AIRCRAFT ACCIDENT REPORT 1/2011

Air Accidents Investigation Branch

Department for Transport

Report on the 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

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

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

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This report contains facts which have been determined up to the time of publication. This information is published to inform the aviation industry and the public of the general circumstances of accidents and serious incidents.

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Air Accidents Investigation Branch
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August 2011

The Right Honourable Philip Hammond
Secretary of State for Transport

Dear Secretary of State

I have the honour to submit the report by Mr P E B Taylor, an Inspector of Air Accidents, on the circumstances of the accident to Eurocopter EC255 LP Super Puma, registration G-REDU, near the Eastern Trough Area Project (ETAP) Central Production Facility Platform in the North Sea on 18 February 2009.

Yours sincerely

Keith Conradi
Chief Inspector of Air Accidents

Contents

Appendices

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIB	Air Accidents Investigation Branch
AC	Advisory Circular
ACAS	Airborne Collision Avoidance System
ADF	Automatic Direction Finder
AFCS	Automatic Flight Control System
AMC	Aircraft Management Computer
amsl	above mean sea level
ANO	Air Navigation Order
AOC	Air Operator’s Certificate
AP	autopilot
ARA	Airborne Radar Approach
ARCC	Aeronautical Rescue Co-ordination Centre
ARRC	Autonomous Rescue and Recovery Craft
AVAD	Automatic Voice Alerting Device
asl	above sea level
BEA	Bureau d’Enquêtes et d’Analyses pour la Sécurité de l’Aviation civile
BHAB	British Helicopter Advisory Board
CAA	Civil Aviation Authority
CAM	cockpit area microphone
CAP	Civil Aviation Publication
CFIT	Controlled Flight into Terrain
CFRP	carbon-fibre reinforced plastic
cm	centimetre(s)
COSPAS	Cosmicheskaya Sistyema Poiska Avariynich Sudov
CPF	Central Production Facility
CPI	crash position indicator
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
CVFDR	Combined Voice and Flight Data Recorder
CWP	Caution and Warning Panel
°C,M,T	degrees celsius, magnetic, true
dc	direct current
DH	Decision Height
EASA	European Aviation Safety Agency
EGPWS	Enhanced GPWS
EHEST	European Helicopter Safety Team
EID	Electronic Instrument Display
ELT(AD)	Automatically Deployable Emergency Locator Transmitter
ELT(S)	Emergency Locator Transmitter (Survival)
ESSI	European Strategic Safety Initiative
ETAP	Eastern Trough Area Project
ETSO	European Technical Standard Order
FAA	Federal Aviation Administration (USA)
FADEC	Full Authority Digital Electronic Control
FAR	Federal Aviation Regulation
FCMC	Fuel Control and Monitoring Computer
FDM	flight data monitoring
FDR	Flight Data Recorder
FL	Flight Level
FLIR	Forward-looking Infra-red
FND	Flight and Navigation Display
FMS	Flight Management System
FORA	Flight Operations Risk Assessment
ft	feet
ft/min	feet per minute

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT (Continued)

g	acceleration due to Earth's gravity
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
HAPI	Helicopter Approach Path Indicator
HLO	Helicopter Landing Officer
HMCG	Her Majesty's Coastguard
HP	handling pilot
hPa	hectopascal (equivalent unit to mb)
hrs	hours (clock time as in 1200 hrs)
HSRMC	Helicopter Safety Research Management Committee
HTAWS	Helicopter Terrain Awareness Warning System
HUET	Helicopter Underwater Escape Trainer
IAS	indicated airspeed
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
IHST	International Helicopter Safety Team
ISI	Integrated Standby Instrument
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirements
kg	kilogram(s)
km	kilometre(s)
kt	knot(s)
m	metre(s)
MAP	Missed Approach Point
MDA	Minimum Descent Altitude
MDH	Minimum Descent Height
MEA	Minimum En Route Altitude
MEL	Minimum Equipment List
MFD	Multi-Function Flight Display
MHz	megahertz
min	minutes
MISD	Mission Display
MMEL	Master Minimum Equipment List
MOD	Ministry of Defence
MOPS	Minimum Operational Performance Standards
MRCC	Maritime Rescue and Co-ordination Centre
NAVD	Navigation Display
NDB	Non-Directional Beacon
NHP	non-handling pilot
nm	nautical mile(s)
NVM	Non Volatile Memory
PF	Pilot Flying
PFD	Primary Flight Display
PLB	Personal Locator Beacon
PNF	Pilot Not Flying
PU	Processor Unit
RA	radio altimeter
RAF	Royal Air Force
RN	Royal Navy
RSV	Regional Support Vessel
SAR	Search and Rescue
SARSAT	Search and Rescue Satellite
secs	seconds
SOP	Standard Operating Procedure
TAWS	Terrain Awareness Warning System
TSO	Technical Standard Order
UHF	Ultra High Frequency
UK	United Kingdom
UKSRR	United Kingdom Search and Rescue Region
UTC	Co-ordinated Universal Time (GMT)
v	Volt(s)
VFR	Visual Flight Rules
VGA	Visual Gate Approach

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT (Continued)

VHF	Very High Frequency
VMC	Visual Meterorological Conditions
VMS	Vehicle Management System
WCP	Warning Caution Panel
W/V	Wind Velocity
WWPLB	Wrist Watch Personal Locator Beacon

Air Accidents Investigation Branch

Aircraft Accident Report No: 1/2011 (EW/C2009/02/06)

Registered Owner and Operator	Bond Offshore Helicopters Ltd
Aircraft Type	Eurocopter EC225 LP Super Puma
Nationality	British
Registration	G-REDU
Place of Accident	Approximately 300 metres southwest of the Eastern Trough Area Project (ETAP) Central Production Facility Platform helideck in the North Sea Central Area Latitude N 57° 17.49' Longitude E 001° 39.41'
Date and Time	18 February 2009 at 1837 hrs All times in this report are UTC (coincident with local time)

Synopsis

The Aeronautical Rescue Co-ordination Centre (ARCC) notified the Air Accidents Investigation Branch (AAIB) of the accident at 1912 hrs on 18 February 2009 and the investigation commenced the following day.

In accordance with established international arrangements, the Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) of France, representing the State of Design and Manufacture of the aircraft, appointed an Accredited Representative and was supported by additional investigators from Eurocopter. The operator co-operated with the investigation and provided expertise as required.

Prior to this Final Report, the AAIB published Special Bulletins on 24 March 2009 and 23 June 2009.

Twenty-seven Safety Recommendations have been made.

The helicopter departed Aberdeen Airport at 1742 hrs on a scheduled flight to the Eastern Trough Area Project (ETAP). The flight consisted of three sectors, with the first landing being made, at night, on the ETAP Central Production Facility Platform. Weather conditions at the platform deteriorated after the aircraft departed Aberdeen; the visibility and cloud base were estimated as being 0.5 nm and 500 ft respectively. At 1835 hrs the flight crew made a visual approach to the platform during which the helicopter descended and impacted the surface of the sea. The helicopter remained upright, supported by its flotation equipment which had inflated automatically. All those onboard were able to evacuate the helicopter into its liferafts and they were successfully rescued by air and maritime Search and Rescue (SAR) assets.

The investigation identified the following causal factors:

1. The crew's perception of the position and orientation of the helicopter relative to the platform during the final approach was erroneous. Neither crew member was aware that the helicopter was descending towards the surface of the sea. This was probably due to the effects of oculogravic[1] and somatogravic[2] illusions combined with both pilots being focussed on the platform and not monitoring the flight instruments.

2. The approach was conducted in reduced visibility, probably due to fog or low cloud. This degraded the visual cues provided by the platform lighting, adding to the strength of the visual illusions during the final approach.

3. The two radio altimeter-based audio-voice height alert warnings did not activate. The fixed 100 ft audio-voice alert failed to activate, due to a likely malfunction of the Terrain Awareness Warning System (TAWS), and the audio-voice element of the selectable 150 ft alert had been suspended by the crew. Had the latter not been suspended, it would also have failed to activate. The pilots were not aware of the inoperative state of the TAWS.

The investigation identified the following contributory factors:

1. There was no specified night visual approach profile on which the crew could base their approach and minimum heights, and stabilised approach criteria were not specified.

2. The visual picture on final approach was possibly confused by a reflection of the platform on the surface of the sea.

1 An oculogravic illusion is a visual illusion that affects the apparent position of an object in the visual field. A full explanation is provided in Appendix A and B to this report.

2 A somatogravic illusion is a non-visual illusion that produces a false sensation of helicopter attitude. A full explanation is provided in Appendix A and B to this report.

1 Factual Information

1.1 History of the flight

1.1.1 Background information

Aberdeen Airport is the helicopter operator's main operating base from which it conducts offshore flights in support of the oil and gas industry.

1.1.2 Flight details

On the day of the accident, the flight crew were rostered to operate a return flight to the Schiehallion oil production vessel, located to the west of the Shetland Islands. The crew reported for duty at 1130 hrs and departed Aberdeen at 1243 hrs with the commander as the pilot flying (PF). The flight was uneventful and the helicopter landed back at Aberdeen at 1600 hrs. As the helicopter was taxiing in, the company's operations department informed the crew that they were required to carry out a second flight. The crew shut down the helicopter and went to the flight planning area to prepare for the next flight. The commander informed the engineering department that there was a fault with the helicopter's cabin heating which would require investigation before the next takeoff.

The following flight, operated on behalf of an oil company, involved transferring 16 passengers and a small amount of freight to the ETAP platform and the Galaxy 1 rig, alongside the Mungo platform, before returning to Aberdeen. The flight had been scheduled to depart earlier in the day but had been delayed due to fog at the ETAP platform.

The ETAP platform is located 125 nm East of Aberdeen. The Galaxy 1 rig is 13 nm to the east-northeast of the ETAP platform.

1.1.3 Conduct of the flight

The following description of events is an amalgamation of information obtained from recorded data and witness statements. Altitudes are above mean sea level (amsl) unless the height of the helicopter is defined by its radio altimeter (RA).

Having completed their flight planning, the crew boarded the helicopter and carried out a normal start. The commander was seated in the right seat and was to be PF for the first and second sectors. He was wearing corrective lenses, in accordance with the limitation of his medical certificate. The crew recalled that, after start, the Terrain Awareness Warning System (TAWS) and Airborne Collision Avoidance System (ACAS) were selected ON. The TAWS, which had worked normally on the previous flight, was tested satisfactorily but the crew reported that the ACAS failed to complete its test and was switched OFF. After starting, the helicopter was taxied to the passenger pick-up point. Having boarded the passengers, the crew then taxied the helicopter for a departure from Runway 34. It took off at 1742 hrs, climbed initially to 3,000 ft and then climbed further to Flight Level (FL)55. There was sufficient fuel on board the helicopter for a return to Aberdeen, in the event of a missed approach at the ETAP platform.

At 1755 hrs the commander recalled turning ON the ACAS and, coincident with that action, a TAWS caution caption being displayed on the Caution and Warning Panel (CWP). It cleared shortly after, with no intervention from the crew, and there was no indication of the system having failed on any of the Multi-Function Flight Displays (MFDs).

At 1802 hrs the co-pilot obtained an updated weather observation from the ETAP platform. The wind was 352°/02 kt, visibility was estimated at 6 nm and the cloud base was estimated to be 800 ft. Similarly, at 1804 hrs the weather at the Galaxy 1 rig was wind 059°/02 kt, visibility 8 nm and cloud overcast at 800 ft.

At 1812 hrs staff on the ETAP platform updated their weather, stating that the cloud base had reduced to 600 ft and the visibility was dropping. Staff on the Galaxy 1 rig reported that they could still see the ETAP platform 13 nm away.

At 1814 hrs the crew confirmed that they were receiving transmissions from the ETAP non-directional beacon (NDB), which they had identified, and the commander carried out a briefing for an Airborne Radar Approach (ARA)[1] to the ETAP platform. It was to be a straight-in ARA, commencing from an altitude of 1,500 ft, descending to a Minimum Descent Height (MDH) of 300 ft, with a Missed Approach Point (MAP) at 0.75 nm. The commander would perform the landing.

At 1819 hrs, the descent checks were completed and the helicopter was descended, using the autopilot (AP), to an altitude of 1,500 ft. At 1825 hrs, after passing through a layer of cloud, visual meterological conditions (VMC) prevailed and the crew could see what appeared to be the ETAP platform at

1 A non-precision approach to a Missed Approach Point (MAP) 0.75 nm from the platform, with a Minimum Descent Height (MDH) of 300 ft above sea level (asl), based on the radio altimeter (RA).

a range of 13 nm. The aircraft descended through a height of 1,500 ft RA at 1828 hrs. The crew 'paged down' the weather radar to a range scale of 20 nm and commenced the approach checks. Being visual with what he believed to be the ETAP platform, the commander rebriefed the co-pilot for the approach and landing, saying: "IT WILL BE AN ENROUTE DESCENT DOWN TO 300 FT USING THE NDB NEEDLE. THERE IS HARDLY ANY WIND THERE'S 5 KT THERE. HE SAID HIS WIND WAS 350. WE'LL GET ANOTHER WIND CHECK FROM HIM BEFORE WE GET THERE. RIGHT LANDING I'LL COME ALONGSIDE MOVE DOWN AND RIGHT. I'LL CALL YOU ON COMMITTED. IF THERE IS A PROBLEM IT'S A GO AROUND, VTOS, VY AND WE'LL GO TO ABERDEEN". The co-pilot acknowledged the briefing and had no questions.

At 1827 hrs the co-pilot carried out the pre-landing passenger briefing whilst the commander contacted the ETAP platform on the radio for an update on the weather. The ETAP reported that the visibility had reduced to what was estimated to be 0.5 nm. The co-pilot was unaware of this report, as he was briefing the passengers at the time. The crew could see the ETAP flare, and the lights of the installation, and agreed to carry out a straight-in visual approach, descending to a height of 300 ft to ensure clearance from any cloud. They carried out the final approach checks and commenced the descent with reference to the radio altimeter.

At 1831 hrs the helicopter descended to a height of 300 ft, at a range of 7 nm from the ETAP. As it did so it entered low cloud and the crew lost sight of the ETAP, so they commenced a climb and at a height of 400 ft they regained visual contact with the platform. The crew discussed the conditions and agreed that they had encountered a fog bank. They elected to remain at 400 ft and, with 5 nm to run to the ETAP, continued the approach visually, monitoring their range using the weather radar.

At 1833 hrs the crew, using the Navigation Display (NAVD), agreed that the wind was about 5 kt from the north. The commander reduced speed from 130 kt to 80 kt and, with 4.5 nm to run, they again 'paged down' the weather radar. With 3 nm to run to the platform, the co-pilot advised the commander to alter the helicopter's heading five degrees to the left, based on the weather radar picture. The commander then stated that they would have to make a left turn into the wind. He again reduced the speed, passing through V_y[2] (80 kt) with some 2 nm to run to the platform.

At 1835 hrs the radar was again 'paged down' and the commander descended the helicopter to a height of 300 ft. The co-pilot stated "JUST ONE MILE TO

2 V_y is the indicated airspeed at which a helicopter will achieve its best rate of climb.

GO" and, when level at 300 ft RA, both pilots could see the glow of the flare, although they were having difficulty seeing the lights of the platform.

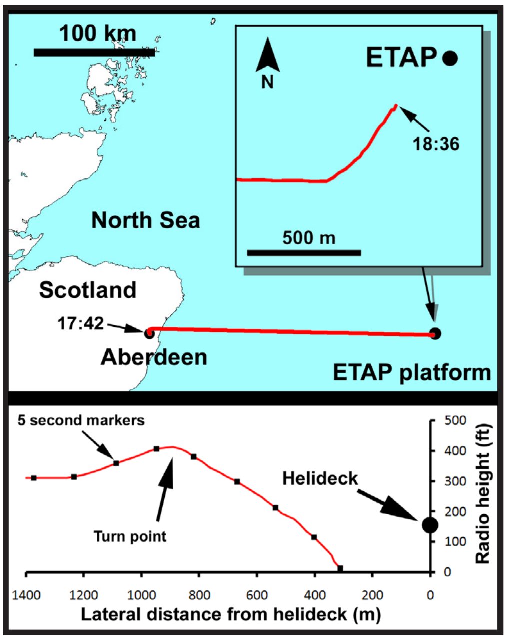


Figure 1

G-REDU's track to the ETAP platform and its vertical profile during the final stages of the flight

At 1836 hrs the co-pilot confirmed that the range to the platform was 0.75 nm. (See Figure 2 for audio extracts and pertinent data from the Combined Voice and Flight Data Recorder (CVFDR) from 18:36:04 hrs onwards.) The commander stated "OK, WE'LL JUST STAY ON THIS HEADING THEN GO UP". The co-pilot responded "OK AS YOU CLIMB, IF WE MAKE A SECOND APPROACH I RECKON WE'LL GET IN. CAN YOU SEE" As the helicopter passed through 350 ft, the commander could see the flare and the diffused lights of the platform. As the helicopter reached the top of its climb, at a height of 415 ft, the co-pilot could see the flare, the diffused lights of the platform and the green perimeter lighting of the helideck, which has an elevation of 166 ft.

The commander decoupled the upper modes of the AP and suspended the 'CHECK HEIGHT' aural alert[3] that would have been activated as the aircraft passed through a height of 150 ft. However, the selected 150 ft height alert remained in the form of visual warnings displayed on each pilot's Primary

3 The height for activation of this audio voice warning is set by the crew and can be suspended to prevent activation. Suspension of the audio warning does not prevent the display of the associated Decision Height (DH) visual warning on the Primary Flight Display (PFD). A second audio voice warning of 'ONE HUNDRED', which cannot be suspended, is automatically activated by the TAWS when the aircraft descends through a height of 100 ft RA.

Flight Display (PFD). The commander commenced a 20° banked turn to the left and the co-pilot informed him that he was descending.

The commander could see the flare and the lights of the platform but could not see the helideck. As the helicopter passed 280 ft, he asked the co-pilot, "CAN YOU SEE THE DECK, THAT'S THE PROBLEM". The co-pilot responded "I CAN SEE THE DECK RIGHT IN FRONT OF US YOU'VE GOT A GROUND SPEED OF FIFTY FIVE. AH". As he finished his response, the helicopter passed through 200 ft. The co-pilot was visual with a diffused picture of green lights but momentarily lost visual contact, simultaneously announcing the word "AH". By moving forward in his seat, he was able to relocate the green deck lights.

The commander rolled the helicopter out of the turn, having turned through 62° instead of the intended 90°. It passed through 150 ft, the height at which the 'CHECK HEIGHT' alert should have activated had it not been suspended, at a rate of descent of 1,096 ft/min with an IAS of 49 kt, achieved 'wings level' and continued to descend. The commander could still make out the lights of the platform and had the sensation that his approach was fast and high.

As the helicopter passed through a height of 100 ft, there was no 'ONE HUNDRED' aural alert (the warning that cannot be suspended if TAWS is operating). Following this, both pilots' attention was fully focused on the external visual picture. The co-pilot, believing that they were above the height of the deck and in close proximity to it, checked the radar for its range. He then advised the commander, "OK STILL VISUAL WITH THE DECK CAN YOU SEE IT'S RIGHT IN FRONT OF YOU TO YOUR RIGHT". The commander could not see the helideck and started to ask the co-pilot "WHO'S LA..(NDING)" but his question was interrupted as the helicopter impacted the surface of the sea.

The helicopter remained upright and the flotation equipment inflated automatically. When the helicopter had settled on the surface of the sea, electrical power to the flight deck was lost. The Emergency Exit Lights were the only lights illuminated and both engines remained running. In the darkened environment, the commander located the engine control switches on the overhead panel, by feel, and selected them to OFF. He shouted to the passengers not to evacuate until the rotors had stopped. With both engines running down, he gently applied the rotor brake in order to prevent the helicopter rolling over. When the rotors had stopped he exited the helicopter through his side door, which he had jettisoned. He then joined the passengers in the liferaft on the right side of the helicopter. The evacuation is covered in detail in paragraph 1.15.8.

1.1.4 Witnesses

Interviews were carried out with the Helicopter Landing Officer (HLO) and other personnel on the ETAP platform who witnessed the helicopter's descent onto the surface of the water.

The HLO was advised at 1740 hrs that the helicopter was inbound for a crew change and was expected to arrive at 1833 hrs. At around 1800 hrs the HLO and his team went onto the helideck to complete a routine inspection and to perform the fuel checks. Whilst on the deck, the HLO noticed that the cloud base was just above the top of the flare pylon, which is 525 ft amsl, and estimated that the visibility, in the dark and foggy conditions, was about 0.5 nm. The HLO relayed this information on the radio to 'Heli-admin', an office inside the platform which controls passenger arrivals and departures. Shortly afterwards, the radio operator on the Galaxy 1 rig radioed that they could see the ETAP platform and estimated the visibility to be around 10 miles. The ETAP HLO confirmed that he could not see any of the other nearby oil installations and that in his opinion the visibility from the ETAP helideck was 0.5 nm. 'Heli-admin' then relayed this visibility to the helicopter.

When the helicopter was 13 nm from the ETAP platform, the flight crew advised the HLO that they were visual with the ETAP. HLO responded that he could not see the helicopter. Sometime later, when the crew again asked the HLO if he was able to see the helicopter, he still could not. At what he thought was about 1827 hrs, the HLO became visual with the landing light of the helicopter. He estimated that it was at a range of 500 metres and appeared to be descending rapidly. He then lost sight of the light and heard a splashing sound "like a surfboard hitting the water" The HLO immediately realised that the helicopter had struck the water and raised the alarm.

At about 1830 hrs, another member of staff on the platform was outside on Level 2 of the ETAP, below the helideck, waiting for a colleague inbound on the helicopter. The visibility was very poor and he did not expect the helicopter to be able to land. He heard a helicopter approaching, saw a white light, which appeared to him to be very low, then heard a splash and saw the white light disappear. He could only see the red tail light and realised that the helicopter had ditched. He, too, raised the alarm.

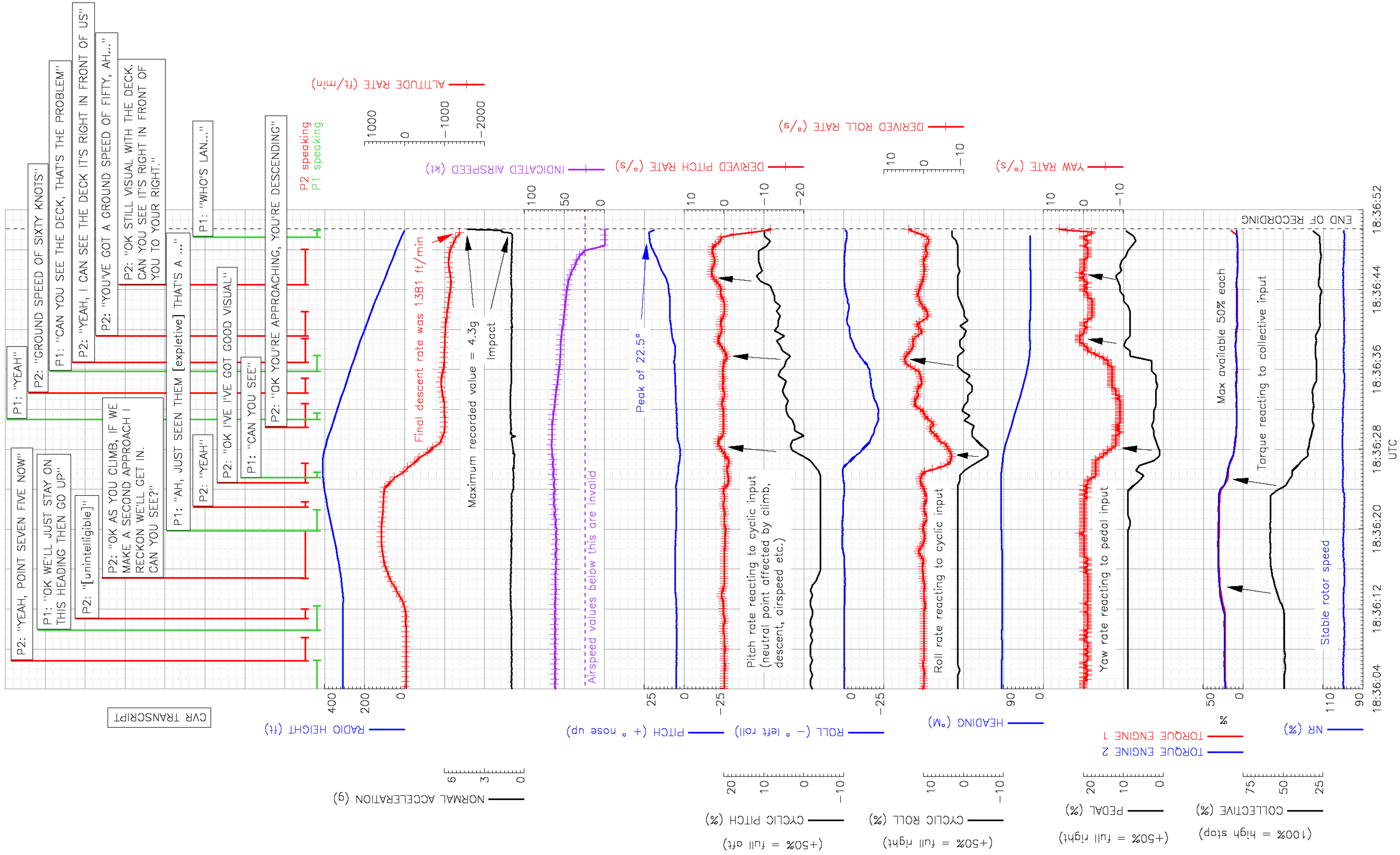


Figure 2

Recorded data and pertinent CVR extracts at the end of the accident flight

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor/none	2	16	-

1.3 Damage to aircraft

The helicopter was damaged beyond economic repair due to the impact with the surface of the sea, prolonged salt water immersion and damage sustained during the salvage operation.

1.4 Other damage

There was no other damage.

1.5 Personnel information

1.5.1 Commander

Age:	55	
Licence:	Airline Transport Pilot's Licence	
Helicopter Ratings:	EC225/ AS332 L2	
Licence Proficiency Check:	Valid to 31 October 2009	
Instrument Rating Renewal	Valid to 31 October 2009	
Line check:	Valid to 31 January 2010	
Night Offshore Check:	Valid to 31 January 2010	
Medical certificate:	Valid to 26 April 2009 This included a limitation that the pilot must wear corrective lenses	
Emergency and Safety Equipment Check:	Valid to 31 October 2009	
Flying Experience:	Total all types:	17,200 hours
	Total on type:	3,018 hours
	Last 90 days:	137 hours
	Last 28 days:	54 hours
	Last 24 hours:	5 hours
	Previous rest period:	15 hours

Background and flying experience:

The commander had carried out his flying training in the Royal Navy (RN) and served on front line squadrons undertaking day and night operations from various vessels. After leaving the RN he flew commercially, mainly in support of the offshore oil and gas industry. Initially this was on North Sea operations but in the late 1980s he moved to an overseas operator, flying offshore oil support operations. Due to the predominance of day operations, the operator required pilots to carry out three night deck landings every three months. Having returned to Europe, he joined the operator of G-REDU in 2007. In September 2007 he carried out an AS332 L2 type conversion course which included five night deck approaches and landings in the simulator. On 14 January 2008 he successfully completed a Night Deck Competency check which comprised one ARA and three night deck landings. In September 2008 he completed the EC225 Differences Course. He was in current night deck landing practice at the time of the accident.

1.5.2 Co-pilot

Age:	32	
Licence:	Commercial Pilot's Licence	
Helicopter Ratings:	EC225/AS332 L2	
Licence Proficiency Check:	Valid to 31 August 2009	
Instrument Rating Renewal:	Valid to 31 August 2009	
Line check:	Valid to31 October 2009	
Night Offshore Check:	Valid to 31 October 2009	
Medical certificate:	Valid to 26 April 2009	
Emergency and Safety Equipment Check:	31 August 2009	
Flying Experience:	Total all types:	1,300 hours
	Total on type:	808 hours
	Last 90 days:	119 hours
	Last 28 days:	38 hours
	Last 24 hours:	5 hours
	Previous rest period:	15 hours 10 mins

Background and flying experience:

The co-pilot had worked initially as a flying instructor, before moving onto North Sea offshore oil and gas support operations in July 2007. In September 2007 he attended an AS332 L2 type conversion course, at the end of which he carried out five day and two night deck landings in the simulator. This qualified him to perform deck landings by day only. On 7 March 2008 he successfully completed a Night Deck Competency Check in the aircraft. This comprised five night deck landings from the left (co-pilot's) seat as PF. In September 2008 he successfully completed the EC225 differences course. He was in current night deck landing practice at the time of the accident.

1.5.3 Night flying and instrument flying recency

Joint Aviation Requirements JAR-OPS 3, *Commercial Air Transportation (Helicopters)*, paragraph 3.970 states:

> *'For night VMC operations:*
>
> *(ii) a pilot with a valid instrument rating satisfies the night recent experience requirement if he has carried out at least three instrument approaches in the preceding 90 days. This recency may be obtained in a Synthetic Training Device'*

The table below shows the commander's and co-pilot's history of approaches and night helideck landings.

	Instrument Approaches		Night Deck Landings	
	90 Days	365 Days	90 Days	365 Days
Commander	14	69	12	15
Co-Pilot	10	51	9	16

1.6 Aircraft information

1.6.1 General

Manufacturer:	Eurocopter
Type:	EC225 LP Super Puma
Aircraft serial number:	2690
Year of manufacture:	2008
Number and type of engines:	2 Turbomeca Makila 2A turboshaft engines
Total airframe hours:	597.1 hours
Total airframe landings:	773 (as of 17 February)
Certificate of Registration:	UK registered on 23 May 2008
Certificate of Airworthiness:	Certificate of Airworthiness issued by the European Aviation Safety Agency (EASA) on 23 May 2008 and expiring on 22 May 2009
Certificate of Release to Service:	17 February 2009 following a 75-hour inspection

1.6.2 Aircraft description

The EC225 helicopter is a twin-engine medium sized type, certificated to EASA Part 29 standards and capable of undertaking passenger or freight transport operations. It is used in a variety of specialized operational roles including offshore oilfield support. The type was developed from the AS332 L2 Super Puma. The primary differences include a five-bladed main rotor with a spheriflex[4] composite rotor hub and uprated Turbomeca Makila 2A engines. As configured for the operator, G-REDU was fitted with 19 staggered crashworthy passenger seats, each equipped with upper torso restraints. Additionally, the normal safety and survival equipment for offshore operation was fitted. Those features relevant to survival of this accident are described in more detail in Section 1.15 of this report.

1.6.3 Aircraft history

The helicopter was delivered to the operator on 23 May 2008. At manufacture it had not been intended for use on the North Sea, so some additional modification work was required to bring G-REDU to the same standard as the operator's other EC225s.

On 23 November 2008, modification work began to embody the manufacturer's Service Bulletin (SB) 25-044. The SB included the installation of TAWS and ACAS systems. The TAWS replaced the original Automatic Voice Alerting Device (AVAD) which produced a number of audio warnings, including 'CHECK HEIGHT' (as selected by the crew using the radio altimeter bug) and 'ONE HUNDRED' (see Section 1.18). There was no regulatory requirement to fit TAWS.

A flight test was carried out by the helicopter manufacture's flight test pilot and engineer on 21 January 2009, following the completion of the modification work, to verify the correct operation of the ACAS and TAWS systems. The systems functioned correctly; however, the original audio warnings for 'CHECK HEIGHT' and 'TOO LOW GEAR' activated, in addition to the same warnings being produced by TAWS. These duplicate warnings were disabled and another test flight was satisfactorily completed on 31 January 2009.

On 11 February 2009 an entry by a pilot in the technical log indicated that the ACAS was unserviceable. A self-test of the ACAS was completed satisfactorily, no fault was found and the system was assessed as serviceable.

4 The Spheriflex composite rotor hub has a single laminated spherical thrust bearing.

1.6.4 Recent activity

G-REDU had flown on 18 February 2009 with the same flight crew. Following that flight the crew had reported a problem with the heating and ventilation system on the left side of the helicopter. Engineers investigated the problem which involved removing some ceiling panels. The fault was found to be due to an incorrect duct having been fitted. During the turnaround inspection the engineers also opened and closed the tail rotor driveshaft cover.

1.6.5 Avionics

The avionic system, 'Avionique Nouvelle', is of a modular design and includes an Automatic Flight Control System (AFCS) with a four-axis digital APM 2000 autopilot, a flight data system, and a Vehicle Management System (VMS) which monitors the helicopter. It also includes an Integrated Standby Instrument (ISI) for airspeed, altimeter and attitude information back-up display.

The helicopter is fitted with four Multi-Function Flight Displays (MFDs), which each comprise a Keyboard Display Unit (KDU), located in the instrument panel and a Processor Unit (PU). There are two smaller displays for the VMS and a separate display for the ISI. Each MFD is configurable by the pilot to provide Flight & Navigation Display (FND), Navigation Display (NAVD), Mission Display (MISD) or Digital Map (DMAP) information. The MFDs feature a composite display mode, which allows FND and NAVD information to be displayed on the same screen. Also, Weather Radar information can be superimposed on NAVD information.

Non-volatile memory (NVM) is provided in the PUs for storing data, required for the initialisation and configuration of the MFDs, and includes a fault log.

1.6.6 Vehicle Management System (VMS)

The VMS comprises an Aircraft Management Computer (AMC) and two Electronic Instrument Display (EID) screens for engine and system monitoring. The AMC processes the signals from the sensors and transmits the data to the EIDs. It is also a centralised failure recording and diagnostic computer for the VMS, detecting failures itself and receiving failure information from other avionic modules. The information is recorded within NVM located inside the AMC.

1.6.7 Caution and Warning Panel

A Caution and Warning Panel (CWP), also referred to as the Warning Caution Panel (WCP), is located in the instrument panel, displaying red warning and amber caution messages.

1.6.8 Terrain Awareness Warning System (TAWS)

The TAWS installation consists of a MkXXII Enhanced Ground Proximity Warning System (EGPWS)[5], a control panel, a video radar unit, a GPS antenna, aircraft wiring and aircraft components such as relays. The software version installed in this aircraft was version V.26. The system interfaces with a number of data sources to provide audio, visual and message warnings to the crew. The modes providing protection against Controlled Flight into Terrain (CFIT), which were designed to be active at the time of the accident, are shown in Figure 3. A more detailed description of the protections provided by TAWS is given in Section 1.18.3 and detail of the AVAD function fulfilled by TAWS is included in Section 1.18.2.

The terrain display can be selected by switching the Navigation Display to the Mission Display. A cyan screen indicates that the surface in the area is at mean sea level and that there are no obstacles in the vicinity.

The look-ahead modes are designed to be inactive when the helicopter is flying at an airspeed of less than 70 kt. The look-down Mode 1, provides warning of an excessive descent rate and Mode 2 warns of an excessive terrain (or surface) closure rate.

Prioritisation of the aural messages generated by the EGPWS is such that the height warnings, the 'CHECK HEIGHT' and 'ONE HUNDRED' aural warnings, have a higher priority than caution alerts, such as 'SINK RATE', but warning alerts, such as 'PULL UP', have the highest priority.

Most of the audio alerts are also accompanied by a visual red or amber 'TERRAIN' message appearing on the PFD. For the 'CHECK HEIGHT' and 'ONE HUNDRED' alerts the TAWS only generates aural warnings. However, the 'CHECK HEIGHT' aural warning is accompanied by a 'DH' annunciation on the PFD, generated by another system.

5 EGPWS is a proprietary make of TAWS. The term will be used when referring to issues specific to the processor unit installed.

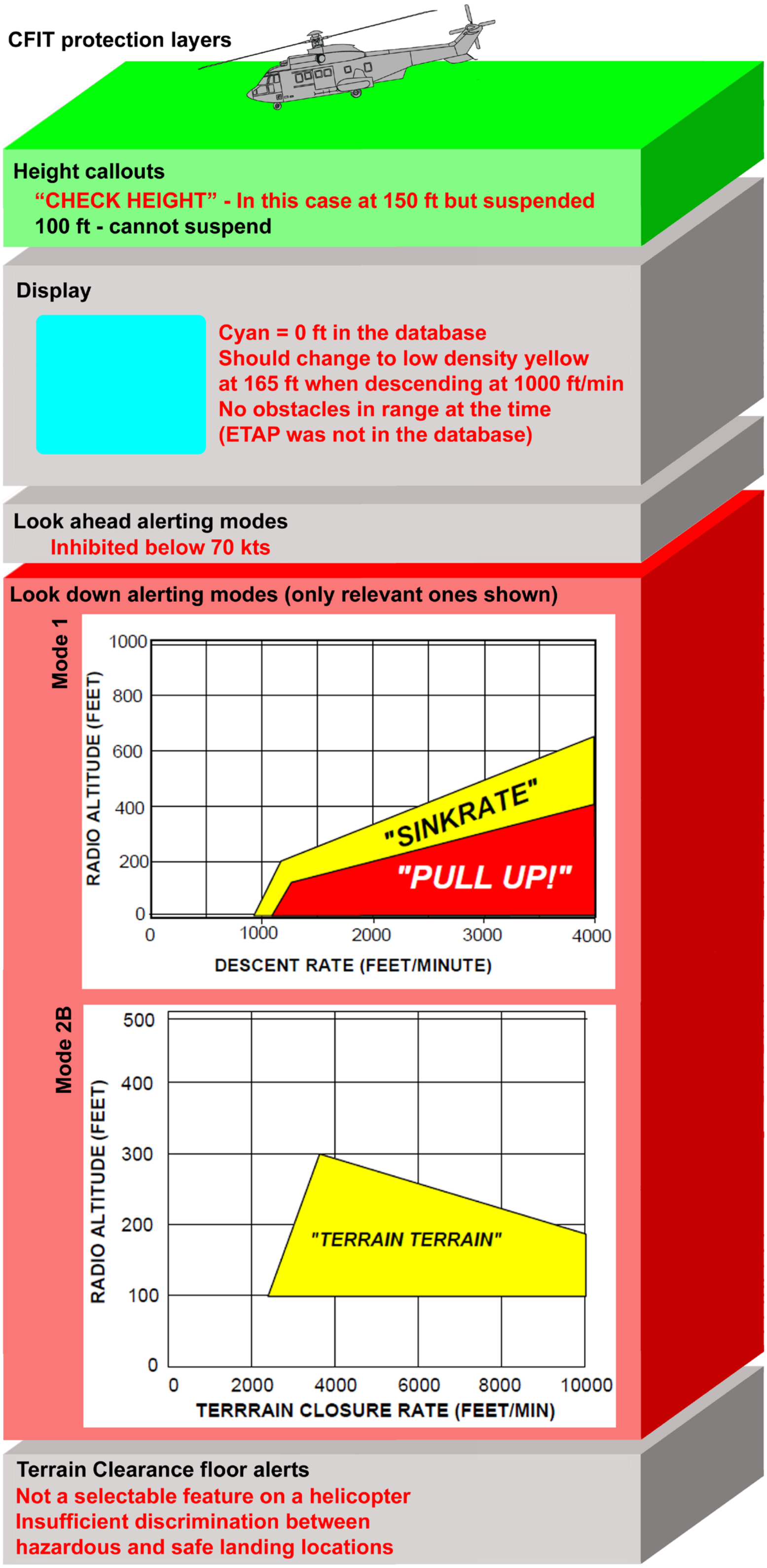


Figure 3

EGPWS modes that would have applied during the final phase of flight, had the TAWS been operating

1.6.8.1 TAWS control and displays

Figure 4 shows the TAWS control panel and how terrain and messages, generated by the system, are displayed to the crew. The ACAS control panel is also shown.

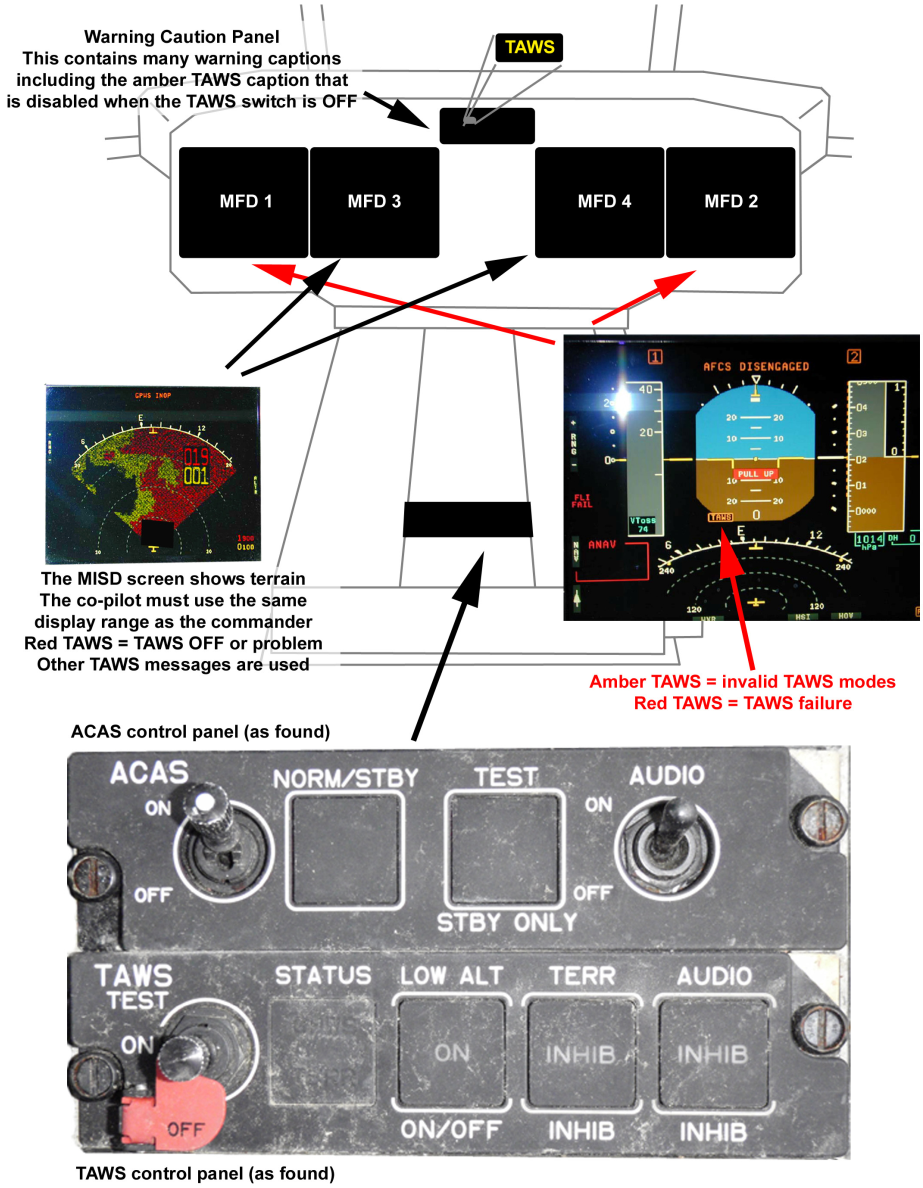


Figure 4

TAWS and ACAS control panels and TAWS indications

With the TAWS switch selected ON, TAWS failures (ie either the EGPWS computer itself or individual TAWS functions) are indicated on the PFD and the MISD, on the TAWS control panel and the CWP. A red TAWS warning is also triggered on the PFD and MISD in the event of loss of only the TAWS display.

Furthermore, TAWS control panel selected inhibits are displayed on the relevant pushbuttons on the control panel itself, on the MISD and on the CWP.

To select the TAWS system OFF, the crew are required to lift the red flap aside and pull and lower the TAWS ON/TEST/OFF toggle switch to the OFF position. This removes power from the TAWS computer and disables the TAWS annunciations on the central warning panel and all other displays, with the exception of the MISD display. With the MFD selected to a display other than the MISD display, the only visible indication that the TAWS system is selected ON or OFF is the position of the switch on the TAWS control panel. The control panel is not in the crew's primary field of view and the operator did not require them to have the MISD display selected. The ON/OFF switch is provided in this installation to enable crews to switch the system OFF, in the event of a malfunction generating permanent false audio alerts. Note: in general, aeroplane installations do not provide crews with a switch for removing power from TAWS.

The EC225 cockpit follows the 'dark cockpit' philosophy, meaning that, if all systems are as they should be, no indicators will be illuminated. The TAWS installation was designed to be in line with this philosophy. Therefore, if a pilot switches TAWS OFF, the pilot should be aware of the system status and no cockpit indication is required. The system status is still available on the MISD screen or by checking the ON/OFF switch on the centre pedestal.

1.6.8.2 TAWS and ACAS interaction

Potentially hazardous, conflicting guidance can be generated by the TAWS and ACAS systems at the same time. To avoid this, and give TAWS the higher priority when it is issuing an aural alert, ACAS is inhibited by TAWS by means of an 'inhibit' wire connecting the two systems. Other than this 'inhibit' wire, and the adjacent locations of their respective control panels, ACAS and TAWS are segregated systems using different dc power buses.

The ACAS transceiver does not have any internal status recorded in non-volatile memory. The manufacturer reported that inhibiting it would result in a delayed audio output but would have no other effect on its operation or validity status.

1.6.8.3 Databases

The EGPWS had the latest database installed. However, during the course of the investigation it was reported that the positions of some of the oil and gas rigs might be inaccurate or out of date because they are occasionally moved. This had resulted in 'nuisance warnings'. EGPWS alerts can also be triggered when aircraft approached platforms, which are accurately defined in the database, in high winds. With airspeeds above 70 kt, the look-ahead alert modes remain active. The manufacturer indicated that some operators would prefer not to have oil and gas platforms included in the database in order to reduce the amount of nuisance warnings. The ETAP platform was not in the database.

1.7 Meteorological information

1.7.1 Synoptic situation

At 1800 hrs on 18 February 2009, a warm front over the North Sea, orientated northeast to southwest, lay to the east of the ETAP platform. Warm sector conditions prevailed over the Scottish mainland and the North Sea to the west of the warm front.

1.7.2 Available forecasts

The forecast for the general area was provided by the Met Office chart Form 215, '*Forecast Weather below 10,000 ft*'. As part of the offshore service provided by the Met Office, 'zoomed in' North Sea specific forecasts for offshore operations are also generated. Both of these forecasts were predicting areas of broken or overcast stratus cloud, base 200 ft to 500 ft in the area of the ETAP platform. In addition, there was a reference to cloud lowering to the surface, in association with fog. A range of visibilities, in varying conditions, were forecast from as much as 15 km in nil weather to, occasionally, 2,000 m in mist or moderate drizzle. There was also a reference to the visibility reducing to 200 m in isolated areas of fog, over the sea and in coastal areas.

1.7.3 Weather, cloud base and visibility

Whilst the ETAP did not have any instrumentation capable of recording cloud base, visibility or precipitation, two platforms within approximately 50 nm could provide an instrumented record of cloud base and visibility information. The Shearwater platform was approximately 25 nm to the southeast of the ETAP and the Fulmar platform was some 50 nm to the south of the ETAP. The cloud base was recorded but not the amount of cloud cover.

1.7.3.1 The Shearwater platform

Shortly before 1200 hrs, the cloud base was at a height of 400 ft amsl. By 1300 hrs it had reduced to 300 ft and at about 1400 hrs it was less than 200 ft. Apart from a brief improvement around 1630 hrs, the cloud base between 1400 hrs and 1900 hrs was 200 ft or lower. Visibility between 1200 hrs and 1400 hrs was between 800 m and 2,000 m. Between 1400 hrs and 2000 hrs, visibility was predominantly 190 m to 800 m although there was a brief improvement at approximately 1630 hrs to in excess of 10 km.

1.7.3.2 The Fulmar platform

The cloud base was at a height of 2,000 ft amsl from about 1200 hrs, reducing to give the first patches of cloud at about 400 ft at 1300 hrs, recovering to some 1,000 ft by 1330 hrs. There was a rapid reduction in cloud base to 400 ft at approximately 1530 hrs, reducing to less than 200 ft by 1545 hrs. Apart from a brief improvement at about 1900 hrs, to 300 ft, the cloud base remained below 200 ft until about 2145 hrs. The visibility varied between 2,000 m and 10 km at about 1200 hrs, falling to 1,000 m by 1400 hrs. Apart from a brief improvement at about 1900 hrs, visibility remained in the range 190 m to 400 m between 1400 hrs to 2300 hrs.

Mean Sea Level Pressure for the area at the time of the accident was 1023 hPa. The 0°C isotherm was 5,000 ft amsl.

1.7.4 Winds and temperatures

In an aftercast, wind was estimated from isobaric analysis and nearby reports from buoys. This indicated a slack gradient in the vicinity of the ETAP platform at 1800 hrs, with the wind essentially light and variable.

Surface temperatures were also obtained from nearby buoys, from which the ‘mean’ surface temperature was estimated for the same time. These temperatures were applied to the most representative radiosonde ascent (Abermarle) to give an estimate for the temperature at a height of 500 ft.

Level Height AMSL	Wind	Temperature °C	Dew Point °C	Humidity
Surface	VRB 05 KT	8.0	7.2	95%
500 ft	VRB 05 KT	7.0	7.0	100%

Table 1

Conditions in the vicinity of the ETAP platform

Met Office Form 214, the *UK Low-Level Spot Wind Chart*, valid for the period 1500 hrs to 2100 hrs, forecast the wind velocity (W/V) and temperature in the area of the ETAP, at an altitude of 1,000 ft, to be 320°/10 kt and +7°C, respectively.

1.7.5 ETAP meteorological observations.

The following observations were passed from the ETAP platform to the helicopter operator in Aberdeen. The decision to undertake the flight was based on the observation at 1708 hrs.

Time	W/V	Visibility	Cloud/ft	Temp°C	Weather
05:54 hrs	282/07	8.0 nm	Not estimated	+7	Fine/dry
11:05 hrs	245/12	0.5 nm	OVC/500	+7	Overcast
11:53 hrs	262/11	0.5 nm	OVC/500	+7	Overcast
13:58 hrs	319/09	3.0 nm	OVC 600-800	+7	Overcast
17:08 hrs	069/10	8.0 nm	OVC 800-1,000	+7	Fine/dry

Table 2

Meteorological observations at the ETAP platform

1.7.6 Sea state and temperature

Wave and sea temperature information was obtained from the buoys in the vicinity of the accident site. The period of the waves from peak to peak was mostly five or six seconds. The height of the waves was between 0.7 m and 1.0 m. On the basis of this information, the sea state would be described as 'State 3, slight', which is defined as wave heights of 0.5 m to 1.25 m.

The sea temperature at 1800 hrs, as reported by a surface vessel in the vicinity of the ETAP, based on a hull contact sensor, was 4.9°C. At 1900 hrs the temperature was 4.8°C.

1.7.7 Celestial information

Sunset at the ETAP was at 1701 hrs, over 90 minutes before the time of the accident. The moon was below the horizon and there was overcast cloud in the vicinity of the ETAP obscuring any celestial illumination. With the helicopter's heading in the north easterly quadrant, the conditions constituted a dark night with no visible horizon.

1.7.8 Meteorological observations

Following an accident on 27 December 2006 which involved an Aerospatiale SA365N, G-BLUN, carrying out a night approach to an offshore installation, the AAIB Aircraft Accident Report 7/2008 made the following Safety Recommendation (SR 2008-037):

> It is recommended that the Civil Aviation Authority ensures that personnel who are required to conduct weather observations from offshore installations are suitably trained, qualified and provided with equipment that can accurately measure the cloud base and visibility.

The CAA accepted the Safety Recommendation and amended CAP 437, Section 4 Meteorological Information in December 2008 and provided additional guidance at Appendix G in April 2010. The content of CAP 437 is guidance material and not a requirement by the CAA. The 2008 amendment stated:

> *'It is strongly recommended that installations are provided with an automated means of ascertaining the following meteorological information at all times.*
>
> *a) Wind speed and direction (including variations in direction)*
>
> *b) Air temperature and dew point temperature*
>
> *c) QNH and, where applicable, QFE*
>
> *d) Cloud amount and height of base (above mean sea level)*
>
> *e) Visibility, and*
>
> *f) Present weather.'*

1.8 Aids to navigation

1.8.1 Surface-based navigation aids

The ETAP platform was equipped with a non-directional beacon (NDB), transmitting on 363.5 MHz with an identification code 'ETP'. The equipment is designed to provide a bearing to the platform from the helicopter, in order to facilitate navigation.

1.8.2 Airborne navigation aids

The helicopter was fitted with a Flight Management System (FMS) which utilised the Global Positioning System (GPS) as one of its references. It is approved as the primary means of navigation in IMC or at night but not for providing final approach track or glidepath data. The helicopter was also equipped with a digital, multimode weather radar. The data received by the radar could be displayed on the flight crew's MFDs on the flight deck, providing the range and bearing of a target. Whilst the primary use of the radar was for the detection of weather, it was also equipped with a Search (SRCH) mode. This mode provided a map image of the surface below and ahead of the helicopter. It displayed topographical features and also comparatively small targets, such as oil rigs, vessels or platform installations, even in unfavourable weather conditions. The range of the display could be reduced as the target was approached, in order to refine the distance to go. This was referred to as 'paging down'.

The helicopter was fitted with Automatic Direction Finder (ADF) equipment which was compatible with the ETAP NDB.

1.9 Communications

Records of radio transmissions between the helicopter and ATC were available from the ATC recording tapes. Radio transmissions between G-REDU, the ETAP platform and other agencies were also recorded on the Cockpit Voice Recorder (CVR).

1.10 Aerodrome information

1.10.1 The Eastern Trough Area Project (ETAP)

The Eastern Trough Area Project (ETAP) is an integrated development of nine oil and gas fields. The ETAP installation is the Central Production Facility (CPF) for the project. The ETAP installation is a dual platform design which effectively separates the major hydrocarbon hazards on the Process, Drilling and Riser platform (PdR) from the location of the majority of personel on board the Quarters and Utility (QU) platform. Each platform comprises a steel jacket which is secured to the seabed with piles. The PdR and QU modules are placed on top of these steel jackets and form the topsides of the platforms. Two bridges connect the QU and PdR platforms, forming the ETAP complex.

A line drawn through the centre of each platform gives an orientation of 030°T, with the PdR platform to the northeast and the QU platform to the southwest. A 22.8 m D-value[6] helideck is mounted on the southwest corner of the QU platform and has an elevation of 166 ft amsl. The highest point of the ETAP installation is the top of the gas flare pylon, at 525 ft amsl.

The ETAP complex is located at position N 57º 17.7' E 001º 39.7', 125 nm east of Aberdeen in the UK sector of the North Sea. The latitude and longitude of the helideck is N 57º 17.60' E 001º 39.65'.

The information chart at Figure 5, as used by the crew, did not provide the height of the installation ie the top of the flare stack. Nor did it provide any orientation. The position given is not that of the helideck.

1.10.2 Helicopter landing area lighting

The helicopter landing area, referred to as the helideck, is equipped with perimeter lighting. Standards and Recommended Practices for lighting are set out in Annex 14 to the Convention on International Civil Aviation, Volume II, entitled *'Heliports'*. The Standards cover both fixed and floating helidecks. The ETAP is a fixed deck and the publication states:

> *'5.3.8.7 The touchdown and lift-off area perimeter lights shall be installed at an elevated heliport or fixed helideck such that the pattern cannot be seen by the pilot from below the elevation of the touchdown and lift-off area.'*

The ETAP helideck is used for both day and night landings and departures. Civil Aviation Publication (CAP) 437, *'Offshore Helicopter Landing Areas – Guidance and Standards'*, contains the guidance material applicable to offshore helicopter operations. With regard to perimeter lighting it states:

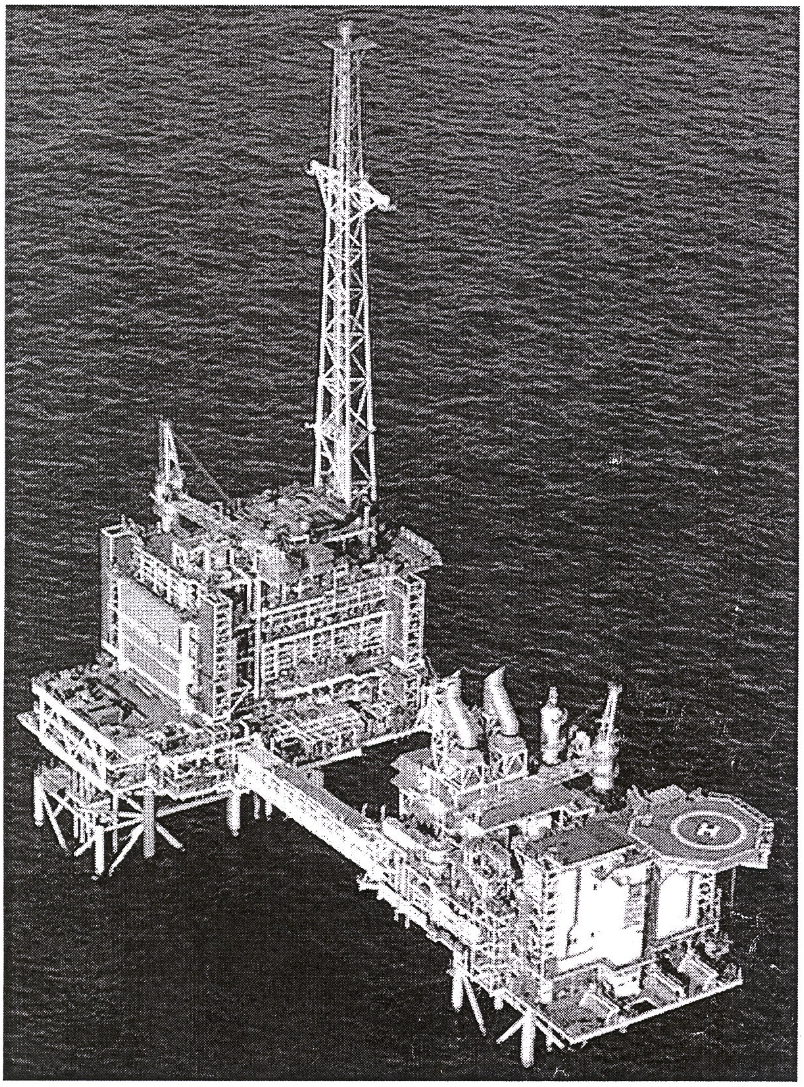
> *'The periphery of the landing area should be delineated by green perimeter lights visible omni-directionally from on or above the landing area. These lights should be above the level of the deck but should not exceed the height limitations in Chapter 3 paragraph 6.2.'*

The height limitation is 25 cm and the ETAP perimeter lights are below that limit.

6 The D-value is the largest overall dimension of a helicopter when rotors are turning.

HELIDECK ELEV **166**	Var **3°W**	Position **N57 17·7 E001 39·7**	**ETAP FIXED PLATFORM**

HEIGHT OF INSTALLATION: **-** HIGHEST OBSTACLE WITHIN 5NM: **Top of Rig**	VHF **Traffic 122.325** **Log 129.7**	NDB **'ETP' 363.5**	**D1** **8 DEC 05**
FUELLING INSTALLATION: **Yes** STARTING EQUIPMENT: **Yes**			
HELIDECK D value: **22.8m** P/R/H Category: **A** MAX WEIGHT: **32190lbs / 14600kg**	DECK MARKINGS **ETAP** SIDE MARKINGS **-**	OPERATING COMPANY **BP Amoco**	APPROVAL AGENCY **HCA**



LIMITATIONS / COMMENTS:	**NON COMPLIANCE:**
Approved friction surface - no net	Nil

Rev: Facilities

etap

Figure 5

The ETAP platform

The guidance in CAP 437 does not include the agreed international standard that the *'pattern cannot be seen by the pilot from below the elevation of the touch down and lift-off area'*, as set out in ICAO Annex 14, Volume II. The intent of which is that the pattern of lights should not be visible below the level of the helideck. However, this does not preclude individual elements of the perimeter lighting being visible from below deck elevation.

Following research and flight trials conducted by the Civil Aviation Authority (CAA), the specification of the colour of helideck perimeter lighting was changed from yellow to green. This was to be implemented by 1 January 2009. The flight trials showed that changing the colour of the lights from yellow to green significantly increased the range at which the pilot could visually locate the helideck amongst other platform lighting. Green perimeter lighting also provided a stronger colour contrast with the existing platform lighting. Trials using the green lighting concluded that it enhanced the situational awareness of a pilot and promoted greater confidence in the conduct of the approach.

Attempts by the CAA to develop a Helicopter Approach Path Indicator (HAPI) were not successful. This was due to the intensity of the HAPI light source required to contrast against the background lighting of the platform. The HAPI was so bright that it distracted the pilot flying the approach.

A recent CAA study identified an enhanced helideck lighting system. Indications to date have shown that it increases the conspicuity of the helideck and offers improved visual references for night approaches. A CAA paper, '*Specification for an Offshore Helideck Lighting System*', has been circulated for consultation. At the time of writing, it is anticipated that the research project will be completed by the end of 2010.

The ETAP helideck lighting and markings fully complied with the guidance contained in CAP 437.

1.11 Flight Recorders

1.11.1 Data sources

The helicopter was equipped with a Honeywell AR-COMBI Combined Voice and Flight Data Recorder (CVFDR)[7]. This records 25 hours of data and two hours of audio. The audio recordings include the commander's and co-pilot's communications, radio transmissions, passenger announcements and audio from the cockpit area microphones (CAM). The CVFDR was installed in

7 Honeywell AR-COMBI CVFDR part number 980-6021-066.

the tail cone, which sank to the sea bed during the accident. The CVFDR and its recordings were successfully recovered. The data recording stopped when the helicopter struck the surface of the sea. The last recorded radio altimeter height was 1.75 ft and the last recorded normal acceleration was 4.31g. The audio recordings were of a good quality and also stopped at the time of impact.

The helicopter installation also recorded a subset of the CVFDR data on a memory card situated in the control panel. This was dismantled, cleaned and copied. The data stopped two seconds before that of the CVFDR, the difference probably being due to data buffering before it was written to the memory card.

The data showed that the Mission Display (MISD) screen was not selected at any time during the 25 hours of data recording.

1.11.2 Helicopter power and control

The recorded data indicated normal engine performance, torque levels and rotor rpm throughout the accident flight. Spectral analysis of the audio recorded, using the cockpit area microphone, showed no anomalies associated with the audio signatures of the mechanical components in the gearbox and main and tail rotor transmission.

A qualitative assessment indicated that the helicopter's behaviour was consistent with the control inputs during the flight. In addition, the flight data was supplied to the helicopter manufacturer for processing through their simulation tools. The simulations showed good parameter shape correlation between the recorded and simulated control inputs and helicopter's manoeuvres. Some steady state offsets were associated with the quality of the input data and the inherent limitations of a simulation.

At no point in the recorded audio was there any indication that control problems were being experienced by the crew.

1.11.3 TAWS, ACAS and warning lights

The CVFDR did not record specific TAWS and ACAS parameters but evidence regarding their performance was obtained from audio warnings and some crew comments recorded on the CVFDR (see Table 3).

UTC (subject to alignment errors)	Extracts from recorded audio	Crew recollection
16:00 (approx)	TAWS 100 ft callout – landing at Aberdeen	
16:09 (approx)	P2: "ACAS AND TAWS"	
	P1: "OFF"	
17:26:24	POST START check list started	
17:26:58	P2: "ACAS AND TAWS" (item 9 on the check list)	
17:27:01	P1: "ON"	
17:27:29	P2: "ACAS" (item 15 on the check list)	
17:27:31	P1: "WELL WE KNOW THAT DIDN'T WORK BEFORE SO WE'LL LEAVE IT AT THE MOMENT"	The co-pilot had flown the aircraft the day before when the ACAS had not become functional until the aircraft was airborne. Also, on the previous flight, ACAS had not been fully functional on the ground but had become operational after departure.
17:27:44	P2: "TAWS" (item 18 on the check list)	
17:27:45	P1: "WE HAD THAT BEFORE, IT WORKS"	
17:27:50	P2: "..PRE-FLIGHT TEST" (item 19 on the check list)	
17:28:08	P1: "ACAS WORKS THIS TIME"	
17:28:30	PRE-TAXI checks started	
17:28:30	P2: "WARNING LIGHTS, TS, PS, DOORS" (item 1 on check list)	
17:28:31	P1: "ALL OK"	
17:28:30	BEFORE TAKE-OFF checks started	
17:36:41	P2: "AND WARNING LIGHTS, TS, PS, DOORS" (item 10 on check list)	
17:36:42	P1: "…JUST WAITING FOR THAT"	The crew recall that this was associated with the passenger door which had not yet been shut. The crew also stated that a TAWS or ACAS issue would not be a cause for delaying operations.

Table 3

CVFDR extracts relating to TAWS, ACAS and warning lights

(continued on next page)

17:36:55	EGPWS: "GLIDESLOPE, PULL UP, WARNING TERRAIN, INTERNAL GPS NOT NAVIGATING"	The commander recalls activating the TAWS self test after it was delayed from a previous check list.
17:37:38	PRE-TAXI checks started (after the passengers were boarded)	
17:37:39	P2: "WARNING LIGHTS, TS, PS, DOORS" (item 1 on check list)	
17:37:42	P1: "..WELL I DON'T KNOW WHAT YOU DID BEFORE BUT IT SEEMED TO WORK BEFORE BUT IT DOESN'T SEEM TO BE WORKING NOW."	The crew were certain in their recollection that this was associated with ACAS and not TAWS.
17:37:47	P2: "THAT'S WHEN IT'S ON TEST"	
17:37:52	P2: "IS IT JUST RUNNING THROUGH ITS TESTING? OH, DON'T LOOK GOOD"	
17:37:57	P1: "RIGHT WE'LL TURN THAT OFF … [UNITELLIGABLE]"	
17:42:15	P2: "AS YOU PULL INTO THE HOVER THE CWP IS CLEAR, EVERYTHING IS IN THE GREEN, WARNING CAPTIONS ARE OUT TOP AND BOTTOM..."	
Take off and climb to cruise		
17:49:06	CRUISE checks started	
17:50:14	P2: "… WARNING LIGHTS TS AND PS." (item 4 on the check list)	
17:50:16	P1: "WARNING LIGHTS ARE OK, TS AND PS ARE ALL OK."	
17:55:23	P1: "I'LL JUST PUT ON THIS AND SEE WHAT HAPPENS"	Despite the specific identification of the TAWS caption, the commander is certain of his recollection that ACAS was being switched on.
17:55:31	P2: "CAUTION TAWS LOOK, IT'S PLAYING UP A BIT…"	
17:55:33	P1: "NO I JUST SAID WE'LL JUST TURN IT ON AND JUST LEAVE IT ON FOR A WHILE"	
17:55:45	P1: "AND ER THIS ACAS IS THAT WORKING. NO. BUT YOU TURNED THAT OFF AND ON AGAIN BEFORE DIDN'T YOU"	
17:55:50	P2: "YEAH IT SEEMED TO, SEEMED TO SORT IT OUT"	

Table 3 (Cont)

CVFDR extracts relating to TAWS, ACAS and warning lights

After landing at Aberdeen, prior to the accident flight, the systems were shut down by the crew. Notably, some of the systems that provide TAWS with data were switched off before TAWS, in accordance with the check list.

1.11.4 Visual Decision Height Indication

The CVFDR recorded that the decision height selected by both crew was 150 ft. Decision height discretes from all four display units were consistent with the appropriate decision height indication being triggered on transitioning through a radio height of 150 ft.

1.11.5 Recorded faults

Some fault codes associated with the Autopilot Module (APM), the four MFDs and the Automatic Flight Control System (AFCS) were recorded on the accident flight and previous flights. Details explaining the codes were not available in all cases and no particular conclusions could be drawn from the information.

1.11.6 Helideck position relative to the cockpit windows

The geometric position of the helideck in the cockpit window, as seen from the nominal commander's position, was calculated for the final part (approximately 30 seconds) of the accident flight (see Figure 6). This did not address the issues of compromised visibility due to visual conditions.

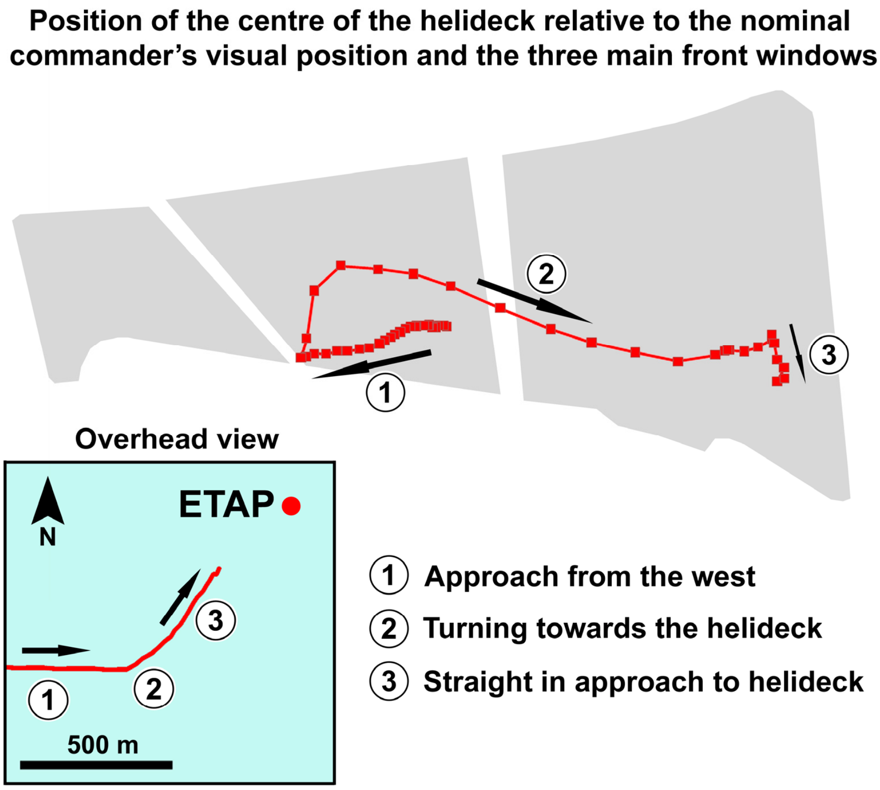


Figure 6

1.11.7 Pitch and visual angle to the helideck

The final approach on the accident flight was compared with three previous platform landings, captured in the same CVFDR data recording, to establish how representative the visual perspective of the helideck in the windscreen was prior to the helicopter striking the surface of the sea. Comparisons were also made with the angle between the sight-line to the helideck and the helicopter's longitudinal axis on each flight. Figure 7 shows that as the helicopter lost height the vertical position of the helideck in the windscreen became higher than on previous platform landings by an average of approximately 5° and that the pitch input towards the end of the flight path served to bring the visual angle back to normal.

1.11.8 Perceived pitch due to sensed accelerations

In the absence of visual cues (ie without reference to a natural horizon or aircraft flight instruments), the human body derives a sense of the vertical from the combination of vertical, fore and aft, and sideways components of acceleration, as sensed by the inner ear. Referring to this sensed vertical axis as the "g" vector and the perpendicular to this as the neutral "g" horizon, Figure 8 provides a comparison of the possible perceived pitch of the helicopter, as sensed by the crew, during the accident flight and the three previously recorded approaches. Further explanation of this somatogravic[8] illusion is provided in Appendix B.

8 A somatogravic illusion is a non-visual illusion that produces a false sensation of helicopter attitude. A full explanation is provided in Appendix A and B to this report.

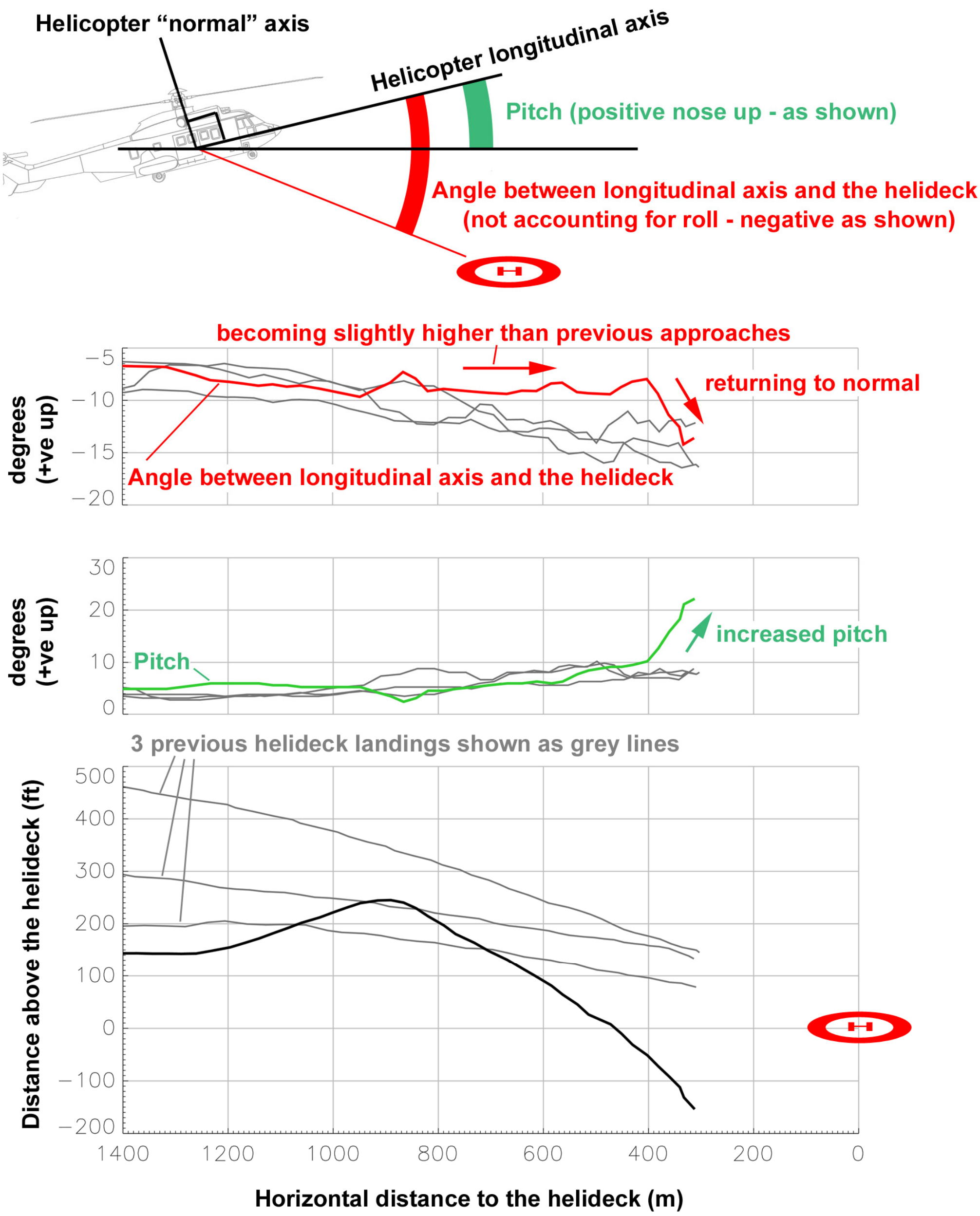


Figure 7

Comparison of the angles between the helicopter's longitudinal axis and the sight line to the helideck during the accident flight and three previously recorded platform landings

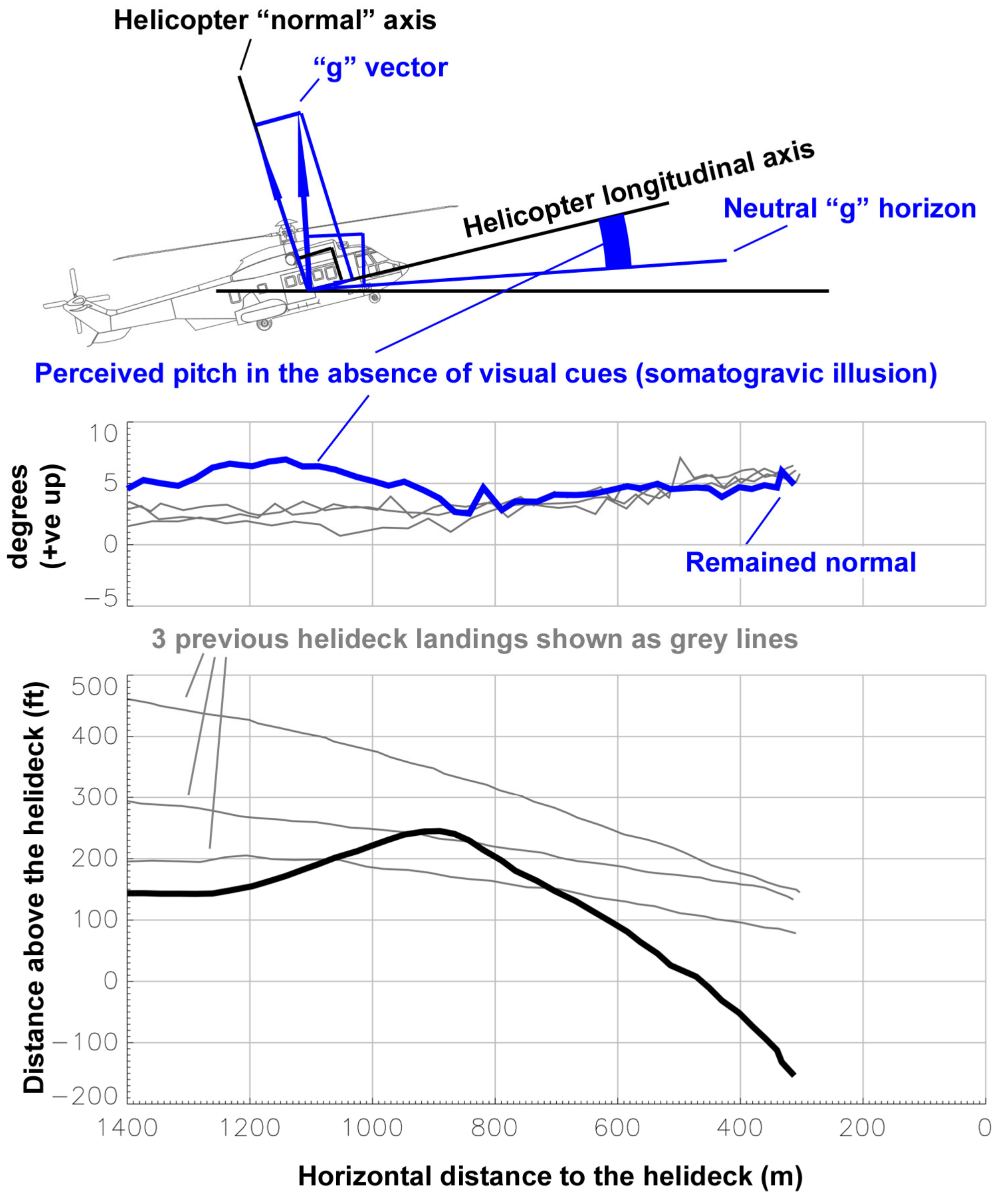


Figure 8

The perceived pitch of the helicopter during final approach, without visual cues

1.12 Wreckage, impact information and aircraft examination

1.12.1 Initial examination

Salvage operations on the day of the accident prevented early examination of the helicopter to identify the extent of any damage occurring at or prior to the impact. Video evidence subsequently showed that the helicopter initially floated upright, as advised by the occupants. By the following morning the helicopter was inverted and was being maintained afloat by the inflated units of its flotation system. It was evident that the tail boom, incorporating the CVFDR, had separated. The passengers and crew reported that it floated away from the helicopter following the impact with the water.

The main helicopter structure was subsequently pulled aboard a salvage vessel to prevent total loss. There was no opportunity to examine it before the salvage and consequently additional damage took place.

A search operation was mounted to locate the tail boom which was presumed to have sunk sometime after drifting away from the main fuselage. The general area of the initial impact was identified by fragments of material, coloured the same red as the exterior of the helicopter, lying on the sea bed. The tail boom, still containing the CVFDR, was located a considerable distance from that initial point. One main cabin door was also recovered from the sea bed.

1.12.2 Detailed examination

1.12.2.1 General

Following return of the main structure and the tail boom to the AAIB headquarters, the former was carefully examined for damage. Particular emphasis was placed on attempting to identify the area(s) from which the sea-bed fragments had originated. The only points of origin appeared to be fairings covering hydraulic pipes routing along the external fuselage skin below the boarding steps on either side of the cabin. These fairings were manufactured from thin laminates of carbon-fibre reinforced plastic (CFRP). Small parts of these fairings remained attached to brackets on both sides of the helicopter, forming sharp projections. Some of this damage may have occurred during salvage, before the aircraft was first examined by the AAIB. However, a degree of this damage was sustained during the impact with the surface of the water, as indicated by fragments observed on the sea bed.

Deformation of skin-panels on the underside of the helicopter was noted. The landing-gear was in the 'down and locked' position. The starboard main cabin door was still attached to the helicopter whilst both flight deck doors were absent. The upper and forward edges of both flight deck door apertures were considerably deformed in a manner which was not consistent with impact effects. Both left and right airframe mounted flight deck door jettison handles were in the 'door release' position and their wire 'tell-tails' were broken.

Examination of the door attachments within the damaged flight deck structure showed that no material fractures were present and the general condition was consistent with both having been ejected by operation of the emergency release handles.

All occupant seats were present, intact and free from any distortion resulting from impact forces.

The externally mounted crash position indicator (CPI) was still retained in its housing attached to the helicopter.

A general examination of the helicopter revealed no evidence consistent with a pre-impact failure of any major systems. Since the recorded data indicated that the aircraft was responding correctly to control inputs and power changes, no detailed examination of systems was carried out.

1.12.2.2 Aircraft Management Computer (AMC)

The AMC was removed and taken to the BEA near Paris for readout and interpretation. The integrated circuit, or microchip, containing the failure log was removed and the contents of the memory downloaded.

The failure log contains a summary of the most recent 250 failures. If there are multiple occurrences of the same failure on one flight, the failure is recorded up to four times. Each failure is recorded together with the time at which the failure most recently occurred (FAILAPPT), the time at which the failure most recently disappeared (FAILDISSAPT) and the number of occurrences on one flight. The timing is from an internal clock which starts at power-up of the unit itself.

The AMC from G-REDU recorded 34 failures on the accident flight (flight number 29). Table 4 shows the failure log entries relevant to the TAWS and ACAS.

FAILAPPT	FAILDISSAPT	No of Occurrences	Failure	Test
31 min 21.50 s	30 min 54.00 s	2	MFD1 TAWS BUS VALIDITY FAIL	Input fail
31 min 21.50 s	30 min 54.00 s	2	MFD2 TAWS BUS VALIDITY FAIL	Input fail
31 min 21.50 s	30 min 54.00 s	2	MFD4 TAWS BUS VALIDITY FAIL	Input fail
31 min 22.00 s	30 min 54.00 s	2	MFD3 TAWS BUS VALIDITY FAIL	Input fail
31 min 20.00 s	30 min 48.50 s	2	MFD1 ACAS BUS VALIDITY FAIL	Input fail
31 min 20.50 s	30 min 49.00 s	2	MFD2 ACAS BUS VALIDITY FAIL	Input fail
31 min 20.50 s	30 min 49.00 s	2	MFD4 ACAS BUS VALIDITY FAIL	Input fail
31 min 20.50 s	30 min 49.00 s	2	MFD3 ACAS BUS VALIDITY FAIL	Input fail

Table 4

Failure log entries in the AMC for TAWS and ACAS

The failures recorded relate to the loss of display information to the MFDs from both the TAWS and the ACAS systems. The data shows that the information was lost on two occasions during the final flight. The last occasion that the display information became available was between 30 min 48.5 secs and 30 min 54 secs (timed from when electrical power was applied to the AMC). The display information was then lost again at between 31 min 20.5 secs and 31 min 22 secs and did not return before impact.

There were no other failures recorded which related to the serviceability of the helicopter. A succession of failures was recorded between 1 hr 11 min 36.50 secs and 1 hr 11 min 51.00 secs which were associated with the impact with the water.

1.12.2.3 MFD Processor Units (PUs)

The four PUs were removed and also taken to the BEA for readout and interpretation. The integrated circuit, or microchip, containing the failure log was removed from each unit and the contents of the memory downloaded. The log consists of a flight number, the time at which the failure most recently occurred (FAILAPPT), the time at which the failure most recently disappeared (FAILDISSAPT) and a test number to indicate the nature or source of the failure. The timing is from an internal clock which starts at power-up of the unit and is synchronised with the AMC.

FAILAPPT	FAILDISSAPT	Test Number	Failure
17 min 10.50 s	End of Flight	15	bit 18 of label 172 of the selected AFCS TRUE
17 min 10.50 s	End of Flight	28	ADF/DF/Homing-3 input line invalid
17 min 10.50 s	30 min 53.50 s	32	TAWS input line invalid
30 min 43.00 s	30 min 48.00 s	31	ACAS input line invalid
31 min 20.00 s	End of Flight	31	ACAS input line invalid
31 min 21.00 s	End of Flight	32	TAWS input line invalid

Table 5

Messages on the MFD Processor Units from the accident flight

The log indicates that 17 min and 10.5 secs after the application of electrical power the TAWS input disappeared. This coincided with an ADF/DF invalid message. At 30 min and 43 secs the ACAS input disappeared, indicating that the ACAS had been ON, but went OFF, and then came ON again 5 secs later. At 30 min 53.5 secs the TAWS input became valid. The ACAS input disappeared again at 31 min 20 secs and remained inactive for the remainder of the flight. The TAWS input disappeared again at 31 min 21 secs and remained inactive for the remainder of the flight.

This log information was consistent with the information recorded in the AMC.

There were no other messages recorded relating to the serviceability of the helicopter. A succession of messages was recorded between 1 hour 11 min 36.50 secs and 1 hour 11 min 37.00 secs which were associated with the impact with the water.

An identical log of 127 failure messages was recorded in each of the units. A review of the failure messages on previous flights showed that it was not uncommon for an ACAS invalid message to be recorded during flight.

1.12.2.4 TAWS and ACAS control panels

Figure 4 in Section 1.6.8.1 includes a photograph of the TAWS and ACAS control panels as they were found when the helicopter was recovered from the sea. The control panel switches for both systems were found in the ON position; the TAWS switch guard was in place.

The TAWS and ACAS control panels had basic testing carried out at the AAIB and, once the corrosion was removed, more comprehensive testing at the manufacturer's facilities. No faults were found.

1.12.2.5 TAWS and ACAS wiring

The ACAS and TAWS wiring on the recovered wreckage was tested to ensure appropriate continuity or isolation in the power, grounding, indication and interlinking wiring. The EGPWS computer was located in the tail of the helicopter which became detached from the main body during the accident sequence. This disrupted a significant amount of wiring between the TAWS control panel and the EGPWS computer. Wiring checks took this into account.

The ACAS wiring, other than the inhibit wiring from TAWS, did not involve any identified accident-related disruption. However, the ACAS transceiver had to be removed to enable access to the TAWS wiring.

The TAWS circuit breaker was found engaged in its normal position and the ACAS circuit breaker was found disengaged. It could not be determined whether the latter circuit breaker disengaged whilst the helicopter was still in the air or as a result of the impact sequence.

There was good continuity of the 28v dc wiring from before the TAWS circuit breaker, through the control panel to the tail break. There was also good continuity of this wiring on the tail side of the tail break to the EGPWS. There was a low resistance to ground of the TAWS 28v dc wiring in the section which was disrupted when the tail detached. In an operational helicopter, a low resistance on this wire would induce a current sufficient for the TAWS circuit breaker to isolate the circuit. No anomalies were found with TAWS grounding.

With the TAWS control panel in its (as found) ON state, there was a good continuity of the ground signal to the PUs to signify that the TAWS was switched on. Testing on the TAWS indication wiring did not find any discrepancies.

No anomalies were found in the wiring associated with the TAWS ability to inhibit ACAS.

Resistance between the TAWS and ACAS control panel ground points varied depending on pressure applied to the side of the ACAS control panel. This was possibly due to corrosion associated with the sea immersion after the accident. A link could not be established between this finding and the inoperative status of ACAS and TAWS during flight.

A contact on the ACAS control panel, which is normally grounded, was found not to be so. The function of the contact is associated with the control panel lighting. No link could be made between this and the recorded system behaviour.

1.12.2.6 EGPWS examination

The EGPWS was removed from the tail of the helicopter on recovery from the sea, cleaned, dried and taken to the manufacturer's facilities for data recovery. The unit was downloaded successfully (see Table 6) but it subsequently suffered power supply problems which halted further work to assess the overall serviceability of the unit. However, the processor board was tested and found to be serviceable. The inhibit link to the ACAS was also tested. No fault was found.

The EGPWS MkXXII records a number of events to internal non-volatile memory (NVM). These are triggered by specific conditions defined by the software design. These records are stamped with a system time stamp. This is a clock that starts running once the EGPWS has finished initialising. The clock carries on from the time reached when the EGPWS was previously shut down. The time stamp therefore refers to the total powered time of the unit, less initialisation times. The application or removal of power from the EGPWS is not recorded. This hampers the alignment of recorded events with phases of flight. However, during system testing on other fully functioning EC225 EGPWS installations a link was established between the system being switched off, or losing power, and EGPWS TERRAIN INHIBIT ON messages being recorded. Documented tests conducted by the AAIB showed that each of the seven instances of removal of power, using the circuit breaker or TAWS OFF switch, created a TERRAIN INHIBIT ON record. Further review of the CVFDR data showed five clear instances where power was removed

System time	Record
36:55:14	NEW CONFIGURATION MODULE – the record indicated that the last configuration change occurred a significant number of flight hours before the accident flight and reflected a configuration consistent with the certified installation.
224:02:48	LANDING – triggered as the aircraft descended through a radio height of 50 ft. The location was consistent with landing at Aberdeen. The pattern of previously recorded takeoff and landing records indicated that this landing was from the flight prior to the accident flight.
224:11:10	Multiple EGPWS external faults.
224:11:13	TERRAIN INHIBIT ON – this record is generated when the crew inhibit TAWS and on the majority of occasions that TAWS is switched off at the control panel or the TAWS circuit breaker is pulled.
224:12:04	TERRAIN NOT AVAILABLE – NO VALID POSITION - Commonly triggered when the GPS is unable to provide a fix when the system is initialized and when GPS satellites are obscured.
224:17:08	
224:19:39	
224:20:31	SELF TEST, LEVEL 1 – crew initiated test. The record shows that it did not have a valid position fix.
224:20:49	TERRAIN NOT AVAILABLE – NO VALID POSITION
224:21:17	TERRAIN INHIBIT ON – the record showed that at this time the system had a valid position for Aberdeen but that it was dead reckoning and did not have a GPS fix. A true heading of 175° and a corrected altitude of 184 ft were recorded.
224:21:19	RUNWAY ENTRY – the record showed no valid positional information but a true heading of 86°.
224:21:20	TAKEOFF – the record also changed the flight leg.
224:21:46	TAKEOFF – the record also showed that no change in flight leg was made and a position source of "IRS2" was indicated. This is consistent with the unit having been powered on a test bench without a configuration module attached.

Table 6

EGPWS recorded events

from the accident helicopter between sets of flights prior to the accident. All but one of these were associated with a TERRAIN INHIBIT ON record in the EGPWS removed from accident helicopter. Therefore, in eleven out of twelve instances where power was deliberately removed from the system a TERRAIN INHIBIT ON message was recorded. The helicopter manufacturer also reported achieving both outcomes in testing but at the time of publishing the report, the details of this testing were not available to the AAIB. Testing also showed that removing power at the EGPWS but not from the control panel does not result in the TERRAIN INHIBIT ON record being generated. It is likely that the recording of the TERRAIN INHIBIT ON record is associated with the TAWS control panel TERRAIN INHIBIT discrete becoming active when power is removed from the control panel, and the EGPWS holding its power up just long enough to register this before it shuts down.

Bench tests showed that powering a MkXXII EGPWS, as if it was in the air, having previously been shut down whilst on the ground, results in a RUNWAY ENTRY record followed by a TAKEOFF record.

1.12.2.7 Summary of evidence

Figure 9 is an amalgamation of the evidence associated with the aircraft's TAWS. The AMC and MFD PUs used synchronised clocks, for time stamping records, which were separate from the clock used by the CVFDR. The CVFDR and AMC-based sources ran at slightly different speeds such that there was a 10 second discrepancy in the time between takeoff and impact. For the purpose of this investigation it was assumed that the clock speed difference was constant and as such was taken into account when aligning the data sources. The final EGPWS records were aligned to the MFD PU records of TAWS validity.

The recording showed that the TAWS "ONE HUNDRED" foot height callout was operational during the previous landing.

Crew discussion on the ground indicated prior problems with ACAS. The MFD PU data showed periods of ACAS being invalid whilst airborne during previous flights.

The TAWS and ACAS were both switched OFF after the previous landing, and back ON again after the engines were restarted, as part of the *'POST START'* checklist. The checklist also required that both systems were tested. The crew refer to the ACAS system when they said: "WELL WE KNOW THAT DIDN'T WORK BEFORE SO WE'LL LEAVE IT AT THE MOMENT", indicating that they had problems with ACAS during the previous flight. On that occasion, the problem was overcome by switching the system to standby and then successfully back ON early in the flight. However, the pre-flight test, which included an ACAS element, was successful. The CVFDR recordings show that the TAWS test was successfully carried out later.

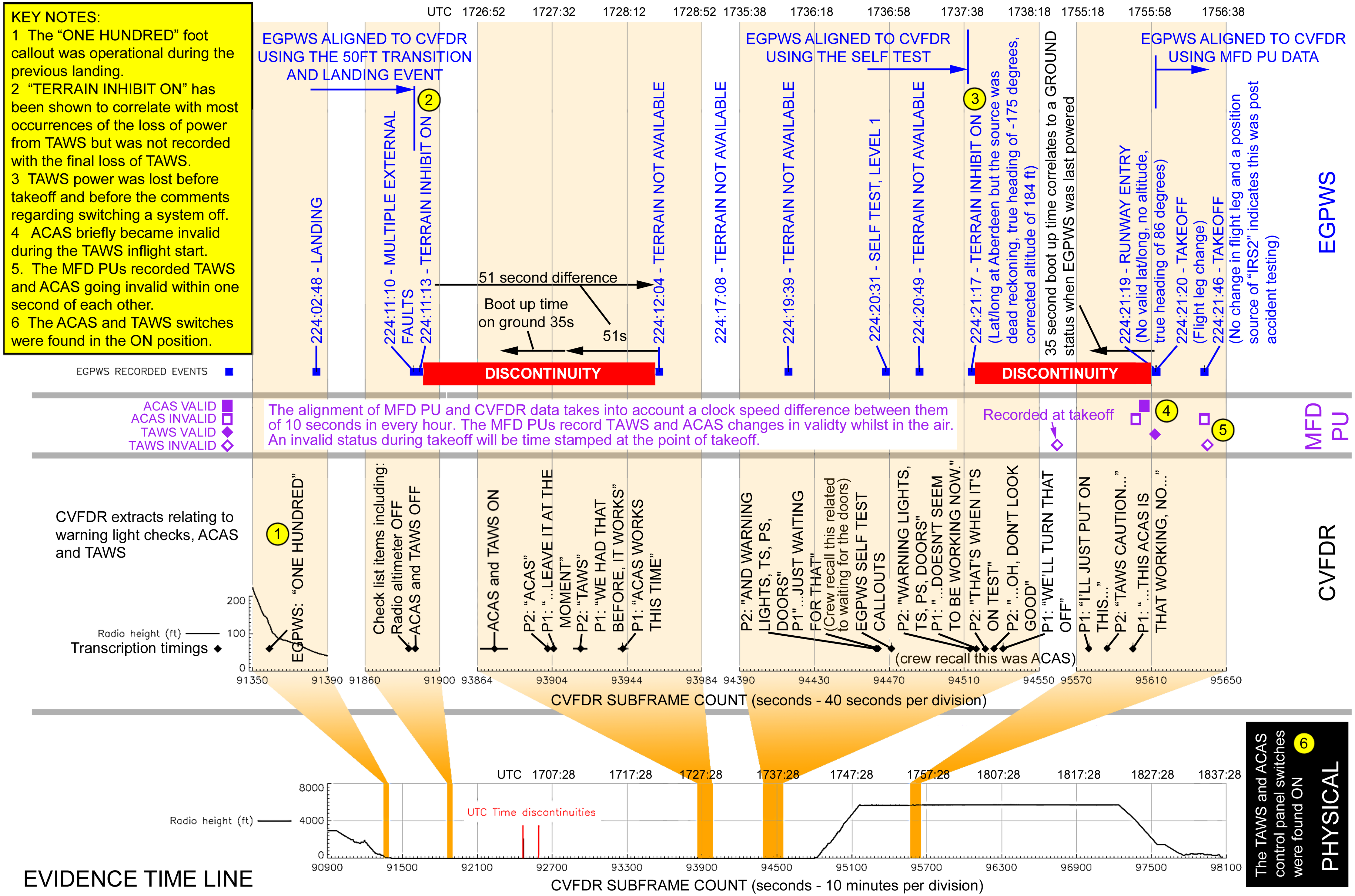


Figure 9

The evidence associated with the TAWS system

A problem was identified during the *'PRE-TAXI'* check before flight. At about the same time, the EGPWS recorded a TERRAIN INHIBIT ON event. This record is generated when the crew inhibits TAWS and on the majority of occasions that TAWS is switched off at the control panel or the TAWS circuit breaker is pulled. Later the crew stated "RIGHT WE'LL TURN THAT OFF..." The crew were certain, in their recollection, that the system they were referring to was ACAS. This implied that the loss of power was not initiated by the crew. However, at the point of the subsequent takeoff the MFD PUs recorded that ACAS was valid and that TAWS was invalid. Therefore, the MFD PU and EGPWS data provides evidence that TAWS was not powered and the CVFDR timing suggests that this was independent of crew action. However, the system is designed such that the combination of TAWS not being powered and not switched OFF at the control panel results in status indications on the CWP and on the PFD. The CVFDR recordings did not capture any mention of this and the crew's recollection was that that the captions were clear. The crew recalled that ACAS was the problem and the commander thought that ACAS was switched OFF using the ON/OFF switch. The crew's recollection that they switched the ACAS OFF disagreed with the MFD PU ACAS validity records. Either the recollection was mistaken or the systems did not respond appropriately to the switch selection.

Early in the cruise, the CVFDR recorded the commander referring to switching a system ON. Again, the commander recalled that this was associated with ACAS. However, the timing and subsequent activity of the TAWS caption, MFD PU records and EGPWS internal recordings indicate that the action initiated power to TAWS. This was associated with a 5 second loss of ACAS validity during the TAWS initialisation period. Eurocopter testing and manufacturer design information showed that TAWS initialisation does not affect ACAS validity. It has not been ruled out that this was associated with a crew action. In the cruise, 27 seconds after the TAWS system became operational it failed, together with ACAS; the MFD PU recordings show them becoming invalid one second apart.

The CVFDR recording did not include any crew communications regarding switching either system OFF, which was contrary to all the other recordings of their interactions with ACAS and TAWS. There was also no TERRAIN INHIBIT ON record in the EGPWS. Testing on a fully functional helicopter could only reliably achieve this by leaving the TAWS switch ON and disconnecting power from the EGPWS at its interface. This was also achieved on one out of the twelve occasions that TAWS was switched OFF using the TAWS OFF switch or power was removed using the TAWS circuit breaker. The combination of the system being invalid whilst selected ON would normally have yielded a status indication to the crew, yet the crew did not recall any TAWS indications to support this.

The ACAS and TAWS control panel ON/OFF gated toggle switches are designed to stop inadvertent switch operation, since positive action is required to operate the switch. The ACAS and TAWS control panel switches were both found in the ON position. Functioning of the switches showed that they operated to prevent accidental switching, as designed. The control panels were cleaned and tested at the manufacturer's facility. No problems were found.

The EGPWS was cleaned and fully tested after the accident. After a significant period of operation in the laboratory, the power supply capacitors started to fail. It is assumed that this was as a result of sea water contamination. Further testing of the processor boards did not reveal any problems with any of the input or output circuits, including the ACAS inhibit link.

The MFD PU data did not reveal any periods of TAWS invalidity during the previous flights examined. The same records showed periods of ACAS invalidity during the majority of the previous flights examined.

Testing of the ACAS unit was not carried out as the failure of this system was not identified as significant until later in the investigation, by which time it was likely that too much corrosion had taken place to make any testing meaningful. Had TAWS and ACAS system status been recorded in the CVFDR, the coincidental timing of the failure of both systems could have been identified early in the investigation and prompted appropriate action.

Analysis of the system designs showed that ACAS and TAWS were powered by completely separate dc buses. The only wiring associated with power to the systems, that was common to both, was the inhibit link used by TAWS to inhibit ACAS from issuing any aural warnings during a TAWS warning. No anomalies associated with this link were found in the helicopter wiring. The EGPWS testing carried out at the manufacturer's facilities included the internal circuitry associated with this function and did not indicate any problems. The ACAS was designed so that an inhibit signal from TAWS would delay any ACAS audio messages but not have any affect on the validity of the ACAS outputs. The recorded data from the period of the 100 ft callout of the previous landing demonstrated that the TAWS audio had no affect on the ACAS validity. This agreed with the behaviour observed when testing fully operational installations, as predicted by the ACAS manufacturer.

The ACAS and TAWS components were distributed in different locations around the helicopter, with the exception of the control panels which were mounted adjacent to each other on the centre console. There was a fault relating to the lighting ground wiring on the ACAS control panel which was present before the accident, but, in isolation, this would not cause both systems to fail. All other ground points associated with the installations were found to be satisfactory. Any installation anomalies which were discovered were associated with damage sustained during the accident.

In summary, the evidence indicated a failure mode associated with the anomalous behaviour of ACAS and TAWS. Testing of the EGPWS at the manufacturer's facilities, wiring checks of the helicopter ACAS and TAWS installations and testing of the system's control panels did not yield any cause which could account for the loss of both systems.

1.13 Medical and pathological information

There were no injuries.

1.14 Fire

There was no fire.

1.15 Survival aspects

1.15.1 Cabin and flight deck layout

The passenger cabin had seating for 19 passengers. The seat distribution and orientations are shown in Figure 10.

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

For normal operation, the doors initially translate in an outboard direction from their closed positions in their apertures. They then slide forwards, on rails, along the outside of the cabin, towards the fully open position. Once in this position they fit closely alongside the cabin outer skin.

The doors can be jettisoned for emergency evacuation. To enable this, a D-ring is positioned in a recess on the cabin wall, beneath a transparent cover, approximately 23 cm forward of the upper forward corner of the door

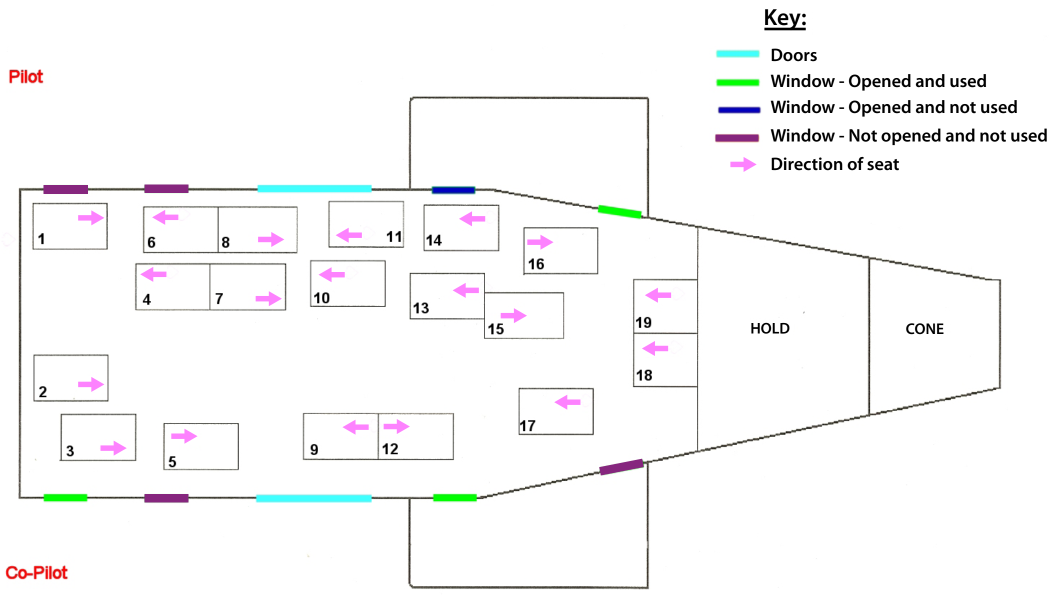


Figure 10

aperture. The D-ring can be pulled to enable the doors to fall vertically from their attachments. (Additional jettison release handles are positioned adjacent to each door aperture in a recess on the outside of the cabin above the leading edge of the sponson.)

The orientation of the seats in G-REDU was such that the seats adjacent to the forward edge of the right cabin door aperture faced rearwards. They effectively obscured the inner D-ring on the right cabin wall from the view of passengers sitting beside the right door (see Figure 12 on page 57).

The flight deck on the helicopter has two hinged exit doors, positioned on either side of the fuselage, one next to each crew seat. Torches are stowed in each of the doors, primarily for use in night evacuation situations. If the torches are not removed before the doors are jettisoned, they may be lost. The doors can be jettisoned in an emergency by operating an external or internal jettison handle fitted to a spindle located on the forward frame of the door aperture, or opened normally using handles mounted on the rear edge of each door. Normal opening of the flight deck doors is impeded by the forward flotation unit when the latter is deployed (see Section 1.15.2). In this accident, it was reported by the commander that the flotation equipment impeded the jettisoning of his door.

All cabin window transparencies can also be jettisoned, to facilitate rapid evacuation. Such rapid exit is possible if the main doors are also jettisoned or remain closed. However, those window exits positioned forward of the cabin doors are obstructed and unusable if the door on the relevant side is slid forward to the open position.

1.15.2 Flotation equipment

The helicopter was equipped with an emergency flotation system consisting of three inflatable units. One was attached to the side of each of the two sponsons, both forming longitudinal cylinders when inflated. The third was attached around the nose of the helicopter just below flight deck floor level, forming a horseshoe-shaped flotation bag when the system operated. Inflation could be initiated automatically, or manually by crew action.

1.15.2.1 Inflation of the flotation equipment

In this event, the flotation bags inflated automatically when the aircraft made contact with the surface of the water.

JAR-OPS 3.843 (a) states:

> *'An operator shall not operate a Performance Class 1 or 2 helicopter on a flight over water in a hostile[9] environment at a distance from land corresponding to more than 10 minutes flying time at normal cruise power unless that helicopter is designed for landing on water or is certified in accordance with ditching provisions.'*

This means that most offshore helicopters are fitted with emergency flotation bags. These can be inflated manually by the crew or automatically when fitted with a water deployment switch that is activated on contact with water.

Whilst this accident did not involve an intentional ditching, the fact that the flotation system was armed and that the flotation bags deployed automatically demonstrably had a positive effect on the outcome.

In March 1992, an AS332L Super Puma, G-TIGH, was involved in an offshore accident. The helicopter was equipped with emergency flotation equipment but the crew did not have time to activate it manually before the helicopter struck the surface. The helicopter remained at the surface for one or two minutes, generally inverted and awash, before it sank. Among the 17 occupants there

9 JAR-OPS 3 states that a hostile environment includes *'For overwater operations, the open sea areas North of 45N and South of 45S designated by the Authority of the State concerned'.*

were 11 fatalities, all as a result of drowning. The AAIB report 2/93 on the accident commented:

> *'In an accident scenario it is unreasonable to rely on flight crew initiation of the emergency floats and therefore an automatic system is highly desirable.'*

The report summarised 28 other helicopter accidents involving collision with the sea for no apparent airworthiness cause.

As part of the AAIB investigation into the accident involving G-TIGH, a number of cases were examined in which helicopters, equipped with flotation equipment but without an automatic deployment system, had accidents that involved impact with a water surface. In most of the cases of controlled ditchings, the crew was able to inflate the flotation equipment successfully. However, in none of the cases of unintended impact with water had the crew been able to inflate the flotation system. This work led directly to the AAIB's Safety Recommendation 93-26, which stated:

> The CAA should consider amending certification requirements for public transport helicopters operating over the sea to include a suitable system for manual and automatic inflation of emergency hull flotation equipment and that this requirement should also apply to helicopter types currently in service.

Since that report, there have been other instances where helicopters have impacted the water in an uncontrolled manner and the flotation equipment has survived the impact but not been manually activated by the crew.

1.15.3 Survival liferafts

The helicopter was equipped with two double-sided RFD/Beaufort 18 MK 3 inflatable liferafts. Each had a deployable canopy and capacity for 18 occupants, with a nominal overload capacity of 27. They were mounted, together with their inflation systems, in the forward sections of the helicopter's sponsons, on either side of the fuselage.

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

(1) Operation of a D-ring, positioned near the top of the bulkhead behind each flight crew position, inflating and deploying the liferaft on the corresponding side of the aircraft.

(2) Operation of deployment handles, positioned externally in recesses on each side of the helicopter just aft of each cabin door, inflating and deploying the liferaft on that side of the helicopter.

(3) Removing either liferaft cover from its sponson, inflating and deploying the enclosed raft.

Once the liferafts deploy, they remain attached to the helicopter by two lanyards. The shorter lanyard enables the liferaft to remain close to the helicopter, thereby assisting and simplifying the task of the passengers and crew in boarding. Procedures call for this lanyard to be cut as soon as the passengers are all on board. The second lanyard is a 12 m line designed to keep the liferaft with the helicopter, thereby assisting location, but sufficiently clear to limit the chances of it becoming damaged by contact with the helicopter.

Instructions on the use of the liferaft are annotated diagrammatically on the inner faces of each of the main rings forming the semi-rigid structure of the inflated raft. These instructions are visible to survivors once they are onboard, if sufficient lighting is available. Each liferaft contains a survival bag in which are stowed various items including flares, water, seasickness tablets, immediate action survival guides, an aircrew survival flip-card and a locator beacon.

Liferafts of this type are of lightweight construction and, even when loaded with the canopies down, have limited draft and considerable freeboard. Thus, they drift readily in windy conditions. They are equipped with drogues or sea anchors to stabilise them and limit the amount of drift. The sea anchor also keeps the liferaft orientated in a particular direction in relation to the wind. Because of the risks of a sea anchor becoming entangled with the helicopter, it does not deploy automatically. It is stowed on the liferaft and is available for manual deployment once the second, longer lanyard is cut. Failure to deploy a sea anchor during a helicopter rescue is likely to make the operation more difficult, since the downwash can cause an unrestrained liferaft to drift rapidly across the surface.

The instructions annotated on the inner faces of the main rings of the liferafts do not include a reminder of the need to deploy the sea anchor. However, instructions on its deployment are contained in the survival flip-cards and the immediate action survival guides. The minimum performance standards for liferafts used in aviation are contained in the European Aviation Safety

Agency (EASA) European Technical Standard Order (ETSO) 2C70a and ETSO 2C505, and Federal Aviation Administration (FAA) Technical Standard Order (TSO) C70a.

Subsequent examination and re-inflation of the liferafts confirmed that the lower ring of the left liferaft was torn and deflated.

The EC225LP was certificated to JAR29 Chg.1, effective 1 December 1999; this included the Acceptable Means of Compliance and Interpretations which referenced FAA AC.29-2B. This AC 29-2B, originally dated 30 July 1997, was updated to Change 1 on 30 September 1998. The FAA AC 29 was totally revised in 1999, to become the AC 29-2C dated 30 September 1999. The certification practices always tend to use the latest available standards. Therefore, practically, for the EC225 Type Certificate (TC), the AC.29-2C has been used instead of the AC 29-2B. Since the original certification of the EC225, the AC 29-2C has been further revised several times, the latest revision is Change 3 dated 30 September 2008 (see Appendix E).

Experience on earlier offshore accidents showed that inflatable liferafts were frequently punctured as a result of contacting sharp projections on the exterior of floating helicopters. Regulations (ref Certification Standard (CS) 29 Advisory Circular (AC) 29.801) were introduced for ditching, which the CS defines as:

> *'an emergency landing on the water, deliberately executed, with the intent of abandoning the rotorcraft as soon as practical.'*

They include the following consideration:

> *'(D) Probable damage due to water impact to the airframe/hull should be considered during the water entry evaluations; i.e. failure of windows, doors, skins, panels, etc.'*

There are no similar requirements for water impact outside the criteria applicable to a ditching.

The CAA published a summary report (CAA Paper 2005/06) in 2005 which summarised the results of research aimed at improving the safety of offshore helicopter operations. It referenced a Helicopter Offshore Safety and Survivability working group Paper on Helicopter Safety and Occupant Survivability (HOSS/WP-99/8.5). This reviewed the airworthiness standards currently associated with both intentional ditching and unintentional water impact, in the light of service experience and ongoing research into occupant safety and survivability, and identified '*requirement inadequacies'*. On the subject of '*life-raft Installation'*, it included the following proposals:

> *'a) FAR/JAR be amended to require design of life-raft installations incorporating the following principles:*
>
> - *primary deployment by single action from normal crew positions,*
> - *secondary deployment from passenger compartment with the cabin in an upright attitude, and*
> - *deployment possible from outside the helicopter when in either an upright or inverted attitude.*
>
> *b) FAR/JAR advisory material be revised to indicate that 'delethalisation' of the fuselage area in proximity to the installation is necessary to prevent life-raft damage.'*

The CAA paper also referenced the Water Impact, Ditching Design and Crashworthiness Working Group (WIDDCWG) which was tasked to review the current regulatory requirements and advisory guidance pertaining to rotorcraft water impact and ditching. It was also tasked to review existing research data associated with rotorcraft survivable water impact and ditching scenarios. Structural ditching requirements are currently defined in terms of the horizontal and vertical velocities of the rotorcraft at the time of impact with the water. The WIDDCWG concluded:

> *'that, although impact velocity greatly affects impact loads, other impact parameters also have a significant effect. In particular, the attitude of the rotorcraft fuselage skin relative to the surface of the water at impact has a large effect on local impact loads; it is not considered practical to define an impact attitude envelope as this depends on the condition of the water surface at the point of impact as well as the attitude of the itself, and is therefore highly variable.'*

Their recommendation on water impact crashworthiness was:

> *'Structural ditching requirements should not be expanded to consider crashworthiness due to:*
>
> *a) high variability of the impact loads, and*
>
> *b) impact loads in survivable accidents can be too high to design for in a practical manner.'*

1.15.4 Electronic location devices

1.15.4.1 Helicopter mounted equipment

The helicopter was equipped with an externally mounted, deployable crash position indicator (CPI). The CPI was mounted on a panel forming the lower left side of the aft extension of the baggage hold at the rear of the main cabin. Deployment could be achieved as a result of any one of the following three actions:

(1) Operation of a g-switch registering more than 6g acceleration in any direction.

(2) Manual operation by a crew member from the flight deck.

(3) Automatic operation by immersion in water of a water switch, positioned just above cabin floor level behind the cabin trim and slightly aft of the left main cabin door aperture.

Regardless of the deployment method, automatic transmission commences once it has separated from the helicopter. The release system uses a very small explosive charge and a light spring to project the CPI away from the helicopter. The CPI subsequently floats and transmits on 406.0 MHz as well as on 121.5 and 243.0 MHz.

The CPI may be switched to a transmit function by the crew whilst the helicopter is in flight.

The CPI fulfilled the requirement in JAR-OPS 3.820, *Automatic Emergency Locator Transmitter*, paragraph (b), that states:

> *'An operator shall not operate a helicopter in Performance Class 1 or 2 on a flight over water in a hostile environment as defined in JAR-OPS 3.480(a)(12)(ii)(A) at a distance from land corresponding to more than 10 minutes flying time at normal cruising speed, on a flight in support of or in connection with the offshore exploitation of mineral resources (including gas), unless it is equipped with an Automatically Deployable Emergency Locator Transmitter (ELT(AD)).'*

1.15.4.2 Other location equipment

Four hand-portable locator beacons were carried in the helicopter. One was incorporated in each of the pilot's life-jackets and there was one stored in each liferaft survival bag. The former are known as Personal Locator Beacons (PLBs) and the latter as an Emergency Locator Transmitter (Survival) (ELT(S)). All four of these units were, however, of identical TechTest 500-12Y design and, like the CPI, JAA approved equipment.

Once switched on, the units transmit coded identification signals on 406.0 MHz, which interface with the international Cosmicheskaya Sistyema Poiska Avariynich Sudov / Search and Rescue Satellite (COSPAS/SARSAT) distress alerting system. The transmitted signal takes the form of short pulses spaced at approximately 50 second intervals.

This system uses geostationary satellites to detect the initial emergency transmission, whilst low earth orbit (LEO) satellites receive a signal and enable the approximate position of the point of origin of that signal to be established over a period of time. The time delay is present since at least two LEO satellites need to be in receipt of an unobstructed signal for triangulation to take place. Although the system is capable of receiving and relaying a GPS position message, neither the CPI nor the 500-12Y units in G-REDU were GPS enabled.

In addition to its 406 MHz function, each of the ELT(S)/PLBs is capable of broadcasting continuous homing signals on 121.5 MHz and 243.0 MHz frequencies. The signal detection range is up to a nominal 40 nm for a search aircraft operating at 3,000 ft. For maximum effectiveness, particularly on the 121.5 MHz frequency, the antenna of each ELT(S)/PLB must be pivoted to the vertical position and the telescopic upper section must be extended. It must remain clear of any wet clothing.

The ELT(S)s/PLBs also have the facility to receive signals on 121.5 MHz and 243.0 MHz. If an external signal on 121.5 MHz or 243.0 MHz is detected when one of these ELT(S)s/PLBs is selected ON, it will operate only in standby mode and not transmit on these frequencies. In the case of multiple ELT(S)s/PLBs in the same vicinity, the first ELT(S)/PLB to transmit becomes the 'master'. It will be the only 500-12Y unit transmitting, until it is switched OFF, its battery becomes depleted or it otherwise ceases to function. The other ELT(S)s/PLBs of this type, in receipt of such signals, remain in standby mode and do not transmit on either of these frequencies whilst external signals are being received from the 'master' ELT(S)/PLB.

This 'smart' feature is designed to avoid the difficulty experienced in homing to two different ELT(S)/PLBs, in close proximity, transmitting on the same frequency. In addition, the battery life of those ELT(S)/PLBs in standby mode is conserved. Once the transmitting ELT(S)/PLB ceases to function, another adjacent 500-12Y ELT(S)/PLB, switched ON and in standby mode, will activate and start transmitting on 121.5 MHz and 243.0 MHz.

The TechTest 500-12Y ELT(S)/PLBs have a voice broadcast facility to assist communication during the final rescue phase. Operation of the 'Press-To-Transmit' button allows the voice of a survivor to be broadcast on 121.5 MHz and 243.0 MHz and to be heard by the crew of a rescue aircraft. This function overrides the 'smart' feature of beacons working in close proximity and allows voice transmissions to take place whilst other beacons are functioning.

Although operating instructions are annotated on the bodies of the beacons, no mention is made of the requirement to position and extend the telescopic antenna section correctly. The crew were unaware of this requirement and did not recall receiving any training on this aspect.

The 406 MHz signal, and hence the COSPAS/SARSAT function, is not affected by the 'smart' feature. The signal will continue to be transmitted by the beacon, even if other 406 MHz signals are being transmitted locally.

1.15.4.3 Passenger location equipment

Passengers on the helicopter were provided with special wrist watches, which incorporated low power transmitters functioning on 121.5 MHz. These Wrist Watch Personal Locator Beacons (WWPLBs) are issued in an armed condition before passengers enter a helicopter and, thereafter, transmit a distress signal on that frequency whenever they come into contact with salt water.

The primary purpose of the WWPLB is to assist in close range location of individual passengers who may have been unable to board a liferaft. Amongst other functions, the WWPLBs are capable of operating automatic alarms in the control rooms of nearby oil and gas platforms and certain surface vessels as part of the oil company's Jigsaw Project (see paragraph 1.15.7), should a WWPLB wearer fall overboard whilst working offshore.

Although the signals from the WWPLBs are understood to be capable of receipt at up to 5 nm range in certain directions and under ideal conditions, the actual transmission range of their signal is usually reduced, especially when worn by liferaft occupants following extensive exposure to the elements. Under such circumstances, they are unlikely to be orientated and positioned optimally to maximise their broadcast signal.

It is known that a number of types of low-power 'personal wear' PLB devices, in the form of wrist watches, pendants and other items, capable of being worn on the body, are available worldwide.

1.15.5 Survival training

The crew and passengers had all received helicopter underwater emergency training. This consisted of classroom instruction and practical experience in a Helicopter Underwater Escape Trainer (HUET). This training covered the actions that should be taken in the event of a helicopter ditching. It also covered the actions that the survivors should take on entering a liferaft, including deploying the sea anchor once clear of the helicopter.

The passengers had also been shown the helicopter passenger safety briefing video immediately prior to the flight. This briefing showed the passengers what to do in the event of an emergency landing on water and how to jettison the helicopter's doors and windows. Whilst the video showed the starboard door being jettisoned, it did not make clear that the release mechanism was not readily accessible from the vicinity of the door.

1.15.6 UK Search and Rescue (SAR) organisation

The Maritime and Coastguard Agency (MCA) is the organisation responsible for UK maritime SAR. The role of SAR Co-ordinator is undertaken by Her Majesty's Coastguard (HMCG), which is responsible for the initiation and co-ordination of civil maritime SAR within the United Kingdom Search and Rescue Region (UKSRR). This is achieved through a network of Maritime Rescue and Co-ordination Centres (MRCCs). For each SAR incident the MRCC allocates a Search Mission Co-ordinator (SMC).

The Ministry of Defence (MOD) is responsible for the co-ordination of civil and military aeronautical SAR assets. This is carried out by the Aeronautical Rescue Co-ordination Centre (ARCC) at RAF Kinloss. The ARCC co-ordinates the use of military SAR assets and MCA SAR helicopters, within the UKSRR, in incidents involving civil or military aircraft in distress, irrespective of nationality.

In civil maritime SAR, which may involve a response by surface vessels and aircraft, overall co-ordination of the incident remains the responsibility of MRCC. The ARCC works closely with the MRCC whenever airborne assets, military, civil or foreign, are used in civil maritime SAR in the UKSRR.

At the time of the accident, the MOD maintained one Nimrod Maritime Patrol Aircraft at RAF Kinloss at two hours readiness, 24 hours a day, for SAR duties. The Nimrod could operate to a distance of approximately 800 nm from its base and search for a period of five hours. It was equipped with radar and a comprehensive array of communications equipment which gave the aircraft the capability of directing activities at the scene. The Nimrod could drop liferafts and survival equipment to people in distress but it was more frequently employed in directing shipping and helicopters to the scene.

SAR helicopters are positioned in several locations throughout the UK. They have a maximum endurance of six hours, giving them a maximum effective radius of action of approximately 240 nm from a refuelling location. One helicopter is normally available at 15 minutes readiness at each location, between 0800 hrs and 2200 hrs, and 45 minutes readiness between 2200 hrs and 0800 hrs. SAR helicopters are capable of homing to UHF and VHF international distress frequencies.

To co-ordinate the SAR assets on-scene, the MRCC will, if appropriate, nominate an On Scene Commander (OSC). This task could have been given to the Nimrod but for incidents that are close to oil installations, this task is normally given to the Offshore Installation Manager (OIM). Where multiple air assets are involved and the role of OSC has been allocated to a ship or OIM, the Nimrod’s replacement can be asked to perform the role of Aircraft Co-ordinator (ACO). The ACO co-ordinates closely with the OSC and the SMC, and his responsibilities include maintaining the safe separation of aircraft.

1.15.7 Jigsaw Project

The ETAP platform is within an area covered by the oil exploration company's Jigsaw Project. This consists of a grouping of oil company SAR assets, including surface vessels and helicopters, predominantly based offshore, who have the declared capability, within their area, of being able to recover up to 21 people from the water in less than two hours.

Fast Autonomous Rescue and Recovery Craft (ARRC) are stowed aboard larger Regional Support Vessel (RSV) mother ships positioned in the general vicinity of constellations of platforms. The ARRCs may be launched in emergencies and can transit at up to 34 kt (in calm conditions) to the scenes of emergencies in their areas. Two dedicated AS332 L2 helicopters, each carrying four crew members (two pilots, a winch operator and a winchman) were based within the area, one on the Miller platform (approximately 90 nm north of ETAP) and one at Sumburgh in the Shetland Isles.

The Jigsaw helicopters were equipped with direction-finding equipment with a declared capability of being able to home to UHF and VHF frequencies, including those used by locator beacons, with the exception of the short-pulse 406 MHz signal format. They carried a variety of SAR equipment, including rescue winches which were operated by a single winch control box, normally positioned forward of the starboard cabin door. The aircraft's SAR role equipment did not, however, include any waterproof means of communication between a deployed winch-man and the aircraft.

The Jigsaw SAR assets are co-ordinated and tasked by an onshore co-ordinator, who is termed JIGCO. Jigsaw assets are dedicated to providing additional SAR for the oil company. They are also considered by the ARCC as an additional rescue organisation but not an integral part of the UK SAR coverage.

1.15.8 Events following the water impact

1.15.8.1 Aircraft evacuation

The passengers were not aware of anything unusual until, after "a heavier than normal" landing, the cabin began to fill with water. They then realised that the helicopter was on the surface of the sea and that the flotation bags had deployed. After a few seconds of confusion, the passengers decided to evacuate the helicopter and deploy the liferafts. The commander, who was shutting down the helicopter, reported that, due to the loss of electrical power to the Passenger Address system, he shouted instructions for the passengers not to evacuate whilst he was shutting down the engines and stopping the rotors. His instructions were only heard by one passenger, who was already evacuating.

The co-pilot operated the forward left liferaft deployment D-ring and the liferaft in the left sponson began to deploy. The commander was unable to operate the right liferaft deployment D-ring, behind his seat, as he was occupied in shutting down the helicopter and, at that stage, the rotors blades were still turning.

As the left liferaft was inflating, it seemed to the passengers to be restricted by various lanyards, so some of them assisted with its deployment. The right liferaft external deployment handles on the side of the fuselage were pulled but the liferaft did not deploy as expected, so the passengers manually removed the liferaft from its housing in the right sponson allowing it to inflate.

The helicopter remained stable and upright on the surface and the passengers evacuated through windows and doors (see Figure 11). The passengers, and the commander, exited the aircraft directly into the life rafts. The co-pilot jumped into the water, via his own door, then climbed into the left liferaft.

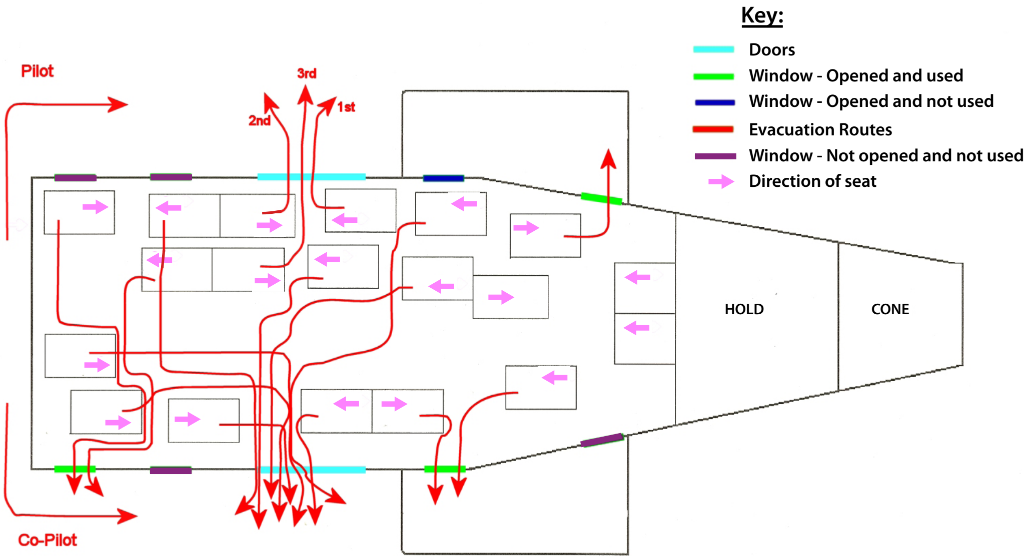


Figure 11

Passenger seating arrangement and evacuation routes

Most of the passengers did not experience any problems with the exits. However, those who were sitting beside the right cabin door were unable to locate that door's jettison handle. They opened the cabin door using the normal method and, in so doing, blocked the right forward cabin window exits (see Figure 12).

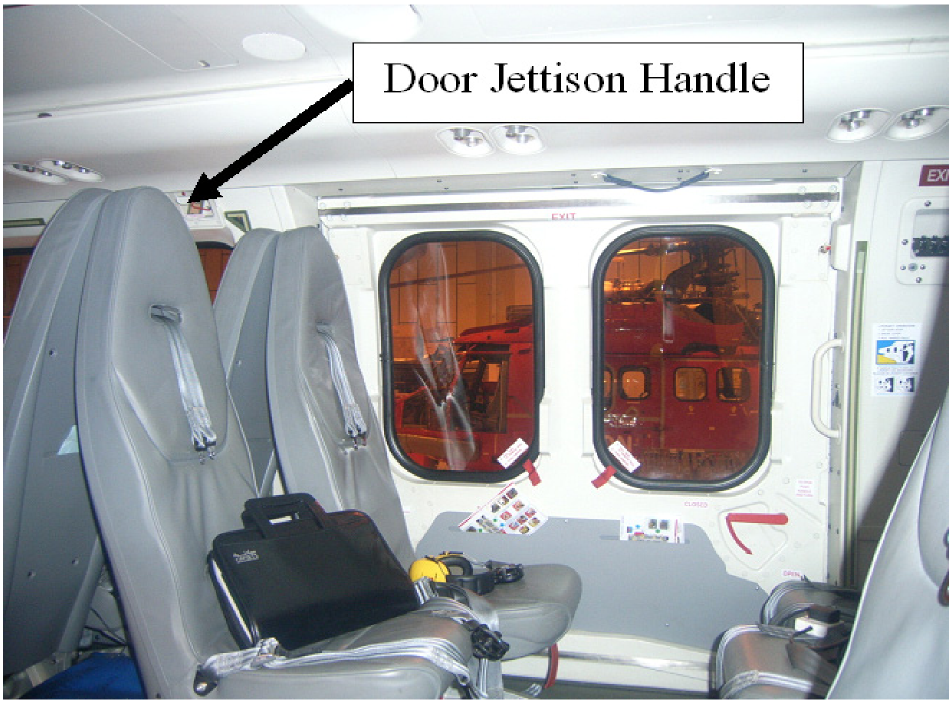


Figure 12

Position of right cabin door internal jettison handle

Thirteen people boarded the left liferaft and five people boarded the right liferaft. The short lanyards in the liferafts were severed, and later, after the helicopter rotor blades started to come close to the rafts, the decision was made to separate the long lanyards from the helicopter and attach the two liferafts together. After that, people were moved to balance the numbers in each liferaft. At no stage were the sea anchors deployed and, as the conditions were calm, the decision was made not to raise the covers of the liferafts. The commander subsequently reported that difficulty was experienced while locating the knife, for cutting the lanyard, in the dark environment.

The liferafts were in close proximity to the ETAP platform and the occupants could see the platform's lights through the 'fog'. They could also hear people on the platform shouting but, aware of the large amount of background noise on a working platform, they realised that the people on the platform could probably not hear them. The aircraft commander fired two mini-flares to let the ETAP personnel know that there were survivors from the helicopter. Two more mini-flares were fired sometime later when the survivors heard a helicopter passing in the fog. The night sections of two 'Day/Night' flares were also fired. During this period it was noted that the lower ring of the left liferaft was not inflated.

A number of the passengers experienced sea sickness and, although sea sickness tablets were available in the survival bags, the passengers experienced difficulty in removing them from the sodden cardboard packaging.

1.15.8.2 Events following the evacuation

After the occupants of the helicopter had entered the liferafts, at least three of the four ELT(S)/PLB units were activated by the crew. Three of the units correctly broadcast coded identification signals on 406 MHz and these were successfully received and logged by the COSPAS/SARSAT alerting system. No signal was identified from the second liferaft stowed unit. This unit was the only one of the four TechTest 500-12Y units not recovered.

Although at least three ELT(S)/PLB units were switched ON, no homing signal on 121.5 MHz or 243.0 MHz was detected by SAR aircraft as they approached the location of the ETAP platform.

The flight crew of G-REDU reported that voice transmission was attempted using the microphone and 'press-to-transmit' facility on one of the ELT(S)/PLBs whilst a rescue helicopter could be heard. No voice signals were reported as having been received by any rescue vessels or aircraft. Only after a period of 27 minutes, searching in the vicinity of the platform, was a faint location signal on 121.5 MHz detected.

Although the antennae were understood to have been pivoted to approximately vertical positions, from their stowage alongside the bodies of the ELT(S)/PLBs, none of the survivors reported extending the telescopic antennae. Enquiries following the accident indicated that, at the time, neither the crew nor passengers were aware of this feature and the need to extend the antennae.

1.15.9 Search and Rescue

Several witnesses on the ETAP platform saw the approaching helicopter's lights descending in the fog. They then heard a sound which they described as "like the sound a surfboard makes when you drop it into the sea". They realised that the helicopter had ditched in the sea and, at 1838 hrs, the alarm was raised with JIGCO. The MRCC was notified by JIGCO at 1840 hrs and the ARCC logged the call notifying them at 1843 hrs. The ETAP platform, like similar installations, was not equipped with a rescue craft capable of recovering the occupants of the liferafts back to the platform.

An RAF SAR helicopter, a Norwegian SAR helicopter, 2 Jigsaw SAR helicopters, 2 passenger helicopters, an RAF Nimrod aircraft, a RSV, 2 ARRC and several other ships were tasked into the area to assist with the search and rescue. The passenger helicopters made an initial sweep of the area then returned to their normal duties as the SAR helicopters approached the scene.

The first SAR asset to arrive on scene was a Jigsaw Rescue helicopter, which arrived at the ETAP platform at 1930 hrs. The helicopter was not receiving any PLB homing transmissions and commenced a search of the area in weather conditions which were described as "very poor".

At 1919 hrs a distress beacon was detected by satellite, followed at 1922 hrs and 1958 hrs by a second and third beacon.

The RAF Nimrod was re-tasked, as it was commencing a training sortie, to attend the scene and act as ACO. As it reached the area, the crew established that there were already several helicopters in the vicinity, apparently working independently. They were unable to establish communications with some of these. The rescue appeared to be fully underway and, unable to establish the full air picture, they could not provide a de-confliction service for the helicopters, which were operating in conditions of very poor visibility.

At 1957 hrs the first Jigsaw SAR helicopter located two liferafts in the water, approximately 400 m from the ETAP platform. They did so using a combination of radar, a very weak PLB homing signal, Forward-looking Infra-red (FLIR) and visual guidance from personnel on the ETAP platform. On arrival, they winched a member of the crew (the winchman) down to the liferafts to establish the number of survivors. The winchman was not equipped with a radio and had to be recovered back into the helicopter to confirm that all of the occupants of G-REDU were in the liferafts and accounted for.

The RAF SAR helicopter was the next SAR asset on scene, arriving as the winching operation commenced. It landed on the ETAP platform, from where its crew were able to observe the rescue. They also saw another helicopter, which they were unable to contact by radio on any frequency, hovering in the fog behind the winching Jigsaw SAR helicopter. This helicopter is believed to have been the Norwegian SAR helicopter that had advised the ETAP platform that it was on scene. The second SAR Jigsaw helicopter landed on a nearby rig to avoid adding to the congestion in the area of the rescue.

The winching operation was complicated by the fog and calm weather conditions in which the liferafts, without their sea anchors deployed, were being drifted by the helicopter's downwash. Without a dedicated pilot's winch switch, the crew discovered that it was difficult to winch two survivors simultaneously into the cabin, and were therefore restricted to winching one survivor at a time.

Jigsaw crews had been unable to practise winching from multi-seat liferafts due to the logistical difficulties the operator had experienced during its numerous attempts to set up the training. As a result, this was the first time that this crew had winched from a multi-seat dinghy. Furthermore, it was in the demanding conditions of a calm night, in fog involving a dinghy with no sea anchor deployed.

The close proximity of the ETAP platform was also a concern and, at one stage, the crew stopped the winching operation and used the helicopter's downwash to blow the liferafts away from the legs of the platform.

At 2023 hrs the first of the ARRCs arrived at the liferafts and the Jigsaw SAR helicopter instructed them to complete the rescue. The ARRC recovered the 15 remaining survivors and the Jigsaw SAR winchman from the liferafts, having them all safely on board by 2028 hrs. The SAR Jigsaw helicopter took its three survivors to the ETAP Platform and they were later transferred ashore by the RAF SAR Helicopter. The 15 other survivors and the Jigsaw helicopter winchman in the ARRC were transferred to their RSV before also being taken ashore.

1.15.10 Other information

The Jigsaw helicopter was equipped to home to signals radiating on 121.5 MHz, 243 MHz and 406 MHz. Although the highest frequency was not inhibited by the 'smart' feature of the ELT(S)/PLBs it was, however, unsuitable for homing using the equipment in the helicopter. The signal broadcast by the beacons on 406 MHz was not continuous; it was a specialised format, intended to integrate with the COSPAS/SARSAT system. This required a series of short period discrete signals, transmitted at approximately 50 second intervals.

1.16 Tests and research

1.16.1 Human performance

The circumstances of the accident were analysed by three Human Factors specialists, in order to try and understand the Human Performance issues related to the accident. The areas addressed were:

1. The Oculogravic (visual) illusions.
2. The Somatogravic (balance) illusions.
3. The visual effect of reflections of the platform structure on the surface of the sea.

Their reports are included in:

- Appendix A, which examines some of the perceptual and procedural Human Factors issues during the helicopter's final approach.
- Appendix B, which considers how the visual environment, the dynamic environment and their interaction led to the misperceptions suffered by the two pilots, and the consequent flight path of the helicopter.
- Appendix C, which examines the potential for visual illusion or effects that might have contributed to the controlled flight onto the surface of the sea

These appendices form the basis for the analysis of the Human Performance aspects in Section 2.1.1.

1.16.2 EC225 TAWS

Ground tests were carried out on another of the operator's EC225s to understand the operation of the EC225 TAWS installation and the recorded data. This involved following a test programme, videoing actions and system responses and capturing data from TAWS using an interface tool. Recorded data was recovered in the same format as that retrieved from the accident helicopter.

The following findings were made:

- TAWS was switched ON once with the helicopter set to an 'in-air' state. This indicated that the time between applying power and the unit becoming operational was 25 seconds. Five other power cycles were captured whilst on the ground. These indicated times of approximately 35 seconds between application of power and the unit becoming operational. The manufacturer verified that if the status during shutdown was 'in-air' then the boot time would be shorter to reduce the amount of time the system was inoperative whilst in the air.

- The EGPWS system time clock did not continue to accumulate time until after the initialisation sequence was complete. During the initialisation sequence the clock remained at the last value recorded before the unit was switched OFF.

- Switching ACAS ON or OFF while TAWS was operating had no noticeable effects on the TAWS.

- Removing power from TAWS using the circuit breaker with the control panel selected to ON, yielded a red TAWS message on the MISD screen and red TAWS indication on the primary instrument display. There were no captions on the WCP or on the TAWS control panel.

- Switching TAWS OFF using the switch on the TAWS control panel created a red TAWS message on the MISD screen but caused no indication on the other display screens or trigger any captions on the central warning panel or the TAWS control panel.

- Initiating a short self test, with no EGPWS GPS acquisition, resulted in an INTERNAL GPS NOT NAVIGATING message, in addition to the normal test aural responses.

- The EGPWS generated a self test record approximately 1.5 seconds after the switch reached TEST and 3 seconds before the onset of the test aural responses.

- Whilst in the open air, there were three measured periods between switching TAWS ON and the TAWS light extinguishing after initialisation, assumed to be associated with the time to GPS acquisition. The times were 3 min 30 secs, 3 min 28 secs and 2 min 12 secs.

- TERRAIN NOT AVAILABLE records were recorded in the live captured data which, adding 35 seconds of initialisation time (on the ground), gave real time periods, from switching ON to the event being stamped, of 1 min 25 secs, 1 min 35 secs and 1 min 25 secs, respectively. The amber TAWS caution on the CWP reactivated immediately after disappearing from the initialisation sequence (ie approx 35 seconds after switch ON). This indicated that the EGPWS, whilst indicating a lack of availability to the crew, did not stamp this in the record until later. Hence, the timing of the TERRAIN NOT AVAILABLE record did not reflect when the condition started or when this was indicated to the crew.

- It was noted that the helicopter rotor blade being directly over the GPS antenna seemed to affect the acquisition time. This would happen sometimes. Also, satellite constellation geometry, at the time of starting the system, and the position of the helicopter relative to buildings would also affect the time taken for the TAWS GPS navigation to become operational.

The aircraft manufacturer also conducted tests, the results of which included:

- When TAWS was switched ON, with the helicopter rigged to simulate an airborne condition, the initialisation sequence did not generate a signal to ACAS.

- When ACAS was inhibited using the TAWS input the ACAS validity was not affected.

- Original testing showed that every time the system was switched OFF a TERRAIN INHIBIT ON event was recorded without the terrain inhibit switch being selected. The only method found of removing power from the EGPWS without generating a TERRAIN INHIBIT ON record was to disconnect the powered connector from the EGPWS, leaving the TAWS control panel powered. The manufacturer reported that subsequent testing showed that this was not always the case, though no details were provided.

1.16.3 Manufacturer EGPWS simulations

The EGPWS manufacturer was asked to simulate how the MkXXII EGPWS would have performed had it been operating.

With the decision height set at 150 ft on the radio altimeter (RA), and not suppressed, a "CHECK HEIGHT – CHECK HEIGHT" aural warning would have been generated as the helicopter descended through a RA height of 150 ft. By the time this had completed, the helicopter would have passed through 100 ft, so the "ONE HUNDRED" callout would have been generated. A "SINK RATE" caution would have been generated at approximately 60 ft. Some simulation runs also produced a "PULL UP" warning just prior to impact.

Without the decision height, the "SINK RATE" caution would have been generated at 125 ft.

The manufacturer advised that warning messages have the highest priority and that height callouts have a higher priority than caution messages.

It was established that, had the terrain display been selected, it would have been entirely cyan in colour during the approach. Assuming perfect altimetry, the cyan would have changed to low density yellow during the display sweep following the helicopter's descent through a height of 165 ft. The destination (the ETAP platform) was not in the obstacle database and would not have been displayed. Given the elevation of some platforms, a normal landing would trigger the change from cyan to low density yellow. Given their greater elevation, platforms included in the obstacle database would appear as areas of higher threat on the display.

1.16.4 Simulation of a recovery during the final descent

The helicopter manufacturer carried out simulation work to evaluate how the helicopter could have reacted had corrective actions been taken in response to a 100 ft callout during the final descent. The simulation used the recorded flight data to form the entry conditions. The conditions for the simulation were:

'• *Weight = 10004 kg*
- *CG = 4.78 m*
- *IAS = 43 kt*

> - *Vz = - 1260 ft/mn (re-calculated from the highest value issuing from the radio-altimeter). It has to be point[ed] out that such [a] high value of vertical speed is not usual for an approach*
> - *The following hypothesis has been made for the simulation:*
>   - *A time limit of 1.5 seconds has been considered for the action on the collective pitch after the 100 ft crossing*
>   - *A ramp of 40% of collective pitch input (2 seconds for this input ramp) has been applied.'*

The simulation indicated that the helicopter could have climbed away and that the minimum clearance would have been 12 ft, with a pitch attitude of 12° nose up, giving a tail skid clearance of 8 ft.

All simulations are subject to errors in the assumptions made, the recorded data used for entry conditions and the accuracy of the simulation models used.

1.16.5 Crash Position Indicator

The airframe-mounted CPI failed to release and remained in its housing throughout the accident, while the helicopter was floating and during salvage. The complete CPI housing was removed from the helicopter and taken to its manufacturer. External power was supplied in the presence of an AAIB specialist and it was noted that the explosive release cartridge and spring functioned correctly.

Electronic components forming part of the release system were examined prior to testing. They were found to be full of sea water and to have suffered extensive internal deterioration due to corrosion. This deterioration rendered them incapable of operating.

1.16.6 Hand-portable and passenger location equipment

Tests and calculations were conducted by the ELT(S)/PLB manufacturer, in the presence of representatives of the WWPLB manufacturer and the AAIB. These showed that one of the WWPLBs is capable of stopping both the 121.5 MHz and 243.0 MHz signals from being transmitted by an operating ELT(S)/PLB, of the TechTest 500-12Y design, when the WWPLB is positioned less than 48 metres from a TechTest 500-12Y unit. Other types of compact low power 'personal wear' type PLBs, if worn by passengers, would have a similar effect on adjacent 'smart' beacons.

Examination of a 500-12Y unit found no reference to the requirement to extend the telescopic antenna when operating the equipment.

1.17 Organisational and management information

1.17.1 General

The operator held an Air Operator's Certificate (AOC) which authorized it to operate AS332 and EC225 helicopter types under the day/night Instrument Flight Rules (IFR). This included night flights in support of the oil and gas industry to offshore vessels and installations, such as the ETAP platform.

The operator was a Type Rating Training Organisation (TRTO) and both pilots had completed their AS332 L2 type ratings and EC225 differences course with the operator. They had completed all the mandatory training and testing requirements to operate in their respective capacities.

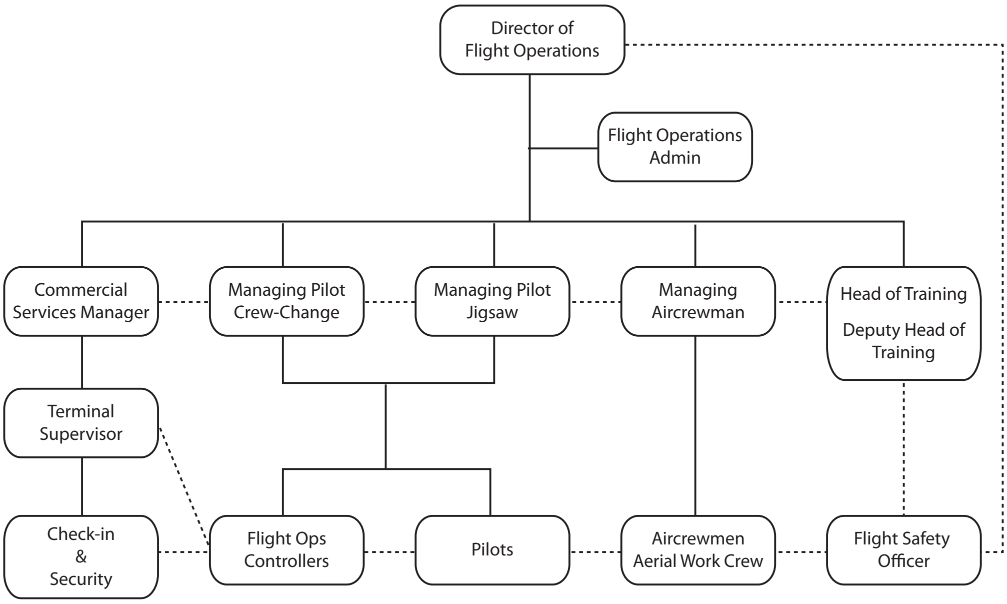
1.17.2 Management structure

In accordance with Joint Aviation Authorities (JAA), JAR-OPS, Part 3 requirements, the operator had set out in an Operations Manual the company policies and procedures for the operation of its aircraft. Included in Part A of that document was the management structure appropriate to the operation. The UK CAA was the regulating body for the acceptance and approval of the Operations Manual.

The management structure is set out in the organigram opposite:

The Director of Flight Operations is the nominated post-holder for Flight Operations. He is responsible to the Accountable Manager for the safe conduct of all flight operations by ensuring that flying staff operate the company's aircraft in accordance with the Operations Manual, current regulations and the terms of the company's AOC. He is responsible for the formulation, dissemination and execution of policies regarding flight operations.

He is supported in this task by the other nominated post-holders in the management structure. Of relevance to the accident are the posts of Head of Training and the Flight Safety officer.



1.17.3 Training and testing

1.17.3.1 General

The operator had extensive experience of offshore day and night deck operations. Both pilots had been type rated and received their operational line training, as well as day/night deck operating approval, with the operator.

There was no specific night visual approach profile or monitoring procedure set out in the Operations Manual, but offshore landing briefing and crew duties and responsibilities were included. The approach monitoring training was delivered during line training. The operator relied upon the minimum weather criteria providing sufficient visibility for a visual landing. If these criteria could not be maintained, an ARA was to be carried out.

1.17.3.2 Procedures

A night offshore deck landing utilises a combination of the visual scene with cross reference to the flight instruments to ensure a safe flight path. There were no specific vertical or horizontal profiles set out in the Operations Manual for an offshore visual approach.

Protections are provided by the radio altimeter, to alert the pilots that they are descending below certain heights, and the radio altimeter indicates the height of the helicopter above the surface. Visual indications on the Primary Flight Displays (PFDs) warn the crew that the helicopter has descended below a pre-selected height and these are accompanied by an audio "CHECK HEIGHT" warning. This audio warning can be suspended before it activates or cancelled when it activates. The company procedure was to set the warning height to 150 ft for offshore approaches and to suspend the warning when the pilot had visually acquired the platform, in order to prevent nuisance warnings. This procedure was included in the AS332 L2 final approach checklist but had not been included in the EC225 final approach checks. The procedure had however been carried over to the EC225.

A second protection is provided at a fixed height of 100 ft on the radio altimeter. As the helicopter passes that height, an audio warning generated by the TAWS announces "ONE HUNDRED". This sounds once and cannot be suspended or cancelled.

Set out in the Operations Manual Part A, Section 8, Para 8.3.13.2 were the *Two-Pilot Operating Procedures-Normal Procedures* for approach and landing. These are:

'***Flight Phase***	***PNF***	***PF***
Approach and landing	*Monitors flightpath* *Monitors PF actions* *Calls and actions checklist items* *Operates radios*	*Acknowledges as required and monitors checklist items* *Handles aircraft'*

More comprehensive duties, challenges and responses were set out for precision and non-precision instrument approaches. These included altitude calls and instrument crosschecks as well as any deviation from the horizontal or vertical profile of the approach.

Set out in the Operations Manual Part B, Section 3 Para 3.2.5 were the points to be covered during an offshore landing crew briefing. These were:

'***3.2.5*** *Offshore Landing Briefing Contents'*

'Direction of approach and go-around Identification and confirmation of correct installation Call when committed to landing (Committal point) TDP and Vtoss'

The committal point is the point at which the pilot assesses that in the event of an engine failure, the safest outcome will be a landing on the helideck rather than attempting a go-around. Up to that point, the pilot has the option to abandon the approach and carry out a go-around. After that point he is committed to a landing.

1.17.3.3 Company offshore approach and landing training

There was no specific company lesson plan for teaching offshore approach and landing techniques. The initial training could be adapted for pilots who had varying degrees of offshore experience and individual instructors had developed their own briefings to deliver the lesson. In the case of the crew of G-REDU, the commander was highly experienced at conducting night deck landings. The co-pilot had, prior to joining the operator, no previous experience of the offshore environment. However, since joining the operator, he had accumulated 13 months of offshore experience, logging 808 flying hours.

Initial deck landing approvals for both pilots were carried out in the AS332 L2 simulator, where the focus of the training was on acting as PF. Subsequently, each pilot carried out a consolidated period of line training, during which helideck approaches and landings were practised.

1.17.3.4 Offshore procedures review

On 27 December 2006, at night, in poor weather conditions, an SA365N helicopter, registration G-BLUN, descended into the sea adjacent to the North Morecambe gas platform. Following that accident, on 12 February 2007, the UK CAA Head of Flight Operations Inspectorate (Helicopters) wrote to all the offshore operating companies. In the letter he stated:

‘***OFFSHORE PROCEDURES***

In light of the fatal SA365N accident and in advance of the publication of the full AAIB report, the Authority has been reviewing relevant offshore procedures to identify areas that might benefit from further consideration.

We would therefore, encourage offshore operators to review the following aspects of Company Operations and keep their assigned FOI advised.

a. *Helideck multi crew procedures*

(1) *for visual approach and departures to/from offshore helidecks, including use of autopilot if appropriate;*

(2) *standard calls between crew members if flight path deviation is identified;*

(3) *specific requirements for the Non Handling Pilot to monitor primary flying instruments, and the policy for assuming control, if required;*

(4) *specific requirements for go around procedures, making use of autopilot, if appropriate; and*

(5) *sterile cockpit (no paperwork) during approach and take off.*

b. *Helideck training procedures*

(1) *night training and checking regime, including go around procedures, and use of simulator, if appropriate; and*

(2) *unusual attitude recovery techniques and training, including use of simulator, if appropriate.*

c. *Rad alt bug setting & usage policy.'*

Following receipt of this correspondence, the company's Director of Flight Operations tasked the Flight Safety Officer with carrying out an audit and Flight Operations Risk Assessment (FORA) of the company's operations against the CAA identified issues. The AAIB investigation of the G-BLUN accident (AAIB Aircraft Accident Report 7/2008) made six Safety Recommendations, all of which were also reviewed by the operator. The results of the audit were circulated in the company's FORA NO 003, December 2008.

The following two AAIB Safety Recommendations and the operator's responses in the FORA were identified as being relevant to the operation of G-REDU on the accident flight:

[AAIB] Safety Recommendation 2008-032

It is recommended that CHC (Scotia) review their Standard Operating Procedures related to helideck approaches, to ensure that the non-handling pilot actively monitors the approach and announces range to touchdown and height information to assist the flying pilot with his execution of the approach profile. This is especially important on the SA365N helicopter when the co-pilot is flying approaches in poor visual conditions and cannot easily monitor a poorly positioned radio altimeter.

Operator's Response:

'This is stated in the [operator's] *Ops Manual Part A section 8.3.13. During line training and checking it is taught to pilots that the non-handling pilot gives speed, height, range and Rate of Descent information to the handling pilot.'*

[AAIB] Safety Recommendation 2008-034

It is recommended that CHC (Scotia) conduct a thorough review of their Standard Operating Procedures related to helideck approaches for all helicopter types operated by the company, with the aim of ensuring safe operations.

Operator's Response:

'[The operator flies] *the AS332 L2 and EC225 and both are flown to a common Standard Operating Procedure. A review of the procedures determined that they are deemed robust.'*

1.17.3.5 Safety action

Immediately following the accident involving G-REDU, the operator carried out a review of their offshore night approach procedures. As a result, the following requirements for offshore night operations were introduced and included in the company's Operations Manual:

'For all Night operations over water, upper modes must be utilized in three or four axis coupled.

For operations at night crews shall carry out one of the following procedures:

> - *Airborne Radar Approach (ARA) Procedure.*
> - *OR*
> - *Visual Gate Approach (VGA) Procedure.'*

The weather minima for the VGA are a cloud ceiling greater than or equal to 1,200 ft and a visibility of not less than 5km. A *Visual Gate Point* is identified by the use of an 'FMS offset waypoint' to establish the aircraft:

> '• *2 nm on Final Approach Track (FAT)*
> - *FAT within 30 degrees of the wind direction*
> - *500 ft Radalt*
> - *Maximum Groundspeed 80kts*
>
> ***Note:***
> *From the Visual Gate Point inbound to the installation/vessel. Groundspeed and Radalt Height may be decreased as required.'*

The purpose of the VGA procedure is to ensure that:

> '• *The aircraft is configured in a 'stable' approach configuration by the 2 nm Visual Gate Point from an installation or vessel.*
> - *The aircraft continues in a 'stable' approach configuration from the Visual Gate Point to 0.75 nm from the installation or vessel.'*

Certain equipment and information requirements are listed and the *Stable Approach Configuration* is defined as:

> *'You are deemed to be in a Stable Approach Configuration when the Company Standard Operating Procedures (SOPs) are met.*
>
> *With regards to the VGA procedure this is as follows:*
>
> - *The aircraft four axis coupled*
> - *Maximum Groundspeed 80kts*
> - *PF Using Visual References*

> - *(The visual reference required is that the destination shall be in view in order that a safe landing may be carried out)*
> - *PNF Monitoring the Aircraft Instruments*
> - *Final Approach Checks Completed'*

In order to ensure that a safe aircraft horizontal and vertical flight path is maintained, clear requirements are placed on the PNF to inform the PF of flight path parameters. These are:

> *'PNF Calls:*
>
> *The PNF calls throughout the VGA are to include the following:*
>
> - *Radalt heights*
> - *Radar range and bearing to the installation/vessel*
> - *Ground/Airspeed*
> - *Rate of descent greater than 500 ft per minute'*

The Visual Gate Approach (VGA) procedure was set out in a Flying Staff Instruction (FSI) 031 which was issued by the operator in May 2009. A copy of the complete FSI is attached at Appendix D.

1.17.4 Weather minima for a flight at night in uncontrolled airspace

The operator's Operations Manual Part A, Section 8, Para 8.1.8.1 states:

> *'The absolute minima for night, VMC operations are: Visibility not less than 5,000 m with a cloud base of 1,200 ft.'*

The minima for an en-route descent over the sea, as stated in the Operations Manual, Part A, Section 8, Para 8.5.6.3, are:

En-Route letdown over the sea		
	Day	***Night***
Visibility	*1500m**	*5km**
Cloud ceiling	*500ft*	*1000ft*
** Minimum visibility for continued VFR flight. Climb to MEA if visibility minima cannot be maintained after letdown.*		

The Operations Manual, Part A, Section 8, Para 8.1.5.2 states that for '*Flight over sea in IMC*' for '*Routes with obstacles above 500 ft within 10 nm of track*' the MEA is '*1,000 ft above obstacles*'. For the ETAP this was 1,525 ft. For VMC flight over the sea by day or night, greater than 10 nm from the destination, the MEA is 1,000 ft.

When visibility and/or cloud base are less than those required, an Airborne Radar Approach (ARA) is required to be flown. This is a non-precision approach utilising a combination of the helicopter's weather radar and the destination installation's NDB. The Minimum Descent Height (MDH) at night is 300 ft or 50 ft above helideck elevation whichever is higher, using the radio altimeter. The Missed Approach Point (MAP) is at 0.75 nm, with the destination offset from the aircraft's heading by 15°, to the left or right, depending on which pilot is due to carry out the landing.

Provision is made in Part A of the operator's Operations Manual for a flight to depart or continue to a destination where weather has deteriorated below the minimum required. Section 8, Para 8.1.7.2.4 states:

> *'En Route*
>
> *A flight may continue towards an onshore destination or an offshore helideck even though the weather has deteriorated below the minima required for destination, so long as there will still be available a heliport meeting destination-alternate minima.'*

1.18 Additional information

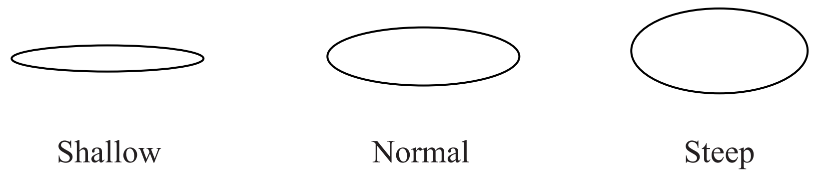
1.18.1 Offshore approaches

An approach to an offshore installation or vessel may be conducted as a completely visual manoeuvre, or an instrument approach to a MAP at MDA(Minimum Descent Altitude)/MDH(Minimum Descent Height) followed by a visual final approach segment.

There are significant differences between the visual element of an approach carried out by day in good weather and an approach conducted at night. By day, the visual cues afforded by the natural horizon and the disrupted surface of the sea provide good visual references to assist with pilot orientation and closure rate. At night, these visual cues become degraded or are nonexistent depending on the level of celestial illumination. Both visual pictures are affected by weather that reduces visibility.

The approach is a judgemental exercise based on maintaining a height above the installation or vessel until adequate visual perspective of the helideck or structure is acquired to determine a sight-picture of the pilot's required descent angle. With reduced visibility, especially at night, the use of the available flight instruments and distance indicating equipment, such as weather radar or, where appropriate, GPS, assists the crew in maintaining a safe flight path.

Ideally, the pilot uses the elliptical shape presented by the helideck as an indication of approach angle. Depending on the ratio of the vertical to horizontal axis of the ellipse, the steepness of the approach angle can be judged. A shallow ellipse indicates a shallow approach angle. As the vertical axis increases, this indicates the approach angle is becoming steeper. The principle is illustrated below.



An optimum approach angle, when combined with a constant reduction in ground speed, ensures that the helicopter arrives at a committal point from which the pilot can manoeuvre to a hover above the helideck for landing. Prior to that point, in the event of an engine failure, a go-around may be flown without the helicopter contacting the structure. The height of the committal point is generally some 40-50 ft above the helideck. In the latter stages of the approach, the platform structure provides increased visual cues to assist in judging the approach.

The latest generation of public transport helicopters have advanced automatic flight control systems which provide modes to maintain a combination of height, airspeed and vertical speed, as well as heading or track following. The use of such systems improves safe flightpath following and reduces flight crew workload, particularly during night approaches.

1.18.2 Automatic Voice Alerting Device (AVAD)

Mandatory height callouts were introduced on helicopters following an investigation into an accident involving a slow descent into the sea (AAIB Accident Aircraft Report 8/84). The current equipment requirement was stipulated in CAP 393, entitled *Air Navigation: The Order and the Regulation, Section 1, The Air Navigation Order (ANO) 2005* under *Schedule 4, Scale EE* and also in JAR-OPS 3.660, *Radio Altimeters*.

ANO Schedule 4 Scale EE stated:

> *'(1) Subject to paragraph (2), a radio altimeter with an audio voice warning operating below a preset height and a visual warning capable of operating at a height selectable by the pilot.*
>
> *(2) A helicopter flying under and in accordance with the terms of a police air operator's certificate may instead be equipped with a radio altimeter with an audio warning and a visual warning each capable of operating at a height selectable by the pilot.'*

The ANO was updated in 2009. This requirement remains the same.

JAR-OPS 3.660 states:

> *'(a) An operator shall not operate a helicopter on a flight over water;*
>
> *(1) when operating out of sight of the land; or*
>
> *(2) when the visibility is less than 1 500 m; or*
>
> *(3) at night; or*
>
> *(4) at a distance from land corresponding to more than 3 minutes at normal cruising speed,*
>
> *unless that helicopter is equipped with a radio altimeter with an audio voice warning, or other means acceptable to the Authority, operating below a preset height and a visual warning capable of operating at a height selectable by the pilot.'*

The CAA provides information and guidance concerning the installation of Radio Altimeter activated audio voice alerting device/systems (AVAD) in CAP 562, *Civil Aircraft Airworthiness Information and Procedures* Part 11, Leaflet 11-35, *Radio Altimeters and AVADs for Helicopters,* referring to the above requirements. Regarding the actual height that should be used for the required preset, non-suspendable height audio voice warning, the leaflet states the following:

> ‘4.1 *The height at which the audio warning is triggered by the radio altimeter should be such as to provide adequate warning for the pilot to take corrective action. It is envisaged that most installations will adopt a height in the range of 100 – 160 ft. It will not be permissible for the datum to be altered in flight.*
>
> 4.2 *The pre-set height should not be set such that it will coincide with commonly used instrument approach minima (i.e. 200 ft). Once triggered, the message must sound within 0.5 seconds.’*

The document does not address whether the height callouts can be switched OFF, whether the lack of this function should be indicated to the crew or whether crew procedures should be amended if this protection is not operational.

In the EC225, the AVAD audio requirement is fulfilled using the TAWS installation, when it is fitted to the helicopter. This provides a ‘CHECK HEIGHT CHECK HEIGHT’ audio callout when the helicopter transitions through the decision height, selectable by the crew, and provides a ‘ONE HUNDRED’ audio callout when transitioning through a height of 100 ft RA. The ‘CHECK HEIGHT’ audio callout can be suspended by the crew using a switch on the cyclic but the ‘ONE HUNDRED’ audio callout will always be annunciated, regardless of crew action, when TAWS is operating. Additionally, the transition through the decision height is visually indicated to the crew on the PFD. This visual indication is independent of TAWS and is designed to operate regardless of the status of TAWS or suspension of the ‘CHECK HEIGHT’ audio callout by the crew. The transition through a height of 100 ft RA is not accompanied by a visual warning to the crew.

At the time of the accident, there was no requirement for the TAWS to be included in the Minimum Equipment List.

1.18.3 TAWS history and certification

In the 1970’s, accidents involving an airworthy aircraft flying into terrain, obstacles or the surface of the sea, because of a crew’s loss of situational awareness, became known as Controlled Flight into Terrain (CFIT).

Technology, in the form of Ground Proximity Warning Systems (GPWS), was introduced to alert crews to the presence of hazardous terrain. This was based largely on the radio altimeter measured distance between an aircraft and the terrain beneath it. Some of the warning modes within these systems used this measurement of height, together with parameters such as airspeed and configuration, to trigger a warning when the aircraft's rate of descent or rate of closure with terrain was considered to be too great for its height.

Operational experience revealed that the nature of terrain on the approach to many airfields provided challenges to this type of alerting system. The selection of a trigger point for an alert mode was a compromise between providing a warning with sufficient time for a crew to avoid terrain and triggering nuisance warnings when over flying ridges or rising terrain on an approach to an airfield at a safe height (see Figure 13). Often these thresholds had to be tailored to different airfields in an attempt to strike an acceptable compromise. Much work was done by the GPWS manufacturer to acquire data from normal operations, nuisance warning events, genuine alert events and accidents in order to fine-tune the algorithms.

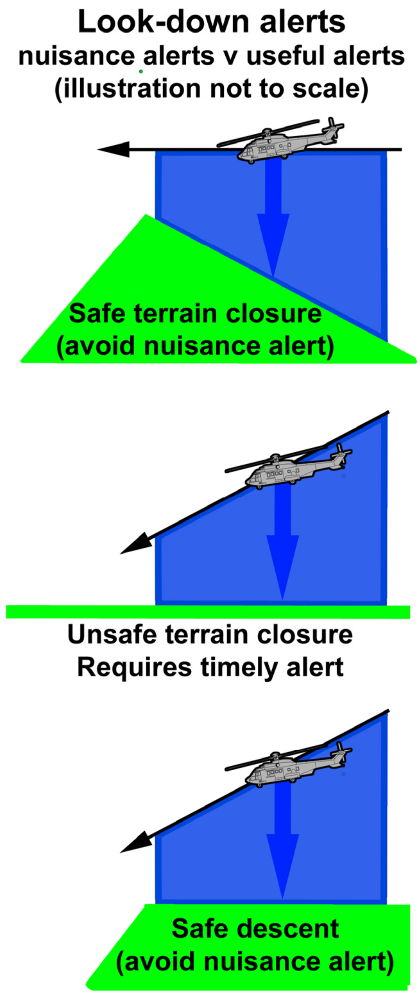


Figure 13

Look-down nuisance warning

1.18.3.1 Enhanced Ground Proximity Warning System (EGPWS)

Technological advances in processor and memory chip capabilities, together with the introduction of GPS technology, enabled new methods for combating CFIT accidents. The Enhanced Ground Proximity Warning System (EGPWS) was developed to take advantage of these advances and provide warnings to crews of hazardous terrain ahead of an aircraft, as well as beneath it. This system has a multi-layered approach to provide protection against CFIT accidents, as illustrated in Figure 14.

The first two layers help situational awareness (of terrain) before an alert warning is triggered. Height callouts on final approach provide crews with information on specific terrain separation. Secondly, the system provides the

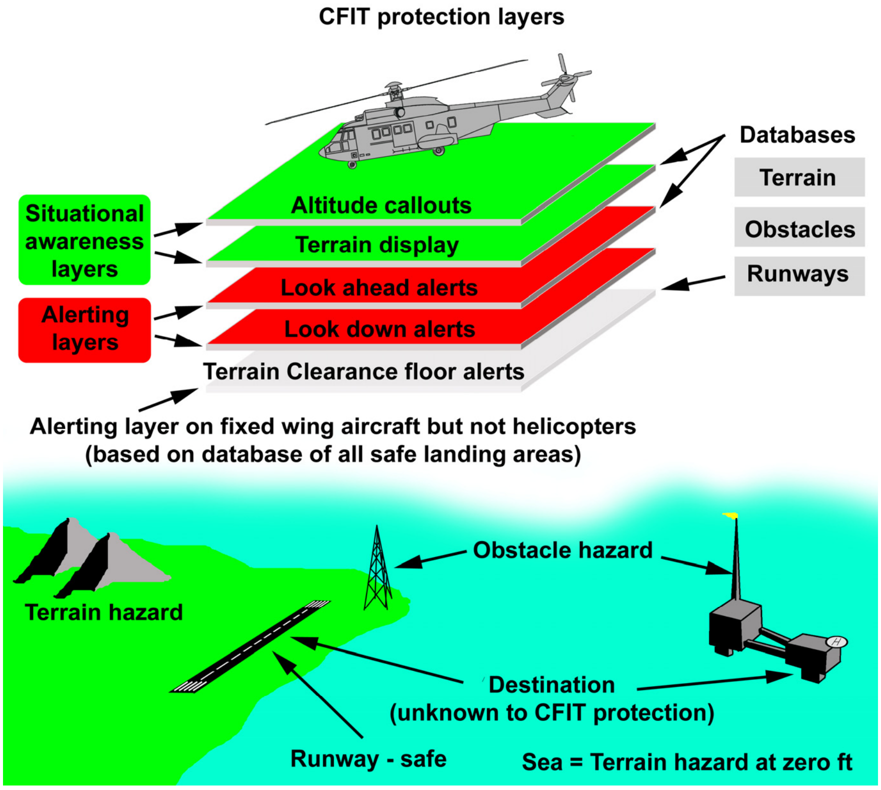


Figure 14

EGPWS layers of protection against CFIT

crew with a terrain display. This is generated by comparing the aircraft position, height and track with a comprehensive database of the terrain, obstacles and runways in the area. In large public transport aircraft, crews can choose to display this under their normal navigational displays with both pilots having independent control of their display selections and display ranges.

In this type of installation the terrain display is a bird's-eye view of the area ahead of the aircraft, using different colours to represent the elevation of the terrain relative to the helicopter's level. This gives situational awareness of the terrain in the area. Obstacles are colour coded in the same way. Over land, when an aircraft's height is such that there are no obstacles or significant terrain, the display appears black. Over the sea, in the same situation, the screen appears cyan. When an aircraft's descent rate is greater than 1,000 ft/min, the colour boundaries are modified. The fixed wing TAWS philosophy is such that runways are not marked with hazard colours but the surrounding terrain is, so that a crew never attempts to land on an area indicated as a threat. This is done through the use of a TAWS runway database.

Helicopters are more versatile as to where they can land, complicating this idea of safe areas to land and hazards to avoid. An oil and gas platform may be a safe landing site for one aircraft but an en route hazard for another. All platforms in databases are obstacles and are colour coded as such on the terrain display.

The next two CFIT layers of protection in the system generate alert warnings. The look-ahead alert warning modes use information on an aircraft's position, height and track, in combination with inbuilt databases, to assess whether there is a threat ahead of the aircraft and alert against it if necessary. The look-down alert warning is based on the original look-down systems and is a safety net should the other layers fail, since they use different sensor inputs and algorithm types. In practice, the look-ahead warnings provide significantly improved warning times and the older look-down alerts are desensitised to reduce nuisance warnings.

The final layer of protection available to fixed wing aircraft is termed the Terrain Clearance Floor (TCF) alert. This creates a terrain separation layer that triggers an alert when penetrated. This layer reduces to the surface leading up to runways held in the runway database. However, given that safe helicopter landing sites are not limited to runways, this protection layer is not currently implemented on helicopter TAWS systems.

The success of EGPWS on large passenger jets was seen as such a benefit that many operators voluntarily adopted the system fleet wide; others followed when the system was mandated. With the regulatory requirement came the need to specify standards rather than adopt a manufacturer's product. These were promulgated under the name Terrain Awareness Warning Systems (TAWS). Other manufacturers have since produced their own TAWS products.

HTAWS is the development for helicopters. Because they can land close to or on nominally hazardous terrain or obstacles, the levels of protection are reduced under certain circumstances, such as low airspeed.

1.18.4 TAWS certification

TAWS is not a primary system by which safe flight is assured and is not mandated on helicopters. The installation certification is designed to ensure the safe integration of this system into the helicopter (ie that it does not adversely affect any other system that is primary to the safe flight of the aircraft). The certification of the installation of TAWS does not require that a comparison be made between TAWS alert envelopes and the ability of the helicopter to recover from the situation once an alert has been triggered. No such comparison was available from Eurocopter. The TAWS manufacturer documentation also states that the alert envelopes are not set such that there is necessarily sufficient warning for the helicopter to recover from a CFIT situation when an alert is triggered.

The installed TAWS system was certified by EASA, with reference to Federal Aviation Administration (FAA) Advisory Circular Miscellaneous Guidance document AC 29 MG 18 '*HELICOPTER TERRAIN AWARNESS AND WARNING SYSTEM (HTAWS)*', which, in turn, refers to the fixed wing standards in FAA TSO (Technical Standard Order)-C151b *'TERRAIN AWARENESS AND WARNING SYSTEM*'. AC 29 MG 18 provides guidance as to where helicopter standards may differ. In the *Background*, it states:

> *'Approximately 60% of helicopter accidents in recent years have been attributed to Helicopter Controlled Flight Into Terrain (CFIT) incidents, resulting in hull loss and fatalities.'*

The latest HTAWS certification criteria, adopted by the FAA and being reviewed for adoption by EASA at the time of publication, are laid down in document RTCA/DO-309, entitled '*The Minimum Operational Performance Standards (MOPS) for Helicopter Terrain Awareness and Warning System (HTAWS) Airborne Equipment*¸ hereafter referred to as the HTAWS MOPS.

1.18.4.1 HTAWS MOPS - alerting envelopes

Section 2.2.2.4 of the HTAWS MOPS defines the alert envelopes. It includes the following requirement:

> *'For descending flight with a descent rate of more than 300 fpm over terrain or an obstacle, the HTAWS shall provide a warning alert at least by the height above terrain or obstacle specified in Column E of Table 2-3 while the aircraft is operating within the speed ranges defined by the HTAWS manufacturer.'*

The table and column referred to gives a '*Minimum HTAWS Warning Alert Height above Terrain (FT)'* as 134 ft and 164 ft, for descent rates of 1,000 ft/min and 1,500 ft/min, respectively.

The manufacturer defined the HTAWS MOPS applicable speed range for the EGPWS MkXXII as 85 kt and above. Therefore, under this certification, there are no alerting requirements below 85 kt.

Section 2.2.6 of the HTAWS MOPS states:

> *'An inhibited, failed, or inoperative HTAWS shall be indicated to the flight crew in a manner consistent with the flight deck design philosophy'.*

1.18.5 TAWS crew reporting rate

The operator reported that TAWS was prone to "nuisance warnings". Their incident reporting scheme included 33 reports associated with TAWS; one for every 123 hours of operation on TAWS equipped helicopters. It was apparent that the majority of the reports were associated with problems with the system and not related to useful alert warnings generated by the system.

The operator is undertaking a more detailed review of TAWS issues as they occur.

1.18.6 Review of helicopter accidents

The CAA published paper 97004 '*INVESTIGATION AND REVIEW OF HELICOPTER ACCIDENTS INVOLVING SURFACE COLLISION'* in May 1997. The focus was on accidents and incidents that involved fully serviceable helicopters that were flown into, or nearly into, the sea or terrain. The paper reported on work carried out to establish common threads between the 30 accidents/incidents being analysed. The paper reported the following:

> *'A review of this database revealed that, out of 30 cases considered in this study:*
>
> - *Twenty-six occurred during visual contact flight and, in all but one of these, cues from one or more aspects of the external environment were either degraded in quality in some way, or were non-existent. Lack of horizon cues, flight over surfaces with no cues (such as glassy water) and misleading feature cues appear to engender particular difficulty in maintaining spatial awareness and orientation.*
> - *Insufficient instrument monitoring was judged to be a factor in 26 cases with lack of awareness of both altitude and rate of descent being critical.*
> - *Crew workload was found to be high in 13 cases.*

- *Inadequate procedures, or failure to correctly follow procedures, were a factor in 15 cases.*
- *Of the 15 cases with 2 flight crew, poor crew interaction was significant in 9 cases, and contributory in a further 4.'*

The paper also listed the problems as follows:

'The top 10 problems, in order of decreasing number of occurrences, were:

- *Insufficient instrument monitoring*
- *Lack of awareness of rate of descent*
- *Lack of awareness of altitude*
- *Poor external horizon cues*
- *Excess external monitoring*
- *Poor visibility*
- *Poor textual cues*
- *High workload*
- *Crew interaction problems*
- *Poor procedures'*

1.18.6.1 Helicopter CFIT industry activity

In 1982 the CAA carried out a review of helicopter accidents in conjunction with the offshore industry. This led to a comprehensive list of projects under the control of the Helicopter Safety Research Management Committee (HSRMC) run by the CAA. Current membership includes the UK MOD, the UK helicopter operators (BHAB), EASA, the Norwegian CAA, the Norwegian oil industry (OLF) and the European Helicopter Association (EHA). Current projects address a number of issues pertinent to the safety of helicopter offshore operations, including helideck lighting and technologies associated with low visibility approaches.

The CAA, on behalf of the HSRMC, is proposing a further project which, at the time of producing this report, is entitled '*Use of HOMP/FDM Data to Refine Helicopter Class A Terrain Awareness Warning System Thresholds.*'

The draft project requirements specification highlights the fact that, as yet, insufficient operational data has been analysed in order to establish alerting criteria appropriate to offshore helicopter operations. The project aims to gather a significant amount of operational data and compare this with a number of relevant CFIT accidents in order to establish a compromise between nuisance warnings and timeliness of warnings, better suited to the offshore environment.

1.18.6.2 The European Helicopter Safety Team

The European Strategic Safety Initiative (ESSI) was formed to identify and implement cost effective ways of enhancing the safety of civil aviation in conjunction with other worldwide safety initiatives. The European Helicopter Safety Team (EHEST), comprising regulators, investigators, manufacturers, research organisations and other interested parties, was brought together to carry out the helicopter-related work. EHEST's aim is to assist in reducing the global helicopter accident rate by 80% by 2016. Part of their work focuses on analysing accidents as a group, ensuring that the issues identified contribute to the global strategy. As well as being the helicopter arm of the ESSI, EHEST is the European component of the International Helicopter Safety Team (IHST), which is based in North America.

1.19 Useful or effective investigation techniques

During the course of the investigation the contents of memory devices from a number of avionics units were retrieved and decoded. This work was dependant on techniques developed by the French BEA and the availability of detailed memory usage information from the manufacturers of the units investigated. There are no regulatory requirements regarding internal recording of the data within avionic units other than flight recorders.

A review of a limited number of previous investigations has highlighted the following as examples where NVM data from avionic units other than flight recorders has helped identify or rule out failures:

- Airbus A320 – 21 May 1998 – NVM was central to establishing the cause of a brake failure.
- Boeing 777 – 26 February 2007 – NVM from the generator control units helped the understanding of an electrical failure.

- Airbus A340 – 8 February 2005 – NVM provided the evidence of a Fuel Control and Monitoring Computer (FCMC) ARINC data bus failure which meant that the crew did not receive timely warnings associated with automated fuel control system malfunctions.

- Boeing 777 – 17 January 2008 – NVM from various avionic units helped to eliminate possible causes of the reduction in engine power leading up to the touchdown short of the runway.

- Boeing 737 – 14 August 2005 – NVM from the cabin pressure controllers provided information important to the understanding of the accident.

- Eurocopter EC135 – 16 September 2007 – NVM from the Full Authority Digital Electronic Controls (FADECs) provided positive evidence of engine power availability.

- Cessna 550 Citation II – 14 March 2008 – NVM from the EGPWS provided data otherwise lost due to a failure of the FDR to record.

- MD Helicopters MD 900 – 4 June 2006 – NVM downloads proved there were no faults associated with key systems.

- Airbus A319 – 22 October 2005 – NVM from the generator units was used in the investigation into the loss of electrical power. Whilst of use, limitations of this source of data resulted in a recommendation specific to the NVM recording in the generator units.

This list is not exhaustive and does not reflect the number of aircraft accident investigations that may have been enhanced had NVM evidence been available.

2. Analysis

2.1 Operational aspects

2.1.1 General

The pilots were properly qualified to conduct the flight and had completed all the operator's training and testing requirements. Both pilots were in current night deck landing practice and the commander was wearing corrective lenses, in accordance with the requirements of his Aircrew Medical Certificate.

No specific night approach profile was set out in the operator's documentation. However, the training staff had detailed lesson plans which identified the need to use the flight instruments to monitor the approach and the Oculogravic illusions which may be experienced when pitching up. Neither crew member could recall receiving this information during their company training.

The weather reported at the ETAP was suitable for the helicopter to depart from Aberdeen. At 1812 hrs, the Galaxy 1 had reported that they could still see the ETAP some 13 nm away. At 1827 hrs, the ETAP reported that the visibility had reduced to 0.5 nm. However, as the helicopter descended through a height of 1,500 ft RA at 1828 hrs, at a range of 13 nm from the ETAP, the pilots could see the flare and lights of the platform, indicating that the visibility and cloud ceiling were above the minima for night VMC operations. In these circumstances the pilots were permitted to conduct a visual approach.

Weather observations at the ETAP were based on an assessment by the installation staff and not produced by measuring equipment. The AAIB's Aircraft Accident Report 7/2008 made the following Safety Recommendation (2008-037):

> It is recommended that the Civil Aviation Authority ensure that personnel who are required to conduct weather observations from offshore installations are suitably trained, qualified and provided with equipment that can accurately measure the cloud base and visibility.

The CAA accepted the safety recommendation and amended CAP 437, *Offshore Helicopter Landing Areas - Guidance on Standards*. The content of CAP 437 is guidance material and as such is not a requirement. The CAA did strongly recommend that an automated means of ascertaining meteorological information should be provided at all times but this was not a regulatory requirement. Therefore:

Safety Recommendation 2011-049

It is recommended that the Civil Aviation Authority re-emphasises to Oil and Gas UK that they adopt the guidance in Civil Aviation Publication (CAP) 437, entitled *Offshore Helicopter Landing Areas - Guidance on Standards*, insofar as personnel who are required to conduct weather observations from vessels and platforms equipped for helicopter offshore operations are suitably trained, qualified and provided with equipment that can accurately measure the cloud base and visibility, in order to provide more accurate weather reports to helicopter operators.

2.1.2 Human performance

The crew had initially briefed for an ARA but when they became visual with the ETAP, the commander re-briefed for an en-route descent to 300 ft RA. The crew were not exhibiting any signs of stress and were demonstrating good Crew Resource Management (CRM), jointly agreeing their plan with no cross-cockpit gradient. They had adequate fuel to continue to their onshore diversion if they were unable to land on the ETAP.

The helicopter was descended to 300 ft where, at a range of 7 nm from the ETAP, it entered cloud. The commander commenced a climb and both crew members regained visual contact with the platform and flare. The operator's procedure, required if the visibility reduced below 5 km, was to '*climb to MEA if visibility minima cannot be maintained after letdown*'. The helicopter was levelled at 400 ft and because the ETAP was visible to the crew, they continued towards it.

There was very little wind and the commander had intended to make a left turn through approximately 90° to bring the helideck onto the right side of the helicopter, to enable him to perform the landing. The workload of flying the helicopter was at this stage undertaken by the upper modes of the AP, with the commander selecting and monitoring height and speed. This provided him with the capacity to look out of the cockpit at the platform whilst the AP maintained a safe flight path. The co-pilot was assisting with range information from the weather radar, as well as 'paging' it down to optimise the range information whilst looking out occasionally at the platform.

At a range of 1.5 nm, the helicopter descended from 400 ft to 300 ft, at which height it once more entered cloud. The commander commenced a climb and shortly afterwards the platform was again visible to both pilots and the climb was stopped.

The co-pilot thought that, as they climbed, a go-around had been initiated and considered that they would be able to land if they made a second approach. However, with the platform visible, the co-pilot could see that the approach was being continued. The option to go around was still available but, having the platform in sight, the commander decided to continue with the approach. Without announcing his actions, the commander de-selected the AP upper modes of airspeed, altitude and heading hold and suspended the RA check height warning. As a result of these actions, the workload involved in flying the helicopter on instruments, as well as maintaining sight of the platform, would have increased. If he retained his instrument scan, the possible effect was to lose sight of the platform at a late stage in the approach. In order to maintain sight of the platform, the attention to instrument flying was reduced. The option to execute a go-around at this stage was available but, with the platform lights visible, there appeared to be no need.

The latest generation of public transport helicopters have advanced automatic flight control systems which provide modes to maintain a combination of height, airspeed and vertical speed, as well as heading or track following. The use of such systems improves safe flightpath following and reduces flight crew workload, particularly during night approaches.

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.

When the commander commenced a left turn, maintaining visual contact with the platform, the co-pilot was monitoring the flight instruments and informed the commander of the ground speed of 60 kt and the helicopter's descent. The commander's response of "CAN YOU SEE THE DECK, THAT'S THE PROBLEM" had the effect of switching the co-pilot's attention from monitoring the flight instruments, in particular the height and rate of descent information, to looking at the platform. Both pilots were then mainly focussed on the external visual picture with the aircraft approximately 80 ft above the helideck elevation and at a range of some 600 metres. Given the proximity of the platform, the co-pilot checked the groundspeed which he announced was 55 kt. Both pilots were focussed on the external visual picture and, not appreciating that the helicopter was descending rapidly towards the surface of the sea, thought they were still above the helideck elevation. The commander was progressively pitching the helicopter's nose up. This had the effect of maintaining the platform in the correct position in the windscreen, giving the impression that the descent angle was constant.

There was no specific night visual approach profile by which the crew could measure their progress in terms of height, range and ground speed. Had this been in place, it would have been possible to identify height against range to give a constant descent angle. It would also have assisted the pilots in identifying excessive rates of descent. Effectively, a stabilised approach could have been maintained by one of the pilots monitoring the flight instruments.

Safety Recommendation 2011-051

It is recommended that the Civil Aviation Authority ensures that commercial air transport offshore helicopter operators define specific offshore approach profiles, which include the parameters for a stabilised approach and the corrective action to be taken in the event of an unstable approach.

2.1.3 Illusions

Three reports were commissioned to assess the possibility of illusions contributing to the pilots' failure to detect the descent. The complete reports are included in Appendices A, B and C.

2.1.3.1 Oculogravic illusion

In Appendix A it states that the helicopter's pitch angle increased over the last 20 seconds or so before impact, and suggests that the effect of this change in pitch was to maintain a constant sight-picture. This, in gross terms, was comparable with that of a normal, stable approach angle until, in the last five seconds, as the pitch rate increased, the approach angle would have appeared to steepen.

In Figure 15, the angle α is the angle subtended at the pilot's eye between the line of sight to the horizon and the line of sight to the helideck. Angle β is the helicopter's pitch attitude relative to the horizon. Angle $\alpha+\beta$ is the apparent position of the helideck relative to the airframe.

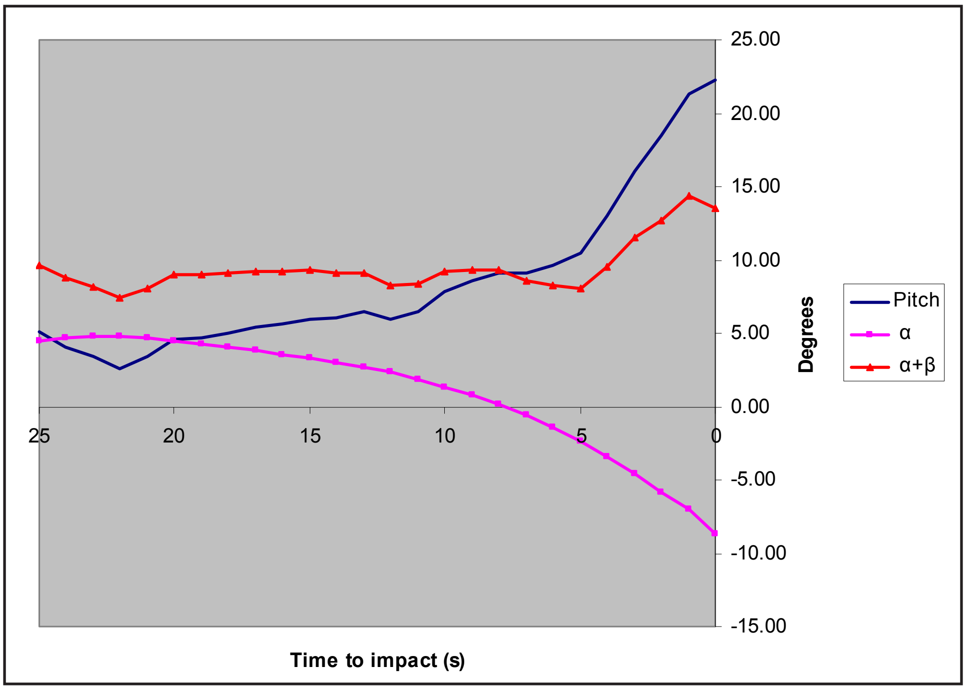


Figure 15

Without a visible horizon or good surface texture cues, the apparent position of the platform would have led to the perception that the approach was normal but becoming high and fast in the final 5 seconds before impact. This accords with the commander's impressions. See Figure 16.

2.1.3.2 Somatogravic illusion

In Appendix B it is suggested that, during the approach, non-visual cues (mediated by the balance system of the inner ear and other somato-sensory channels) would have been inadequate to support detection of the change in helicopter attitude: '*The helicopter would have continued to feel level.*'

This is illustrated in Figure 17 which shows the direction of the resultant force vector derived from the recorded longitudinal (Gx) and aircraft normal (Gz) accelerations during the final 50 seconds of the flight. The graph shows no significant difference in the direction of the resultant force between the first 10 seconds of the record, when the aircraft was in level flight, and the final 10 seconds, during which the pitch attitude of the aircraft was increasing to a peak of 22.5° nose up. In the absence of adequate visual references, this force vector can be misperceived as the direction of the gravitational vertical and, in consequence, form the frame of reference that determines the apparent location of the platform.

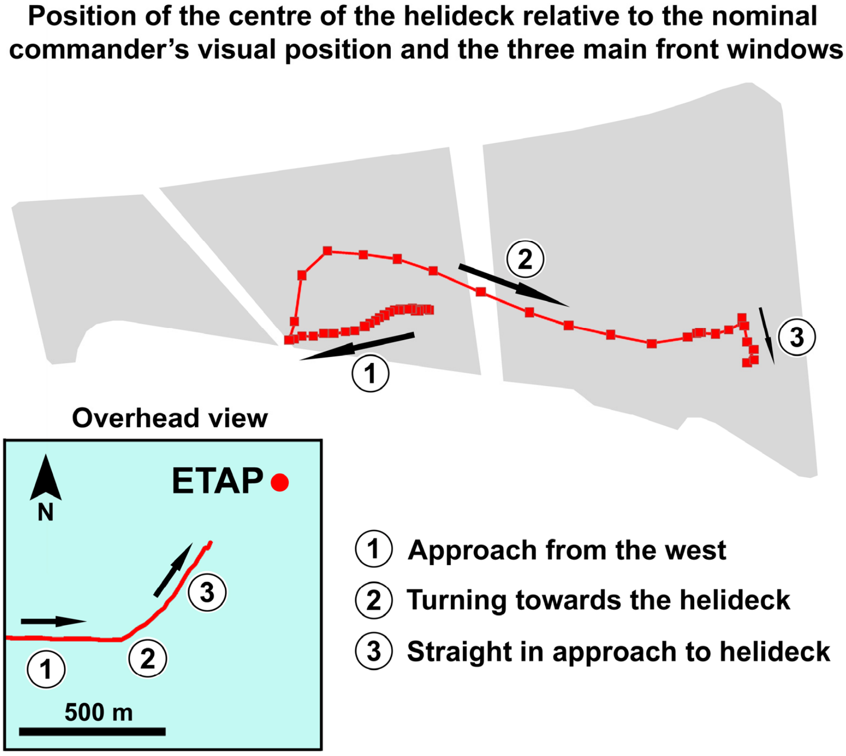


Figure 16

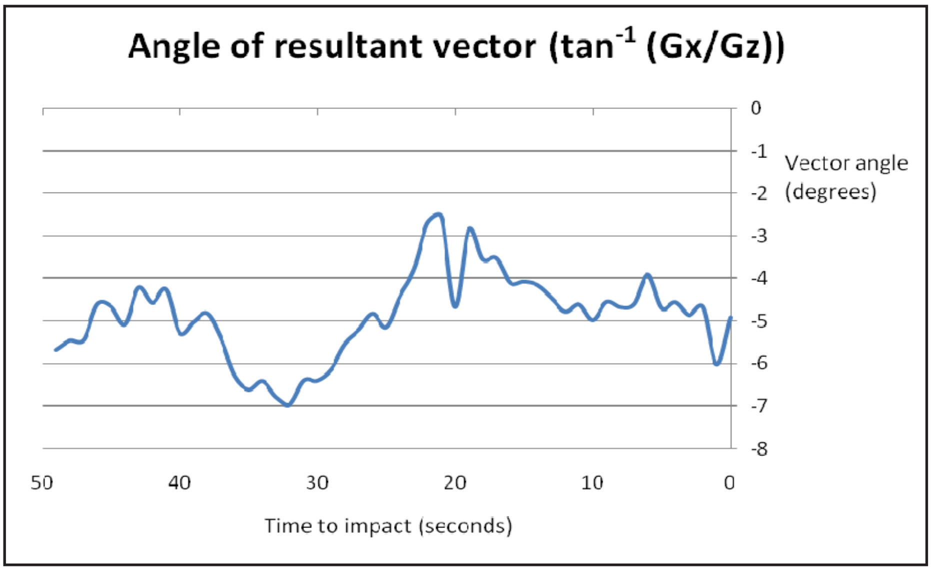


Figure 17

2.1.3.3 Visual perception

In Appendix C it is suggested that the appearance of the platform and its reflection on the surface of the sea, diffused by the fog/reduced visibility, could have been confusing. Orientation and position cues that might have been gleaned from details in the sight-picture were degraded and the platform could have appeared nearer and lower than it actually was.

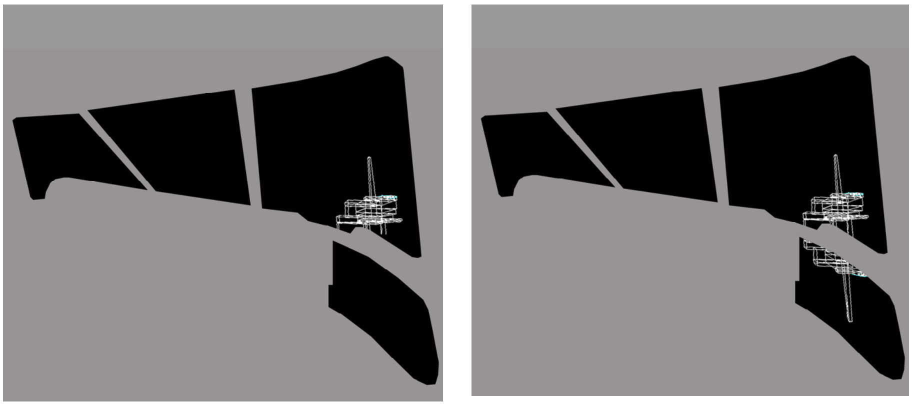


Figure 18

The platform as it would have appeared to the commander just before impact without the reflection and with the reflection. The diagram is drawn to scale using the manufacturers Cockpit View Diagram

The report considered that:

> *'As a result of this analysis it is considered that there would not have been a reflection of ETAP platform of suitable fidelity that the pilot would have simply confused the reflection for a direct view of the platform. Any contribution from reflections would have added to the direct view of the platform, not dominated over the direct view. That said the nature of the diffuse pattern of light could have led to confusion over the orientation of the platform.'*

The three appendices together provide as coherent a view as could be established of the illusions suffered by the crew. The absence of the 'ONE HUNDRED' height warning and the crew's focus on external cues denied them the opportunity to carry out instrument crosschecks on their visual assessment during a critical period. The visual cues were inadequate; there was no visible horizon or surface texture and the appearance of the platform was ambiguous and confusing. Somato-sensory cues to orientation were also inadequate in providing them with a proper appreciation of the helicopter's pitch attitude. As a result, increasing pitch was confused with, firstly, a stable approach angle and, secondly, with becoming high and fast in the final stages. These misperceptions can be summarily described as an oculogravic illusion.

Safety Recommendation 2011-052

It is recommended that the Civil Aviation Authority commissions a project to study the visual illusions that may be generated during offshore approaches to vessels or offshore installations, in poor visibility and at night, and publicises the findings.

2.1.3.4 Protective strategies

A visual approach flown at night to an offshore vessel or platform is a demanding task that requires a combination of visual and instrument flying. The final approach track to the helideck should be as close as possible into wind. This may result in the helideck being partially or totally obscured by the upper structure of the installation.

Improvements in the conspicuity of helidecks, using additional lighting to further assist crews in determining the shape and, consequently, an appreciation of their approach angle, is currently being undertaken by the CAA. A proposed pattern of lights has been identified and a meeting with the Oil and Gas Producers Aviation Safety Committee was scheduled for September 2010.

Technical development is ongoing but the consultation to date has provided support for the system.

Safety Recommendation 2011-053

It is recommended that the Civil Aviation Authority (CAA) amends Civil Aviation Publication (CAP) 437, *Offshore Helicopter Landing Areas - Guidance on Standards*, to encourage operators of vessels and offshore installations, equipped with helidecks, to adopt the new lighting standard, for which a draft specification has been published in Appendix E of CAP 437, once the specification has been finalised.

If the helideck is visible, then the apparent shape can be used as an indication of the approach angle. Monitoring of distance against height and rate of descent can allow for a consistent, safe and repeatable approach profile. The setting of minimum heights for range can also provide for an artificial floor to be set preventing a helicopter from descending too low.

The radio altimeter on G-REDU should have provided two audio voice height warnings, had the TAWS been operational. The first would have been at 150 ft. This was the standard setting adopted by the operator. It was set on the instrument but suspended by the commander when he first saw the flare and the diffused lights of the platform, a practice often used to prevent nuisance warnings. The second should have activated at 100 ft. Either of these warnings would have alerted the crew to their height. Furthermore, both warnings, activating at a specific time interval may also have provided the crew with an indication of their rate of descent allowing them to react promptly and initiate a climb.

Irrespective of TAWS, visual alerts were displayed on the PFD screens as the helicopter descended through a height of 150 ft. These were not observed by the pilots, who were focussed on the external picture. This emphasises the importance of the audio alert. Therefore:

Safety Recommendation 2011-054

It is recommended that the Civil Aviation Authority reviews the procedures specified by commercial air transport helicopter operators as to when a crew may or should suspend a radio altimeter aural or visual height warning.

Consideration was given to the response of a pilot who believes he is at a safe height but receives a height warning. Valuable height may be lost if he looks down at the instrument, rather than reacting immediately. The situation may be recoverable with a high rate of descent at 150 ft if immediate action is taken but insufficient time may be available with a warning announced at 100 ft. The 'CHECK HEIGHT' warning at 150 ft is often suspended to prevent nuisance warnings. At night this alert provides an additional warning if both crew members become focused on the visual picture.

Safety Recommendation 2011-055

It is recommended that the Civil Aviation Authority reviews commercial air transport offshore helicopter operators' procedures to ensure that an appropriate defined response is specified when a height warning is activated.

The only method of confirming a safe flight path is the monitoring of the flight instruments. When the PF is occupied with the visual picture, the PNF must monitor the approach using the flight instruments and distance-to-go information.

Safety Recommendation 2011-056

It is recommended that the Civil Aviation Authority reviews the procedures set out by commercial air transport offshore helicopter operators to ensure that a member of the flight crew monitors the flight instruments during an approach in order to ensure a safe flight path.

2.2 Engineering aspects

There was nothing in the recorded data, helicopter simulation work or crew recollection that indicated any problem with the controllability of the helicopter.

2.3 TAWS

The data recorded in the EGPWS, AMC and MFD PUs, together with the lack of any height warnings or alerts in the CVFDR recordings, indicated that the TAWS was inoperative at the time of the accident. The CVFDR recordings and crew interviews indicated that the crew were not aware of this. This raised three questions of concern:

- why was the system not operational?
- why was this not noticed by the crew?
- how would the system have performed had it been fully operational?

The evidence indicated that the loss of ACAS was associated with the loss of TAWS. Therefore, the ACAS system was included as part of the TAWS investigation.

2.3.1 TAWS system status

2.3.1.1 Possible scenarios

Switching both ACAS and TAWS OFF at the same time would replicate the final recorded loss of validity of the systems recorded by the MFD PUs. However, the control panel switches were found in the ON position with no evidence that the mechanisms designed to prevent inadvertent switching had been damaged. This would then have required positive crew action during the post-impact and evacuation period, when the crew had more pressing priorities, and is considered unlikely.

All other TAWS and ACAS switching activity was evident in the CVFDR recording of crew communications; no such communication was evident when both systems became invalid. AAIB testing indicated that switching TAWS OFF would most likely result in a TERRAIN INHIBIT ON record being generated in the EGPWS; this did not occur.

This leaves the likelihood of a failure rendering both ACAS and TAWS inoperative. Post-accident testing of the systems did not identify any definitive faults. However, the crew discussions captured on the CVFDR indicated that there were serviceability issues associated with ACAS. This is consistent with the number of ACAS related valid/invalid records in the MFD PU data which indicated an intermittent problem.

The MISD page on the MFD displays, other than the control panel switch position, provides the only indication to the crew that TAWS is switched OFF. If a fault had occurred in TAWS, which appeared to other systems in the aircraft that it was switched OFF, then the only indication to the crew of this status would have been on the MISD screen. There was no requirement for the crew to view the MISD screen and the CVFDR recordings show that it had not been viewed in the last 25 hours of recorded operation.

The CVFDR recorded the crew communications when carrying out check lists. This included checks that the CWP did not have any captions illuminated. The co-pilot noticed the TAWS caption illuminate when the TAWS initialised while in the cruise. The lack of further reference to the TAWS caption suggests that it was inactive for the remainder of the flight. The crew did not recall seeing a TAWS caption on the PFD at any point in the flight.

It is feasible that the failure mode manifested itself to the display systems as a TAWS OFF selection, without one being made, or that any associated indications went unnoticed by the crew. However, a review of the installations did not yield any obvious mechanism for such a failure mode.

2.3.1.2 Recording TAWS and ACAS parameters

The TAWS and ACAS system related parameters were not recorded by the CVFDR, and were not required to be. Had these parameters been available it is possible that the failure mode could have been identified or that failure modes could have been ruled out. A review of the system status over many previous flights, and flights on other helicopters of the same type, could also have been carried out had the parameters been available to the operator's flight data monitoring (FDM) programme.

The initial part of the investigation, focusing on the lack of TAWS warnings, was centred on whether the crew had switched the system OFF or whether there was a failure. The investigation was also inconclusive regarding the status indications presented to the crew. These issues could have been resolved had the switch positions and indicator status conditions been recorded. As some of these were displayed on the MFD, image recordings of the centre control panel and the instruments, as presented to the crew, could also have aided the identification of the failure mode associated with these systems.

Safety Recommendation 2011-057

It is recommended that the International Civil Aviation Organisation introduces a Standard for crash-protected recordings of the operational status of Airborne Collision Avoidance System (ACAS) and Terrain Awareness and Warning System (TAWS) equipment, where fitted, on helicopters required to carry a flight data recorder.

2.3.2 TAWS control and indication

The EC225 TAWS installation provides the crew with an ON/TEST/OFF switch on the control panel. This is contrary to typical fixed wing aircraft installations that permanently power TAWS. The ability for the helicopter crew to switch the system OFF introduces the possibility of inadvertent system loss, including the removal of the mandatory height callouts.

The data retrieved from the EGPWS, AMC and MFD PUs, together with the CVFDR audio recordings, indicated that TAWS was inoperative for the majority of the accident flight, with a period of operation of less than one minute en route. In particular, the crew were not aware that the TAWS system and the mandatory height callouts were inoperative for the approach. It cannot be shown conclusively whether the crew did not observe failure indications on all four display units or whether it was a failure of the TAWS that manifested itself as an OFF condition.

The only indications that the TAWS system is switched OFF are the position of the TAWS switch on the control panel in the centre pedestal and messages on the MISD page on the MFD screens. There was no requirement for the crew to monitor the MISD page and, in the 25 hours of data recorded on the CVFDR, the MISD page had not been selected once. Should TAWS be switched OFF, or a failure mimics this condition, there is no indication of this in the crew's normal field of view, on the flight instruments or CWP, with normal screen selections.

The HTAWS MOPS (Helicopter Terrain Awareness and Warning System Minimum Operational Performance Standards) states:

> *'An inhibited, failed, or inoperative HTAWS shall be indicated to the flight crew in a manner consistent with the flight deck design philosophy.'*

The lack of a visual cue, in the crew's normal field of view, that TAWS has been switched OFF is in line with the 'dark cockpit' philosophy applied to the EC225. The concept is that the crew does not need an indication in these circumstances as they should already be aware of the lack of TAWS because it requires positive crew action to switch the system OFF. There are limitations to this approach, associated with multiple crews not communicating a switch selection, the wrong switch being actioned and exposure to hidden failure modes mimicking the OFF status of the system. Given the implications of the loss of this system, which also fulfills the AVAD function, this concept would appear to be inappropriate in this case. This could equally apply to other TAWS installations that use the same 'dark cockpit' philosophy. Therefore:

> **Safety Recommendation 2011-058**
>
> It is recommended that the European Aviation Safety Agency requires that crews of helicopters, fitted with a Terrain Awareness and Warning System, be provided with an immediate indication when the system becomes inoperative, fails, is inhibited or selected OFF.

Also, in the EC225, switching OFF TAWS removes the mandatory height callouts required under the Air Navigation Order 2005 Schedule 4 Scale EE and JAR OPS 3.660. Therefore:

Safety Recommendation 2011-059

It is recommended that the European Aviation Safety Agency reviews the acceptability of crew-operated ON/OFF controls which can disable mandatory helicopter audio voice warnings.

2.3.3 TAWS performance

At the time of the accident, TAWS was not operating. TAWS provides CFIT protection using a number of functions or protective layers. The key ones relevant to this analysis can be grouped under the headings 'height callouts' and 'TAWS alerting'.

2.3.3.1 Height callouts

Height callouts are designed to improve a crew's situational awareness of the proximity of their aircraft to the surface. Requirements for a fixed height callout and a crew-selectable height callout are given in the Air Navigation Order 2009 Schedule 4 Scale EE and in JAR OPS 3.660 but they do not specify a value for the fixed height callout. The CAA guidance material regarding the certification of AVADs for helicopters, Leaflet 11-35 '*Radio Altimeters and AVADs for Helicopters*' of CAP 562, states that the fixed height callout is envisaged to be in the range of 100 to 160 ft.

The Eurocopter simulations showed that, had the 100 ft callout been issued and had the crew reacted in sufficient time, the helicopter would have come within 8 ft of the surface. This represents a small margin for successful recovery action, albeit based on simulated results.

In CAP 562, *Civil Aircraft Airworthiness Information and Procedures* Part 11, Leaflet 11-35, *Radio Altimeters and AVADs for Helicopters* states that:

> '4.1 *The height at which the audio warning is triggered by the radio altimeter should be such as to provide adequate warning for the pilot to take corrective action. It is envisaged that most installations will adopt a height in the range of 100 – 160 ft. It will not be permissible for the datum to be altered in flight.*

> 4.2 *The pre-set height should not be set such that it will coincide with commonly used instrument approach minima (i.e. 200 ft). Once triggered, the message must sound within 0.5 seconds.'*

The requirement for mandatory height callouts on helicopters originated from an accident involving a slow descent into the sea. The accident to G-REDU involved a higher descent rate and subsequent analysis highlights the possible inadequacy of the 100 ft height callout in such circumstances. Therefore:

Safety Recommendation 2011-060

It is recommended that the Civil Aviation Authority reviews the guidance in Civil Aviation Publication (CAP) 562, *Civil Aircraft Airworthiness Information and Procedures*, Part 11, Leaflet 11-35, *Radio Altimeters and AVADs for Helicopters*, regarding the pre-set audio height warning that is triggered by the radio altimeter and may not be altered in flight, to ensure that crews are provided with adequate warning to take corrective action.

2.3.3.2 TAWS alerting

Historically, alerting modes 1 and 2 formed part of the main protection against CFIT on fixed wing aircraft. Experience showed that these alerts were susceptible to nuisance warnings due to the shape of terrain beneath safe flight paths. This led to the alert mode envelopes being adjusted to provide a compromise between nuisance warnings and timely alerting. It also involved further specific adjustments at locations with varied terrain under the approach path. The advent of look-ahead warnings provided alerts, significantly before reaching a hazard, that were not susceptible to the problems of look-down warnings.

When look-ahead alerting is active, in this case above 70 kt, timely warning is provided. Below 70 kt look-ahead alerting is deactivated so that the helicopter can land without triggering a warning. This leaves only the look-down warnings to guard against excessive descent rates.

This was a low speed approach, leaving the EGPWS look-down alerting algorithms as the only alerting modes that would have been active at the time of the accident, had the system been operating. Manufacturer simulations showed that, had the TAWS system been operating, it would have triggered a mode 1 "SINK RATE" caution at approximately 125 ft but that the "PULL UP" warning would have occurred just prior to impact. However, whilst "PULL UP" warnings have a higher priority than audio height warnings, audio height warnings have a higher priority than TAWS cautions, such as "SINK RATE". Therefore, with an active visual height warning at 150 ft, the "SINK RATE" caution would not have been given until approximately 60 ft, after both the visual height warning and the 100 ft audio warning. However, in this situation, the visual and audio height warnings should be providing the situational awareness.

The surface beneath the approach path of a helicopter operating in the offshore environment is nominally level. In this environment it may be possible to increase warning times while reducing what are regarded as nuisance warnings.

The look-ahead alerting for fixed wing aircraft drew much of its strength from the inclusion of a database of the safe locations within approaching terrain (ie runways). Helicopters do not require a runway to land, so safe terrain/obstacles are not so easily defined. Additionally, a platform may be a safe destination for one flight but an en route hazard for another. However, this flight, like many others, had a pre-defined destination. In this particular case, the equivalent fixed wing implementation of the advanced features of TAWS would not have been of use as the accident happened very close to the safe landing site. Limitations associated with positional accuracy of the aircraft and the database resolution and accuracy of the safe landing zone mean that the best fixed wing installations still have a 0.25 nm unprotected zone around the designated landing sites. This prevents nuisance warnings when positional accuracy is compromised. In this case the helicopter impacted the sea less than 0.25 nm from the safe landing site, rendering the look-ahead function ineffective if the platform is coded as a safe landing site.

The HTAWS MOPS do not differentiate between look-down and look-ahead warnings. They provide a simple set of alerting standards but then alleviate the requirement below a speed to be defined by the HTAWS manufacturer, which in this case is 85 kt. This leaves a gap in the minimum standards.

TAWS is not a primary system by which safe flight is assured and is not mandated on helicopters. The installation certification is designed to ensure the safe integration of this system into the aircraft (ie that it does not adversely affect any other system that is primary to the safe flight of the aircraft). The certification of the installation of TAWS does not require that a comparison be made between TAWS alert envelopes and the ability of the helicopter to recover from the situation once an alert has been triggered. No such comparison was available from Eurocopter. The TAWS manufacturer documentation also states that the alert envelopes are not set such that there is necessarily sufficient warning for the aircraft to recover from a CFIT situation when an alert is triggered.

The MkXXII EGPWS provides a greater degree of protection than the HTAWS minimum standards require. The fixed wing performance was developed through years of gathering data to fine-tune the system. At the moment, the helicopter variant is much less mature, with much less operational data supporting it.

The CAA published paper 97004 '*INVESTIGATION AND REVIEW OF HELICOPTER ACCIDENTS INVOLVING SURFACE COLLISION*' in May 1997. The report gave a list of the top ten problems in order of decreasing numbers of occurrences. The lack of awareness of rate of descent and altitude were the second and third items on the list, respectively. TAWS is a warning system designed to address these types of situational awareness problems. While TAWS is currently required by the oilfield operator, there is no mandatory requirement for TAWS on helicopters.

The UK CAA has begun a new HSRMC project entitled '*Use of HOMP/FDM Data to Refine Helicopter Class A Terrain Awareness Warning System Thresholds.*'

The HTAWS MOPS affect all helicopters in which TAWS is fitted, not just those engaged in offshore helicopter operations. The EHEST have been reviewing both onshore and offshore helicopter accidents.

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 operator provided 33 crew safety reports related to TAWS, averaging one report every 123 flight hours. It was apparent that the majority of the reports were associated with problems with the system and not related to useful alert warnings generated by the system. Therefore:

Safety Recommendation 2011-062

It is recommended that the European Aviation Safety Agency reviews the frequency of nuisance warnings generated by Terrain Awareness and Warning System equipment in offshore helicopter operations and takes appropriate action to improve the integrity of the system.

2.3.4 TAWS database

The current terrain display philosophy for fixed wing aircraft is that runways are not marked with hazard colours but the surrounding terrain is. Offshore platforms and mobile landing sites cannot be similarly identified as non-hazardous as they are en-route threats to passing aircraft. This leaves the current issue that, during offshore operations, the same symbology would be used on the terrain display to represent areas to avoid as well as the areas suitable for landing.

The accuracy of the look-ahead warning systems and terrain display are reliant on the accuracy of information regarding the position and motion of the helicopter and the location/elevation of the hazards. During the investigation it became clear that some platforms were in the obstacle database and others, including ETAP, were not. It was also stated that nuisance warnings have been generated due to inaccurate or out of date positional information of some platforms within the obstacle database. It was also reported that nuisance warnings could be triggered during operations to platforms accurately represented in the database and that some operators would prefer that platforms were not in the database at all.

Safety Recommendation 2011-063

It is recommended that the European Aviation Safety Agency, in conjunction with the Federal Aviation Administration, defines standards governing the content, accuracy and presentation of obstacles in the Terrain Awareness and Warning System obstacle database for helicopters operating in the offshore environment.

Currently there is an AFM entry that ‘The crew must check that the TAWS database is up to date and covers the area of operations (refer to pilot’s guide).’ This is an approach that is common to fixed wing operations. However, in practice the database is maintained as an engineering function with little or no crew input or understanding of the latest appropriate standards applicable to their operation.

2.3.5 Minimum Equipment List (MEL)

For the EC225, at the time of the accident, the TAWS equipment was not included in the helicopter's MEL. TAWS equipment has subsequently been included in its Master Minimum Equipment List (MMEL).

2.4 Recording aspects

2.4.1 System status recording

The investigation into the TAWS and ACAS failure required the use of specialised techniques to extract data from the unprotected memories of a number of different avionic systems. Aircraft systems are placing an ever increasing reliance on processor-based line replaceable units. These units are vulnerable to accident damage and, at present, there is no requirement for these units to record internally or retain any data for use in subsequent investigations.

A review of a number of previous accident investigations (detailed in Section 1.9) indicates, however, that data recovered from the NVM of systems not required to record data has been of value. The costs and complexity of requiring future systems to record this valuable source of evidence by a more robust method is not well understood. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2011-064

It is recommended that the European Aviation Safety Agency establishes the feasibility of recording, in crash-protected memory, status indications from each avionic system on an aircraft.

2.5 Survival procedures and equipment

2.5.1 General

The helicopter struck the water approximately 312 metres from an oil installation and the alarm was raised immediately. The first rescue helicopter was on scene 52 minutes later, but it took 27 minutes to locate the liferafts, and a further 26 minutes to recover three personnel from one liferaft. The weather conditions prolonged the visual search and the winching operation was hampered by a variety of factors.

However, the actions of the passengers and crew, deploying and deplaning into the liferaft, and surviving for almost 2 hours without injury in the prevailing conditions, reflects the value of the training and safety briefings provided, and the availability and type of safety equipment.

2.5.2 The helicopter's emergency flotation equipment

The emergency flotation equipment inflated automatically following the impact with the water and the helicopter remained afloat and upright. The passengers and crew exited the cabin and flight deck into the liferafts and were subsequently rescued, uninjured. During the night the helicopter rolled inverted but remained on the surface.

In a previous accident (G-TIGH, AAIB report 2/93) in which a helicopter struck the surface of the sea and the emergency flotation equipment did not inflate, the helicopter sank in about two minutes and 11 of its 17 occupants drowned. In that event, inflation required manual activation by the crew. The report states that they did not have time to do so.

There is no requirement for emergency flotation equipment fitted to helicopters to inflate automatically following water entry. However, the fact that it did so in this accident, following an impact with the surface of the sea, demonstrably contributed to a positive outcome in which all the occupants of the helicopter survived. Therefore:

Safety Recommendation 2011-065

It is recommended that the European Aviation Safety Agency considers amending certification requirements for rotorcraft, that are certified in accordance with ditching provisions, to include a means of automatically inflating emergency flotation equipment following water entry.

2.5.3 Aircraft evacuation

The helicopter's tail detached when it struck the water. This resulted in the helicopter floating in a more nose down attitude than it would have, had it been fully intact. This probably contributed to the commander's observation that the helicopter's flotation equipment impeded the jettisoning of his door. This accident did not involve an intentional emergency water landing, for which the flotation equipment is designed.

The passengers were all trained and briefed for offshore helicopter operations. The training material, however, did not focus on the difficulty of carrying out an emergency jettison of the starboard main door. It was not made clear that the emergency release handle may need to be operated by a passenger seated in a row further forward than the row adjacent to the door. The passengers were therefore unable to locate the starboard main door emergency release handle and subsequently it was not jettisoned. Instead they opened it normally, sliding it to its forward position and obstructing the two forward right cabin window exits.

2.5.4 Liferafts

Despite the passengers and crew all having received practical and theoretical training on the use of the survival liferaft, no-one deployed the sea anchor. The sea anchor cannot be made to self deploy, as the sea anchor should not be deployed until the liferaft is clear from the aircraft. Liferaft specifications are issued by EASA (ETSO 2C70a and ETSO 2C505) and the FAA (TSO C70a).

Information advising liferaft occupants of the need to deploy the sea anchor to limit the liferaft's movement across the surface, was not annotated on labels attached to the inside of the liferafts. It is likely that this resulted in the sea anchors not being deployed which subsequently inhibited the helicopter rescue by allowing the liferafts to be pushed across the surface of the sea by the helicopter's downwash.

Safety Recommendation 2011-066

It is recommended that the European Aviation Safety Agency modifies European Technical Standard Order (ETSO) 2C70a and ETSO 2C505 to include a requirement for multi-seat liferafts, that do not automatically deploy their sea anchor, to include a label, visible from within the inflated liferaft, reminding the occupants when to deploy the sea anchor.

Safety Recommendation 2011-067

It is recommended that the Federal Aviation Administration modifies Technical Standard Order (TSO) C70a to include a requirement for multi-seat liferafts, that do not automatically deploy their sea anchor, to include a label, visible from within the inflated raft, reminding the occupants when to deploy the sea anchor.

Subsequent examination and re-inflation of the liferafts confirmed that the lower ring of the left liferaft was torn and deflated. This was confirmed by reports from the occupants. Damage must therefore have occurred before the liferaft was salvaged and it can only be assumed was caused by some projection on the aircraft.

It was noted, on examination of the main wreckage, that the CFRP fairings covering longitudinal pipe-work beneath the boarding steps had separated. This left attached sections of CFRP which exhibited jagged and sharp projecting edges. It was also noted, during the underwater search for the missing tail boom, that fragments of red painted material were clustered in a small group in an area close to the platform. Examination of the salvaged wreckage indicated that the only likely sources of broken and fragmented red material, similar to that observed on the sea bed, were the CFRP fairings. It is, therefore, reasonable to assume that the fairings shattered as the aircraft struck the water and fragments sank close to the initial impact point. Thus, the sections remaining attached to the hull would have presented jagged edges, close to the plane of flotation, capable of puncturing the inflation chamber of a floating or deploying liferaft, even in the relatively benign surface conditions associated with this water impact.

The impact with the water was survivable, involving little or no main fuselage deformation, no seat damage and no reported occupant injuries. The high strength of each of the CFRP fairings on the lower fuselage surfaces would have been accompanied by high stiffness. Hence, a water impact, which might have distorted a metallic fairing, is likely to have generated greater forces in a CFRP fairing, increasing the risk of shattering the latter. The advisory material used in the certification of the EC225 LP did consider ‘delethalisation’ of the fuselage. However, this process did not expose the possibilities for damage which occurred in this accident.

Therefore:

Safety Recommendation 2011-068

It is recommended that the European Aviation Safety Agency requires Eurocopter to review the design of the fairings below the boarding steps on AS332 and EC225 series helicopters to reduce the possibility of fairings shattering during survivable water impact and presenting sharp projections capable of damaging liferafts.

The possibility of liferafts being punctured as a result of contacting sharp projections on the exterior of floating helicopters has been recognised from previous accidents. The current requirements are only applicable to ditching although there are many examples of survivable water impacts. It may not be possible to broaden the ditching requirements to include all water impacts. However, it is important to consider the 'delethalisation' aspects which try to ensure that the liferafts remain in a useable condition over a broad spectrum of impacts.

Therefore:

Safety Recommendation 2011-069

It is recommended that the European Aviation Safety Agency, in conjunction with the Federal Aviation Administration, review the design requirements and advisory material for helicopters for the 'delethalisation' of the structure to prevent damage to deploying and floating liferafts following a survivable water impact.

2.5.5 Seasickness tablets

Seasickness can reduce an individual's survival time in adverse conditions, by reducing their body fluids and inhibiting the sufferer's ability to contribute to their own and their colleagues' safety and subsequent rescue. The anti-seasickness tablets in the survival bags were stowed in sodden cardboard packaging which did not allow the contents to be dispensed easily, despite the relatively benign conditions. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2011-070

It is recommended that the European Aviation Safety Agency ensures that a requirement is developed for all emergency equipment, stowed in deployable survival bags, to be capable of being easily accessed and utilised by the gloved hands of a liferaft occupant whilst in challenging survival situations when a liferaft may be subject to considerable motion in cold, wet and dark conditions.

2.5.6 PLBs

The tests showed that the close proximity of a transmitting WWPLB to a PLB can have a detrimental effect on the PLB's performance by invoking the 'smart' feature and causing the PLB to cease transmitting the more powerful homing signals. Other 'personal wear' types of PLBs would have a similar detrimental effect.

It was also established that the crew were not aware that the upper section of the antenna on the beacon type is telescopic. Consequently, although each antenna was reported to have been correctly pivoted to an angle close to the vertical, the telescopic sections were not extended. This had a detrimental effect on transmission power, especially on the 121.5 MHz emergency frequency.

It is most probable that the presence of the WWPLBs adjacent to the TechTest 500-12Y ELT(S)/PLBs inhibited the operation of the latter's more powerful emergency homing signals on 121.5 MHz and 243.0 MHz. As a result, the search facility using the ELT(S)/PLBs was eliminated, leaving the much weaker signals transmitted by the WWPLBs.

By not extending the antenna on any of the ELT(S)/PLBs the crew unknowingly reduced the available broadcast strength of the emergency transmissions, handicapped the homing ability of the search and rescue aircraft and contributed to the non-receipt of voice signals by SAR aircraft when the press-to-transmit buttons were operated, even though this action eliminated the suppression effect of the WWPLBs.

2.5.7 SAR

The Jigsaw SAR helicopter crew experienced several difficulties with the rescue significantly reducing their effectiveness. They were not provided with regular multi-seat liferaft winch training, as part of their SAR role currency and there was not a suitable waterproof communication system between the winch man and other crew members. Additionally, the absence of a pilot's winch control switch prevented two people from being hoisted simultaneously on the winch.

The Nimrod crew also experienced some difficulties in obtaining the air picture and were unable to deconflict the SAR helicopters in the poor weather conditions.

2.5.8 Follow-up safety actions

The following initiatives have been implemented since the accident:

- North Sea Operators of EC225 helicopters have now fitted visual aids to indicate to passengers the location of the starboard main door jettison handle.

- The helicopter passenger safety briefing video has been modified to improve the way passengers are briefed on the location of the door jettison handles.

- The oil company has improved the Jigsaw aircraft's capabilities by ensuring crews have multi-seat liferaft winch training as a part of their SAR role currency.

- The winch man equipment now includes a 'wet fit' radio.

- A pilot's winch switch has been embodied in the Jigsaw SAR helicopters.

- The ARCC, in consultation with air traffic control authorities, will normally apply for the establishment of a Temporary Restriction of Flying Regulation around any major incidents where more than two SAR helicopters are being tasked, requiring all aircraft wishing to enter the area to obtain permission, thereby ensuring that it is easier for an Aircraft Co-ordinator (ACO) crew, on arrival at the scene, to gain an awareness of the air picture and co-ordinate participating air assets.

- Temporarily, the 'smart' capability has been inhibited on the ELT(S)/PLBs to prevent their homing signals from being 'switched off' by low powered WWPLBs or similar 'personal wear' devices. A long term method of enabling these devices to co-exist safely is being sought.

2.5.9 Crash Position Indicator (CPI)

The primary means of location of the floating aircraft would normally have been the airframe mounted CPI. This should, under the circumstances of this accident, have released automatically and commenced broadcasting on the COSPAS/SARSAT frequency, together with the VHF distress/homing frequency of 121.5 MHz. Although, in the event, the survivors were successfully located, considerable delay and difficulty in establishing that location occurred, and complete failure of the CPI to separate and function contributed to that delay. Had the CPI released correctly, the initial location of the main wreckage could have been established rapidly and rescue initiated without some of the problems encountered on this occasion.

Many deliberate ditching events and accidental water impacts involving commercial air transport helicopters have been investigated by AAIB. This was, however, the first such survivable event to have been so investigated since the provision of a present generation airframe mounted Automatically Deployable Emergency Locator Transmitter (ELT (AD)) has been a mandatory requirement. The fitment of the CPI was intended to satisfy that requirement.

The circumstances of this accident, ie the combination of forward speed and rate of descent, with associated nose-up attitude, resulted in both linear vertical and nose-down angular pitching accelerations at impact. These, in combination, created sufficient bending moment at the tail-boom attachment to cause downward structural failure. This, in turn, led to downward displacement of the rotating tail-rotor drive shaft. Entanglement with wiring looms and consequent damage to those incorporating part of the CPI release system, then occurred.

The resulting nose-down attitude of the floating aircraft, following the separation of the tail-boom, appears to have resulted in the water switch remaining above the waterline following automatic deployment of the flotation equipment.

The reason for the failure of the CPI to deploy on G-REDU was not fully determined. It was, however, judged to have been influenced by one or more of the following factors:

1. The crew release was not utilised - the crew did not report using it and the release switch was found positioned and gated in the normal flight setting after salvage.

2. The relatively low linear acceleration imparted to the 'G' switch in any direction during the impact, resulting in the switch failing to trigger.

3. The low position of the CPI unit mounting, both in relation to the floating waterline and to the initial point of impact of the fuselage with the water, resulting in water immersion of that unit and associated wiring.

4. The adjacent low position of the associated beacon release electronic unit similarly resulting in water immersion.

5. The vulnerability of the routing of the electrical cabling to the CPI release system in relation to the plane of the structural failure of the tail-boom attachment and the axis of the tail-rotor drive shaft, resulting in entanglement and wiring disruption.

6. The relatively high position of the water activated switch in relation to the floating waterline following structural failure, resulting in that switch failing to become immersed in water.

Therefore:

Safety Recommendation 2011-071

It is recommended that the European Aviation Safety Agency reviews the location and design of the components and installation features of Automatically Deployable Emergency Locator Transmitters and Crash Position Indicator units, when required to be fitted to offshore helicopters, to ensure the reliability of operation of such units during and after water impacts.

3 Conclusions

(a) Findings

1. The helicopter was certified, equipped and maintained in accordance with existing regulations and approved procedures. At the time of the accident there were no recorded Acceptable Deferred Defects that might have contributed to the accident.

2. The flight crew were properly licensed and qualified to conduct the flight and were well rested. Their training was in accordance with the operator's requirements and they were in recent night deck landing practice.

3. The flight crew had the relevant meteorological information and, although the weather was suitable for departure, the helicopter entered an area of reduced visibility in the immediate vicinity of the ETAP platform.

4. A TAWS caution caption on the CWP illuminated en-route to the platform and was announced by the co-pilot who was the non-handling pilot. The caution immediately extinguished without crew intervention.

5. The commander, who was the pilot flying, initially briefed the co-pilot for an Airborne Radar Approach due to the updated weather at the ETAP platform.

6. The flight crew visually acquired the lights and flare of the ETAP platform at a range of about 20 nm. This led to their decision to carry out an en-route descent to a height of 300 ft to position the helicopter for a visual approach and landing.

7. The helicopter entered low cloud during the initial en-route descent to a height of 300 ft, so the crew initiated a climb. On reaching a height of 400 ft, the crew regained and were able to maintain visual contact with the ETAP. Consequently, a further climb to MEA was not carried out.

8. A second descent to 300 ft was initiated at a range of 1.5 nm but, again, the helicopter entered low cloud and a climb was commenced. At 400 ft the platform lights and the flare were visible and the commander stopped the climb and continued the approach.

9. There was no specified visual approach profile providing the crew with recommended range, height and rate of descent information for the approach. Also, there were no minimum heights at which a go-around must be initiated.

10. There was no specified procedure for the 'pilot not flying' to monitor the approach using the flight instruments.

11. The co-pilot stated the opinion during the climb, thinking that it was a go-around, that a second approach would be successful.

12. The commander de-selected the upper modes of the Automatic Pilot, at a range of approximately 0.75 nm, and suspended the height alert of the radio altimeter.

13. The commander executed a 20° banked turn to the left through 62°, during which the helicopter entered a continuous descent.

14. The co-pilot identified the descent and announced it to the commander but no corrective action was taken. He also provided range and speed information.

15. The commander could see the platform flare and diffused lights but not the green perimeter lights of the helideck.

16. The co-pilot could see the flare, diffused lights of the platform and the green perimeter lights of the helideck.

17. The green helideck perimeter lights were visible from below the elevation of the helideck.

18. The commander's attention became focussed on visually acquiring the helideck which was not visible to him.

19. The co-pilot monitored the helicopter's groundspeed and range from the platform and attempted to assist the commander in visually acquiring the helideck.

20. Both flight crew members were unaware of the helicopter's continued descent.

21. Neither pilot observed the oval shape defined by the perimeter lighting of the helideck and could not determine the helicopter's approach path angle.

22. The commander gradually pitched the helicopter's nose up in order to reduce speed. He maintained what he thought was a constant approach angle using the visual picture of the ETAP relative to his windscreen.

23. The fixed 100 ft height audio voice alert failed to activate, due to a likely malfunction of the TAWS, and the selectable 150 ft audio voice alert would also have failed to activate for the same reason, had it not already been suspended by the crew.

24. The pilots were not aware of the inoperative status of the TAWS.

25. The commander had the sensation that the helicopter was high and fast and increased the nose-up pitch attitude.

26. Both pilots thought that the helicopter was still above the level of the helideck when it impacted the surface of the sea.

27. It was probable that both pilots were subjected to the effects of oculogravic and somatogravic illusions possibly reinforced by the reflection of the platform lights in the surface of the sea.

28. The accident was survivable and all those onboard were rescued by a Search and Rescue helicopter and other surface vessels.

(b) Causal factors

The investigation identified the following causal factors:

1. The crew's perception of the position and orientation of the helicopter relative to the platform during the final approach was erroneous. Neither crew member was aware that the helicopter was descending towards the surface of the sea. This was probably due to the effects of oculogravic and somatogravic illusions combined with both pilots being focused on the platform and not monitoring the flight instruments.

2. The approach was conducted in reduced visibility, probably due to fog or low cloud. This degraded the visual cues provided by the platform lighting, adding to the strength of the visual illusions during the final approach.

3. The two radio altimeter-based audio-voice height alert warnings did not activate. The fixed 100 ft audio-voice alert failed to activate, due to a likely malfunction of the Terrain Awareness and Warning System (TAWS), and the audio-voice element of the selectable 150 ft alert had been suspended by the crew. Had the latter not been suspended, it would also have failed to activate. The pilots were not aware of the inoperative state of the TAWS.

(c) Contributory factors

The investigation identified the following contributory factors:

1 There was no specified night visual approach profile on which the crew could base their approach and minimum heights, and stabilised approach criteria were not specified.

2 The visual picture on final approach was possibly confused by a reflection of the platform on the surface of the sea.

4 Safety Recommendations

Safety Recommendations made previously in Special Bulletin S4/2009 published on 23 June 2009.

4.1 **Safety Recommendation 2009-064:** It is recommended that the Civil Aviation Authority review the carriage and use in commercial air transport helicopters of any radio location devices which do not form part of the aircraft's certificated equipment.

4.2 **Safety Recommendation 2009-065:** It is recommended that the Civil Aviation Authority advise the European Aviation Safety Agency of the outcome of the review on the carriage and use in commercial air transport helicopters of any radio location devices which do not form part of the aircraft's certificated equipment.

4.3 **Safety Recommendation 2009-066:** It is recommended that the European Aviation Safety Agency require manufacturers of Emergency Locator Transmitters (ELT(S)s)/Personal Locator Beacons (PLBs) units to add details, where absent, of the correct use of the antenna to the instructions annotated on the body of such beacons.

4.4 **Safety Recommendation 2009-067:** It is recommended that the Civil Aviation Authority ensure that all aspects of Emergency Locator Transmitter (ELT(S))/ Personal Locator Beacon (PLB) operation, particularly correct deployment of the antenna, are included and given appropriate emphasis in initial and recurrent commercial air transport flight crew training, as applicable.

Safety Recommendations made in this report.

4.5 **Safety Recommendation 2011-049:** It is recommended that the Civil Aviation Authority re-emphasises to Oil and Gas UK that they adopt the guidance in Civil Aviation Publication (CAP) 437, entitled *Offshore Helicopter Landing Areas - Guidance on Standards*, insofar as personnel who are required to conduct weather observations from vessels and platforms equipped for helicopter offshore operations are suitably trained, qualified and provided with equipment that can accurately measure the cloud base and visibility, in order to provide more accurate weather reports to helicopter operators.

4.6 **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.

4.7 **Safety Recommendation 2011-051:** It is recommended that the Civil Aviation Authority ensures that commercial air transport offshore helicopter operators define specific offshore approach profiles, which include the parameters for a stabilised approach and the corrective action to be taken in the event of an unstable approach.

4.8 **Safety Recommendation 2011-052:** It is recommended that the Civil Aviation Authority commissions a project to study the visual illusions that may be generated during offshore approaches to vessels or offshore installations, in poor visibility and at night, and publicises the findings.

4.9 **Safety Recommendation 2011-053:** It is recommended that the Civil Aviation Authority (CAA) amends Civil Aviation Publication (CAP) 437, *Offshore Helicopter Landing Areas - Guidance on Standards*, to encourage operators of vessels and offshore installations, equipped with helidecks, to adopt the new lighting standard, for which a draft specification has been published in Appendix E of CAP 437, once the specification has been finalised.

4.10 **Safety Recommendation 2011-054:** It is recommended that the Civil Aviation Authority reviews the procedures specified by commercial air transport helicopter operators as to when a crew may or should suspend a radio altimeter aural or visual height warning.

4.11 **Safety Recommendation 2011-055:** It is recommended that the Civil Aviation Authority reviews commercial air transport offshore helicopter operators' procedures to ensure that an appropriate defined response is specified when a height warning is activated.

4.12 **Safety Recommendation 2011-056:** It is recommended that the Civil Aviation Authority reviews the procedures set out by commercial air transport offshore helicopter operators to ensure that a member of the flight crew monitors the flight instruments during an approach in order to ensure a safe flight path.

4.13 **Safety Recommendation 2011-057:** It is recommended that the International Civil Aviation Organisation introduces a Standard for crash-protected recordings of the operational status of Airborne Collision Avoidance System (ACAS) and Terrain Awareness and Warning System (TAWS) equipment, where fitted, on helicopters required to carry a flight data recorder.

4.14 **Safety Recommendation 2011-058:** It is recommended that the European Aviation Safety Agency requires that crews of helicopters, fitted with a Terrain

Awareness and Warning System, be provided with an immediate indication when the system becomes inoperative, fails, is inhibited or selected OFF.

4.15 **Safety Recommendation 2011-059:** It is recommended that the European Aviation Safety Agency reviews the acceptability of crew-operated ON/OFF controls which can disable mandatory helicopter audio voice warnings.

4.16 **Safety Recommendation 2011-060:** It is recommended that the Civil Aviation Authority reviews the guidance in *Civil Aviation Publication (CAP) 562, Civil Aircraft Airworthiness Information and Procedures*, Part 11, Leaflet 11-35, *Radio Altimeters and AVADs for Helicopters*, regarding the pre-set audio height warning that is triggered by the radio altimeter and may not be altered in flight, to ensure that crews are provided with adequate warning to take corrective action.

4.17 **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.

4.18 **Safety Recommendation 2011-062:** It is recommended that the European Aviation Safety Agency reviews the frequency of nuisance warnings generated by Terrain Awareness and Warning System equipment in offshore helicopter operations and takes appropriate action to improve the integrity of the system.

4.19 **Safety Recommendation 2011-063:** It is recommended that the European Aviation Safety Agency, in conjunction with the Federal Aviation Administration, defines standards governing the content, accuracy and presentation of obstacles in the Terrain Awareness and Warning System obstacle database for helicopters operating in the offshore environment.

4.20 **Safety Recommendation 2011-064:** It is recommended that the European Aviation Safety Agency establishes the feasibility of recording, in crash-protected memory, status indications from each avionic system on an aircraft.

4.21 **Safety Recommendation 2011-065:** It is recommended that the European Aviation Safety Agency considers amending certification requirements for rotorcraft, that are certified in accordance with ditching provisions, to include a means of automatically inflating emergency flotation equipment following water entry.

4.22 **Safety Recommendation 2011-066:** It is recommended that the European Aviation Safety Agency modifies European Technical Standard Order (ETSO) 2C70a and ETSO 2C505 to include a requirement for multi-seat liferafts, that do not automatically deploy their Sea Anchor, to include a label, visible from within the inflated liferaft, reminding the occupants when to deploy the Sea Anchor.

4.23 **Safety Recommendation 2011-067:** It is recommended that the Federal Aviation Administration modifies Technical Standard Order (TSO) C70a to include a requirement for multi-seat liferafts, that do not automatically deploy their Sea Anchor, to include a label, visible from within the inflated raft, reminding the occupants when to deploy the Sea Anchor.

4.24 **Safety Recommendation 2011-068:** It is recommended that the European Aviation Safety Agency requires Eurocopter to review the design of the fairings below the boarding steps on AS332 and EC225 series helicopters to reduce the possibility of fairings shattering during survivable water impact and presenting sharp projections capable of damaging liferafts.

4.25 **Safety Recommendation 2011-069:** It is recommended that the European Aviation Safety Agency, in conjunction with the Federal Aviation Administration, review the design requirements and advisory material for helicopters to require 'delethalisation' of the fuselage to prevent damage to deploying and floating liferafts following a survivable water impact.

4.26 **Safety Recommendation 2011-070:** It is recommended that the European Aviation Safety Agency ensures that a requirement is developed for all emergency equipment, stowed in deployable survival bags, to be capable of being easily accessed and utilised by the gloved hands of a liferaft occupant whilst in challenging survival situations when a liferaft may be subject to considerable motion in cold, wet and dark conditions.

4.27 **Safety Recommendation 2011-071:** It is recommended that the European Aviation Safety Agency reviews the location and design of the components and installation features of Automatically Deployable Emergency Locator Transmitters and Crash Position Indicator units, when required to be fitted to offshore helicopters, to ensure the reliability of operation of such units during and after water impacts.

Appendix A

Report on accident to Super Puma G-REDU on 18 February 2009
by Mr John Chappelow

Introduction

This report addresses some perceptual and procedural issues in the final approach of G-REDU on the night of 18 February 2009. It should be read in association with the report of my colleague, Dr Rollin Stott, which addresses the perceptual issues in more detail.

The captain, as handling pilot (HP), monitored by the non-handling pilot (NHP), flew the approach to the ETAP platform. In the final stages, the aircraft descended unchecked into the sea about 300m short of the platform. The fact that neither pilot appears to have anticipated the impact suggests that misperception may have been an important factor.

Perceptual aspects of the approach

About 25s before impact (I-25s), the HP, 'looking in', initiated a turn into wind towards the platform, decoupled the auto-pilot, and inhibited the radio altimeter 150ft warning. It is assumed that his attention was directed increasingly towards the platform from this point on. However, he reports being unable to see the green lights of the helideck. From about I-12s, the aircraft heading was roughly stable. It is assumed that the HP's attention was concentrated on the platform from this point on.

Primary visual cues: It is possible to conduct a stable, visual approach by maintaining a constant approach angle (α in Appendix A Figure 1). If α is constant, the aircraft will arrive at the aiming point even though airspeed and vertical speed may vary. In principle, it is possible to maintain a constant approach angle by reference to the apparent depression of the target below the horizon. In practice, it is often easier to achieve the same effect by keeping the apparent position of the target constant with reference to the airframe. If the horizon is visible or there is enough visible texture in the ground plane, a change in pitch angle will be obvious and is likely to be interpreted correctly, i.e. the external world, including the aiming point, appears to move relative to the airframe (Appendix A Figure 2).

If there is no visible or texturally implied horizon, the possibility arises of a pitch change being misinterpreted as a change in approach angle. In the case represented in Appendix A Figure 3, the perceived approach angle is steeper than the actual approach angle. In addition to the absence of external visual cues defining orientation with respect to the horizontal, this case also requires that the change in pitch angle be undetected by reference to instruments or by non-visual senses.

The final approach was conducted in darkness and poor visibility. The possibility of a misperception of this sort warrants consideration. Appendix A Figure 4 is derived from data from the airborne data recorder. It shows that the approach angle to the helideck declined from about I-22s, passing zero at about I-7s, i.e. the helicopter passed below the

Appendix A

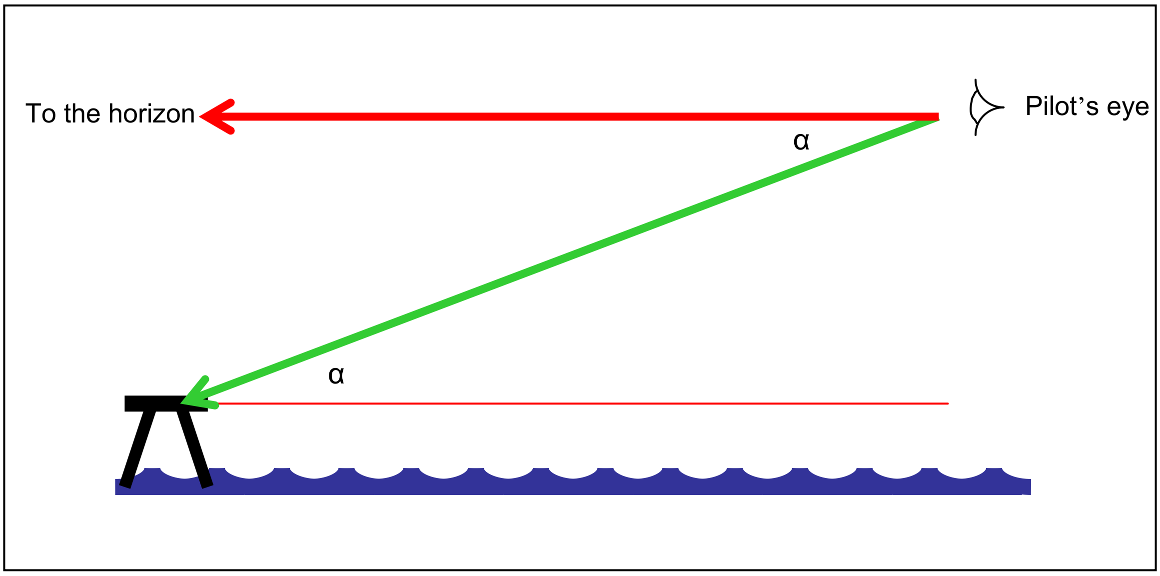


Figure 1

Basic approach geometry

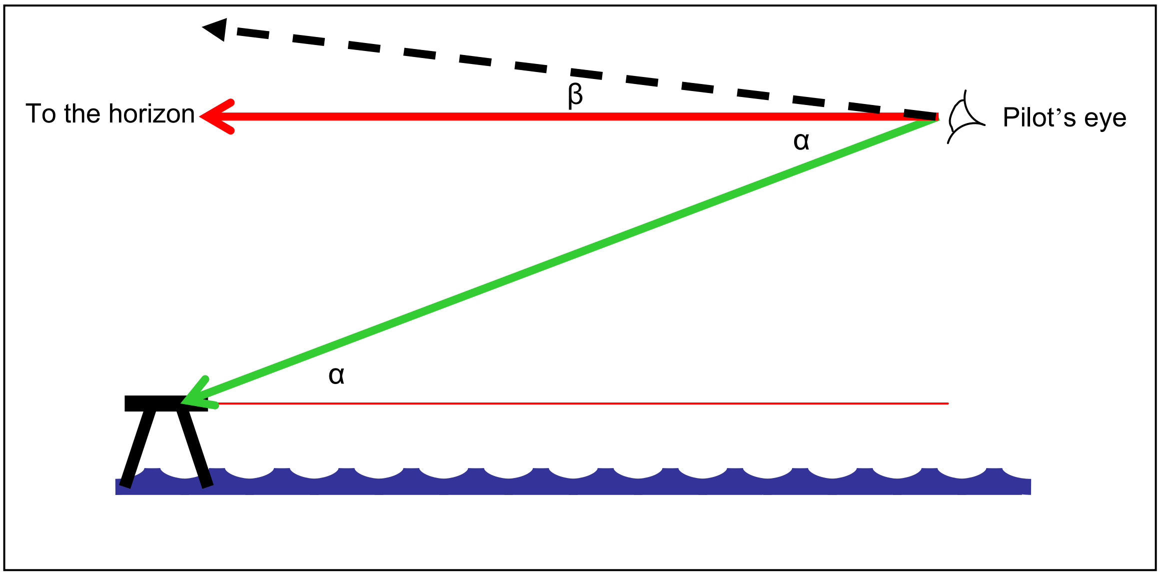


Figure 2

Approach geometry with pitch up

Appendix A

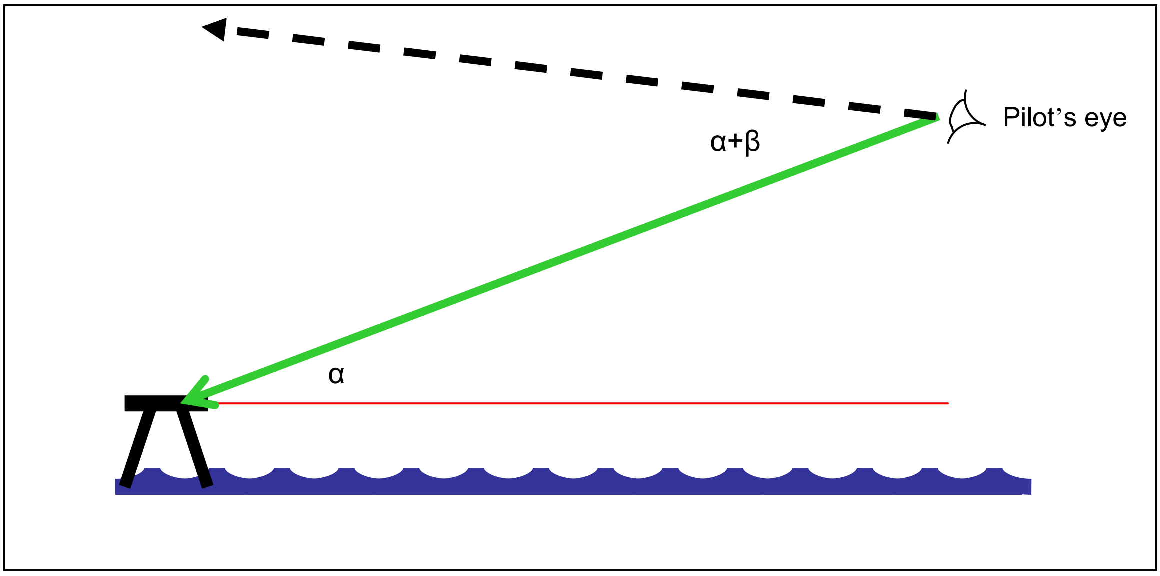


Figure 3

Misperceived approach geometry

level of the deck. Throughout this period, the pitch angle increased steadily. The apparent position of the helideck relative to the airframe (α+β) remained more or less constant, i.e. the approach may have appeared normal and stable. The cyclic input required to achieve this apparent stability was not large and, given the HP's concentration on external visual cues could well have passed unnoticed. After I-7s, the rate of reduction in α increased. Without other cues to stabilise the HP's perception of orientation, this could be interpreted as being both high and fast. Dr Stott estimates the apparent increase in speed as about 5kts. At about I-5s, pitch angle began to increase more sharply. This may have been an attempt to correct for the apparently high and fast condition. There was no increase in collective demand, so airspeed declined and the rate of descent increased until the aircraft hit the sea.

Non-visual cues: The account thus far is in accord with Dr Stott's analysis and he has described the effect succinctly as an oculogravic illusion. Of particular note is his conclusion that there was no significant overall change in the apparent G_z vector throughout the critical period (his Appendix B Figure 4), i.e. detection of the pitch change through non-visual senses was unlikely.

Secondary visual cues: The account so far has ignored potentially informative visual features of the platform and helideck. In principle, the apparent orientation of the lights of the accommodation block and other parts of the platform could provide some guidance as to aircraft attitude and position relative to the platform. However, although the mass of lights might provide a rough indication of roll attitude, particularly as the range decreased, its utility as a guide to height would be very limited, particularly if degraded by poor

Appendix A

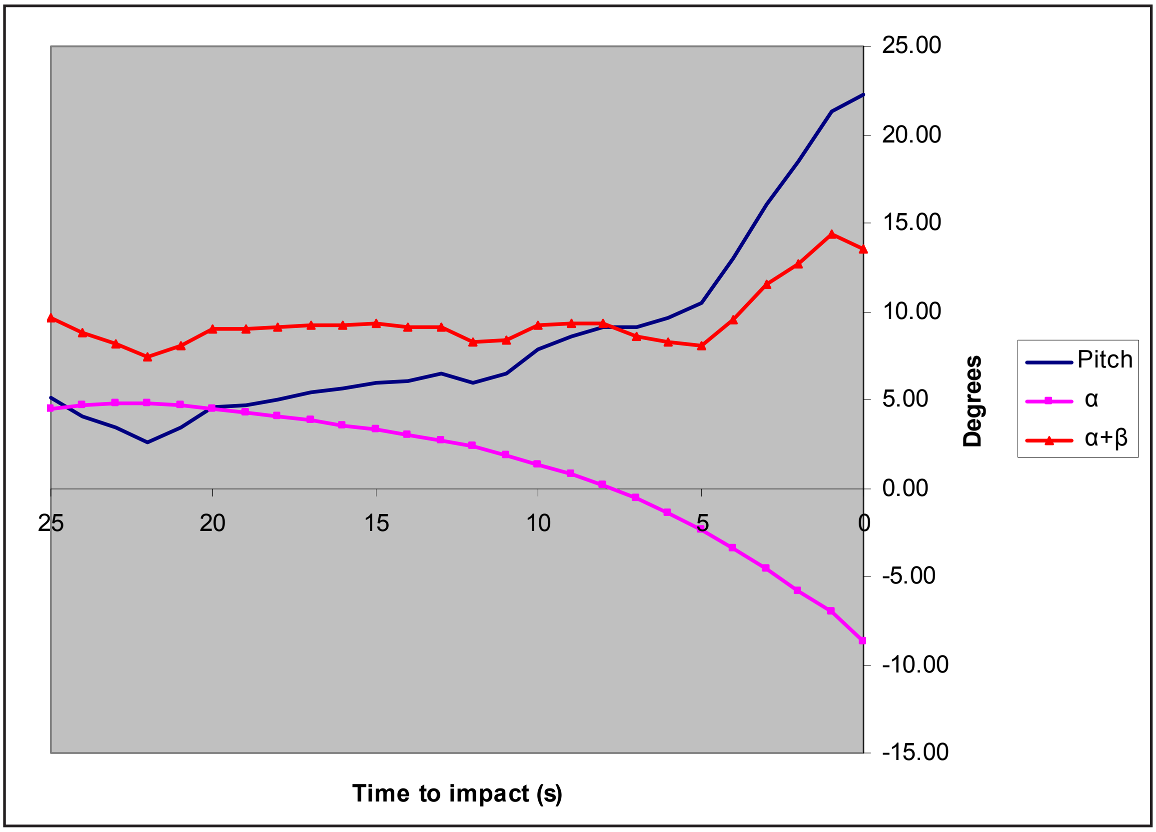


Figure 4

The final approach

visibility. The helideck itself could be more useful. As a horizontal feature of standardized shape and size, its appearance would be expected to change in a predictable way as the approach progressed. It should appear as an ellipse becoming progressively nearer to a circle as range reduced. Dr Stott's analysis shows that the maximum ratio of the short to the long axis occurred at about I-20s and the far-side circumferential lights would have become obscured as the aircraft descended below deck height (around I-7s). The HP did not see the deck at all. He asked the NHP several times if he could see it. Although the NHP reported that he could, it is possible that, due to poor visibility, the deck appeared more as a diffuse, green glow rather than as a sharply defined shape, and he may not have attended closely to its appearance.

Procedural aspects of the approach

Finally, deviation from the normal or expected approach path could have been detected by monitoring the instruments. In principle, three specific methods are relevant:

1 A comparison of the radio altimeter height with the expected height at any range (derived from radar or other aids) would identify deviations from the intended approach path.

Appendix A

2 Continuous monitoring of key parameters such as airspeed, vertical speed, and attitude would allow gross deviations from the intended approach path to be anticipated and prevented.

3 Spot checks at specific heights or ranges could identify conditions outside the normal and allow the approach to be aborted.

On the evidence of the cockpit voice recording, this crew did not avail themselves effectively of these methods. The NHP called ranges, presumably from the radar, but no heights, speeds, or rates of descent. The repeated requests by the HP for assurance that the helideck was visible may have degraded the NHP's ability to maintain a comprehensive instrument scan to some degree. In addition, the practice of disabling radio altimeter warnings effectively eliminated a useful and reliable way of implementing the third method. Although there were also technical reasons why such warnings were not available in this case, the principle stands. A warning at 150ft could have alerted the crew to the fact that they were below the helideck height. Setting a warning at, say, 50ft above deck height might have provided an even more useful alert and prompted a formal spot check on all important parameters that could form the basis of a go/no go decision.

Company procedures required the NHP to monitor the flight path and the HP's actions. This stipulation is, on the face of it, vague and might be effective only if their training specified what methods were to be employed and the acceptable range of each of the parameters to be monitored continuously or checked at specific 'gates'. It is also advisable that these methods are routinely employed in all conditions so that they are second nature when conditions are difficult and the checks become vital.

Conclusions

The conditions during the final approach were such that maintenance of a stable approach path could not be guaranteed solely by reference to external visual cues. An unnoticed, steady increase in pitch caused the approach angle to appear normal then to appear steep and fast although the aircraft was accelerating towards the sea. The change in pitch was unlikely to be detected by non-visual senses. The monitoring of the flight path and the HP's actions by the NHP was inadequate to detect the deviation from normality.

Recommendations

The most effective way to prevent similar accidents due to misperception is to train crews in effective monitoring procedures. This requires the definition of acceptable limits for airspeed, vertical speed, and attitude throughout the approach as well as expected values for height against range. The use of specific gates, if possible identified by radio altimeter warnings, to prompt spot checks on key parameters would also reduce risk.

Appendix B

Report on accident involving EC225 Helicopter G-REDU on 18 February 2009
by Dr Rollin Stott

Aim

The purpose of this aspect of the investigation is to consider how the visual environment, the dynamic environment and their interaction led to the misperceptions suffered by the two pilots and the consequent flight path of the aircraft.

Information supplied

Excel file of FDR output for the entire flight
Graphical output of selected aircraft variables for the final 46s of flight
GPS coordinates of the platform and of the aircraft during the final 50s of the flight
Written statements from the aircraft captain and co-pilot dated 20 Feb 2009
AAIB Bulletin S3/2009

Initial observations

This report is concerned with the final 50s of the flight. For this period there are GPS data which together with RadAlt data allow determination of the three dimensional position of the aircraft relative to the platform. Until impact (I)-36s the aircraft was in level flight at an altitude of 310ft, airspeed 61kt and heading 094deg. At I-36s the aircraft began to climb in order to clear fog and by I-25s the aircraft was at 412ft and the crew were visual with the platform. At I-25s the pilot initiated a left hand turn, which he states was carried out on instruments and which continued until I-12s when a heading of 030deg was established. From I-25s the aircraft began to descend. By I-20s the descent rate was 980ft/min and this descent continued until the point of impact, the rate increasing gradually to 1380ft/min at impact. Also from I-25s a very gradual increase in the pitch attitude of the aircraft became evident; at I-15s it was increasing at 0.5deg/s and by I-5s at 2deg/s. At impact the FDR indicated a pitch-up of 22 degrees. The change in pitch attitude was associated with a corresponding reduction in airspeed, which had decreased to 30kt immediately before impact.

From the pilots' statements it is evident that impact with the sea was entirely unanticipated. Both pilots reported seeing the platform below them shortly before impact and were probably unaware of the pitch attitude of the aircraft. During the critical final 15s of the flight both pilots appear to have been preoccupied with the identification of features of the platform, in particular the helideck which the co-pilot was recorded as having identified but the captain had not.

Appendix B

Variables used in data analysis

GPS coordinates of the aircraft relative to the platform
Angle of aircraft pitch
Airspeed
Aircraft altitude from RadAlt
Fore-aft (Gx) and aircraft-vertical (Gz) accelerations

Derived variables

Horizontal distance to platform
Angle of platform relative to aircraft heading
Corrected pitch angle derived by subtraction of the mean pitch angle recorded in the period I-50 to I-38 when the aircraft was in level un-accelerated flight
Expected airspeed on the basis of the corrected pitch attitude
Direction of resultant Gx + Gz force vector relative to aircraft
Angle of helideck below true horizontal in the vertical plane (glideslope)
Perceived angle of helideck below pilots' horizontal on the basis of unperceived pitch attitude
Perceived altitude of aircraft on the basis of an accurate assessment of separation from the platform but unperceived pitch attitude
Perceived horizontal distance to platform on the basis of erroneous perception of altitude
Visual perception of airspeed

Data Analysis

The flight path of the aircraft on approach to the platform is shown in Appendix B Figure 1. At the initiation of the left hand turn on the final approach the platform would have appeared at 042 degrees to the left of the aircraft and immediately following the turn at 12 degrees to the right (Appendix B Figure 2).

In a helicopter acceleration in the line of flight is achieved by pitch down of the aircraft and deceleration by pitch up in order that a component of the lift force of the rotor acts in the line of flight. For this reason there is a direct relationship between the pitch attitude of a helicopter and changes in airspeed. In attempting to confirm this relationship, it was noted that in the 12s period at the start of the record when the aircraft was in level flight and at constant airspeed there was a mean recorded pitch attitude of 5.11 degrees nose-up. When this offset was subtracted from the values of pitch attitude throughout the record it was possible to determine the horizontal component of lift acting to produce forward acceleration or deceleration in the line of flight of the aircraft and hence to predict airspeed from a knowledge of the aircraft pitch attitude.

Appendix B

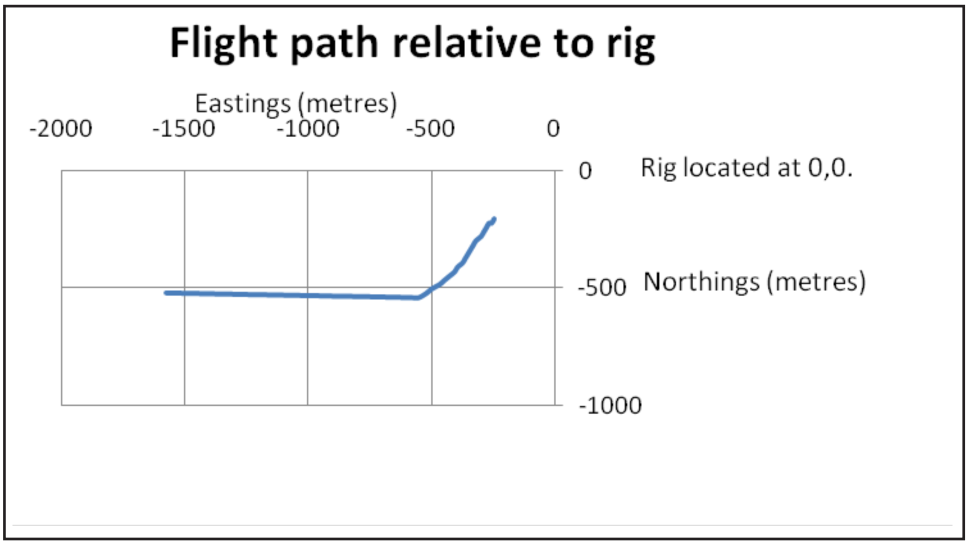


Figure 1

Approach path of the aircraft relative to the platform.

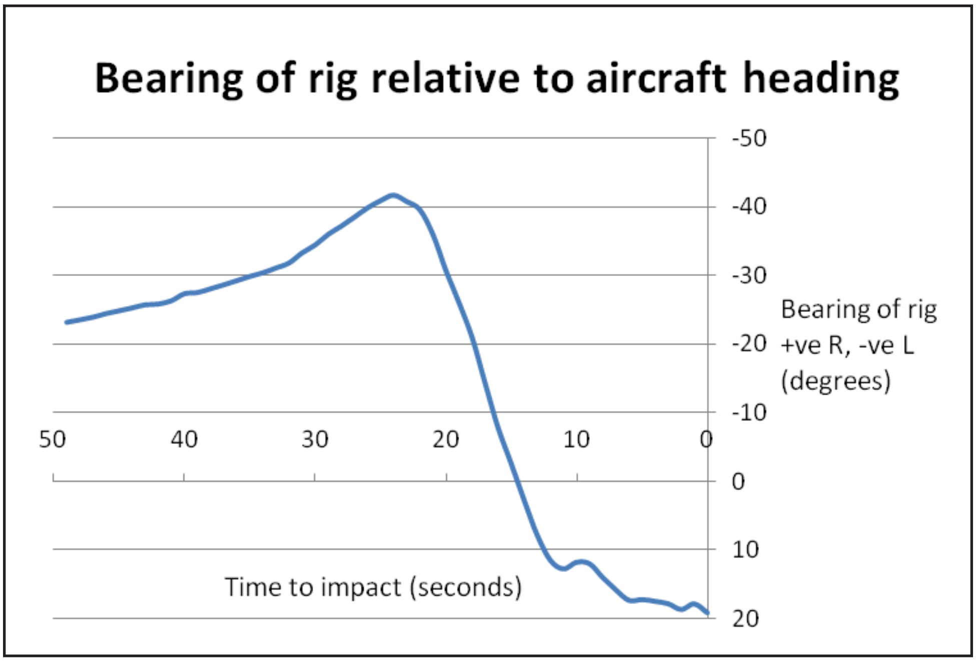


Figure 2

Direction of platform in relation to aircraft heading. At 25s before impact the pilots would have seen the lights of the platform at about 42 degrees to their left. Following the turn the platform would have appeared about 15 degrees to their right.

Appendix B

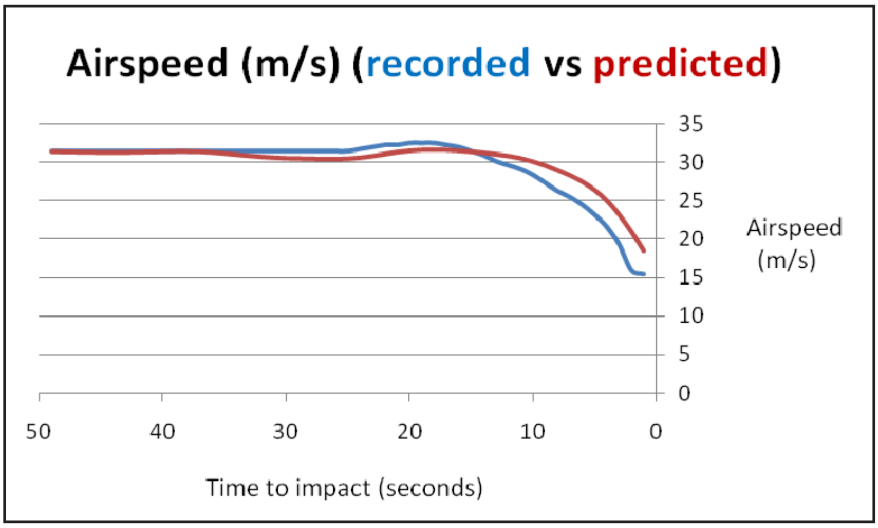


Figure 3

Comparison of recorded airspeed with values derived from corrected pitch attitude.

A comparison of actual versus calculated airspeed is shown in Appendix B Figure 3. There is reasonable agreement between predicted and actual airspeed given the errors associated with the integration of forward acceleration to derive airspeed, the 0.25 degree resolution of the pitch record and the sensitivity to small changes in subtracted offset. The validation of this relationship provides the justification for the use of the corrected rather than the recorded pitch attitude in the subsequent analysis.

The recorded values of longitudinal (Gx) and aircraft-vertical (Gz) accelerations were summed to give the resultant force vector and its angle relative to the longitudinal axis of the aircraft (Appendix B Figure 4). This force vector is generated by the lift force of the rotor and gives the occupants of the aircraft a perception of gravity in both intensity and direction. In un-accelerated flight the direction of this force corresponds to the true vertical but in the presence of a changing velocity the perceived and true vertical no longer correspond. This is the basis of the somatogravic effect/illusion in which there may be erroneous perceptions of both pitch and roll attitude.

It can be observed from the graph of Appendix B Figure 4 that the angle of the resultant force vector varies by little more than ±2 degrees from its mean value of -5 degrees. (This mean value of -5 degrees is the same as the offset that it was found necessary to subtract from the recorded pitch attitude of the aircraft.) It is important to note that, despite the increasing pitch up of the aircraft in the final 10s of the record, the direction of the force vector relative to the aircraft is unchanged from that obtained in the first 10s of the record when the aircraft was in level flight. This implies that, from the perceptions derived from the force environment of the aircraft, the aircrew had no reason to think that in the final seconds before impact the aircraft was not in level flight.

Appendix B

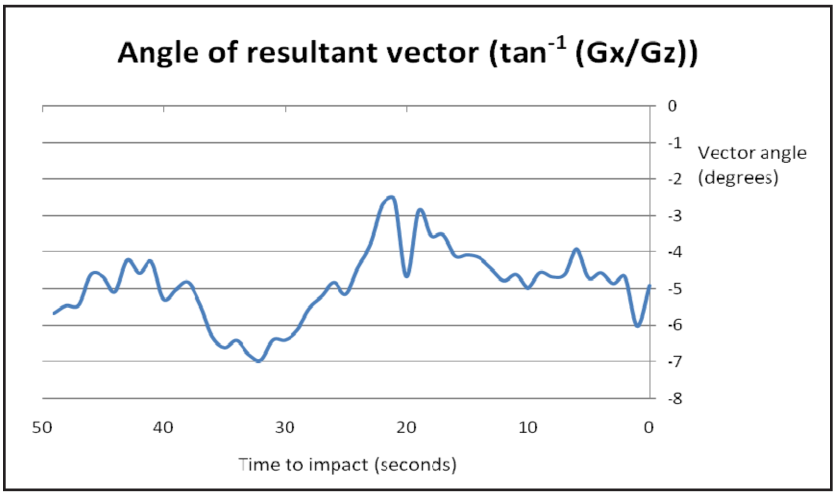


Figure 4

Direction of resultant force vector by summation of longitudinal (Gx) and aircraft-vertical (Gz) accelerations. Small scale fluctuations are probably the result of rounding errors in the flight data records.

A knowledge of the aircraft height above the sea and distance from the platform allows calculation of the glideslope to the helideck. It also enables a calculation of what the crew might have been able to see of the green lights around the periphery of the helideck on the approach to the platform. A sequence at 2s intervals from I-48s of the helideck appearance is shown in Appendix B Figure 5. This shows that the ellipse of lights on the periphery of the helideck would have appeared most 'open' at 20s before impact when the aircraft was turning on to the final approach, some 820m from the platform. From 8s before impact the aircraft was below the height of the helideck and the lights of the further edge of the helideck would no longer have been visible.

If the aircrew, on account of the force environment of the aircraft, felt themselves to be in level flight despite increasing pitch attitude of the aircraft, this would have had consequences for their perception of the spatial location of the platform. Specifically, the glideslope would have appeared to the pilots to be steeper than was actually the case and they would have seen the lights of the platform to be below rather than ahead of them. This is a manifestation of the oculogravic effect/illusion and is illustrated in Appendix B Figure 6. The extent of this misperception in angular terms is likely to have been the angle of pitch of the aircraft. Based on this assumption, an estimate of the perceived glideslope can be obtained by adding the corrected pitch angle to the actual glideslope (Appendix B Figure 7). Over the final 10s of the flight there is a marked disparity between the actual decreasing, and ultimately negative, glideslope and the likely visual perception that the glideslope appeared to be increasing.

Appendix B

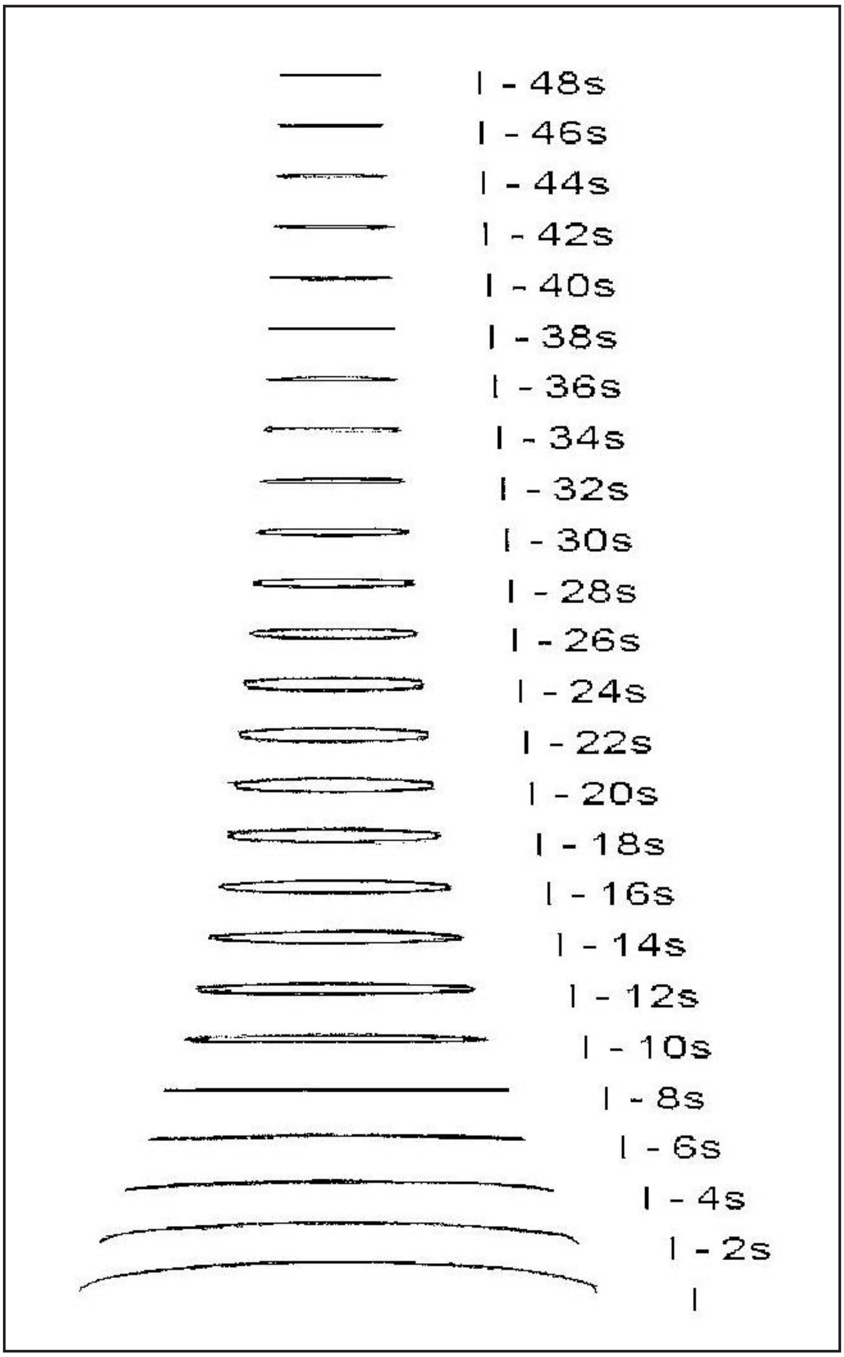


Figure 5

The likely appearance of the helideck at 2s intervals from 48s before impact. The side-to-side subtended angle of the helideck is as it would have been seen by the pilots if this figure is viewed at a distance of 70cm from the eye.

Appendix B

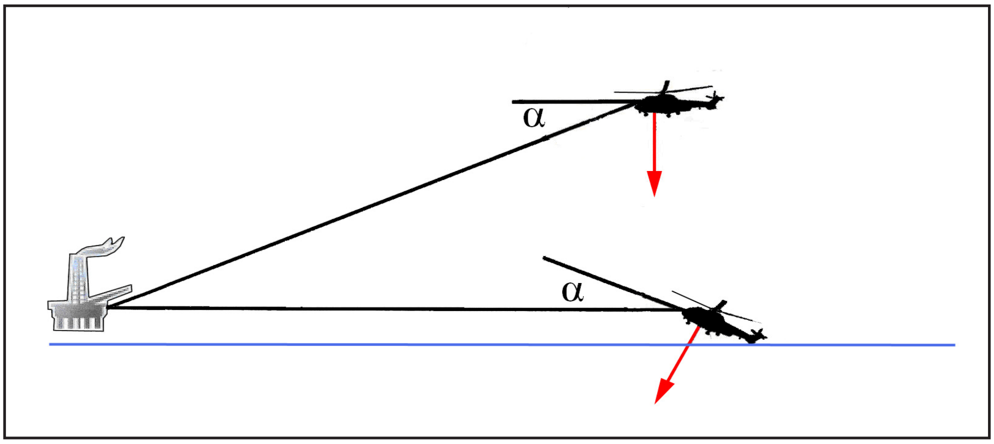


Figure 6

The oculogravic illusion. Because the force vector generated by the lift of the main rotor remains vertical with respect to the aircraft despite increasing pitch up, the aircraft feels to the occupants as it would if it were still in level flight. This misperception leads to error in the spatial localisation of isolated objects in the field of view.

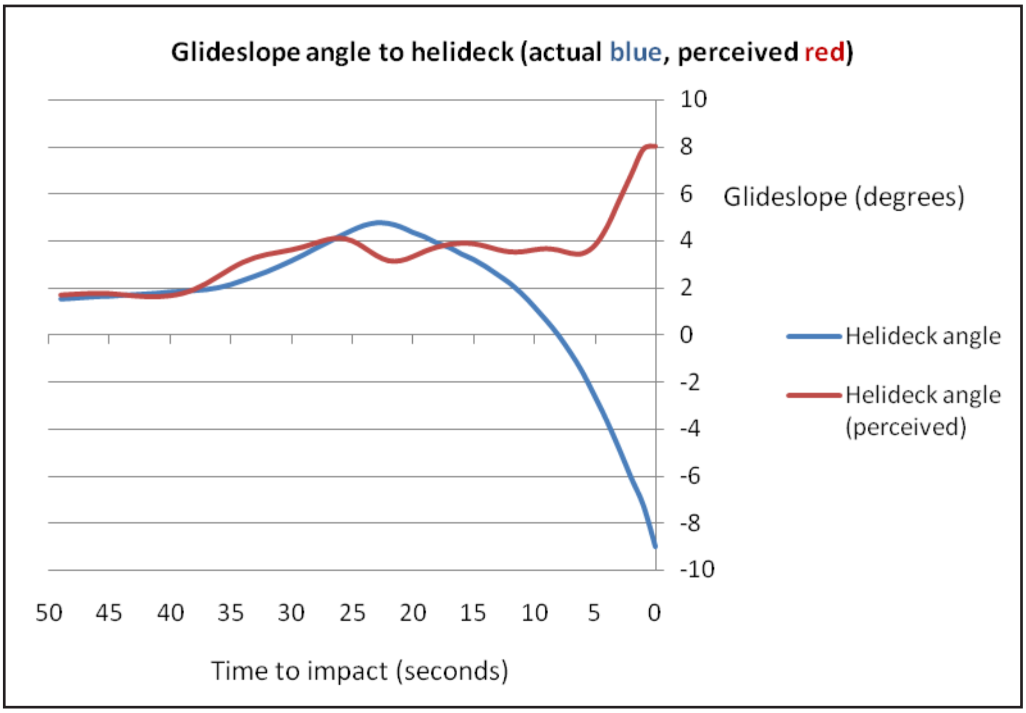


Figure 7

Comparison between the actual and likely perceived glideslope to the helideck. From 8s before impact the aircraft was below the level of the helideck but might have been perceived as between 4 to 8 degrees above it.

Appendix B

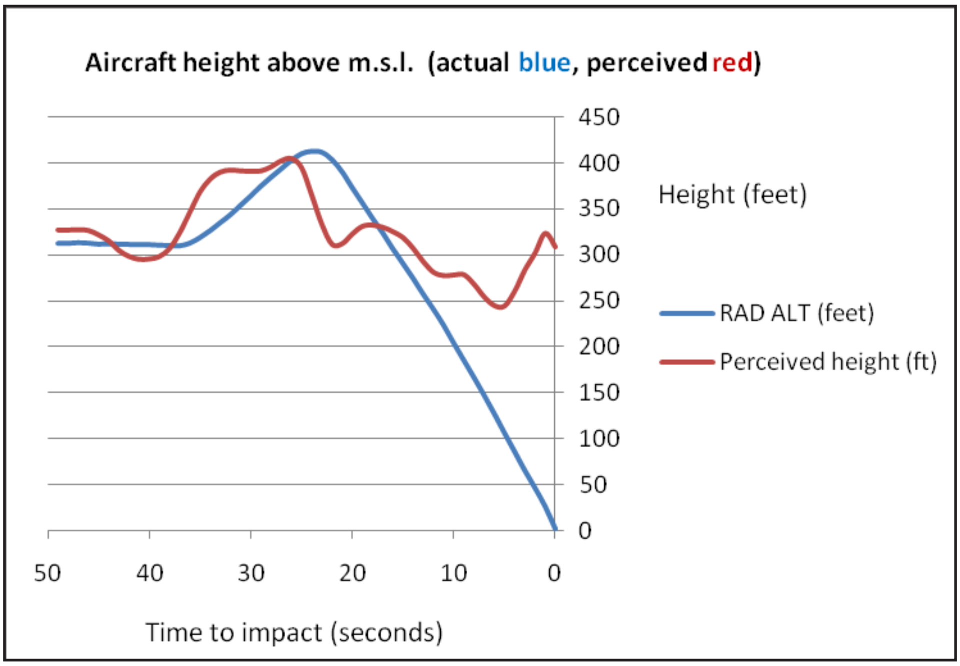


Figure 8

Actual and visually perceived height above sea level.

An unperceived pitch attitude would not only lead to an altered perception of glideslope but also to a false perception of increased height above the sea, a decrease in the apparent horizontal distance to the platform and an apparent increase in the velocity of approach. The calculation of perceived height is made by considering the line joining the aircraft to the platform as the radius of a circle and rotating the helicopter about that radius centred on the platform through an angle equal to the pitch-up of the aircraft so that the aircraft is apparently in level flight, as the aircrew were likely to have felt it to be. This calculation establishes a perceived height above the sea and a new horizontal distance to the platform. An estimate of the change in apparent height above the sea is given in Appendix B Figure 8. Fluctuations in the graph of perceived height are the result of the sensitivity of this estimate to small changes in pitch attitude and are therefore of no significance. However, in the final 10s of the flight this calculation gives a basis on which to understand how the aircrew could have perceived themselves to be at 250 – 300 ft above the sea, though the configuration of the helideck lighting, if indeed it had been correctly identified, should have told them otherwise.

Appendix B Figure 9 shows the actual and possible perceived horizontal distance to the platform during the final 10s of the flight. A discrepancy between the actual and perceived horizontal distance from the platform only becomes evident in the final 3 – 4s of the flight and the effect is small. However, based on these differences over the 4s before impact, the actual horizontal ground speed was 32.1kt but might have been perceived to be 37.2kt, a 16% difference.

Appendix B

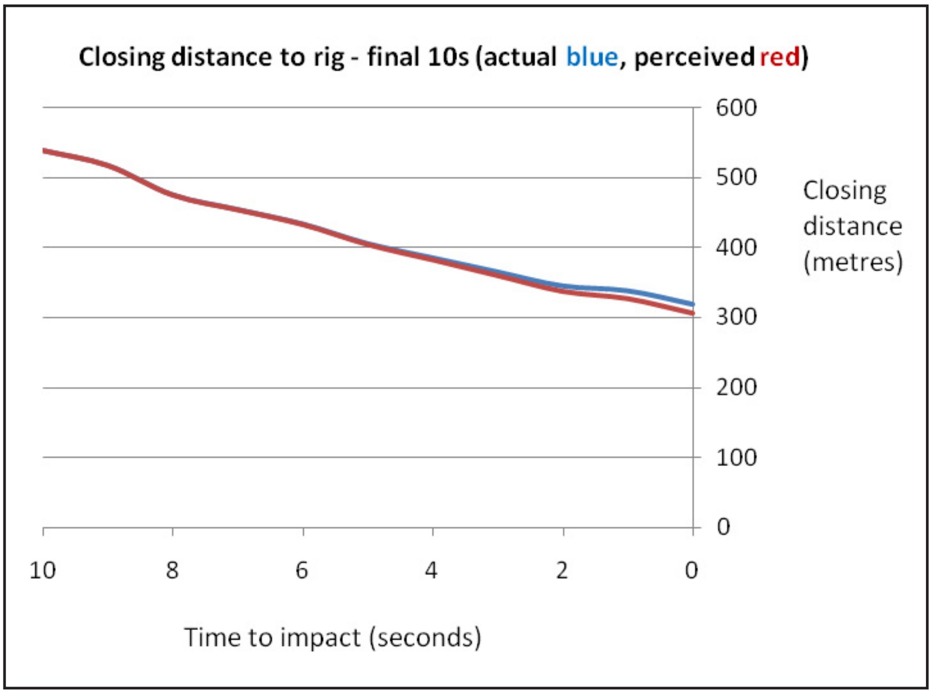


Figure 9

Actual and perceived distance from the platform.
A small discrepancy becomes evident in the 4s before impact.

Opinion

Both pilots experienced a form of oculogravic illusion. The nature of this illusion can be described as follows:

If a pilot views an object in the external scene whose position cannot be visually related to other features within the field of view, such as a true horizon, its position in space will tend to be determined in relation to what the pilot feels to be the gravitational vertical. The forces associated with velocity change in an aircraft can lead to a perception of the direction of gravity that does not align with the true vertical. In such circumstances this will lead to corresponding errors in the spatial location of isolated objects within an otherwise featureless visual scene.

In the case of the present accident, the lights of the platform would have been seen by the aircrew as an isolated two-dimensional object in an otherwise featureless scene. (A perception of depth is only likely to be evident late in the approach.) Cloud cover would have precluded a view of stars, there was no moon and, with fog in the area, it is unlikely that there would have been a visible horizon. Both pilots were probably unaware of the increasing pitch-up attitude of the aircraft and the consequent loss of airspeed. The dynamics of this situation generates a force vector, and hence a sense of gravity, that remains vertical with respect to the aircraft despite the change in pitch attitude. For this reason the aircraft would continue to feel to be in level flight. As a result, the lights of the platform would have appeared to be located below the pilots' erroneously perceived horizontal even at the point of impact with the sea. This was indeed what both pilots reported.

Summary

A helicopter has a tendency to feel level whatever its actual attitude. This arises because the lift force of the rotor, which for the aircraft occupants generates the sensation of weight, at all times acts in a predominantly vertical direction with respect to the aircraft. This can lead to the somatogravic effect – an erroneous perception of the gravitational vertical during manoeuvring flight.

The aircrew were preoccupied with the visual identification of the helideck and were unaware of the continued descent or of increasing pitch up of the aircraft and the consequent reduction in airspeed.

An erroneous perception that the aircraft was in level flight despite increasing pitch up led to a visual perception of the platform being below them and of the aircraft remaining at a safe height above the sea. Such a visual misperception is known as the oculogravic effect and occurs in circumstances where there is little or no visual context to give a correct sense of spatial location to the object in the field of view.

Appendix C

Visual illusions/effects that might have contributed to the crash of G-REDU
by Dr Richard Jones

1. Background

This report examines the potential for visual illusion or effects that might have contributed to the controlled flight into the sea of G-REDU near the North Sea ETAP platform on the 18th February 2009.

The visual conditions during the flight have been noted in the flight accident record AAIB/S3/2009. The flight was during darkness, and the last meteorological report for the flight noted low surface wind (2 knots), cloud overcast at 800ft and a visibility of 6nm. In addition, reports from the Galaxy platform indicated a higher visibility (a platform 13nm distant could see the lights of ETAP platform) but also a fog formation below approximately 200-400 ft. The last reported visibility on ETAP prior to the crash of G-REDU was 800 metres.

2. Visual illusions / effects - Reflections

Given the low surface wind condition, it has been proposed[1] that specular reflections from the ETAP platform lights could have misled the commander as to their position relative to the platform.

In the Beaufort wind scale a mirror-like surface to the sea is an indication of Beaufort scale 0 – correlated with a wind-speed of less than 1 knot. Given the wind speed of 2 knots (Beaufort scale 1) the sea surface would likely have been composed of multiple small waves. These conditions are not optimal for a specular reflection to be formed; any reflections would have been formed of multiple points from each individual wave, resulting in a diffuse pattern rather than a well formed image.

However, as there was a low lying fog, the conditions to form a well defined specular reflection are not necessary – the presence of fog would have resulted in a diffuse circle of light around each individual point source on the platform, and the level of fog reported would suggest that these diffuse circles of light would be sufficiently large to merge into one another to produce one large diffuse patch of light with perhaps only the grossest level of detail. Moreover, in these conditions the multiple reflections provided by the surface of the sea would only have *contributed* to the diffuse appearance. Thus it is possible that the appearance of the ETAP platform was of a flare (considered to be above the fog), with below a diffuse glow from the platform and below that another diffuse glow from the reflection of the platform.

It has been suggested that the fog might have formed a band, with a higher visibility closer

1 AAIB, Personal communication, 28th May 2009.

Appendix C

to the surface of the sea. There is no evidence for or against this suggestion; however, it would be unlikely to change the diffuse nature of the reflections. Furthermore, so long as the observer was inside or above the fog the light path for the reflected light would always pass through more fog than for the direct view, resulting in more diffusion from fog even with a band of higher visibility. This, and the reflection from the surface of the sea, would have resulted in a reflected image more diffuse than the direct view through the fog even with a band of higher visibility close to the sea surface.

As a result of this analysis it is considered that there would not have been a reflection of the ETAP platform of suitable fidelity that the pilot would have simply confused the reflection for the direct view. Any contribution from reflections would have added to the direct view of the platform, not dominated over the direct view. This said, the nature of the diffuse pattern of light could have led to confusion over the orientation of the platform.

3. Visual illusions / effects - Reflections and orientation

The nature of the ETAP platform and the approach angle of G-REDU are such that any reflections would give a more complex view than might be possible from a simple monolithic platform.

For a single platform the reflection from the body of the platform would sit under the view of the legs of the platform. As such the composite view would be of a light patch from the direct view of the platform, a dark patch from the view of the unilluminated platform legs (and their reflection), and a lower bright patch from the reflection of the main body. In addition, there could also be a top-most view of the platform flare, and a complementary lower reflection of the flare.

However, the ETAP platform is composed of separate processing and accommodation blocks, and reflections from the two blocks might have led to a complex view of the platform. These blocks are separated by a distance of approximately 60 metres. Preliminary information suggests that the blocks are aligned at an angle approximately 40 degrees east of north, and with the accommodation block to the south. Information from the fight data recorder shows that G-REDU approached the platform with a heading of approximately 45 degrees east of north and towards the platform. Thus available information suggests that the approach of G-REDU was broadly aligned with the alignment of the two blocks.

As a result of this alignment of the flight path with the platform orientation, it is possible that any reflection from the processing block would be seen directly underneath the accommodation block. Thus the apparent view would be of an extended light source, without the normal large dark area resulting from the unilluminated legs of the platform. Furthermore, the fog during the 18th February 2009 would have removed the fine detail necessary to resolve the inverted nature of the reflection, and the view to the pilots would have been an extended diffuse patch of light (Appendix C figure 1).

Appendix C

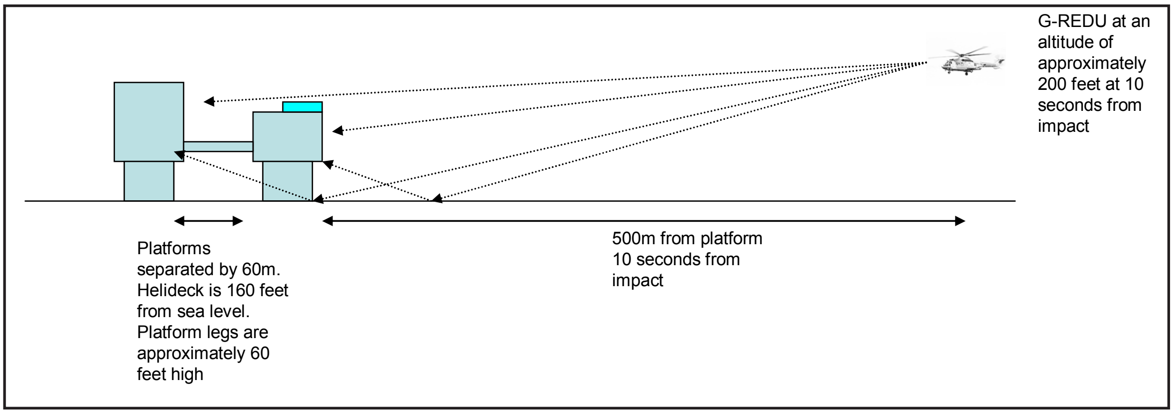


Figure 1

A schematic showing the potential view for G-REDU 10 seconds from impact. Above the direct view of the helideck would be the lights from the processing block. Under the helideck would be the lights from the accommodation block, the reflection from the processing block and then the reflection from the accommodation block. In fog these reflections would be diffuse and would only contain gross detail.

It has been proposed that the change in pitch angle of G-REDU in the final 25 seconds of the flight led to an oculogravic illusion in both pilots[2]. If this were the case then the pilots would have perceived G-REDU to have had a much higher altitude and be slightly closer to the platform than was actually the case. Calculations of the nature of the illusion in this case[2] suggest that at 3 seconds to impact the perceived altitude of G-REDU was approximately 250 ft (compared with approximately 60 ft), and the perceived distance to the platform was approximately 300m (compared with approximately 350m).

It is interesting to note that for the orientation of the approach, a reflective sea surface and in fog the actual view of the platform would be composed of an elongated diffuse patch of light (direct view of accommodation block on top, reflected views of the processing and accommodation blocks underneath), and that this could be confused with the view from an altitude of 250 ft of an elongated diffuse light patch (direct view of accommodation block underneath, direct view of processing block above) (see Appendix C figure 2). Furthermore, for this illusion, the perceived location of the helideck would have been at the bottom of the diffuse light patch, whereas for the actual view the helideck would have been at the top of the diffuse light patch.

As a result it is possible that the presence of a diffuse reflectance from the processing block underneath the accommodation block could have appeared sufficiently like the apparent view of the platform complex from a higher altitude to make any oculogravic illusion more compelling to the pilots.

2 JRR Stott. Personal communication.

Appendix C

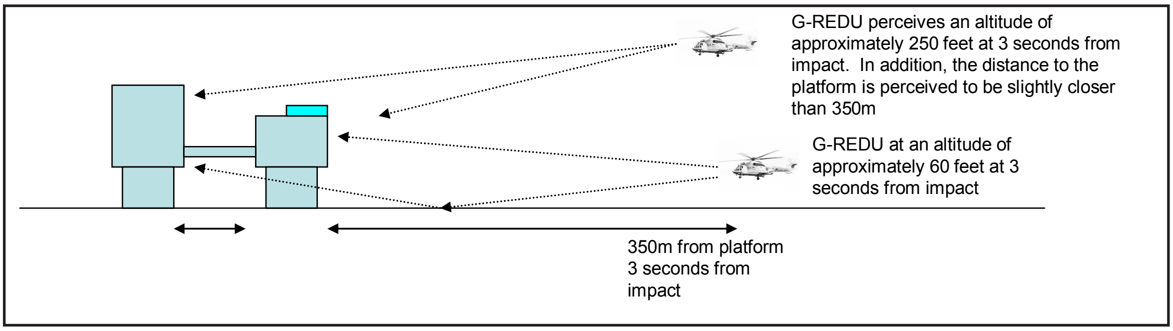


Figure 2

The schematic from figure 1 redrawn for 3 seconds to impact. Again, the view from G-REDU would include a direct view of the accommodation block and a reflection from the processing block, and the presence of fog would have resulted in an elongated diffuse light source. If G-REDU had been at an altitude of 250 ft and a range of 300m then the view of the platform would have been composed of a direct view of the processing block with a direct view of the accommodation block underneath. It is postulated that the two elongated blur patterns could appear similar.

4. Visual illusions / effects - Fog

The impact of fog on visual perception is generally well recognised. Flying in conditions where visual references have a reduced visibility usually:

- Create an illusion of being too high[3].
- Create an illusion of being further away from the reference[3].

In addition, descent into fog can create the perception of a pitch-up[3]. Although there is little reference in the literature, it is possible that the reciprocal to this would also be true – ascent out of fog should result in a pitch-down sensation.

The flight data records for G-REDU suggest that approximately 0.75 nm from the platform G-REDU climbed from 300 ft to approximately 400 ft, and that shortly after the co-pilot indicated he was visual with the helideck. It is possible that this climbing out of the fog layer introduced a pitch-down sensation that was counteracted by the pilot with a slight pitch-up manoeuvre. This pitch up manoeuvre and associated altitude and velocity changes could then have been the input to an oculogravic illusion that was exacerbated by the visual environment of the flight.

3 For example, from Flight Illusions Awareness, Flight Operations Briefing Notes, Airbus.

Appendix C

5. Conclusions

The analysis of the visual environment during the last stages of the flight of G-REDU on the 18th February 2009 has found that visual illusions might have paid some part in the accident and that the visual environment was likely to have confirmed any oculogravic illusion in the pilots:

- It is possible that the ascent out of the fog layer introduced a perceived pitch-down that was counteracted by a physical pitch-up, and that this might have been the seed that resulted in the gross oculogravic illusion and eventual loss of G-REDU.

- The presence of reflections of the platform in the sea is unlikely to have introduced a direct confusion for the pilots.

- However, the reflection of the processing block underneath the accommodation block, along with the presence of fog, might have introduced a gross visual signature similar to that seen if G-REDU was at a higher altitude. Thus the visual scene could have confirmed the perception of a higher altitude resulting from an oculogravic illusion.

- The presence of fog could have introduced a sensation of being too high, and again this aspect of the visual scene could have confirmed an oculogravic illusion.

Appendix D

Bond OFFSHORE HELICOPTERS

OPERATIONS MANUAL
PART A
FLYING STAFF INSTRUCTION

DOC	F-OPS A
FSI NO	031
REV NO	Re-Issue
DATE	May 2009
PAGE NO	1 OF 7

EFFECTIVE	**FROM: 05 May 2009**	**TO: UFN**
SUBJECT	**Offshore Operations**	
AUTHORISED BY	**DIRECTOR of FLIGHT OPERATIONS**	

In light of recent events and acknowledging that both the AAIB investigation and our own internal investigation are ongoing, the following changes to our current procedures are to be adopted as an interim measure with immediate effect.

Further changes or additional procedures may be implemented once recommendations have been published by the AAIB, the CAA or by our own internal investigation.

Changes to the Current AS332L2 & EC225LP Finals Checklist

Ref. EC225 OM Pt B Appendix B/B1 Final Approach

FINAL APPROACH		
1	Landing Gear -------	LEVER DOWN 3 GREENS
2	Radalt Bugs/Altimeters-----	SET, CROSSCHECK
3	External Lights ----------------------------	RED
4	Flotation Gear ---------------------------	ARMED
5	Compasses --------------------------------	DG
6	Landing Site-------	CLEARANCE, AVAILABILITY
SHORT FINALS OFFSHORE		
7	Helideck Name-------------------------	CONFIRM
8	Check Height---------------------------	SUSPEND

Ref. EC225 OM Pt. B Appendix A/A19 Final Approach

1. **Landing Gear** ------------------ **LEVER DOWN 3 GREENS**
Landing Gear -------------------- Confirm Lever Down 3 Greens

2. **Radalt/Altimeters** ------------- **SET**
Radalt Bugs/Altimeters ---------- Set in accordance with Company Procedures

3. **External Lights**---------------- **RED** **OFFSHORE**

4. **Flotation Gear**----------------- **ARMED** **OFFSHORE**
Flotation Gear------------------- Armed

5. **Compasses**-------------------- **DG** **OFFSHORE**
Compasses----------------------- DG

6. **Landing Site**------------------- **CLEARANCE, AVAILABILITY**
Landing site--------------------- Obtain clearance/availability to land

Appendix D

Bond OFFSHORE HELICOPTERS

OPERATIONS MANUAL
PART A
FLYING STAFF INSTRUCTION

DOC	F-OPS A
FSI NO	031
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SHORT FINALS OFFSHORE

7.	**Helideck Name**------------------	**READ/CONFIRM** Identify visually	**OFFSHORE**
8.	**Check Height**--------------------	**SUSPEND**	**OFFSHORE**

Notes:

- It is Mandatory that items 7 and 8 in the Short Finals Offshore Checklist are carried out in the correct order.
- The Radar is now to be left on and is only to be switched to standby during the after landing checks
- Whilst carrying out the Final Approach checks Offshore, the Short Final Approach checks are also to be read out and completed from memory.

Ref. AS332L2 OM Pt. B Appendix B/B1 Final approach

	FINAL APPROACH	
1	Landing Gear -------	LEVER DOWN 3 GREENS
2	Radalt Bugs/Altimeters---	SET, CROSSCHECK
3	External Lights ----------------------------	RED
4	Flotation Gear ----------------------------	ARMED
5	Compasses ---------------------------------	DG
6	Bleed Valves/NR -----------------	OFFSET/+10
7	Landing Site--------	CLEARANCE, AVAILABILITY
	SHORT FINALS OFFSHORE	
8	Helideck Name-------------------------	CONFIRM
9	Check Height---------------------------	SUSPEND

Ref. AS332L2 OM Pt B Appendix A/A21 Final Approach

1.	**Landing Gear** ------------------- Landing Gear --------------------	**LEVER DOWN 3 GREENS** PF to confirm Lever Down 3 Greens	
2.	**Radalt Bugs / Altimeters** ----- Altimeters / Radalt --------------	**SET, CROSSCHECK** Set in accordance with Company Procedures. Crosschecked	
3.	**External Lights** ----------------	**RED**	**OFFSHORE**
4.	**Flotation Gear** ----------------- Flotation Gear -------------------	**ARMED** Armed	**OFFSHORE**
5.	**Compasses** -------------------- Compasses -----------------------	**DG** DG	**OFFSHORE**
6	**Bleed Valves** ----------------- NR+10 --------------------------	Offset Normal. Offset for Helipad approach	
7.	**Landing Site**-------------------- Landing site----------------------	**CLEARANCE, AVAILABILITY** Obtain clearance/availability to land	

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SHORT FINALS OFFSHORE

8. **Helideck Name**------------------ **READ/CONFIRM** Identify visually **OFFSHORE**

9. **Check Height**-------------------- **SUSPEND** **OFFSHORE**

Notes:

- It is Mandatory that items 8 and 9 in the Short Finals Offshore Checklist are carried out in the correct order.
- The Radar is now to be left on and is only to be switched to standby during the after landing checks
- Whilst carrying out the Final Approach checks Offshore, the Short Final Approach checks are also to be read out and completed from memory.

Amendments to Operations Manual Part A

Ref. OM Pt A Sect. 8.1.7.2.3

Take-off Minima - Performance Class 2	
Onshore	**Visibility**
The Commander must establish that the take-off flight path is free of obstacles and that the helicopter will be able to remain clear of cloud during the take-off manoeuvre and until reaching Performance Class 1 capabilities.	800m
Offshore Helideck	**Visibility**
Two pilot operations	250 m
Single pilot operations	500 m
The Commander must ensure that the helicopter will be able to remain clear of cloud, free of obstacles and in sight of the surface during the take-off manoeuvre until reaching Performance Class 1 capabilities.	

Ref. OM Part A 8.5.5. Airborne Radar Approach to Offshore Helideck

Ref. OM Part A 8.5.5.1 General

The radar must be serviceable for this approach.

One rad-alt must be serviceable for this approach.

The Company ARA approach plate included in OM Part C is to be followed.

The radar fitted must provide course guidance to ensure obstacle clearance.

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Amendments to Operations Manual Part A (Continued)

All ARA approaches are to be conducted four axis coupled to a minimum of 0.75 nm radar range from the installation/Vessel.

Use of the 'Go-around' button is restricted to minimum airspeed of 80 kts on the Right Hand Side airspeed indicator.

Once the airspeed is greater than 80kts the 'Go-around' button may be used.

The PNF calls throughout the ARA are to include the following:

- Radalt heights
- Radar range and bearing to the installation/vessel
- Ground/Airspeed
- Rate of descent greater than 500 ft per minute

Before commencing the approach, the Commander must receive a report from the destination giving details of all vessels within a 1nm radius from the installation.

Before commencing final approach the Commander must ensure that a clear path exists on the radar screen for the final approach and missed approach segments. Lateral clearance from structures on the final approach segment must be at least 1nm. If clearance is less than 1nm, approach to a nearby target structure and then proceed visually to the destination or make the approach from another direction leading to a circling manoeuvre 300ft day 500ft night.

The cloud ceiling must be sufficiently clear above the helideck to permit visual descending flight for at least the last 50ft.

An ARA to a ship making way is only permitted with a two-pilot crew, trained in multi-crew procedures. (Note: a ship 'under way' is not anchored or moored but may be stopped. A ship 'making way' is moving through the water.)

Offshore Night Operations

Ref. OM Part A 8.5.11.

For all Night operations over water, upper modes must be utilised in three or four axis coupled.

For operations at night crews shall carry out one of the following procedures:

- **Airborne Radar Approach (ARA) Procedure.**

  OR

- **Visual Gate Approach (VGA) Procedure.**

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Weather Minima for a Visual Gate Approach

- Cloud Ceiling 1200ft
- Visibility 5km

Visual Gate Approach (VGA) Procedure:

The purpose of the VGA procedure is to ensure that:

- The aircraft is configured in a 'stable' approach configuration by the 2 nm Visual Gate Point from an installation or vessel.
- The Aircraft continues in a 'stable' approach configuration from the Visual Gate Point to 0.75 nm from the installation or vessel.

The radar must be serviceable for this approach.

One rad-alt must be serviceable for this approach.

All Visual Gate Approaches are to be conducted four axis coupled to a minimum of 0.75 nm radar range from the installation/Vessel.

Before commencing the approach, the Commander must receive a report from the destination giving details of all vessels within a 1nm radius from the installation.

The bar-alt must be matched to the rad-alt prior to starting the procedure.

The standby altimeter must remain on Regional Pressure Setting.

These procedures are mandatory for Jigsaw operations other than SAR Role specific profiles.

Note:

Stable Approach Configuration

You are deemed to be in a Stable Approach Configuration when the Company Standard Operating Procedures (SOPs) are met.

With regards to the VGA Procedure this is as follows:

- The Aircraft four axis coupled
- Maximum Groundspeed 80kts
- PF Using Visual References
  (The visual reference required is that the destination shall be in view in order that a safe landing may be carried out)
- PNF Monitoring the Aircraft Instruments
- Final Approach Checks Completed

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Visual Gate Point:

By the use of an " FMS Offset Waypoint" establish the aircraft:

- 2 nm on Final Approach Track (FAT)
- FAT within 30 degrees of the wind direction
- 500 ft Radalt
- Maximum Groundspeed 80kts

Note:

From the Visual Gate Point inbound to the Installation/Vessel, Groundspeed and Radalt Height may be decreased as required.

Go Around:

If at any time after the 'Visual Gate Point', visual contact with the installation/vessel is lost or becomes uncertain a "Go-around" to MEA is mandatory.

If at any time either pilot becomes uncomfortable with the stability of the approach a "Go-around" is mandatory.

Notes:

(1) Use of the 'Go-around' button is restricted to minimum airspeed of 80 kts on the Right Hand Side airspeed indicator.

(2) Once the airspeed is greater than 80kts the 'Go-around' button may be used.

(3) The Go-around track must be briefed during the Initial Approach Checks.

PNF Calls:

The PNF calls throughout the VGA are to include the following:

- Radalt heights
- Radar range and bearing to the installation/vessel
- Ground/Airspeed
- Rate of descent greater than 500 ft per minute

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Shuttle Operations at Night

Shuttle Operations may take place without carrying out an ARA or VGA provided the following criteria are met:

- Minimum Cloud Base 500ft and a visibility of 5km
- The aircraft is to be established on a Final Approach Track at a range of 0.75nm at helideck height +200ft or 400ft rad-alt whichever is the higher.
- Maximum Groundspeed 80kts
- Height Hold engaged

Appendix E

Extract from AC29-2C Change 3 dated 30/9/2008 - AC29.801 Ditching

AC 29.801. § 29.801 (Amendment 29-12) DITCHING.

a. Explanation.

(1) Ditching certification is accomplished only if requested by the applicant.

(2) Ditching may be defined as an emergency landing on the water, deliberately executed, with the intent of abandoning the rotorcraft as soon as practical. The rotorcraft is assumed to be intact prior to water entry with all controls and essential systems, except engines, functioning properly.

(3) The regulation requires demonstration of the flotation and trim requirements under "reasonably probable water conditions." The FAA/AUTHORITY has determined that a sea state 4 is representative of reasonably probable water conditions to be encountered. Therefore, demonstration of compliance with the ditching requirements for at least sea state 4 water conditions is considered to satisfy the reasonably probable requirement.

(4) A sea state 4 is defined as a moderate sea with significant wave heights of 4 to 8 feet with a height-to-length ratio of:

(i) 1:12.5 for Category A rotorcraft.

(ii) 1:10 for Category B rotorcraft with Category A engine isolation.

(iii) 1:8 for Category B rotorcraft.

The source of the sea state definition is the World Meteorological Organization (WMO) Table. (See figure AC 29.801-1.)

(5) Ditching certification encompasses four primary areas of concern: rotorcraft water entry, rotorcraft flotation and trim, occupant egress, and occupant survival.

(6) The rule requires that after ditching in reasonably probable water conditions, the flotation time and trim of the rotorcraft will allow the occupants to leave the rotorcraft and enter liferafts. This means that the rotorcraft should remain sufficiently upright and in adequate trim to permit safe and orderly evacuation of all personnel.

(7) For a rotorcraft to be certified for ditching, emergency exits must be provided which will meet the requirements of § 29.807(d).

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(8) The safety and ditching equipment requirements are addressed in §§ 29.1411, 29.1415, and 29.1561 and specified in the operating rules (Parts 91, 121, 127, and 135). As used in § 29.1415, the term ditching equipment would more properly be described as occupant water survival equipment. Ditching equipment is required for extended overwater operations (more than 50 nautical miles from the nearest shoreline and more than 50 nautical miles from an offshore heliport structure). However, ditching certification should be accomplished with the maximum required quantity of ditching equipment regardless of possible operational use.

(9) Current practices allow wide latitude in the design of cabin interiors and consequently, the stowage provisions for safety and ditching equipment. Rotorcraft manufacturers may deliver aircraft with unfinished (green) interiors that are to be completed by the purchaser or modifier. These various "configurations" present problems for certifying the rotorcraft for ditching.

(i) In the past, "segmented" certification has been permitted to accommodate this practice. That is, the rotorcraft manufacturer shows compliance with the flotation time, trim, and emergency exit requirements while the purchaser or modifier shows compliance with the equipment provisions and egress requirements with the completed interior. This procedure requires close cooperation and coordination between the manufacturer, purchaser or modifier, and the FAA/AUTHORITY.

(ii) The rotorcraft manufacturer may elect to establish a "token" interior for ditching certification. This interior may subsequently be modified by a supplemental type certificate or a field approval. Compliance with the ditching requirements should be reviewed after any interior configuration and limitations changes where applicable.

(iii) The Rotorcraft Flight Manual and supplements deserve special attention if a "segmented" certification procedure is pursued.

b. Procedures.

The following guidance criteria has been derived from past FAA/AUTHORITY certification policy and experience. Demonstration of compliance to other criteria may produce acceptable results if adequately justified by rational analysis. Model tests of the appropriate ditching configuration may be conducted to demonstrate satisfactory water entry and flotation and trim characteristics where satisfactory correlation between model testing and flight testing has been established. Model tests and other data from rotorcraft of similar configurations may be used to satisfy the ditching requirements where appropriate.

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(1) Water entry.

(i) Tests should be conducted to establish procedures and techniques to be used for water entry. These tests should include determination of optimum pitch attitude and forward velocity for ditching in a calm sea as well as entry procedures for the highest sea state to be demonstrated (e.g., the recommended part of the wave on which to land). Procedures for all engines operating, one engine inoperative, and all engines inoperative conditions should be established. However, only the procedures for the most critical condition (usually all engines inoperative) need to be verified by water entry tests.

(ii) The ditching structural design consideration should be based on water impact with a rotor lift of not more than two-thirds of the maximum design weight acting through the centre of gravity under the following conditions:

(A) For entry into a calm sea--

(1) The optimum pitch attitude as determined in 337(b)(1)(i) with consideration for pitch attitude variations that would reasonably be expected to occur in service;

(2) Forward speeds from zero up to the speed defining the knee of the height-velocity (HV) diagram;

(3) Vertical descent velocity of 5 feet per second; and

(4) Yaw attitudes up to 15°.

(B) For entry into the maximum demonstrated sea state--

(1) The optimum pitch attitude and entry procedure as established in (b)(1)(i);

(2) The forward speed defined by the knee of the HV diagram reduced by the wind speed associated with each applicable sea state;

(3) Vertical descent velocity of 5 feet per second; and

(4) Yaw attitudes up to 15°.

(C) The float system attachment hardware should be shown to be structurally adequate to withstand water loads during water entry when both deflated and stowed and fully inflated (unless in-flight inflation is prohibited). Water entry conditions should correspond to those established in paragraphs AC 29.801(b)(1)(ii)(A) and (B). The appropriate vertical loads and drag loads determined from water entry conditions (or as limited by flight manual procedures) should be addressed. The effects of the vertical loads and the drag loads may be considered separately for the analysis.

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(D) Probable damage due to water impact to the airframe/hull should be considered during the water entry evaluations; i.e., failure of windows, doors, skins, panels, etc.

(E) The ditching maximum demonstrated sea state for water entry is the same or greater than the maximum demonstrated sea state for flotation and trim.

(2) Flotation Systems.

(i) Normally inflated. Fixed flotation systems intended for emergency ditching use only and not for amphibian or limited amphibian duty should be evaluated for:

(A) Structural integrity when subjected to:

(1) Air loads throughout the approved flight envelope with floats installed;

(2) Water loads during water entry; and

(3) Water loads after water entry at speeds likely to be experienced after water impact.

(B) Rotorcraft handling qualities throughout the approved flight envelope with floats installed.

(ii) Normally deflated. Emergency flotation systems which are normally stowed in a deflated condition and inflated either in flight or after water contact during an emergency ditching should be evaluated for:

(A) Inflation. The float activation means may be either fully automatic or manual with a means to verify primary actuation system integrity prior to each flight. If manually inflated, the float activation switch should be on one of the primary flight controls and should be safeguarded against spontaneous or inadvertent actuation for all flight conditions.

(1) The inflation system design should minimize the probability of the floats not inflating properly or inflating asymmetrically. This may be accomplished by use of a single inflation agent container or multiple container system interconnected together. Redundant inflation activation systems will also normally be required. If the primary actuation system is electrical, a mechanical backup actuation system will usually provide the necessary reliability. A secondary electrical actuation system may also be acceptable if adequate electrical system independence and reliability can be documented.

(2) The inflation system should be safeguarded against spontaneous or inadvertent actuation for all flight conditions. It should be demonstrated that float inflation at any flight condition within the approved operating envelope will not result in a hazardous condition unless the safeguarding system is shown to be extremely reliable. One safeguarding method that has been successfully used on previous certification programs is to provide a separate float system arming circuit which must be activated before inflation can be initiated.

(3) The maximum airspeeds for intentional in-flight actuation of the float system and for flight with the floats inflated should be established as limitations in the RFM unless in-flight actuation is prohibited by the RFM.

(4) The inflation time from actuation to neutral buoyancy should be short enough to prevent the rotorcraft from becoming more than partially submerged assuming actuation upon water contact.

(5) A means should be provided for checking the pressure of the gas storage cylinders prior to takeoff. A table of acceptable gas cylinder pressure variation with ambient temperature and altitude (if applicable) should be provided.

(6) A means should be provided to minimize the possibility of overinflation of the float bags under any reasonably probable actuation conditions.

(7) The ability of the floats to inflate without puncture when subjected to actual water pressures should be substantiated. A full-scale rotorcraft immersion demonstration in a calm body of water is one acceptable method of substantiation. Other methods of substantiation may be acceptable depending upon the particular design of the flotation system.

(B) Structural Integrity. The flotation bags should be evaluated for loads resulting from:

(1) Airloads during inflation and fully inflated for the most critical flight conditions and water loads with fully inflated floats during water impact for the water entry conditions established under paragraph AC 29.801(b)(1)(ii) for rotorcraft desiring float deployment before water entry; or

(2) Water loads during inflation after water entry.

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(C) Handling Qualities. Rotorcraft handling qualities should be verified to comply with the applicable regulations throughout the approved operating envelopes for:

(1) The deflated and stowed condition;

(2) The fully inflated condition; and

(3) The in-flight inflation condition.

(3) Flotation and Trim. The flotation and trim characteristics should be investigated for a range of a sea states from zero to the maximum selected by the applicant and should be satisfactory in waves having height/length ratios of 1:12.5 for Category A rotorcraft, 1:10 for Category B rotorcraft with Category A engine isolation, and 1:8 for Category B rotorcraft. Model tests in a wave basin on a number of different rotorcraft types have indicated that an improvement in sea keeping, response of the rotorcraft to waves, performance of approximately one sea state can consistently be achieved by fitting float scoops. If the basic flotation system (without scoops) has demonstrated compliance with the minimum flotation and trim requirements, credit for float scoops to achieve stability in more severe water conditions may be allowed. However, the effect of scoops on improved sea keeping must be demonstrated during model testing.

(i) Flotation and trim characteristics should be demonstrated to be satisfactory to at least sea state 4 conditions.

(ii) Flotation tests should be investigated at the most critical rotorcraft loading condition.

(iii) Flotation time and trim requirements should be evaluated with a simulated, ruptured deflation of the most critical float compartment. Flotation characteristics should be satisfactory in this degraded mode to at least sea state 2 conditions.

(iv) A sea anchor or similar device should not be used when demonstrating compliance with the flotation and trim requirements but may be used to assist in the deployment of liferafts. If the basic flotation system has demonstrated compliance with the minimum flotation and trim requirements, credit for a sea anchor or similar device to achieve stability in more severe water conditions (sea state, etc.) may be allowed if the device can be automatically, remotely, or easily deployed by the minimum flightcrew.

(v) Probable rotorcraft door/window open or closed configurations and probable damage to the airframe/hull (i.e., failure of doors, windows, skin, etc.) should be considered when demonstrating compliance with the flotation and trim requirements.

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(4) Float System Reliability. Reliability should be considered in the basic design to assure approximately equal inflation of the floats to preclude excessive yaw, roll, or pitch in flight or in the water.

(i) Maintenance procedures should not degrade the flotation system (e.g., introducing contaminants which could affect normal operation, etc.).

(ii) The flotation system design should preclude inadvertent damage due to normal personnel traffic flow and excessive wear and tear. Protection covers should be evaluated for function and reliability.

(iii) Float design should provide a means to minimize the likelihood of damage or tear propagation between compartments. Single compartment float designs should be avoided.

(iv) Where practical, design of the flotation system should consider the likely effects of an uncontrolled water entry and locate system components away from the major effects of structural deformity.

(v) Visual identification of the helicopter following a ditching (and possible capsize) is made easier by the choice of material for the construction of the floats that has high visual conspicuity properties.

(5) Occupant Egress and Survival. The ability of the occupants to deploy liferafts, egress the rotorcraft, and board the liferafts should be evaluated. For configurations which are considered to have critical occupant egress capabilities due to liferaft locations and/or ditching emergency exit locations and floats proximity, an actual demonstration of egress may be required. When a demonstration is required, it may be conducted on a full-scale rotorcraft actually immersed in a calm body of water or using any other rig/ground test facility shown to be representative. The demonstration should show that floats do not impede a satisfactory evacuation. Service experience has shown that it is possible for occupants to have escaped from the cabin but have not been able to board a liferaft and have had difficulties finding handholds to stay afloat and together. Where practical, handholds or lifelines should be provided. The normal attitude of the rotorcraft and the possibility of a capsize should be considered when locating the handholds or lifelines.

(6) Rotorcraft Flight Manual. The Rotorcraft Flight Manual is an important element in the approval cycle of the rotorcraft for ditching. The material related to ditching may be presented in the form of a supplement or a revision to the basic manual. This material should include:

(i) The information pertinent to the limitations applicable to the ditching approval should include the range of sea state conditions that has been demonstrated for water entry and flotation stability. If the ditching approval is obtained in a segmented fashion (i.e., one applicant performing the aircraft equipment installation and operations portion and another designing and substantiating the liferaft/lifevest and ditching safety equipment installations and deployment facilities), the RFM limitations should state “Not Approved for Ditching” until all segments are completed. The requirements for a complete ditching approval not yet completed should be identified in the “Limitations” section.

(ii) Procedures and limitations for flotation device inflation.

(iii) Recommended rotorcraft water entry attitude, speed, and wave position.

(iv) Procedures for use of emergency ditching equipment.

(v) Ditching egress and raft entry procedures.

(vi) Information stating the flotation system has been certificated for Ditching (as opposed to Emergency Flotation) to facilitate compliance with operational requirements.

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