Have Control"*
>
> *"Continue"*
>
> *If PNF does not respond to the "Decide" call, PF shall initiate a go-around in accordance with the briefed procedure.'*

If the decision is *'Go Around'* there is no handover of control and the missed approach profile is flown by the PF.

If the call is '*Visual I Have Control',* the PNF has the required visual references and takes over control to conduct the landing.

If the call is '*Continue'*, the PNF has the required visual references but is not happy to take control until the visual cues improve. PF retains control and the PNF gives steering guidance until visual references are satisfactory, when he calls '*Visual I Have Control'.* Handover of control must be achieved by 250 ft aal for a Non-Precision Approach.

1.17.2.7 Standard calls

A summary of the operator's standard calls and responses for the Runway 09 LOC/DME approach at Sumburgh is provided in Table 3.

31 Not applicable to this approach due to *'marginal conditions'.*

Condition	PNF call	PF call
Localiser alive	*Localiser alive*	*Checked*
Localiser capture	*Localiser captured* (if coupled)	*Checked*
FAF	Calls out and crosschecks the altitude	*Checked*
500 feet above MDA	*500 feet to go*	*500 to go*
100 feet above MDA	*100 feet to go*	*Levelling*
At MDA (xx) miles to MAP	*MDA, Level Off* (XX) to run	
At MAP		*Decide*
Nothing seen	*Go Around*	*Going around*

Table 3

SOP calls and responses: Non-Precision Approach (monitored)

1.17.2.8 Operator's SMS monitoring of SOP compliance

The Operator implemented a Safety Management System in 2006 and the procedures were provided in the following document, last reviewed in December 2012: '*Integrated Safety Management System Compliance Procedures; Demonstrating an Acceptable Means of Compliance for CHC.'*

The document included the following requirement:

> *'CHC shall maintain procedures for allowing the comparison of standard operating procedures (SOPs) with those actually achieved in everyday line flight.'*

The AS332 helicopter was fitted with a crew jumpseat, but this was not considered suitable or practicable for training captains conducting line checks. Line checks were therefore conducted by training captains occupying one of the crew seats and acting as part of the operating crew.

1.17.2.9 Operator's revisions to SOPs since the accident

After the accident the operator reviewed its SOPs and made a number of revisions. A FSI was issued in late 2013. This was subsequently refined and FSI 2014 - 078 *'Crew monitoring and automation procedures*' became effective and implemented in July 2014. The SOPs for the use of automation were amended, together with revised crew monitoring functions and responsibilities.

The stated aim of these revisions was to *'maximise the ability of the crew to conduct effective crew monitoring'* and to *'harness the protection afforded by automation'*. The changes aimed to *'provide repeatable and predictable procedures... in recognition of the benefits of creating a strong normal expectation during critical phases of flight'*.

Safety action

Key elements of the SOP changes for the operator's Super Puma fleet were:

All instrument approaches to be flown 4-axes coupled.

A specified,[32] pre-briefed, nominated fixed airspeed to be used for onshore approaches below 1,000 aal.

Changes to the stabilised approach definitions and criteria.

When climbing or descending in 3 axis/2 cue[33] without the collective coupled, crews shall couple airspeed, not vertical speed, to the pitch axis.

1.17.3 Flight manual information

The Rotorcraft Flight Manual (RFM) is produced by the helicopter manufacturer[34]. It is divided into two volumes: Volume 1 constitutes the Flight Manual, containing the required approved information. Volume 2, the Complementary Flight Manual (CFM), contains information not subject to regulatory approval. There is limited information in the RFM concerning operating procedures.

Certification standards for large aeroplanes are provided in EASA CS-25. Subpart G specifies material to be included in Aircraft Flight Manuals (AFM), which includes information concerning operating procedures:

'For those manufacturers and operators that do not produce other sources of procedures information (generally manufacturers and operators of small transports), the AFM is the only source of this information. In this circumstance, the AFM operating procedures information must be comprehensive and include information such as cockpit checklists, systems descriptions and associated procedures.'

32 According to approach type and helicopter type.
33 According to helicopter type.
34 On 1 January 2014 Eurocopter was renamed as Airbus Helicopters.

To date there is no similar requirement for the provision of operating procedures material for RFMs.

Safety action

In December 2014, in a presentation given at the EASA Rotorcraft Symposium 2014, Airbus Helicopters reported on an initiative that was launched in September 2013: the Airbus Helicopters Safety Partnership. This was an *'initiative bringing together Airbus Helicopters' efforts to implement and improve safety practices and standards in close cooperation with oil and gas operators, authorities and industry stakeholders*'.

One of the cornerstones of this initiative was that *'standards drive safety and efficiency*'. To achieve this the manufacturer would focus on the harmonisation of operating procedures. Accordingly, a working group has been established to produce a Flight Crew Operating Manual (FCOM) for the EC225 helicopter[35]. The purpose of this FCOM is to support operators in producing their own OM and to complement the approved RFM.

Safety action update

In November 2015, the helicopter manufacturer advised the AAIB that:

> *'the FCOM 225 for oil and gas operations has been released by AH and AH has committed to release FCOM for all new AH helicopters flying in oil and gas operations. It will be done at least for the H175 and the H160. For the 332L2, a FOBN (Flight Operational Briefing Note) related mainly to the optimized use of the AFCS is planned by AH.'*

In October 2014 a new industry association, HeliOffshore, was established for organisations with an interest in working together on safety in offshore helicopter transport. It is a global safety association and since inception it has worked towards and introduced a number of safety initiatives. The following information was published in the HeliOffshore July 2015 News Bulletin[36]:

'Automation: all manufacturers for those aircraft types used by the offshore industry have agreed to produce Flight Crew Operating Manuals, following the Airbus Helicopters publication of its EC225 FCOM.'

35 Press release available at; http://www.airbushelicopters.com/site/en/press/Focus-on-safety:-Airbus-Helicopters-develops-with-helicopter-operators-the-rotorcraft-industrya-s-first-Flight-Crew-Operating-Manual_1231.html?iframe=true&width=700.

36 http://helioffshore.org/wp-content/uploads/2015/07/HeliOffshore_Bulletin_July2015.pdf [Accessed 9 November 2015]

1.17.4 Rescue co-ordination

Sumburgh Airport Aerodrome Manual provided procedures for staff which included Emergency Orders for use in the event of an aircraft accident. A sequence of actions was provided in the form of a checklist for the Air Traffic Services Assistant (ATSA) to fulfil, the first of which was to notify the Police Scotland Command and Control Centre at Inverness.

Once notified, the Control Centre was responsible for contacting and deploying the necessary emergency resources. A transcript of the initial conversations between the ATSA and the Control Centre is included at Appendix J. The notification procedures between Sumburgh ATC and the Control Centre were tested weekly on a Friday afternoon.

Since the accident, a new national network centre for coastguard operations was established in 2014; the National Maritime Operations Centre (NMOC). Operational control for some areas was transferred in September 2014; the network is scheduled to be fully operational by the end of 2015. The new network is designed to allow the coastguard centres to work together to manage the workload, providing an enhanced national support network. Existing notification procedures remain unchanged.

1.17.5 Flight Data Monitoring (FDM)

1.17.5.1 Background

At the time of this accident, North Sea helicopter operators had in place voluntary FDM programmes. There was no regulatory requirement for helicopter operators to conduct FDM.

A FDM programme assists operators in identifying, quantifying and assessing operational risks for the purpose of improving safety through the systematic analysis of information obtained from aircraft flight data recordings. Aspects such as non-compliance with SOPs, poor airmanship and weaknesses in crew performance or training may be monitored through FDM.

The history of FDM can be traced to the 1960s when a CAA-led programme identified the benefits of routinely analysing flight data. Many airlines followed by developing their own voluntary FDM programmes, and in 2001 the International Civil Aviation Organisation (ICAO) made FDM a standard for all operators of passenger aircraft weighing more than 27,000 kg with effect from 2005. Shortly afterwards this requirement was incorporated into UK and European regulations. ICAO also recommended in 2005 that FDM should be extended to helicopters weighing more than 7,000 kg (or having a passenger capacity of more than nine) and when equipped with a flight data recorder. This recommendation was adopted into regulation by the EASA, becoming effective from 1 January 2019.

Operators typically download recorded flight data[37] from each aircraft on a daily basis. This is then processed by a ground-based computer analysis system. The core analysis function used within FDM systems is known as 'event' detection. Each event is typically developed to monitor a specific aspect of an aircraft's operation or its systems by using algorithms to identify if the data exceeds pre-defined trigger thresholds. The basis for many events and their trigger thresholds is the flight manual, operator's SOPs and principles of good airmanship.

The development of event algorithms and trigger thresholds can be a complex process, with the aim of achieving 100% reliability of detection, whilst minimising nuisance and false events.

Within large programmes, a team of data analysts normally support the initial validation of each event and collation of results. An FDM manager and representatives from the flight operations and safety departments provide the link through which results are integrated into the operators Safety Management System (SMS)[38]. In smaller programmes, one person may be responsible for the entire programme.

Event review and follow-up safety action

Having passed validation, events are then categorised by their type and the extent to which trigger thresholds have been exceeded. Events exceeding lower level thresholds are typically retained as part of a statistical trend analysis only, whereas a higher level event exceedance may result in the flight crew being contacted for additional information. Analysis of the data then forms part of the review process to establish if remedial safety action is required.

The CAA Civil Aviation Publication (CAP) 739 - *'Flight Data Monitoring'* provides guidance for fixed and rotary wing operators on the processes and actions required to establish and operate an FDM programme. It includes the following guidance on remedial action following the identification of a safety issue:

---

37 The majority of operators use a recorder known as a Quick Access Recorder (QAR) to support FDM analysis. Unlike the CVFDR, the QAR is designed so that flight data may be quickly retrieved using removable media or by wirelessly transmitting the data from the aircraft after flight.

38 A 'Safety Management System' is an explicit element of the corporate management system that sets out a company's safety policy and defines how it intends to manage safety as part of its overall business (reference CAA Publication Flight Data Monitoring CAP 739 Chapter 4, section 4.5).

> *'Remedial Action[39] – Once a hazard or potential hazard has been identified, then the first step has to be to decide if the level of risk is acceptable. If not, then appropriate action to reduce the effect should be investigated along with an assessment of the wider effects of any proposed changes. This should be carried out to ensure the risk is not moved elsewhere. The responsibility for ensuring action is taken must be clearly defined and those identified must be fully empowered.'*

If changes are made, such as to SOPs or crew training, the FDM programme can provide a closed-loop monitoring system within the operator's SMS to determine if the desired outcome has been achieved (Figure 20). The principle of this closed-loop process should also be applied during routine day-to-day operation of the programme.

Experience has shown that even programmes considered to be mature may not always identify areas of risk prior to an accident[40]. It is therefore important that an FDM programme, whether fixed or rotary wing, be considered a safety tool that requires ongoing support and development.

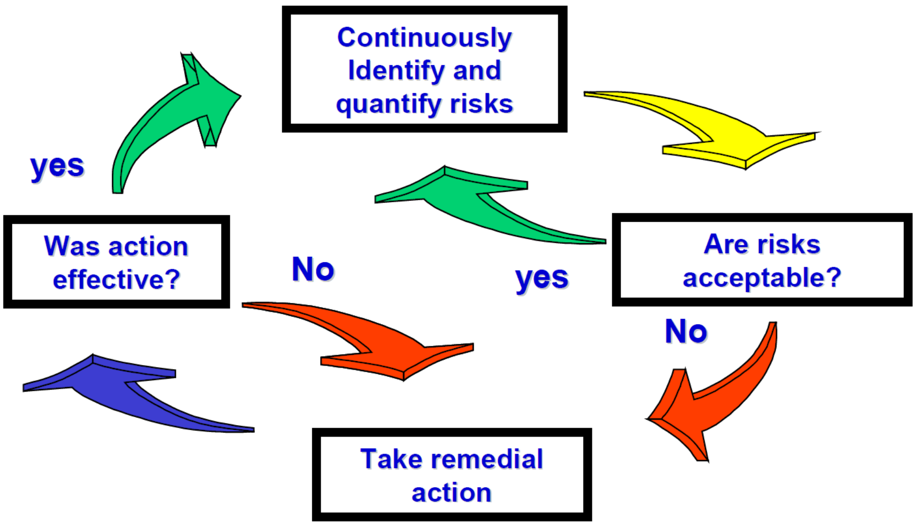


Figure 20

FDM closed-loop monitoring process (image courtesy of CAA)

39 Chapter 3, Section 3.25.
40 Accident to Boeing 767, registration G-OOBK, at Bristol Airport (AAIB report EW/C2010/10/01). Two Safety Recommendations (2012-014 and 2012-015) were made regarding FDM.

1.17.5.2 Helicopter Flight Data Monitoring (HFDM)

In 1998 a trial was initiated by the CAA, with the support of Shell Aircraft Ltd, to establish if FDM could be applied to helicopters. Five AS332L helicopters operated by Bristow Helicopter Ltd (BHL) in support of the North Sea oil and gas industry were selected. Following a two year operational phase, the CAA published CAA Paper 2002/02 – *'Final Report on the Helicopter Operations Monitoring Programme (HOMP)* [41]*'*. The report concluded that FDM could be successfully applied to helicopters, with a number of operational safety issues identified during the trial.

A second CAA trial followed shortly thereafter, with FDM expanded to BHL's fleet of Sikorsky S-76 helicopters and two AS332L helicopters operated by CHC. This trial concluded in March 2003 after a 6-month operational period, with results published in CAA Paper 2004/12 – *'Final Report on the Follow-on-Activities to the HOMP trial'.*

The report concluded that FDM could be applied both to a different helicopter type and operator, with further operational issues identified. The report made a number of recommendations, including:

> *'Helicopter operators should continue to develop and refine the HOMP measurements to maximise their accuracy in characterising different aspects of the operation and to provide further analysis capabilities.'*

Following the CAA trials, clients within the oil and gas industry started to require that FDM programmes were in place as a contractual prerequisite. Within the UK, this led to CHC and Bond Offshore Helicopters (Bond) introducing programmes in 2006 and further expansion of the programme at BHL. Several other international helicopter operators have also introduced FDM programmes.

1.17.5.3 HFDM regulatory requirements

There is no current UK or European regulatory requirement for a HFDM programme. On 6 June 2013, the EASA issued Notice of Proposed Amendment (NPA) 2013-10 applicable to commercial air transport offshore helicopter operations. Amongst other changes, NPA 2013-10 proposed the implementation of an FDM programme for helicopters required to be equipped with a flight data recorder[42], with a suggested implementation period of two to three years, to allow operators to establish a programme.

41 The FDM programme was referred to as the Helicopter Operations Monitoring Program (HOMP). FDM programmes used in rotary wing operations is now more widely referred to as Helicopter Flight Data Monitoring (HFDM).

42 CAT.IDE.H.190: Helicopters with an MCTOM of more than 3,175 kg and first issued with an individual C of A on or after August 1999 and all helicopters with an MCTOM of more than 7,000 kg, or an MOPSC of more than nine, and first issued with an individual C of A on or after 1 January 1989 but before 1 August 1999.

In 2014, the EASA published Comment Response Document (CRD) 2013-10 and, following responses from across industry, a compliance period of three years for an FDM programme was agreed. In May 2015, the EASA ratified the requirement for a HFDM programme for offshore commercial air transport operators. The date for compliance is 1 January 2019.

The CAA has stated in CAP 739 Chapter 18:

> *'As FDM data becomes increasingly important in Safety Management Systems (SMS) and Alternative Training and Qualification Programmes (ATQP), National Aviation Authorities need to be (a) assured of the effectiveness of FDM programmes and (b) its compliance with requirements.'*

1.17.5.4 National Aviation Authority (NAA) fixed wing and rotary wing FDM programme assistance

Since approximately 2001, the UK CAA has been hosting a National FDM forum where airlines from across the UK and Republic of Ireland have met biannually to openly discuss and share FDM findings. This has included safety issues, new analysis techniques and CAA-led projects, with the aim of ensuring that all participants obtain the maximum safety benefit from FDM. The focus of this forum was on fixed wing operations; however, helicopter operators were invited to attend.

In 2010 the Global Helicopter Flight Data Monitoring (GHFDM) Steering Group was formed. This is a voluntary organisation which, according to its website, includes representatives from operators, manufacturers and support from the FAA. The GHFDM has no regulatory powers, but its aim is to promote best practice and cooperation in the design, support and operation of helicopter FDM programmes. CHC was instrumental in the setting up and chairing of the GHFDM.

In 2012, as part of the European Aviation Safety Plan (EASP), the EASA created the European Operators FDM (EOFDM) forum. This is based on similar principles to the CAA-hosted forum, but encompasses operators from across Europe. The EASA also formed the European Authorities Coordination Group on Flight Data Monitoring (EAFDM), with the publication of guidance material for NAA's to promote FDM and establish their own national forums. The focus of both the EOFDM and EAFDM forums is the development of FDM programmes exclusively for fixed wing aircraft.

CHC and two other helicopter operators supporting the North Sea Oil and Gas industry had informally shared HFDM techniques and safety information over several years. In November 2012 the CAA proposed a joint North Sea HFDM forum. In July 2013, the three operators met to formalise the sharing of FDM information. This was followed by a meeting with the CAA in December 2013, to discuss opportunities of working with the forum to improve offshore helicopter safety performance, and to promote its continuous improvement through HFDM.

Approximately 230 helicopters operate within 11 European member states in support of offshore operations. To date there is no EASA-led HFDM forum for helicopter operations.

1.17.5.5 FDM guidance material

The CAA first published CAP 739 in August 2003. The guidance relating to setting up and operating a programme contained within the CAP was generic to fixed wing and helicopter operators, although details on events were limited to fixed wing aircraft only. CAP 739 Chapter 2 stated:

> *'A FDM system allows an operator to compare their Standard Operating Procedures (SOPs) with those actually achieved in everyday line flights.'*

In 2011, the GHFDM published a best practice guide. This contained a list of generic helicopter FDM events, with 17 focused on identifying if the helicopter's approach is stabilised. The International Helicopter Safety Team[43] (IHST) has also published guidance, which cross-refers to the generic events provided within the GHFDM document.

In June 2013 the CAA revised CAP 739. A new chapter specific to helicopters (Chapter 11) was introduced, with a summary of the findings and list of events previously published in CAA Paper 2002/02 and 2004/12.

CAP 739 Section 11.9 states:

> *'Due to the characteristics of helicopter flight dynamics and operating techniques, helicopter FDM events are generally more complex than fixed wing equivalents.'*

CAP 739 Section 11.10 further states:

> *'As a result of the greater operational flexibility of helicopters and the greater variability in the nature of helicopter operations, 'normality' is harder to define.'*

43 www.IHST.org. The International Helicopter Safety Team (IHST) is a cooperative government-industry team formed in 2006 with the aim of reducing the worldwide helicopter accident rate.

In December 2013, the EASA issued guidance document *'Developing Standardised FDM-Based Indicators'.* This material offers a set of standardised FDM events and specific details of detection logic for fixed wing aircraft that National Aviation Authorities (NAA's) can promote to operators.

The EASA guidance document addressed four safety issues identified as high priority within the European Aviation Safety Plans 2012-2015 and 2013-2016. These were: runway excursions, controlled flight into terrain (CFIT), loss of control in flight, and mid-air collisions. No similar guidance material has been published by the EASA for helicopter operators or NAA's.

1.17.6 Operator's FDM programme

At the time of the accident there was no regulatory requirement for helicopter operators to conduct FDM. However, this operator and other North Sea helicopter operators had voluntarily established and developed FDM programmes.

The operator had been monitoring its UK-based AS332 L2 fleet since 2006. At the time of the accident its FDM analysis system[44] applicable to the AS332 L2 was configured to detect 127 events, of which 21 were specific to monitoring an onshore approach.

The operator advised that its FDM events were initially based on those published in CAA Paper 2002/02, in conjunction with a review of its own operational procedures. As its knowledge of FDM and ability to use the analysis system increased, the 'event set' was further developed. In January 2013, the operator introduced standardised event thresholds across all helicopter types with the aim of improving cross-fleet trending.

The operator stated that, given the complexities of its helicopter operation, the adaptation of FDM systems originally developed for fixed wing aircraft and limited ongoing assistance from NAA's, made the task of developing HFDM difficult. Discussions with other UK-based North Sea helicopter operators also indicated a similar situation.

In accordance with industry common practice, events were configured with three trigger thresholds, identified as Level 1, 2 and 3. The operator's FDM procedures[45] defined the Level 1 threshold as being set lower than one which would constitute an aircraft or airmanship limitation; Level 2 thresholds were typically set just above the aircraft or airmanship limitation; and a Level 3 threshold was set to trigger when *'significant breaches of aircraft or airmanship limitations occur'.*

44 Manufactured by Aerobytes Ltd: www.aerobytes.co.uk.
45 Operator's Integrated SMS Compliance Procedures, dated December 2012, Page C-7.

1.17.6.1 AAIB review of operator's HFDM programme

During the investigation the AAIB reviewed previous flights operated by the commander of G-WNSB, in conjunction with FDM events specific to monitoring the approach phase of flight for its fleet of AS332 L2 helicopters.

The primary purpose of this review was to identify if the commander's FDM record was unusual compared to his peers. It was also to determine how the programme was used to identify compliance with the operational procedures applicable to an onshore approach.

1.17.6.2 Onshore approach HFDM review

At the time of the accident, the operator's standard for a stabilised approach and the actions to be taken if an approach became unstable were published in *'Flying Staff Instruction FSI UK 2012-03'*. The FSI came into effect on 1 July 2012, replacing Section 8.4.5.12 within the operator's Operations Manual Part A. The FSI included changes to the stabilised approach standard and the inclusion of a new procedure applicable to the visual segment of an offshore approach to land on a helideck[46]. FSI 2012-03 stated:

'8.4.5.12 Stabilised approach

8.4.5.12.1 Generic

The following applies to all approaches:

a. All instrument approaches in IMC shall be stabilised by 1000 feet above touchdown elevation (onshore) or above the surface (offshore). An en route let down in IMC with the intention of transitioning to VMC flight at or above the let down minimum descent altitude does not count as an instrument approach for the purposes of this paragraph.

…

46 The operator advised that it had issued the new offshore stable approach standard in response to AAIB Safety Recommendation 2011-051, which recommended to the UK CAA that offshore helicopter operators should define specific offshore stable approach profiles. The recommendation was made following the investigation into the accident to Eurocopter EC225, registration G-REDU, which impacted the sea whilst approaching to land at the Eastern Trough Area Project (ETAP) Central Production Facility Platform helideck in the North Sea. (AAIB Aircraft Accident Report 1/2011, published 14 September 2011).

> c. *An approach is stabilised when the following criteria are met:*
>
> *i. The aircraft is on the correct flight path*
>
> *ii. The aircraft is in the correct landing configuration*
>
> *iii. All briefings and checklists – except the final checks - have been completed*
>
> *iv. Unless required by the published approach profile, only small changes in attitude, heading and power are required to maintain the correct flight path*
>
> *v. The sustained rate of descent should not be greater than 600 fpm, unless required by the published onshore approach profile*
>
> *vi. The aircraft is at the correct approach speed for the procedure in use*
>
> *...*
>
> e. *A go-around is mandatory and shall be carried out immediately if at any time: either pilot becomes uncomfortable with the stability of the approach; and/or the parameters are outside the stabilized approach criteria.'*

The AAIB review of the operator's FDM programme with respect to onshore approaches identified the following items of note:

i. The aircraft is on the correct flight path.

For a Non-Precision Approach, such as to Sumburgh Airport Runway 09, there was no monitoring in place to identify if the vertical flight path deviated from the published vertical descent profile.

AAIB discussions with the operator highlighted the technical challenges in monitoring NPAs based on the SOPs in place at the time of the accident.

iv. Unless required by the published approach profile, only small changes in attitude, heading and power are required to maintain the correct flight path.

There were no events configured to monitor changes in collective pitch position, engine power settings or heading deviations during an onshore approach.

The 'event set' provided for the detection of excessive pitch and roll attitudes. Events would be triggered if the pitch attitude exceeded 14° nose-down or 16° nose-up, or the roll attitude exceeded 33° when the helicopter was above 300 ft agl, or 30° when below 300 ft agl.

v. *The sustained rate of descent should not be greater than 600 fpm, unless required by the published onshore approach profile*

No specific events were in place to identify if the descent rate was consistent with a published onshore approach profile. Discussion with the operator highlighted the difficulties in identifying what published approach was being conducted for the purposes of HFDM.

Events were in place to alert if the rate of descent exceeded: (1) 1,200 fpm whilst in flight; (2) 500 fpm when the helicopter's airspeed was less than 30 kt; (3) 600 fpm when the helicopter was below 500 ft aal; (4) 1,000 fpm below 500 ft for four seconds or more; (5) 1,000 fpm below 300 ft for three seconds or more.

vi. *The aircraft is at the correct approach speed for the procedure in use*

At the time of the accident, the operator's Operations Manual Part B – Normal Procedures section 3.9.8 '*Use of AP coupled modes during instrument approaches'* stated in subpart 3.9.8.1 General:

> *'The recommended speed range is 80-120kt IAS and Approaches may be flown in 3-axes or 4-axes.'*

Monitoring was not in place to identify if the recommended approach speeds were complied with, or if the autopilot upper modes were engaged in either 3-axes or 4-axes.

Events were monitored if the manufacturer's maximum airspeed limitations were exceeded and, when above 600 ft[47] agl, the airspeed was less than 60 kt (the Level 1 event limit was set at 60 kt, Level 2 at 50 kt and Level 3 at 35 kt).

1.17.6.3 Stabilised approach monitoring at other helicopter operators

The AAIB met with two other helicopter operators supporting the North Sea oil and gas industry to discuss their FDM programmes and analysis systems. One operator used an FDM system developed by a Canadian manufacturer and the second operator was in the process of moving to the same FDM system manufacturer used by CHC, who was providing its set of event logic and thresholds to assist the other operator.

Findings were similar at both of the other operators, with difficulties in identifying if an approach was compliant with their SOPs applicable to an onshore approach.

47 The operator advised that the threshold of 600 ft had been selected as a measure to reduce nuisance events triggered when the helicopter's airspeed was being reduced during the later stages of the approach, in preparation for landing.

1.17.6.4 The operator's FDM management and review process

There was no regulatory requirement for an HFDM programme at the time of the accident. The operator's FDM programme was operated on a voluntary basis and was a contractual requirement of some of its clients. Since its inception, the operator's FDM programme has become one of the largest internationally, with three full-time data analysts and 28 base FDM Representatives supporting 165 helicopters across 26 bases of operation.

Each of the operator's bases of operation had an FDM Representative. They were pilots, whose role was to review and interpret events that exceeded Level 2 or Level 3 thresholds, and to provide the link through which flight crew were contacted for confidential feedback. (The operator's procedures stated that Level 3 events required an automatic crew contact.) The information obtained was then fed back into the FDM programme to provide the context as to why the events might have been triggered.

An FDM report was generated quarterly for each of the operator's bases. This provided, among other aspects, qualitative and statistical information on the highest rate events and their trends. Each base report was to be reviewed by an FDM Review Group, whose core members included the Manager Flight Operations, Flight Standards Representatives, FDM Representative and Chief Pilot.

Recommendations from the FDM Review Group could include: a need for changes to procedures, training methods, event trigger thresholds, or new events to be developed. Each recommendation was to be allocated to the appropriate department for review, with closing actions recorded in the operator's Safety Quality Integrated Database (SQID) and the next appropriate FDM report.

The responsibilities of each base FDM Representative included the convening of the FDM Review Group, with the operator's Integrated SMS Compliance Procedures recommending: '*meetings will generally take place quarterly'.*

AAIB review of the quarterly FDM reports for Aberdeen for the period of Q3 2012 to Q3 2013 showed that the low airspeed event did not feature in the reports' list of top events. The list of events was selected based on regularity of occurrence, number of high severity events, and increasing trends in frequency and risk.

1.17.7 CAP 1145 FDM review findings

The CAA review[48] included the following statement:

> *'Although not yet mandated for helicopters, the CAA and industry have been actively promoting and developing the programme for several years. Perhaps due to the lack of a requirement and the somewhat complex nature of helicopter operations, the rate of progress has not allowed the full potential to be realised yet.'*

The CAA raised the following action in response to its findings:

> *'A2 The CAA will accelerate its work with industry to develop and apply Safety Performance Indicators[49] to improve the effectiveness of helicopter operators' Flight Data Monitoring programmes. (Delivery Q3/2014).'*

In January 2015, the CAA published CAP 1243, which provided an update on progress regarding the actions and safety recommendations raised in CAP 1145. For action A2, this stated '*Initial action complete, revised delivery date for expanded scope Q2/2015*.' The accompanying information advised that the scope of this activity had expanded '*to improve safety performance monitoring capability of helicopter operators' SMS*'.

1.17.8 G-WNSB Commander's FDM event history

A review of FDM events triggered whilst the commander was operating as PF during 11 flights to Sumburgh Airport and 20 to Aberdeen Airport between 31 January 2013 and 22 August 2013 was undertaken. The results were as follows:

Number of commander's flights analysed	Flights triggering events	Number of events	Number of Level 1 / 2 / 3 events	Commander's flights containing events (%)	Company AS332 L2 fleet - flights containing events (%)
31	10	18	13 / 3 / 2	32	38

Table 4

Commander of G-WNSB FDM event rate compared to fleet average

48 CAP 1145 Section B: Analysis – Chapter 4 Occurrence Investigation.
49 Quote from CAP 1145: '*The CAA has established a suite of safety performance indicators (SPIs), predominantly based on accident and MOR data, that are monitored in support of one of its key strategic objectives, i.e. to enhance aviation safety performance by pursuing targeted and continuous improvements in systems, culture, processes and capability. Whilst these SPIs currently monitor safety performance for significant issues associated with large commercial air transport aeroplane operations, the same principles can be extended to other aviation sectors such as public transport helicopter operations, business aviation and general aviation.*'

The two Level[50] 3 events had been triggered due to excessive yaw pedal application during ground taxi and high engine torque in flight. No events were triggered due to low airspeed.

1.17.8.1 G-WNSB commander's previous approaches to Sumburgh and Aberdeen Airports

Analysis of the commander's 29[51] most recent approaches to Sumburgh Airport indicated that all of the approaches had transitioned to manual flight. The flightpaths and recorded weather were consistent with the crew having become visual with the airport environment at or above 500 ft aal. Of the 29 approaches, the commander was PF[52] during 20 of them, of which three were to Runway 09; the ALT.A mode was not used during these approaches.

Figure 21 is a time series plot of flight data that shows variation in the use of the autopilot upper modes in 3-axes and 4-axes during two approaches to Runway 09 on 17 May 2013, compared with the accident approach. The first approach was similar to the accident approach, with the autopilot set to 4-axes for the intermediate descent and 3-axes during the approach. The second approach was with the autopilot in 4-axes. Both approaches maintained the vertical descent profile until about 600 ft aal, when the approaches were broken off to land on Runway H06 and Runway 33 respectively. The recorded cloud base and visibility at Sumburgh Airport during the period of the two approaches was about 900 ft and 7,000 m, respectively.

Lowest recorded cloud base during G-WNSB commander's previous landings

In addition to the 29 approaches to Sumburgh, 267 approaches to Aberdeen were studied. The lowest recorded cloud base was on the last sector to Aberdeen on 22 August 2013, the day before the accident. The commander was PF and the ILS approach was made with the autopilot set to 4-axes. The recorded cloud base at Aberdeen Airport at 1920 hrs was broken at 300 ft and at 1950 hrs, broken at 200 ft. The helicopter landed at 1941 hrs.

50 Refer to Section 1.17.6 for a description of event Level 1, 2 and 3.
51 The records were from between 01 August 2012 and 22 August 2013. One record for a flight to Sumburgh Airport on 17 June 2013 was not available. Analysis of the recorded weather on this day indicates that the approach would not have been operating in IMC during the latter stages of this approach, with a lowest recorded cloud base of 800 ft.
52 The VHF keying parameter was used to determine which member of the flight crew was most likely to have been PF and PNF.

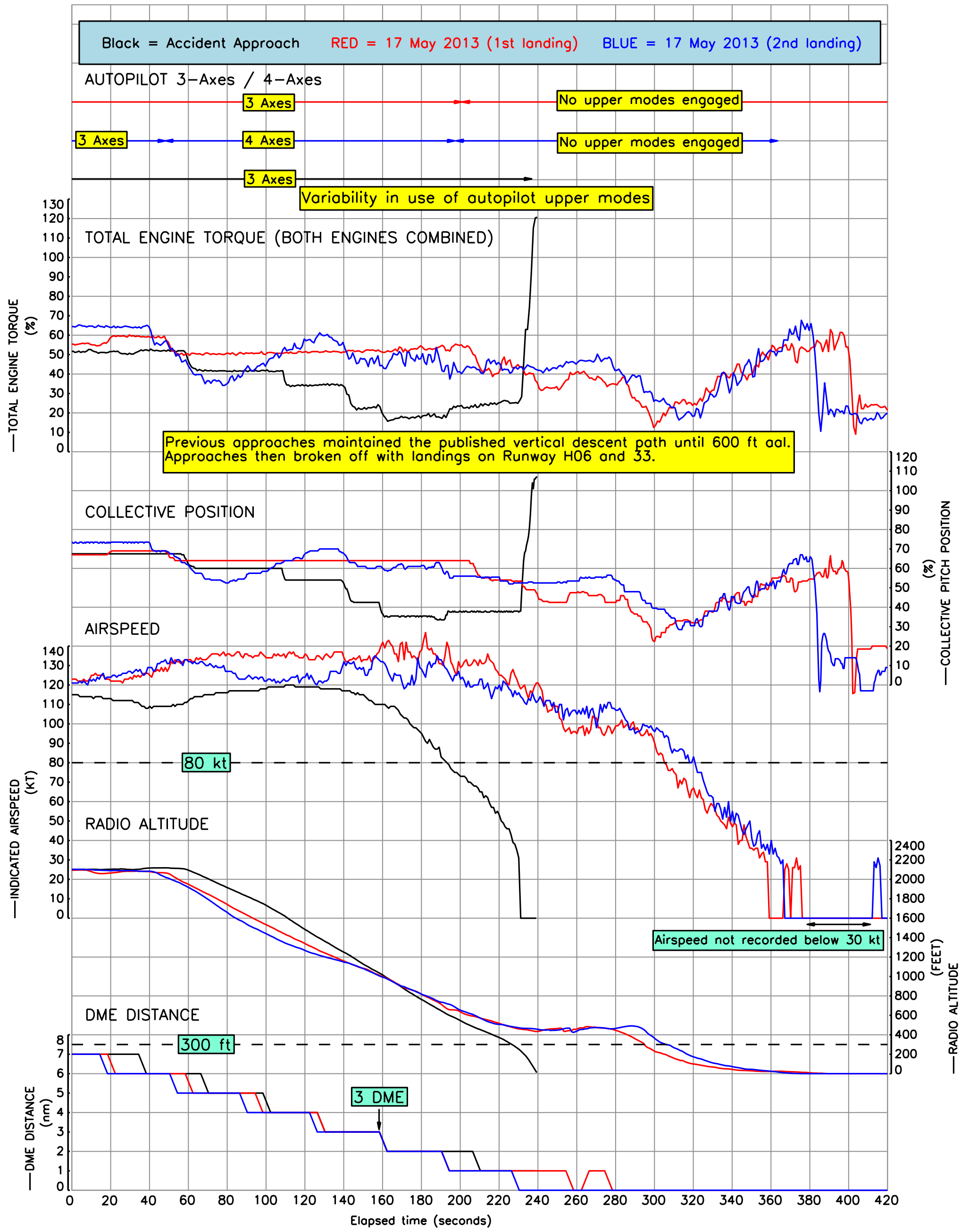


Figure 21

Previous approaches to Sumburgh Airport flown by commander

1.17.8.2 Approaches to Sumburgh Airport Runway 09 flown by different flight crew

Figure 22 is a time series plot of flight data showing the difference in vertical descent paths, approach speeds, engine power and autopilot 3- and 4-axes settings during two approaches to Sumburgh Airport Runway 09 flown by different crews. The accident approach is included for comparison, with the data aligned at 3 DME SUB. The following paragraphs describe the two approaches:

Approach on 21 August 2013

The helicopter departed Aberdeen Airport and made one approach to Sumburgh Airport Runway 09; a go-around was flown before returning to land at Aberdeen. The approach was flown with the autopilot set to 4-axes, the MDA was bugged at 300 ft and the ALT.A mode set to 350 ft prior to the start of the approach. The helicopter was established on the localiser and approach speed was maintained above 100 kt until the later stages of the approach. At a height of 350 ft and approximately 0.5 DME, a go-around was carried out; the time was 0942 hrs. The recorded visibility and cloud at Sumburgh Airport at 0920 hrs UTC was 8,000 m, few cloud at 300 ft and scattered at 500 ft. At 0950 hrs UTC the visibility and cloud was: 8,000 m, few cloud at 200 ft, scattered at 300 ft and broken at 400 ft.

Approach during the morning of 23 August 2013

Both 3-axes and 4-axes upper autopilot modes were set during periods of this approach. The MDA was bugged at 300 ft and the ALT.A mode was set, but not until after the descent had started. The helicopter was established on the localiser with the airspeed at 130 kt and the autopilot set to 3-axes with V/S mode. Shortly after, the autopilot was set to 4-axes and the airspeed was reduced.

At about 1,000 ft the autopilot was briefly set to 3-axes, before being set to 4-axes as the airspeed stabilised at about 80 kt. At 3 DME the helicopter was 300 ft below the published vertical descent path. The descent continued to 380 ft, when the autopilot was set to 3-axes with the ALT mode engaged. The airspeed then increased to a maximum of 111 kt, before being reduced. At 1.9 DME the upper modes of the autopilot were disengaged and the helicopter completed its descent to Runway 09, before making a right turn to land on Runway 15 at 1023 hrs. The recorded visibility and cloud at Sumburgh Airport at 1020 hrs UTC was: 10 km or greater, few cloud at 800 ft, scattered at 900 ft and broken at 1,000 ft.

Comparison of engine torque settings at 80 kt

During the approach on the morning of 23 August 2013, the rate of reduction of airspeed between 109 kt and 80 kt was similar to that during the accident approach (1.2 kt per second, compared to 1 kt per second; Figure 22 Points A and B). The vertical descent rates during this period were also similar (about 700 fpm).

When the airspeed was stabilised at 80 kt during the earlier approach, a combined engine torque of 32% (collective pitch of 44%) was set. On the accident approach about 23% combined torque (collective pitch of 38%) was set but the airspeed continued to reduce below 80 kt (Figure 22 Points C and D).

1.17.8.3 Autopilot upper mode setting during onshore approaches

During the 20 approaches flown by the commander as PF between 1 August 2012 and 22 August 2013 to Sumburgh Airport, 16 approaches were with the autopilot set to 3-axes with V/S mode and 4 were set to 4-axes.

Table 5 provides a summary of autopilot upper mode setting during the last 1,000 ft of the approach for the operator's AS332 L2 fleet:

Airport	Date / year	Total approaches	3-axes engaged (% of total)	4-axes engaged (% of total)	No upper modes engaged (% of total)
Aberdeen	January 2013 to September 2013	3,405	2,026 (59.5%)	456 (13.4%)	923 (27.1%)
Sumburgh	January 2013 to September 2013	744	320 (43%)	72 (9.7%)	352 (47.3%)
Sumburgh	2012	590	243 (41.2%)	42 (7.1%)	305 (51.7%)

Table 5

Autopilot upper mode utilisation

A review of the CVFDR data for a sample of 43 of the above approaches showed that, for those that were flown in 3-axes, V/S mode was selected, rather than IAS mode.

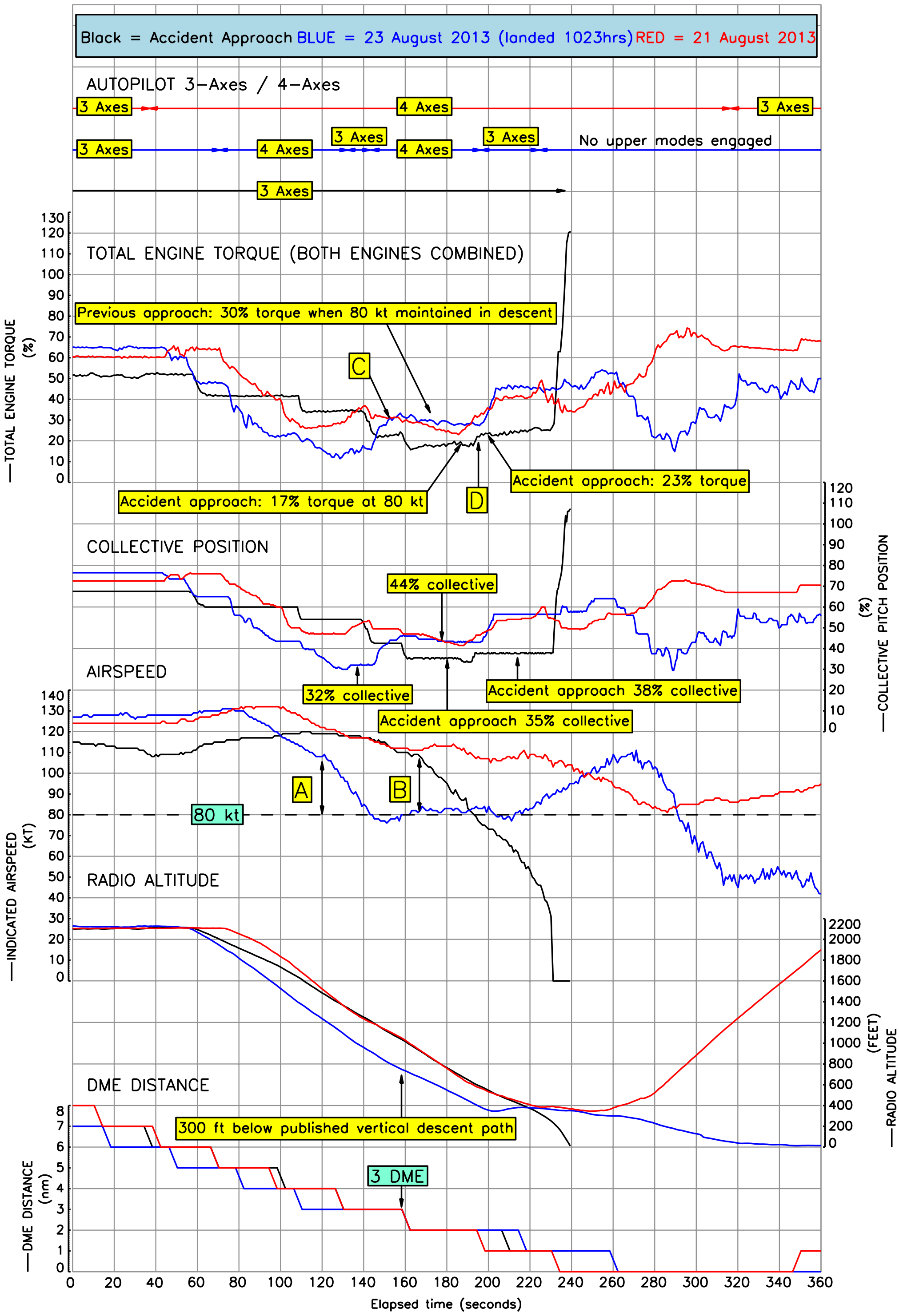


Figure 22

Approaches to Sumburgh Airport Runway 09 by different crew

1.17.8.4 Minimum airspeeds during onshore approach

Table 6 provides a summary of the minimum recorded airspeed during 2,611 onshore approaches made by the operator's fleet of AS332 L2 helicopters whilst the autopilot was set to 3-axes. The period was between 1 January 2013 and 31 December 2013.

A total of 53 onshore approaches were identified where the autopilot was in 3-axes and the airspeed was less than 70 kt between 1,000 ft and 400 ft amsl. This was 2% of the approaches analysed. The weather reports[53] were reviewed for the 53 approaches to establish if the cloud base or visibility were indicative of the helicopter operating in IMC when the airspeed was less than 70 kt (RFM IFR operating limitation). Five approaches were identified with cloud bases reported at less than 1,000 ft. Of these, the lowest combination of visibility and cloud base was 1,500 m broken at 300 ft, with an airspeed of 68 kt between 1,000 ft and 800 ft; the visibility ranged from greater than 4,200 m and the cloud from broken at 300 ft, to few at 800 ft for the four other approaches. The lowest airspeed among the five approaches was 65 kt, which occurred between 600 ft and 400 ft.

Of the 53 approaches, 12 would have triggered a FDM low airspeed event. Two of the approaches would have triggered the Level 2 FDM event threshold of ≤ 50 kt and ten the Level 1 FDM threshold of < 60 kt. None of the approaches triggered the Level 3 threshold (set at 35 kt).

The commander of G-WNSB flew two approaches where the airspeed was less than 70 kt. Neither of these would have triggered the FDM low airspeed event.

Altitude ranges (ft)	**Lowest airspeed – all crew (kt)**	**Lowest airspeed – Commander of G-WNSB (kt)**	**Number of approaches per altitude range with an airspeed of less than 70 kt (% of total)**
1000 to 800	46	68	23 (0.9 %)
800 to 600	50	65	33 (1.2%)
600 to 400	56	70	10 (0.4%)

Table 6

Minimum recorded airspeed during onshore approaches

53 The weather reports were updated once every 30 minutes. The report having the closest time to that of the deviation below 70 kt was utilised.

1.17.8.5 Review of G-WNSB commander landing in weather below minima

An analysis of the commander's 29 approaches to Sumburgh Airport and 267[54] approaches to Aberdeen Airport, between 1 August 2012 and 22 August 2013, showed no evidence that the commander had continued with an onshore approach to land in weather conditions below the minima.

1.18 Additional information

1.18.1 Instrument flight

1.18.1.1 Instrument approaches

The accident occurred during an instrument approach in Instrument Meteorological Conditions (IMC). The aim of an instrument approach is for the aircraft to arrive at a point from which a landing may be completed visually. The method and procedures for conducting an instrument approach in any aircraft, either fixed wing or rotary, are broadly similar; the differences apply only once visual references are attained. A minimum altitude to which an aircraft may descend during an approach is specified to ensure that there remains adequate clearance from terrain and obstacles. The pilot must not, under any circumstances, descend below this altitude unless he has achieved and can maintain a visual reference with the landing environment. For a Non-Precision Approach this altitude is referred to as the Minimum Descent Altitude (MDA).

1.18.1.2 Instrument scan techniques and training

Training in basic instrument flying using a selective radial scan technique was included as part of the syllabus for the initial issue of UK pilot's licences for many years. The selective radial scan identifies the attitude indicator as the master instrument and employs an instrument scan pattern that radiates out from, and always returns to, the attitude indicator. The scan rate varies according to the relative importance of the instrument, related to the manoeuvre being flown. CAA Paper 2013/02 '*Monitoring Matters - Guidance on the Development of Pilot Monitoring Skills'* highlights the importance of the: '*selective radial instrument scan which must be a priority task that is not compromised by other priority tasks*'.

In a letter from the CAA to North Sea helicopter operators, dated October 2013, reference is made to the development of instrument flying (IF) skills: '*Modern EFIS aircraft have displays that differ considerably from the standard analogue instrument flying 'T' panel that many pilots were initially trained on'* and poses the

54 Weather reports for each day were reviewed for conditions indicative that a flight may have experienced either reduced visibility and/or a low cloud base. From this review, 43 flights were then analysed in detail in combination with METAR data.

following questions: '*What consideration is given during a pilot's conversion-to type to the adaption of basic IF skills to the EFIS-equipped aircraft?'* and ' *Is an IF scan taught and assessed?*'

Modern 'glass cockpit' instrument displays, such as those fitted to the AS332 L2 Super Puma, utilise a variety of different layouts for the performance instruments and therefore require a modification of the pilot's selective radial scan technique. Some research has been conducted with military helicopter pilots, into pilot scan techniques, to understand how a skill level is achieved so that appropriate training can be developed.

1.18.1.3 Instrument scan research

A research project conducted in the USA in the early 1990's was outlined in the Naval Aerospace Medical Research Laboratory (NAMRL) Technical Memorandum 96-1: 'Background and instrumentation for the helicopter instrument scan pattern research conducted at Naval Air Station, Whiting Field.' The project was initiated as a result of '*concerns regarding training strategies for effective instrument scanning techniques*' raised by senior instructors at the Advanced Helicopter Training Squadron, HT-18, at Naval Air Station (NAS) Whiting Field.

A more recent research project 'Tracking Visual Scanning Techniques in Training Simulation for Helicopter Landing'[55] cited the following:

> *'Modern glass cockpits consist of complex display systems so that information processing is characterized by high cognitive workload and increasing head down activities by the pilot. Thus, there is a growing need for training effective scanning techniques since visual attention is the most crucial resource of pilots.'*

One outcome from this project identified that feedback of recorded eye-tracking information to pilots could be a useful training aid for learning instrument scan techniques.

New research into operational performance monitoring, which includes eye tracking tools and Line Oriented Safety Audits (LOSA) is underway as a result of a HeliOffshore safety initiative.

55 Robinski, M., Stein, M. (2013) Journal of Eye Movement Research 6(2):3, 1-17.

1.18.2 Flight Safety Foundation (FSF) study of approach and landing accidents

The approach and landing phase of flight has been identified as a key period of increased risk for aircraft accidents. In 1996 the Flight Safety Foundation commissioned a task force of working groups (FSF ALAR Task Force) to study the reduction of Approach and Landing Accidents (ALAs). The work was published in a special report.[56] The Operations and Training Working Group (OTWG) examined flight operations and training. This group arrived at eight conclusions, with associated recommendations. These were data-driven and supported by factual evidence of their relevance to the reduction of approach-and-landing incidents and accidents.

One conclusion stated:

> *'Establishing and adhering to adequate standard operating procedures (SOPs) and flight-crew decision making processes improve approach and landing safety.'*

Four of the recommendations made in relation to this conclusion were:

> *'States should mandate, and operators should develop and implement, SOPs for approach-and-landing operations.'*
>
> *'Operators should develop SOPs that are practical and can be applied in a normal operating environment. The involvement of flight crews is essential in the development and evaluation of SOPs.'*
>
> *'Operators should implement routine and critical evaluation of SOPs to determine the need for change.'*
>
> *'Operators should develop SOPs regarding the use of automation in approach and landing operations, and train accordingly.'*

1.18.3 Use of automation

A report produced by the FAA Human Factors Team in 1996 entitled '*The Interfaces between Flightcrews and Modern Flight Deck Systems*' discussed the use of differing levels of automation. Although the study concerned the use of automation in fixed wing aircraft, much of the work was also applicable to helicopter operations. This comprehensive study examined in part the merits or otherwise of mixed-mode automation: part autopilot, part manual flight, for example, the use of autopilot without autothrust. The report included the following two recommendations concerning automation management:

56 Flight Safety Foundation Flight Safety Digest Killers in Aviation: FSF Task Force Presents Facts About Approach-and-landing and Controlled-flight-into-terrain Accidents Volume 17/No 11-12 – Volume 18/ No 1-2 Nov.-Dec.98/Jan.-Feb.99.

> *'Recommendation AutomationMgt-1:*
>
> *The FAA should ensure that a uniform set of information regarding the manufacturers' and operators' automation philosophies is explicitly conveyed to flightcrews.'*

and:

> *'Recommendation AutomationMgt-2*
>
> *The FAA should require operators' manuals and initial/recurrent qualification programs to provide clear and concise guidance on:*
>
> - *Examples of circumstances in which the autopilot should be engaged, disengaged, or used in a mode with greater or lesser authority;*
> - *The conditions under which the autopilot or autothrottle will or will not engage, will disengage, or will revert to another mode; and*
> - *Appropriate combinations of automatic and manual flight path control (e.g., autothrottle engaged with the autopilot off).'*

1.18.4 Previous similar accidents

There have been several previous accidents and serious incidents resulting from periods of inattention to the task of monitoring key flight instruments by pilots. Many of these have involved an unintentional loss of airspeed and concern both fixed wing and helicopter operations. Four such events are summarised below:

1.18.4.1 Inadvertent loss of altitude during approach, Sikorsky S-61N, PH-NZG, Waddenzee, near Den Helder, 30 November 2004.

This event, investigated by the Dutch Safety Board[57], did not result in a loss of the helicopter, but there were some key similarities to the G-WNSB accident. The following text is from the introduction to the accident provided on the Dutch Safety Board's website[58]:

57 Project number 2004215.
58 http://www.onderzoeksraad.nl/en.

> *'The cloud base and the visibility were just above the required minima to allow for the execution of a landing at Den Helder Airport. During the ILS approach, that was flown in clouds, the speed of the helicopter dropped back slowly from the initial 70 knots to approximately 20 knots. This was not noticed by the crew of the helicopter. Since the forward speed reduction was not compensated for by adding power, a high rate of descent developed. The pilot in command, who did not control the helicopter personally, observed this only at the last moment and took over the controls. In order to stop the high rate of descent he pulled maximum collective. However this action did not prevent the helicopter touching the water of the Waddenzee.'*

The following passages of text are extracted from the report:

> *'The helicopter is liable to speed instability when its speed decreases below a certain value. This means that, a decrease in speed requires an increase in power in order to maintain altitude. If extra power is not selected the speed will further decrease requiring even more power to return to the original speed and/or altitude. If no extra power is selected the helicopter will descend in an ever increasing rate.*
>
> *Initially the pilot flying reduced the speed of the helicopter on purpose because its speed was higher than the 70 knots which would be maintained during the approach. However, this speed reduction was not stopped; the air speed of the helicopter continued to decrease. Because the reducing speed was not compensated for, by increasing engine power, the rate of descent of the helicopter increased.'*

The Safety Board did not succeed in establishing a single cause of the occurrence but the report included:

> *'Findings:*
>
> *The forward (air) speed of the helicopter decreased during the approach from approximately 70 kt to approximately 20 kt. This gradual decrease in speed occurred in a period of approximately 20 seconds.*
>
> *and .... both pilots failed to observe the decrease in speed.*

> *Causes:*
>
> *The occurrence was caused, because the airspeed of the helicopter decreased unnoticed as a result of a high pitch attitude without taking timely corrective action.*
>
> *The causal factors were:*
>
> - *Deviation of cockpit procedures and failure to use checklists*
> - *Inadequate monitoring and instrument scan of both pilots'*

1.18.4.2 Accident to Eurocopter EC225 LP Super Puma, G-REDU near the Eastern Trough Area Project (ETAP) Central Production Facility Platform in the North Sea, on 18 February 2009[59].

This accident was investigated by the AAIB. The flight crew made a visual approach at night to the platform, during which the helicopter descended and impacted the surface of the sea. It was considered that more use of the automated systems that were available on the aircraft might have prevented the accident and the following Safety Recommendation was made:

> **Safety Recommendation 2011-050:**
>
> It is recommended that the Civil Aviation Authority encourages commercial air transport helicopter operators to make optimum use of Automatic Flight Control Systems.

The UK CAA accepted this recommendation and issued Safety Notice Number: SN–2011/017, issued 31 October 2011, to all helicopter AOC Holders and all Type Rating Training Organisations.

1.18.4.3 Boeing 737-800, TC-JGE, crashed on approach to Amsterdam Schiphol Airport, 25 February 2009

This accident, which was investigated by the Dutch Safety Board, involved a fixed wing aircraft, but once again the significant factor was that airspeed decayed to a critical point, unobserved by the crew. The final report acknowledged that airspeed is a parameter that experience has shown is prone to being overlooked and a safety recommendation regarding low speed warning systems was made.

59 Report reference: AAIB 1-2011 G-REDU.

> *'When subsequently, the airspeed reached 126 knots, the frame of the airspeed indicator also changed colour and started to flash. The artificial horizon also showed that the nose attitude of the aircraft was becoming far too high. The cockpit crew did not respond to these indications and warnings. The reduction in speed and excessively high pitch attitude of the aircraft were not recognised until the approach to stall warning (stick shaker) went off at an altitude of 460 feet.'*
>
> *'The investigation revealed that the available indications and warnings in the cockpit were not sufficient to ensure that the cockpit crew recognised the too big a decrease in speed at an early stage. The Board has thus formulated the following recommendation:*
>
> *Boeing, FAA and EASA should assess the use of an auditory low-speed warning signal as a means of warning the crew and – if such a warning signal proves effective – mandate its use.'*

1.18.4.4 Descent below visual glidepath and impact with seawall; Asiana Airlines Flight 214, San Francisco, California, July 6, 2013

This accident was investigated by the US National Transportation Safety Board. At the time of writing this report a final report had not been issued, but the Accident Report Summary was published at the Public Meeting of June 24, 2014[60]. Finding number eight cited the following:

> *'Insufficient flight crew monitoring of airspeed indications during the approach'*

The document also highlighted the lack of an effective low energy alerting system and recommended the following action:

> *'Task a panel of human factors, aviation operations, and aircraft design specialists, such as the Avionics Systems Harmonization Working Group, to develop guidance for design of context-dependent low energy alerting systems for airplanes engaged in commercial operations and establish requirements for such systems, based on the guidance developed by the panel.'*

60 Information subject to editing.

1.18.5 Previous similar accidents, survivability factors

In 1992, an AS332L Super Puma helicopter, registration G-TIGH, impacted the sea near the Cormorant A Platform in the East Shetland Basin. 11 of the 17 occupants died, five of whom were unable to escape from the cabin. Although fitted with flotation devices, these were not activated by the crew and the helicopter sank after impact. The AAIB report[61] made 11 Safety Recommendations.

- Recommendation 93-25 recommended a study into human 'error' related accidents

- Recommendation 93-26 related to emergency hull flotation equipment

- Recommendation 93-30 related to survivability following helicopter ditching or uncontrolled impact with the sea

In 2009, an S-92A helicopter, registration C-GZCH, impacted the sea off the coast of Newfoundland, after a main gearbox malfunction[62]. The flotation equipment on the helicopter did not activate and of the 18 occupants, only two managed to escape, with only one surviving the ascent to the surface and period prior to rescue.

In response to the accident a number of survivability related safety actions were taken, including: improvements to HUET instructional facilities, a program of reissue of survival suit size where wrist and neck seals were found to be the wrong size, introduction of a new survival suit with more effective seals and introduction of a new crew lifejacket.

Additionally, TSB Canada, who conducted the accident investigation, recommended that it be mandatory for all offshore passengers to be provided with a supplemental underwater breathing apparatus.

1.18.6 Image Recording System

The pilots of G-WNSB had a limited recollection of the events that immediately preceded the accident and the recorded data from the CVFDR did not provide a complete picture of what happened within the cockpit during the approach.

61 Report reference: AAIB AAR 2-1993 G-TIGH.
62 Report reference: TSBC A09A0016.

Accident investigators have recognised for many years that recorded 'images' of the cockpit environment are needed to augment existing data and audio recordings. However, it has only recently become economically realistic to record cockpit images in a crash-protected recording medium. Therefore, supplementing existing data and audio recorder information with an image recording of the cockpit environment is the next logical step in the evolution of flight recorder systems.

The combination of audio, flight data and cockpit image recordings has been acknowledged[63] as providing air safety investigators with the necessary information to better define the facts, conditions and circumstances of an occurrence, and to broaden the scope of the vitally important human factor aspects of investigations.

Data and audio recordings have provided accident investigators with information on aircraft performance, operation of aircraft systems and, to a more limited degree, flight crew activity. However, vital information regarding the cockpit environment, non-verbal flight crew communications, flight crew workload and activity, and the status of instrumentation is not possible or practicable to record on the CVFDR. This has limited the scope of many investigations and often left investigators unable to provide a conclusive answer, hindering the identification of safety issues and thus the safety actions needed to prevent future occurrences.

Accident investigators believe that image recording in the cockpit will substantially assist in confirming findings, thereby allowing the aviation industry to focus on important safety issues. The NTSB list[64] of most wanted transportation safety improvements includes the fitment of crash-protected image recorders to cockpits, with recommendations dating back to 2000. On 22 January 2015, the NTSB reiterated its recommendation for a cockpit image recording system to the FAA[65].

However, the regulatory introduction of image recorders has been hampered by concerns, raised internationally, that records may not be adequately protected and that they may be used for purposes other than safety investigation. The ICAO is aware of these difficulties and is currently working to establish international requirements for the protection of such records.

63 The European Organisation for Civil Aviation Equipment L'Organisation Européenne pour l'Equipement de l'Aviation Civile (EUROCAE) document ED112A refers.

64 Available at: http://www.ntsb.gov/news/events/2007/most_wanted_progress/presentations/aviation_recorders.htm

65 http://www.ntsb.gov/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=A-15-008.

Although no current regulatory requirement exists, since 2011, Airbus Helicopters has fitted a combined image[66], data and audio recorder to its AS350 helicopter. This was extended to some of the other helicopters it manufactured, such as the EC135. In June 2015 Airbus Helicopters issued the following statement:

> *'All helicopters from the commercial range (H125 to H225) will be fitted in 2015 with a cockpit image recorder (recording cockpit image, ambient noise, GPS and IMU data).'*

The equipment can support routine FDM analysis, in addition to recording data to an accident-hardened memory enclosure for use by safety investigators. A single-camera device, mounted in the cabin ceiling looking forward, provides a view of the cockpit instrumentation, controls and the crew actions. Airbus Helicopters are also reviewing the feasibility of retrofitting such a system across its entire range of helicopters.

For the most part, safety investigation activities have focused on capturing images within the cockpit. However, investigations can also be hindered by a lack of information available from within the passenger cabin environment. Following an event such as an evacuation, investigators may be solely reliant on the recollection of witnesses to piece together the sequence of events. Trying to establish the exact reasons where passengers fail to escape can be difficult, given the lack of reliable evidence. As such, there remains the possibility that safety deficiencies will go undetected until aircraft cabins are also equipped with image recorders.

66 Appareo manufactured Vision 1000.

2 Analysis

2.1 Introduction

The North Sea operating area is acknowledged as a challenging and hazardous operating environment and the scale of the task of managing the risks should not be underestimated. Since the start of helicopter operations, in support of the offshore oil and gas industry in the mid-1970s, there have been a number of accidents and incidents, many of which have subsequently led to safety improvements.

This investigation has considered the causes of the accident, reasons why there were fatalities and mitigation strategies that might be put in place to prevent reoccurrence.

There was no evidence to suggest that a technical defect with the helicopter was causal or contributory to the accident. Therefore, the investigation focused on understanding the operational and survivability aspects of the accident and developing Safety Recommendations intended to improve safety and prevent similar accidents in the future.

Section 2.2 discusses the serviceability of the helicopter. Section 2.3 contains the analysis of the causes of the accident. Sections 2.4 and 2.5 consider possible strategies for future accident prevention through the development of programmes such as HFDM and HTAWS. Section 2.6 covers the installation of image recorders and Section 2.7 the factors related to survivability.

The investigation determined that the causal and contributory factors identified in this accident are unlikely to be particular to this flight crew and therefore appropriate safety action should be taken in order to prevent future similar accidents.

2.2 Helicopter serviceability

General

No issues considered causal to the accident were identified in the helicopter's technical log, maintenance records and stored fault code data. No evidence was found that the helicopter had not been maintained or certified in accordance with current regulations. Finally, no evidence was found of a causal fault occurring on the helicopter during the accident flight. These findings were supported by both the AAIB and the manufacturers' independent assessments of the recovered wreckage and the CVFDR data.

Continue to land

Intermittent collective pitch trim issue

The CVFDR data show that the commander experienced an intermittent problem with his collective pitch lever during the accident flight, in that it moved, uncommanded, from the selected position. It was not possible to inspect the collective lever physically post-accident. However, an assessment of the system design and the symptoms of the problem showed it was likely to have been caused by the trim release trigger on the commander's collective pitch lever intermittently failing to release the trim system. This would have resulted in the collective trim system returning the collective to its last successful trim position when the lever was released after being moved by the commander.

During the flight the commander requested that the co-pilot exercise his collective trim release trigger switch, suggesting that the commander had identified this as a potential cause of the problem. There was also the option of using an alternative trim release switch on the AFCAU panel, had this been required.

The position of the collective lever and the corresponding performance of the helicopter remained consistent with the settings and changes which the commander verbalised during the final approach, all of which were captured by the CVFDR. The helicopter manufacturer also confirmed that the control positions and performance were consistent with their design model. The collective pitch trim issue therefore had no bearing on the final stages of the flight prior to impact with the water.

Commander's reference to speed during the approach

The commander made two references to speed during the early stages of the approach that were inconsistent with the recorded data. At about 6.4 nm DME, he referred to a speed of 98 kt (when the airspeed and groundspeed on the CVFDR were 110 kt and 111 kt, respectively) and at 3.8 nm DME he referred to a groundspeed of 113 kt, when the CVFDR groundspeed was 119 kt.

However, subsequent analysis of the CVFDR data in conjunction with radar information found no anomalies in the recorded data. Furthermore, no evidence was found of a defect within the FDR data acquisition system. Additionally, the crew's later references to speed were consistent with the CVFDR record. Therefore, it remains unexplained why the commander's references to speed earlier in the approach did not correlate with the CVFDR record.

Summary

The investigation found no evidence of a technical defect having been causal or contributory to the accident.

2.3 Operational aspects

This section of the analysis focuses on the operational issues relevant to the accident, including pilot training, helicopter operating procedures, the operating culture and human performance.

The approach was flown with the autopilot in 3-axes with V/S mode; therefore the commander was required to control the airspeed using the collective pitch lever. An alternative method of accomplishing this would have been to engage IAS mode on the cyclic pitch axis and adjust the vertical speed with the collective pitch lever; this method has since been incorporated into FSI 2014-078.

In the early stages of the approach a relatively low collective pitch lever position was set to allow the airspeed to reduce towards the target of 80 kt. As the helicopter reached the target speed, the collective lever position was increased slightly, but not sufficient to maintain 80 kt. It would be expected that the commander, having increased the collective pitch, would have cross-checked the ASI to confirm 80 kt was being maintained; however, it appears this did not happen. The airspeed therefore continued to decrease, unnoticed by either pilot, until a very late stage, by which time the helicopter was in a critically low energy state. The commander's subsequent attempt at recovery was unsuccessful in preventing the helicopter from impacting the water.

2.3.1 Safety barriers

Safety barriers were designed within the operation to ensure that instrument approaches were performed safely, whether to a landing or, if visual reference was not acquired, to a go-around. These safety barriers proved to be ineffective. This suggests that safety actions are required to improve their effectiveness, in order to prevent a similar accident in the future. Figure 23 presents a schematic showing the operational safety barriers (highlighted in green); these are considered in turn.

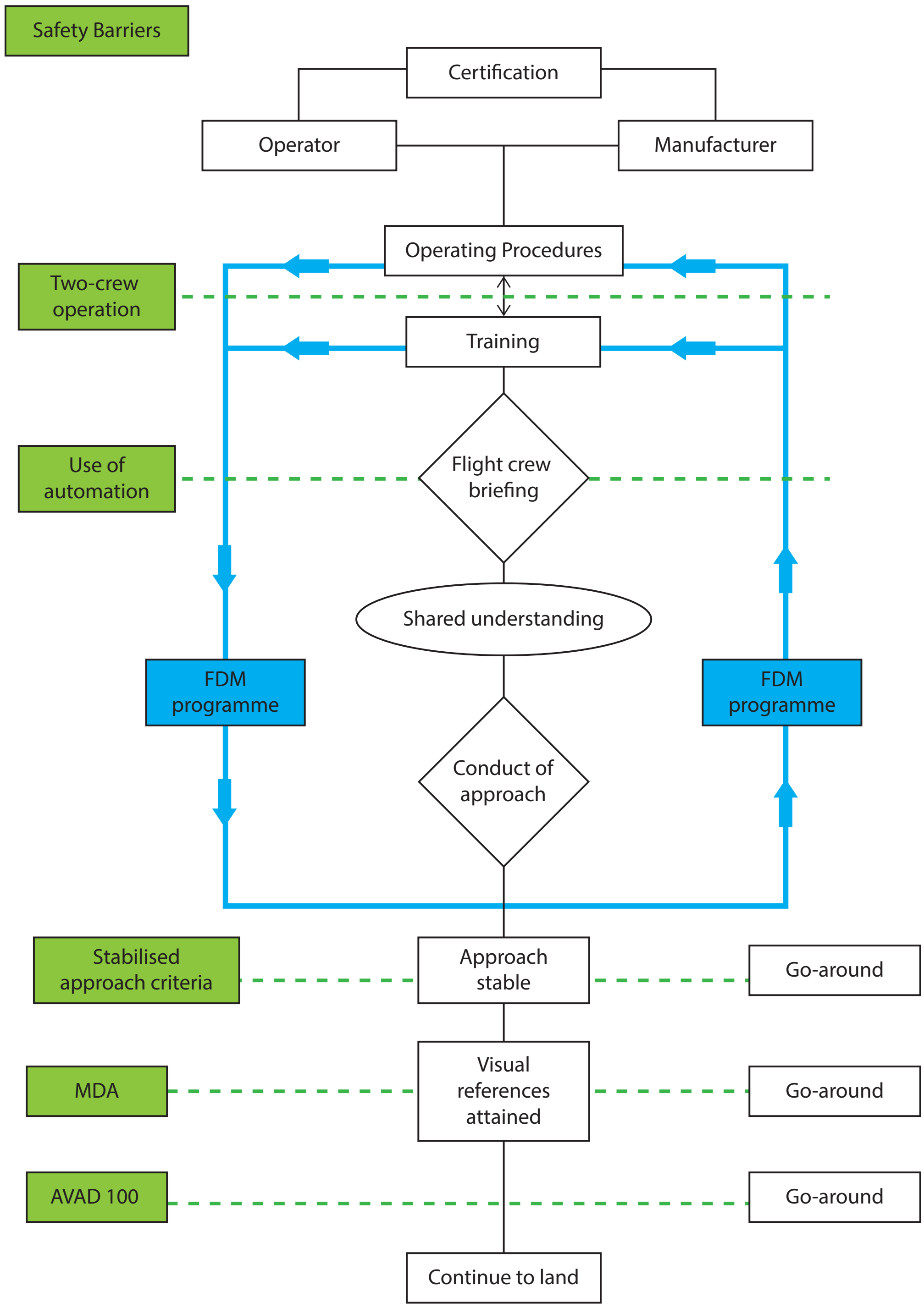


Figure 23

Operational Safety Barriers

Two-crew operation

A benefit of a two-crew operation is to reduce the possibility of an individual error or omission by one pilot compromising the safety of the flight. SOPs are developed to provide pilots with a set of procedures designed to ensure consistency and predictability in operating the aircraft. These procedures should be well understood, repeatable and practised regularly. This accident shows that, in hindsight, the operator's SOPs for Non-Precision Approaches were not sufficiently well defined, allowing crews to fly such an approach in a number of different ways. The pilots of G-WNSB therefore did not arrive at the same, unambiguous understanding of how the approach was to be flown. The operator has since taken safety action to amend the applicable SOPs to make them more prescriptive and less ambiguous.

The use of SOP phraseology by pilots is intended to prevent misunderstanding or ambiguity in operating the aircraft and provide the opportunity to confirm or challenge actions. The pilots did not adhere to the specified phraseology, with the result that it was more difficult for the co-pilot to challenge events. Both pilots had received Crew Resource Management (CRM) training, conducted by the operator, and the commander had set an informal atmosphere during the flight, engaging in a number of discussions with the co-pilot, mainly about operational matters. Therefore the co-pilot should not have been discouraged from challenging the commander's actions if required.

There was both an experience and an authority gradient between the two pilots, as evidenced on a number of occasions when the co-pilot asked the commander for information or advice, and in his acceptance of the commander's ambiguous comments during the approach briefing. It was apparent from the CVR and interviews with the co-pilot that he tended to defer to the commander's decisions, rather than questioning them. The co-pilot himself suggested that this may have been because of the commander's greater experience.

The HF specialist report A noted that neither pilot was monitoring the key parameter of airspeed during the latter stages of the approach. It was observed in the HF specialist report B that persons with a lower level of experience could be subject to higher workload demands. The co-pilot was relatively inexperienced in two-crew operations and there were comments in his training records that suggested he could at times become overloaded. The high workload demands during this Non-Precision Approach could have reduced a co-pilot's capacity to detect an undesirable reduction in airspeed.

This safety barrier of two-crew operation was, for these reasons, rendered ineffective.

Automation modes of the helicopter

The automation modes of the helicopter are designed to reduce the workload of the crew by taking on the manual flying tasks, giving the PF more time to concentrate on flight path management. In the absence of any advice from the helicopter manufacturer (no FCOM was available, nor required to be, for the AS332 L2), the operator's SOPs allowed Non-Precision Approaches to be flown in either 3-axes or 4-axes modes. Data showed that the use of 3-axes with V/S for onshore approaches was more prevalent amongst the operator's pilots. Use of the 4-axes mode for the approach would have reduced the commander's workload, by relieving him of the task of operating the collective pitch lever, and the autopilot would have maintained the selected airspeed during the approach.

At the time of the accident the operator's SOPs did not mandate the use of 4-axes mode for Non-Precision Approaches, but provided the crew with an option. Therefore use of automation was not optimised and this safety barrier was ineffective. Following the accident, the operator took a safety action to amend its SOPs for Non-Precision Approaches, requiring them to be flown exclusively with 4-axes coupled, and at a specific, pre-briefed, and nominated fixed airspeed.

There was no evidence that use of the ALT.A mode would have prevented this accident. As the descent rate was being controlled through the use of the V/S mode, a reduction in the selected rate of descent, without an associated increase in power, would result in a loss of airspeed. The ALT.A mode, on capture of the selected altitude, would have resulted in a nose-up pitch and similar loss of airspeed.

Stabilised approach criteria

The crew are required to initiate a go-around if the stabilised approach criteria are not met at the specified height. At the specified height for this approach, 1,000 ft aal, the helicopter was configured for landing, and was 30 ft above the published approach profile, with an airspeed of 108 kt and descent rate of some 660 fpm. The published rate of descent for maintaining a 3° approach at 120 kt was 640 fpm. The stabilised approach criteria are therefore considered to have been satisfied.

Minimum Descent Altitude with automated callouts

The automated callout at the MDA is to ensure that the approach minima are not overlooked at a time when the workload may be high and other distractions may be present. Compliance with the MDA is a fundamental requirement of an instrument approach. The operator's SOPs were clear that a descent below MDA was not permitted unless the appropriate visual reference had been acquired. There was, however, potential for ambiguity about the action required on reaching the MAP. For this approach, the crew had four options on reaching the MAP but the options were not specified during the commander's approach briefing, thereby creating uncertainty. The automated 'CHECK HEIGHT' callout activated, but the commander's actions did not result in the helicopter levelling off as required. This safety barrier was therefore breached.

Automated 100 foot callout (non-cancellable)

The automated 100 ft callout was the final alert, with priority over all other callouts, to advise the crew of the proximity of terrain. It is designed to alert the crew on every approach. In this accident the alert came only moments before impact and, given the helicopter's high rate of descent, it was too late to be effective.

2.3.2 Flight crew background and training

Both crew members held current licences and valid ratings on the AS332 L2 helicopter.

The commander was experienced in operating the AS332 L2 in the North Sea offshore operating environment and he was familiar with the Runway 09 LOC/DME approach procedure at Sumburgh Airport.

The co-pilot was, by comparison, relatively less experienced, both in North Sea two-crew operations and on the AS332 L2. He had flown into Sumburgh on several occasions and was also familiar with the airport and the approach procedure.

There was no requirement for training in instrument scan techniques for the types of instrument displays in the AS332 L2 and neither pilot had received training in developing and maintaining an effective instrument scan technique specific to this helicopter type. Human factors Report B identified the importance of an effective technique to scan the cockpit instruments so that pilots can manage their attentional resources, gather necessary information and reduce the likelihood of missing important information.

Training in instrument scan techniques for the helicopter type being flown might have prevented the reduction in airspeed from going unnoticed by the crew in the latter stages of the approach. The following Safety Recommendation is therefore made:

Safety Recommendation 2016-001

It is recommended that the European Aviation Safety Agency introduces a requirement for instrument rated pilots to receive initial and recurrent training in instrument scan techniques specific to the type of aircraft being operated.

2.3.3 Conduct of the flight

Flight planning

The flight planning activity prior to departure from Aberdeen was routine and the forecast meteorological conditions for the chosen route were favourable. The commander decided, however, to discard Sumburgh as a route option for the outbound sector because the actual conditions there appeared unfavourable.

The decision making and further planning for the accident sector was conducted in-flight during the first outbound sector, due to the late request to accept an additional passenger for the inbound sector. The commander decided to accept the additional passenger, which now required re-routing the return flight via Sumburgh to refuel.

The reason the commander decided to accept the additional passenger may have been influenced by several factors such as: the weather forecast suggested that conditions would be suitable, passenger load changes were commonplace, a willingness to accommodate the customer as far as he could, and a desire to help offshore personnel to return home.

Consideration of alternate airports

During the first sector when the return route via Sumburgh was re-planned, the available weather forecast for Scatsta met the requirements for planning minima. There was no attempt to obtain an up-to-date weather report for Scatsta, the nominated alternate airport, or any other potential alternate airport during the accident sector, even though the weather at Sumburgh was deteriorating. Thus, the approach was commenced without the crew having established that there was an available alternate with acceptable weather. If up-to-date weather information had been obtained for Scatsta, it would have indicated to the crew that the weather there was also deteriorating.

As the weather at Sumburgh deteriorated, the co-pilot raised a concern about a possible diversion to Scatsta and how it would be achieved. This suggests that he was thinking there was a realistic possibility of a diversion, and trying to prepare for it. The commander, however, expressed several times the view that a diversion would not be necessary and they were likely to be landing at Sumburgh. This suggests that, despite his earlier briefing, he had not formulated an alternative plan and his focus had narrowed to landing at Sumburgh.

The weather conditions prevailing at Scatsta after 1720 hrs, the likely time of a diversion, would probably have precluded landing there, but the pilots remained unaware of this. The fuel state of the helicopter was such that diversions either to Kirkwall or Wick would have been possible.

Accident sector

The discussions between the pilots throughout the flight were principally concerned with operational matters.

A technical problem with the collective lever pitch trim became apparent during the climb and the pilots discussed the nature of the problem during the cruise. They made no reference to the effect it might have had on the AFCS and whether 4-axes coupled flight would be possible. Therefore, this does not appear to be the reason why the approach was conducted in 3-axes with V/S mode, although it did cause a degree of distraction prior to commencing the approach to Sumburgh. The FDM data showed that the majority of approaches flown by the operator's crews were conducted in 3-axes with V/S mode.

During the cruise and in the approach briefing, the co-pilot asked questions to check that he and the commander had the same understanding of the approach and the possible diversion strategy. The OM did not provide a sufficiently detailed description of how to carry out a Non-Precision Approach and evidence from FDM data indicates that a variety of techniques were used by pilots. Hence, the co-pilot may not have had a clear expectation of what to expect during the approach.

The commander briefed that he would fly the approach using a constant descent angle. In his briefing he stated that he would fly the latter part of the approach at 80 kt and also said that he would "BRING THE SPEED RIGHT BACK". The co-pilot had commented earlier that day that "THE CAPTAIN THE OTHER DAY WAS EH REALLY WANTING IT RIGHT BACK BUT VY'S PROBABLY GOOD AT THIS POINT ISN'T IT". Although the circumstances of the flight referred to are not known, it suggests the co-pilot had a degree of uncertainty about what were appropriate approach speeds. This, together with the range of acceptable approach speeds provided in the OM, may have led to his acceptance of speed variations during the accident approach, making it more difficult for him to monitor the speed effectively. This task would have been easier had there been a more clearly defined approach and speed management technique included in the OM.

During the latter stages of the approach the co-pilot's workload was high, which may have affected his ability to monitor effectively. The co-pilot's early training records indicated a tendency towards becoming overloaded and HF Specialist Report B observed that limited type experience and the requirement to perform a number of concurrent tasks could have adversely affected his ability to detect cues to hazard entry. However, although it was not his primary task to monitor the flight instruments, it was he who ultimately detected the reduction in airspeed and alerted the commander. The OM offered four different options on reaching the Missed Approach Point (MAP) on a Non-Precision Approach. The commander's approach briefing did not include a clear description of what the expected visual picture would be, or the precise crew actions required on reaching the MDA and then the MAP. It is possible, therefore, that the co-pilot did not have a clear idea of what to expect as they descended in the final stages of the approach.

Final approach

The stabilised approach criteria were met at 1,000 ft aal, but there was a critical point later in the approach when the commander noted the airspeed at 80 kt, a speed he apparently intended to maintain. However, his adjustment of the collective pitch lever was insufficient to maintain this and the airspeed continued to reduce, unnoticed by either pilot. The reason for this could not be explained with certainty. It seems most likely that his attention was outside the helicopter seeking the desired visual reference; as evidenced by the co-pilot who noticed the commander looking out at one point. Eventually the autopilot was unable to maintain the selected vertical speed and the descent rate increased, and continued to increase, as the speed reduced.

The commander acknowledged the co-pilot's call of 'HUNDRED TO GO' but did not respond with the SOP call of 'LEVELLING'. The collective lever position was not adjusted and the helicopter continued to descend. Around this time the selected vertical speed was recorded at 424 fpm[1], a decrease from the earlier calculated value of 550 fpm. It may have been adjusted again, but this was not recorded. Reduction of the target vertical speed, without a corresponding increase in collective lever position, caused an increase in nose-up pitch attitude and a further decay in airspeed, until the helicopter was in a critically low energy state.

The required visual references for a Non-Precision Approach had not been achieved as the helicopter descended below the MDA of 300 ft. The first AVAD 'CHECK HEIGHT' warning sounded at 300 ft. It came just after a call from ATC providing the latest surface wind, and it is possible this caused a degree of distraction. The descent, however, continued unchecked.

1 This parameter is recorded at 64-second intervals.

The co-pilot alerted the commander to the low airspeed just before the second AVAD 'CHECK HEIGHT' warning; the commander responded verbally and there was an associated increase in collective lever position. This was followed 5 seconds later by the 'ONE HUNDRED FEET' AVAD warning. There was then a rapid application of full collective pitch and the combined engine torque increased to a peak of 120%. The commander recollected having seen the sea at a late stage of the approach and it is probably this that prompted his final collective input. By now the descent rate was high and the helicopter was yawing and rolling, consistent with entry into a Vortex Ring State, making recovery difficult, if not impossible, in the height available.

Commander's expectation concerning the approach

Updated meteorological information was supplied to the crew on the Alwyn North platform; however, they commented that it did not include a report for Scatsta. The lowest cloud base for Sumburgh, given in the reports, was broken cloud at 500 ft. At this time there was no indication that the cloud base at Sumburgh would be at, or close to, the approach minima of 300 ft. It was only when en route to Sumburgh that the crew became aware that an instrument approach to minima would be required. There was nothing markedly unusual about the task or operational conditions at Sumburgh, except that it would be relatively unusual to make an approach with the cloud base exactly at the MDA, rather than 100 ft above or below.

The weather conditions did not preclude carrying out the approach, but there was a strong possibility that, with the deteriorating weather, visual reference might not be attained. Although the co-pilot appeared to recognise this, the commander, on receipt of each weather update, reiterated his opinion that the conditions remained acceptable for the approach. This suggested that he still expected that visual contact with the runway would be achieved, despite the gathering evidence to the contrary. As described in HF Specialist Report B, the commander's expectation may have arisen as a result of his previous experience in making a considerable number of approaches to Sumburgh, during all of which visual reference was attained in good time. This may have been reinforced by the fact that, on the day before the accident flight, he had made a successful approach into Aberdeen with the cloud ceiling at 200 ft to 300 ft, which was the lowest recorded for his previous 267 approaches there.

Prior to commencing the approach, while discussing options for a diversion, the commander intimated that it would be possible to continue below the MDA on a localiser approach, and in one instance he suggested that it would be their course of action: "BUT REALLY, REALISTICALLY IF WE WENT AROUND FROM THIS ONE, BECAUSE THE WEATHER'S ON ON LIMITS REALLY, THEN THE SECOND ATTEMPT, I THINK THE DRILL WILL BE, WE WILL BE LANDING, BECAUSE YOU'RE IN A, A LOCALISER, SO JUST, I WOULD BE FLYING IT ONTO THE TARMAC."

Subsequently, during this discussion, the commander used the phrase "BUT I THINK WE WILL BE LANDING, IF YOU KNOW WHAT I MEAN". The co-pilot concurred. His agreement may have been as a result of his reliance on the commander's greater experience, as he suggested himself. However, effective CRM training should have enabled the co-pilot to overcome this type of experience gradient. A search through the commander's analysed flight history did not reveal any instances of flights continuing below minima without attaining visual reference.

Approach lighting was mentioned in the briefing between the two pilots, in the context of brightness and in the consideration of the minima. The abbreviated Approach Lighting System (ALS) on Runway 09 was not mentioned specifically. It is not clear whether the commander was expecting the normal full, or abbreviated approach lighting.

The evidence suggests that the commander may have retained an expectation of being able to see the runway during the latter stages of the approach and did not adjust his mental model to allow for a possible level-off at MDA, or flying a go-around.

2.3.4 Human performance

Fatigue

The pilots' previous rest periods of approximately 16 hours, report time of 1230 hrs, and flight duty period of 4 hours 47 minutes were not exceptional. The weather conditions during the day, up to the time of starting the approach to Sumburgh, were not especially challenging. The pilots decided earlier in the day that, because of the warm temperature, they would not wear immersion suits, so it is likely that they were not experiencing any particular physical discomfort. The sequence of flights and requirement to re-plan en route were not unusual. Therefore, none of these potential fatigue factors are considered to have significantly affected the crew's performance.

Research reports

The two human performance studies utilised different methodologies, but reached similar conclusions. Material from the reports has been included in this analysis of the operational aspects. Both reports identified that a decay in airspeed and associated low total energy state of the helicopter were not observed by the crew until it was too late. Neither study was able to determine, with any certainty, why this situation arose and was not detected, although various possibilities were discussed.

Report B cited evidence that there were risk factors within the operation which were common to all the operator's flight crew and therefore it should be considered that the circumstances which led to this accident may not have been specific to this flight crew. The operational deficiencies were such that, had another crew been substituted for the accident crew, the outcome may have been similar.

Detection of reducing airspeed

The evidence suggests that the appropriate flight instrument displays were not being monitored adequately in the latter stages of the approach. There is evidence from similar accidents, in both fixed wing and rotary wing aircraft, with highly automated and non-automated flight decks, that pilot monitoring of the airspeed in particular, can be overlooked. While there are potential technological solutions to this problem (for example, low energy alerting systems, as recommended by the NTSB) improved pilot training may also be beneficial.

Several research projects have been undertaken which have identified a need for revised training in pilot instrument scan techniques. The new research initiated by HeliOffshore using eye-tracking tools and LOSA observations should provide valuable new data.

With the introduction of modern integrated flight displays, often referred to as 'glass cockpits', a new methodology for training pilots in revised instrument scan techniques has yet to be established. The following Safety Recommendation is therefore made:

Safety Recommendation 2016-002

It is recommended that the European Aviation Safety Agency reviews the existing research into pilot instrument scan techniques, particularly with respect to glass cockpit displays, with a view to addressing shortcomings identified in current instrument scan training methods.

The physical sensation of the helicopter's increasing nose-up pitch attitude and decreasing airspeed went undetected by the crew. However, this, and other similar accidents, show that these cues are not always apparent to pilots and can be masked by other effects.

The evidence suggests that the attention of the pilots was diverted away from the flight instruments for a significant period. One possible explanation is that the commander, who was the Pilot Flying (PF) and therefore held the primary responsibility for monitoring the flight instruments, with the expectation of landing from the approach, became focused on the landing and switched his attention to 'looking out' for a visual reference.

As a result of several fixed wing accidents, in which low airspeed has been a factor, the NTSB recently recommended that research into alternative low energy alerting systems should be carried out. For helicopter operations, the most effective alerting system may come from the development of enhanced HTAWS. Another possibility is the development of a Helicopter Low Airspeed Warning Device.

Commander

The commander was a professional pilot who was experienced in offshore helicopter operations on the AS332 L2 and had a good training and operational record. This accident demonstrates, however, that despite training and experience, an individual can, on occasion, deviate from expected behaviour. Adherence to comprehensive and effective SOPs can help the crew detect and correct such deviations before they prejudice the safety of the aircraft.

2.3.5 Operating procedures

Standard Operating Procedures

The operator identified, in their SMS, the need to '*maintain procedures for allowing the comparison of standard operating procedures (SOPs) with those actually achieved in everyday line flight*', but it had not implemented an effective method for achieving this. Thus, there was limited evidence to confirm that SOPs were complied with routinely during everyday line operations. It is possible that this may also be the case for other UK North Sea helicopter operators. The following Safety Recommendation is therefore made:

Safety Recommendation 2016-003

It is recommended that the Civil Aviation Authority reviews the methods used by UK North Sea helicopter operators for confirming compliance with their Standard Operating Procedures (SOPs), to ensure they are effective.

The SOPs provided in the OM included the specific phraseology to be used. The pilots did not generally adhere to the specified phraseology during the accident flight, but calls were, in most cases, made at the appropriate time. This non-use of the specified phraseology was not challenged during the flight.

Non-Precision Approach

The technique to be used for flying Non-Precision Approaches specified by the operator was open to interpretation. However, a constant descent angle method for the vertical profile was reportedly taught during training. In practice, a variety of techniques were adopted by flight crews, as evidenced by the recorded data from other flights.

The commander's decision to fly the Non-Precision Approach using a reducing airspeed meant that there were two parameters changing during the approach. These were: a) the vertical speed, controlled through the autopilot, and b) the airspeed, controlled through manual collective pitch adjustment. This method increased the risk that any significant period of inattention to either parameter would lead to an undesired approach profile.

The ALT.A mode was not set to the OM recommended MDA plus 50 ft, and FDM data showed that it was not the commander's normal practice to set it for an approach to Sumburgh. If it had been set as prescribed in the OM in these circumstances, it would not have prevented the decay in airspeed. The autopilot would have increased the pitch attitude further at the MDA plus 50 ft, requiring an even greater adjustment to the collective pitch lever position to maintain airspeed.

Since the accident the operator has taken the safety action to review and revise their SOPs to include more specific procedures for conducting Non-Precision Approaches; eg: all instrument approaches to be flown 4-axes coupled and a specified approach speed to be pre-briefed. If 4-axes mode is not available then 3-axes with IAS mode is required.

It may be that other helicopter operators supporting the UK offshore oil and gas industry do not have optimum procedures for conducting Non-Precision Approaches. Therefore the following Safety Recommendation is made:

Safety Recommendation 2016-004

It is recommended that the Civil Aviation Authority reviews the Standard Operating Procedures of helicopter operators supporting the UK offshore oil and gas industry, to ensure their procedures for conducting Non-Precision Approaches are sufficiently defined.

Adherence to SOPs

The Operations and Training Working Group (OTWG), as part of the Flight Safety Foundation (FSF) study into the reduction of approach and landing accidents, concluded:

> *'Establishing and adhering to adequate standard operating procedures (SOPs) and flight-crew decision making processes improve approach and landing safety.'*

There was evidence to suggest that, in this case, there was flexibility within the operator's SOPs for Non-Precision Approaches which had led to a lack of standardisation. This same instrument approach was flown in several different ways on different occasions and during the accident flight non-standard phraseology was accepted without challenge. The operator did not have an effective method in place whereby they could monitor adherence to their SOPs.

The SOPs were, however, specific regarding adherence to MDA; adherence to this safety barrier would have prevented this accident. As the helicopter descended towards the MDA, it should have started to level at 400 ft amsl, and it should have been stabilised in level flight at the MDA of 300 ft amsl. With the lack of visual references, it should have maintained MDA to the published Missed Approach Point and then carried out a go-around.

Rotorcraft Flight Manual (RFM) information

An aircraft manufacturer can make a significant input into the operating procedures for their aircraft. This is reflected in the certification requirements for fixed wing aircraft, whereby manufacturers are required to provide comprehensive operational guidance in the form of an FCOM, or similar.

The use of appropriate autopilot modes to manage the flight path of the helicopter is a factor in this accident. Information and guidance for the use of the autopilot system fitted to the helicopter was not provided in the RFM at the time and neither was it an airworthiness requirement. More comprehensive information from the manufacturer, concerning how the helicopter should be operated, has the potential to provide more adequate and effective SOPs.

Airbus Helicopters have acknowledged the contribution that a manufacturer can make to flight safety though the provision of good operational information in the form of an FCOM, or similar. An FCOM has been developed for the EC225 helicopter. However, at present this is the only FCOM provided by the manufacturers for large public transport helicopter types; although AH has advised that they have committed to release FCOMs for all new AH helicopters flying in oil and gas operations. The HeliOffshore July 2015 News Bulletin noted that work was in progress by other helicopter manufacturers to provide FCOMs.

Large public transport helicopters require an equivalent level of safety regulation to that provided for large public transport fixed wing aircraft. The design and provision of SOPs is a multi-tiered process which should begin with a certification requirement for aircraft manufacturers to provide comprehensive operating procedures. These procedures should be available for operators to incorporate, and modify as required, to suit their specific operational needs.

Therefore the following Safety Recommendations are made:

Safety Recommendation 2016-005

It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29) to align them with the Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes (CS 25), with regard to the provision of operational information in Flight Manuals.

and:

Safety Recommendation 2016-006

It is recommended that the European Aviation Safety Agency requires manufacturers of Large Rotorcraft to develop Flight Crew Operating Manuals for public transport types already in service.

2.3.6 Meteorological information

The weather observations for Sumburgh Airport around the time of the accident showed that the cloud base was lower and the visibility was poorer than had been forecast earlier in the day. A similar deterioration took place at Scatsta, the planned alternate airport. The deterioration in the weather did not become apparent to the crew until they were en route to Sumburgh. The commander had obtained updated forecast weather information after landing on the Alwyn North platform at 1525 hrs. The actual weather conditions, received from the Sumburgh ATIS (Information 'W' and 'X') were discussed by the crew whilst en route to Sumburgh. This information reflected that the weather at Sumburgh had deteriorated from that which was forecast. Knowledge of the revised information, however, did not appear to change the commander's preconception that a landing at Sumburgh would still be possible.

2.3.7 Rescue co-ordination procedures

The system in place at the time of the accident, whereby all calls were routed through the Police Scotland Command and Control Centre at Inverness, created a potential delay to the tasking of the SAR resources following this accident. The Air Traffic Services Assistant's first duty was to notify the Control Centre of the accident immediately. A brief initial notification should have been sufficient but the ATSA was kept engaged in discussion for some five minutes, delaying the ATSA from completing other required duties.

The test of the notification procedures was routinely conducted on a Friday afternoon; the time at which the accident occurred. This could have led the Control Centre to expect the notification to be an exercise rather than an actual accident. This may explain the length of time the ATSA was kept engaged whilst notifying the Control Centre, and which led to a short delay in the Control Centre alerting the coastguard. This delay, however, had no bearing on the outcome of the rescue.

2.4 Helicopter Flight Data Monitoring (HFDM)

This section examines the programme of flight monitoring, giving an insight into typical operations and improvements to the programme that may contribute to the prevention of future accidents.

2.4.1 HFDM Regulatory oversight

One of the fundamental tools for ensuring compliance with SOPs is FDM. The CAA concluded, in CAP 1145, that in relation to HFDM '*the rate of progress has not allowed the full potential to be realised yet';* with a lack of a requirement cited as one explanation by the CAA. At present there is no regulatory requirement for an offshore helicopter operator to implement an HFDM programme. Whilst the EASA has proposed to introduce such a requirement, the planned time frame indicates that this may not come into effect until at least 2018.

Therefore, possible improvements through regulatory oversight may not be realised for several years in the UK, where HFDM programmes have already been widely established. Therefore the following Safety Recommendation is made:

Safety Recommendation 2016-007

It is recommended that the Civil Aviation Authority expedites the requirement for companies operating helicopters in support of the UK offshore oil and gas industry to establish a Helicopter Flight Data Monitoring (HFDM) programme.

2.4.2 HFDM NAA support

The CAA has previously acknowledged that HFDM is generally more complex than FDM for fixed wing aircraft and recommended as part of its findings in CAA Paper 2004/12:

> *'Helicopter operators should continue to develop and refine the HOMP measurements to maximise their accuracy in characterising different aspects of the operation and to provide further analysis capabilities.'*

However, having acknowledged the difficulties of HFDM, its ongoing development was then predominantly left to the operators. In comparison, during the same period, UK airlines operating fixed wing aircraft benefited from a CAA-supported FDM forum, which included aspects such as the sharing of new analysis techniques and findings, aimed at obtaining the maximum safety benefit from FDM.

Following the accident to G-WNSB, the CAA met with CHC, Bond and BHL to discuss opportunities of sharing safety information and promoting continuous improvement. In February 2014, the CAA reported in CAP 1145:

> *'The CAA will accelerate its work with industry to develop and apply Safety Performance Indicators to improve the effectiveness of helicopter operators' Flight Data Monitoring programmes. (Delivery Q3/2014).'*

Although the CAA has raised an action to accelerate its work, there remain 10 other European member states with offshore helicopter operations, for which no HFDM specific forum exists for the sharing, development and its promotion. In comparison, the EOFDM and EAFDM forums have been put in place by the EASA to support fixed wing FDM. Therefore, the following Safety Recommendation is made:

> **Safety Recommendation 2016-008**
>
> It is recommended that the European Aviation Safety Agency considers establishing a European Operators Flight Data Monitoring forum for helicopter operators to promote and support the development of Helicopter Flight Data Monitoring programmes.

2.4.3 HFDM Guidance material

In December 2013, the EASA issued a guidance document: *'Developing Standardised FDM-Based Indicators'.* This material offers a set of standardised FDM events and specific details of detection logic for fixed wing aircraft that NAA's can promote to operators to address the four safety issues recognised as a high priority by the European Aviation Safety Plans 2012-2015 and 2013-2016. One of the safety issues is controlled flight into terrain (CFIT). There is no similar documentation to which helicopter operators or NAA's can refer. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2016-009

It is recommended that the European Aviation Safety Agency collaborates with National Aviation Authorities and helicopter operators to develop and publish guidance material on detection logic for Helicopter Flight Data Monitoring programmes.

2.4.4 Review of G-WNSB commander's FDM history

There was no evidence that the commander's FDM record during the period between 31 January 2013 and 22 August 2013 was unusual compared to his peers within the company; his event rate per flight was less than the operator's fleet average crew rate on the AS332 L2.

Furthermore, there was no evidence that the commander had a prior history of FDM events related to flying at slow airspeeds during an approach. Retrospective analysis of onshore approaches flown by the commander identified that the lowest airspeed between 1,000 ft and 400 ft, when the autopilot was in 3-axes, had been 65 kt. This was above the FDM event threshold of 60 kt.

There was also no evidence among the analysis of onshore approaches to either Sumburgh or Aberdeen Airport that the commander had continued an approach to land when the weather had been below minima.

2.4.5 Operator's FDM monitoring of onshore approach procedures

The operator advised that the complexities of its helicopter operation, the adaptation of FDM systems originally developed for fixed wing aircraft and limited assistance from NAA's had made the task of developing FDM for helicopters difficult. However, whilst it is acknowledged that the more complex nature of helicopter operations can make the process of developing FDM events more difficult, the review of the operator's monitoring of the onshore stabilised approach indicates the development task was perhaps further exacerbated by the procedure itself, with aspects such as differences between IMC and VMC thresholds.

CAP 739 Chapter 2 –*'Objectives of an Operator's FDM system'* states *'A FDM system allows an operator to compare their Standard Operating Procedures (SOPs) with those actually achieved in everyday line flights'*. The operator's FDM programme provided a comprehensive event set, but it did not enable a direct comparison against its onshore approach procedures. A constant descent approach was reportedly taught during training, but deviation from the published vertical descent path during a Non-Precision Approach was not being monitored by the programme.

The operator's HFDM programme was monitoring for low airspeed. The AAIB review of the HFDM quarterly reports showed that low airspeed events did not feature in the reports' list of top events due to the low number of occurrences. Therefore there was no indication in the operator's HFDM findings of a precursor to an accident such as this, involving excessively low airspeed on approach.

Although a helicopter FDM programme is not currently required by regulation, an FDM programme that compares SOP's with those actually achieved in everyday line flights is recommended by the CAA. Given the lack of existing guidance material it is possible that other operators' FDM programmes also may not enable a direct comparison with their published procedures. Therefore the following Safety Recommendation is made:

Safety Recommendation 2016-010

It is recommended that the Civil Aviation Authority, in co-operation with UK offshore helicopter operators, initiates a review of existing Helicopter Flight Data Monitoring programmes to ensure that operating procedures applicable to approaches are compared with those actually achieved during everyday line flights.

2.5 Helicopter Terrain Awareness Warning System (HTAWS)

GPWS, and subsequently TAWS, have provided significant safety benefits to fixed wing aircraft over several decades. The existing warning envelope within HTAWS would not have been effective in the circumstances of this accident. However, enhanced warning envelopes currently being developed may have the potential to prevent similar accidents.

The work of the HSRMC group, led by the CAA, is significant in contributing to the further refinement of HTAWS. It is important that the report is published as soon as possible. In addition, it is also important that HTAWS development is progressed, as experience of fixed wing TAWS has shown that continued refinement is necessary. Therefore, the following Safety Recommendations are made:

Safety Recommendation 2016-011

It is recommended that the Civil Aviation Authority expedites the publication of the Helicopter Safety Research Management Committee report into improving warning envelopes and alerts.

Safety Recommendation 2016-012

It is recommended that the Civil Aviation Authority supports the ongoing development of Helicopter Terrain Awareness Warning Systems, following the publication of the Helicopter Safety Research Management Committee report into improving warning envelopes and alerts.

In 2011, the following AAIB Safety Recommendation was made to EASA:

Safety Recommendation 2011-061

It is recommended that the European Aviation Safety Agency ensures that helicopter performance is taken into consideration when determining the timeliness of warnings generated by Helicopter Terrain Awareness and Warning Systems.

The EASA responded in 2013, stating that it is awaiting publication of the final report on the development of HTAWS by the CAA on behalf of the HSRMC, before proceeding to address the recommendation. As the report has yet to be published, and a Safety Recommendation has already been made, no further safety action is considered appropriate at this time.

The EASA has proposed that HTAWS will be required to be fitted to helicopters used in Commercial Air Transport (CAT) offshore operations with a Maximum Certificated Take-off Mass (MCTOM) of more than 3,175 kg, or a Maximum Operational Passenger Seating Configuration (MOPSC) of more than 9, and first issued with an individual Certificate of Airworthiness after 31 December 2018. However, this proposal does not address helicopters already in service, many of which could still be operating after 2018 without the safety benefits of HTAWS. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2016-013

It is recommended that the European Aviation Safety Agency requires the installation of Helicopter Terrain Awareness Warning Systems to all helicopters, used in offshore Commercial Air Transport operations, with a Maximum Certificated Take-off Mass (MCTOM) of more than 3,175 kg, or a Maximum Operational Passenger Seating Configuration (MOPSC) of more than nine, manufactured before 31 December 2018.

2.6 Image recording for accident investigation

It has been acknowledged, in a number of previous investigations, that cockpit image recordings can provide air safety investigators with vital information to aid in establishing the facts, conditions and circumstances of an occurrence. The CVFDR recordings from G-WNSB provided information on the helicopter's performance and its operation by the flight crew, but did not provide a complete picture of their focus of attention and workload. Such additional information may have enabled the human factors investigation to reach a more definitive conclusion.

Furthermore, had recorded images of the cockpit instrumentation been available, the anomaly of the difference between the commander's verbal references to speed and the recorded data could have been resolved. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2016-014

It is recommended that the European Aviation Safety Agency introduces a requirement for the installation of cockpit image recorders, in aircraft required to be equipped with Flight Data and Cockpit Voice Recorders, to capture flight crew actions within the cockpit environment.

Less commonly discussed in accident reports are the benefits which may be obtained from video recordings of the passenger cabin during impacts and emergency evacuations. Investigations into crashworthiness and survivability often have to rely on assessment of the wreckage or eyewitness and survivor testimony. Wreckage can be damaged or lost to the investigation during post-impact events and survivor testimony can often be limited or confused during highly traumatic, short duration and disorientating experiences such as an aircraft impact with terrain, or evacuation from a submerged aircraft. As a consequence, there is limited understanding of why some passengers survive accidents when others do not. This may limit the potential for an investigation to recommend effective safety improvements with respect to survivability. The following Safety Recommendation is therefore made:

Safety Recommendation 2016-015

It is recommended that the European Aviation Safety Agency introduces a requirement to install image recorders, capable of monitoring the cabin environment, in aircraft required to be equipped with Flight Data Recorder and Cockpit Voice Recorders.

2.7 Accident survivability

This section of the analysis examines the survivability aspects of the helicopter and its safety equipment, as well as the safety equipment and training provided to the passengers and crew.

2.7.1 Analysis of fatalities

For the majority on-board the helicopter the impact with the water was not catastrophic. Fifteen of the eighteen occupants were able to evacuate the helicopter successfully, despite some suffering injuries.

One of the passengers successfully exited the helicopter, but then suffered a severe cardiac event in the liferaft. Resuscitation attempts by other survivors and subsequently the SAR helicopter crew were not successful. The post-mortem report identified that the passenger had significant pre-existing heart disease.

The body of one of the fatalities was recovered from the helicopter fuselage, still strapped in the seat. The post-mortem findings showed that the passenger was likely to have been rendered unconscious by an injury to the brain, preventing any attempt to escape. Superficial evidence of bruising and lacerations were predominantly on the left side of the face and head. As the passenger was seated on the right side of the cabin facing forward, it was not possible to determine from the available evidence what had caused the injury.

The bodies of the two remaining fatalities were recovered floating clear of the wreckage, adjacent to the coastline, after the helicopter fuselage began to break up on the rocks. However, some surviving passengers reported seeing a single lifeless body floating nearby immediately after they exited the helicopter. This suggests the individual may have managed to escape from the cabin but succumbed to drowning in the process. The post-mortem report for this passenger raises the possibility of an incapacitating injury to the brain. However, in order to release the seat harness, exit the fuselage and inflate the lifejacket, the passenger must have been conscious. There was insufficient evidence to determine why this passenger drowned, despite apparently reaching the surface supported by an inflated lifejacket.

The body of the fourth fatality showed no evidence of an ante-mortem incapacitating injury or illness. The post-mortem report determined the cause of death to be drowning. Evidence from inspection of the rebreather supports the conclusion that this individual attempted to use it during the event, successfully deploying it from the stowed position on the lifejacket and activating the mouthpiece valve. Subsequent testing confirmed the air bladder of the EBS was punctured. It was not possible to determine whether this damage was present at the time it was deployed by the passenger or occurred prior to or during recovery of the body. It was not possible to determine whether the user had been able to purge the mouthpiece or successfully breathe from the deployed air supply. There was therefore insufficient evidence to explain why this passenger did not escape from the helicopter.

2.7.2 Analysis of survivors' evidence

Successful evacuation of the crew can be an important factor for survival of the passengers following a water impact event, due to their leadership role and specialist technical knowledge. This was demonstrated by the co-pilot taking the lead in gathering survivors on the upturned fuselage. He deployed the liferafts using the above-water deployment handles; a facility not known by the passengers.

The crew reported difficulties in using their emergency door jettison handles in an inverted position, eventually reverting to the normal door handle. The co-pilot experienced difficulty in forcing his door open and the commander tried several times to move his door handle in the wrong direction before realising it was upside down. Whilst both crew managed to exit the helicopter eventually using their normal door handles, this is not a reliable means of emergency exit, as distortion of the door frame during impact or obstruction of the door by obstacles can prevent it from opening. It was not possible to recover the cockpit doors for further investigation, but Safety Recommendations 2016-021 and 2016-022 regarding emergency exits made in Section 2.7.3 of this report are equally applicable to cockpit exits as to passenger cabin exits.

All the hybrid rebreathers worn by the passengers were found to have functioned correctly in terms of releasing the air supply automatically. However, the passengers reported they were unaware of this feature and believed they had to manually inflate it with their breath. The surviving passengers reported they were unable to locate or deploy the mouthpiece in time to achieve this, so their rebreathers were not used.

Several passengers reported leaking survival suits. One passenger reported that his suit significantly filled with water. Whilst the passenger was treated for the effects of heat loss, the water temperature was sufficiently warm that this did not become a survivability issue. It was not possible to test this passenger's suit due to the damage sustained during his rescue.

The other suits reported as leaking were successfully tested. The absence of any large leak paths on the suits supported the most likely causes of water ingress as being ill-fitting neck or wrist seals, or the access zip not being fully closed. These issues have been demonstrated to result in unexpectedly high water ingress rates and previous investigations and research papers have identified that the increase in survival time in cold water provided by wearing a survival suit is notably reduced when significant leakage occurs. A small amount of water leakage into the suit is not unusual and has no discernible impact on survival times.

It may not be practical to mandate that passengers select suit sizes with optimum neck and wrist seals, and it is difficult to enforce that access zips are kept fully closed at all times during the flight. However, pre-flight safety videos inform passengers of the importance of ensuring that the suits are fitted and worn correctly to ensure that the performance of their suits is not compromised in emergency situations.

2.7.3 Helicopter crashworthiness and survivability

Controlled ditching

There is a distinct difference between a controlled ditching and an unintentional water impact. Controlled ditching is a deliberate action in response to an emergency which allows for a period of preparation and usually results in impact forces within the tolerance of the airframe and the occupants. Experience from recent helicopter ditchings involving G-REDW and G-CHCN demonstrated that with undamaged, fully inflated flotation bags, and a sea state within the design limitations of the helicopter, the fuselage can float upright for an extended period, sufficient to allow the passengers and crew to evacuate into liferafts.

Unintentional water impact

Unintentional water impact does not allow for preparation time and the impact is likely to result in some level of damage to the helicopter and injury to the occupants. Experience from previous accidents suggests that, in many cases, the helicopter rapidly sinks or inverts following impact. This may be due to damage to flotation equipment, or as a result of lateral inertia and the helicopter's high centre of gravity.

The safety concerns relating to evacuation from an inverted and submerged helicopter have been well documented in AAIB accident investigations (such as G-TIGH) and studies by the CAA. The shock of unanticipated inversion presents significant challenges to a successful evacuation. Occupants may experience: cold shock in low water temperatures, panic, disorientation and poor visibility in a dark, inverted cabin, often containing turbulent and contaminated water. Occupants must also deal with the physical challenges of releasing their seat harness and locating, opening and evacuating through emergency exits, whilst hampered by bulky equipment and buoyancy issues. The time available to evacuate is nominally dictated by the length of time an individual can hold their breath. Trials suggest that, when suffering from 'cold shock' in very cold water, this can be as little as 6 seconds.[2] Mitigating actions can be taken to address some of these issues, however, not all the risks associated with helicopter operations over water can be entirely eliminated.

Mitigating actions which can be taken concern: equipment design and provision, training and operational procedures; all of which are likely to significantly improve the chances of survival for passengers and crew. Several safety initiatives have been introduced by the oil and gas industry since the early 1980s, which have made significant improvements to survivability. However, prior to the CAA's North Sea review and the publication of CAP 1145 and SD-2014/001, these initiatives have almost exclusively been introduced voluntarily by the industry.

Regulatory response

Since the early 1980s, regulatory authorities responsible for overseeing helicopter operations in the UK have initiated and participated in studies, resulting in recommendations to address many of the known issues. However, few, if any, of these recommendations were followed up with amendments to design or operational regulations. During this period the responsibility for design and operational regulation of UK offshore helicopters has twice transferred to a new organisation. First, from the UK CAA to the JAA, and then from the JAA to the EASA; both transfers introduced delays. However, it is difficult to account for the 30-year timeframe taken to begin a delivery of regulatory change.

The regulatory authorities have stated that their primary focus during this period was to reduce the likelihood of an accident by improving helicopter reliability and operating procedures. They also reasoned that any new regulations relating to water impact have to deal with a post-crash scenario, where the severity of the accident, and thus the implications for survivability, are variable and impossible to predict. Whilst this is a valid concern, CAA

2 Tipton and Vincent 1989, Tipton et al 1995, Tipton et al 1997.

and FAA research[3] has shown that the primary risk following a water impact is from drowning, rather than impact forces or structural failure.

During the same period, a number of design regulation changes for large fixed wing commercial aircraft have been introduced. These concerned: seat pitch, aisle width, emergency exit size and evacuation time limits. They were successfully introduced into FAR 25 and CS 25 and its predecessors, following recommendations from investigations into a number of land-based accidents and associated research[4]. Whilst these regulation changes have been adopted into CS 29, covering large transport helicopters, underwater evacuation has not been addressed, despite this being the more hazardous and time critical emergency.

Studies and research

A number of studies have been carried out over the last 25 years into the issues associated with underwater evacuation. However, cost, safety and ethical considerations meant these trials have, for the most part, used simulated fuselages and seats, and have been conducted in warm, still water conditions. Additionally, research trials have tended to centre on one aspect of the participants' evacuation experience; for example, use of survival equipment, rather than researching the whole evacuation process from start to finish under realistic conditions. Furthermore, whilst passengers who experienced a real evacuation have been interviewed as part of an investigation, few if any, studies have collated and analysed their first-hand experiences. Survivors from this accident repeatedly commented that their experience of escaping from the helicopter cabin was very different from that simulated in training.

Furthermore, anthropometric data relating to offshore workers has not been updated for changing social demographics and preliminary results from a university research project in the UK suggested offshore workers have increased in weight by 19% on average since the previous study 26 years ago.

There is very little evidence available on the reasons why passengers who drowned in accidents were not successful in evacuating the helicopter, when others onboard survived. Regulators have therefore relied on extrapolation from historical data and use of assumptions, rather than on baseline data derived from contemporary empirical evidence. This issue becomes significant when defining new regulations to better facilitate underwater evacuation with respect to cabin layout, emergency exit size and location, evacuation time limits or personal survival equipment. Whilst the difficulties associated with

3 DOT/FAA/CT-92/13&14, CAP 641.
4 NTSB/SS-00/01, AAIB AAR 8/1988 G-BGJL.

gaining this evidence are acknowledged, it is preferable to carry out controlled testing and analysis, rather than relying extensively on accident investigation evidence to validate certification assumptions.

The following Safety Recommendation is therefore made:

Safety Recommendation 2016-016

It is recommended that the European Aviation Safety Agency instigates a research programme to provide realistic data to better support regulations relating to evacuation and survivability of occupants in commercial helicopters operating offshore. This programme should better quantify the characteristics of helicopter underwater evacuation and include conditions representative of actual offshore operations and passenger demographics.

CAA North Sea review (CAP 1145)

The review into North Sea helicopter operations by the CAA took a significant step forward towards addressing, by regulatory action, safety concerns identified in numerous accident investigations and safety studies over the last 30 years. This is a positive interim step but the CAA has a limited ability to instigate unilateral changes, as the majority of regulatory powers have been transferred to the EASA. The changes documented in CAP 1145 were introduced using the operational directive powers granted by the UK ANO. However, since October 2014, commercial air transport (CAT) operations for UK and other European operators come under Regulation (EC) No 216/2008. This causes difficulty in the CAA applying more restrictive regulatory requirements in the UK. Although provision is currently made for differing state requirements for offshore operations, this may no longer be the case once NPA 2013-10 changes come into effect, as the corresponding CRD published by the EASA specifically rejects some of the changes introduced by CAP 1145. The CAA also no longer has the ability to enforce changes to helicopter design requirements, which are now exclusively the provision of the EASA. In order for the safety actions introduced or recommended by CAP 1145 to be effective, they need to be formalised through changes to EASA regulations.

The operational limitation, introduced in CAP 1145, to restrict passengers to seats directly adjacent to an exit addressed a valid and specific concern regarding passengers' ability to escape from an inverted helicopter. The options for removing this operational limitation were the introduction of either a side-floating capability for the helicopter, or provision of a Category A EBS. Whilst provision of an EBS is highly desirable, there are limitations associated with the systems currently available. These have been detailed in the CAA's own research publications[5]. The benefits in terms of risk mitigation of a side-floating capability have been demonstrated by test to be more consistent and have been documented by the CAA as providing the best level of mitigation. Whilst the provision of Category A EBS is a beneficial short term safety action, it does not provide the same degree of risk mitigation as the introduction of a side-floating capability.

RMT.409

The changes introduced by RMT.409 add a number of new requirements specifically relating to offshore operations. Whilst this formalises, by regulation, a number of safety initiatives already adopted by the industry, it falls short of introducing many of the changes which have been recommended in AAIB accident reports or the various industry and CAA research papers published over the last 30 years, including CAP 1145. The reasons why some of the changes were not adopted is explained in the CRD to RMT.409. The changes resulting from RMT.409 are not proposed to take full effect until 2019.

RMT.120

The regulatory changes likely to be proposed by the RMT.120 working group effectively represent the culmination of 30 years of research and analysis by regulators and industry working groups. As a consequence, there is an expectation, in the industry and the CAA, that RMT.120 will address all of the outstanding issues relating to survivability and crashworthiness. As this work is still relatively immature, there is uncertainty over what changes will actually be made at the end of the process.

The NPA can only propose changes to Certification Specifications, which are the design requirements applicable to aircraft. It will not introduce regulations to address issues such as compulsory provision of passenger training, or the quality and content of training courses such as HUET. Additionally, no decision has been made regarding the retrospective application of any regulatory changes to existing helicopter designs. If the design changes introduced by RMT.120, proposed to be introduced in 2016, are not retrospectively applied, they are unlikely to significantly improve offshore helicopter safety for at least the design cycle of a new product, which could take five to ten years, or longer. Given the recent introduction of types such as the EC 225 and S-92, the current level of risk could remain substantially unchanged for the foreseeable future. The following Safety Recommendation is therefore made:

5 CAP 1034 and CAA Paper 2003/13.

Safety Recommendation 2016-017

It is recommended that, where technically feasible, the regulatory changes introduced by the European Aviation Safety Agency Rulemaking Task RMT.120 are applied retrospectively by the EASA to helicopters currently used in offshore operations.

Flotation equipment

The successful deployment of the flotation equipment is necessary to prevent a helicopter from sinking. Evidence from the G-TIGH and C-GZCH investigations showed that the probability of successful evacuation from a sinking helicopter is significantly reduced, compared to one that remains afloat. Helicopters operating in the UK sector of the North Sea have been fitted with flotation equipment that automatically deploys following contact with water; however, this has been introduced by operators on a voluntary basis and is not required by any existing airworthiness regulation.

The flotation systems currently in use must be manually armed by the flight crew. In this accident, it was only the co-pilot's quick reaction, following his realisation that the helicopter was going to hit the water, which ensured the equipment was armed, as it was not required to be armed for onshore approaches. While the co-pilot was arming the system, the helicopter struck the water and he received a minor head injury. Fortunately, this was not incapacitating and did not prevent his successful evacuation. The CAA and the EASA have accepted the need for flotation systems to be armed during all approaches over water. However, they have not proposed mandating an automatic deployment system or addressed the risks associated with relying on the manual arming of systems. These concerns would be addressed by the introduction of automatic arming and deployment systems for flotation equipment. The following Safety Recommendation is therefore made:

Safety Recommendation 2016-018

It is recommended that the European Aviation Safety Agency amends the Certification Specifications for rotorcraft (CS 27 and 29) to require the installation of systems for the automatic arming and activation of flotation equipment. The amended requirements should also be applied retrospectively to helicopters currently used in offshore operations.

Side-floating capability

Extensive research has been conducted regarding evacuation from a side-floating helicopter fuselage, compared to one that is fully inverted. These studies concluded that the side-floating scenario gives an improved likelihood of successful evacuation. Although a side-floating cabin has some potential disadvantages, such as difficulty in releasing seat harnesses for passengers seated on the high side of the cabin, or inadvertent inflation of high level float bags in-flight, these disadvantages are outweighed by the potential benefits.

The benefits include:

- providing an exit that remains above water;
- creating an air pocket which passengers can locate and use by standing or floating upwards;
- allowing the use of seats to assist with evacuation through exits, rather than acting as an obstruction;
- using the inherent buoyancy of the survival suit to assist passengers towards an exit;
- providing a light source from an exposed window that acts as an orientating feature for occupants during daytime evacuations;
- providing redundancy in the event of damage occurring to the primary flotation bags during the initial impact.

The following Safety Recommendation is therefore made:

Safety Recommendation 2016-019

It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29), certified for offshore operation, to require the provision of a side-floating capability for a helicopter in the event of impact with water or capsize after ditching. This should also be applied retrospectively to helicopters currently used in offshore operations.

Emergency exit size

The current regulations relating to exit size, number and location are based on experience gained from fixed wing aircraft evacuations on land, where the main issue is the time taken for a large number of passengers to exit. The difficulties associated with underwater evacuation are very different from those of a land-based evacuation. Evidence from this accident, previous accident investigations, associated research and training experience, has identified that the most successful outcomes are achieved when passengers evacuate from exits directly adjacent to them. Using exits which require negotiating a route through a cabin can lead to disorientation and increases the time taken to exit the aircraft. Similar problems are encountered when more than two passengers have to evacuate via the same exit.

Regulations only require one Type III-sized emergency exit on each side of the fuselage for a helicopter carrying 19 passengers, such as the AS332. This means that, if both exits are used equally, up to 10 passengers may have to use the same exit, whilst negotiating a route through the cabin during an underwater evacuation. However, most helicopter designs have additional windows which can be removed, but these are not designated as emergency exits and are currently unregulated. The minimum size limits within the airworthiness requirements are only applicable to designated emergency exits. Specific regulations are therefore required to address underwater evacuations to improve the chances of escape. All removable exits, including windows, should be of sufficient size to allow for the successful egress of a 95th percentile-sized offshore worker, wearing the maximum recommended amount of personal survival clothing and equipment. Additionally, cabin seating layouts should be restricted such that, in an emergency (assuming all the exits are available), sufficient exits are available that each exit need only be used by a maximum of two passengers seated directly adjacent to it. The following Safety Recommendations are therefore made:

Safety Recommendation 2016-020

It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29), certified for offshore operation, to ensure that any approved cabin seating layouts are designed such that, in an emergency (assuming all the exits are available), each exit need only be used by a maximum of two passengers seated directly adjacent to it.

> **Safety Recommendation 2016-021**
>
> It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29), certified for commercial offshore operations, to include minimum size limitations for all removable exits, to allow for the successful egress of a 95th percentile-sized offshore worker wearing the maximum recommended level of survival clothing and equipment.

Exit release mechanisms

During this accident several passengers reported problems removing the window rubber sealing strip, or with the unexpected amount of force required to push the window pane out. This is a recurring theme from numerous previous accident investigations. Release of an exit should be achievable with one hand to allow the occupant to keep hold of their harness release mechanism at the same time. Research[6] has also identified issues with having numerous different exit opening mechanisms depending on helicopter type. This has a detrimental impact on the ability to conduct effective evacuation training and thus the likelihood of a successful evacuation in a real emergency situation. The following Safety Recommendation is therefore made:

> **Safety Recommendation 2016-022**
>
> It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29), certified for use in commercial offshore operations, to require a common standard for emergency exit opening mechanisms, such that that the exit may be removed readily using one hand and in a continuous movement.

EBS

A number of fatal accident investigations, CAA research, and research by other agencies, have shown that drowning is the main risk faced by occupants when a helicopter inverts following impact with water. This is because the time required for the individual to evacuate the helicopter may exceed the period for which they can hold their breath, particularly in cold water. Whilst successful evacuation without using an EBS is possible, as demonstrated in this accident, success can be dependent on injury, age, body size and fitness.

The use of an EBS can increase the likelihood of escape for all passengers and the passengers of G-WNSB were provided with hybrid rebreathers. The main weakness of the hybrid rebreather, in the post-impact scenario where it

6 Coleshaw 2006, CAP 641.

is most likely to be needed, is that the mouthpiece cannot easily be purged of water if not fitted in the mouth before submersion. A compressed air EBS does not suffer from this issue, can be rapidly deployed in any scenario and is simple to use. As a result of a mandatory requirement for the use of Category A EBS issued by the CAA (as described in CAP 1145 and CAP 1034), UK offshore operators have chosen to introduce a compressed air EBS for all their passenger operations. Whilst use of EBS is likely to be included in regulatory changes resulting from RMT.409, this has not yet been confirmed by EASA, nor has the type of EBS been specified. The following Safety Recommendation is therefore made:

Safety Recommendation 2016-023

It is recommended that the European Aviation Safety Agency amends the operational requirements for commercial offshore helicopters to require the provision of compressed air emergency breathing systems for all passengers and crew.

Emergency evacuation training

The training received by passengers on G-WNSB was the result of a safety initiative voluntarily undertaken by the UK offshore oil and gas industry. The standard of training facilities and course content associated with this initiative are currently regulated by a UK oil and gas industry body. Other regional bodies in other parts of Europe and the world set their own standards.

Whilst this voluntary initiative has saved lives, there is no common minimum standard specified by the regulator for the provision of such training, nor any regulatory requirement to have undertaken training prior to travelling offshore. In response to discussions about why this has remained the case, the EASA stated that they are not able to directly regulate passengers under the provisions of EC 216/2008. However, interviews with surviving passengers highlighted the significance that helicopter underwater escape training made to their successful evacuation from the helicopter. This accident also demonstrated that failure to escape is likely to result in fatalities. This reflects the findings from previous investigations and research, and supports the fact that this training is a key element in the safety case for conducting offshore passenger operations. The following Safety Recommendation is therefore made:

Safety Recommendation 2016-024

It is recommended that the European Aviation Safety Agency (EASA) amends the operational requirements for commercial offshore helicopter operations, to require operators to demonstrate that all passengers and crew travelling offshore on their helicopters have undertaken helicopter underwater escape training at an approved training facility, to a minimum standard defined by the EASA.

Liferaft deployment

After the helicopter became inverted, all three of the standard deployment handles for the liferafts were submerged, as they were designed to be used with the helicopter floating upright. It was fortuitous that G-WNSB had been used originally in the Norwegian sector of the North Sea and, as such, had been modified by the operator to have a fourth set of liferaft deployment handles installed for use if the helicopter was floating inverted. This voluntary modification was specific to helicopters operated by the Norwegian subsidiary of the operator and was not fitted to the majority of helicopters operated in the UK sector. None of the passengers were aware that the liferafts could be deployed using these handles, as their existence was not included in the pre-departure safety video. The co-pilot only became aware of the additional deployment handles as a result of an informal conversation with another pilot who worked as an instructor for all the operator's subsidiary companies, including the one based in Norway. Also, the Flight Manual supplement covering the modification had not been updated to reflect the helicopter's change of registration; therefore there was no information to inform UK company pilots that the modification was relevant to G-WNSB.

No instructions or signs for liferaft deployment are provided on the underside of a UK-standard North Sea helicopter. Even though G-WNSB was fitted with the modified handles, the co-pilot experienced difficulty deploying the liferafts, as their installation in the sponsons was biased for raft release from an upright helicopter. In the inverted attitude, the buoyancy of the raft caused it to become trapped in its compartment, rather than inflating freely. The co-pilot had to reach below the waterline to pull the rafts free before they began to inflate properly. The current regulations for the design of survival systems focus exclusively on the upright ditching scenario, and therefore do not cater for unintended impact with water and post-impact inversion of the helicopter. (Nor is the possibility of capsize after ditching, due to sea state or Emergency Flotation System failure, considered.) The following Safety Recommendations are therefore made:

Safety Recommendation 2016-025

It is recommended that the European Aviation Safety Agency amends the design requirements for helicopters to ensure that where liferafts are required to be fitted, they can be deployed readily from a fuselage floating in any attitude.

Safety Recommendation 2016-026

It is recommended that the European Aviation Safety Agency requires that, for existing helicopters used in offshore operations, a means of deploying each liferaft is available above the waterline, whether the helicopter is floating upright or inverted.

3 Conclusions

(a) Findings

Operational aspects

1. The pilots were properly licensed, qualified and sufficiently rested to conduct the flight.
2. Both pilots had flown into Sumburgh Airport previously and they were familiar with the method of flying a Localiser DME approach.
3. The flight crew had obtained a meteorological forecast for Sumburgh which indicated that the weather conditions would be better than they actually were. Whilst en route to Sumburgh the crew received up to date meteorological reports which indicated that conditions had deteriorated.
4. The flight crew did not obtain up to date weather reports for alternate airports during the final flight sector and did not have a well rehearsed plan for a diversion.
5. The weather conditions at Scatsta, the nominated alternate airport, would probably have precluded making a successful approach, but the flight crew were not aware of this.
6. The company Standard Operating Procedures allowed a variety of Non-Precision Approach methods to be employed; the crew conducted a Localiser DME approach to Runway 09 at Sumburgh Airport using a continuous descent approach technique with a reducing airspeed.
7. The approach was planned and flown by the commander who had engaged the autopilot in 3-axes with V/S mode.
8. The company stabilised approach criteria were met at 1,000 ft amsl. Below 1,000 ft amsl, the flight path deviated from the published vertical profile and the airspeed reduced below the IFR operating limit of 70 kt for 3-axes flight.
9. There was no evidence in the historic FDM data reviewed that the commander had ever continued with an approach to land in weather conditions below minima; his previous 29 approaches to Sumburgh Airport had all transitioned to manual flight at altitudes above 500 ft aal. No FDM events were found that indicated that the commander had flown at low airspeed during an approach.
10. The commander maintained an expectation that he would be able to see the runway at, or before, MDA and the helicopter would land at Sumburgh.

11. In the latter stages of the approach there was a period of some 30 seconds when the flight instruments were not adequately monitored and the helicopter's airspeed continued to reduce unchecked below 80 kt.

12. The Automatic Flight Control System control of the flight path was compromised before the helicopter reached the Minimum Descent Altitude due to the helicopter's low energy state.

13. The 'CHECK HEIGHT' audio alert sounded at the Minimum Descent Altitude (MDA) of 300 ft.

14. The descent continued below the MDA without the required visual references having been acquired.

15. The commander attempted recovery action and ultimately applied maximum collective pitch, but evidence suggests that the helicopter had probably entered Vortex Ring State and the situation was unrecoverable in the remaining height available.

Flight Data Monitoring (FDM)

16. The FDM event rate per flight for the commander was below the operator's AS332 L2 fleet average.

17. Analysis of FDM data showed that flight crew on the operator's AS332 L2 fleet adopted different methods of conducting the Sumburgh Airport Runway 09 Non-Precision Approach. There were variations in vertical descent paths, airspeeds and autopilot upper mode setting in 3-axes and 4-axes.

18. FDM data showed that on the operator's AS332 L2 fleet in the previous two years, the ratio of 3-axes to 4-axes approaches was about four to one.

Engineering aspects

19. No evidence was found of a causal or contributory fault with the helicopter either before or during the accident flight.

20. No evidence was found that would indicate the helicopter had not been maintained or certified in accordance with current regulations.

21. The collective pitch trim system problem identified by the crew during the flight was considered to have had no bearing on the final stages of the flight.

Evacuation and survivability

22. The impact with the water was survivable.

23. One passenger died in the liferaft from a chronic heart condition which was likely to have been exacerbated by the stress of the evacuation.

24. One passenger managed to escape from the helicopter cabin but drowned prior to, or immediately after, reaching the surface of the water. There was insufficient evidence to determine why this had occurred.

25. One passenger was incapacitated by a head injury during or immediately following the impact with the water and most likely drowned without regaining consciousness.

26. One passenger died as a result of being unable to successfully escape from the cabin; this passenger had attempted to use their EBS.

27. The pilots were unable to jettison their doors using the emergency lever and had to revert to the normal door opening mechanism to exit from the cockpit.

28. The EBS hybrid rebreathers, worn by the passengers, functioned correctly but were not used by the majority of the passengers, either because they were unaware of the air supply that was available within them, or because they were unable to locate or deploy the mouthpiece.

29. Those passengers who escaped from the cabin used the windows as exits. A number of window panes were displaced during the initial impact; others were removed by the passengers.

30. The majority of passengers who removed window panes reported that this was not easy and was significantly harder than they experienced during training.

31. Water ingress into some passenger survival suits was most likely the result of poorly fitting neck or wrist seals, or access zips not being fully closed.

32. Both liferafts were successfully deployed by the co-pilot using deployment handles fitted to the underside of the helicopter fuselage. He was only aware of the additional handles as a result of an informal conversation with a pilot who had instructed in the Norwegian sector.

33. The handles used were non-standard for UK helicopters and had been fitted when the helicopter was operated on the Norwegian register.

34. The Flight Manual supplement describing the additional liferaft deployment handles had not been updated to reflect the helicopter's change of registration.

35. The co-pilot was unable to manoeuvre the second liferaft to recover passengers from the water due to the sea current.

Search and Rescue (SAR)

36. ATC contacted the Sumburgh RFFS approximately six minutes after the helicopter's final radio transmissions acknowledging the clearance to land; transmissions from the helicopter's ELT received during this period were not recognised at first by the Sumburgh tower controller.

37. Within one minute of notification, the airport fire vehicles and rescue boat reported manned.

38. There was a short delay in the coastguard being notified by the designated police control centre; however, this did not affect the outcome of the rescue.

39. There was a significant delay to the launch of the airport Fast Rescue Craft because of the tide state and location of the slipway; this did not affect the outcome of the rescue.

40. The survivors were all recovered by winch to SAR helicopters and flown to a casualty reception centre at Sumburgh Airport.

(b) Causal factors

The investigation identified the following causal factors:

- The helicopter's flight instruments were not monitored effectively during the latter stages of the non-precision instrument approach. This allowed the helicopter to enter a critically low energy state, from which recovery was not possible.
- Visual references had not been acquired by the Minimum Descent Altitude and no effective action was taken to level the helicopter, as required by the operator's procedure for an instrument approach.

(c) Contributory factors

The following contributory factors were identified:

- The operator's SOP for this type of approach was not clearly defined and the pilots had not developed a shared, unambiguous understanding of how the approach was to be flown.

- The operator's SOPs at the time did not optimise the use of the helicopter's automated systems during a Non-Precision Approach.
- The decision to fly a 3-axes with V/S mode, decelerating approach in marginal weather conditions did not make optimum use of the helicopter's automated systems and required closer monitoring of the instruments by the crew.
- Despite the poorer than forecast weather conditions at Sumburgh Airport, the commander had not altered his expectation of being able to land from a Non-Precision Approach.

4. Safety Recommendations and actions

Safety Recommendations made previously in Special Bulletin S7/2013 published on 18 October 2013:

4.1 **Safety Recommendation 2013-021:** It is recommended that the operator of Sumburgh Airport, Highlands & Islands Airports Limited, provides a water rescue capability, suitable for all tidal conditions, for the area of sea to the west of Sumburgh, appropriate to the hazard and risk, for times when the weather conditions and sea state are conducive to such rescue operations.

4.2 **Safety Recommendation 2013-022:** It is recommended that the Civil Aviation Authority review the risks associated with the current water rescue provision for the area of sea to the west of Sumburgh Airport and take appropriate action.

The following new Safety Recommendations are made in this report:

4.3 **Safety Recommendation 2016-001:** It is recommended that the European Aviation Safety Agency introduces a requirement for instrument rated pilots to receive initial and recurrent training in instrument scan techniques specific to the type of aircraft being operated.

4.4 **Safety Recommendation 2016-002:** It is recommended that the European Aviation Safety Agency reviews the existing research into pilot instrument scan techniques, particularly with respect to glass cockpit displays, with a view to addressing shortcomings identified in current instrument scan training methods.

4.5 **Safety Recommendation 2016-003:** It is recommended that the Civil Aviation Authority reviews the methods used by UK North Sea helicopter operators for confirming compliance with their Standard Operating Procedures (SOPs), to ensure they are effective.

4.6 **Safety Recommendation 2016-004:** It is recommended that the Civil Aviation Authority reviews the Standard Operating Procedures of helicopter operators supporting the UK offshore oil and gas industry, to ensure their procedures for conducting Non-Precision Approaches are sufficiently defined.

4.7 **Safety Recommendation 2016-005:** It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29) to align them with the Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes (CS 25), with regard to the provision of operational information in Flight Manuals.

4.8 **Safety Recommendation 2016-006:** It is recommended that the European Aviation Safety Agency requires manufacturers of Large Rotorcraft to develop Flight Crew Operating Manuals for public transport types already in service.

4.9 **Safety Recommendation 2016-007:** It is recommended that the Civil Aviation Authority expedites the requirement for companies operating helicopters in support of the UK offshore oil and gas industry to establish a Helicopter Flight Data Monitoring (HFDM) programme.

4.10 **Safety Recommendation 2016-008:** It is recommended that the European Aviation Safety Agency considers establishing a European Operators Flight Data Monitoring forum for helicopter operators to promote and support the development of Helicopter Flight Data Monitoring programmes.

4.11 **Safety Recommendation 2016-009:** It is recommended that the European Aviation Safety Agency collaborates with National Aviation Authorities and helicopter operators to develop and publish guidance material on detection logic for Helicopter Flight Data Monitoring programmes.

4.12 **Safety Recommendation 2016-010:** It is recommended that the Civil Aviation Authority, in co-operation with UK offshore helicopter operators, initiates a review of existing Helicopter Flight Data Monitoring programmes to ensure that operating procedures applicable to approaches are compared with those actually achieved during everyday line flights.

4.13 **Safety Recommendation 2016-011:** It is recommended that the Civil Aviation Authority expedites the publication of the Helicopter Safety Research Management Committee report into improving warning envelopes and alerts.

4.14 **Safety Recommendation 2016-012:** It is recommended that the Civil Aviation Authority supports the ongoing development of Helicopter Terrain Awareness Warning Systems, following the publication of the Helicopter Safety Research Management Committee report into improving warning envelopes and alerts.

4.15 **Safety Recommendation 2016-013:** It is recommended that the European Aviation Safety Agency requires the installation of Helicopter Terrain Awareness Warning Systems to all helicopters, used in offshore Commercial Air Transport operations, with a Maximum Certificated Take-off Mass (MCTOM) of more than 3,175 kg, or a Maximum Operational Passenger Seating Configuration (MOPSC) of more than nine, manufactured before 31 December 2018.

4.16 **Safety Recommendation 2016-014:** It is recommended that the European Aviation Safety Agency introduces a requirement for the installation of cockpit image recorders, in aircraft required to be equipped with Flight Data and Cockpit Voice Recorders, to capture flight crew actions within the cockpit environment.

4.17 **Safety Recommendation 2016-015:** It is recommended that the European Aviation Safety Agency introduces a requirement to install image recorders, capable of monitoring the cabin environment, in aircraft required to be equipped with Flight Data Recorder and Cockpit Voice Recorders.

4.18 **Safety Recommendation 2016-016:** It is recommended that the European Aviation Safety Agency instigates a research programme to provide realistic data to better support regulations relating to evacuation and survivability of occupants in commercial helicopters operating offshore. This programme should better quantify the characteristics of helicopter underwater evacuation and include conditions representative of actual offshore operations and passenger demographics.

4.19 **Safety Recommendation 2016-017:** It is recommended that, where technically feasible, the regulatory changes introduced by the European Aviation Safety Agency Rulemaking Task RMT.120 are applied retrospectively by the EASA to helicopters currently used in offshore operations.

4.20 **Safety Recommendation 2016-018:** It is recommended that the European Aviation Safety Agency amends the Certification Specifications for rotorcraft (CS 27 and 29) to require the installation of systems for the automatic arming and activation of flotation equipment. The amended requirements should also be applied retrospectively to helicopters currently used in offshore operations.

4.21 **Safety Recommendation 2016-019:** It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29), certified for offshore operation, to require the provision of a side-floating capability for a helicopter in the event of impact with water or capsize after ditching. This should also be applied retrospectively to helicopters currently used in offshore operations.

4.22 **Safety Recommendation 2016-020:** It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29), certified for offshore operation, to ensure that any approved cabin seating layouts are designed such that, in an emergency (assuming all the exits are available), each exit need only be used by a maximum of two passengers seated directly adjacent to it.

4.23 **Safety Recommendation 2016-021:** It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29), certified for commercial offshore operations, to include minimum size limitations for all removable exits, to allow for the successful egress of a 95th percentile-sized offshore worker wearing the maximum recommended level of survival clothing and equipment.

4.24 **Safety Recommendation 2016-022:** It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29), certified for use in commercial offshore operations, to require a common standard for emergency exit opening mechanisms, such that that the exit may be removed readily using one hand and in a continuous movement.

4.25 **Safety Recommendation 2016-023:** It is recommended that the European Aviation Safety Agency amends the operational requirements for commercial offshore helicopters to require the provision of compressed air emergency breathing systems for all passengers and crew.

4.26 **Safety Recommendation 2016-024:** It is recommended that the European Aviation Safety Agency (EASA) amends the operational requirements for commercial offshore helicopter operations, to require operators to demonstrate that all passengers and crew travelling offshore on their helicopters have undertaken helicopter underwater escape training at an approved training facility, to a minimum standard defined by the EASA.

4.27 **Safety Recommendation 2016-025:** It is recommended that the European Aviation Safety Agency amends the design requirements for helicopters to ensure that where liferafts are required to be fitted, they can be deployed readily from a fuselage floating in any attitude.

4.28 **Safety Recommendation 2016-026:** It is recommended that the European Aviation Safety Agency requires that, for existing helicopters used in offshore operations, a means of deploying each liferaft is available above the waterline, whether the helicopter is floating upright or inverted.

Summary of Safety Actions

CAA Safety actions

The CAA published CAP 1145, Civil Aviation Authority – Safety review of offshore public transport helicopter operations in support of the exploitation of oil and gas. In this document the following actions are of relevance to the G-WNSB accident:

A4 The CAA will work with the helicopter operators via the newly established Helicopter Flight Data Monitoring (FDM) User Group to obtain further objective information on operational issues from the FDM programme.

A7 With effect from 1 June 2014, the CAA will require helicopter operators to amend their operational procedures to ensure that Emergency Flotation Systems are armed for all over-water departures and arrivals.

A8 With effect from 1 June 2014, the CAA will prohibit the occupation of passenger seats not adjacent to push-out window emergency exits during offshore helicopter operations, except in response to an offshore emergency, unless the consequences of capsize are mitigated by at least one of the following:

a) all passengers on offshore flights wearing Emergency Breathing Systems that meet Category 'A' of the specification detailed in CAP 1034 in order to increase underwater survival time;

b) fitment of the side-floating helicopter scheme in order to remove the time pressure to escape.

A9 With effect from 1 April 2015, the CAA will prohibit helicopter operators from carrying passengers on offshore flights, except in response to an offshore emergency, whose body size, including required safety and survival equipment, is incompatible with push-out window emergency exit size.

A10 With effect from 1 April 2016, the CAA will prohibit helicopter operators from conducting offshore helicopter operations, except in response to an offshore emergency, unless all occupants wear Emergency Breathing Systems that meet Category 'A' of the specification detailed in CAP 1034 in order to increase underwater survival time. This restriction will not apply when the helicopter is equipped with the side-floating helicopter scheme.

In the case of **Action A10** the UK Oil and Gas Industry have introduced a new CAA approved Category A Compressed Air Emergency Breathing System (CA-EBS). From **1 September 2014**, all UK passengers travelling by helicopter to and from an offshore installation, who are not seated next to an emergency exit will be required to wear this device. From **1 January 2015, ALL** UK passengers on all UK helicopter flights to and from an offshore installation will be required to wear this device.

Safety actions by the operator

The operator took action to review and revise its standard operating procedures and promulgated them to its flight crews in July 2014.

Key elements of the changes for the Super Puma fleet were:

- All instrument approaches to be flown 4-axes coupled. If 4-axes mode is not available then 3-axes with IAS mode is required.
- A specified, pre-briefed, nominated fixed airspeed to be used for onshore approaches below 1,000 aal.
- Changes to the stabilised approach definitions and criteria.
- When climbing or descending in 3 axis/2 cue[1] without the collective coupled, crews shall couple airspeed, not vertical speed, to the pitch axis.

Safety actions by the manufacturer

In December 2014, in a presentation given at the EASA Rotorcraft Symposium 2014, Airbus Helicopters reported on an initiative that was launched in September 2013, the Airbus Helicopters Safety Partnership. This was an ‘initiative bringing together Airbus Helicopters’ efforts to implement and improve safety practices and standards in close cooperation with oil and gas operators, authorities and industry stakeholders’.

1 According to helicopter type.

In November 2015, the helicopter manufacturer advised the AAIB that:

> ‘*the FCOM 225 for oil and gas operations has been released by AH and AH has committed to release FCOM for all new AH helicopters flying in oil and gas operations. It will be done at least for the H175 and the H160. For the 332L2, a FOBN (Flight Operational Briefing Note) related mainly to the optimized use of the AFCS is planned by AH.*’

Other safety actions

The safety issue highlighted in AAIB Special Bulletin S1/2014, published on 23 January 2014, concerned the content of the pre-flight safety briefing video. UK operators in the North Sea took safety action to amend the pre-flight safety briefing video for passengers to include information on the automatic air supply feature.

In response to Safety Recommendation 2013-021, Highlands & Islands Airports Limited took action to modify the Runway 09 slipway to allow a water rescue capability to be provided in all tidal conditions, subject to weather conditions.

Appendix A

AUTOPILOT SYSTEM

The autopilot system provides a means of reducing workload by allowing the pilot to transfer from manual flight control inputs to automated inputs generated by a computer.

In manual flight the pilot controls the helicopter in all axes. This is achieved by applying a combination of inputs on the three flying controls: the cyclic, controlling helicopter pitch and roll attitude; the anti-torque pedals, controlling yaw; and the collective pitch, which controls the pitch of the main rotor blades to vary the amount of lift they generate[1]. In order to replicate the pilot's manual control inputs, the autopilot computer is connected to hydraulic actuators attached to each of these flying controls. They convert commands from the computer into physical movement of the flight controls.

The autopilot on the AS332 L2 has two levels of automation. On the lower level are the basic stabilisation functions providing fixed attitude control of the helicopter. The pilot can trim the flight controls in all four axes to maintain an input, even when the controls have physically been released. If the pilot wishes to adjust to a different attitude, then to change the input they release the trim and manually move the control to the new position. On the upper level are the higher-order modes. These can be used by the pilot to set an objective for the autopilot. The computer will then determine which controls to move and the level of input required to achieve and then maintain the objective. In these modes, changes can be made by the pilot to the objective parameter alone, without any requirement to move the controls manually.

The autopilot system has several higher-order modes which can be selected by the pilot to achieve different objectives. Some of the simple objectives, when used individually, only require the autopilot to engage on one or two of the control axes. For example: Indicated airspeed (IAS) mode controls on the pitch axis to maintain the helicopter's current airspeed; heading mode (HDG) engages on the roll and yaw axes to turn the helicopter, onto and then maintain, the compass bearing selected by the pilot. Some modes change the axis they control depending on what other modes are also selected, such as vertical speed (V/S) which makes the helicopter climb or descend at a vertical speed selected by the pilot by controlling either the helicopter pitch attitude or the rotor blade pitch (collective). Other modes remain armed only until they are triggered to become active, such as altitude acquire (ALT.A), which causes the helicopter to level off once a selected altitude has been reached, by engaging on the pitch or collective axis.

Some of the modes combine the objectives of other individual modes to achieve more complex manoeuvres. For example go-around (G.A), selected during a missed approach, engages both V/S on the collective and IAS on the pitch axis to climb away at constant

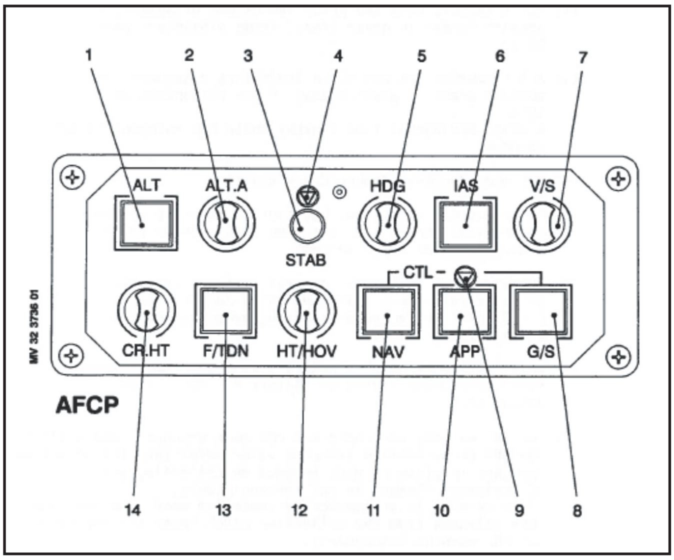
1 The AS332 L2 has a constant rotor rpm system rather than pilot-operated engine throttles. The system automatically adjusts engine power output to maintain a constant main rotor rpm as rotor blade pitch is varied.

Appendix A (cont)

vertical and horizontal speeds. The autopilot can also be coupled to other systems such as the navigation system to automatically fly a pre-programmed flight path (NAV), or descend following an instrument landing system glideslope to a runway (G/S). In normal operation a number of higher-order modes are selected together to control manoeuvres in either three or four axes simultaneously. When the selected higher-order modes are controlling all four axes, the autopilot can use all the controls to achieve the objectives set by the pilot. When the modes selected are only controlling three axes (pitch, roll and yaw) the remaining axis must be manually controlled by the pilot using the collective. In this case the autopilot computer may not be able to achieve its objective without the pilot making the appropriate manual control input. If that does not happen, there is no dedicated indication provided to the pilot and the autopilot computer will continue to make inputs on the axes under its control, up to the limit of its authority, to try to achieve the requested objective.

Appendix B

ADDITIONAL AUTOFLIGHT CONTROLS AND FLIGHT INSTRUMENT DISPLAYS



Automatic flight control panel (AFCP)

3.3 Automatic Flight Control Panel (AFCP) (Fig. 26)

(1) ALT Pushbutton Function : Engage/disengage present altitude hold mode.

(2) ALT.A Rotating Pushbutton Function : Engage/disengage selected altitude acquisition mode, and select altitude setpoint.

Utilization : - First, press to arm ALT.A mode.
- Then, turn to select altitude setpoint.

(3) STAB Pushbutton Function : Engage/disengage AP basic stabilization function on all 4 axes.

Note : Pressing the STAB pushbutton disengages any active higher-order modes.

(4) STAB Indicator Light Function : Monitors AP engagement/disengagement.

Color : Amber : illuminates when AP is powered-on, goes out when AP is effectively engaged.

(5) HDG Rotating Pushbutton Function : Engage/disengage selected heading acquisition and hold mode, and select heading setpoint.

Utilization : - Turn to select heading setpoint.
- Press to engage/disengage HDG mode.

(6) IAS Pushbutton Function : Engage/disengage present airspeed hold mode.

(7) V/S Rotating Pushbutton Function : Engage/disengage selected vertical speed hold mode, and select vertical speed setpoint.

Utilization : - Turn to select vertical speed setpoint.
- Press to engage/disengage V/S mode.

Appendix B (cont)

(8) G/S Pushbutton Function : Engage/disengage GlideSlope acquisition and hold mode.

Note : If G/S mode is engaged on a control panel (CTL light illuminated), pressing the G/S pushbutton on the second control panel does not disengage the mode, but switches to the G/S mode of the DCU connected to the panel : the pushbutton must be pressed a second time to disengage the mode.

(9) CTL Indicator Light Function : Indicates master control panel for NAV and APP modes.

Color : Green.
Condition : NAV or APP mode engaged on corresponding control panel.

(10) APP Pushbutton Function : Engage/disengage the Approach mode, or switch mode to second control panel

Note : Same as for G/S pushbutton (8) for engagement/ disengagement on second control panel.

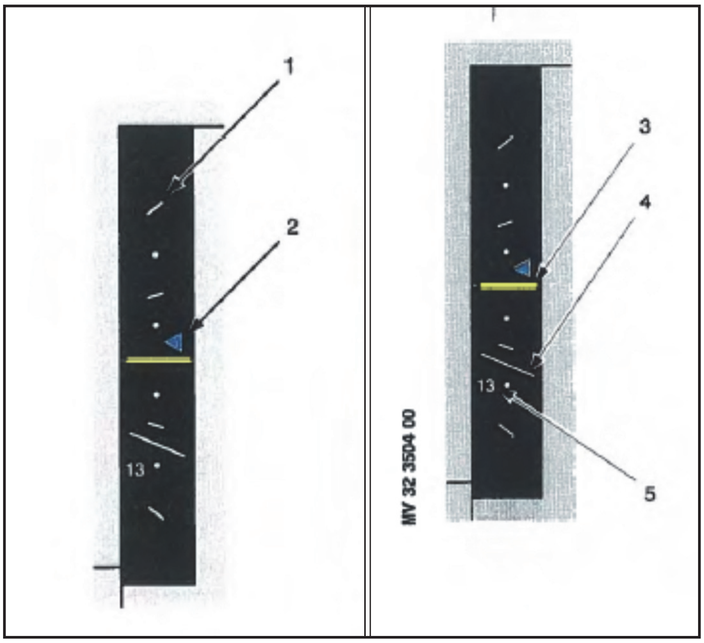
(11) NAV Pushbutton Function : Engage/disengage NAV mode, or switch mode to second control panel.

Note : Same as for G/S pushbutton (8) for engagement/ disengagement on second control panel.

NOTE : The APP and NAV pushbuttons are used to engage two submodes :

APP : - VOR.A submode : VOR approach radial capture and tracking.
- LOC submode : Localizer beam capture and tracking.

NAV : A.NAV submode : navigation computer course capture and tracking.
- VOR submode : VOR radial capture and tracking.



See page - Appendix B 158

Appendix B (cont)

(1) Vertical Speed Scale : fixed symbols.

Range	: -2000 ft/min to +2000 ft/min.
Graduations	: 500 ft/min intervals.
Displayed	: Permanently.
Color	: White.

(2) Selected Vertical Speed Index : moves vertically

Parameter	: V/S mode setpoint (refer to AFCS).
Displayed	: Permanently except when V/S mode is not engaged for V/S setpoint between ± 10 ft/min.
Colors	: Green, V/S mode engaged and coupled, Blue, other configuration.
Note	: - Disappears if AFCS function is inoperative. - Nominal color changes to white during transient phase of the parameter.

(3) Aircraft Reference Mark : fixed symbol

Parameter	: Zero V/S.
Displayed	: Permanently.
Color	: Yellow.

(4) Vertical Speed Index : moves vertically

Displayed	: Permanently.
Color	: White.
Note	: Travel limited to ± 2500 ft/min.

(5) Digital Display : moves vertically

Parameter	: Vertical speed.
Displayed	: If V/S exceeds 50 ft/min.
Color	: White.
Note	: Expressed in hundreds of ft/min, limited by aircraft performance.

Appendix B (cont)

COMPLEMENTARY FLIGHT MANUAL

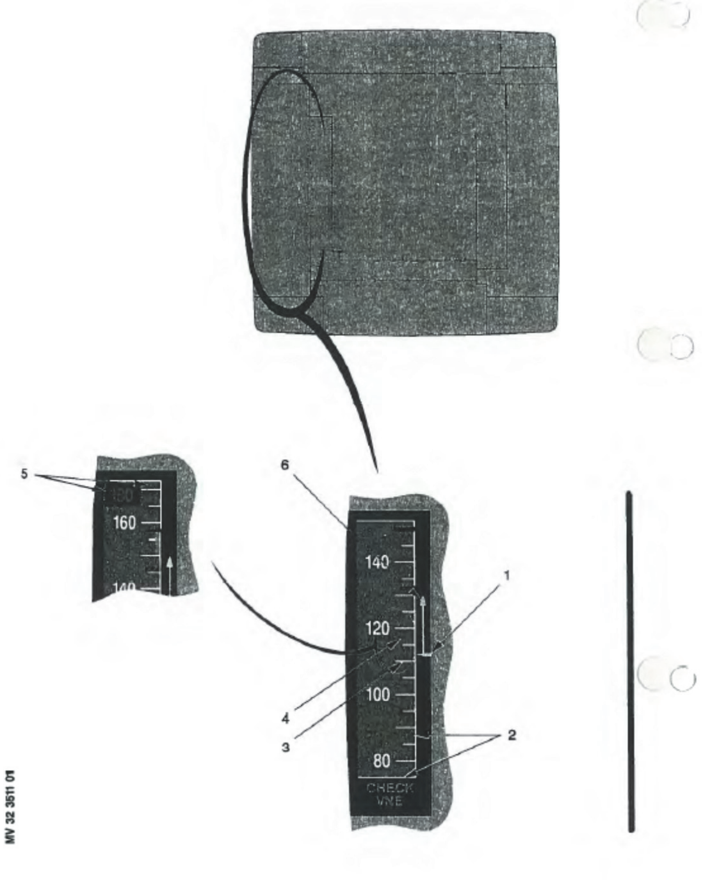


Fig. 13

Appendix B (cont)

3.10 Airspeed Indicator (Fig. 13)

3.10.1 Airspeed Indicating Function

(1) Aircraft Reference Mark : fixed symbol

Parameter : Indicates present airspeed.
Displayed : Permanently.
Color : Yellow.

(2) Scale Window : fixed symbol

Displayed : Permanently.
Color : White.
Note : Displays a 70-kt range.

(3) Airspeed Scale : linear scale

Range : Scrolls from 20 kt to 250 kt.
Graduations : 5-kt intervals.
Displayed : Permanently.
Color : White.
Note : Between 0 and 20 kt, only the zero graduation is not marked with a numerical value.

(4) Selected IAS Index : moves vertically

Parameter : IAS mode setpoint (refer to AFCS).
Displayed : When IAS mode is engaged on F/D or engaged and coupled on AFCS.
Colors : Green : IAS mode engaged and coupled on AFCS,
Blue : IAS mode engaged on F/D.

(5) Note

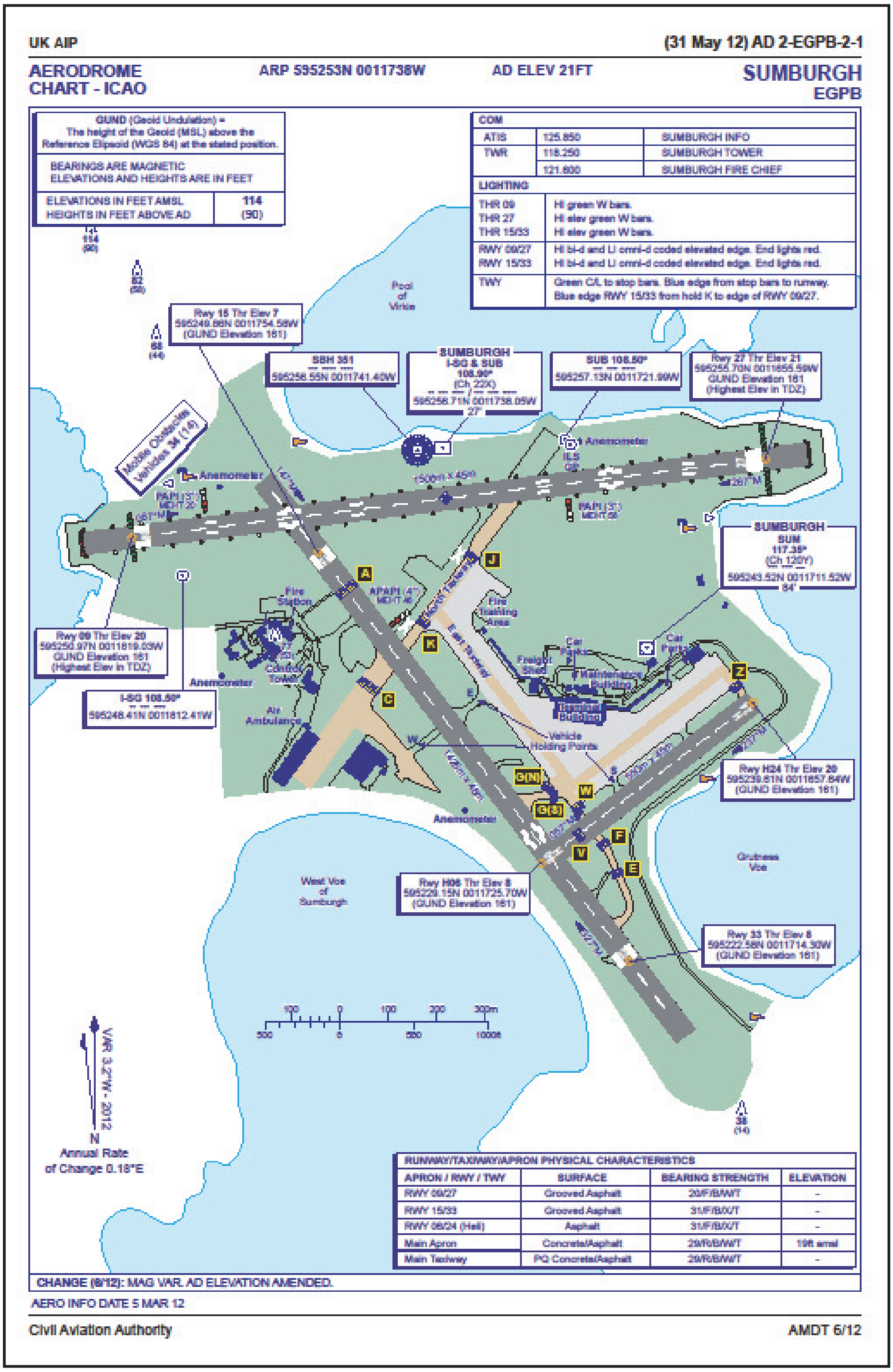
- IAS setpoint index and numerical value are displayed as shown when setpoint value is off scale.
- Nomimal color changes to white during parameter change phases.

(6) Airspeed Trend : length varying vertically from aircraft mark reference

Parameter : Predicted airspeed within 5 s, calculated from the rate of change of the present mean airspeed (acceleration or deceleration)
Color : Yellow

Appendix C

AERONAUTICAL INFORMATION PUBLICATION (AIP) SUMBURGH AIRPORT



Appendix D

COMBINED COCKPIT VOICE AND FLIGHT DATA RECORDER (CVFDR) TRANSCRIPT

Introduction

The transcription process included verification by AAIB Senior Inspectors from the disciplines of Flight Recorders, Engineering and Operations. Both crew also reviewed the transcript for accuracy. Non-operational conversations during the flight are omitted.

The UTC time stamp used in the transcript was derived from the ground-based records of ATC communication with G-WNSB. The ground recording system is required to have a tolerance of +/- 2 seconds in accordance with CAP 670. The transcript is provided to 1/100 second precision, with the start of each word or sound based on visual identification within the signal wave form.

Audio quality

The audio recording of the two crew channels was categorised as being of good quality, where the majority of the crew conversations could be accurately and easily understood. It was noted that the recording level of the co-pilot's communications channel was lower than that of the commanders, such that if the commander spoke at the same time as the co-pilot, the commander's speech could mask the recording of the co-pilot's voice.

ATC radio transmissions

Only radio transmissions to and from G-WNSB have been transcribed.

Word transcription

Words may be expressed with excess vowels, letters or drawn out syllables.

Appendix D (cont)

Legend

Cmdr	Commander.
CP	Co-pilot.
RTO	Radio Transmission from G-WNSB to ATC.
RTI	Radio Transmission to G-WNSB from ATC.
PA	Announcement to passengers using the helicopter's PA system.
?	The voice is not identified as being one of the crew.
< >	Sounds generated by the helicopter's avionics systems, such as the AVAD.
//	Sounds such as those made by the movement of a switch in the cockpit or other sound not generated by the helicopter's systems or crew.
( )	Conversation that is of a non-operational content.
#	Expletive.
*	A word that is unintelligible, or if there is doubt over its accurate transcription.
(0.4)	If there is a pause between words spoken by the same person of between 0.3 seconds and 3.0 seconds, this will be expressed in seconds and tenths of seconds.
[ ]	Overlapping speech or sound. The source and word/s or sound will be inserted adjacent to the corresponding word/s or sound.
-	A word or sound that is cut-off/ends prematurely.
: :	Laugh or laughter.
" "	A sound such as an exhale of breath, or tut-tut.
^^	Person's name that is excluded from the transcript.

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:01:33.67 **RTO-Cmdr**	Uh Borgsten Radio Helibus two three Romeo		G-WNSB on the helideck of the Borgsten Dolphin
16:01:38.94 **RTI-Borgsten Dolphin**		Two three Romeo Borgsten Radio pass your message	
16:01:42.36 **RTO-Cmdr**	Okay sir from the Borgsten to Sumburgh now uh direct track two thousand feet (0.4) it says the mach- the re- well the machine says forty six minutes en-route four six (0.4) uh one eight persons on board after uh lift the fuel will be one four eight zero that's about uh two hours five zero endurance nil defects		
16:02:04.36 **RTI-Borgsten Dolphin**		That's all copied to Sumburgh two thousand feet four six minutes one eight POB two hours fifty one four eight zero negative defects copied	
16:02:15.24 **CP**	Hello mate		
16:02:23.03 **Cmdr**	Did you find room in there		
16:02:24.96 **?**	Yeah yeah *****		
16:02:41.91 **?**	*****		
16:06:52.64 **Cmdr**	Nine three uh nav eight nine three twenty five		
16:07:22.49 **PA**	<passenger announcement double chime>		
16:07:31.88 **PA**	<passenger announcement double chime>		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:07:34.18 **PA-Cmdr**	Okay ladies and gents welcome aboard if you have just joined next stop is Sumburgh and we're going to have to go via Sumburgh before we return Aberdeen (0.7) um (0.4) fif- fifty minutes or so just well actually it is about fifty five minutes to Sumburgh (0.4) weather is not too good in Sumburgh but it uh be a (0.7) an instrument approach so an extra five minutes so fifty five minutes into Sumburgh (0.8) um (0.5) I know you've all seen a video brief just ask you then to check please your harnesses and lap straps make sure they are secure as is on the tape (0.5) uh for your information you'll find the flight safety card in the side pockets adjacent to your seats showing the location and operation of your nearest emergency exit (0.6) once again in the unlikely event of an emergency please follow the instructions of the crew (0.6) if you've got any problems during the trip back uh feel free not during takeoffs and landings though but in the cruise if you need to one of you can un-strap come forward (0.4) tap either of us on the shoulder we'll try and sort things out for you (0.7) other than that a few checks now uh then we'll be lifting so in the meantime sit back relax make yourselves as comfortable as you can I'll leave you in peace and give you a call as we approach Sumburgh thanks		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:08:34.69 **Cmdr**	Helloooo		
16:08:34.69 **CP**	Hi mate I had there was jackets on the back seat a guy went out two of the jackets just flung on the floor		
16:08:41.32 **Cmdr**	Oh did he		
16:08:41.99 **CP**	So I just moved them		
16:08:42.91 **Cmdr/CP**	**Cmdr:** Aye aye sometimes they do that aye [**CP:** Aye]		
16:08:46.18 **CP**	Alrighty so		
16:08:47.09 **Cmdr**	Right um aye I've spoken to them and I've been trying to put in a seventy mile point for you and I've just ###### given up it won't take it		Commander and co-pilot enter waypoint into navigation system
16:08:54.33 **CP**	The last time I did it it from here		
16:08:55.42 **Cmdr**	The tracks two four eight		
16:08:57.24 **CP**	Right uh the last time I did it it was (0.9) two nine		
16:09:02.78 **Cmdr**	You got a waypoint in there		
16:09:03.77 **CP**	B (1.1) C yeah and it was tell you when it was when it was working at Sumburgh		
16:09:10.60 **Cmdr**	Right		
16:09:13.04 **CP**	Now let's see if that works		
16:09:15.55 **Cmdr**	That'll do that be seventy miles can you uh that scale that's sixty so that looks about right it's not direct track but that will do		
16:09:22.86 **CP**	It's not a million miles off		
16:09:23.96 **Cmdr**	Aye		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:09:24.50 **CP/Cmdr**	**CP:** But I can take it out and put it in the back so it will give you [**Cmdr:** Aye that's fine yeah we can do that] direct to Sumburgh		
16:09:28.55 **CP**	Eh so clear it		
16:09:28.70 **Cmdr**	Aye then you know where it is then **** I was trying to give you a and I made up a waypoint and I just called it um nine five one a diagonal run back and three times it wouldn't accept it and I was going what the #### am I doing wrong		
16:09:40.79 **CP**	Aye		
16:09:42.38 **Cmdr**	Well it wasn't ask it I was uh refer it the reference was SUM and it usually asks it usually comes up and goes uh (0.4) you know		
16:09:31.07 **CP**	That should uh (0.6) there there's just an indicator it's just off track for us		
16:09:55.07 **Cmdr**	Aye that's fine yeah perfect okay		
16:09:57.23 **CP/Cmdr**	**CP:** :laughs: Okay heating and ventilation uh no change [**Cmdr:** Yeah] anti icing no change transponders are transponding radio and nav aids uh for me to set once we are up and going but this will do for now		Before takeoff checklist
16:10:09:00 **Cmdr**	Okay		
16:10:09.40 **CP**	Altimeters bugs and MSA		
16:10:11.49 **Cmdr**	Uh last known one zero one seven the Cormorant the bugs still at two hundred MSA we'll call it a thousand plus obstacles		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:10:17.35 **CP**	Okay uh flight instruments		
16:10:19.77 **Cmdr**	Uh yeah just DG no flags no everything looks sensible		
16:10:22.94 **CP**	Uh bleed valves are offset takeoff mass		
16:10:26.64 **Cmdr/CP**	**Cmdr:** I've updated [**CP:** ****] it should be in there about nine three fifty or nine three yeah nine three O nine perfect		
16:10:31.36 **CP**	Sounds good to me (0.6) and um cabin briefing notices		
16:10:35.66 **Cmdr**	That was done yeah		
16:10:36.44 **CP**	All done takeoff and departure briefing		
16:10:38.44 **Cmdr**	Yeah avoiding this bit down here I'll come into the middle back to the right of the deck there is no obstruction there and I'll go in the middle		
16:10:43.72 **CP**	Roger (0.8) uh fuel we're in good shape that's uh fifteen hundred I see		
16:10:48.42 **Cmdr**	Aye		
16:10:49.05 **CP**	Uh doors and captions		
16:10:50.41 **Cmdr**	I'm locked in		
16:10:50.99 **CP**	**** clear uh (1.1) ground crew and chocks ****.		
16:10:54.72 **Cmdr**	I got a thumb yeah he's walking away now		
16:10:56.89 **CP**	Uh internal external lights (0.6) uh floats armed and ready for autopilot		
16:11:05.25 **Cmdr**	Yes please		
16:11:06.45 **CP**	Uh CWP's clear.		
16:11:08.03 **Cmdr/CP**	**Cmdr:** It is [**CP:** ****** you have]		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:11:10.13 **CP/Cmdr**	**CP:** Uh lifting call from me I don't think Brent Radar can hear me so what I'll [**Cmdr:** No] do I will make it but then uh if if not		
16:11:16.81 **Cmdr**	Aye that's fine		
16:11:18.53 **RTO-CP**	Brent Radar Helibus two three romeo		
16:11:22.40	/static recorded on crew channels – five seconds duration/		
16:11:25.42 **Cmdr**	Yeah (1.3) I reckon you're shielded (0.5) maybe just do it once we are airborne		
16:11:29.83 **CP**	Yeah I'll do it then		
16:11:30.29 **Cmdr**	I'll just fly it visually and then you can just do radios if you like		
16:11:34.73 **RTO-CP**	Okay and (1.6) all stations Borgsten Dolphin at time o- one one Helibus two three romeo lifts deck of the Borgsten Dolphin to Sumburgh two thousand feet		
16:11:48.16 **RTI-Borgsten Dolphin**		Time one one uh two three romeo leaving the Borgsten that's all copied	
16:11:53.53 RTO-CP	Roger		
16:11:53.95 **Cmdr**	Okay then good to go power coming in AP is done all the checks are done		
16:12:04.07 **CP**	Both engines responding wind calm (0.9) hover checks complete (1.1) and (0.6) at the moment your pulling sixty five percent torque (0.4) si- just under six and a half for the FLI		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:12:15.78 **Cmdr**	Okay then all clear (2.1) steady on what you doing three two one now		G-WNSB lifts from Borgsten Dolphin
16:12:26.60 **Cmdr**	Going		
16:12:27.28 **CP**	Roger airspeed's alive		
16:12:35.56 **CP**	Blue line powers good accelerating climbing		
16:12:47.65 **CP**	Still climbing still accelerating that's us approaching approaching Vy		
16:12:54.32 **Cmdr/CP**	**Cmdr:** Yeah we can take the [**CP:** *****] bleeds and the gear and we'll get some more power out of the engines then		
16:12:57.67 **CP**	Would you like me to leave the NR		
16:12:59.33 **Cmdr**	Uh no just uh back to normal yeah that's all good		
16:13:02.48 **CP**	Okay uh (0.8) and a set of after takeoffs when you're ready		
16:13:08.17 **Cmdr**	Yeah any time you like		
16:13:09.05 **CP**	Okay landing gear		After takeoff checklist
16:13:09.08 **Cmdr**	Four hundred feet fifteen hundred to ****		
16:13:11.21 **CP**	Bleed valves and NR are both normal compass is coming back to MG uh radar uh should be on now floats are off parking brake is off external lights are now set and radios and nav aids I need to deal with after takeoff checks complete		
16:13:29.19 **Cmdr**	Thank you (2.3) I'll just level at a thousand until you're two way then		
16:13:33.95 **CP**	No worries		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:13:40.62 **CP**	Okay eighteen eighteen POB		
16:13:45.20 **RTO-CP**	Brent Radar Helibus two three romeo		
16:13:49.12 **Cmdr**	One to go		
RTI-Brent Radar		Helibus two three romeo Brent Radar squawk ident pass your message the Cormorant QNH one zero one six	
16:13:56.47 **RTO-CP**	Ident you have one zero one six uh Helibus two three romeo has lifted off of the Borgsten Dolphin for Sumburgh we're currently a thousand and looking for two thousand we're a range of ninety seven miles on a zero six seven and we have eighteen souls on board		
16:14:14.20 **RTI-Brent Radar**		Helibus two three romeo roger no known traffic to affect your climb to altitude two thousand feet direct track for Sumburgh	G-WNSB levels at 1,000 ft amsl
16:14:19.97 **RTO-CP**	Climb two thousand and nothing to affect us doing that direct track Sumburgh Helibus two three romeo		
16:14:27.66 **Cmdr**	Okay one zero one six I have then two thousand alt acquire coming on		
16:14:31.32 **CP**	Roger		
16:14:38.88 **Cmdr**	And I'll chase the bug		G-WNSB climbs to 2,000 ft amsl
16:14:39.67 **CP**	Two thousand I see		
16:14:45.17 **Cmdr**	Uh that cyclic is not the collective sorry		Commander refers to collective lever (first occasion)

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:14:47.83 **CP**	I know it's sticky isn't it		
16:14:48.71 **Cmdr**	Is it the trigger		
16:14:50.43 **CP**	I couldn't work out whether it was maybe something to do with the friction		
16:14:53.77 **Cmdr/CP**	**Cmdr:** Yeah I've got the friction fully off [**CP:** uh huh] and struggling to maintain sixty five but that's it now		
16:15:11.05 **CP**	I'll give you a direct to		
16:15:11.75 **Cmdr**	Okay yeah ta		
16:15:12.70 **CP**	There's the direct to mate		
16:15:13.78 **Cmdr**	Ta		
16:15:26.00 **Cmdr**	Five to go then		Autopilot in 3-axes with V/S mode
16:15:27.10 **CP**	Five to go		
16:15:33.12 **CP**	Can you remind me I have got a question about bug settings that I'd like to ask you		
16:15:37.69 **Cmdr**	Kay		
16:15:42.79 **Cmdr**	Uh thirty five knots already yeah		
16:15:44.39 **CP**	Aye		
16:15:46.57 **CP**	Aye we'll be glad for the extra fuel from Sumburgh today		
16:15:50.37 **Cmdr**	Aye yeah		
16:15:51.46 **CP**	You know especially if we get back to Aberdeen and it's absolutely (1.4) good old Scottish		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:15:55.43 **Cmdr**	That's the only way to do it you know with Inverness uh (1.0) uh that's all we can do		
16:16:00.99 **CP**	There's one to go		
16:16:01.78 **Cmdr**	Right and she should capture then levelling		
16:16:11.36 **CP**	Okay		
16:16:11.88 **Cmdr**	Aye bug away		
16:16:12.87 **CP**	Clearance and MSA		Cruise checklist
16:16:13.98 **Cmdr**	And the clearance is direct to Sumburgh (0.5) uh MSA is below us and we se- see the surface about fifteen hundred feet		
16:16:20.78 **CP**	Altimeters and bugs		
16:16:22.08 **Cmdr**	Just levelling back on top now two thousand feet one zero one six and bugged a thousand		
16:16:27.30 **CP**	Anti-icing is plus well nearly plus twenty but the pitots are on uh mats are off detectors on fuel uh we'll maybe start a wee transfer soon but uh what we have got there is um (1.4) I see fourteen forty		G-WNSB levels at 2,000 ft amsl
16:16:46.39 **Cmdr**	Yeah we lifted with fourteen eighty one so that's perfect		
16:16:49.90 **Cmdr**	Can you do me a favour mate see your trigger can you just ping it a couple of times		Commander refers to collective lever (second occasion)
16:16:53.32 **CP**	Yeah		
16:16:54.19 **Cmdr**	Because (0.8) just snap it open and shut because there's something holding the cyclic uh "tut"		
16:17:00.00 **CP**	The collective		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:17:00.50 **Cmdr**	The collective cyclic :laugh:(1.0) I cannae I cannae pull what I want it just keeps pinging back to where it decides it wants to be (0.6) oh no that's better yeah		
16:17:10.60 **CP**	Is that better now		
16:17:11.71 **Cmdr**	I think (0.6) I'll keep an eye on it		
16:17:13.43 **CP**	Aye great		
16:17:13.76 **Cmdr**	Maybe a wee squeeze of friction as well would help okay ta		
16:17:20.74 **CP**	Okay		
16:17:21.40 **Cmdr**	Did you find trouble with it on the way up		
16:17:22.88 **CP**	No I didn't actually uh		
16:17:24.47 **Cmdr**	It's just it seems to be locked up it's uh (0.9) anyway it's okay now		
16:17:33.21 **CP**	****		
16:17:33.94 **Cmdr**	We can start a wee transfer there before you do that yeah		
16:17:35.64 **CP**	Uh no worries mate uh fourteen o six uh		
16:17:46.64 **CP**	That'll do for ****		
16:17:47.63 **Cmdr**	Yeah that's good enough		
16:17:48.61 **CP**	**** the plan		
16:17:49.21 **Cmdr**	Yeah		
16:17:52.38 **RTO-CP**	Brent Radar Helibus two three romeo l- uh level at two thousand feet uh with estimates		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:17:58.56 **RTI-Brent Radar**		Helibus two three romeo pass your message	
16:18:00.78 **RTO-CP**	Estimating the boundary one six two eight and Sumburgh one seven zero six		
16:18:07:02 **RTI-Brent Radar**		Helibus two three romeo roger and uh could you squawk ident again please I missed your last one	
16:18:13.67 **RTO-CP**	Ident you have Helibus two three romeo		
16:18:18.44 **RTI-Brent Radar**		Helibus two three romeo identified offshore traffic service reduced SSR only	
16:18:22.60 **RTO-CP**	Offshore traffic service reduced SSR only Helibus two three romeo		
16:18:30.09 **RTO-CP**	Borgsten Dolphin Borgsten Dolphin that's Helibus two three romeo on our way two way with Radar and at level two thousand feet we're anticipating uh being on chocks at one seven one zero at (1.5) Sumburgh (1.3) uh thanks to the deck crew for a quick turn around and the galley for the food and thank you to (0.8) the North Alywn for also their assistance turn around and fuel (0.8) and coffees much appreciated and we'll see you again soon thanks two three romeo		
16:19:04.64 **RTI-Borgsten Dolphin**		Two three romeo thank you for that quick turnaround have a safe journey have a good weekend and hope to see you next time	

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:19:11.86 **RTO-CP**	And al- and to you :laugh: have a good weekend bye two three romeo		
16:19:16:03 **Cmdr**	Great that's it then		
16:19:17.94 **CP**	Life is good that's done (1.5) I'll complete a line		
16:19:42.15 **Cmdr**	I know what it was		
16:19:44.00 **CP**	What mate		
16:19:45.94 **Cmdr**	Maybe I should have used SBH I have used SUM before (0.6) it didn't seem to know what (0.9) SUM was		Commander refers to difficulty entering a waypoint into navigation system
16:19:55.54 **CP**	I always just end up using two		
16:19:57.02 **Cmdr**	Maybe that's what I should have done may be I us-		
16:19:58.64 **CP**	Aye		
16:19:59.72 **Cmdr**	I'll show you what I was doing when you finish all that and I'll see you can tell me what I am doing wrong		
16:20:22.99 **CP**	So just over a thousand a thousand and fifteen in (0.7) uh Sumburgh		Crew discuss fuel quantity on arrival at Sumburgh
16:20:29.44 **Cmdr**	For Scatsta be about seven hundred and something		
16:20:31.50 **CP**	Uh if I take out the boundary (1.0) uh (0.8) actually got the boundary in should have put the boundary in after (1.1) Scatsta just uh		
16:20:25.36 **CP**	Yeah Scatsta's looking just over nine hundred mate		
16:20.57.57 **Cmdr**	Nine hundred oh well that's fine aye		
16:21:01.03 **CP**	Give you a couple of goes won't it		
16:21:03.39 **Cmdr**	Aye aye at least it's a bolt hole		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:21:05.52 **CP**	Yeah		
16:21:05.82 **Cmdr**	Based on the last TAF we had so all we can do		
16:21:08.35 **CP**	Aye that's all we can do yeah		
16:21:10.01 **Cmdr**	I'm jus- g- just going to plug me ears in again for a second		
16:21:12.45 **CP**	Yeah and I'll do the radios ****		
16:21:13.19 **Cmdr**	Okay		
16:21:39.22 **Cmdr**	Right I'm back		
16:21:40.43 **CP**	Do you want me to pass you up another coffee mate		
16:21:32.19 to 16:21:57.01	(non-operational conversation)		
16:21:58.13 **Cmdr**	Aye so I'll tell you what I was doing uh data forward oh that's my**** forward and I'll call it nine five one		Crew discuss previous problem with entering waypoint into navigation system
16:22:07.27 **CP**	Yeah		
16:22:09.90 **Cmdr**	From (0.8) I'll just do it again		
16:22:12.13 **CP**	Uh huh		
16:22:13.96 **Cmdr**	S (0.4) U (1.4) M (2.9) that M yeah		
16:22:21.39 **CP**	Yeah		
16:22:23.89 **Cmdr**	It usually s- it usually interrupts you there and says SUM is this this what you mean		
16:22:28.34 **CP**	Yeah		
16:22:28.63 **Cmdr**	So that is the flaw I think		
16:22:29.66 **CP**	Yeah		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:22:29.96 **Cmdr**	The track was two four eight (0.7) zero let's call it fifty miles for the hell of it now 'cause (0.4) if it works we'll see it in the screen (1.0) uhhh (1.3) and that's all I can do (0.7) enter (1.0) but it doesn't like it		
16:22:51.00 **CP**	It's put something in there hasn't it		
16:22:52.36 **Cmdr**	Aye but it's uh ten thousand miles away		
16:22:54.96 **CP**	Yes aye		
16:22:56.37 **Cmdr**	So		
16:22:56.72 **CP**	Aye		
16:22:56.99 **Cmdr**	It's it that's the fault then it's SUM isn't it		
16:22:59:35 **CP**	Yes		
16:22:59.76 **Cmdr/CP**	**Cmdr:** So let's see NAV aid forward forward forward oh no no no no "tut"(2.0) try it again with two (1.1) nine five one (3.0) two (2.4) uhh (1.0) two four eight (0.9) two four eight does that make sense aye uh oh no that's ##### it's the reciprocal that what's I am doing wrong "tut"[**CP:** ******]		
16:23:27.65 **CP**	It will be		
16:23:28.63 **Cmdr**	Uh the opposite of that what's that one eighty zero six eight		
16:23:31.16 **CP**	Zero six eight		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:23:32.47 **Cmdr/CP**	**Cmdr:** Clear (0.5) found it now then zero six eight (0.5) zero five uh yeah zero five (1.6) right (0.9) gonna take that one (3.0) okay (1.1) flight plan (0.6) one (2.7) nine five one (1.7) enter (0.8) ah (0.7) I didn't put the reciprocal what a ####[**CP:** ******] that's better		
16:24:00.43 **CP**	That's sorted		
16:24:01.05 **Cmdr/CP**	**Cmdr:** That would have put it right at seventy (0.4) okay happiness (1.8) aye 'cause some of them ask you a question is it this VOR you selected [**CP:** Right] I just couldn't see it just like what we were talking about earlier		
16:24:11.41 **CP/Cmdr**	**CP:** I've noticed though that this this that RNAV is slightly different and I don't know whether it's a newer one or because it this is [**Cmdr:** ****] a Norwegian aircraft		
16:24:20.22 **Cmdr**	That's right aye		
16:24:20.85 **CP**	It's not got everything in it that we have in ours		
16:24:23.41 **Cmdr**	Ah maybe that's why it doesn't give you the question is it the VOR Sumburgh you are asking for		
16:24:27.96 **CP**	Yeah I think um because we've got we've got one that is set up (1.6) locally where as-		
16:24:34.72 **Cmdr**	Uh huh		
16:24:36.01 **CP**	I suspect that's had a		
16:24:37.51 **Cmdr**	Maybe it has yeah		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:24:38.07 **CP**	***** update and then		
16:24:40.41 **Cmdr/CP**	**Cmdr:** Aye I'm sure you're right that makes [**CP:** ****] sense aye		
16:24:42.19 **CP/Cmdr**	**CP:** **** pilots are putting them in on the ones [**Cmdr:** Aye] that we fly normal		
16:24:50.76 **Cmdr**	Yeah		
16:24:51.34 **CP**	My question about bugging was		
16:24:52.65 **Cmdr**	Aye		
16:24:52.99 **CP**	You know like um say you're climbing through I don't know eight hundred feet on uh rad alt		
16:25:00.35 **Cmdr**	Aye		
16:25:00.92 **CP**	And you're really quick to bug a thousand		
16:25:04:35 **Cmdr**	Aye		
16:25:05.02 **CP**	So you over took it		
16:25:06.43 **Cmdr**	Right		
16:25:06.91 **CP**	Some aircraft you'll get a (1.7) ping		
16:25:11.07 **Cmdr**	Aye		
16:25:11.45 **CP**	Some you won't		
16:25:11.95 **Cmdr**	Aye it depends does it not oh I don't know the answer but does it not depend on where the other bug is as well		
16:25:17.57 **CP**	Ahhhhh		
16:25:18.93 **Cmdr**	It depends where the other bug is (0.4) and (1.6) i- some aircraft they don't all do the same thing		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:25:26.03 **CP**	Right (0.7) that makes sense (1.3) that makes sense (0.6) yeah ‘caus-		
16:25:30.82 **Cmdr**	If the other bug is at zero (1.8) eeuhhh (1.2) in fact they have done this in the simulator to find out because the simulator is b-		
16:25:38.99 **Sumburgh ATIS**		Bird activity within the aerodrome boundary	
16:25:41.00 **Cmdr**	Ah here we go		
16:25:42.34 **Sumburgh ATIS/ CP**		Sumburgh information acknowledge receipt of [**CP:** ******] information whisky time one six two zero runway in use zero nin-er surface wind one fife zero one eight knots visibility four thousand metres haze scattered three hundred feet broken fife hundred feet temperature plus one fife dew point plus one four QNH one zero one four runway zero nin-er dry dry dry increased bird activity within the aerodrome boundary Sumburgh information acknowledge receipt of information whisky time one	Sumburgh 1620 hrs ATIS
16:26:26.10 **CP**	Sorry mate just thought we would grab that while		
16:26:23.61 **Cmdr**	Aye (0.7) that’s fine (0.4) so that’s its still uh (0.6) it’s doable but uh aye		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:26:29.34 **CP**	Gonna be right on minimums yeah		CP refers to weather being on minima
16:26:33.35 **Cmdr**	Uh we'll do the uh localiser DME for zero nine then we can ask for that aye		
16:26:37.27 **CP**	Yeah (0.5) no worries mate		
16:26 39.92 **Cmdr**	Radar vectors to that will be easy		
16:26:42.18 **CP**	Yeah		
16:26:42.50 **Cmdr**	He'll send us around the corner then		
16:26:44.02 **CP**	Yeah (1.4) ********		
16:26:48.14 **Cmdr**	It's Friday (0.4) let's make it easy		
16:26:49.96 **CP**	Yeah		
16:26:50.36 **Cmdr**	:laughs:		
16:26:50.91 **CP**	Yeah I'll agree on that with you		
16:26:54.88 **CP**	One three zero		
16:26:55.88 **Cmdr/CP**	**Cmdr:** In fact he's just going to put you over shortly anyway so you can tell um Sumburgh Radar when we get over so [**CP:** *****] no rush		
16:27:01.11 **CP**	I just thought we'd I'd give them		
16:27:03.31 **Cmdr**	Aye ***** that's fine yeah go for it		
16:27:05.86 **CP**	Oh no no no your absolutely right I just uh I just wanted the the the ATIS you just know there		CP refers to obtaining ATIS
16:27:11.73 **Cmdr/CP**	**Cmdr:** Right [**CP:** ****]		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:27:11.89 **CP**	And then one for Scatsta (0.8) the crew (3.0) just a wee message out for (0.7) aero well they don't call themselves aero ramp now I noticed yesterday it's Logan (1.0) Logan han-		
16:27:25.82 **Cmdr**	Have they changed again		
16:27:26.97 **CP**	Aye		
16:27:27.21 **Cmdr**	It was aero handling it was OBC before that		
16:27:29.81 **CP**	Right		
16:27:30.04 **Cmdr**	And then it went to aero handling aero ramp		
16:27:31.86 **CP**	Yeah		
16:27:32.69 **Cmdr**	And now its Logan is it ah that's new to me I didn't know that		
16:27:37.36 **RTI-Brent Radar**		Helibus two three romeo contact Sumburgh Radar now one three one decimal three	Crew handed over to Sumburgh Radar frequency
16:27:41.55 **RTO-CP**	Contact Sumburgh Radar one three one decimal three Helibus two three romeo		
16:27:46.00	<beep>		
16:27:47.15 **CP**	And		
16:28:02.45 **RTO-CP**	Sumburgh Radar Helibus two three romeo is with you level two thousand feet at the boundary uh in receipt of whisky		
16:28:10.52 **RTI-Sumburgh Radar**		Helibus two three romeo Sumburgh Radar good afternoon offshore deconfliction service SSR only	

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:28:15.39 **RTO-CP**	Good afternoon offshore deconfliction service SSR only Helibus two three romeo		
16:28:23.11 **CP**	There all getting to be pleasant :laugh: you know like good afternoon or good morning		
16:28:27.84 **Cmdr**	Aye		
16:28:29.90 **CP**	Um what am I doing ********		
16:28:58.43 **Cmdr**	That's the one there aye that's fine		
16:30:06.77 **Cmdr**	Right I'll just leave that there for later		
16:30:08.46 **CP**	No worries mate		
16:30:10.69 **Cmdr**	Aye we can just call um Sumburgh Radar now at your own time (0.6) now we're uh looking for a (0.7) a localiser DME zero nine Radar vect- sorry Radar vectored to localiser D*		
16:30:20.73 **Sumburgh Radar**		radio communications with another aircraft	
16:30:24.98 **Cmdr**	That's uh		
16:30:28.78 **Cmdr**	******* (0.9) what am I talking about localiser DME for zero nine Radar vectors that will be fine (1.0) just gives them a heads up		
16:30:39.12 **RTO-CP**	And Sumburgh Radar Helibus two three romeo		
16:30:32.60 **RTI-Sumburgh Radar**		Helibus two three romeo pass your message	
16:30:45.03 **RTO-CP**	If it's possible um can we have um r- Radar vectors for a localiser DME zero nine Helibus two three romeo		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:30:52.34 **RTI-Sumburgh Radar**		Helibus two three romeo affirm you can anticipate Radar vectors localiser DME approach runway zero nine I'll give you a climb and a heading when you get a wee bit closer	
16:31:00.78 **Cmdr**	Perfect		
16:31:02.43 **RTO-CP**	Fantastic Radar uh vectors localiser DME zero nine (0.6) climb (0.4) and vectors when a bit closer Helibus two three romeo		
16:31:10.75 **Cmdr**	I love it when a plan works out		
16:31:12.36 **CP**	Awesome (0.6) awesome		
16:31:13.85 to 16:31:20.20	(non-operational conversation)		
16:31:21.18 **Sumburgh Radar**		radio communications with another aircraft	
16:31:28.26 to 16:32:11.80 **Cmdr/CP**	(non-operational conversation)		
16:32:12.67 **CP**	(non-operational conversation)		
16:32:16.02 **Cmdr**	(non-operational conversation)		
16:32:17.81 **Cmdr**	(non-operational comment)		
16:32:52.86 To 16:42:49.73 **Cmdr/CP**	(non-operational conversation)		
16:42:53.23 **CP**	I see twelve fifty		
16:42:53.23 **Cmdr**	Uh yeah bang on I would agree		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:42:56.41 **CP**	*******		
16:43:03.34 To 16:44:58.29 **Cmdr/CP**	(non-operational conversation)		
16:44:59.44 **RTI-Sumburgh Radar**		Helibus two three romeo the Sumburgh QNH one zero one four	
16:45:04.28 **RTO-CP**	One zero one four thank you Helibus two three romeo		
16:45:06.24 **Cmdr**	Roger one four for a nineteen forty for me		
16:45:09.55 **CP**	That's crosschecked		
16:45:10.71 **Cmdr**	I'll just sneak back up then		
16:45:28.87 To 16:47:34.50 **Cmdr/CP**	(non-operational conversation)		
16:47:34.51 **RTI-Sumburgh Radar**		Helibus two three romeo new information x-ray the visibility uh two thousand eight hundred meters in mist the cloud few at two hundred broken three hundred	ATC advises that visibility and cloud base have reduced since 1620 hrs ATIS
16:47:44.75 **RTO-CP**	And copied that thanks Helibus two three romeo		
16:47:47.99 **Cmdr**	This could get interesting		
16:47:49.05 **CP**	This could get interesting		
16:47:54.25 **Cmdr**	What was the vis there just now		
16:47:55.57 **CP**	Two thousand five hundred		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:47:56.73 **Cmdr/CP**	**Cmdr:** Right so this look is not going to stop us making the approach [**CP:** *****] we just need to bring the speed right back on this one so with that in mind will I brief you now		Start of commander's approach brief
16:48:02.94 **CP**	Yes please		
16:48:03.66 **Cmdr**	Alright		
16:48:04.06 **CP**	And then I'll go on and speak to-		
16:48:05.20 **Cmdr**	Aye okay		
16:48:05.83 **CP**	The handling		
16:48:06.35 **Cmdr**	So I've got uh CAT ABC Sumburgh (1.0) fifty dash two June twelve localiser runway zero nine CAT ay- CAT ABC uh (1.7) it's based on one O eight point five SUB which I have set up in the background in fact **** (0.5) ****** so I am going to put that one over there now (1.0) um inbound (1.9) QDM is zero eight five (0.8) uh i- he's already mentioned that he is going to get us to climb to twenty one		
16:48:33.90 **CP**	Yeah		
16:48:34.25 **Cmdr**	So whatever way he takes us around from here coming in from here around North ****** be from the South to capture uh final approach fix at seven (1.2) s- based on SUM um we're based on SUB so six point four D		
16:48:50.16 **CP**	Right		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:48:50.58 **Cmdr**	Will be the start of the three degree slope all the way down (0.4) minimum or missed approach point is point five miles		
16:48:56.46 **CP**	Roger		
16:48:57.57 **Cmdr**	Um(1.8) and then we will be climbing (0.8) on zero eight five so straight back out off shore to fifteen hundred feet right turn to the VOR again		
16:49:07.01 **CP**	Right		
16:49:08.02 **Cmdr**	Uh (1.2) but we'll ask well we've got enough for a couple of goes		
16:49:12.07 **CP**	Aye		
16:49:12.78 **Cmdr**	Uh we'll see how get on and uh (0.8) after the second attempt we'll brief for Scatsta		
16:49:18.76 **CP**	Sounds good to me		
16:49:19.96 **Cmdr**	So this one then (0.4) it's uh (1.1) localiser DME minima is three hundred so bugs to three hundred		
16:49:26.39 **CP**	Roger		
16:49:27.78 **Cmdr**	And if you can read out (0.7) uh I'll let it capture the localiser itself I'll arm that but what I'll need is uh heights coming down		
16:49:35.80 **CP**	To to gauge your ****		
16:49:36.88 **Cmdr**	Aye I'm going to get the speed back to (0.8) eighty ***** call it in in between there so about five hundred feet a minute we're looking for		
16:49:45.40 **CP**	Roger		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:49:46.33 **Cmdr**	So I'll try and get that on right away no messing so that it		
16:49:48.97 **CP**	O- okay		
16:49:49.43 **Cmdr/CP**	**Cmdr:** We don't end up speeding up to try and capture (0.5) so um I am the glideslope (0.5) and I'll be maintaining something like five hundred feet a minute [**CP:** Okay] and at the latter end I'm gonna to bring it back to eighty knots and make sure we can get in [**CP:** Aye] (0.7) so uh (0.4) expecting you to look up at three hundred feet and you'll be taking control at some point or going a- if I can't see we'll be going around		Commander refers to final target approach speed of 80 kt
16:50.07.89 **CP**	Yeah		
16:50:08.09 **Cmdr**	But if you have visual or see the lead in lights at any point then um (0.7) just take control and make the landing		
16:50:13.50 **CP**	Roger		
16:50:14.12 **Cmdr**	Uh so if you can read out six point four at twenty one all the way down		
16:50:17.31 **CP**	Roger		
16:50:17.75 **Cmdr**	Uh three hundred feet is point seven so we'll be right down there		
16:50:22.32 **Cmdr/CP**	**Cmdr:** So [**CP:** *****] we've always got a continue call just to remind you		
16:50:25.87 **CP**	Yeah so I could say (0.6) um (0.6) visual		
16:50:28.53 **RTI-Sumburgh Radar**		Helibus two three romeo turn right one zero degrees report new heading	

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:50:31.66 **Cmdr**	Two four zero		
16:50:34.01 **RTO-CP**	Right one zero and that's onto two four zero Helibus (0.8) two three romeo		
16:50:39.26 **RTI-Sumburgh Radar**		Helibus two three romeo roger	
16:50:42.01 **RTO-CP**	Roger		
16:50:42.45 **Cmdr**	Aye so all you need is some lead in lights or some sort of point if you can see any bit of ground		
16:50:47.33 **CP/Cmdr**	**CP:** Then I'll say visual continue and that means [**Cmdr:** Yeah] you continue on instruments		
16:50:50.16 **Cmdr**	Aye		
16:50:50.54 **CP**	Right		
16:50:51.82 **CP**	That's probably		
16:50:53.03 **Cmdr**	Yeah that's probably what we might be doing but we'll see		
16:50:56.14 **CP**	Yeah (0.4) I'll just give uh if you could cover two I'll just give		
16:50:58.55 **Cmdr**	I've got box two yep and well get set up for this one then (0.9) where's my glass case gone now oh there it is		
16:51:05.24 **CP**	I'm just gonna call aero-		
16:51:06.21 **Cmdr**	Yeah I've got box two you go ahead		
16:51:09.06 **RTO-CP**	Aero handling Sumburgh Helibus two three romeo		
16:51:17.92 **RTI-Ground handling agent**		Helibus two three romeo uh Logan Air ops here	

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:51:24.00 **RTO-CP**	Helibus uh two three romeo um we're a AS three three two L two uh off the Borgsten Dolphin eh estimated time of arrival in uh Sumburgh is one seven zero six um we have sixteen passengers in the back would you like my onward uh details Helibus two three romeo		
16:51:46.27 **RTI-Ground handling agent**		That's copied Helibus two three romeo if you give me your onward details	
16:51:50.73 **CP**	So it's for pressure refuel and our onward details are IFR at two thousand feet an hour thirty nine en-route eighteen souls on board two hours fifty five endurance and one four eight zero in the tanks (2.3) Helibus two three romeo		
16:52:11.60 **RTI-Ground handling agent**		That's copied Helibus two three re- romeo I've got you uh IFR two thousand feet um one three nine time en-route eighteen souls onboard two five five endurance I presume your destination is Aberdeen and uh I couldn't get your tanks and can you give me your reg as well please	
16:52:31.93 **CP**	Um will I point out our our divs or our alternates Inverness (1.4) no		
16:52:38.71 **Cmdr**	Um the destination's Aberdeen but with Inverness alternate if that's what she is asking		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:52:43.92 **RTO-CP**	Uh our registration is golf whisky november sierra bravo and uh the tanks one four eight zero which was two hours fifty five endurance Aberdeen is indeed the destination and our alternate for Aberdeen is Inverness Helibus two three romeo		
16:53:01.26 **RTI-Ground handling agent**		That's copied Helibus two three re- romeo see you at zero six	
16:53:06.74 **RTO-CP**	See you soon and it might be a little after ******* thanks Helibus two three ro-		
16:53:11.25 **Cmdr**	Maybe ask her for a updated TAF's if it's possible because they should be coming in before we land		Request for latest TAF's after landing
16:53:16.29 **RTO-CP**	And Helibus two three romeo um if it's possible can be we have up to date uh TAF's and METARS		
16:53:18.18 **RTI-Sumburgh Radar**		Helibus two three romeo climb to altitude two thousand five hundred feet	Climb prior to routing to the north of Sumburgh
16:53:23.95 **RTI-Ground handling agent**		That's copied Helibus two thre-	
16:53:25.10 **RTO-Cmdr to Sumburgh Radar**	Climb altitude two thousand five hundred feet Helibus two three romeo		
16:53:29.69 **RTO-CP to Ground handling agent**	Thank you		
16:53:32.14 **CP**	Two thousand five hundred I heard		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:53:33.69 **Cmdr**	Two thousand five hundred up we go and alt acquire coming on for that one zero one four two thousand five hundred		Climb to 2,500 ft amsl
16:53:39.52 **CP**	Two thousand five hundred seen that's cross checked		
16:53:44.25 **CP**	Okay let's get serious		
16:53:46.37 **Cmdr**	Yeah we've got thirteen minutes to go alright so yeah I'll talk to them in another five minutes or so		
16:54:01.10 **Cmdr**	Least there is somebody behind us		
16:54:02.74 **CP**	Aye (0.6) aye		
16:54:11.85 **Cmdr/CP**	**Cmdr**: Sumburgh is notorious though it can come right down so hopefully we- we need to get in [**CP:** Aye] :laugh:		
16:54:23.45 **Cmdr**	Approaching one to go starting to level		
16:54:34.20 **Cmdr**	Captured that bug can go away then		G-WNSB levels at 2,500 feet amsl
16:54:35.92 **CP**	Roger		
16:54:47.83 **Cmdr**	That's quite a thick layer eh.		
16:54:49.18 **CP**	Aye		
16:54:50.18 **Cmdr**	What's the latest ah (1.0) there's no ATIS on that frequency so never mind		
16:54:55.42 **CP**	Do you want me to dial up the ATIS		
16:54:56.52 **Cmdr**	Uh yeah if you're finished with uh one thirty sixty five		
16:54:59.45 **CP**	Yeah uh		
16:55:01.34 **Cmdr**	One two five eight five I think it should be		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:55:02.72 **CP**	Yeah it's one two five eight five		
16:55:04.42 **CP/Cmdr**	**CP:** Um (1.5) the one under underneath here is apparently if your (0.4) [**Cmdr:** Aye] the rampies[1]		
16:55:10.80 **Cmdr/CP/ Sumburgh ATIS**	**Cmdr:** That's a new thing the last year [**CP:** Yeah] yeah the last since uh January they did that to me and I thought what the guy's outside going like that	[**ATIS:** Dew point plus one four QNH one zero one four runway zero niner]	
16:55:19.55 **Sumburgh ATIS/ Cmdr**	[**Cmdr:** Ah that's alright we'll be fine]	Dry dry dry increased bird activity within the aerodrome boundary Sumburgh Information acknowledge receipt of information x-ray time one six fife zero runway in use zero niner surface wind one fife zero one two knots visibility two thousand eight hundred metres mist few two hundred feet broken three hundred feet temperature plus one fife dew point plus one four QNH one zero one fou-	Sumburgh 1650 hrs ATIS
16:55:58.37 **Cmdr**	Yeah few at two we'll see something at three hundred feet uh that will be fine		Commander refers to becoming visual at 300 feet
16:56:09.43 **CP**	Let's get them to put the runway (1.1) approach lighting on extra bright		

1 Slang referencing aircraft ground handling staff.

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:56:14.32 **Cmdr**	Aye I don't know have they got any a- they must have something on I have never actually zero nine (0.8) uh it's going to be at the front isn't it (1.5) doh doh doh no there's nothing there ***** that's Stornaway that's right it's at the back (0.4) silly me		
16:56:30.50 **Cmdr**	Uh ***** lighting not available		
16:56:33.63 **CP**	Alright so they don't hav-		
16:56:34.38 **Cmdr**	So it's basic lighting that's all we can do here		
16:56:36.30 **CP**	Yeah (0.5) okay		
16:56:50.79 **Cmdr**	We'll just have to use all the eye balls we got to spy these (0.4) lead in lights		
16:56:55.02 **CP**	I'm sure (0.5) between us		
16:56:57.36 **Cmdr**	Aye		
16:57:00.83 **CP**	I'm flying with an A team captain.		
16:57:02.47 **Cmdr/CP**	**Cmdr:** :laughs: [**CP:** :laughs:] that's put the kibosh on it :laughs:		
16:57:07.62 **Cmdr/CP**	**Cmdr:** Aye years ago there was two TRE's doing this (1.2) and neither of them wanted to continue you know it was uh (0.6) down pea soup		
16:57:15.93 **CP**	Yeah		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:57:16.72 **Cmdr**	go-around I think they did it twice and then had to what did they do the second time (1.8) but it was yeah we can get in on a continue call but they didn't want to do that they wanted to do it by the book each being TRE's		
16:57:28.44 **CP**	Right		
16:57:28.89 **Cmdr/CP**	**Cmdr:** But that was a chuckle in the kitchen for a while you know [**CP:** :laugh:] everybody else was landing but your two TRE's couldn't do it		
16:57:36.44 **Cmdr**	Safe pace and all that you know		
16:57:37.97 **CP**	Oh yeah		
16:57:40.65 **CP**	Maybe we'd want there to be a bit of practicality there		
16:57:43.59 **Cmdr**	Aye		
16:57:57.89 **Cmdr**	It's pretty peasee[2] though isn't it		
16:57:59:44 **CP**	Yeah		
16:58:06.14 **CP**	It's all going to be rather interesting		
16:58:25.21 **CP**	Suppose we being in heading we'll be okay to set up wouldn't it		
16:58:28.44 **Cmdr**	Aye we're on a heading two four zero so yeah we can set that up I'll set box two the switches come down uh HSI coming on and inbound we said zero eight five so dial that one up (1.8) zero eight five QDM		
16:58:42.88 **RTI-Sumburgh Radar**		Helibus two three romeo Radar control service	

2 Reference to reduced visibility.

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:58:46.00 **RTO-CP**	Radar co- control service Helibus two three romeo		
16:58:49.98 **CP**	Zero eight five is (0.4) set		
16:58:52.76 **Cmdr**	Yeah we can maybe bimble through eight seven minutes now to overhead so let's go through some of that		
16:58:56.91 **CP**	Approach briefing		
16:58:58.13 **Cmdr**	Yeah I think I've briefed I've got nothing to add to that um (1.0) yeah that's all I've got to say		
16:59:03.02 **CP**	Roger radios and nav aids (0.6) no change uh altimeters and bugs		
16:59:06.94 **Cmdr**	One zero one four uh bugs I'll set three hundred if you hold a thousand initially until we finish the checks		
16:59:13.88 **CP**	Okay and before landing we shall speak to the guys		
16:59:18.11 **Cmdr**	Okay I'll go boxes		
16:59:19.01 **CP**	****** that we're doing an IFR approach and (0.6) uh		
16:59:22.12 **Cmdr**	Aye		
16:59:22.32 **CP**	The weather's pants		
16:59:23.32 **Cmdr**	Yep aye that's fine		
16:59:24.50 **CP**	I'll use different words		
16:59:25.44 **Cmdr**	Okay		
16:59:27.54 **PA**	<passenger announcement double chime>		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
16:59:30.12 **PA/CP**	Hi folks we've got about ten minutes to landing if you can just ensure that your seatbelts are securely fastened and that everyone around you is indeed awake um we are going to be doing an IFR approach the weather isn't uh fantastic at uh Sumburgh (1.0) and um (1.6) once we are on deck if uh on spot (0.7) if you can uh follow the ground crews uh (0.6) instructions (0.5) remain seated with your seatbelts fastened until they give the okay to disembark we'll take a (0.4) a quick suck of fuel and get on our way as uh as soon as we possibly can with as quick a turn around as possible so ca- just wear your your life vests into the facility and if you do wear your ear defenders just please do remember to bring them back (0.7) and we'll speak you to once uh we've done our turnaround okay thank you		
17:00:21.51 **Cmdr**	***** no calls		
17:00:25.86 **CP**	*****		
17:00:29.39 Cmdr	That'll be fine		
17:00:29.92 **CP**	****** anti-icing (0.5) uh plus twenty		
17:00:32.43 **Cmdr**	Yeah amazing		
17:00:33.65 **CP**	Landing briefing		
17:00:35.11 **Cmdr**	Uh yeah you're going to make the landing uh (1.8) runway zero nine and I'll bring the speed right back		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
17:00:33.60 **CP/ Sumburgh Radar/ Cmdr**	**CP:** Yeah be a standard hundred foot thirty five knots ********* [**Sumburgh Radar:** transmission to another aircraft][**Cmdr:** Okay]	radio communications with another aircraft	
17:00:48.95 **CP**	Landing gear (2.5) rad alt bugs		
17:00:52.83 **Cmdr**	You can join now three hundred		
17:00:55.20 **CP**	Uh **** um ****		
17:01:02.98 **Sumburgh Radar**		radio communications with another aircraft	
17:01:10.67 **CP**	What did it say it was three		
17:01:12.46 **Cmdr**	Uh three hundred it should be for this one		
17:01:18.87 **CP**	Three hundred set (1.3) okay fuel		
17:01:22.49 **Cmdr**	Uh yeah eleven hundred so enough for two goes		
17:01:24.97 **CP**	Yeah		
17:01:27.30 **CP**	That takes care of those (1.2) uh radios and nav aids no change NR ILS		
17:01:32.91 **Cmdr/CP**	**Cmdr:** Uh yeah I can do that now then we might as well so watching NR [**CP:** Radar] it drops that's fine		
17:01:36.76 **CP**	Radar to go		
17:01:37.57 **Cmdr**	Uh yeah it's not doing any help is it		
17:01:40.67 **CP/ Sumburgh Radar**	Uh nope :laugh: compasses wer-	radio communications with another aircraft	
17:01:44.60 **Cmdr**	We're two four zero heading		
17:01:48.56 **CP**	Landing gear		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
17:01:49.83 **Cmdr**	Three greens the lever is down (1.2) I cannae move that collective (0.6) that's it now aye		Commander refers to collective lever (third occasion)
17:01:55.19 **CP**	Uh		
17:01:56.68 **Cmdr**	It's the electric lock I think it's not see when I let it go it just pings back so I'll give it a couple of clicks (2.7) ah that'll do		
17:02:05.37 **CP**	That's frustrating isn't it		
17:02:14.24 **Cmdr**	And we can put three five one on as well see if there's we'll test that uh beacon as well aye		
17:02:18.85 To 17:02:31.08	<radio reception noise>		
17:02:20.21 **Cmdr**	It's pointing (2.6) that's at eight miles		
17:02:27.84 **Cmdr**	Bit of noise on it though		
17:02:28.82 **CP**	Yeah		
17:02:34.78 **CP**	So maybe they did fix it		
17:02:36.70 **Cmdr**	Well it said in the book because ^^^^^^^ had written in as a defect and uh (0.4) can't remember what the sentence was but yeah		
17:02:32.81 **CP**	Because a-		
17:02:33.14 **Cmdr**	I don't need two		
17:02:44.51 **CP**	Is (0.4) you can go without it (0.5) unless it's practical (0.7) to have it changed before the next flight		
17:02:50.76 **Cmdr**	Aye aye		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
17:02:51.46 **CP**	Typically that is isn't it		
17:02:52.45 **Cmdr**	Aye I ca- can't remember the wording again but that's right aye a lot of these defects you can carry		
17:02:57.14 **CP**	Yeah		
17:02:57.48 **Cmdr**	Uh but so- a- also some of them if you landed at a maintenance base like Aberdeen (0.5) uh you shouldn't be carrying them but that's up to engineering		
17:03:04.84 **CP**	Yeah		
17:03:05.09 **Cmdr**	But the tech log tells you the B- the A defect is a no go so you never even mention them B defects can be carried so can C and we tend to carry C's for months Just like little things like that decals upside down or a wee crack in that you know minor things but things that need attention		
17:03:21.54 **CP**	And a B defect would be the likes of a pump not working		
17:03:24.22 **Cmdr**	Aye aye aye aye a B defect h- I cannae remember how's it worded (0.5) um (0.7) it's it's only got ten hours it must be sorted within ten hours		
17:03:33.48 **CP**	Something that's pertinent but maybe not critical to flight or something		
17:03:35.73 **Cmdr**	Aye aye		
17:03:37.63 **Cmdr**	And B defects uh that's maybe not true to say (0.5) uh (1.5) the MEL (0.4) n- uh no no I'd b- and I am not going to say that no		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
17:03:47.71 **Cmdr**	****** next time you're in have a look in the tech log there's actually a cover sheet for it B defects what the rules are		
17:03:54.41 **CP**	Yeah I mi- I I I'd like to go down a wee bit early with a captain one day and se- see what you do		
17:03:59.77 **Cmdr**	Aye		
17:04:00.17 **CP**	Yeah		
17:04:00.69 **Cmdr**	Aye ay- sure I'm sure everyone can come down no problem at all		
17:04:14.12 **Cmdr**	Twenty five hundred feet he must be taking us over right over the field		
17:04:17.48 **CP**	On top aye		
17:04:21.28 **CP**	I wondered if he was (1.0) if he had an idea of (0.4) timings for (0.5) you know (0.6) some times they get wee windows the guys seem to be quite good at knowing when those windows are gonna be appearing		
17:04:39.81 **CP**	Done a huge amount of these ****		
17:04:52.72 **Cmdr**	Aye Radar is going to be working us right round to the final part of the approach I think		
17:04:58.52 To 17:05:20.73 **Sumburgh Radar**		radio communications with another aircraft	
17:05:01.67 **Cmdr**	There it looks pretty thick there		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
17:05:34.74 **CP**	All good (1.7) well (1.8) ****** it's looking rather thick (1.4) never been into Scatsta have you been into Scatsta before		CP refers to procedures if a diversion to Scatsta is required
17:05:43.90 **Cmdr**	Aye a while ago it's just basically a strip		
17:05:46.24 **CP**	Aye		
17:05:48.78 **CP**	What would our call be to them uh just call them up eh just say we've had to go-around at Sumburgh		
17:05:54.80 **Cmdr**	Aye (0.6) aye Sumburgh will handle it for you		
17:05:57.36 **CP**	Would they		
17:05:57.69 **Cmdr**	If you tell them that uh (0.4) yeah that second attempt and uh we're going to make an attempt at Scatsta (0.4) but really r- realistically if we went around from this one (1.4) because the weather's on on limits really then the second attempt I think the drill will be we will be landing because you're on a- a localiser		
17:06:17.88 **CP**	Okay		
17:06:18.44 **Cmdr**	So just (0.4) I would be flying it onto the tarmac		
17:06:21.18 **CP**	Uh huh		
17:06:22.50 **Cmdr**	But that's I didn't say that but we're doing it by the book but on the second attempt uh the call would be excuse me "exhale of breath" this will be to land		Commander refers to second approach
17:06:31.97 **CP**	Interestingly enough you know the scenario they give in the L two sim		
17:06:34.91 **Cmdr/CP**	**Cmdr:** Uh which [**CP:** ******] one		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
17:06:36.07 **CP**	There's a new scenario there's a scenario		
17:06:37.65 **Cmdr**	^^^^ been writing ****		
17:06:39.81 **CP**	Aye and one of the scenarios is tight on fuel and what do you do do you brief it do you just		
17:06:44.90 **Cmdr**	Aye aye		
17:06:45.46 **CP**	Continue (0.4) and uh		
17:06:46.70 **Cmdr**	Well the thing is (0.6) you are on a published procedure you know where in space you are as long as you get that rate of descent right (0.5) then and that localisers armed and captured the aircraft will fly right down the centre line		
17:06:59.07 **CP**	Aye		
17:06:59.60 **Cmdr**	It's up to you to make the wheels touch that's how I see it		
17:07:02.73 **CP/ Sumburgh Radar**	I agree I agree	radio communications with another aircraft	
17:07:05.19 **Cmdr/ Sumburgh Radar**	Different if it's an NDB you don't know where the #### you are	radio communications with another aircraft	
17:07:07.42 **CP**	True		
17:07:07.71 **Cmdr/ Sumburgh Radar**	But an ILS uh a localiser approach uh you know where you start in space it's all published etcetera it's all been measured so you just have to make sure you come down that slope	radio communications with another aircraft	

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
17:07:17.36 **RTI-Sumburgh Radar**		Helibus two three romeo descend to altitude two thousand one hundred feet	
17:07:21.64 **RTO-CP**	Descend to two thousand one hundred Helibus two three romeo		
17:07:25.50 **Cmdr/CP**	**Cmdr:** Two thousand one hundred [**CP:** *****] down we [**CP:** Seen] go		G-WNSB starts to descend to 2,100 ft amsl
17:07:29.61 **Cmdr**	And I'll stick airspeed in as well just to control it		Autopilot set to 4-axes
17:07:34.75 **Cmdr**	And I'll tweak that I've got yeah uh almost twenty one this side a wee bit out		
17:07:38.68 **CP**	Twenty one		
17:07:39.24 **Cmdr/ Sumburgh Radar**	One zero one four	radio communications with another aircraft	
17:08:03.08 **Cmdr**	Right before it busts our airspeed is back out now		Autopilot set to 3-axes with V/S mode
17:08:05.05 **CP**	Roger		
17:08:06:58 **CP**	One to go		
17:08:07.71 **Cmdr**	And levelling		
17:08:19.53 **Cmdr**	Captured twenty one hundred feet bug goes away		G-WNSB levels at 2,100 ft amsl
17:08:33.39 **Cmdr**	What is that ten past six local not heard any other traffic which is a wee bit disconcerting		
17:08:38.57 **CP**	Yeah		
17:08:53.36 **Cmdr/CP**	**Cmdr:** Yeah if we go around (0.5) uh we'll ask for another (0.6) Radar vectored back to attempt two (1.3) but [**CP:** ***] uh I think we'll be landing (0.4) if you know what I mean		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
17:09:03.26 **CP**	I'm with you one hundred percent capitaine		
17:09:13.75 **Cmdr/CP**	**Cmdr:** Ahh so they've taken us (0.4) to the north side of the island over (0.6) probably for a left turn I think (1.1) is that right NDB's pointing off to the left so [**CP:** yeah] (0.4) that's what it's saying		
17:09:23.63 **CP**	Yeah		
17:09:44.63 **Cmdr**	It's like a bit of elastic in it it just pings right back		Commander refers to collective lever (fourth occasion)
17:09:46.69 **CP**	I can see that it's just um that's quite frustrating		
17:09:56.51 **Cmdr**	Yeah it's lost (0.9) five percent there look		
17:10:03.08 **CP**	Okay to take that that plate out		
17:10:04.88 **Cmdr/CP**	**Cmdr:** Aye [**CP:** *****] that's right		
17:10:10.67 **CP**	That's the localiser CAT A B and C for runway		
17:10:13.52 **Cmdr**	Is that the one (0.4) zero niner		
17:10:14.92 **CP**	Zero niner		
17:10:21.37 **CP**	You okay with me popping it up here a-****		
17:10:22.76 **Cmdr**	Absolutely yeah that's fine aye		
17:10:26.13 **Cmdr/CP**	**Cmdr:** Aye so if you just call out the uh once we establish (0.7) there is a six point four miles and then all the [**CP:** ****] it will just give me something to target you know every mile		
17:10:34.42 **CP**	Aye absolutely I'm I'll I'll give you that		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
17:11:52.27 **RTI- Sumburgh Radar /Cmdr**		Helibus two three romeo turn left heading [**Cmdr:** Yeah] one three zero degrees close the localiser from the left report established	
17:12:00.59 **RTO-CP**	Turn left one three zero degrees uh close the localiser from the left report established Helibus two three romeo		
17:12:08:43 **Cmdr/CP**	**Cmdr:** Okay that's what I thought she was doing yeah [**CP:** Aye ****] so to the left one three zero		
17:12:23.74 **Cmdr**	And so when we capture etcetera etcetera I shall I'll put the bug for five hundred feet a minute to kick off with		
17:12:29.68 **CP**	Aye sounds a good idea		
17:12:31.25 **Cmdr**	Ten to roll (0.4) rolling out (0.8) and she's cleared us to so I will now that its wings level wait til it levels		
17:12:40.28 **Cmdr**	One three zero (0.5) I'm gonna arm (0.7) the localiser it's armed this side		
17:12:44.96 **CP**	Roger armed this side		
17:12:52.35 **Cmdr**	I'll just take off a little bit of power and bring the speed back		
17:12:55.03 **CP**	Roger		
17:13:06.17 **Cmdr/CP**	**Cmdr:** Will you stick the bleeds in now 'cause I'm not going to use a lot of power [**CP:** *****] so do that now		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
17:13:09.91 **CP**	Okay landing gear can confirm is down bleed valves we've done n- no NR required landing site well it's (0.8) an electronic (0.8) confirmation		
17:13:17.95 **Cmdr**	Roger		
17:13:19.91 **CP**	For a visual at the bottom		
17:13:22.71 **Cmdr**	Yep we may be visual		
17:13:23.94 **RTI-Sumburgh Radar**		Helibus two three romeo make uh a right turn by ten degrees heading one four zero	
17:13:29.48 **RTO-CP/Cmdr**	**CP:** Right turn by ten degrees one four zero Helibus ******* [**Cmdr:** Yeah that's a strong wind she she missed that aye]		
17:13:35.28 **Cmdr**	Okay		
17:13:36.79 **CP**	Sorry		
17:13:37.46 **Cmdr**	Seven miles		
17:13:38.88 **CP**	We're good (0.7) six point four's our		
17:13:43.37 **Cmdr**	The start isn't it so a mile away		
17:13:44.72 **CP**	Localisers alive		
17:13:45.63 **Cmdr**	It is this side captured she's turning		Localiser captured
17:13:48.73 **CP**	Beautiful		
17:13:49.28 To 17:14:18.65 17:14:16.27 **Cmdr**	 **Cmdr:** Right our descent is coming on	radio communications with another aircraft	

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
17:14:20.07	That's ninety eight knots and power coming off		Start of descent at 6.4 DME
17:14:22.50 **CP**	I'll just give her a call to say we've captured		
17:14:24.53 **Cmdr**	Affirm yeah we're inside		
17:14:28.39 **RTO-CP**	And Helibus two three (0.4) romeo that's localiser established		
17:14:33.14 **RTI-Sumburgh Radar**		Helibus two three romeo further descent in accordance with the procedure the Sumburgh QNH one zero one three	G-WNSB at 6 DME and about 1,990 ft amsl
17:14:38.68 **RTO-CP**	Descend with the procedure one zero one three Helibus two three romeo		
17:14:41.06 **Cmdr**	One zero one three then		
17:14:44.74 **RTI-Sumburgh Radar**		Two three romeo contact Sumburgh tower one one eight decimal two five zero	Crew handed to Sumburgh Tower 118.250 MHz
17:14:46.75 **RTO-CP**	Sumburgh (0.6) tower one one eight two five zero Helibus two three romeo		
17:14:51.47	<beep>		
17:14:52.25 **Cmdr**	Aye		
17:14:53.77 **Cmdr**	Coming up to five miles what's the next height we're looking for		G-WNSB at 5.2 nmDME
17:14:55.99 **CP**	Five miles (0.5) sixteen one seventy		
17:14:59.36 **Cmdr**	Sorry say again		
17:15:00.28 **CP**	Five miles is one six seven zero		
17:15:02.08 **Cmdr/CP**	**Cmdr:** One six seven zero okay so I'll just increase then to capture that [**CP:** Okay]		G-WNSB at 5 nm DME

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
17:15:08.20 **RTO-CP**	Sumburgh Tower Helibus two three romeo is with you established localiser zero nine		
17:15:14.03 **RTI-Sumburgh Tower**		Helibus two three romeo Sumburgh Tower good afternoon continue approach for runway zero nine the wind one five zero one four gusting two four QNH one zero one three	
17:15:22.75 **RTO-CP**	One zero one three continue approach Helibus two three romeo		
17:15:26.84 **CP** **RTI-Sumburgh Tower**	**CP:** So four [**RTI-Sumburgh Tower:**] miles is one three five zero	Two three romeo report your range	
17:15:30.03 **Cmdr**	Four miles		
17:15:31.18 **RTO-CP**	We're at four miles Helibus two three romeo		G-WNSB at 4 nm DME
17:15:33.25 **RTI-Sumburgh Tower**		Roge-	
17:15:33.78 **Cmdr**	And say again four miles		
17:15:34.93 **CP**	Was one three five O		
17:15:36.33 **Cmdr**	Okay so that's pretty good so if I back off the rate of descent (0.8) uh we're doing a hundred and thirteen knots groundspeed so just going to take that one off		G-WNSB at 3.8 nm DME and approximately 1,360 ft amsl
17:15:45.22 **CP**	Three miles is one zero three zero		
17:15:48.47 **Cmdr**	One zero three zero at three okay		

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
17:15:52.29 **RTI-Sumburgh Tower**		**** (0.8) Helibus two three romeo runway zero nine cleared to land wind one five zero one four gusting two four	
17:15:59.26 **CP-RTO**	Cleared to land zero nine Helibus two three romeo		
17:16:03.89 **CP**	Three miles you're at a thousand so that's good um two miles you're looking for seven ten		G-WNSB at 3 nm DME
17:16:09.50 **Cmdr**	Okay we're on target for that height		
17:16:10.86 **CP**	Yeah we're looking good		
17:16:11.85 **Sumburgh Tower**		(Radio transmission to ground vehicle at Sumburgh Airport)	
17:16:20.43 **CP**	That's five to go		
17:16:21.95 **Cmdr**	Good call five to go		
17:16:29.12 **CP**	And good at two miles		G-WNSB at 2.4 nm DME and 710 ft amsl
17:16:36.01 **Cmdr/CP**	**Cmdr:** Right that's eighty knots that'll do [**CP:** Yeah] there (1.2) and two miles was good was it		Recorded airspeed is 80 kt
17:16:40.38 **CP**	That's good yeah we were were below it so that's that's good		590 ft amsl
17:16:43.40 **Cmdr**	Okay		
17:16:43.84 **CP**	And one mile is three ninety		2.13 nm DME at 450 ft amsl
17:16:45.62 **Cmdr**	Three ninety at one mile okay (1.3) so I'll just arrest that rate of descent then		
17:16:50.88 **CP**	Yeah		
17:16:52.70 **CP**	Uh 'cause two miles was seven ten so we're looking good		G-WNSB at 2 nm DME and about 460 ft amsl

Appendix D (cont)

TIME / Sound source	Intra-Cockpit Communications/sounds	ATC communications	Comments
17:17:02.09 **CP**	Hundred to go		
17:17:03.41 **Cmdr**	Roger		
17:17:06.15 **RTI-Sumburgh Tower**		Wind check one five zero one three gusting two four out	
17:17:10.31 **AVAD/ Cmdr**	**AVAD:** <four tones (0.3) CHECK HEIGHT > [**Cmdr:** ****]		300 ft RA. Vertical speed approximately 600 fpm; airspeed about 40 kt
Cmdr 17:17:11.73 to 17:17:12.56	Checking the height		291 ft RA
17:17:12.79 **CP**	Just watch your airspeed now		Airspeed is 35 kt
17:17:13.84 **Cmdr**	Oh yeah		
17:17:14.99 to 17:17:16.66 **AVAD**	<four tones (0.3) CHECK HEIGHT >		230 ft RA and airspeed less than 30 kt
17:17:17.55 **Cmdr/CP**	**Cmdr:** Wow what's [**CP:** Wow] going on here wow wow wow oh no oh no no no no		167 ft RA
17:17:21.17 **AVAD**	<ONE HUNDRED FEET>		100 ft RA and vertical speed approximately 1,800 ft/min
17:17:21.85 **Cmdr**	Oh ####		
17:17:22.65 to 17:17:23.13	(sound of impact)		
17:17:23.13	End of Recording		

Appendix E

CVFDR PARAMETER ACQUISITION AND VALIDITY CHECKING

Encoded parametric data is provided to the CVFDR for recording by a Digital Flight Data Acquisition Unit (DFDAU) installed in the electrical rack aft of the co-pilot's seat. Parameters are acquired from the helicopters systems by the DFDAU through a combination of analogue and discrete electrical inputs and ARINC 429[1] digital data bus inputs consisting of the Primary Flight Display (PFD) buses A1 and A2, Automatic Flight Control System (AFCS) buses B1 and B2 and the Digital Engine Control Unit (DECU) buses G1 and G2. The A1 and B1 buses are provided by the co-pilot's instrumentation and A2 and B2 by the commander's.

Parameters acquired from the PFD buses include indicated airspeed, groundspeed, collective pitch position, engine torque, pressure altitude and radio altitude. Under normal operation the DFDAU defaults to acquiring parameters from the PFD A2 and AFCS B2 buses (commander's side) for recording. Every second the DFDAU checks the status of the acquired ARINC 429 data words to determine if they are valid and that each word is being updated. If all of the data words acquired from a bus are detected as invalid or are not updating, the DFDAU automatically switches to acquiring parameters[2] from the alternate (co-pilot's side) data bus. Therefore, if a fault with the PFD A2 bus is detected, the DFDAU automatically switches to the PFD A1 bus and a fault with the AFCS B2 bus results in the DFDAU switching to the AFDS B1 bus. Parameters are recorded once every second onto the CVFDR that identify if bus switching occurred between either the PFD A2 and A1 bus or the AFCS B2 and B1 bus.

The failure of individual data words on a bus will not result in the DFDAU switching to the alternate PFD or AFCS bus and no bus switching is in place for the DECU buses, from which a total of four parameters are recorded. If individual data words on a bus are detected as being invalid or stop updating, the DFDAU will record an alternating data pattern once every four seconds onto the CVFDR in place of the parameter/parameters encoded within the respective data word.

At power up, the DFDAU runs a test of its internal operation through its Built In Test (BIT) function, which includes checking of the ARINC 429 input ports connected to the PFD and AFCS buses. Once the power-up test has been completed, the DFDAU continues to monitor the status of its internal operation and both analogue and ARINC 429 digital

1 ARINC 429 Digital Information Transfer System (DITS) is the technical standard that defines an electrical interface and data transfer protocol for the distribution of information between avionics systems using a 32 bit digital word. The protocol ensures that the integrity of each word can be checked through the use of a parity bit and that the validity of parameter data transmitted within a word can be determined. If the source avionics unit transmitting the word detects an internal fault or that data is missing or inaccurate, the word will be marked accordingly through the use of a Sign Status Matrix (SSM).

2 Seven parameters recorded from the IFDS A2 bus and seven parameters recorded from the IFDS A1 bus are specific to individual crew selections, such as the setting of their IFDS nav sources. These parameters are not switched by the DFDAU as they are not available from the alternate source.

Appendix E (cont)

data inputs for faults once every second. The DFDAU stores internally a history of the most recent 16 faults detected, which are also recorded onto the CVFDR once every 64 seconds.

Appendix F

AFCS FAULT CODES RECOVERED FROM Non-Volatile Memory

FL/NB	EQUIP	FAIL 1	FAIL 2	OCC_TIME	DIS_TIME	NB	source of information	bit number	comment
3042	FDC1 (9)	2h	0Ah	2 h 51 mn 29.40 s	2 h 52 mn 36.00 s	1	param ET1FDC label 271	21	pb temperature FDC
3042	AFCS1 (7)	6h	08h	3 h 47 mn 33.80 s	3 h 47 mn 35.40 s	1	param DISCA label 172	18	dissenblance ILS amber "ILS DISC"on PFD
3042	AFCS1 (7)	6h	08h	3 h 47 mn 38.80 s	3 h 47 mn 39.20 s	2	param DISCA label 172	18	dissenblance ILS amber "ILS DISC"on PFD
3042	AFCS1 (7)	6h	08h	3 h 47 mn 40.40 s	3 h 47 mn 41.20 s	3	param DISCA label 172	18	dissenblance ILS amber "ILS DISC"on PFD
3042	AFCS1 (7)	6h	04h	3 h 56 mn 43.80 s	0 s	1	param DISCA label 172	14	dissenblance FDC "CHECK ATT" in the middle of PFD (on ADI)
3042	AFCS1 (7)	2h	04h	3 h 56 mn 44.00 s	0 s	1	param EPA11 label 216 (proc1/AP1)	14	default of FDC acquisition
3042	AFCS1 (7)	2h	03h	3 h 56 mn 44.00 s	0 s	1	param EPA11 label 216 (proc1/AP1)	13	hands on alarm "CYRP" blinking (AFCS upper mode area)
3042	AFCS1 (7)	3h	04h	3 h 56 mn 44.00 s	0 s	1	param EPA21 label 276 (proc2/AP1)	14	default of FDC acquisition

FL/NB	EQUIP	FAIL 1	FAIL 2	OCC_TIME	DIS_TIME	NB	source of information	bit number	comment
3038	AFCS1 (7)	6h	08h	2 h 51 mn 40.60 s	2 h 51 mn 40.80 s	1	param DISCA label 172	18	dissenblance ILS amber "ILS DISC"on PFD
3038	AFCS1 (7)	6h	08h	2 h 51 mn 42.00 s	2 h 51 mn 42.20 s	2	param DISCA label 172	18	dissenblance ILS amber "ILS DISC"on PFD
3038	AFCS1 (7)	6h	08h	2 h 51 mn 43.40 s	2 h 51 mn 43.80 s	3	param DISCA label 172	18	dissenblance ILS amber "ILS DISC"on PFD
3038	AFCS1 (7)	6h	09h	3 h 1 mn 27.40 s	3 h 1 mn 29.00 s	1	param DISCA label 172	19	dissemblance AFCS amber "AFCS DISC" on PFD
3038	AFCS1 (7)	2h	04h	3 h 1 mn 27.60 s	3 h 1 mn 29.40 s	1	param EPA11 label 216 (proc1/AP1)	14	default of FDC acquisition
3038	AFCS1 (7)	2h	03h	3 h 1 mn 27.60 s	3 h 1 mn 29.40 s	1	param EPA11 label 216 (proc1/AP1)	13	hands on alarm "CYRP" blinking (AFCS upper mode area)
3038	AFCS1 (7)	3h	04h	3 h 1 mn 27.60 s	3 h 1 mn 29.40 s	1	param EPA21 label 276 (proc2/AP1)	14	default of FDC acquisition
3038	AFCS1 (7)	3h	03h	3 h 1 mn 27.60 s	3 h 1 mn 29.40 s	1	param EPA21 label 276 (proc2/AP1)	13	hands on alarm "CYRP" blinking (AFCS upper mode area)
3038	AFCS2 (8)	4h	04h	3 h 1 mn 27.80 s	3 h 1 mn 29.60 s	1	param EPA 12 label 357 (proc1/AP2)	14	default of FDC acquisition
3038	AFCS2 (8)	4h	03h	3 h 1 mn 27.80 s	3 h 1 mn 29.60 s	1	param EPA 12 label 357 (proc1/AP2)	13	hands on alarm "CYRP" blinking (AFCS upper mode area)
3038	AFCS2 (8)	5h	04h	3 h 1 mn 27.80 s	3 h 1 mn 29.60 s	1	param EPA 22 label 171(proc2/AP2)	14	default of FDC acquisition
3038	AFCS2 (8)	5h	03h	3 h 1 mn 27.80 s	3 h 1 mn 29.60 s	1	param EPA 22 label 171(proc2/AP2)	13	hands on alarm "CYRP" blinking (AFCS upper mode area)

FL/NB	EQUIP	FAIL 1	FAIL 2	OCC_TIME	DIS_TIME	NB	source of information	bit number	comment
3027	AFCS1 (7)	2h	04h	1 h 26 mn 45.00 s	1 h 26 mn 45.20 s	1	param EPA11 label 216 (proc1/AP1)	14	default of FDC acquisition
3027	AFCS1 (7)	2h	03h	1 h 26 mn 45.00 s	1 h 26 mn 45.20 s	1	param EPA11 label 216 (proc1/AP1)	13	hands on alarm "CYRP" blinking (AFCS upper mode area)
3027	AFCS1 (7)	3h	04h	1 h 26 mn 45.00 s	1 h 26 mn 45.20 s	1	param EPA21 label 276 (proc2/AP1)	14	default of FDC acquisition
3027	AFCS1 (7)	3h	03h	1 h 26 mn 45.00 s	1 h 26 mn 45.20 s	1	param EPA21 label 276 (proc2/AP1)	13	hands on alarm "CYRP" blinking (AFCS upper mode area)
3027	AFCS2 (8)	5h	04h	1 h 26 mn 45.20 s	1 h 26 mn 45.40 s	1	param EPA 12 label 357 (proc1/AP2)	14	default of FDC acquisition
3027	AFCS2 (8)	5h	03h	1 h 26 mn 45.20 s	1 h 26 mn 45.40 s	1	param EPA 12 label 357 (proc1/AP2)	13	hands on alarm "CYRP" blinking (AFCS upper mode area)
3027	AFCS2 (8)	4h	04h	1 h 26 mn 45.20 s	1 h 26 mn 45.40 s	1	param EPA 22 label 171(proc2/AP2)	14	default of FDC acquisition
3027	AFCS2 (8)	4h	03h	1 h 26 mn 45.20 s	1 h 26 mn 45.40 s	1	param EPA 22 label 171(proc2/AP2)	13	hands on alarm "CYRP" blinking (AFCS upper mode area)
3027	AFCS1 (7)	2h	04h	1 h 26 mn 50.00 s	1 h 26 mn 50.20 s	2	param EPA11 label 216 (proc1/AP1)	14	default of FDC acquisition
3027	AFCS1 (7)	2h	03h	1 h 26 mn 50.00 s	1 h 26 mn 50.20 s	2	param EPA11 label 216 (proc1/AP1)	13	hands on alarm "CYRP" blinking (AFCS upper mode area)
3027	AFCS1 (7)	3h	04h	1 h 26 mn 50.00 s	1 h 26 mn 50.20 s	2	param EPA11 label 216 (proc1/AP1)	14	default of FDC acquisition

Appendix G

SEATING POSITIONS AND SURVIVOR EVIDENCE

The following table provides details of where each passenger was seated, together with a summary of the survivors' recollections of their escape and the exit used, if known.

Identifier	Age	Seat	Exit window used	Comments
Commander		RH	Right door	Suffered a serious back injury on impact. Could not locate his door emergency jettison handle. Opened the door with the normal handle and escaped.
Co-pilot		LH	Left door	Suffered a head injury on impact. Inhaled water and had difficulty locating the emergency door jettison handle. Once found, could not operate it so he used the normal handle, opened the door with his shoulder and escaped.
A	37	1A	L2	Saw the water approaching out of the window and felt the helicopter hit on the left side. Inhaled a large amount of water. When submerged, the passenger saw a window (lighter square) and escaped through it.
B	27	1B	R1	Felt a rocking motion and the helicopter dropping, then it struck the water. The cabin instantly filled with water, but the passenger was able to take a breath. Found a pocket of air at floor level and took a large breath. There was a patch of light to the right (R1 exit) and the passenger escaped through it.
C	24	1D	R1	Felt the helicopter in turbulence. Adopted the brace position and felt the impact with the sea, followed by the helicopter rolling over. Took a breath and removed the window seal as the helicopter rolled over. Tried pushing the window out, but had to use an elbow to forcibly remove it, before unstrapping and escaping.
D	24	2A	L2	Saw the water approaching with the helicopter banking towards the left side. Adopted the brace position. When the helicopter struck the sea, the water came in around the door, but the door remained in place. The door windows and some windows further down the passenger cabin were forced in. Jettisoned the window with difficulty and escaped.

Appendix G (cont)

Identifier	Age	Seat	Exit window used	Comments
E	45	2C		Deceased. Passenger did not escape from the cabin.
F	35	2D	L2	Passenger was so quickly immersed in water after impact that they could not take a breath. Could not locate the rebreather or find the window seal tab. Did not realise the helicopter was upside down. Located a window on the left side (probably L2) and escaped.
G	41	3C	L3 or L4	Heard the pilot give ten-minute-to-landing call. Heard a bang and felt a rocking motion. The helicopter hit the water, rolled inverted and the door windows on the right were blown in. Tried to locate the rebreather, but could not find it. Released harness whilst upside down and escaped through one of the windows that had blown in.
H	57	3D		Deceased. The passenger was found floating on the surface of the sea with their lifejacket inflated.
I	59	4A		Deceased. The passenger escaped from the passenger cabin but subsequently died in the liferaft.
J	28	4C		Tried to take a breath when the helicopter hit the sea, but inhaled water. Released the harness, found an air pocket and took a breath. Passenger then submerged, found an open window and escaped. Could not see under the water and located the window by feel.
K	46	4D		Deceased. The passenger suffered a head injury which probably rendered them unconscious and the passenger did not escape from the cabin.

Appendix G (cont)

Identifier	Age	Seat	Exit window used	Comments
L	32	5A	R5	Became submerged immediately and could not locate the rebreather. Inadvertently inflated the life jacket. Could not locate the window seal tab, although visibility was good underwater. Released the harness and saw a light which was an air pocket, so took a breath. Saw others going out window R5 and followed them, with great difficulty due to the inflated life jacket.
M	44	5C	R5	Passenger was looking to the left when the helicopter hit the water and saw some left side windows blown in. Had no time to take a breath. Unfastened the harness and found a small air pocket. Took a breath, but also inhaled water. It was pitch black, but felt down the seat and found the window with a foot. Pushed themself down, found the opening with a hand and exited.
N	48	5D	R5	Had been asleep and events happened very quickly. Took a breath as the helicopter rolled over. Aware of being upside down and fully immersed in the water, but located and pulled the seal tab on the window and pushed it dead centre. It fell away on the second push. No time to use the rebreather and exited through the window.
O	31	6C	R6	Helicopter was descending and shaking a lot and there was a loud whining sound. Saw the water as the helicopter hit it and water came in everywhere. Released the harness when upside down. Passenger P jumped over this passenger and removed the window seal. The passenger struck the window, but it remained in place until the seal was removed. Followed Passenger P through the window.
P	41	6D	R6	Helicopter pitched nose-up, impacted the sea and rolled over. The passenger removed the window retaining seal with the tab and Passenger O pushed the window out. Passenger then exited through the window.

Appendix H

REPORT ON ACCIDENT TO SUPER PUMA G-WNSB ON 23 AUGUST 2013

by Mr John Chappelow

Introduction

These comments are based on a review of the flight data, the cockpit voice recording, the company training records of the crew, statements to AAIB made by the crew, and police interviews.

The crew attempted a non-precision instrument approach to Runway 09 at Sumburgh. The captain was the PF; the co-pilot was the PNF. Late in the approach, the airspeed reduced below 80kt (the target speed for the approach) and the aircraft started to pitch up at an accelerating rate. The co-pilot called attention to the airspeed. By this time the pitch up was more than 17° and the rate of descent was increasing past 1000ft/min. The captain was unable to recover the situation before the aircraft struck the sea.

The SOP in force at the time of the approach required the PF to fly on instruments to a decision point then to overshoot unless the PNF announced that he had visual references and took control. The PNF was required to monitor the instrument approach, checking height against range in comparison with the profile tabulated in the IAP, and, late in the approach, to seek external visual references in preparation for taking control.

Neither crewmember appears to recall the gradual decay in airspeed below 80kt or the consequent change in pitch attitude. This suggests a period of 20s or more during which the flight instruments were not monitored and ending when the co-pilot noticed the low airspeed. This period of inattention demands explanation. In addition, it is pertinent to ask why the aircraft diverged from a stable flight path. The fact that neither pilot can provide useful recollections of the critical period means that answers to these questions must, in some degree, be speculative.

Discussion

Inattention: The co-pilot had three responsibilities during the approach:

- Monitoring the DME and comparing height with the profile tabulated in the IAP.
- Monitoring the approach by reference to the flight instruments.
- Seeking external visual references in preparation for taking control.

Appendix H (cont)

The approach profile adopted by the captain involved varying both airspeed and vertical speed according to the stage of the approach. This would have somewhat increased the demand on the co-pilot's attention due to the first responsibility at the cost of a marginal impact on the other two. More importantly, the last must increasingly have compromised the second as the approach proceeded. This was unavoidable within the constraints of the SOP, and it is highly likely that, during the critical period, the co-pilot's attention was directed outside so that, when he looked in and noticed the low airspeed, it came as a surprise. Comments he made in interview indicate that he believed the captain expected him to devote significant effort to the search for external visual references at this stage of the approach and, indeed, it was a requirement of the SOP. The safeguard provided by the co-pilot's monitoring of the instrument approach was, necessarily, limited by his other duties.

There appears to be no concrete evidence for any incidental distraction or preoccupation that might explain a lack of attention to the flight instruments on the part of the captain. It is conceivable that his instrument scan was compromised by his seeking external visual references in the later stages of the approach. It is difficult to imagine anything else that would have drawn his attention away from the flight instruments. There is no direct evidence that this did happen apart from a remark in interview by the co-pilot to the effect that he was aware, when he was looking out, of the captain also glancing up.

The captain's expectations and attitude to SOPs are relevant to this possibility. The fact that the weather forecast specified few clouds at 200ft and broken clouds at 300ft could well have led him to expect a reasonable chance of completing the approach and landing from the outset. A firm expectation of acquiring visual references would increase the temptation to look up as the decision point approached. Shortly before the approach, the captain related a story about two type rating examiners who could not achieve a landing in poor weather conditions (by adhering strictly to the SOP) when other pilots were doing so. He elaborated on the idea that it is generally possible to gain visual references and achieve a landing even in very poor weather. I do not believe he made a conscious decision to demonstrate the truth of this assertion come what may, but the comments illustrate a general attitude concerning flexible interpretation of SOP minima and expressing them may have made him more confident about landing than the actual conditions warranted. The captain's record contains no indication of a tendency to recklessness or disregard of risk; there is no evident reason to believe that his behaviour on this occasion was exceptional or untypical of that of his peers.

Divergence from stable flight: The captain stated in interview that his intention was to fly the approach at 80kt. During the approach the airspeed reduced from about 120kt until, at about 2.3nm to go, it reached 80kt. At this point, the captain increased collective pitch slightly, but the airspeed continued to decline. The increase in collective pitch was insufficient to stabilise the airspeed, but this was not immediately noticed by either crewmember.

Appendix H (cont)

Although the aircraft was on the localiser and glideslope throughout the approach, the approach was not fully stabilised, i.e. the changes in power required to maintain the correct flight path were not '*only small*' as required by the SOP. Had the approach been fully stabilised by 1,000ft, the risk attached to a short period of inattention late in the approach would have been markedly less. The combination of inattention and dynamically changing flight parameters allowed the aircraft to enter a state from which safe recovery became progressively less likely.

The company generic SOP for instrument approaches required that they be stabilised by 1,000ft and flown at '*the correct airspeed for the procedure in use*'. Two previous flights into Sumburgh recorded by the FDR of this aircraft indicate the latitude apparently permitted by the SOP. One was flown at around 110kt until late in the approach when airspeed reduced to 80kt. In the other, airspeed was reduced early in the approach to 80kt and then remained stable. The latter was flown coupled in 4 axes, the former partially with 4-axis, partially with 3-axis coupling. Differing weather conditions may have influenced the choices made on these two occasions. At certain airports, notably Aberdeen, it is also routine for helicopters to fly the initial stages of an approach at 120kt or more, reducing to 80kt in the final stages. On this basis, the style of approach flown on 23 August does not immediately appear exceptional. Nevertheless, it embodied a significant risk that could be managed only as long as the captain paid close, uninterrupted attention to the flight instruments and the co-pilot monitored the flight instruments.

Crew attention is a limited and critical resource on instrument approaches. Late stabilisation of the approach increases the demand on this resource in terms of instrument monitoring at a time when the demand due to seeking external visual references is increasing. It is debatable whether the resource is better managed by requiring a handover of control by the decision point or by requiring the PF on instruments to transition to visual flight. However, in both cases, early, full stabilisation of the approach would reduce both risk and peak attentional demand. It would introduce a margin of safety to cater for distractions or lapses in concentration at all stages of the approach. Modification of the SOPs to ensure early, full stabilisation is worthy of consideration.

Conclusions

Two things in combination provided the immediate causes of this accident: a period of inattention to the flight instruments starting 30 to 40 seconds from impact, and the dynamic approach profile.

Given that part of the co-pilot's responsibilities involved seeking external visual references, it was crucial that the captain maintained close attention on the flight instruments as they approached the decision point. It is probable that he did not do so and a firm expectation of being able to gain visual references based on the weather forecast and his previous experience may have influenced his behaviour in this regard.

Appendix H (cont)

Had a stable airspeed and vertical speed been achieved early in the approach, then the lack of close monitoring of the flight parameters in the later stages would have been less risky. Even if the SOP in force was intended to require such a constraint, in practice it appears to have been routinely interpreted with more latitude.

Abbreviations

FDR	Flight data recorder
PF	Pilot flying
PNF	Pilot not flying
SOP	Standard operating procedure
IAP	Instrument approach plate

Appendix I

ROYAL AIR FORCE CENTRE OF AVIATION MEDICINE

AIRCRAFT ACCIDENT HUMAN FACTORS REPORT

AS322 L2 SUPER PUMA, G-WNSB, SUMBURGH, 23 AUGUST 2013

The findings, conclusions and recommendations contained in this report are based on the evidence that was made available to the Accident Investigation and Human Factors Section, Royal Air Force Centre of Aviation Medicine (RAF CAM).

The report has been written prior to the final conclusions of the Air Accident Investigation Branch (AAIB) accident report.

16 October 2014

Appendix I (cont)

Contents

Acronyms and abbreviations

AAIB	Air Accident Investigation Branch
ATC	Air Traffic Control
ALT. A	Altitude Acquire
ARM	Accident Route Matrix
AVAD	Automatic Voice Alerting Device
CVR	Cockpit Voice Recorder
DME	Distance Measuring Equipment
FDM	Flight Data Monitoring
FDR	Flight Data Recorder
FSI	Flying Staff Instruction
HF	Human Factors
HFACS	Human Factors Analysis Classification System
HOMP	Helicopter Operations Monitoring Programme
HOTAS	Hands On Throttle and Stick
IMC	Instrument Meteorological Conditions
kts	Knots
KTP	Key Transition Point
LOC	Localiser
MAA	Military Aviation Authority
MDA	Minimum Decision Altitude
NM	Nautical Miles
OM	Operations Manual
OMA	Operations Manual part A
OMB	Operations Manual part B
PF	Pilot Flying
PFD	Primary Flight Display
PNF	Pilot Not Flying
RAF	Royal Air Force
SOP	Standard Operating Procedure

Appendix I (cont)

Introduction

1. RAF CAM was tasked by the AAIB to investigate the Human Factors (HF) aspects of the Super Puma G-WNSB accident that occurred approximately 1.5 NM west of Sumburgh Airport on 23 August 2013. The RAF CAM investigation has focussed on the actions that took place during the flight, up until the point of impact, and has conducted a high level assessment of the HF issues that were present prior to the day of the incident.

HF investigation approach

2. The RAF CAM HF investigation methodology is summarised in Figure 1[1].

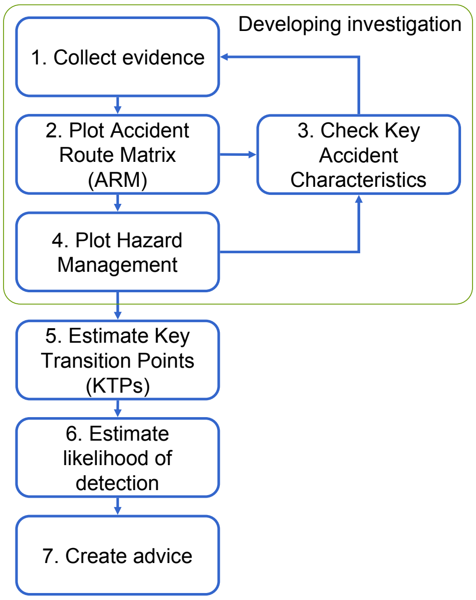


Figure 1: RAF CAM's HF investigation approach

The structure of this report is based on the approach shown in Figure 1: RAF CAM's HF investigation approach, with four sections as follows:

a. **Introduction.** This section of the report introduces the HF investigation approach and provides an overview of the Super Puma G-WNSB accident.

b. **Evidence collection.** This section outlines the evidence that was made available to the HF team that was used in the analysis presented in this report (Item 1 in Figure 1: RAF CAM's HF investigation approach).

1 For a full descrition see: Harris, S. (2011). Human factors investigation methodology. *International Symposium on Aviation Psychology*. Available from: http://www.wright.edu/isap/.

Appendix I (cont)

c. **Accident Route Matrix (ARM) and hazard management.** The majority of the HF analysis is presented in this section which describes the ARM and Key Transition Points (Items 2 and 5 in Figure 1: RAF CAM's HF investigation approach).

d. **Conclusions and recommendations.** The final section of the report summarises the findings of the investigation and presents the recommendations (Item 7 in Figure 1: RAF CAM's HF investigation approach).

Accident overview

3. On 23 August 2013, Super Puma G-WNSB operated by CHC Scotia took off from Aberdeen at 13.44 for a return flight to Alwyn North and Borgsten Dolphin. During the sector to Alwyn North the crew were advised that there would be an additional passenger on the return journey. As a result, it would be necessary to stop for additional fuel. The crew planned the refuel to take place at Sumburgh Airport and continued with the journey completing the segments to Alwyn North and Borgsten Dolphin as planned.

4. The crew took off from Borgsten Dolphin at 16.12 and during this sector from Borgsten Dolphin to Sumburgh the Commander was the Pilot Flying (PF) and the Co-Pilot was the Pilot Not Flying (PNF). Weather reports received during the sector indicated deteriorating weather conditions such that the approach would be on the weather minima (300ft). The crew briefed for a non-precision approach in IMC. The localiser was captured at 17.14 for the approach and the aircraft continued down the vertical descent profile towards Sumburgh, controlled in 3-axes by the autopilot with the PF controlling the power.

5. At approximately 2.6 NM from Sumburgh Airport, the PF stated that he intended to maintain the speed at 80kts which had been achieved at that time but, despite an input on the collective, G-WNSB continued to decelerate and began to adopt a pitch up attitude. Approximately 1.6 NM from Sumburgh Airport, the aircraft reached the Minimum Decision Altitude (MDA) and the crew acknowledged the system warnings and the PNF warned the PF to watch the airspeed. However, at this stage the aircraft was at low speed, in a high rate of descent and with an increasing pitch up attitude. The PF input on the collective and cyclic, but by this stage the aircraft was probably irrecoverable and impacted with the surface of the sea at 17.17.

6. The HF investigation focused on the events that occurred up until the point of impact, and did not look in to escape and survival aspects.

Appendix I (cont)

Evidence collection

7. The HF team was not involved in the initial investigation, but had access to evidence collected by the AAIB. Table 1: AAIB evidence used as part of HF input summarises the AAIB evidence that was used as part of the HF investigation.

Potential evidence		Evidence reliability	
		Lower reliability	Higher reliability
Objective evidence	Cockpit Voice Recorder (CVR)		✓
	Flight Data Recorder (FDR)		✓
	Training records		✓
	Company record of flying hours		✓
	Company FDM data		✓
	Documentation and procedures		✓
	Met Office records		✓
	Duty Card Report		✓
	Approach Plate		✓
Subjective evidence	Aircrew interviews	✓	

Table 1: AAIB evidence used as part of HF input

8. Evidence was restricted to that collected by AAIB, and therefore evidence that is usually collected by the RAF CAM HF team for military air accident investigations (such as HF interviews with the aircrew) were not performed. As a result, there were limitations to the depth and breadth of the HF analysis that could be conducted.

Accident Route Matrix (ARM) and hazard management

9. The evidence that was collected (as described in the previous section) was plotted against the ARM and the hazard management process. The ARM for the G-WNSB accident is presented in Figure 2: Accident Route Matrix (ARM) for Super Puma G-WNSB on 23 Aug 2013. The remainder of this section presents evidence related to the HF considerations identified in the ARM. The section begins by describing the entry conditions on the left of the ARM – that is those factors present before the day of the accident that influenced readiness and hazard management. The section then describes the factors on the right hand side of the ARM – that is the factors that were specific to the day of the incident and the hazard management process itself.

Appendix I (cont)

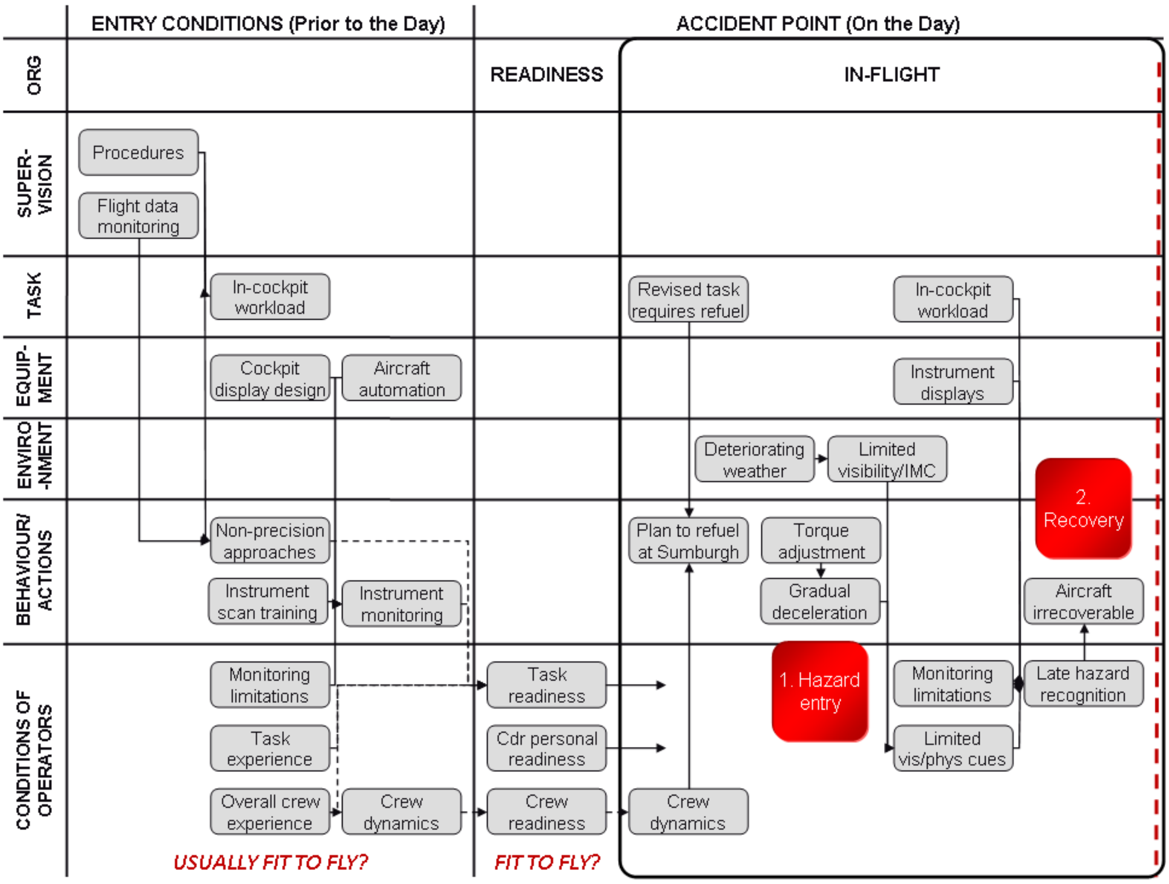


Figure 2: Accident Route Matrix (ARM) for Super Puma G-WNSB on 23 Aug 2013

Entry conditions

10. Introduction. The entry conditions describe HF aspects that were relevant to the G-WNSB accident and were present before the day of the incident. The majority of the entry conditions were not specific to the G-WNSB crew or to the day of the accident, but were common issues that could have influenced any crew. At the end of this section, a summary is provided of the HF risks that were carried as a result of these entry conditions.

11. Procedures. Three characteristics of the procedures were identified that were relevant to the G-WNSB accident.

a. **Subjectivity and ambiguity.** Operations Manual Part B (OMB) Revision frequently used subjective terms, such as 'may', and included multiple options as to how climbs and approaches should be flown, broadening the bounds on acceptable performance. For instance:

Appendix I (cont)

(1) Section 3.9.8.1 (Use of AP coupled modes during instrument approaches) stated that the recommended speed range is 80-120kts and that instrument approaches may be flown in 3-axes or 4-axes.

(2) Section 3.9.3 stated that Altitude Acquire (ALT.A) should be set at MDA +50 feet for non-precision approaches, however this was not clear in other sections of the Operations Manual (OM) where non-precision approaches are discussed.

A lack of clarity in the procedures would be anticipated to result in pilots adopting a number of different approach profiles (paragraph 16).

b. **PNF descent task procedures.** OMA Section 8.4.1.1.2 stated that the PNF is to:

(1) Monitor and support PF with necessary information and assistance to minimise PF workload;

(2) Perform the administrative functions in the cockpit, including use of radios, except that at busy periods PF may operate one radio if required;

(3) Monitor the helicopter's systems;

(4) Call out deviations from planned parameters. If PF does not respond, the call shall be repeated; and

(5) Take control of the helicopter if an unsafe or dangerous situation occurs, and is not controlled by PF.

The listed duties are typical tasks for a PNF, thus OMA Section 8.4.1.1.2 is not an unreasonable procedure. However, the requirement to perform all these tasks concurrently during a demanding situation could place a high workload onto the PNF. High workload can act as a stressor and so reduce capacity for undertaking other tasks, influence decision making, and reduce the ability to gather information[2]. High workload could, therefore, be expected to reduce the frequency of the PNF's scan and/or completeness of each scan. Overall, the PNF's performance could be reduced as a result of their task requirements.

2 Klein, G. (1996). The effect of acute stressors on decision making. In Driskell, J.E. and Salas, E. (Eds). Stress and Human Performance. Lawrence Erlbaum Associates: Mahwah, NJ.

Appendix I (cont)

c. **Approach plate.** The Sumburgh Airport approach plate contained two tables, each depicting height and range from different Distance Measuring Equipment (DME). The two tables appeared similar and were not clearly labelled; this may create further workload for the PNF, to ensure the correct table was being read when calling out deviations from planned parameters.

12. **Flight Data Monitoring (FDM).** The Civil Aviation Authority defines FDM as “the systematic, pro-active use of digital flight data from routine operations to improve aviation safety within an intrinsically non-punitive and just Safety Culture”[3]. FDM was conducted by CHC Scotia, however, during the course of this investigation, the AAIB identified a key limitation with CHC Scotia’s FDM related to the analysis of vertical descent profiles. Aircrew may deviate from the documented vertical descent profile for procedural reasons and so it was difficult to set suitable criteria for the acceptability of vertical descent profile without identifying a very large number of approaches for further investigation. It was recognised by the CAA that FDM systems can trigger a large number of nuisance or false events to be investigated[4]. However, as a result of this difficulty, vertical descent profiles were not tracked or monitored, and so inappropriate approach profiles could go undetected. Failing to detect poor vertical descent profile trends increases the risk that inappropriate vertical descent profile habits may become accepted.

13. **Instrument scan technique.** Pilots must use an effective technique to scan the cockpit instruments to enable them to manage their attentional resources, gather the necessary information from the aircraft systems, and reduce the likelihood that important information would be missed. There were no regulations requiring pilots to conduct instrument scan training, nor were there any training programmes in existence. Therefore, there was scope pilots could develop a poor scan technique over time. Pilots may be unaware of their scan deficiencies if they have successfully detected important changes in instrument readings in the past and any missed information had not resulted in negative consequences. An insufficient scan technique increases the risk of aircrew failing to notice important information resulting in a hazardous situation and/or failure to successfully recover.

14. **Cockpit display design.** The Super Puma Primary Flight Display (PFD) contains key information regarding airspeed, altitude, pitch, and rate of descent. The display design and alerting systems highlight cues to some changes in these parameters, for instance, movements in the artificial horizon, and the audible alert to low altitude, are particularly salient cues. Smaller or less significant changes in these parameters may be indicated solely by changes of the numbers on the display or a small and static trend arrow (if there is a slow and steady wash off of airspeed) and so require a greater level of monitoring and vigilance to detect (paragraph 17).

3 Civil Aviation Authority (2013). CAP 739 Flight Data Monitoring.
4 CAA Paper 2002/02. Final Report on the Helicopter Operations Monitoring Programme (HOMP) Trial.

Appendix I (cont)

15. Aircraft automation. The automation of control functions is common in aviation and has realised benefits such as improved safety, reliability, economy, and comfort[5]. In terms of HF aspects, automation has been cited as reducing workload and fatigue[6]. However, the introduction of automation has changed aspects of the pilot's role and has been implicated in a number of aviation accidents. Some of the most commonly cited HF issues associated with high levels of aircraft automation are: increased complexity, unexpected actions from the automatic system, inadequate feedback, increased monitoring demands, loss of manual flying skills, out-of-the-loop performance issues[7], increased workload during demanding stages of flight, mode errors, and crew co-ordination difficulties [5,8]. Most relevant to the G-WNSB incident is the change in the pilot task to focus on monitoring the information provided by aircraft systems. This change in focus has been linked with a loss of Situation Awareness (SA) and an increased risk that information will not be detected (or detected late) and, if detected, is not understood (or understanding of the issue is delayed[9]). Such difficulties arise as a result of the level of automation (that is the proportion of tasks that are automated or conducted manually), the nature of feedback (paragraph 14), and monitoring limitations of operators (paragraph 17).

16. Non-precision approach profiles. FDR and FDM evidence indicates that there was variation within and between pilots in how they conducted their non-precision approach profiles. Such variation may be beneficial to adapt to the situation in which the approach is flown. However, a lack of a standardised process makes it difficult to undertake FDM of approaches (paragraph 12) and increases the difficulty of the PNF task to "call out deviations from planned parameters" (paragraph 11). Variation in approach profiles could result in a PNF failing to alert a pilot to unacceptable performance, calling a go around, or taking control, as there is no agreed definition of what a correct and normal approach profile is.

17. Monitoring limitations. It is well documented in research that human performance at monitoring tasks is limited. Such limitations reduce the likelihood that a motivated and trained operator will detect and respond to a target of interest. This section provides a summary of key findings related to this area and the implications for a pilot.

---

5 Billings, C.E. (1997). Aviation Automation: The Search for a Human-Centred Approach. Mahwah, NJ: Lawrence Erlbaum Associates.

6 Weiner, E.L. and Curry, R.E. (1980). Flight deck automation: Promises and problems. NASA Technical Memorandum 81206. Moffett Field, CA: NASA-Ames Research Center.

7 Endsley, Bolte, and Jones define these as "a tendency for automation to reduce situation awareness such that human operators have a diminished ability to detect automation failures or problems and to understand the state of the system sufficiently to allow them to take over operations manually when needed. Designing for Situation Awareness (2003), London: Taylor & Francis.

8 Harris, D. (2011). Human Performance on the Flight Deck. Farnham, UK: Ashgate Publishing Limited.

9 Kaber, D.B. and Endsley, M.R. (2003). The effects of level of automation and adaptive automation on human performance, situation awareness, and workload in a dynamic control task. Theoretical Issues in Ergonomic Science, 1-40.

Appendix I (cont)

a. **Attention and distraction.** Attention is a top-down cognitive process that enhances responses to the target that is in the attentional focus and inhibits the response to other items. Thus, when attention is targeted at a particular area, then it is likely to be at the expense of the other areas[10]. Thus, it is impossible for pilots to provide full attention to all areas at the same time. Distraction acts to shift attention from where a person was intending to focus their attention to another point. Distraction can be used by alarms to draw attention to new and critical information, but when distracted by an irrelevant item of information it may mean that important information in the intended focus of attention is missed.

b. **Change blindness.** Changes that occur within an item in the attentional focus are likely to 'pop out' to the viewer. However, if there is a break in the observation of a scene, for instance, due to distraction or due to eye movements, even major changes may not be detected when attention returns to that point of focus[10]. Therefore, when attention shifts from a display to another item and back again, changes that occurred while attention was elsewhere may not be recognised.

c. **Vigilance decrement.** A significant decline in performance has been noted over time when an individual is performing a monitoring task[11], [12]. At least half of the performance loss occurs within the first fifteen minutes, with performance reaching its floor within 20 to 35 minutes[13]. The vigilance decrement (as this performance loss has become known) is greater when the task is prolonged and continuous, targets occur infrequently, the task is very simple or complex, and the target is more difficult to distinguish from the background. Where pilots are monitoring the aircraft systems for an extended period of time, vigilance will be more difficult to maintain and could result in important information being missed.

d. **Expectation.** Where a task is frequently performed, an individual may develop an expectation or mental model of the anticipated visual scene or display readouts. These expectations can influence perception of the scene, by driving how we search for information and interpret the information that we find. As such, expectations increase the likelihood that the scene or display would be perceived as it was expected to be rather than what

10 Gibb, R, Gray, R and Scharff (2010). Aviation Visual Perception. Research, Misperception and Mishaps. Fareham: Ashgate publishing Limited.

11 A monitoring task is defined as one where a person must attend to a situation for an unbroken period of time and detect and respond to changes that occur

12 Mackworth, N.H. (1948). The breakdown of vigilance during prolonged visual search. Quarterly Journal of Experimental Psychology, 1, 6-21.

13 Teichner, W.H. (1974). The detection of a simple signal as a function of time of watch. Human Factors, 16, 339-353.

was actually presented[14]. Such a perception may also be likely to occur when the observed scene is accepted as a match for the intended object, for something that looks like it, something that is in the expected location, or something that does a similar job. When a set of actions is routine, as may be anticipated for an experienced crew, there would be a tendency to perceive the information as being in line with what was expected rather than observe deviations (particularly if those deviations were small).

e. **Individual differences.** A pilot's eyesight can affect the ability to correctly perceive the information being viewed. However, both the Commander's and Co-Pilot's medicals (Commander assessed in May 2013 and Co-Pilot assessed in November 2012) revealed that their eyesight met the required standard[15].

18. Summary. The combination of the before the day factors results in four specific HF issues that increased the risk of the G-WNSB accident. These HF issues were common to all CHC Scotia crews operating the Super Puma aircraft and using Sumburgh Airport.

a. Adoption of approach profiles with a greater scope for error due to a lack of standardisation of approaches (paragraph 16), procedural ambiguity (paragraph 11), and lack of FDM for vertical descent profiles (paragraph 12).

b. Inappropriate approach profiles not being detected in-flight due to the lack of standardisation of approach profiles (paragraph 16) and high PNF workload (paragraph 11).

c. System information being missed or responded to ineffectively due to high reliance on monitoring (paragraph 14 and 15), monitoring limitations (paragraph 17), or an insufficient scan technique (paragraph 13).

d. High workload for the PNF during approach due to procedural requirements (paragraph 11).

Readiness

19. Introduction. Readiness describes HF aspects relevant to the G-WNSB accident that relate to the specific crew involved and occurred on-the-day of the accident but before the flight itself. Readiness factors encompass the tasks undertaken to plan and prepare for the flight, and the attributes of the G-WNSB crew. This section discusses a few HF issues that were identified.

14 Goldstein, E.B. (1999). Sensation and Perception. London: Brooks/Cole publishing Company.
15 The Co-Pilot was to wear corrective lenses and carry a spare pair of glasses.

Appendix I (cont)

20. Overall crew experience. The G-WNSB Aircraft Commander was an experienced Super Puma pilot who had approximately 15 years experience on the L1 Super Puma and 3 years experience (1894 flying hours) on the L2 Super Puma. The Co-Pilot had been a flying instructor on single engine, single pilot aircraft at a different company with approximately 3000 flying hours but was new to Super Puma operations. He had been with the company for only a year, initially training on 225 Super Puma but then retrained onto the L2 Super Puma, qualifying in February 2013. The Co-Pilot had approximately 400 flying hours on the L2 Super Puma. Although the Co-Pilot's overall level of experience was high, his experience on the L2 Super Puma was more limited. Persons with a low level of experience will have had less opportunity to build expertise and, therefore, are less likely to execute tasks 'automatically' and so are likely to require a higher level of attentional focus to achieve the same level of performance as a more experienced person[16]. There was also a considerable experience gradient between the Commander and the Co-Pilot. Although it can be beneficial to team up experienced pilots with those who are less experienced, it is possible that a large experience gap could influence crew dynamics (paragraph 21).

21. Crew dynamics. As a result of the differences in task experience (paragraph 20), there could have been a gradient between the two pilots. Indeed, CVR evidence indicates that this was likely as throughout the flight the Co-Pilot asked the Commander's advice on aspects of flying, and the Commander took on a coaching role. Although, the gradient did not appear to be large, as the Co-Pilot was happy to raise any concerns he had regarding the flight, it was possible that the gradient between the Commander and Co-Pilot was large enough to have affected the Co-Pilot's input during the accident sequence.

22. Non-precision approach experience in IMC. A non-precision approach is conducted every time a crew land onto a rig. However, onshore non-precision approaches (such as into Sumburgh) differ as there is a fixed navigation aid. The Commander had previously conducted 28 approaches in to Sumburgh (between 1 Aug 2012 - 23 Aug 2013), 20 of which he was PF, with the last two being conducted on the 17 May. However, all of these approaches were conducted in conditions where the crew were visual with the airport by 500ft. It was possible the previous successful approaches into Sumburgh could have influenced the Commander's expectation that an approach into Sumburgh was usually successful and that visual references would be gained. The Co-Pilot had conducted one LOC DME 09 approach in Sumburgh on 12 June 2013 as PNF and between the 27 May 13 and 23 Aug 13 the Co-Pilot had conducted 10 instrument approaches. The Co-Pilot therefore had low experience of conducting LOC DME approaches into runway 09 and low experience of instrument approaches. Those with a low level of experience will have had less opportunity to build expertise and, therefore, are less likely to execute tasks 'automatically' and so are likely to require a higher level of attentional focus to achieve the

16 Patrick, J. (2003). Training. In Chi, R., Glaser, M.T.H. and Farr, M.J. (Eds). The Nature of Expertise. Hillsdale, NJ: Lawrence Erlbaum Associates.

Appendix I (cont)

same level of performance as a more experienced person[17]. Evidence from the review of the FDR data shows that conducting an approach to minima was less common so it was possible that both the Commander and Co-Pilot may have a lack of experience or skill fade in performing a non precision approach in IMC.

23. Weather. The meteorological reports for nearby platforms prior to departure showed good visibility with scattered or broken cloud. The lowest cloud base was at around 900ft. Overall, the weather was perceived to be fine when departing Aberdeen.

24. Summary. Before the crew took off for the first leg of the flight, the crew were at risk of the following. These risks arise as a result of the readiness factors described in this section, and are in addition to those relevant to all crews (outlined in paragraph 18).

a. Reduced task readiness for the Co-Pilot due to limited experience on the aircraft and with CHC Scotia, and at flying Non-Precision Approaches/DME (paragraph 20).

b. Reduced crew readiness as a result of a crew gradient between the Commander and Co-Pilot (paragraph 12).

Flight: From Aberdeen to Borgsten Dolphin via North Alwyn

25. Overview. The crew planned to fly from Aberdeen to North Alwyn and return to Aberdeen via Borgsten Dolphin. However, during the sector from Aberdeen to North Alwyn the crew were informed of a change in passenger loads which meant that they would now be carrying 16 passengers back to Aberdeen instead of 15. This change necessitated a change to the flight plan to ensure adequate fuel for the journey with the increased aircraft load. The crew elected to re-fuel at Sumburgh, after visiting Borgsten Dolphin.

26. Standard Operating Procedure (SOP) calls. It was noted that throughout the flight the crew were using non-standard terminology for their SOP communications. There were scripted communications in the SOPs (OMB 3.9.4.4 – Normal calls during an approach) which pilots should use to reduce the likelihood of miscommunication and to assist the PNF task to "monitor and support PF", "call out deviations from planned parameters" and identify "if an unsafe or dangerous situation occurs, and is not controlled by the PF" (paragraph 11). However, by using non-standard or abbreviated communications, this mitigation is not in place and so the scope is increased for miscommunication as is the risk of not recognising a hazardous situation (paragraph 37). Further, there was no challenge made to the non-standard terminology used. This may highlight a norm within the organisation that it is not uncommon for crews to deviate from the scripted communication requirements, or may reflect the crew dynamics (paragraph 21) or another factor.

17 Patrick, J. (2003). Training. In Chi, R., Glaser, M.T.H. and Farr, M.J. (Eds). The Nature of Expertise. Hillsdale, NJ: Lawrence Erlbaum Associates.

Appendix I (cont)

Sector: From Borgsten Dolphin until the localiser was captured for Sumburgh Airport

27. Overview. The crew took off from Borgsten Dolphin at 16.12 and, during the sector to Sumburgh Airport, received a number of weather reports which indicated that the weather conditions at Sumburgh were deteriorating (paragraph 28). Autopilot was used in the 3-axes mode[18] throughout the sector. Just prior to the localiser capture, the Commander engaged the 4-axes[19] mode on the auto pilot briefly to control the airspeed during the early stages of the descent before returning to 3-axes mode. FDR evidence indicates that the Commander was aware of which autopilot mode he was in as he was actively using the collective.

28. Weather information. At 16.26 (51 minutes before impact), the crew receive an Air Traffic Control (ATC) weather report stating there was broken cloud at 500ft at Sumburgh and scattered cloud at 300ft. The Co-Pilot stated that the weather was on minima. The Commander then suggested a suitable method of achieving the landing given the weather (using a non-precision approach) to which the Co-Pilot agreed (precision landing facilities were not available at Sumburgh). Although the crew discussed diverting to Scatsta, a weather report for Scatsta was not obtained and alternative airports were not considered. At 16.48 and 16.55, the crew received two further weather reports stating that the visibility had reduced from 4000m in haze to 2800m in mist, and that cloud was now broken at 300ft.

29. In-flight planning. During the sector from Bogstein Dolphin to Sumburgh, planning was undertaken for the landing. Although the weather information was acknowledged (as described in paragraph 28), the deteriorating conditions did not result in any changes to the plan to land at Sumburgh. It was likely that the plan to land at Sumburgh was not changed for the following reasons:

a. OMA Section 8.1.3.7.1 (Destination minima IFR) stated that for a non-precision approach, the cloud ceiling can be at or above approach MDA, therefore the weather remained within limits to land at Sumburgh.

b. The Commander briefed that there was adequate fuel for two attempts at Sumburgh before it would be necessary to divert (see also paragraph 30).

c. The Commander appeared to be confident that a landing a Sumburgh could be achieved in the reported weather conditions. For instance, after the 16.55 weather report the Commander stated "Yeah, few at two, we'll see something at three hundred feet, eh, that will be fine" indicating that he believed that the crew to become visual with Sumburgh Airport in the

18 3 axes mode enables manual control of airspeed.
19 4 axes mode automatically controls the airspeed.

weather conditions reported. The Commander's confidence may have been influenced by his expectation that the approach was likely to be successful (paragraph 21) and the good weather forecast earlier in the day (paragraph 23).

d. The changes to the weather conditions were received in a gradual manner. When information changes in small increments, there is an increased risk that the overall impact will not be identified and so the plan may be less likely to be changed.

30. Crew dynamics. During the planning for landing at Sumburgh, the Co-Pilot highlighted that the weather would be on minima and asked the Commander what calls would be required if diverting to Scatsta. These comments did provide suggestions of the weather risks associated with the plan to land at Sumburgh, but did not question the decision to land at Sumburgh. Indeed, CVR evidence indicated that the Co-Pilot listened to the Commander's response to these points and agreed with the plan as briefed by the Commander. There are many factors that could have contributed to these comments and responses by the Co-Pilot. However, given the experience gradient between the Commander and Co-Pilot and the crew dynamics noted during the flight (paragraph 11), it is not possible to rule out crew dynamics as a contributory factor to the manner in which potential reservations were raised.

Hazard entry

31. Overview. The localiser was captured at 17.14 (3 minutes before impact), approximately 7 NM from Sumburgh Airport for a non-precision approach. Figure 3: FDR trace shows details of the FDR trace for the final 2 minutes and 40 seconds of the flight. The descent commenced at 6.4 NM and at 5 NM the Co-Pilot began to report the heights that were required to achieve the vertical descent profile. The Commander commented on his airspeed on several occasions until the aircraft reached 80 kts, 46 seconds prior to impact and approximately 2.3 NM from Sumburgh. The reference to 80 kts was the Commander's last reference to airspeed during the flight. FDR, CVR and witness testimony indicated the engine Torque was raised from 18% to 24% to maintain airspeed. However, the airspeed continued to gradually decrease from this point accompanied by a progressive nose-up pitch until 9 seconds prior to impact. Between approximately 20 seconds to 10 seconds prior to impact, the Rate of Descent (ROD) increased from 500 ft per minute to 1000 ft per minute. However, hazard detection did not take place until between 12 and 10 seconds prior to impact (at approximately 17.17).

Appendix I (cont)

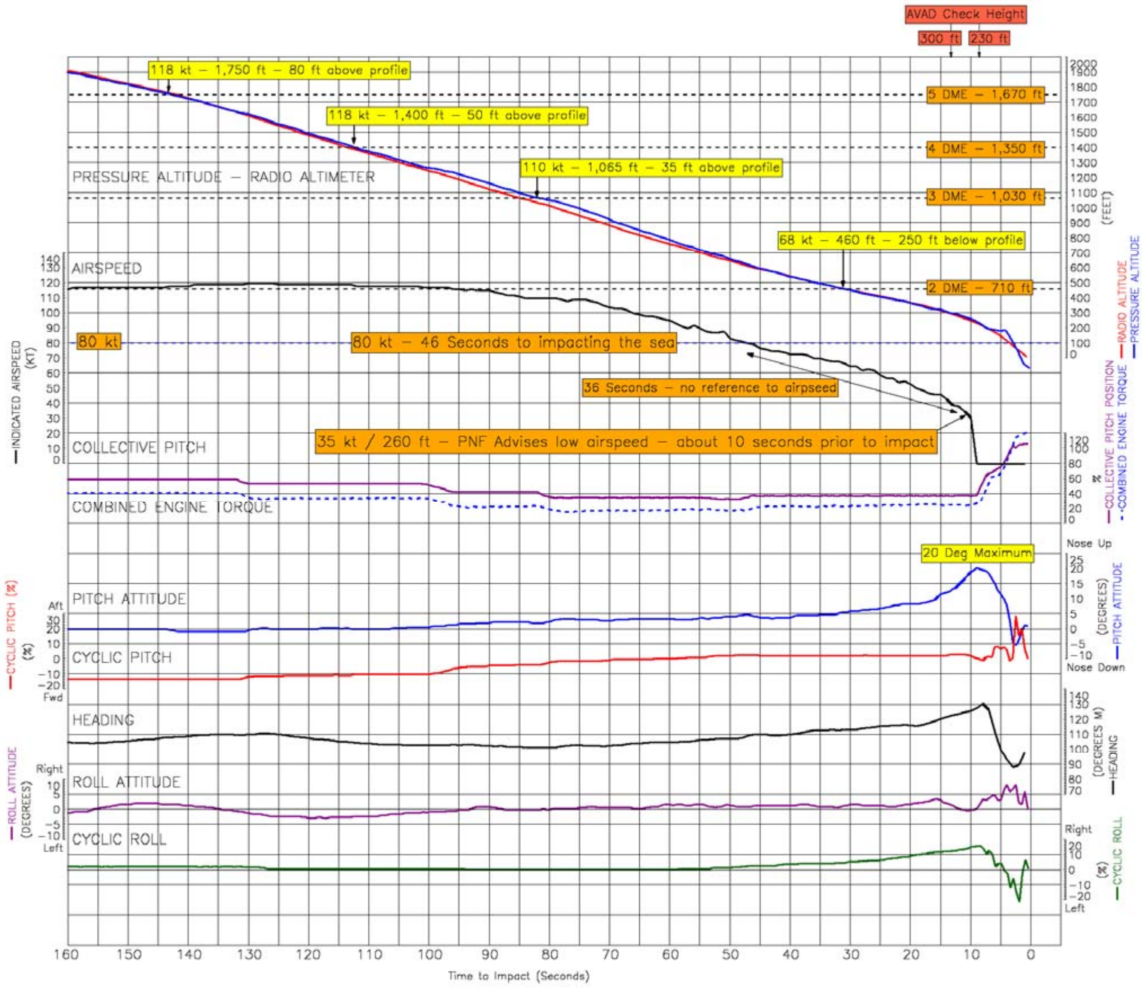


Figure 3: FDR trace

32. Torque adjustment. At approximately 46 seconds prior to impact the Commander adjusted the torque to attempt to maintain the airspeed of 80 kts. However, this input was not sufficient and the airspeed continued to decrease. Torque adjustment is a skill-based task, which would have been routine and automatic for the Commander due to his experience levels. In any skill-based task, however, there remains a possibility of error. It is understood that there was only a small difference between the required collective movement (to maintain airspeed at 80 kts) and the actual collective movement made by the Commander. Where minor adjustments are required the margin for error is reduced and so the risk of error is increased (compared to tasks that have a larger margin for error). Given the scope for error that exists in skill-based tasks that involve minor adjustments, it is important to consider workload and point of focus during the time following the torque adjustment and what cues were available to the crew to check that the torque adjustment had been effective.

Appendix I (cont)

33. Crew workload. There was limited evidence regarding the tasks undertaken by the crew in the period immediately leading up to the accident, thus, inference of the level of workload that the crew were experiencing is challenging. However, studies have shown the landing phase of flight to have high workload demands[20] and that persons with a lower level of experience may be subject to higher workload demands[16]. It was, therefore, possible that the Commander or Co-Pilot were experiencing a high level of workload, but that workload may have been increased for the Co-Pilot in particular due to his limited experience on type and the number of concurrent tasks he was conducting (paragraph 11). Workload may have negatively affected the crew's capacity to detect cues to hazard entry.

34. Point of focus. There was limited evidence to identify a complete picture of what the crew were focusing on during this stage of the flight. The points of focus described below are those which can be inferred directly from the evidence.

a. Co-Pilot. From approximately 5 NM the Co-Pilot communicated the next required height for the vertical descent profile and made comments to the Commander that the aircraft was on target from 30 seconds to 20 seconds before impact. The Co-Pilot's task was also to look out to identify Sumburgh Airport so he could take control of the aircraft for the landing. Therefore, the Co-Pilot was likely to have been shifting his attention between reading the approach plate, the DME on the instrument display and looking outside the cockpit.

b. Commander. According to OMA Section 8.4.1.1.1, the PF is to handle and control the helicopter either manually or by monitoring and adjusting the autopilot to remain within the planned parameters and to respond correctly to communication calls from the PNF. The Commander reported that he was flying the aircraft solely on instruments as required by procedure and making various inputs during the descent. CVR evidence indicates that the Commander was verbalising the aircraft's airspeed until the aircraft reached 80 kts indicating he was focusing on airspeed up until this time. After reaching 80 kts, the Commander acknowledged the Co-Pilot's statement that the next target height (1 NM from Sumburgh) was 390 ft and reduced the ROD from 700 ft per minute to 500 ft per minute (approximately 32 seconds to impact). Therefore, it was likely that the Commander was monitoring the ROD at this stage and conducting actions in relation to the autopilot control of the vertical descent profile. Based on the limited communications on the CVR it is difficult to infer the Commander's point of focus was after the change in ROD until the AVAD alert, 12 seconds before impact (paragraph 38).

20 For instance, Hankins, T.C and Wilson, G.F. (1998). A comparison of heart rate, eye activity, EEG and subjective measures of pilot mental workload during flight. Aviation, Space, and Environmental Medicine, 69, 360-367; Hart, S.G. and Hauser, J.R. (1987). Inflight application of three pilot workload measurement techniques. Aviation Space and Environmental Medicine, 58, 402-410.

Appendix I (cont)

c. **Radio transmissions.** At approximately 17 seconds prior to impact an ATC weather report can be heard on the CVR. Neither crew member was communicating at this point, so it is possible that both crew's attention was focussed on the weather information.

In the final phase, it is not possible to definitely detail what the crew were attending to, therefore, the HF analysis examined what cues were or were not available to the crew to alert them of the deteriorating situation, which are outlined in the following paragraphs.

35. **Visual and physiological cues to hazard entry.** During the vertical descent profile between 45 and 10 seconds prior to impact there were limited physiological and visual cues to enable the crew to judge the aircraft position and flight profile.

a. **Visual.** The crew were flying in IMC and so there were few external visual cues to indicate speed and aircraft orientation. However, the Co-Pilot did appear to be accurately stating the aircraft height.

b. **Physiological.** There were minimal physiological cues for the crew to detect the changes in airspeed and pitch owing to the following factors:

(1) **Acceleration/deceleration.** The amount of fore/aft (Gx) acceleration that is necessary for a pilot to detect motion equates to approximately 0.01 G of acceleration or deceleration[21]. Figure 4: Gx acceleration for G-WNSB4 shows the change in acceleration for G-WNSB from 45 seconds to 13 seconds prior to impact. It can be seen that the change in acceleration is mostly below the 0.01 G threshold, occasionally entering (slightly) into the detectable range. However, the aircraft was in turbulence and this could have masked the slight changes in acceleration as well as potentially masking other physiological cues to airspeed and orientation.

(2) **Rate of rotation.** When a pilot is directly concerned in flying the aircraft, a rate of rotation of 3° per second for 0.2 seconds or longer about any axis is required in order for it to be detected, or if the pilot is attending to another task, 5° per second for 0.25 seconds or longer[22]. From 45 seconds to 10 seconds prior to impact the rate of change ranged from approximately 0.3° per second to 1.7° per second. Therefore, it is unlikely that the change of pitch would have been detected.

21 Lee, A. (2005). *Flight Simulation: Virtual Environments in Aviation.* Farnham, UK: Ashgate publishing. Cited in Gibb, R, Gray, R & Scharff, L. (2010). *Aviation Visual Perception.* Farnham, UK: Ashgate publishing.

22 DEF STAN 00-970, Part 1/12 Section 4, Leaflet 36: Flight Control Systems, Failures in Flight Control Systems.

Appendix I (cont)

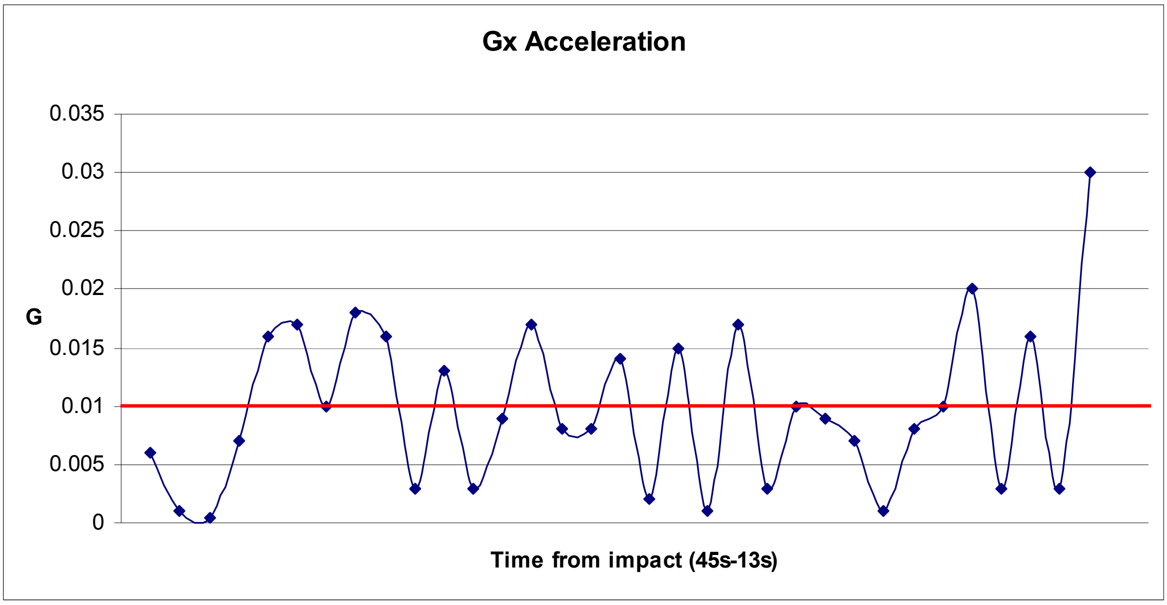


Figure 4: Gx acceleration for G-WNSB

c. **Somatogravic illusion.** In the absence of external visual cues, the brain is more prone to misperceptions. When an aircraft decelerates it will give a false-sensation of pitch down and so if accompanied with an actual nose-up attitude may cause the aircraft to feel level[23]. As the aircraft gradually decelerated, the pitch-up attitude of G-WNSB gradually increased. Therefore, the associated counteracting forces may have led the crew to perceive that the aircraft was straight and level with no decrease in airspeed, when in fact it was nose-up and losing airspeed.

In summary, there were few visual or physiological cues to the loss of airspeed and pitch up attitude that was taking place between 45 seconds and 10 seconds prior to impact. In addition, the combination of deceleration and pitch could have contributed to a somatogravic illusion which led the crew to perceive that they were flying straight and level and at a constant speed. As a result, the visual and physiological information provided very limited cues to the initial hazard entry and this may have contributed to the crew failing to recognise the hazard.

36. Instrument display. Where there are few or contradictory visual and physiological cues to the aircraft position, crew must rely on the information presented on the instruments. Analysis of a flight test[24] showed that during the accident sequence the speed trend arrow

23 Benson, A.J., & Rollin Stott, J.R. (2006). Spatial disorientation in flight. In: Rainford, D.J. & Gradwell, D.P. (Eds). *Ernsting's Aviation Medicine*. (4th Ed, pp433-458). London, Hodder Arnold.

24 Video footage of a CHC flight which mimicked the flight profile of G-WNSB was collected by AAIB; the test crew set similar power levels to the G-WNSB crew and allowed the Super Puma to decelerate to less than 30kts.

Appendix I (cont)

was likely to have remained fairly constant until the final few seconds before impact. Smaller or less significant changes in the speed trend arrow would require a greater level of monitoring and vigilance to detect (paragraph 14), increasing the likelihood the crew would not detect a loss in airspeed.

37. Monitoring limitations. The ability of the crew to detect the changes on the instruments would be limited as a result of the factors identified in the entry conditions (paragraph 17), this section of the report highlights the extent to which each of these factors were likely to have influenced the G-WNSB crew during the vertical descent profile.

a. **Attention.** The analysis of crew tasks does not provide evidence that either crew member's attention was focussed on the airspeed or aircraft pitch (paragraph 32). The Commander was also observed by the Co-Pilot to glance outside the cockpit. If the airspeed and aircraft pitch was outside the Commander and Co-Pilot's attentional focus it is unlikely that a change in these items would be detected.

b. **Distraction.** It was possible that the crew were focusing on the airspeed and pitch but had their attention drawn away by a distracter. The Commander could have been distracted by the Co-Pilot announcing height information, and both crew members may have been distracted by other factors such as the ATC weather announcement (it was noted that there were multiple ATC weather announcements in the final two minutes of the flight). If attention had been drawn away from the intended displays the likelihood of a change in these items being detected is reduced.

c. **Change blindness.** There were indications that the Co-Pilot and Commander were breaking their visual scans – the Co-Pilot reported that he saw the Commander glance up and the Co-Pilot's tasks required him to shift attention between different points of focus (paragraph). Therefore, a change on the displays may have been missed as a result of the breaks in visual scan causing change blindness.

d. **Vigilance.** It was possible that the crew's vigilance performance had deteriorated during the sector from Borgsten Dolphin to 2.3 NM from Sumburgh, increasing the risk that an item that is attended to may have been missed. 23 minutes prior to impact the crew comment on seeing a thick layer of cloud. It was therefore likely that the crew entered IMC shortly after this, allowing a sufficient amount of time for vigilance performance to deteriorate.

Appendix I (cont)

e. **Expectation.** The crew may have provided adequate attention to the airspeed and attitude displays, but perceived the display to show what they expected to see, rather than what was actually presented. The crew perceived that the vertical descent profile was proceeding effectively, this perception may have arisen as a result of:

(1) Co-Pilot's reassurance that the vertical descent profile was looking good may have influenced the Commander's mental model that this descent was being monitored and proceeding as expected.

(2) When the Co-Pilot called "100 to go" (the call required when 100 ft to MDA) no distance information was provided (the aircraft was 1.5 NM from Sumburgh). Therefore, there was no indication that they were below the vertical descent profile, which required the aircraft to be at 390ft (90ft above MDA) at 1 NM. This may have also influenced the Commander's perception that they were closer than they actually were to Sumburgh and may have started glancing out to try and see the airfield.

(3) The calls made by the crew during the descent did not match the SOP requirements; some were missed and some did not use the correct phraseology. This was in line with crew communications earlier in the flight (paragraph 26). There was a 'Two Communication' rule outlined in OMA 8.3.14 which stated that the onset of incapacitation should be suspected when a pilot does not respond appropriately to a second verbal communication associated with a significant deviation from a standard operating procedure or flight profile. The 'Two Communication' rule was not applied and thus the incorrect calls made by the crew were not challenged; therefore, there may have been reduced opportunity to detect deviations from the intended vertical descent profile.

(4) Crew confidence that the landing could be achieved (paragraph 29).

(5) A variety of vertical descent profile profiles were used, and so it was more difficult to detect where the profile deviates from what is a suitable profile (paragraph 18).

Taken together, these monitoring limitations identify a number of perceptual and cognitive factors that may have reduced the likelihood of detection of the gradual loss of airspeed and change in aircraft pitch during this part of the vertical descent profile. There was very

Appendix I (cont)

limited evidence (as outlined above) to indicate which, if any, of these aspects occurred in flight. However, these issues do present a challenge to individual performance and the likelihood of these issues occurring may be increased as a result of crew workload (particularly for the Co-Pilot, paragraph 11 and 33), or an insufficient scan technique (paragraph 13).

38. First AVAD alert. At approximately twelve seconds before impact and at a height of 300ft, the crew were alerted by the Automatic Voice Alarm Device (AVAD) stating "CHECK HEIGHT". The Commander acknowledged the AVAD alert by stating "Checking the height". It was, therefore, possible the Commander's attention was then directed to the altimeter. 300ft is a MDA, where it would be anticipated that vertical descent profile would be levelled off. However, there was no evidence of G-WNSB slowing down or levelling, up to or after the 300ft MDA. There are many reasons why this may have occurred, however there was no evidence to indicate why this may have happened in this instance.

Hazard recognition

39. Airspeed warning. Upon hearing, "CHECK HEIGHT", the Co-Pilot reported feeling the aircraft sink and the nose to pitch up. He then looked at the airspeed indicator on the PFD and upon observing the large downwards airspeed trend vector, warned the Commander to watch his airspeed (17.17.14 - 9 seconds prior to impact).

40. Full hazard recognition. Upon being warned to check airspeed, the Commander saw 40 kts on PFD, raised the collective slightly and then the crew became visual with the sea. It was at this point the crew gained full hazard recognition. The ROD had now increased from 1000ft per minute to 2000ft per minute and the airspeed was dropping to less than 30kts.

Recovery

41. Recovery. Upon becoming visual with the sea, the Commander pulled fully up on the collective and pushed the cyclic forward to gain airspeed, whilst the Co-Pilot armed the floats. The AAIB have advised that at this time the aircraft was probably irrecoverable owing to a lack of airspeed, height and high ROD, and the aircraft impacted with the sea at 17.17.23.

Appendix I (cont)

Conclusions and recommendations

42. Summary. This report has presented the results of an HF analysis of the Super Puma G-WNSB accident at Sumburgh on 23 August 2013. This section summarises the conclusions and provides suggested recommendations arising from the HF analysis presented in this report. These suggested recommendations are made to the AAIB for consideration for inclusion in the AAIB Report.

43. The Operations Manual Part B frequently used subjective terms which could result in a lack of clarity and pilots adopting a number of different approach profiles. It is therefore recommended that the Operations Manual is reviewed to reduce the ambiguity in terms used where possible.

44. A PNF may experience high workload during a descent owing to the large number of PNF task requirements detailed in OMA Section 8.4.1.1.2. It is recommended that the nature of the PNF descent tasks be reviewed and mitigations implemented to manage high workload situations.

45. The Sumburgh approach plate DME tables could increase workload for the PNF due to their similar appearance and lack of clear labelling. It is recommended that the layout and labelling of the tables in the approach plate are improved to ensure clear differentiation between the tables.

46. The AAIB found that it was difficult to set suitable criteria for the acceptability of vertical descent profiles for FDM and so vertical descent profile habits may go undetected and/or become accepted. The Civil Aviation Authority HOMP trial identified the potential for this issue and recommended that FDM is refined to minimise the nuisance event rate and optimise the detection of operational risks so that maximum safety benefits can be gained.

47. It was possible that pilots had developed poor instrument scan techniques, increasing the risk of aircrew failing to notice important information on the aircraft displays. It is recommended that the content and frequency of training provided to aircrew in relation to instrument scan is reviewed and enhanced if required.

48. Small or less significant changes in parameters on the PFD require greater level of monitoring and vigilance to detect. It is recommended that research is conducted to gain greater understanding of the extent to which information is missed from PFDs. Any issues identified through this process should be addressed.

49. The crew were using non-standard terminology for their SOP communications which increases the likelihood of miscommunication. It is recommended that the norms

Appendix I (cont)

associated with SOP calls are identified to determine the extent of the risk and actions put in place to address.

50. There was limited consideration of alternative landing options as a result of the deteriorating weather conditions. It is recommended that the suitability of current procedures and training for in-flight re-planning (due to weather conditions) be reviewed and updated as required.

51. The crew did not level off the aircraft at or above the 300ft MDA, even upon hearing the first AVAD alert. It is therefore recommended that aircrew interpretation and use of AVAD alerts and actions before and after a MDA are reviewed and mitigations be put in place to address any limitations identified.

Appendix J

SUMBURGH AIR TRAFFIC SERVICES ASSISTANT (ATSA) POSITION TRANSCRIPT

(Friday 23rd August 2013 17:23:30 hrs to 17:28:46 hrs UTC)

Date	Time	Station	Event
23/08	17:23:30	ATSA	Call to Inverness Police Control Room:
		Police	Police Scotland how can I help?
		ATSA	Hello this is Sumburgh Airport.
		Police	Oh hello there have you got an emergency?
		ATSA	Yes aircraft accident.
		Police	Oh right okay just bare with me a moment please. Its aircraft accident, is this actually at the terminal?
		ATSA	No it's at sea.
	17:23:57	Police	At sea, okay just bare with me a second sorry to keep you.
		ATSA	Okay
		Police	I'll just get the basic details on and then you know people can start doing things while I'm on the phone to you okay. I'm sorry to keep you.
		ATSA	That's okay.
	17:24:33	Police	Sorry I was just telling my sergeant so he can put it on there so it's an aircraft accident at sea. What aircraft is it?
		ATSA	It's a helicopter.
		Police	Okay, em.
		ATSA	I don't have any persons onboard at this time.
		Police	There's nobody in.
		ATSA	We don't know how many persons onboard at this time but I can find that out and let you know.
		Police	Yes if you will please.
		ATSA	Okay
	17:25:00	Police	Okay sorry to keep you.
		Police	Okay where abouts is it?
		ATSA	Eh he was about 4 miles out on approach to Sumburgh. So he was just about 4 miles for runway 09, he was coming in for runway 09.
		Police	So he was heading South?
		ATSA	He was approaching runway 09 at Sumburgh Airport.
		Police	Yeh.
		ATSA	And he was 4 miles out the last we knew of him.
		Police	Okay alright.

Appendix J (cont)

		ATSA	Okay.
		Police	Yes. Any other details at all?
		ATSA	No, that's all the details I have.
		Police	That's all you've got okay em who is the helicopter owned by, which company?
		ATSA	It's eh Helibus, it's Scotia CHC.
		Police	CHC Scotia?
		ATSA	Yes. So do you call out the Coastguard now then?
		Police	We'll do all of that yeh. Have have you advised anybody, the ARCC, anybody at all? Coastguard, hospital anything?
		ATSA	No eh you do all that as far as I know. I just call you, your my first point of contact and then I go down my list from here. I don't have the Coastguard or.....
	17:26:22	Police	No it's alright it's just so we know. Okay then. Alright. As far as you know it was approximately 4 miles out but you've no definite, you've no definite location.
		ATSA	So was on an approach for runway 09.
		Police	Okay so would you have any co-ordinates for it at all?
		ATSA	No not at this time, I have no co-ordinates for it at this time.
		Police	Okay
		Police	Okay sorry I'm just double checking if there's anything else I need to say. Okay, was the mayday message sent?
	17:26:54	ATSA	No, no, no he was just eh...they lost contact with him.
		Police	Okay did you lose radar contact as well?
		ATSA	We're just Sumburgh Tower, but eh we don't have a radar here in the Tower.
		Police	Okay.
		ATSA	Eh
		Police	Okay so how do you actually know that they that they the aircraft has gone down?
		ATSA	Because he's not contacting us. We've been calling him and em and Sumburgh radar, I don't think they can see him on their radar. He was they were working him previously before us.
		Police	Alright. Have you got a flight identification

			number for this em this helicopter?
	17:27:41	ATSA	Eh what do you mean flight identification number? Is that a squawk?
		Police	I don't know what you mean by that, sorry. Is there, is there any reference for the aircraft at all?
		ATSA	Eh, no I'm sorry that's all the details I have at the moment. So , eh you will, you will alert the Coastguard?
		Police	Oh, yeh, yeh that's all being done now. That's is being done now, I'm just double checking to make sure everything the sergeant wants to know. But we'll be doing that okay em right so you'll let us know how many people are onboard and any other details if you get them at all?
		ATSA	Yes I'll do that I'll phone you back.
		Police	Okay that's lovely. Sorry what's your name please?
	17:28:17	ATSA	Eh it's the assistant, the Tower assistant.
		Police	Yeh, what's your name?
		ATSA	It's [redacted]
		Police	I'm sorry?
		ATSA	[redacted]
		Police	[redacted] Okay and what will the best telephone number to contact you on?
		ATSA	This [redacted]
		Police	Yeh.
		ATSA	461.
		Police	Yeh.
		ATSA	008.
		Police	Okay alright no problem and we can contact you on that number.
		ATSA	Okay.
		Police	Yep, okay, thank you.
		ATSA	Thank you.
		Police	Bye.
	17:28:46	ATSA	Bye, bye.

Unless otherwise indicated, recommendations in this report are addressed to the appropriate regulatory authorities having responsibility for the matters with which the recommendation is concerned. It is for those authorities to decide what action is taken. In the United Kingdom the responsible authority is the Civil Aviation Authority, CAA House, 45-49 Kingsway, London WC2B 6TE or the European Aviation Safety Agency, Postfach 10 12 53, D-50452 Koeln, Germany.