Air Accident Investigation Unit Ireland

FORMAL REPORT APPENDICES

ACCIDENT
Sikorsky S-92A, EI-ICR
Black Rock, Co. Mayo, Ireland
14 March 2017

An Roinn Iompair
Department of Transport

Foreword

This safety investigation is exclusively of a technical nature and the Final Report reflects the determination of the AAIU regarding the circumstances of this occurrence and its probable causes.

In accordance with the provisions of Annex 13[1] to the Convention on International Civil Aviation, Regulation (EU) No 996/2010[2] and Statutory Instrument No. 460 of 2009[3], safety investigations are in no case concerned with apportioning blame or liability. They are independent of, separate from and without prejudice to any judicial or administrative proceedings to apportion blame or liability. The sole objective of this safety investigation and Final Report is the prevention of accidents and incidents.

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

Extracts from this Report may be published providing that the source is acknowledged, the material is accurately reproduced and that it is not used in a derogatory or misleading context.

[1] **Annex 13**: International Civil Aviation Organization (ICAO), Annex 13, Aircraft Accident and Incident Investigation.
[2] **Regulation (EU) No 996/2010** of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation.
[3] **Statutory Instrument (SI) No. 460 of 2009**: Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulations 2009.

CONTENTS

Appendix A — S-92A Dimensions

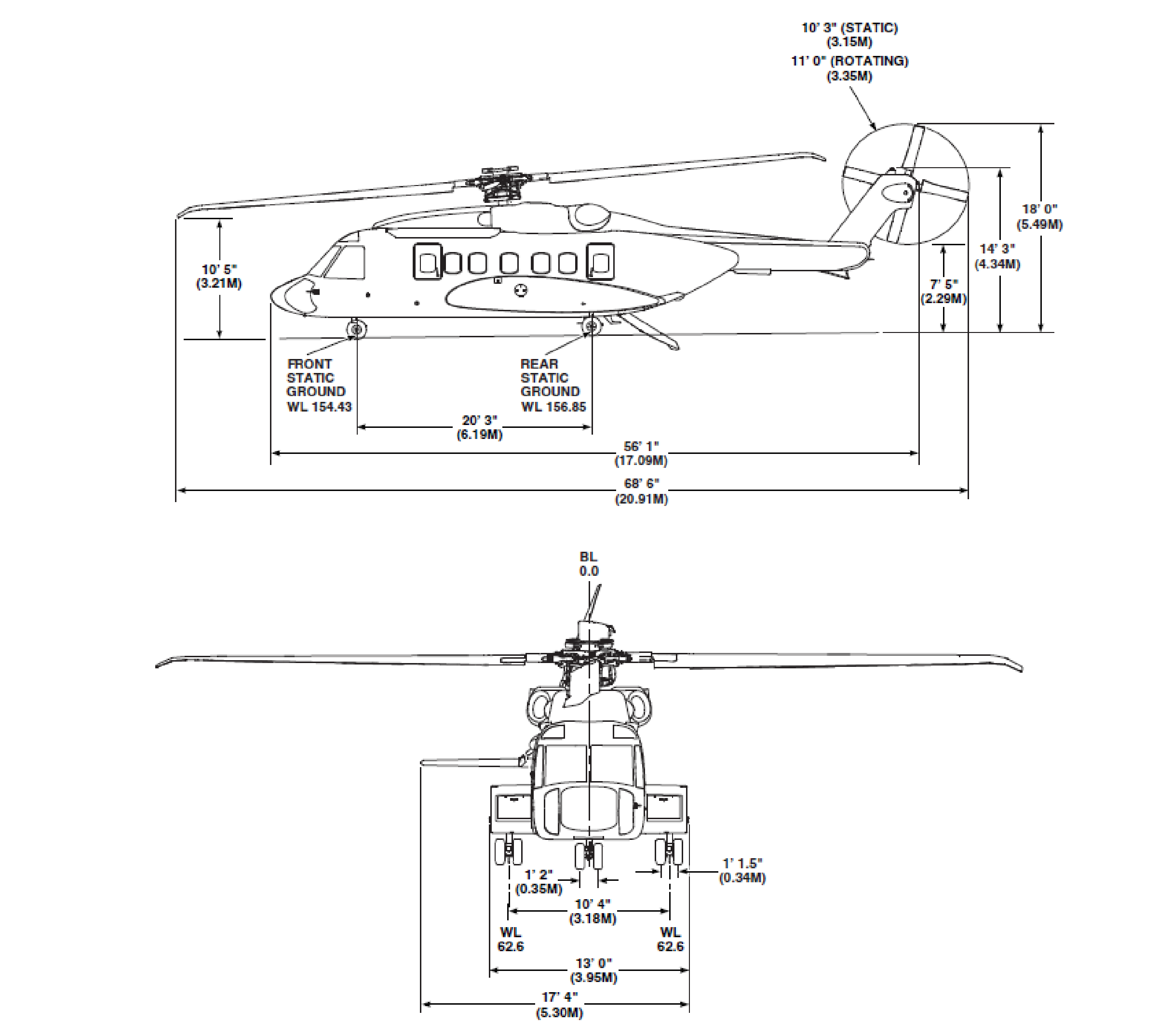

Figure No. A1: The principal dimensions of the S-92A helicopter

Appendix B — Automatically Deployable Emergency Locator Transmitter (ADELT)

The IRCG S-92A helicopters are equipped with a Model 503 ADELT, manufactured by HR Smith. It is compatible with the search and rescue systems, including the COSPAS/SARSAT satellite-based locator system. The Helicopter Manufacturer's RFM describes the ADELT as an emergency locator transmitter, mounted on the aircraft, which generates two radio beacons to aid in locating downed aircraft. When the beacon is activated, the 406 MHz transmitter transmits a digital signal to the satellites every 50 seconds. The satellites receive the signal and relay it to a ground station that decodes the data providing the aircraft tail number, country of origin, and beacon type. This allows the beacon position to be located to within 3 miles (4.8 Km) directing SAR resources to the general search area.

Once within 50 miles (80 Km) of the search area, the 121.5 MHz beacon, which transmits every three seconds, will be received to allow SAR resources to home-in on the ADELT and the crash site. The technical specification for the ADELT states that it will transmit a tone of 520ms (±1%) duration every 50 secs (±5%) for the 406 MHz transmitter, and a tone of 520ms (±1%) duration every 3 secs for the 121.5 MHz transmitter. The main components of the ADELT System are shown in **Figure No. B1**.

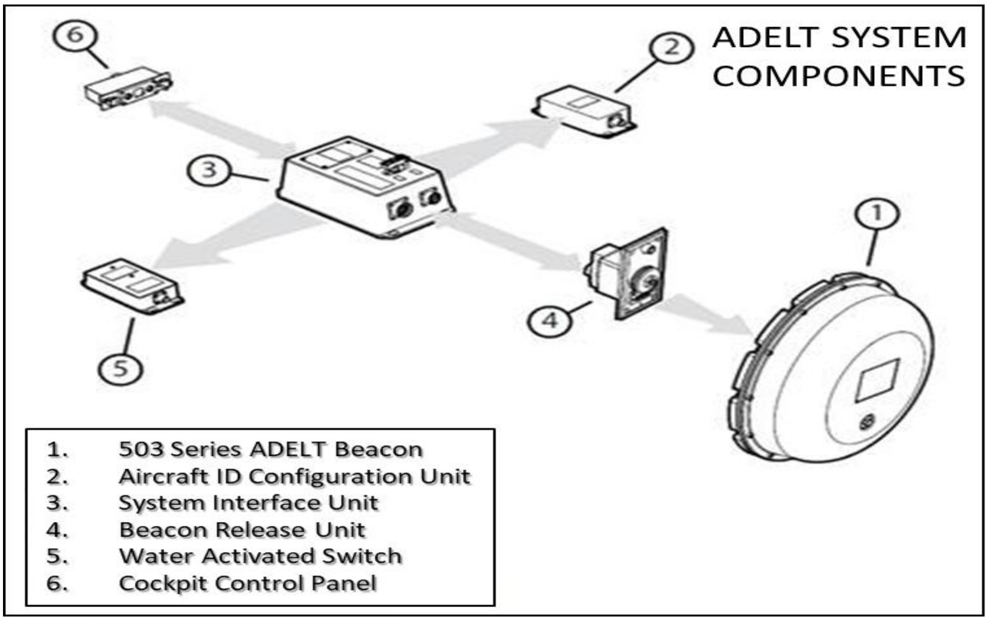

Figure No. B1: The main components of the ADELT System

The ADELT System consists of an ADELT beacon, Aircraft ID Configuration Unit, System Interface Unit, Beacon Release Unit, Water Activated Switch, Cockpit Control Panel, and three crash sensors. The DEB is mounted on the left side of the tail boom and is activated either manually or automatically in response to airframe deformation and/or water submersion. When ejected in flight, aerodynamic forces will carry the ADELT safely away from the aircraft. If ejected on the ground or in the water, the ADELT will fall close to the aircraft to aid in recovery. The system includes three crash sensors, two of which are frangible switches; one below the floor at the aft end of the cockpit and the other amidships.

The third is a hydrostatic switch that is located in the tail-cone near the Beacon Release Unit (BRU). The frangible switches are normally open switches enclosed in glass envelopes that close when crushed. The hydrostatic switch detects water pressure at a depth between three and 10 feet (0.91 to three meters). Upon impact, the crushing of the frangible switch envelope or water pressure will trigger a deploy signal to the BRU.

The Manufacturer informed the Investigation that based on the damage to the ADELT baseplate shown in AAIU Preliminary Report 2017-006, '*The beacon itself would most certainly not continue to function in this condition*.'

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Appendix C — Automatic Identification System (AIS)

1. General

AIS was developed by the International Maritime Organization (IMO) technical committees as a technology to avoid collisions among large vessels at sea that are not within range of shore-based systems. AIS is intended, primarily, to allow ships to view marine traffic in their area and to be seen by that traffic. It enables vessels and Coast Guard shore stations to transmit and receive information regarding identity, position, course and speed of vessels. The AIS standards include a variety of automatic calculations based on these position reports, such as Closest Point of Approach (CPA) and collision alarms. As AIS is not used by all vessels, AIS is usually used in conjunction with radar.

The system requires a dedicated VHF AIS transceiver that allows local traffic to be viewed on an AIS enabled chart-plotter or computer monitor, while transmitting information about the ship itself to other AIS receivers. Port authorities or other shore-based facilities may be equipped with receivers only, so that they can view the local traffic without the need to transmit their own location. All AIS transceiver-equipped traffic can be viewed this way very reliably, but it is limited to the VHF range – about 10-20 nautical miles.

In Ireland, AIS transmissions and information is broadcast over VHF radio by IRCG Operations, via one of sixteen AIS base stations located around the coast and is freely available to those with AIS equipment. Recent regulations have mandated the installation of AIS systems on all Safety Of Life At Sea (SOLAS) vessels and vessels over 300 metric tons, but AIS can be used by small craft as an additional safety feature. The AIS standard also envisioned the possible use on SAR aircraft, and included a message (AIS Message 9) for aircraft to report their position. To aid SAR vessels and aircraft in locating people in distress, the specification (IEC[4] 61097-14 Ed 1.0) for an AIS-based SAR transmitter (AIS-SART) was developed by the IEC's TC80 AIS work group. AIS-SART was added to Global Maritime Distress Safety System regulations effective January 1, 2010. AIS-SARTs have been available on the market since at least 2009.

All IRCG SAR helicopters are equipped with AIS and utilise an R4 AIS Class A Transponder System through the Toughbook.

The AIS aids to navigation (AtoN) product standard was developed with the ability to broadcast the positions and names of objects other than vessels, such as navigational aid and marker positions and dynamic data reflecting the marker's environment (e.g. currents and climatic conditions). These aids can be located on shore, such as in a lighthouse, or on water, platforms, or buoys. AtoNs enable authorities to remotely monitor the status of a buoy, such as the status of the lantern, as well as transmit live data from sensors (such as weather and sea-state) located on the buoy back to vessels fitted with AIS transceivers or local authorities.

[4]**IEC**: International Electrotechnical Commission

An AtoN will broadcast its position and Identity along with all the other information. The AtoN standard also permits the transmit of '*Virtual AtoN*' positions whereby a single device may transmit messages with a '*false*' position such that an AtoN marker appears on electronic charts, although a physical AtoN may not be present at that location.

2. Public Access

AIS data can be viewed publicly on the internet without the need for an AIS receiver. Global AIS transceiver data collected from both satellite and internet-connected shore-based stations are aggregated and made available on the internet through a number of service providers. Data aggregated this way can be viewed on any internet-capable device to provide near global, real-time position data from anywhere in the world. Typical data includes vessel name, details, location, speed and heading on a map, is searchable, has potentially unlimited global range, and the history is archived. Most of this data is free of charge, but satellite data and special services such as searching the archives are usually supplied at a cost. The data is a read-only view and the users will not be seen on the AIS network itself. AIS mobile apps are also readily available for use with Android, Windows and iOS devices.

-END-

Appendix D — ToughBook Functionality

In addition to the Helicopter's avionics suite, a stand-alone ruggedized Toughbook computer, loaded with specific application software and map data, was located at the SAR operator's console. The following description was extracted from the Operator's User Guide.

It is loaded with several applications:

1) Memory-Map: This is the main mapping application for rear crew and is suitable for use on all missions, whether inland, coastal or offshore. AIS data is available to Memory-Map via an add-on application.

2) K-Nav: This is an *Excel* spreadsheet application, which is designed to assist with time-distance-fuel calculations.

3) PHECC CPG Book and Field Guide – This is provided for reference.

The Operator's Memory-Map User Guide states:

> '*The Toughbook provides the main electronic mapping and GPS navigation capability for the rear crew. Its main purpose is twofold, namely to assist with mission planning and to provide a back-up and cross-check to the cockpit navigation systems*.'

OMF states '*Secondary navigation equipment: i. Independent GPS position (Memory map, cockpit moving map, GPS)*'.

Memory-Map System Description

The helicopter AIS transponder feed contains a combination of GPS position information and encrypted AIS vessel data. On its own, Memory-Map can utilise the GPS element of the feed to establish the current position of the helicopter; however, it cannot decrypt the AIS element of the feed – to do this it needs to work together with '*Memory-Map AIS'*, which is a separate add-on app, that integrates closely with Memory-Map. Its function is to decrypt the helicopter AIS feed and supply the GPS position and decrypted AIS data to Memory-Map itself in a format that Memory-Map recognises. The AIS feed can only be utilised by a single software application at any given time – if one app is already using the AIS feed it becomes unavailable to any other app on the Toughbook.

There are three main aspects to Memory-Map: the **Map Display**, the **Overlay display,** and the **Navigation display**:

The **Map Display** allows for the viewing of a variety of different map types and scales (Ordnance Survey, Marine and Aeronautical, from 1:2,500 through to 1:1,500,000). The user can select the required map and zoom in/out as necessary.

The **Overlay Display** comprises a wide range of additional data, which forms a layer on top of the chosen map. Individual overlay items can be displayed or hidden as required. Overlay items include current GPS position, pre-planned routes, FMS and temporary waypoints, helicopter '*snail trail*', and AIS items etc.

The **Navigation Display** is used when the GPS signal is live and comprises a separate small window (the '*position window*'), which usually sits on top of the main map window and shows information such as current location, speed, direction of travel, altitude, etc. If a destination has been set, two further windows will also display: one showing destination information (e.g. distance, bearing and ETA to the next waypoint and the final destination) and the other showing an arrow, which indicates the approximate direction to the next and subsequent waypoints relative to the current direction of travel. In order to ensure speed of operation, maps in Memory-Map always display in '*north-up*' format - it is not possible to display maps in a '*track-up*' orientation.

The Toughbook is pre-loaded with the following maps:

- 1:50,000 ordnance survey maps (Island of Ireland) (elevations in m)
- All marine charts (Ireland and UK) (elevations in m)
- IAA 1:250,000 and 1:500,000 aeronautical charts (elevations in feet)
- CAA 1:250,000 and 1:500,000 aeronautical charts (UK) (elevations in feet)
- Road atlas and regional maps (Ireland and UK)

9 **Viewing Map Scale**

Memory-Map doesn't have a scale-bar; however, there are a few alternative ways of providing visual cues:

- When the GPS feed is active and the position icon is visible, an adjustable range ring can be displayed around your current position.

- You can use the route feature to create a single-leg '*route*'. This will display as a line on the map giving a visual indication of the map scale. This can either be an accurate measurement of the distance between two landscape features or can be a convenient distance (e.g. 1 mile, 10 miles etc.) to be used as a scale reference line on a blank area of the map.

Working with Routes

A route is a selection of single points, which are linked together. In Memory-Map, a mark, which is incorporated into a route, is known as a waypoint. Distance and bearing of each leg of the route can be displayed, and if height data is available for the underlying map (OS maps) a surface profile of the route can be viewed, which can be useful to determine areas of high ground.

When GPS is active, a '*Follow Route*' option is available. When activated, Memory-Map will display the direction and estimated time to the next waypoint and to the final destination.

Operator pre-planned FMS routes have been created and saved as an .mmo (memory-map overlay) file and can be imported and displayed as required. This database is updated periodically.

If height data is available for the displayed map (OS maps), right clicking the route and selecting '*Profile*' will display the surface profile along the selected route (with an exaggerated vertical scale). The elevation profile gives an indication of the high ground to be aware of. Moving the cursor along the profile will display a red marker point and the surface elevation at that particular point, along with a corresponding red marker on the map.

The Position Marker

The helicopter position marker will display as a red circle with crosshairs as soon as GPS data is received. In addition, the centre spot of the crosshairs will continually pulse as confirmation that the GPS data stream is live. In the absence of GPS data, the position marker will display in grey at the last known position. The position marker can be displayed with a radius ring, and when the AIS stream is live, a velocity vector line can also be displayed. You can choose to have the position marker stationary on-screen with the map scrolling beneath it (GPS lock on), or the map stationary on-screen with the position marker travelling over it (GPS lock off).

When the AIS stream is live, a '*velocity vector*' can be displayed based on AIS data for the helicopter course and speed. This feature indicates the current direction of travel and the projected future position of the helicopter after a specified time (represented by the head of the arrow). Moving AIS vessels can also be configured to display a velocity vector.

AIS vessel markers

When AIS data is being received, vessels will display as a triangular icon on screen (usually green for moving vessels). The overlay properties box for an AIS vessel is identical to the properties box for the aircraft [helicopter] position marker, i.e. you can display a velocity vector and radius ring for the vessel in the same way as you can for the helicopter.

-END-

Appendix E — Significant Weather Chart

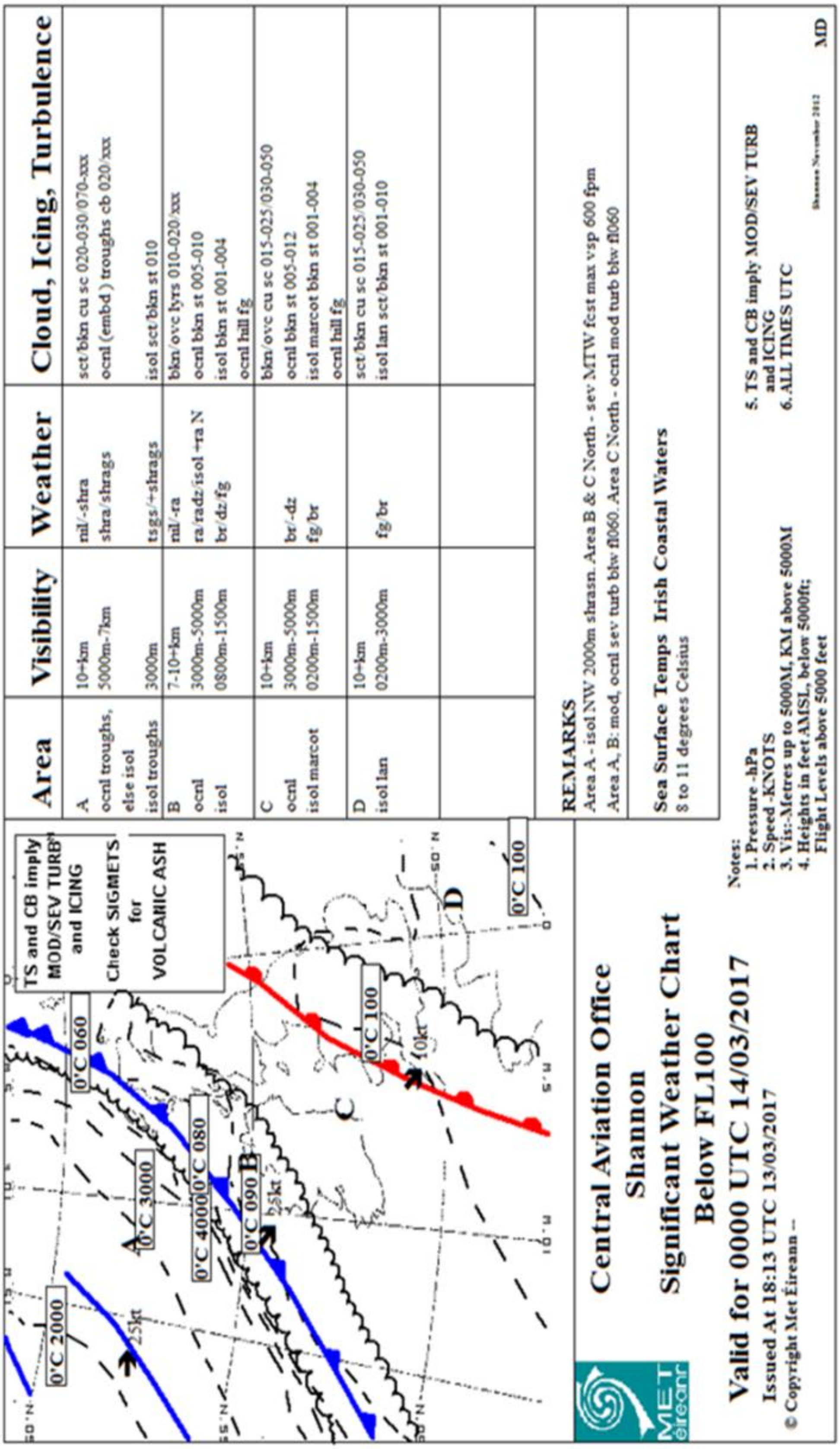


Figure No. E1: Significant weather chart valid for 00.00 hrs UTC 14 March 2017

Appendix F — Meteorological Information

1. Hourly Weather Conditions

Summary of the hourly weather conditions experienced in the occurrence area (18 km west of Blacksod) for the period 23.00 hrs on 13 March 2017 until 04.00 hrs on the 14 March 2017 **(Table No. F1)**.

Date/Time	Wind	Visibility	Cloud Ceiling	Weather
13 March 23.00 hrs	230° 25 kt gusting 35 - 40 kt	3000 m - 6 km with a risk of 2000 m	BKN 1000 - 1500 ft TEMPO 600 - 800 ft	RADAR echoes clear - only risk of very light precipitation. Misty
14 March 00.00 hrs	240° 25 kt gusting 35 - 40 kt	3000 m - 6 km with a risk of 2000 m	BKN 1000 - 1500 ft TEMPO 600 - 800 ft	RADAR echoes clear - only risk of very light precipitation. Misty
14 March 01.00 hrs	240° 25 kt gusting 35 - 40 kt	3000 m - 6 km with a risk of 2000 m	BKN 1000 - 1500 ft TEMPO 600 - 800 ft	RADAR echoes clear - only risk of very light precipitation. Misty
14 March 02.00 hrs	250° 27 kt gusting 35 - 40 kt	5 - 8 km with a risk of 3000 m	BKN 2000 - 2500 ft PROB30 TEMPO BKN 1000 ft	RADAR echoes clear - only risk of very light precipitation. Misty
14 March 03.00 hrs	250° 25 kt gusting 35 kt	5 - 8 km with a risk of 3000 m	BKN 2000 - 2500 ft PROB30 TEMPO BKN 1000 ft	RADAR echoes clear - only risk of very light precipitation. Misty
14 March 04.00 hrs	240° 25 kt gusting 35 kt	10+ km with risk 5 km	BKN 2000 - 2500 ft PROB30 TEMPO BKN 1000 ft	RADAR echoes clear - only risk of very light precipitation.

Table No. F1: Hourly weather conditions for the occurrence area 23.00 - 04.00 hrs

2. Sea Area Forecast

Sea Area Forecast for Irish Coastal Waters issued at 18.00 hrs on 13 March 2017 (**Table No. F2**).

Forecast for Irish coastal waters	From Valentia to Erris Head to Malin Head
Wind:	Southwest force 5 to 7 and gusty, veering southwest to west force 4 to 6 for a time overnight
Weather for all Irish coastal waters and the Irish Sea	Occasional light rain or drizzle. Patchy mist and fog
Visibility for all Irish coastal waters and the Irish Sea	Moderate to poor in precipitation, mist and fog. Otherwise good
Warning of heavy swell	Developing overnight and Tuesday on west and north coasts

Table No. F2: Sea Area Forecast Irish Coastal Waters

3. Belmullet Automatic

A graphical representation of the recorded weather conditions at Belmullet automatic synoptic weather station between 00.00 hrs and 01.00 hrs on the 14 March 2017 **(Figure No. F1)**.

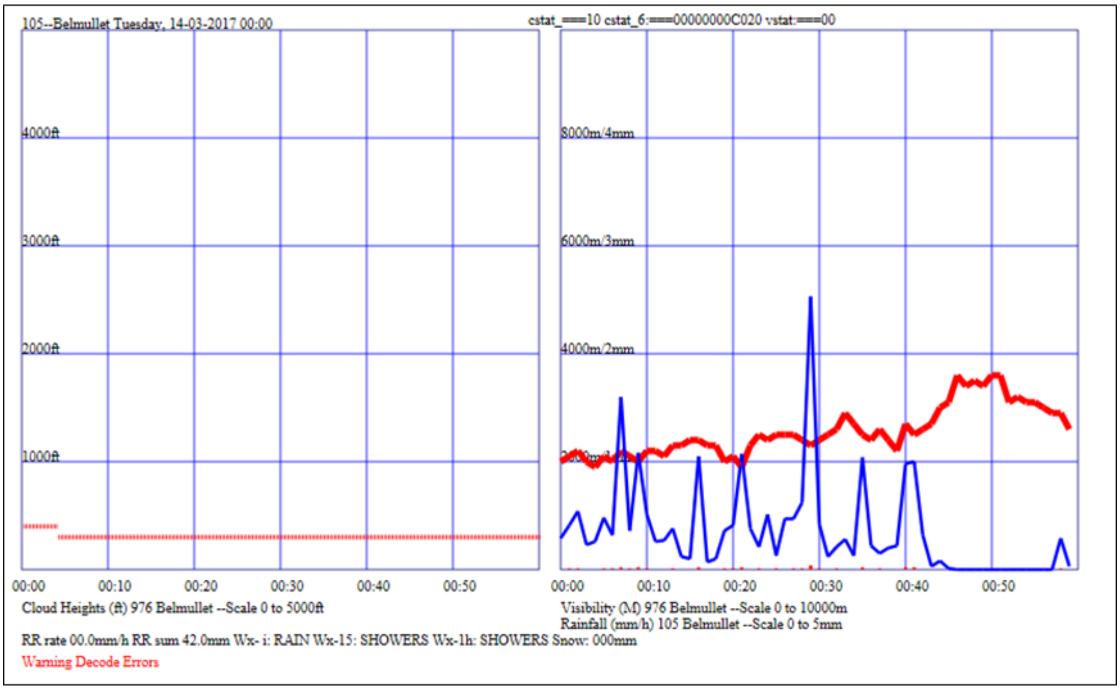


Figure No. F1: Graphical representation of weather conditions Belmullet automatic

4. Forecast for R118 mission and Blacksod Bay

A forecast for a position west of the intended mission location for R118 on the evening of the 13 March 2017, was issued by Met Éireann at 22.34 hrs and is presented as **Table No. F3** (Forecast No. 1).

A second forecast was issued by Met Éireann at 02.28 hrs on 14 March 2017) for the Blacksod Bay area and is presented as **Table No. F3** (Forecast No. 2).

Report Type	Forecast No. 1	Forecast No. 2
Location:	5417N 1406W (263 km west of Blacksod)	Blacksod Bay
Date and Time:	13 March 2017, 22.30 - 04.30 hrs	14 March 2017, 02.30 - 08.30 hrs
Wind (surface):	250° 25 - 30 kt with a 40% probability of a temporary change to 25 kt gusting 40 kt in the same direction	240° 20 kt gusting 30 kt
Wind (1000 ft):	35 kt at 250°	32 kt at 250°
Visibility:	Temporary change between 22.00 and 24.00 hrs of 4 km (30% probability)	In excess of 10 km with a 30% probability that this will temporarily reduce to 5 km
Weather:	Temporary change to rain and drizzle	30% probability of temporary light rain and mist
Cloud coverage and height above mean sea level (MSL):	Temporary change to broken cloud at 1200 ft, 30% probability of a temporary shift to broken cloud at 700 ft between 22.00 and 24.00 hrs	Scattered at 300 ft with broken cloud at 1500 ft, becoming broken cloud at 3000 ft between 03.00 - 06.00 hrs
Air Temperature:	10/11°C	10°C
Sea Temperature:	10°C	9°C
State of Sea:	Very rough becoming high	Rough
MSL Pressure:	1034 hPa	1026 hPa
Freezing Level:	8000 ft becoming 5000 ft	8000 ft
Additional information:	Cold front moving eastwards through area	Cold front clearing eastwards

Table No. F3: Forecast for R118 mission and Blacksod Bay

-END-

Appendix G — Preliminary Report/Interim Statement Safety Recommendation Responses

Preliminary Report

A Preliminary Report into the accident to Sikorsky S-92A, EI-ICR at Black Rock, Co. Mayo, Ireland on 14 March 2017 was published on the 13 April 2017 and contained two Safety Recommendations. The first (IRLD2017005) related to Route Guides and the second (IRLD2017006) related to PLB Installation in Mk44 Lifejackets. Both Safety Recommendations from the Preliminary Report and the associated responses to date are set out below.

Safety Recommendation IRLD2017005

CHC Ireland should review/re-evaluate all route guides in use by its SAR helicopters in Ireland, with a view to enhancing the information provided on obstacle heights and positions, terrain clearance, vertical profile, the positions of waypoints in relation to obstacles and EGPWS database terrain and obstacle limitations.

Response:

On 10 October 2017, the Operator advised the AAIU by letter that:

'1. CHCI Manager of Flight Operations (MFO) issued Flight Staff Instruction (FSI) – 030 CHCI Route Guide on 14th April 2017 (see attached). This FSI put immediate additional weather controls on the use of all routes within the current route guide, pending the full review in accordance with the Safety Recommendation, and is still in force today.

2. A review of all routes in the CHCI route guide was conducted between April and June 2017 culminating in a general communication sent to all staff by email on the 4th July 2017:

a. Email sent to all CHCI flight and technical crew which provided an update to all personnel on the progress and methodology being used to review the route guide.

b. Plates_Preamble_and_Guides_2017-Jun-30 which provides a detailed explanation of the process for 'proving' the routes as well as introducing the new format and content of each route.

c. Proving flight check list_v2 which is the actual checklist to be completed by the crews allocated to conduct each of the proving flights.

3. The first review of 'proving flight check lists' provided by crew having flown the revised routes was conducted on 5th September 2017. The review takes into consideration obstacle heights and positions, terrain clearance, vertical profile, positions of waypoints in relation to obstacles and EGPWS database terrain and obstacle limitations. Any revisions required are currently being input and this process is due for completion by 30th October 2017'.

The Operator further advised by email on 12th March 2018 that:

'The Route Guide has been reviewed and re-evaluated in line with the Safety Recommendation contained within the Preliminary Report dated 13 April 2017. Following an extended period of 'proving' the revised routes (a process undertaken by a number of crews from across the bases), pre-publication of the revised FMS Route Guide details had been circulated to crews via a company Ops Memo. The new FMS Route Guide will be formally encapsulated in the relevant Operations Manual (OMC) as part of the next scheduled revision to be submitted to the IAA at the end of March 2018'.

On 12 March 2019, the Operator informed the AAIU that:

'The Route Guide has been reviewed and re-evaluated in line with the Safety Recommendation contained within the Preliminary Report dated 14 April 2017. Following an extended period of 'proving' the revised routes (a process undertaken by a number of crews from across the bases), pre-publication of the revised FMS Route Guide details had been circulated to crews via a company Ops Memo. The new FMS Route Guide will be formally encapsulated in the relevant Operations Manual (OMC) as part of the next scheduled revision to be submitted to the IAA at the end of March 2018'.

1. CHCI Ops Memo No 06/2018 was issued on the 12th March 2018 to inform flight and technical crew of how to access the newly formatted 'FMS Route Guide' in order to review changes prior to its operational introduction.

2. OPS Memo No 07/2018 was issued on the 27th March 2018 delaying the introduction of the new 'FMS Route Guide' until the next FMS cycle update due at end April 2018 and also to permit the routes to be overlaid on the new IRE Aeronautical Charts.

3. The 'go live' date for the new FMS Route Guide was anticipated to be in April 2018. The assumption was that the new IRE Aeronautical charts would be available to CHCI by then. The optimal solution in introducing the new FMS route guide for operational use, would be to have the same revision of IRE Aeronautical charts on the Euronav display, Toughbook, Hard Copy (paper charts) and on the 'cockpit/cabin FMS Route Guide'. As the introduction of the new IRE Aeronautical charts was delayed, OPS Memo No: 09/2018(27 Apr '18) was issued to advise all flight and technical crew that the issue of the new FMS Route Guide would be deferred until the publication of the new aeronautical charts.

4. The following updates to the FMS Route guide were made on completion of the review process. The roll out date for the new FMS Route Guide was scheduled for the end of September 2018:

- *Coastal Routes and Onshore Routes are overlaid on the 2018 Aeronautical charts (except 2 x Heathrow rotes)*

- *New presentation of 'Route description' information*
- *Introduction of 'joining arc' for each route and location of 'initial' waypoint over sea on each Coastal Route.*
- *'Significant obstacle' information displayed on 'Route Description' page and corresponding reference on the respective 'Route Map' page.*
- *Redesign of routes following crew feedback after proving flights*
- *Amalgamation of routes:*
    - *Inisboffin – reduction from 3 to 2 Coastal routes*
    - *Dublin – reduction from 2 to 1 Coastal routes*
    - *Sligo – reduction from 2 to 1 Coastal routes*
    - *Blacksod – reduction from 3 to 1 Coastal Routes*
- *Removal of routes following proving flight feedback*
    - *Cork – 2 Coastal Routes*
    - *Carlingford – removal of Coastal route*
- *Operations Manual text changes in OMC and OMF providing to be used when using the FMS Route Guide.*
- *Introduction of a '90 day' currency item in OMF for the use of the FMS Route Guide for flight and technical crew*
- *Control and Management of FMS Route Guide comes under the direct control of the MFO*

5. The introduction of the new FMS Route guide was delayed from September 2018, due to the ongoing process of configuring the new IRE Aeronautical charts onto the cockpit 'Euronav display'. This was completed with the various 3rd party agencies in October 2018. The revised FMS Master Waypoint database (19 Sept 2018) list was sent for configuration to Euroavionics and a delivery date for this update was given as 21 November 2018. As a result, a 'go live' target date was set for 30th November 2018. The following Ops memos were issued to inform flight and technical crew of the ongoing process:

a) 18/2018 (10 July '18) – IRE Aeronautical charts
b) 19/2018 (1 Aug '18) – Clarification of weather minima for flying the CHCI Route Guide
c) 25/2018 (16 Oct '18) – Euronav system chart revisions
d) 26/2018 (1 Nov '18) – Toughbook update
e) 27/2018 (17 Nov '18) – FMS Route Guide
f) 28/2018 (26 Nov 2018) – FMS Route Guide

6. In addition the following FSI's were issued in advance of the 'go live' date for both OMC and OMF:

a) FSI – 2018 -064 FMS Route Guide information in OMC
b) FSI - 2018 – 417 Changes to OMF

7. The new FMS Route Guide went 'live' on the 30th November 2018 while FSI 2017 – 030 'CHCI Route Guide' issued on the 13th April 2017 (reissued as FSI 2018 – 027 CHCI Route Guide dated 26th April 2018) remained in force until the 14th December 2018 when it was withdrawn.

8. OMC Rev 02 and associated FMS Route Guide were accepted by the IAA on the 4th December 2018.

9. The unrestricted 'FMS Route Guide' came into use with CHCI on the 14th December 2018.'

AAIU Comment:

The AAIU notes the Operator's responses and awaits further updates in relation to this Safety Recommendation. While references are made in the Operator's response to files which were provided to the AAIU as supporting material, these files will not be made available by the AAIU to any third party. The Operator provided the Investigation with a copy of the revised Route Guide referred to in its response of 12 March 2019 and the Investigation provided the Operator with some observations. The Investigation considers that this Interim Safety Recommendation remains '*Open*'.

Safety Recommendation IRLD2017006

RFD Beaufort Ltd should review the viability of the installation provisions and instructions for locator beacons on Mk 44 lifejackets and if necessary amend or update these provisions and instructions taking into consideration the beacon manufacturer's recommendations for effective operation.

Response:

On 7 July 2017 RFD Beaufort informed the AAIU by email that:

'Following our review with CHC Ireland concerning the Mk44 lifejacket and integration of the SARBE 6 406 beacon, we have performed a number of modifications to the lifejacket to optimize the performance of the beacon unit. These changes have also been validated through a trial with CHC and MRCC last month, as the report attached refers.

Our next action is to formalize the service bulletin advising of the change and have one of our Part 145 organizations preform the necessary revision to the CHC lifejackets. An advance draft of the service bulletin is included within the report and we will provide you with a copy of the final version when it is released. We will also advise when all the CHC lifejackets have been updated and returned to them'.

On 8 March 2018 RFD Beaufort further informed the AAIU by email of the following:

'In May 2017, we (RFD Beaufort), in conjunction with the Operator, carried out a review of the Mk44 lifejacket and the integration of the SARBE 6 406 beacon. Following this review we performed a number of modifications to the lifejacket and validated the changes through a trial with the Operator and MRCC held in June 2017.

In August 2017, we formalised the modification by issuing Service Bulletin 25-147, Version 1. This service bulletin describes the components, tools and method required to install the SARBE 6 406 Beacon in the Mk 44 lifejacket such that the signals from the beacon antennas meet requirements.

In February 2018, we issued Service Bulletin 25-147, Version 2, to provide the maintenance and service personnel more detailed instructions on the installation of the beacon, the routing of cables and positioning of the antennas. A copy of this service bulletin has been provided to EASA.'

On 6 June 2019 RFD Beaufort informed the Investigation by e-mail that:

- SB 25-147 V2 had been issued to all registered holders of the Mk 44 lifejacket Component Maintenance Manual (CMM) and RFD Beaufort believed that all affected units in service had been updated to the latest standard.
- A full review of all RFD Beaufort lifejacket installations and the beacons fitted to them had been completed.

RFD Beaufort also informed the Investigation of changes to its internal procedures:

- All enquiries for commercial lifejackets requiring beacons to be fitted are reviewed. If it is an assembly that has been supplied within the last 2 years, the order can proceed. If not, a full review is carried out to assess the feasibility
- A Design Failure Mode Effects Analysis is carried out on all work.
- The CMM is updated, or created as appropriate, for all new assemblies entering production. The CMM is then checked as part of the initial production phase.

On 6 November 2019, in response to the Investigation's Draft Final report RFD Beaufort informed the Investigation that:

"[...] *communication continued with EASA between February and June 2018. The Manufacturer* [RFD Beaufort] *has provided EASA with copies of all trial documentation, service bulletins, etc. related to this safety recommendation, however, there have been no comments received from EASA."*

EASA informed the Investigation that they had received and reviewed the documentation from RFD Beaufort relating to this Safety Recommendation and that as the modification that was described in SB 25-147 V2 did not affect the primary function of the lifejacket, EASA considered the change acceptable at equipment approval level.

AAIU Comment:

The AAIU notes these responses and considers the status of this Safety Recommendation as "Closed".

First Interim Statement

An Interim Statement into the accident to Sikorsky S-92A, EI-ICR at Black Rock, Co. Mayo, Ireland on 14 March 2017 was published on the 16 March 2018 and contained a further three Safety Recommendations. The first relates to the Flight Data Recording System, the second to the Operator's Safety Management System (SMS) and the third to the Oversight of SAR Helicopter Operations in Ireland. All three Safety Recommendations from the first Interim Statement and the associated responses to date are set out below.

Safety Recommendation IRLD2018001

The Sikorsky Aircraft Corporation should make the necessary updates/modifications to the S-92A helicopter to ensure that the latitude and longitude information recorded on the Flight Data Recorder reflects the most accurate position information available during all flight regimes and mission profiles.

Response:

In a letter dated 17 July 2018, the Sikorsky Aircraft Corporation advised the Investigation that:

> *'Following the issue of the AAIU's Interim Report dated 16 Mar 2018, Sikorsky's engineering safety leadership team convened to specifically address the AAIU's recommendation. Our S-92 program Platform System Integration lead presented information detailing the findings of the investigation.*
>
> *Sikorsky recognizes that while this is not a safety critical deficiency, incorporating the recommendations of the AAIU would provide a benefit to recipients of the FDR data. It is Sikorsky's intent to incorporate the recommendations of the AAIU in the next update to the S-92A AMS software. Sikorsky is currently wrapping up a three-year certification effort of S-92A AMS software which began in 2015.*

The window for changes to that software closed in 2016, after which all the testing and certification efforts have been accomplished. Sikorsky is currently awaiting foreign validation of the completed update.

The next update to S-92A AMS Software has been funded for planning and requirements analysis. The recommendations of the AAIU have been considered by the analysis team and are on the list for incorporation in the next update. However, because Sikorsky is in the early stages of defining this AMS update, the schedule for completion has not been determined. Once the analysis team completes their recommendations, the list of changes will be sent to the supplier and a proposal requested. Once the suppliers cost and schedule proposal is received, negotiations will begin. Because Sikorsky has executed a project of this type many times in the past, we can confirm that this next AMS update will likely take about three years to complete. That would position the update completion at the end of 2021, with field deployment available to customers starting the next year, 2022'.

AAIU Comment:

The AAIU notes the response of the Sikorsky Aircraft Corporation. The status of the recommendation will remain '*P*' (In process of implementation) until the Sikorsky Aircraft Corporation formally advises the AAIU that the appropriate software update has been distributed.

Safety Recommendation IRLD2018002

CHCI, with external input, should conduct a review of its SMS and ensure that the design of its processes and procedural adherence are sufficiently robust to maximize the safety dividend; this review should consider extant risk assessments and a thematic examination of the corpus of all safety information available to the Operator, both internally and externally.

Response:

On 24 July 2018 CHCI informed the Investigation that:

'As part of continued internal safety oversight of CHCI, we have engaged with two independent aviation SMS specialists to carry out compliance audits as per EASA ORO.GEN.200 requirements. To complement this we will continue to carry out corporate SMS oversight audits.

In addition all SMS processes are currently being subjected to a rigorous review in order to ensure that their design and subsequent procedural adherence are sufficiently robust to maximize the safety dividend. This review will consider extant risk assessments and a thematic examination of the corpus of all safety information available to CHC Ireland, both internally and externally.

The results and output of the review will be the subject of analysis by an experienced independent aviation safety expert.

These various activities will ensure CHCI's SMS continues to meet all regulatory, contractual and internal safety requirements'.

AAIU Comment:

The AAIU notes the response of CHCI and awaits further updates on this ongoing work.

Safety Recommendation IRLD2018003

The Minister for Transport, Tourism and Sport, as the issuing authority for the Irish National Maritime Search and Rescue Framework, should carry out a thorough review of SAR aviation operations in Ireland to ensure that there are appropriate processes, resources and personnel in place to provide effective, continuous, comprehensive and independent oversight of all aspects of these operations.

Response:

On 13 June 2018, the Secretary General of the Department of Transport, Tourism and Sport, writing on behalf of the Minister, informed the Investigation by letter that:

'The review is underway and is being conducted by a three-member independent consultancy team whose members have extensive range of experience in the areas of aviation regulation, Search and Rescue requirements, safety oversight, auditing and Search and Rescue operations. It is expected that the review should conclude within two months and a report with recommendations will be published.

The terms of reference for the consultancy team require them to focus in particular on:

- *The specific reports, audits and frameworks highlighted in the AAIU's interim statement in relation to oversight arrangements for Search and Rescue (SAR) aviation operations, including any follow-up actions arising from these.*
- *The practices and procedures in place for oversight of SAR aviation operations within the IAA, as the national aviation regulator and the Irish Coast Guard, as the tasking authority for SAR aviation operations, and any other entities deemed relevant, and benchmark them in terms of their effectiveness, continuity, comprehensiveness and independence against models of best practice internationally (ideally using analogous models of SAR provision).*
- *The legal basis underpinning the oversight roles related to SAR aviation operations.*
- *The resourcing of these roles and processes within each organisation.*

Based on a thorough review of these and any other issues determined by the Reviewer as relevant to the AAIU recommendation, the review should:

- *Identify any gaps or lack of clarity in terms of roles, legal vires, processes, training, resources and/or personnel within these organisations to carry out their oversight of SAR aviation operations.*

- *Make recommendations on practical measures to address these to ensure oversight arrangements for SAR aviation operations in Ireland measure up to international best practice in terms of effectiveness, continuity, comprehensiveness and independence.*

In order to meet the requirements of the recommendation in the AAIU's interim statement, the review will need to be completed as a matter of urgency'.

On 20 September 2018 the Secretary General of the Department of Transport, Tourism and Sport provided the Investigation with a copy of a consultants' report, which was subsequently published on the DTTAS website on 21 September 2018.

The Investigation notes that the consultants' report contains 12 recommendations.

On the 3 July 2019 the Secretary General of the Department of Transport, Tourism and Sport provided a further response to the AAIU in relation to AAIU Safety Recommendation No IRLD2018003:

In its interim report (No.2018-004), the AAIU called on the Minister for Transport Tourism and Sport to carry out a thorough review of SAR aviation operations in Ireland to ensure that there are appropriate processes, resources and personnel in place to provide effective, continuous, comprehensive and independent oversight of all aspects of these operations.

As notified to you on 24 August 2018, this review was completed and the report was published on 21 September 2018. As you know, the Minister accepted the 12 recommendations and set out a series of actions to follow-up on the report. He also undertook to keep the AAIU updated on developments on a periodic basis.

Please find attached, (see link below) herewith the latest update in the form of a report from the SAR Framework Review Group, including various appendices, notably a new National SAR Plan (to replace the existing National Maritime SAR Framework document).

Apart from those AQE recommendations specific to the terms of reference for the Review of the SAR Framework itself, the report also provides progress updates on the other recommendations arising from the AQE Report.

The Minister has approved the report and the National SAR Plan. He is bringing the report to Cabinet for their information next week.

On the 19 July 2019, the Minister issued a Press Release relating to the National SAR Plan and other matters relating to ongoing response to AAIU Safety Recommendations No. IRLD2018003:

Http://www.dttas.ie/press-releases/2019/minister-ross-publishes-new-national-search-and-rescue-plan-ireland

AAIU Comment:

The AAIU notes the responses from the Department of Transport, Tourism and Sport and awaits further updates.

Note: Further Safety Recommendation responses received post-publication of the Final Report can be viewed on each Safety Recommendation link contained within the Report itself.

-END-

Appendix H — Extracts from OMA and OMD (Route Familiarisation)

OMD Vol 1-1 states:

'2.1.10 Route and aerodrome competence qualification
[…] The Company shall only designate a flight crew member to act as commander if they have:
[…]
b. Adequate knowledge of the route or area to be flown and of the aerodromes, including alternate aerodromes, facilities and procedures to be used

2.1.10.2 Required training

Aerodrome and area of operation training is required for pilots to qualify them for areas of operation to which they are assigned. Before being assigned, the pilot shall undergo initial familiarisation training to ensure they have obtained adequate knowledge of the route to be flown and of the heliports (including alternates), facilities, and procedures to be used. Training ensures safe operations and is detailed as follows:
[…]
c. Required for each geographic area of operation
d. Route and aerodrome competence flights flown under supervision of a training pilot may be required with the amount of flights determined on a case-by-case basis
e. Sub-bases (an additional base with the same scope of work within the same country) do not require an additional route and aerodrome check, however the local base area examination or detailed briefing shall cover any differences to mitigate risk. An orientation should also be provided upon arrival at a sub-base, with documentation to record that the pilot has been thoroughly prepared. Course details are provided in OMD Vol 3, and training is recorded in the QMS or other approved tracking program.'

OMD Vol 3 states:

'2.1.10 Route and aerodrome competence
[...] *For commercial air transport (CAT) operations, the experience of the route or area to be flown and of the aerodrome facilities and procedures to be used shall include the following:*

a. Area and route knowledge
i. Area and route training should include knowledge of:
A. Terrain and minimum safe altitudes
[...]
ii. Depending on the complexity of the area or route, as assessed by the Company, the following methods of familiarisation should be used:
A. For the less complex areas or routes, familiarisation by self-briefing with route documentation, or by means of programmed instruction;
and

B. In addition, for the more complex areas or routes, in-flight familiarisation as a PIC / commander or co-pilot under supervision, observer, or familiarisation in a flight simulation training device[5] (FSTD) using a database appropriate to the route concerned
b. Aerodrome knowledge
i. Aerodrome training should include knowledge of obstructions, physical layout, lighting, approach aids and arrival, departure, holding and instrument approach procedures, applicable operating minima and ground movement considerations
ii. Knowledge of the method of categorisation of aerodromes and, in the case of CAT operations, where a list of those aerodromes categorised as B or C is documented (usually OMC)
iii. All aerodromes to which the Company operates should be categorised in one of these three categories:
A. Category A: an aerodrome that meets all of the following requirements:
I. An approved instrument approach procedure
II. At least one runway with no performance limited procedure for takeoff and / or landing
III. Published circling minima not higher than 1000 feet above aerodrome level; and
IV. Night operations capability
B. Category B: an aerodrome that does not meet the category A requirements or which requires extra considerations such as:
I. Non-standard approach aids and / or approach patterns
II. Unusual local weather conditions
III. Unusual characteristics or performance limitations; or
IV. Any other relevant considerations including obstructions, physical layout, lighting etc
C. Category C: an aerodrome that requires additional considerations to a category B aerodrome […]'

The Operator informed the Investigation that it '*would regard our 4 bases as category A aerodromes.'*

OMA Chapter 8 '*Operations procedures*' states:

8.1.1 Minimum flight altitudes
CAT.OP.MPA.145, CAT.OP.MPA.270, SERA.3105, SERA.5005(f)
The minimum altitude or flight level except for the purpose of takeoff and landing shall be the highest of national regulations, ATC requirements, published procedures and minimum altitudes for specified routes.

a. IFR flights onshore:

IFR flights shall be conducted at an altitude / flight level ensuring:
i. *1000 feet terrain or obstacle clearance for elevations up to 5000 feet*
ii. *2000 feet terrain or obstacle clearance for elevations exceeding 5000 feet*

[5] The Investigation was informed that routes from the Route Guide were not available for use in the FSTD that the Operator used.

These minimum altitudes shall be sufficient for navigation signal reception and for communication with flight following. These minimum altitudes shall be corrected if necessary for the effects of wind, temperature and pressure.

b. IFR flights offshore:

The minimum cruising altitude shall be 1000 feet MSL providing radar does not identify any obstacles within 5 nm of aircraft track. If any obstacles are identified within 5 nm of track, the minimum cruising altitude shall be 1500 feet, or higher if a known obstacle exceeds 500 feet.

c. VFR flights:

Except by permission from the competent Authority, a VFR flight shall not be flown:
i. *Over the congested areas of cities, towns or settlements or over an open air assembly of persons at a height less than 1000 feet above the highest obstacle within a radius of 600 m from the aircraft*
ii. *Elsewhere than as specified in* ***i.*** *above, at a height less than 500 feet above the ground or water, or 500 feet above the highest obstacle within a radius of 150 m from the aircraft*

Commanders shall ensure that flight does not take place below the minimum altitude or flight level for the route except when necessary for takeoff and landing.

8.1.1.1 Altitude selection

Cruise altitude shall be selected in accordance with tables of cruising levels as described in the AIP ENR. Commanders are to give due regard to weather, wind, icing, turbulence, etc., when selecting altitudes. For offshore operations in strong winds, the lower altitudes should be avoided due to salt laden atmosphere, which reduces the efficiency of rotors and engines.

[…]*When operating within 20 nm of terrain with a maximum elevation above 2000 feet AMSL, the effect of wind may create pressure variations. Commanders are to increase the minimum flight altitude according to the table below.*

[…]

8.1.1.6 Minimum IFR flight altitudes

Commanders are responsible for ensuring that flight does not take place below the minimum altitude or flight level for the route except when necessary for takeoff and landing or in accordance with section 8.1 Flight preparation instructions.

There are various definitions for and methods of calculating minimum flight altitudes. The common terms are MEA [Minimum En route Altitude]*, MOCA and MORA, all of which equate to a correctly calculated minimum safe altitude appropriate to the flight. Those terms used within CHC are described below. For convenience, the term MSA is normally used in the OMB and associated checklists.*

8.1.1.7 Minimum obstacle clearance altitude (MOCA)

The MOCA represents the minimum safe altitude on a defined route. On published routes defined by navaids or waypoints, for example airways, MOCA for that route will be shown or may be calculated. Chart MOCA for an airway between VORs, for example, will be valid for a maximum assumed width of airway of 20 nm out to 140 nm from the VOR. Note also that the minimum usable flight level may be above the MOCA for the route. Within the Company, MOCA is defined as:
a. *The elevation of the highest obstacle within 5 nm of a route extending a maximum of 100 nm from navigation aid to navigation aid or between defined waypoints in the area navigation equipment, including a circle radius 5 nm round the fix or waypoint, rounded up to the next 100 feet, plus*
b. *An appropriate altitude increment from the table below*

Calculation of MOCA:

Elevation of obstacle Altitude increment
Below 5000 feet 1000 feet
5001 feet or above 2000 feet

8.1.1.8 Minimum off-route altitude (MORA)

The MORA represents the minimum safe altitude when not on a defined route. When operating off published routes (for example, when on a direct routing) it is essential that pilots calculate an appropriate MORA by referring to the relevant chart. Depending on the chart convention, it will either show the appropriate grid safety altitudes, or the MEFs, from which the basic MORA may be calculated. MORA is calculated on a similar basis to MOCA as follows:

a. *The elevation of the highest point in the applicable grid square through which the track runs, rounded up to the next 100 feet, plus*

b. *An appropriate altitude increment from the 'Calculation of MOCA' table above.'*

-END-

Appendix I — Communications Equipment

Introduction

The S-92A helicopter is equipped with a wide array of communications equipment, with voice and data capabilities, for use during SAR missions. This Appendix focuses on the voice communications between the Crew Members within the Helicopter, and the external communications with the supporting organisations, such as Air Traffic Control, other aircraft, other helicopters, IRCG radio stations or bases.

Communication Controls

The heart of the helicopter's communication system, both internal and external, is the *dB Systems* (now *Cobham*) *Model DB380 Audio Controller Panel* (**Figure No. I1**). There are five of these panels located throughout the helicopter. Their purpose is to link the various radio and communication systems to the microphone and headset/speakers in the cockpit and cabin in order to enable the selection of the required source by each person on board the helicopter. The panel consists of three rows of controls, which are labelled '*Radio Transmit', 'Radio Receive'/'Vol',* and '*NAV receive'*. There are additional buttons on each row that have specific features not directly associated with the three main categories.

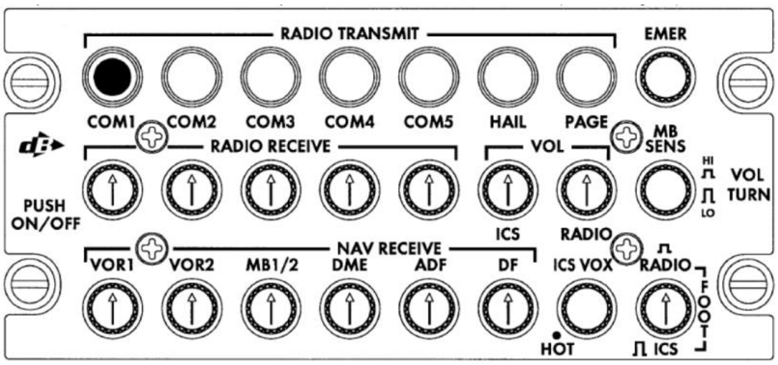


Figure No. I1: DB380 Audio Controller Panel designed for IRCG S-92A Helicopters

The '*RADIO TRANSMIT*' buttons (top row) are used to select the radio that is to be used by the crew member for transmitting. Each button is a single use pushbutton. In the example shown in **Figure No. I1**, COM1 is selected for transmission and receipt of audio on the COM1 selected frequency. Pressing any of the other COM buttons on the same row would select that source for transmit and receive, while simultaneously causing COM1 to deselect by popping the associated button up again. This ensures that only one source is in use for transmission at any time. The HAIL function is disabled on the ICRS S-92A. The PAGE button is used for making internal cabin announcements. The EMER button links the pilot's headset and microphone directly to the respective on-side's COM1 or COM2 box in order to maintain communications with ATC in the event of a failure of the DB380 box.

The centre row of the Audio Controller Panel consists of RADIO RECEIVE knobs, which are used to select the source that the user can hear in their headset or on the speaker system. Each control is a push/pull rheostat type control.

The rheostat is turned to control the volume of the respective individual source, and pulling the button up enables the audio source to be heard by the user. Unlike the TRANSMIT function, the RECEIVE function can be enabled for multiple radios at the same time. The VOL knobs to the right of the centre row control the volume for the Interphone Communication System (ICS), and a combined master volume control for the RADIO RECEIVE sources. The MB SENS knob controls the sensitivity and volume of marker beacons that are used during an ILS approach.

The bottom row of the Audio Controller Panel consists of NAV RECEIVE knobs, which are also of the push/pull rheostat type control knobs. These are used to listen and control the audio volume of the various radio navigation sources available to the crew. The purpose of these volume controls is to permit identification by the crew of navigation beacons that transmit a discreet Morse code signal. Some airports or ATC organisations transmit important navigation and weather information on the navigation beacon frequency. The ICS VOX knob controls the quality of the interphone signal (known as '*squelch*') and the RADIO/ICS FOOT button at the lower right corner of the box controls the functioning of the foot transmission switches which are located on the cockpit floor at the pilot and co-pilot stations. The locations of the Audio Panels are shown in **Figure No. I2**. The rear passenger cabin has been omitted for clarity.

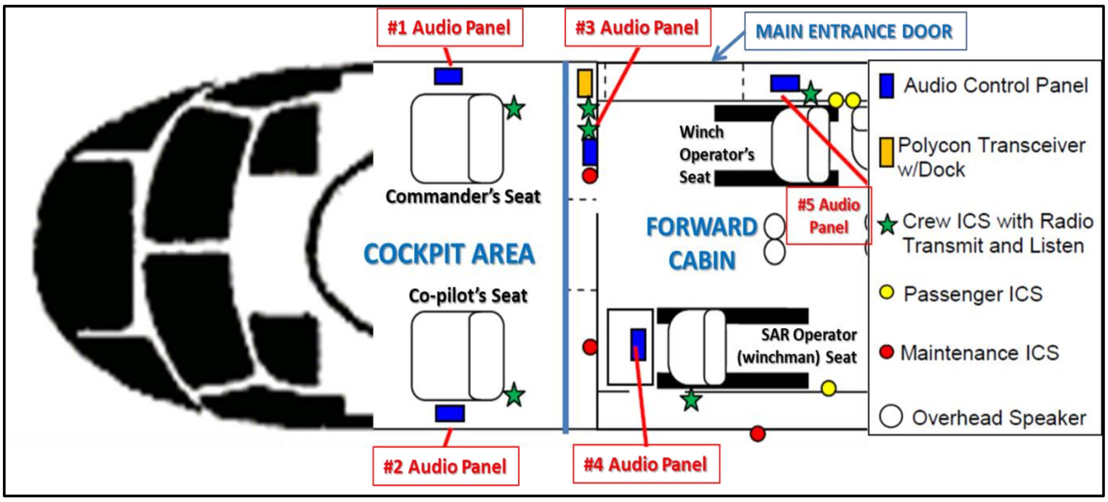


Figure No. I2: Audio Panel Locations

The radio communications systems available to the crew are as follows;

- COM1 enables VHF1 (Collins VHF -422D radio) audio, transmit/receive.
- COM2 enables VHF2 (Collins VHF -422D radio) audio, transmit/receive.
- COM3 enables FLEXCOMM II (Global Wulfsberg RT-5000) audio, transmit/receive.
- COM4 enables SATCOM (Skytrac ISAT-100) audio, transmit/receive.
- COM5 enables TETRA (Chelton 7-450) *or* Honeywell HF1050 audio, transmit/receive.

The TETRA radio and HF radio share the COM5 channel on the Audio Controller Panel. The active radio is selected by use of a separate COM5 toggle switch located beside each of the five Audio Controller Panels. The HF control head which permits the selection of the required radio frequency is located on the main cockpit instrument panel just below MFD5. A change to the desired HF frequency would require the rear crew member to request a member of the cockpit crew member to manually tune the HF control head. The TETRA control panel is located at the SAR Operator's Station.

The crew ICS enables effective communication between the flight crew, those in the cabin, and maintenance crew as required. There are a total of 19 ICS jack-sockets. These are located in the cockpit area, at the main entrance door, and in the main cabin. The jack-sockets are installed in the cabin ceiling to allow a user to easily plug in a headset and microphone. The S-92A ICS system is separated into distinct zones (**Figure No. I3**[6]) and is designed so that both crew and passengers may communicate independently.

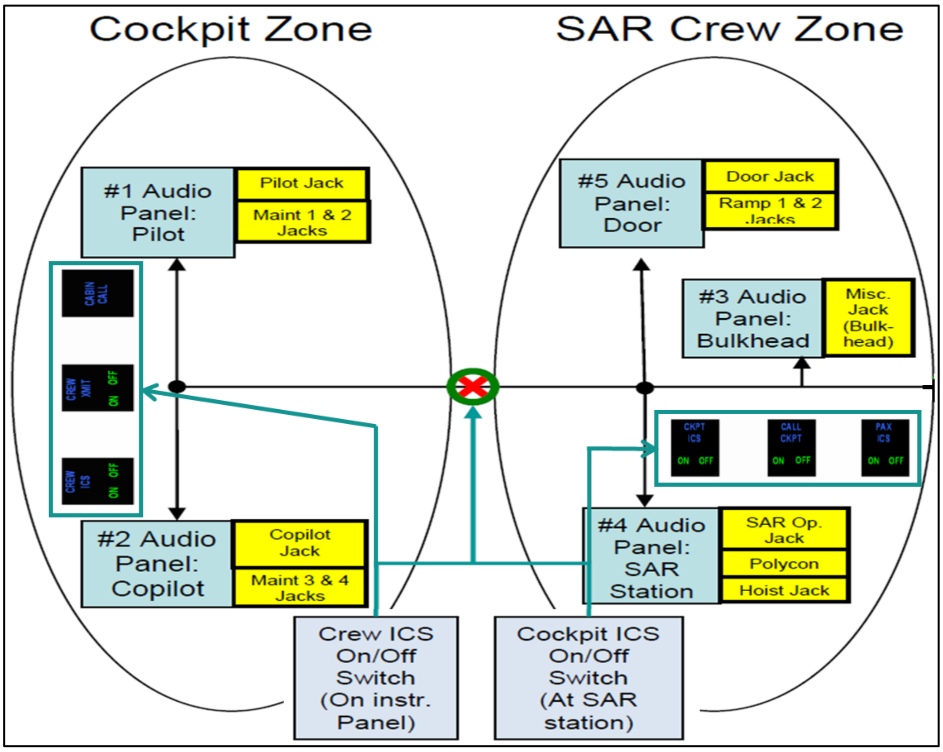


Figure No. I3: S-92A ICS Zones

The '*SAR Crew Zone'* ICS is controlled from annunciator switches at the SAR operator's station, although the cockpit crew has the ability to override the selection if required. The '*Cockpit Zone'* ICS is controlled from annunciator switches in the centre of the cockpit instrument panel. This allows the flight crew to isolate the cockpit zone from all other ICS zones when a sterile cockpit environment is necessary. The configuration of the ICS annunciator switches are not recorded on the FDR or HUMS.

-END-

[6] There is a third *'Passenger Zone'* which has been omitted from **Figure 999** for clarity.

Appendix J — R116 Radio Communications

All communications between the Helicopter and ATC during the flight were conducted by either the Pilot, or the Co-pilot. The first communication from the Helicopter was to Dublin Ground Control by the Co-pilot at 22.53 hrs, and consisted of a verbal flight plan request, and confirmed that there were four persons on board. The Co-pilot stated at that time that they were unsure whether the destination would be Sligo or Blacksod, and that they might need to use RWY 28 for departure. Dublin Ground acknowledged the transmission and asked if R116 was ready to start engines. The Co-pilot confirmed that they were ready, and ATC granted start clearance. Dublin Ground asked R116 to confirm if RWY 28 was essential as the active runway was about to change and might result in a delayed departure. The Commander replied that R116 was happy to use RWY 16 for departure. At 23.01 hrs the Co-pilot advised that R116 was ready for departure and that they could depart from RWY 16. Dublin Ground Control handed R116 over to the Tower frequency. The Tower subsequently cleared R116 for take-off and the Helicopter departed Dublin at 23.02 hrs. The Co-pilot confirmed that R116 would be departing from RWY 16 as they were '*quite heavy here with fuel*'.

After departure, the Tower cleared R116 to route on a westerly heading and climb to an altitude of 3,000 ft, which was read-back to ATC by the Co-pilot. At 23.07 hrs the Tower handed R116 over to Dublin Centre frequency 132.575 MHz for onward clearance. The Co-pilot acknowledged the handover and immediately contacted Dublin Centre. The Co-pilot requested a right turn onto a heading of 310 degrees. Dublin Centre advised the Helicopter to turn initially onto 290 degrees. The Co-pilot acknowledged and confirmed that 3,000 ft would be acceptable as the Helicopter's cruising altitude. At 23.12 hrs, the Co-pilot contacted Dublin Centre and asked if it was ok for R116 to route direct to Sligo. Dublin confirmed that R116 was cleared for '*own navigation and terrain separation*'. At 23.14 hrs, the Co-Pilot advised Dublin that R116 would require 4,000 ft altitude at some stage in the flight. Dublin approved climb to 4,000 ft and the Co-pilot acknowledged the clearance.

Following a crew discussion about destination planning, the Commander called Dublin Centre at 23.21 hrs to change the Helicopter's destination from Sligo to Blacksod, near Belmullet, Co. Mayo and that this would entail a left turn of approximately 20 degrees. Dublin Centre confirmed the re-routing and that R116 would be handed over to Shannon Centre in about 12 miles. At 23.26 hrs, Dublin centre advised R116 to contact Shannon Centre on 119.075 MHz.

At 23.27 hrs, the Commander called Shannon ATC and advised that R116 was seven miles south of Kells at 3,000 ft on a QNH of 1029 hPas and confirmed that they were routing to Blacksod and not Sligo. Shannon ATC advised that R118 was passing the west coast at that time but was not in radio contact. Shannon requested R116 to contact R118 to request them to call Shannon ATC. The Winchman noted at this time that R118 was on the AIS display at 12 miles west of Blacksod. At 23.34 hrs, following a call on TETRA by R116, R118 called Shannon ATC and provided an estimate arrival time at the casualty vessel of 00.47 hrs.

At 23.51 hrs, the Commander requested, and received confirmation from Shannon that Connaught Airport was closed and had no traffic as they would be routing over the top of the airport.

At 00.01 hrs, the Winch Operator requested the Commander to try and call R118 on the Aero-VHF frequency. The Commander called first on the Operator's Company frequency of 131.875 Mhz and then responded '*nope*'. The Co-pilot suggested that they could ring them on the Sat Phone, to which the Winch Operator replied '*yeh, if we got desperate*'. The Commander then tried to call R118 on 123.1 Mhz and again said '*nope*' soon after. The Commander also remarked to the other crew that they were at 4,000 ft and directly overhead Connaught Airport. At 00.07 hrs, the Commander tried again on the Operator's company frequency to call R118. No reply was received. The Commander then called Shannon ATC to ask if they have two-way communications with R118. Shannon did not, but offered to conduct a radio relay through another commercial aircraft to establish contact with R118. At 00.09 hrs, Shannon called the Lufthansa Cargo 8231 and requested them to call R118. This aircraft was high level and in the vicinity of the casualty vessel. The aircraft called R118 requesting a position and ETA for the fishing vessel. There was no reply.

At 00.15 hrs, the Co-pilot called Shannon Centre and requested the latest weather for Sligo. Shannon replied that they would need to call the controller for the current weather. The Shannon controller then provided the Sligo TAF which the Co-pilot acknowledged. At 00.17 hrs, Shannon provided R116 with the METAR for Sligo which the Co-pilot acknowledged. At 00.18 hrs, Shannon provided R116 with the TAF for Dublin Airport, which the Co-pilot acknowledged.

At 00.19 hrs, Shannon asked R116 how far west they intended to go, and whether they would go all the way to the vessel. The Co-pilot replied that it was not their intention, but that it was a possibility. He also advised Shannon that they were having problems establishing two-way communications with R118. He said that they would '*land-on Blacksod refuel and eh we'll, we'll figure it out from there Rescue one one six*'.

At 00.34 hrs, the Co-pilot called Shannon and advised that R116 was leaving 4,000 ft and making their way into Blacksod for refuelling. Shannon requested R116 to call again when airborne. The Co-pilot acknowledged this request. This was the last transmission received from R116. At 01.11 hrs Shannon attempted to call R116 but received no reply.

Other Radio Communications

There was no indication from the CVR that either pilot or the Winchman transmitted on any of the non-ATC radios. Other radio communications were conducted by the Winch Operator for the duration of the flight.

The first transmission by the Winch Operator that was recorded on the CVR was at 22.58 hrs. It was on the TETRA radio and it was an advisory call to MRCC Dublin that R116 was starting engines on the ramp at EIDW. MRCC Dublin acknowledged the transmission.

While TETRA was being used for communications with MRCC Dublin, at 23.02 hrs during the take-off sequence, the CVR recorded the sound of a transmission advising all stations of the marine weather forecast for the east coast, including Carlingford, Dublin, Wicklow Head and Rosslare areas. This indicated that the Winch Operator was maintaining a listening watch on Marine Channel 16.

At 23.03 hrs, just after the Helicopter was airborne, the Winch Operator called MRCC Dublin to advise that they were airborne and enroute to Sligo initially with four people on board and a fuel endurance of three and a half hours. He advised that the next call would be on Marine Channel 83. MRCC Dublin acknowledged the transmission. At 23.06 hrs, R116 called R118 on the TETRA radio. R118 replied that they were receiving R116 strength 5 and requested R116 to standby as R118 was landing at Blacksod, and that they would call R116 when on the ground. R116 replied to R118 that he just wanted them to know that R116 was airborne from EIDW.

At 23.11 hrs, R118 is heard on the CVR calling Malin Head Coastguard advising that they are on the ground at Blacksod and receiving fuel. R116 then called R118 to request the weather conditions at Blacksod. R118 advised that conditions at the pad were fine, that there was some low cloud approximately five hundred feet up to the north while they were inbound through Broadhaven Bay. The Winch Operator acknowledged this transmission and advised the Commander that the conditions at Blacksod were good. The Winch Operator then responded to what he believed was a call from MRCC Dublin. MRCC Dublin advised that they did not call, but that Malin Head Radio now had flight watch on R116. At 23.13 hrs, R116 called Malin Head Radio and advised that their destination was Sligo, and that they would advise if this changed. Malin Head Radio acknowledged this transmission. R116 then called MRCC Dublin on Marine Channel 83 to advise that they had established communications with Malin Head Radio, but that they would stay with MRCC Dublin for the moment. The Winch Operator then advised the Commander that R116 had established 2-way communications with Dublin on Marine Channel, and with R118 on TETRA.

At 23.20 hrs, the Winch Operator contacted Malin Head Radio and advised them that R116 was now proceeding direct to Blacksod with an estimate of one hour and twelve minutes for arrival, and that they were listening on Marine Channel 16. Malin Head Radio acknowledged the transmission and advised that they would notify the staff at Blacksod of their arrival details. At 23.21 hrs, R118 called R116 on TETRA and advised that they had departed Blacksod routing out to the west, that they had heard R116's communication with Malin Head Radio in relation to R116 heading to Blacksod. R116 replied that they would be operating on Marine Channel 16 and probably a HF frequency as well.

R118 did not reply to this transmission, but Malin Head Radio interjected that R118 had received the transmission from R116 and that they were transmitting on marine radio at the time. R116 requested a HF frequency and Malin Head Radio advised 3023 kHz. Malin Head Radio advised that they were getting the casualty vessel very well, that they were transmitting on 1677 kHz and receiving on 2102 kHz. Malin Head Radio offered to conduct a radio check with R116 on HF, but the Winch Operator suggested that they wait for around 30 minutes. Malin Head Radio acknowledged this transmission. The Winch Operator requested the Flight Crew to tune 3023 kHz on the HF radio in the cockpit.

At 23.33 hrs, the Winch Operator called R118 on TETRA and advised that Shannon ATC were looking to talk to them. R118 acknowledged the transmission. R118 was subsequently heard on the R116 CVR calling Shannon ATC on the aero-VHF frequency. At 23.37 hrs, R116 called MRCC Dublin on Marine Channel 83, advised that they were '*Ops Normal*', passing Longford, and were going to hand over helicopter watch to Malin. MRCC Dublin acknowledged the transmission.

R116 then called Malin Head Radio to advise the transfer of flight watch, that R116 was listening on Marine Channel 16, TETRA and HF. The Winch Operator then requested the non-handling pilot to tune channel 16 on the marine radio. There then followed a sequence of communications on HF and TETRA that continued regularly for the remainder of the flight as R116 tried unsuccessfully to establish communications on HF with Malin Head Radio or R118. During this period, the various crew members commented on the quality of the on-board communications. At 23.41 hrs, the Winch Operator noted '*Good ol' HF…it's terrible, eh bad, nearly unworkable'* following a sequence of test calls that Malin Head Radio could not receive.

At 23.46 hrs, Malin Head Radio called R116 on TETRA and advised that they were trying to establish two-way communications with R118, and asked R116 to do a radio check on the HF frequency of 2182 kHz. The Winch Operator asked the Co-pilot to tune the frequency on the HF radio in the cockpit. The Co-pilot asked the Winch Operator in response '*do you have to key the, the mike for this to do the, the way it used to do the old way, for tuning it*.' The Commander interjected '*don't know*'. The Winch Operator did not answer the Co-pilot's question directly, but began calling Malin Head Radio on the HF radio. The CVR recorded a garbled response on the HF frequency. The Winch Operator called Malin Head Radio on the TETRA and described the HF as '*Strength two, a lot of background noise, unworkable really*'. Malin Head Radio requested R116 to maintain communications with R118 on Marine Channel 16. R116 then began to call R118 on channel 16 without success. The Co-pilot then suggested trying HF again as he had just made some changes to the 'squelch' settings on the radio.

The Winch Operator continued to attempt contact with R118. He noted that Malin Head Radio was unreadable on HF, and strength one on Marine Channel 16. R118 was unreadable on any frequency. At 23.51 hrs, the Winch Operator stated that '*yeh no point in us not having comms with one one eight. That's what we're here for.*'

The Commander asked '*were you chatting with them on it before?*' to which the Winch Operator replied that '*yeh I was but now they've gone out of reach of TETRA once they go off shore by twenty miles they're out of reach of TETRA so I'm trying to get them now on sixteen and HF…anything at all just to make contact would be..*'. At 23.54 hrs, Malin Head Radio advised R116 that they wanted to try an optional piece of equipment and asked R116 to do another HF test call. During this transmission, Malin Head Radio also advised that '*I just wanted to let you know as well actually while I've got you that the visibility at eh Blacksod is now down to three nautical miles that's three miles Over*'.

Over the following period, R116 continued unsuccessfully to contact Malin Head Radio on HF and R118 on HF or marine radio. At 23.59 hrs, the Winch Operator asked Malin Head Radio if they had contact with R118. Malin Head Radio responded that '*I'm going to try them again there now on sixteen briefly but he's moving further out now so that's obviously just a bit concerning that we might not be able to establish contact with them there via HF so I'll just try them once more on sixteen*'. During this period there was an internal discussion about the communications in general. The Winch Operator said that '*this all happened last week as well it's an almighty* [mess] *with the radio*'. The Co-pilot asked if the HF worked the previous week, to which the Winch Operator replied '*no it didn't we drop kicked it we got fed up with it after about ten minutes and we went onto sixteen, never known it to work yeh we were high enough then to keep in contact on sixteen with the eh one one eight ah it never works*'.

In the background on the CVR, Malin Head Radio can be heard calling R118. The Winch Operator observed that '*he can't get them on sixteen it's not good if there's no one talking to them… it would surely be listening out wouldn't it on sixteen em eh the one one eight ah they would yeh*'. The Commander then attempted to call R118 on both the company aero-VHF frequency and an aero-VHF chat frequency without response from R118. Malin Head Radio told R116 that '*yeh just to advise there is some sort of problem with one one eight at the moment on sixteen*' and that they would try to contact R118 via the casualty vessel, and that R118 was still visible to them on AIS. The Winch Operator continued to try to contact R118 by all available on-board means. At 00.02 hrs, the Co-pilot suggested that they '*could always ring them on the Sat Phone I suppose*', to which the Winch Operator replied '*yeh if we got desperate*'.

At 00.08 hrs, the Winch Operator called Blacksod Helipad on Marine Channel 16 and received a response. The Winch Operator requested details of the wind, cloudbase and visibility at Blacksod. This was provided as 'three four five hundred feet…it's good enough to come in over'. Blacksod advised that the wind was west south west at 25 to 33 knots, and that the sea-level visibility was two miles. The Winch Operator acknowledged the information and said that he would talk to them again when landing. During this sequence of communications, the Flight Crew were transmitting to Shannon ATC and asked the Winch Operator to standby. Ten seconds after this, the Commander told the Winch Operator that she had copied him and repeated the transmission as '*three hundred feet and whatever*'. The Winch Operator said that he would '*carry on trying to get them on all the different channels until we reach them on something*'.

At 00.27 hrs, Malin Head Radio, using the callsign '*Belmullet Coastguard Radio*' called R116 on Marine Channel 16 and advised that they had two-way communication with R118 via the casualty vessel. R116 replied that they would be shortly landing at Blacksod and would call again when airborne. At 00.31 hrs, the Winch Operator called Blacksod Helipad and said that they could probably hear the helicopter, and that they were working their way into the pad. This was acknowledged by the staff at Blacksod.

At 00.44 hrs, the Winch Operator called Belmullet Coast Guard Radio to advise that '*we should be landing very shortly now at Blacksod and we'll call again when airborne, over*'. Malin Head Radio acknowledged the transmission. This was the final radio transmission received from the helicopter.

Appendix K — MPFR Corrosion Report (AAIB UK)

Flight Recorders

Introduction

EI-ICR was equipped with a Penny & Giles[7] manufactured Multi-Purpose Flight Recorder (MPFR), part number D51615-102, which records the most recent 120 minutes of cockpit audio and 25 hours of flight data into a solid state, non-volatile memory that is protected within a Crash Survivable Memory Module (CSMM).

The MPFR was installed in the left-hand avionics rack located behind the co-pilots seat and is stopped automatically if the helicopter lands on water by the activation of an immersion switch, or if an acceleration of 10 g or greater is sensed by an inertia switch.

MPFR Certification

The MPFR was certified in 2001 under the manufacturer's design and production authority[8], which was granted by the UK CAA. The MPFR was certified as meeting the requirements of European Organization for Civil Aviation Equipment (EUROCAE) ED-55 'Minimum Operational Performance Specification For Flight Data Recorder Systems' Category A1[9], ED-56A[10] 'Minimum Operational Performance Specification For Cockpit Voice Recorder System' Amendment 1, (J)TSO-C123a and (J)TSO-C124a.

ED-55 and ED-56A specify the crash survivability requirements for the FDR and CVR respectively, which include impact shock, penetration resistance, static crush, fire, fluid, deep sea pressure and sea water immersion. Of note, there is no requirement that a hermetic seal is in place to prevent fluids entering the CSMM and coming into contact with the recording medium. Therefore, the design should ensure that the recording medium is not damaged through mechanisms such as corrosion.

The ED-55 and ED-56A crash survivability fluid, deep sea pressure and sea water tests specify that the recorder is immersed in:

1. Sea water at a pressure equivalent to a depth of 6,000 m (20,000 ft) for 30 days[11].
2. Sea water at a depth of 3 m (9 ft) and nominal temperature of 25°C for a period of 30 days.
3. Aviation fuel, oil, fire extinguishing agents, hydraulic and toilet flushing fluids for 48 hours.

[7] Part of the Curtiss Wright group of companies http://www.curtisswright.com
[8] DAI/5817/59, Issue 1996 and Joint Aviation Authorities, Production Organisation Approval Ref CAA.G.0214 respectively.
[9] Class A1 is equivalent to ICAO Type 1, which is a recorder that has sufficient memory capacity to meet the parameter recording requirements specified for '*large aeroplanes'.*
[10] Both ED-55 and ED-56A are applicable to the MPFR as it is a combined CVR and FDR.
[11] This may be reduced to 24 hours if the materials used to protect the recording medium have been shown to be unaffected by sea water.

The crash survivability tests are combined into three test sequences[12]. Following each sequence the recorder is readout to ensure that the data is '*readily recoverable'*, which ED-55 and ED-56A defines as meaning '*only minor repairs can be permitted for a damaged storage medium….e.g renewal of the interface connection of a solid state memory module'* and that the '*repair of individual memory devices is not permitted'*.

MPFR Design

There are several different models of the MPFR, however, the same basic design layout of CSMM is used across the model range. Since the MPFR was introduced in 2001, the manufacturer has made two design changes to the internal construction of the CSMM; this is discussed later in this report. **Image No. K1** is a photograph of an MPFR and the CSMM that is installed within its chassis. MPFR's are fitted to a range of commercial and military operated helicopters and aircraft, and is standard equipment on the Sikorsky manufactured S-92 helicopter.

The MPFR records audio and flight data to non-volatile memory devices that are installed on a circuit board that is protected within the CSMM. This circuit board is referred in this report as the Accident Protected Memory Board (APMB) (**Image No. K2 and No. K3** show the same type of APMB fitted to the MPFR from EI-ICR). The APMB provides the interconnection between the MPFR's electronics that are external to the CSMM that process the incoming flight data and cockpit audio, and the non-volatile memory devices fitted to the APMB that store the data.

The non-volatile memory devices on the APMB are modular in design and use disk-on-chip (DOC) technology[13] **(Image No. K4 and No. K5)**. There are four DOC modules fitted[14] to the APMB, with each DOC module consisting of a controller and three flash memory devices. One in-line flash memory device[15] per DOC module are also installed on the APMB (image 3). The four DOC modules are defined by the manufacturer as 'FDR1', 'FDR2', 'CVR1' and 'CVR2'. The CVR1 module stores audio from the Cockpit Area Microphone (CAM), CVR2 stores audio from the crew microphone channels and FDR1 and FDR2 store flight data; the two FDR modules record the same data with the dual design intended to provide redundancy if one module fails.

[12] The test sequences consist of a combination of impact shock, penetration resistance, static crush, fire, fluid immersion and deep sea pressure and sea water immersion. More than one recorder may be used to complete the test sequences.
[13] https://en.wikipedia.org/wiki/M-Systems
[14] Each module is attached by being soldered to the APMB.
[15] The in-line flash is used to store data before it is written to the three flash memory devices on the DOC.

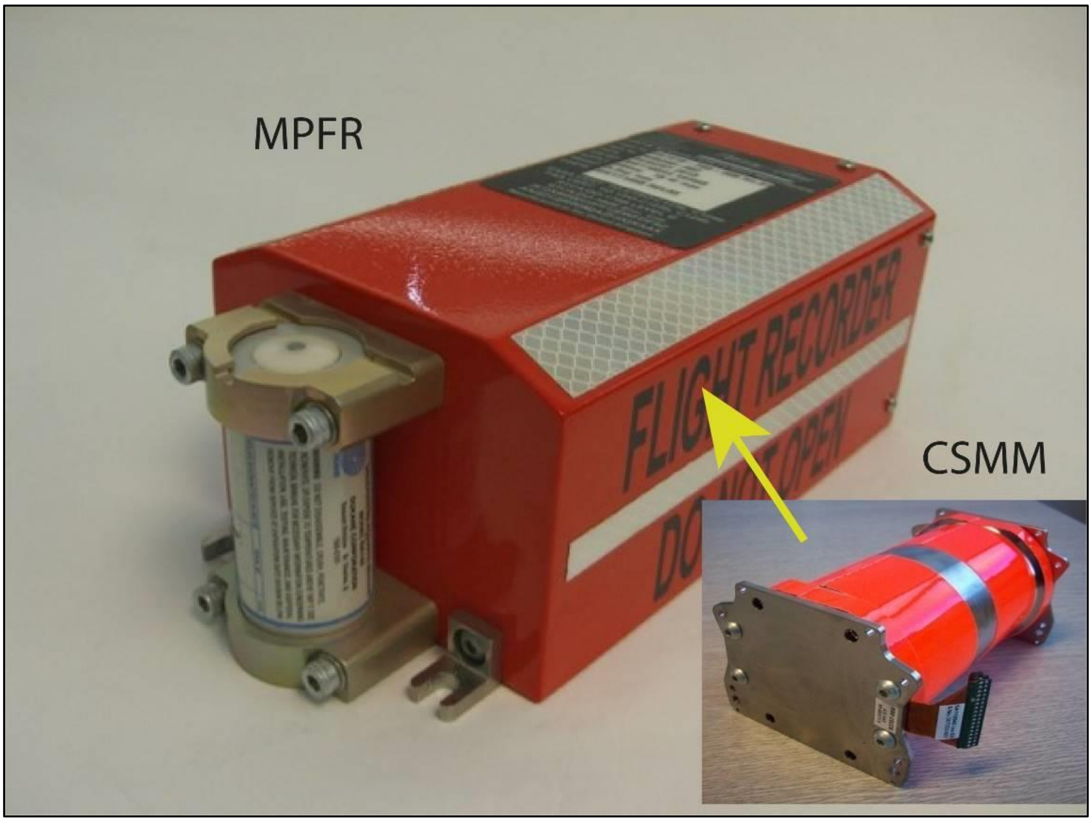


Image No. K1: MPFR and internal CSMM

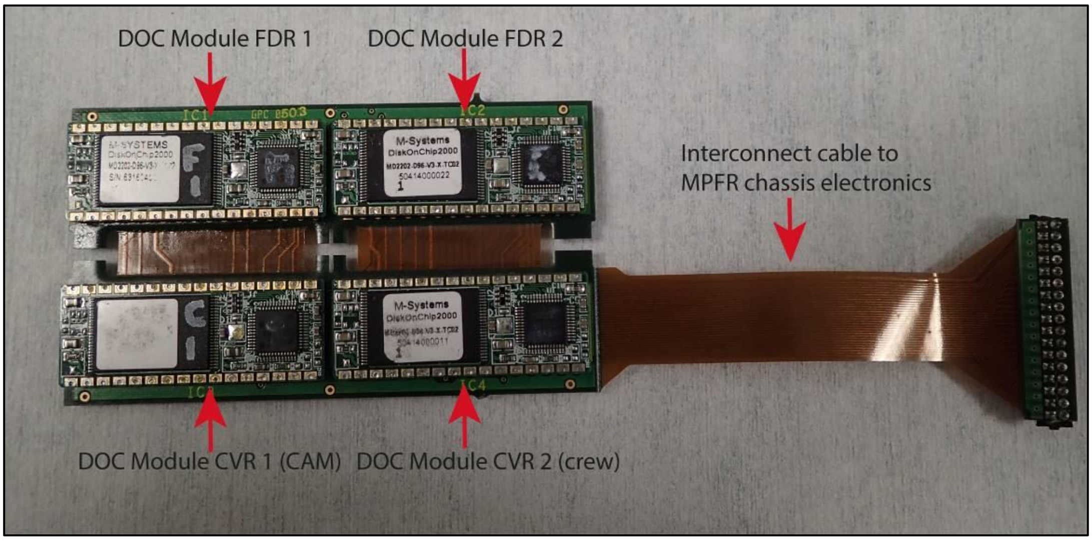


Image No. K2: Top of an APMB showing four DOC modules

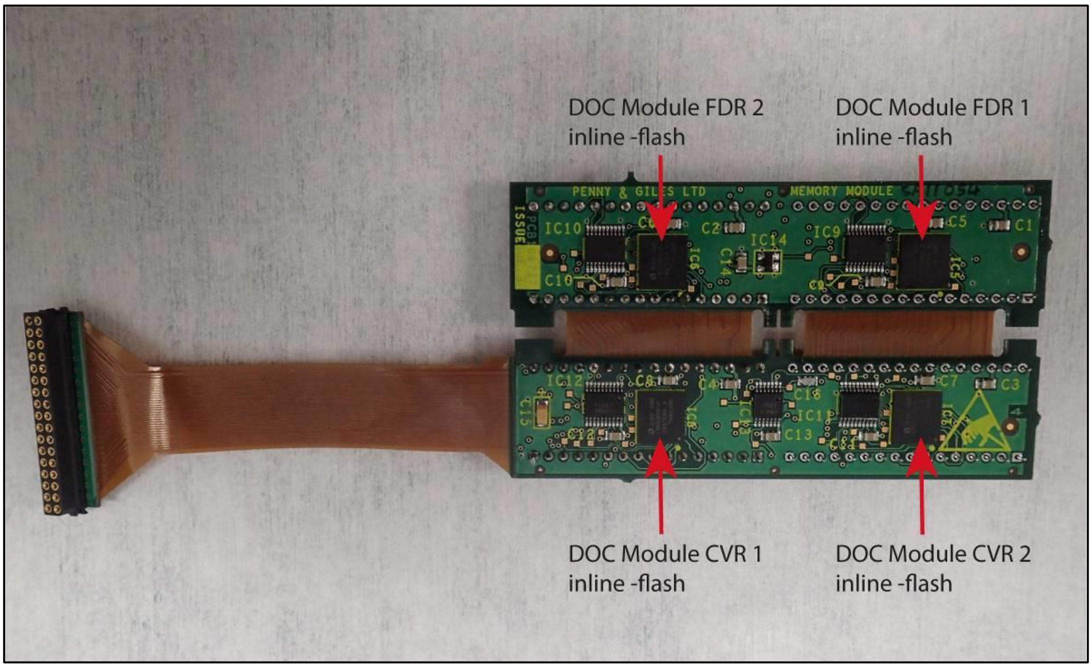



Image No. K3: Underside of an APMB showing in-line flash memory

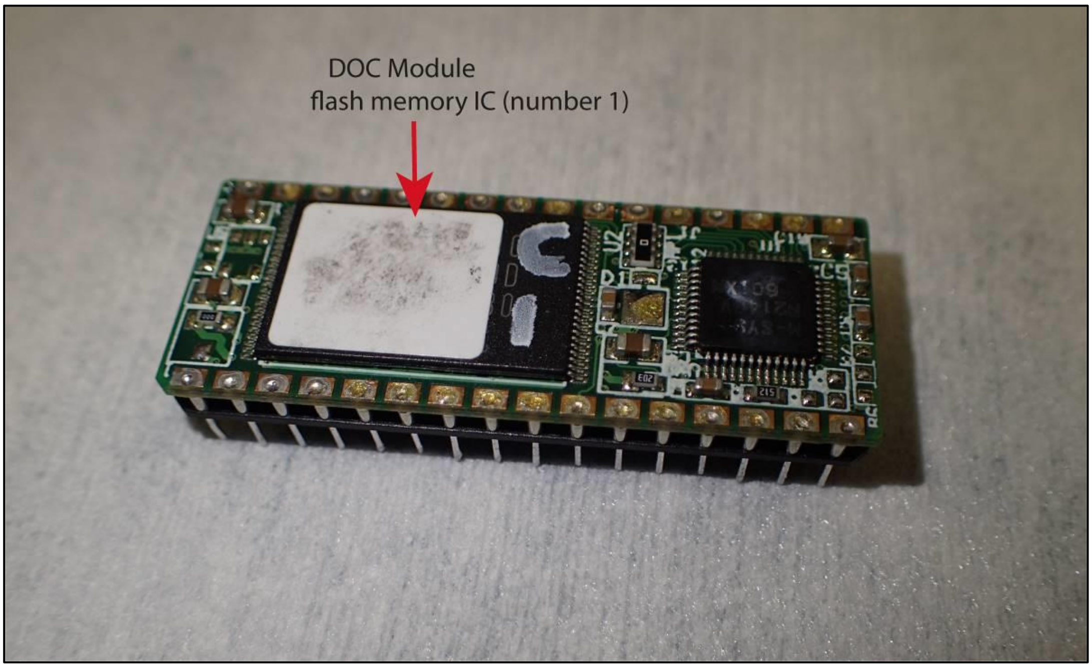


Image No. K4: Top of a DOC module (removed from APMB)

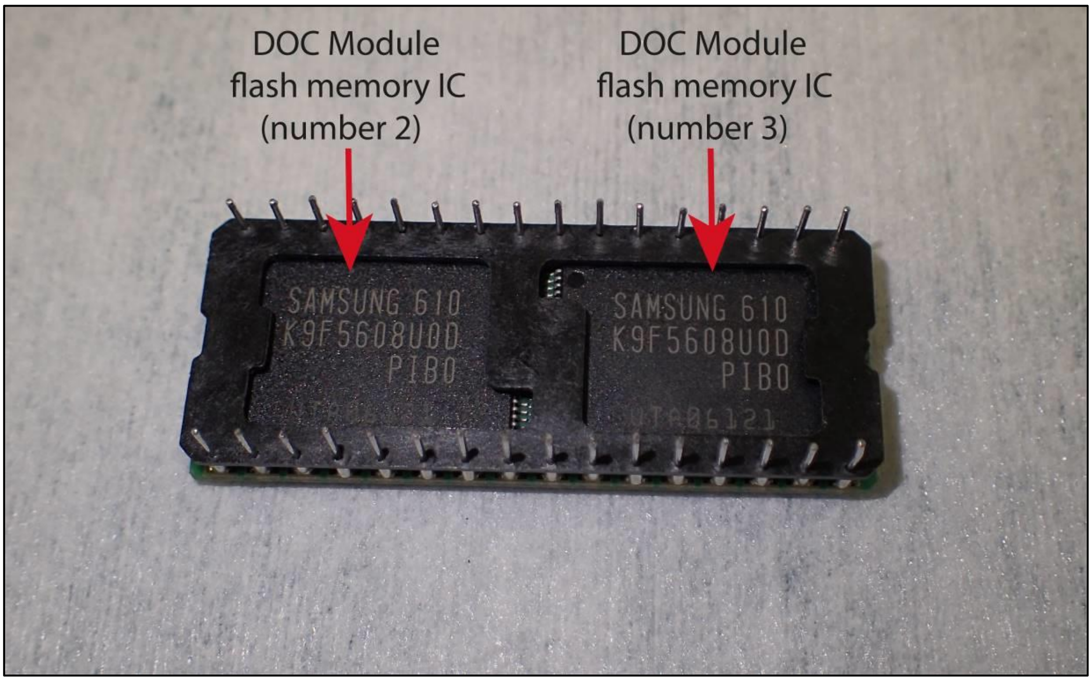


Image No. K5: Underside of a DOC module (removed from APMB)

The APMB and DOC modules are coated with a conformal coating. This is a layer of synthetic material that is intended to provide protection against mechanical hazards that may damage the board and electronic components. These hazards include corrosion.

41 The CSMM fitted to the MPFR is of a cylindrical design **(Figure No. K1 and Image No. K6)**. The APMB is installed in the centre of the CSMM within a metal cylinder. This cylinder is filled with 'glass spheres' and is enclosed at both ends by metal caps. This inner cylinder is surrounded by a 'ring' of thermal insulation material (referred to as 'insulation material A'), which is contained within a second metal cylinder that is capped at both ends with insulation material. Installed between the second cylinder, and inner wall of the outer case, is a second layer of thermal insulation material (referred to as insulation material B). Different materials are used for insulation A and B.

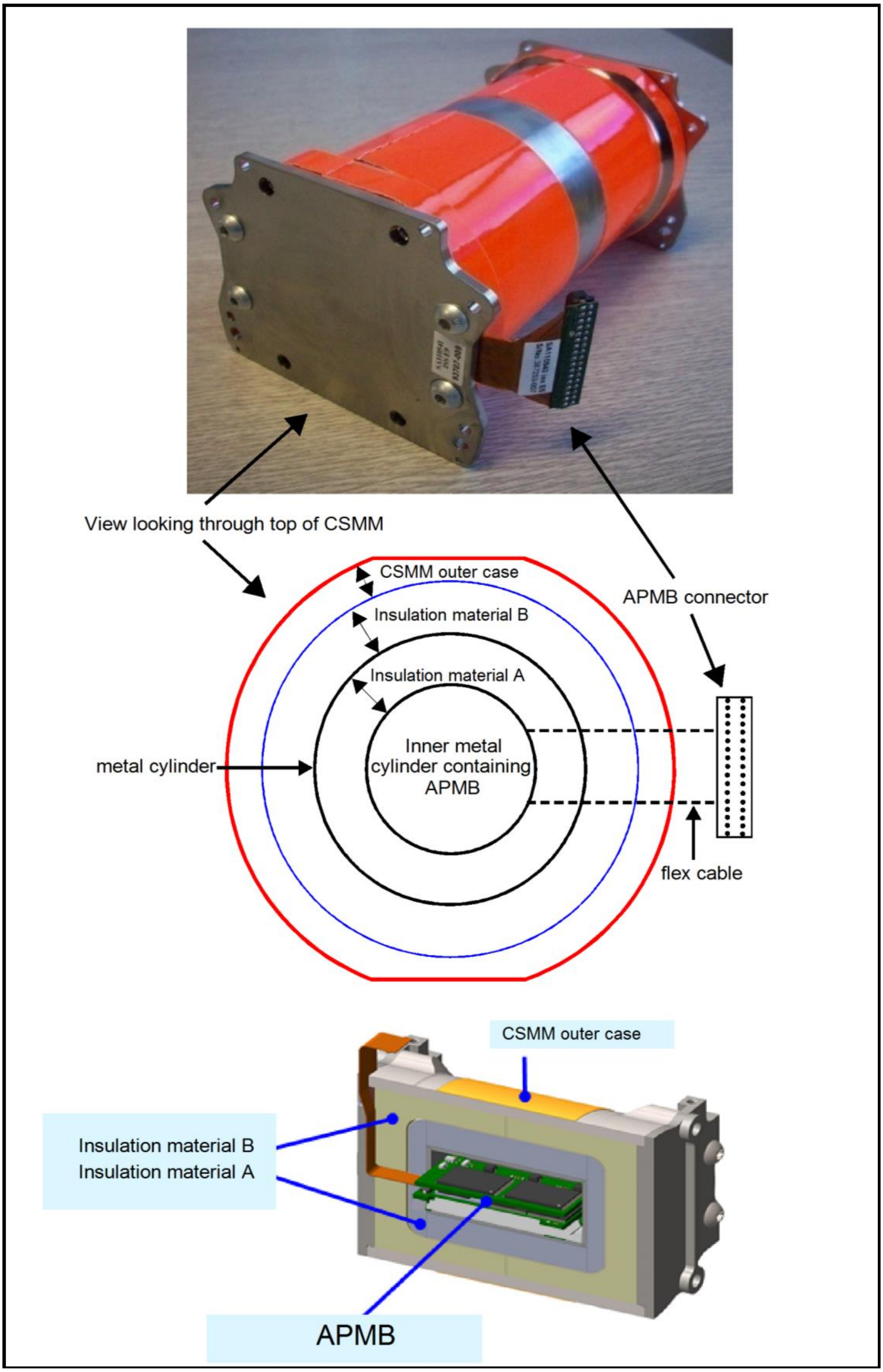


Figure No. K1: CSMM internal design

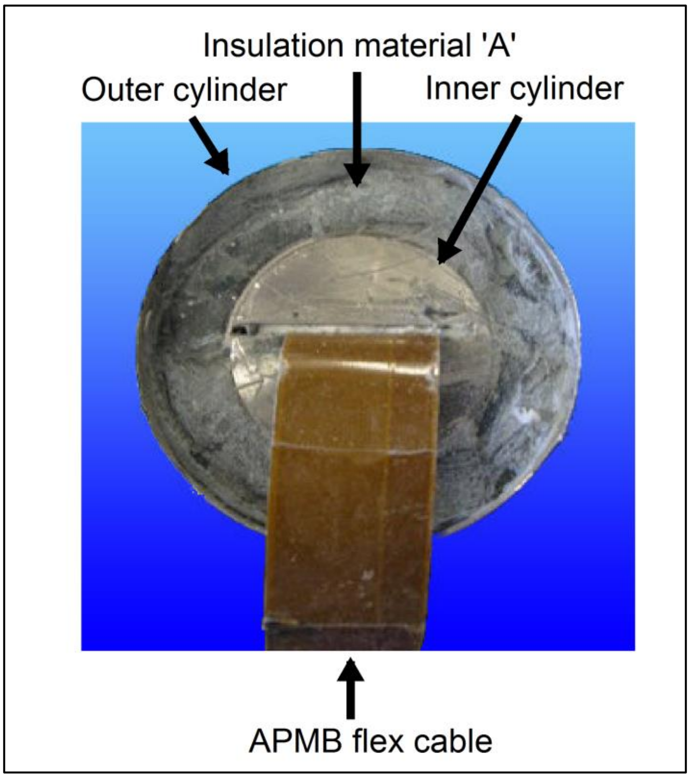


Image No. K6: Inner and outer cylinders and position of insulation material 'A'.

When the MPFR entered service in 2001, insulation material A was constructed from boric acid, and a Polyurethane based conformal coating was applied to the APMB.

In 2006, the manufacturer reviewed the CSMM design and identified that a change in the composition of insulation material A from boric acid to a copper based product would improve the performance of the CSMM in a fire; insulation material B remained unchanged. The change to the CSMM insulation material A was classified by the manufacturer as 'minor' and approved under its design authorisation[16]. As the change was classified as 'minor', it was not necessary to consult with the EASA. The manufacturer retested the modified CSMM against the ED-55 and ED-56A crash survivability requirements for impact shock, penetration resistance, static crush, and high temperature fire. However, the manufacturer concluded that it was not necessary to repeat the low temperature fire, fluid, deep sea pressure or sea water immersion tests. The AAIB was made aware of this by the MPFR manufacturer after the accident to EI-ICR.

In accordance with the manufacturer's procedures, 'engineering change notices' were issued as a record of the design change. No written record was available as to how the manufacturer satisfied itself that the low temperature fire, fluid, deep sea pressure or sea water immersion tests did not need to be repeated. The modified CSMM passed the impact shock, penetration resistance, static crush, and high temperature fire tests and entered service towards the end of 2006.

[16] After 28th September 2005, design changes needed to be compliant with the requirements of the EASA. Design changes to equipment, parts and appliances, which included the MPFR, originally certified prior to 28 September 2003 were provided with 'grandfather provisions', meaning that minor changes to grandfathered equipment could be undertaken by the design holder.

In 2013, an alternative design[17] of the APMB was introduced. The CSMM insulation materials remained the same, using the copper based product for insulation material A, but the conformal coating applied to the APMB was changed to 'Parylene'[18]. The manufacturer advised that this type of conformal coating had been demonstrated as providing improved protection compared to the Polyurethane used in the first and second generation CSMM. The CSMM with alternative design of APMB was retested against all of the crash survivability requirements of ED-55 and ED-56A, which it passed.

The manufacturer stated that the change to the conformal coating applied to the APMB had not been instigated by a 'specific design review', although it had taken into consideration two previous occasions[19] when it had assisted the AAIB in the recovery of data from accidents where MPFR's had been submerged in the sea. On both occasions the DOC modules had suffered from corrosion resulting in damage to the memory devices storing the FDR and CVR data.

MPFR's Manufacturing History

Approximately 2,400 MPFR's have been manufactured since 2001. Of these, about 1,950 units are fitted with second generation CSMM's that use a combination of the copper based insulation and Polyurethane conformal coating on the APMB. Of this batch, 781 units are certified for fitment to civil aircraft with the remainder certified for military aircraft.

Of the remaining units, about 320 are of the first generation CSMM design fitted with boric acid insulation and 130 units are of the third generation CSMM design fitted with the alternate design of APMB that is coated in Parylene.

MPFR Accident Readouts

The AAIB contacted the manufacturer and other international accident investigation laboratories to ascertain how many MPFR's had suffered from corrosion of the APMB following submersion in sea water. The following table (**Table No. K1**) provides these results; those units that suffered from corrosion of the APMB are highlighted in yellow:

[17] Referred to by the manufacturer as the Replacement Crash Survivable Memory Module (RCSMM).
[18] Parylene is the trade name for a variety of chemical vapor deposited poly(p-xylylene) polymers used as moisture and dielectric barriers.
[19] Helicopter registrations EC-KYR and B516.

No	Date of accident	Reg	Lead SIA[20] for readout	Insulation material A	Type of conformal coating	Duration submerged / approximate depth	Corrosion on AMPB	Repairs required to APMB to recover data
1	12/03/09	C-GZCH	TSB Canada	Boric Acid	Polyurethane	5 days / 169 m	NO	NO
2	04/01/09	N748P	NTSB USA	Boric Acid	Polyurethane	~14 days / <1m shallow water	NO	NO
3	23/08/13	G-WNSB	AAIB UK	Boric Acid	Polyurethane	7 days / ~3 m	NO	NO
4	Not provided[21]	Not provided	US Military	Copper based product	Parylene	<3 days / 30 m	NO	NO
5	Not provided	Not provided	US Military	Copper based product	Parylene	<3 days / 2 m	NO	NO
6	03/07/12	ZD743	QinetiQ Boscombe Down	Copper based product	Parylene	7 days / 50 m	NO	NO
7	03/07/12	ZD812	QinetiQ Boscombe Down	Copper based product	Parylene	15 days / 50 m	NO	NO
8	03/07/12	ZG792	QinetiQ Boscombe Down	Copper based product	Parylene	23 days / not reported	NO	NO
9	15/02/16	5N-BQJ	AAIB UK	Copper based product	Polyurethane	<2 days / <1 m helicopter rolled inverted on sea	NO[22]	NO
10	19/08/11	PR-SEK	NTSB USA	Copper based	Polyurethane	~14 days / 100 m	NO	NO
11	03/02/10	EC-KYR	AAIB UK	Copper based product	Polyurethane	9 days / 85 m	YES	YES
12	17/03/11	B516	AAIB UK	Copper based product	Polyurethane	16 days / shallow water	YES	YES
13	25/03/17	EI-ICR	AAIB UK	Copper Based product	Polyurethane	10 days / 40 m	YES	YES
14	Not provided	Not provided	US Military	Copper Based product	Polyurethane	<3 days/ 50 m	YES	YES
15	Not provided	Not provided	US Military	Copper Based product	Polyurethane	<3 days/ 50 m	YES[23]	NO

Table No. K1: MPFR's readouts following submersion in sea water (Units highlighted in yellow had suffered from corrosion of the APMB)

[20] Safety Investigation Authority (SIA).
[21] This information was not provided due to confidentiality.
[22] Fluid had not entered the CSMM inner cylinder containing the APMB.
[23] Did not result in the need for repairs over and above that specified by the ED-55/ED-56A crash survivability requirements.

A common feature during disassembly of units fitted with the copper based insulation and where water had entered the inner cylinder of the CSMM, was discolouration of the glass spheres surrounding the APMB, which were stained 'blue' by the copper based insulation. **Image No. K7** is of the APMB from EI-ICR taken shortly after removal from its CSMM. It was also noted by the AAIB that the Polyurethane conformal coating did not appear to have been applied 'evenly' to all surfaces of the APMB and it had not penetrated behind all pins of the memory devices. This has also been observed on other APMB's by the AAIB.

Image No. K7: APMB from EI-ICR showing copper based insulation staining of glass beads

From the 15 reported cases of MPFRs that have been submerged in sea water, five had suffered from corrosion of the APMB. All five of these units were fitted with the second generation CSMM fitted with a combination of copper based insulation and APMB's coated in Polyurethane. Four out of five of these units suffered from the loss of electrical pins on the memory devices due to corrosion.

In 2010, the AAIB worked on its first MPFR that had been submerged in sea water. This unit was from helicopter registration EC-KYR. Following disassembly, corrosion was found on the APMB and the unit was taken to the MPFR manufacturer. Several pins on the memory devices had corroded away, but these were subsequently identified as not being critical to the operation of the memory devices. Following repairs to remove corrosion, the data was successfully recovered.

In 2011, the AAIB assisted with the download of the MPFR fitted to helicopter registration B516. This unit required the most extensive repairs to date. All of the memory devices were 'de-soldered' and removed from their DOC modules so they could be readout individually. Four of the memory devices required new lead-wires to be attached to the internal die structure due to the extent of the corrosion damage (**Image No. K8**).

This process required '*acid-etching*'[24] of the memory devices to expose the lead-wire pads. The '*raw binary*' images from each memory device were then combined using specialist software to recover the CVR and FDR data. The process took over a month and required specialist support to repair the memory devices.

The recorder from helicopter registration B516 was transported to the AAIB '*dry*'[25], which may have exacerbated the level of damage by some degree, but did not account fully for the extensive damage.

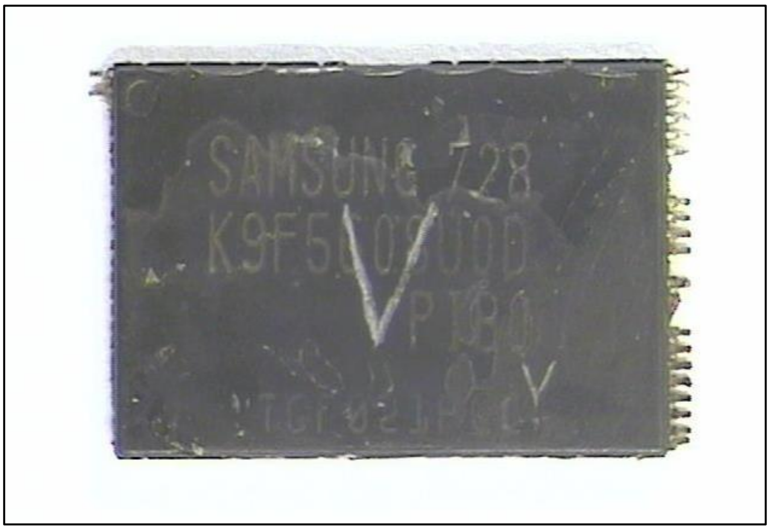


Image No. K8: Helicopter registration B516 missing pins from MPFR non-volatile memory device due to corrosion

The corrosion of the MPFR fitted to EI-ICR had effected two DOC modules (FDR1 and CVR1), causing electrical 'short circuits' that prevented the normal recovery of data.

Both FDR1 and CVR1 modules were de-soldered and removed from the APMB for repair. The most significant area of corrosion was on the underside of the DOC modules (image 10), which cannot be readily accessed whilst installed on the APMB. A number of pins were missing on four of the memory devices due to corrosion.

Among the missing pins were two on each device that provided electrical power to the memory device. At the opposite end of the memory device are pins that also provide electrical power. Although corroded, these pins were still intact and the memory devices were able to operate following the removal of short circuits **(Image No. K9)**. The other pins that were missing were not used by the memory devices. Using a combination of specialist hardware and software, the CVR and FDR data from all DOC modules was eventually recovered. The corrosion delayed the data recovery by several days.

[24] The packaging material surrounding the pins was removed using a chemical erosion process.
[25] It is recommended that flight recorders that have been submerged, remain stored and transported in water until they can be disassembled at a specialist laboratory. This is to reduce the unit's exposure to air which accelerates the effects of corrosion.

The US Military has also worked with the MPFR manufacturer to recover data from a corroded memory device. Specific details of the work carried out are not available due to confidentiality restrictions, but the AAIB is aware that repairs were required to a memory device that were similar to those applied to the MPFR fitted to helicopter registration B516.

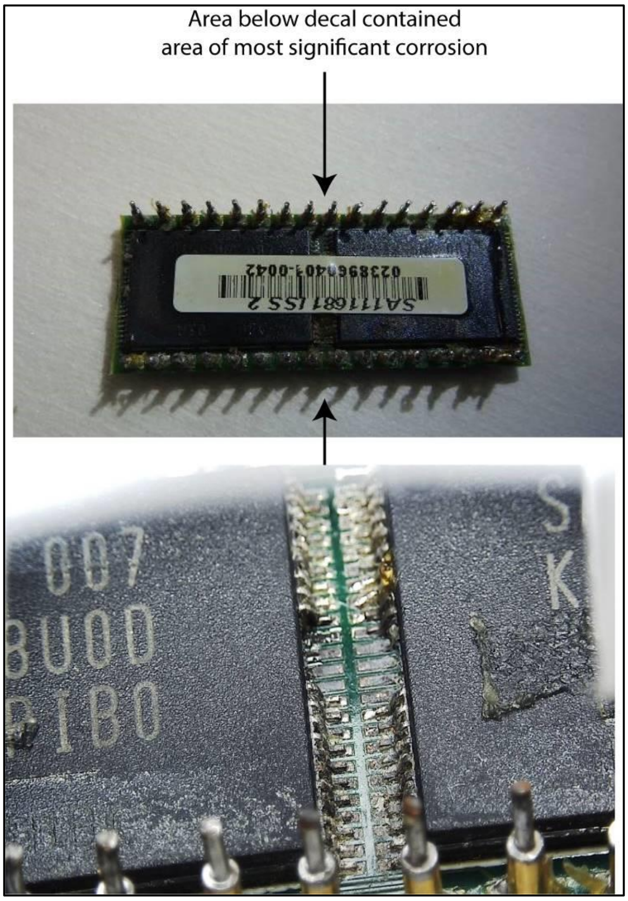


Image No. K9: Underside of FDR1 DOC module from EI-ICR showing missing pins due to corrosion

Other Cases of FDR and CVR Corrosion

The AAIB has experience of replaying accident damaged flight recorders manufactured by several other manufacturers. Of those flight recorders using non-volatile solid state memory, the AAIB has not experienced any other recorder model that has suffered from the same effects of corrosion of the APMB memory devices as the MPFR. The AAIB is also not aware of any other international safety investigation laboratory that has experienced data recovery issues from flight recorders using non-volatile solid state memory due to corrosion, except the MPFR.

MPFR Corrosion Analysis

The AAIB asked the manufacturer for its opinion on the cause of the corrosion of APMB's fitted to second generation CSMM's. The manufacturer stated *'We now know that the combination of sea water and the copper compound* [insulation material A] *can cause corrosion on memory modules………This problem was resolved in early 2013 when the change from varnish* [Polyurethane] *to Parylene as a conformal coating was made'.* The manufacturer subsequently carried out research to understand the mechanism by which second generation CSMM's 'corroded'.

It was identified that two different types of material were used to construct the pins of the memory devices fitted to the APMB used in the second generation CSMM. One batch of memory devices was fitted with pins constructed of a base material manufactured from Alloy 42, which consists of 58% iron and 42% nickel, plated in either tin-lead or tin, and the other batch were manufactured with pins that used a copper base material plated in tin. The external appearance, form, fit and function of the two batches of memory devices are identical.

The manufacturer advised that during construction of the second generation CSMM's, the two batches of memory devices were not mixed. However, it was not possible to identify from manufacturing data which CSMM's had been installed with memory devices constructed using Alloy 42 or the copper base material. In addition, the manufacturer carried out a test on an APMB fitted with memory devices manufactured with pins constructed of Alloy 42 base material. The APMB was submerged in a solution of water and copper for three weeks before being removed, cleaned and inspected. The results of this test showed that the water / copper solution was able to permeate the polyurethane conformal coating and come into contact with the pins of the memory devices. Thereafter, a chemical 'single substitution reaction' took place, whereby the iron in the Alloy 42 was depleted to the extent that the pins structural integrity were lost and electrical connections broken.

The manufacturer confirmed that memory devices with pins constructed of the copper base material are not similarly affected and will not suffer from a loss of structural integrity leading to the loss of pins.

Safety Action Taken

- As of December 2017, the MPFR manufacturer started to replace second generation CSMM's fitted to commercial aircraft with third generation CSMM's.
- In February 2018 the MPFR manufacturer issued Service Bulletin (SB) D51615-31-22. This lists the part and serial number of MPFR's that require modification from second to third generation CSMM. The modification is free of charge to operators.
- The EASA has issued Safety Information Bulletin (SIB) 2018-05 to raise awareness of SB D51615-31-22.
- The EASA has stated that the MPFR modification program is to be completed by September 2023.

Further Safety Action

- The manufacturer of the MPFR has stated that it is developing specialist techniques to recover data from memory devices fitted to second generation CSMM if they suffer from the loss of pins due to water immersion.

Analysis

The MPFR recovered from EI-ICR was fitted with a 'second generation' design of CSMM, which was introduced in 2006 when the manufacturer changed one of the two thermal insulation materials within the CSMM from boric acid to a copper based product. Approximately 1,950 MPFR's fitted with this type of CSMM have been manufactured.

During the course of the investigation, the AAIB was advised by the manufacturer that the second generation design of CSMM had not been tested against the effects of low temperature fire, fluid, deep sea pressure or sea water immersion as specified in ED-55 and ED-56A. The manufacturer stated that it had repeated the tests for impact shock, penetration resistance, static crush, and high temperature fire, but had concluded at the time that the remaining tests were not necessary.

The data show that only those CSMM's fitted with the copper based insulation material and APMB's coated in a Polyurethane conformal coating have suffered from corrosion of the memory devices. The corrosion of the memory devices is understood to be caused by a solution of water and the copper based insulation material entering the inner cylinder of the CSMM and coming into contact with the APMB. Testing by the manufacturer has shown that a change in conformal coating to Parylene has resolved the problem of corrosion. Therefore, it can be concluded that the Polyurethane conformal coating has not provided adequate protection against the combined corrosive effect of water and copper solution. This finding is also supported by that of the manufacturer.

Of the six[26] CSMM's fitted with copper based insulation material and APMB's coated in a Polyurethane conformal coating that have been submerged in sea water that has come into contact with the APMB, five units suffered from the effects of corrosion. Of these five, four required repairs to remove damaged pins, three required repairs that necessitated the need to de-solder devices, and two required specialist repairs to the memory devices themselves. None of the units that had corroded had been submerged in sea water for a period, or at a depth, in excess of the 30 day sea water immersion test specified by ED-55 and ED-56A.

The reason why the unit fitted to helicopter PR-SEK did not corrode is not fully known. However, one explanation is that the CSMM was fitted with memory devices, whose pins were constructed from a copper base material, which the manufacturer stated would not be susceptible to corrosion compared to those constructed from Alloy 42.

[26] The MPFR fitted to helicopter registration 5N-BQJ is not included as fluids had not entered the CSMM inner cylinder containing the APMB.

ED-55 and ED-56A state that the CVR and FDR data *'shall be readily recoverable'* which means that '*only minor repairs can be permitted for a damaged storage medium….e.g renewal of the interface connection of a solid state memory module',* and that '*repair of individual memory devices is not permitted'.* Had the manufacturer carried out the sea water immersion test on the CSMM fitted with the copper based insulation and APMB coated in Polyurethane conformal coating, the evidence indicates that it is likely that the CSMM would have failed this test.

To date, the CVR and FDR data has been successfully recovered from all MPFR's that have suffered from corrosion of the APMB following sea water immersion. However, in all cases, there has been a delay in the recovery of data due to the technical challenges faced when dealing with damaged electronic components. Further, the facilities capable of making repairs at 'chip-level' are very limited, the process is slow, there is a risk of further damaging the devices, and success is not guaranteed. In the case of EI-ICR, it was fortunate that the corrosion had not extended to other pins on the memory devices, as had it done so, it may have been several months before all of the CVR data was available to the investigation.

It is important that flight recorders survive accidents so that the CVR and FDR information can be quickly recovered and made available, enabling accident investigators to understand the cause of an accident, and make timely safety recommendations where required to prevent future occurrence. MPFR's fitted with CSMM's using a copper based insulation in combination with APMB's coated in Polyurethane pose a significant risk that they will corrode when submerged in sea water following an accident. The corrosion will, at best delay the availability of the CVR and FDR data, and at worst, could result in the data not being recoverable. Further, those MPFR's fitted with CSMM's using copper based insulation in combination with APMB's coated in Polyurethane have not been tested for fluid and sea water immersion. Therefore they may be considered to not be fully compliant with their certification basis of ED-55 and ED-56A.

In the UK, and across Europe, several helicopter types used in the support of the offshore oil and gas industry, and for Search and Rescue (SAR) activities, are fitted with MPFR's. These helicopters frequently operate over the sea, and therefore the risk of submersion of an MPFR is increased in the event of an accident or ditching where the helicopter does not remain upright.

In light of the identified safety action being taken by the MPFR manufacturer and EASA, the Investigation did not consider that a Safety Recommendation was necessary

16 February 2018

-END-

Appendix L — EASA MPFR SIB

Safety Information Bulletin

Airworthiness – Operations

SIB No.: 2018-05

Issued: 08 February 2018

Subject: **Multi-Purpose Flight Recorders**

Ref. Publications:
Penny & Giles Aerospace Limited Service Bulletin (SB) No. D51615-31-22, dated Feb 2018.

Applicability:
Penny & Giles multi-purpose flight recorders (MPFRs), as listed in the effectivity of SB No. D51615-31-22, a copy of which is attached to the record of this SIB on the EASA SP Tool.

Description:
During data recovery from crash-damaged MPFRs, previously installed on five helicopters involved in accidents where the aircraft was submerged in water, corrosion was detected on the pins of memory devices inside the recorder. To recover the data, these units required the use of special techniques, not permitted according to the Minimum Operational Performance Specifications of the relevant ETSO, which delayed the availability of data to accident investigation boards.

This type of corrosion is due to a chemical reaction between the fire insulation material, when partially dissolved in water, and the iron content within the pins of the memory device. Under certain circumstances, the conformal coating on the memory module can be insufficient to protect the device pins from the corrosive solution.

This issue potentially affects certain second generation “GEN2” memory modules installed on MPFRs manufactured between 06 April 2006 and 02 January 2013. The subsequent GEN3 memory modules use a different conformal coating process and are protected from corrosion.

At this time, the safety concern described in this SIB is not considered to be an unsafe condition that would warrant Airworthiness Directive (AD) action under Regulation (EU) 748/2012, Part 21.A.3B, nor the issuance of an operational directive under Regulation (EU) 965/2012, Annex II, ARO.GEN.135(c).

Recommendation(s):
EASA recommends owners and operators to accomplish the actions as specified in Penny & Gilles Aerospace Limited SB No. D51615-31-22 dated Feb 2018.

This is information only. Recommendations are not mandatory.

Extract from EASA SIB No.2018-05 - Multi-Purpose Flight Recorders

Appendix M — CVR Transcript from Preliminary Report (updated)

Note: One minute and forty seconds approximately of relevant CVR data from the period immediately prior to the accident

Elapsed time	Commander	Co-pilot (PM)	Rear Crew Channel	Other Source	Comment
2.01:27.694 2.01:31.544			Belmullet Coast Guard Radio from Rescue one one six, sixteen		
2.01:33.789. 2.01:37.332				Rescue one one six This is Belmullet Coastguard Radio sixteen go ahead	Received transmission on Marine VHF Radio
2.01:38.964 2.01:39.032 2.01:41.622 2.01:41.847 2.01:46.998	[unintelligible] coming left yep slowly coming left	Roger	Roger Belmullet Coast Guard Radio from one one six eh yes we should be landing very shortly now at Blacksod and we'll call again when airborne, over		
2.01:47.291 2.01:48.650	Groundspeed's gonna start increasing				
2.01:49.834 2.01:53.085				That's all copied, we'll standby, thanks very much, standing by on sixteen	Received transmission on Marine VHF Radio

Elapsed time	Commander	Co-pilot (PM)	Rear Crew Channel	Other Source	Comment
2.01:55.479 2.01:57.746	Eh the baro's a little bit off but we're on radalt only				
2.01:57.935 2.01:58.301		Roger			
2.02:13.597 2.02:16.632 2.02:16.857 2.02:19.575	Roger	One point three err miles to run to eh blackmo… and after that its bravo kilo sierra delta alpha			
2.02:19.589 2.02:22.981 2.02:22.990	Copied and with you have eh indicated airspeed search and radalt confirmed	Roger			

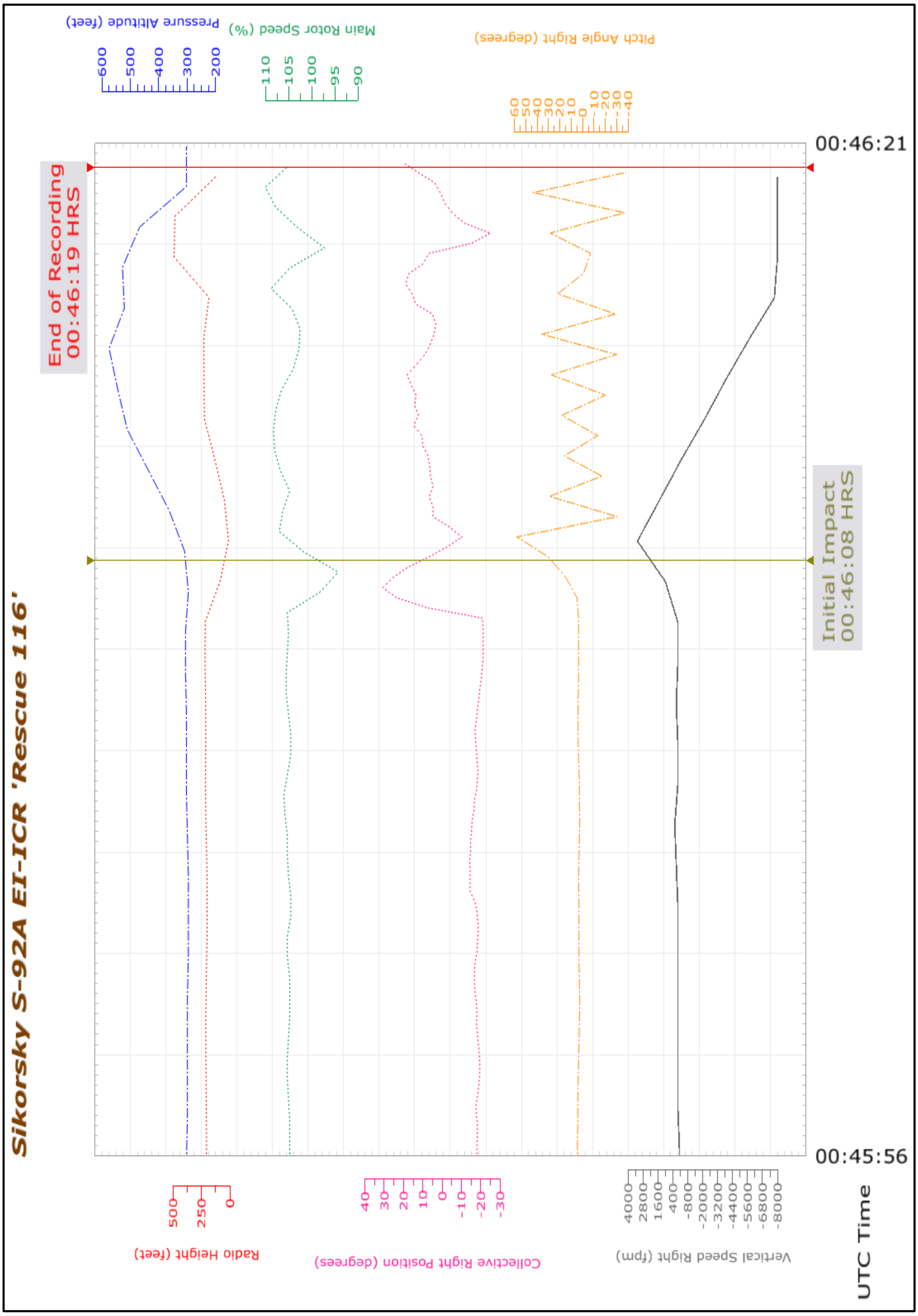
Elapsed time	Commander	Co-pilot (PM)	Rear Crew Channel	Other Source	Comment
2.02:28.261 2.02:31.234 2.02:31.533 2.02:32.411 2.02:33.561 2.02:33.580 2.02:33.624 2.02:36.184	 Roger There's just a small little island that's B L M O itself	OK so small targets at six miles eleven o'clock Large out to the right there ehm		 ALTITUDE ALTITUDE	 Radalt Automated callout
2.02:46.767 2.02:50.417			K…looking at an island just in, directly ahead of us now guys, you want to come right [Commander's Name]		
2.02:50.862 2.02:51.810	OK, come right just confirm?		 About…		
2.02:52.035 2.02:52.888			twenty degrees right yeah		
2.02:53.404 2.02:54.416	OK Come Right…select heading				

Elapsed time	Commander	Co-pilot (PM)	Rear Crew Channel	Other Source	Comment
2.02:55.231 2.02:55.384 2.02:55.691 2.02:56.164 2.02:57.231	Select heading	 Roger… Heading selected			
2.02:57.691 2.02:59.005			Come right now come right COME RIGHT		
2.02:59.097 2.02:59.893 2.03:00.730 2.03:01.198		 [Expletive] OOOHHHH [Expletive]		ALTITUDE ALTITUDE	Automated callout Loud noise Automated callout
2.03:01.734				SMOKE IN BAGGAGE	Automated callout
2.03:02.557		We're gone			
2.03:03.647				SMOKE IN BAGGAGE	Automated callout
2.03:04.305 2.03:05.377				2 Pings	Sound of ELT transmission
2.03:05.565				DECOUPLE	Automated callout
2.03:06.605 2.03:06.707					Engine note variance
2.03:06.601 2.06:06.959					Unknown sound
2.03:07.109				TOO LOW GEAR	Automated callout
2.03:08.526 2.03:08.990		[Short muffled sound]			

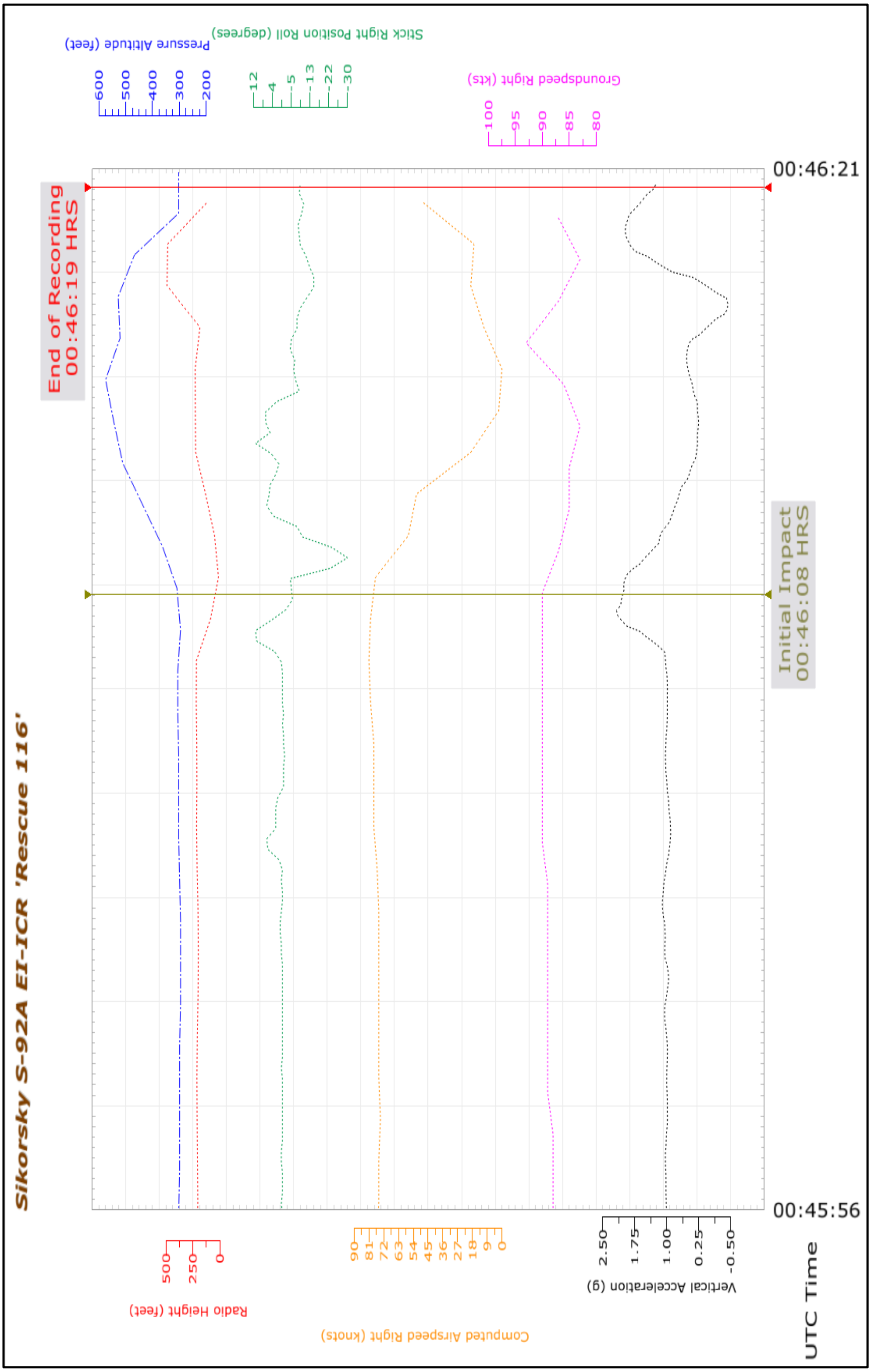
Elapsed time	Commander	Co-pilot (PM)	Rear Crew Channel	Other Source	Comment
2.03:09.026 2.03:09.676				TOO LOW GE..	Automated callout cut-off by static noise
2.03:09.676 2.03:09.868					Loud static noise
2.03:09.868 2.03:09.963					Silence
2.03:09.963					Sound similar to that of audio disconnection
2.03:10.168					End of Recording

-END-

Appendix N — FDR Parameters



Graphic No. N1: Flight Data Recorder Parameters



Graphic No.N2: Flight Data Recorder Parameters

A number of additional binary parameters were recorded on the FDR between 00.46:09 hrs and the end of the recording at 00.46:19 hrs. These parameters indicated the functional state of particular systems. The term 'binary' refers to a system that was recorded as either ON or OFF, ACTIVATED or DEACTIVATED, FUNCTIONAL or FAILED. They were, in chronological order;

- CHIP SYS FAULT .... activated
- LOW ROTOR RPM WARNING .... deactivated
- #1 AIRSPEED MODE FAIL caution .... activated
- #1 AIRSPEED MODE ON .... deactivated
- #1 Heading Select Fail .... activated
- #1 Heading Select ON .... deactivated
- Co-pilot Pitch IAS Captured .... deactivated
- Co-pilot Roll Heading Captured .... deactivated
- Landing Gear Up Warning .... deactivated
- MGB Low Press SW DCU2 .... activated
- EGPWS – Gear .... deactivated
- MGB Low Press SW DCU1 .... activated
- #1 Weight on Wheels .... deactivated
- #2 Weight on Wheels .... deactivated
- HYD 3 RSVR LOW .... activated
- Temp Ch6 IGB .... deactivated
- #1 NAV Vertical Mode ON .... activated
- #2 NAV Vertical Mode ON .... activated
- Co-pilot Coll Alt Captured .... deactivated
- MGB OIL PRESS warning .... activated
- ENG 2 OIL PRESS warning .... activated
- 'SMOKE IN BAGGAGE' caution .... deactivated
- Temp Ch6 IGB .... activated
- #1 Baro Altitude Mode ON .... deactivated
- Co-pilot FD Valid .... deactivated
- EGPWS – Gear .... activated
- HYD 3 PUMP FAIL caution .... activated
- ENG 1 OIL PRESS warning .... activated
- EGPWS – Gear .... deactivated
- MGB Low Press SW DCU2 .... deactivated
- MGB Oil Bypass .... activated
- #1 Tail Stage Hyd System Select OFF .... deactivated
- #2 Heading Hold ON .... activated
- #2 Tail Stage Hyd System Select OFF .... deactivated
- APU Bleed Valve Position .... deactivated
- MGB OIL BYPASS caution .... activated
- EGPWS – Gear .... activated
- Landing Gear Up Warning .... activated
- MGB Low Press SW DCU1 .... deactivated
- MTOP Bypass IBIT Complete .... deactivated
- MTOP Bypass IBIT Pass .... deactivated
- Pilot FD1 Selected .... deactivated

-END-

Appendix O — Warning and Caution Annunciations

Note: RFM Part 2, Section I: Avionics Management System

SA S92A-RFM-001, -002, -003
SA S92A-RFM-004, -005, -006

Part 2, Section I
AVIONICS MANAGEMENT SYSTEM

EICAS CAUTIONS	EXPLANATION
TRN PIT HEAT ON	Turn pitot heat on. In flight only. Set when OAT is less than 41°F and any of the three pitot heat switches are off.
TURN RIPS ON	Turn rotor ice protection system on. Set by RIPS controller when the aircraft is in the air, ice is detected, and RIPS is off.

The warning and aural alert table lists all possible red warnings, yellow alerts, and aural alerts in order of precedence. If two aural alerts are initiated simultaneously, the higher priority alert will be heard first. The following information is provided for each warning and aural alert:

The warning/alert as it is shown on the affected display

The aural alert as it is heard over the intercom system

Title of the warning/alert

Brief explanation of the warning/alert

The conditions that will cause the warning/alert to illuminate or sound

Where the warning/alert will be shown

How often an aural alert will be heard

The conditions that will cause an aural alert to be silenced or suppressed

WARNING "AURAL ALERT"	EXPLANATION
LOW ROTOR **"LOW ROTOR"**	Low rotor speed. Set when N_r <95% and aircraft is in flight. Red warning light on master warning panel. Aural alert will sound continuously until N_r increases above 95%, the aircraft is landed, or the VOICE CNCL button is pressed.
FIRE **"FIRE ENGINE 1"** **"FIRE ENGINE 2"** **"FIRE APU"**	Engine/APU fire. Set when fire is detected by either of two fire detectors located in the affected main engine bay or the single fire detector located in the APU compartment. Red warning light on master warning panel. Red warning on affected fire control panel. Aural alert will sound twice.
#1 ENG OUT **"ENGINE 1 FAILURE"** **#2 ENG OUT** **"ENGINE 2 FAILURE"**	Engine failure. Set by the FADEC of the non-affected engine when either of the following occurs: 1. Affected engine N_g is 4% below idle. (67%-4% = 63% at sea level on a standard day). 2. N_g decelerates faster than commanded by the FADEC. Red warning light on master warning panel. Red **X** over affected engine on EICAS. Aural alert will sound twice. Aural alert suppressed on the ground.
LNDG GEAR **"TOO LOW GEAR"**	Gear is not down prior to landing. Set by EGPWS when airspeed is below 60 KIAS and radar altitude is below 150 feet. Red warning light on master warning panel. Aural alert will sound twice and will sound twice again each time altitude is decreased 20% with the gear still up. Aural alert is silenced when the conditions no longer exist or the VOICE CNCL button is pushed.

OCTOBER 15, 2005
Revised: January 31, 2006 **I-4-52K**

WARNING "AURAL ALERT"	EXPLANATION
MASTER CAUTION S/P TEMP LIMIT "SWASHPLATE TEMPERATURE"	Swashplate temperature limit. Swashplate temperature above 300°F. Set by the BMU with inputs from two temperature sensors located on the stationary swashplate. Red warning on EICAS. Aural alert will sound twice.
MASTER CAUTION MGB OIL PRES "GEARBOX OIL PRESSURE"	Main gearbox oil pressure. Set when both conditions below occur: 1. Oil pressure less than 35 psi as measured by the pressure transducer located on the input manifold. 2. Oil pressure less than 24 psi set by a switch located at the "last jet" in the left accessory module. Red warning on EICAS. Aural alert will sound twice. Caution and aural alert suppressed when the aircraft is on the ground and $N_r < 40\%$.
MASTER CAUTION SMOKE IN BAGGAGE "SMOKE IN BAGGAGE"	Smoke in baggage. Smoke detected in the rear baggage compartment. Set by the smoke detector located in the rear compartment overhead. Red warning on EICAS. Aural alert will sound twice.
TERRAIN "WARNING TERRAIN"	Terrain is obstructing the aircraft flight path. Set by EGPWS when the aircraft is approximately 20 seconds from hitting terrain. Based on inputs from GPS position, geometric altitude, aircraft flight path, and the Digital Terrain Elevation Database (DTED). Red warning on PFD. Aural alert will sound continuously until the conditions no longer exist or the VOICE CNCL button is pushed. Aural alert suppressed by selecting AUD INHB.
OBSTACLE "WARNING OBSTACLE"	An obstacle is obstructing the aircraft flight path. Set by EGPWS when the aircraft is approximately 20 seconds from hitting an obstacle. Based on inputs from GPS position, geometric altitude, aircraft flight path, and the obstacle database. Red warning on PFD. Aural alert will sound continuously until the conditions no longer exist, the VOICE CNCL button is pushed, or AUD INHB is selected.
DON'T SINK "DON'T SINK"	Inadvertent descent after takeoff. Set by EGPWS based on radar altitude and time since takeoff. The aircraft must be above 40 KIAS and gear up. Yellow caution on PFD. Aural alert will initially sound twice and will sound twice again each time the radar altitude decreases by 20%. Aural alert is silenced when a climb rate is established or the VOICE CNCL button is pushed. Aural alert suppressed by selecting AUD INHB.
PULL UP "TERRAIN TERRAIN PULL UP PULL UP"	Excessive terrain closure rate. Set by EGPWS based on radar altitude closure rate. The "TERRAIN TERRAIN" call is a caution which will be closely followed by a continuous "PULL UP" warning. Red warning on PFD.

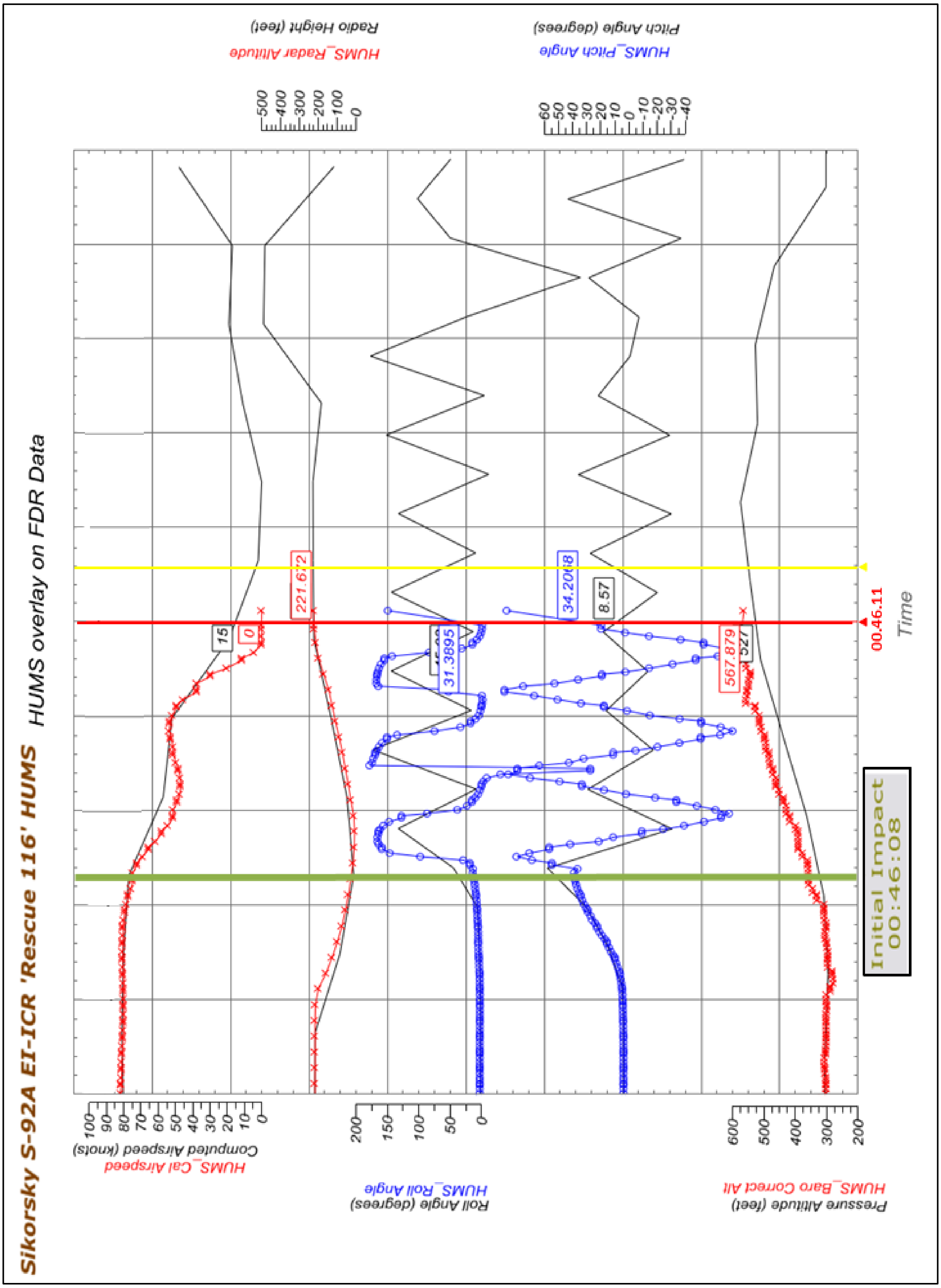
WARNING "AURAL ALERT"	EXPLANATION
	Aural alert (PULL UP) will sound continuously until the conditions no longer exist or the VOICE CNCL button is pushed. Aural alert suppressed by selecting AUD INHB. This mode is inhibited when the enhanced portion of the EGPWS has sufficient integrity, when the Low Altitude Mode is selected, or during autorotation.
TERRAIN "CAUTION TERRAIN"	Terrain is obstructing the aircraft flight path. Set by EGPWS when the aircraft is approximately 30 seconds from hitting terrain. Based on inputs from GPS position, geometric altitude, aircraft flight path, and the DTED. If the aircraft flight path is not changed, this caution will be replaced with the "WARNING TERRAIN" alert. Yellow caution on PFD. Aural alert will sound every seven seconds until the conditions no longer exist or the VOICE CNCL button is pushed. Aural alert suppressed by selecting AUD INHB.
OBSTACLE "CAUTION OBSTACLE"	An obstacle is obstructing the aircraft flight path. Set by EGPWS when the aircraft is approximately 30 seconds from hitting an obstacle. Based on inputs from GPS position, geometric altitude, aircraft flight path, and the obstacle database. If the aircraft flight path is not changed, this caution will be replaced with the "WARNING OBSTACLE" alert. Yellow caution on PFD. Aural alert will sound every seven seconds until the conditions no longer exist or the VOICE CNCL button is pushed. Aural alert suppressed by selecting AUD INHB.
TERRAIN "TOO LOW TERRAIN"	Low terrain clearance. Set by EGPWS in accordance with two schedules: 1. Gear up: Airspeed is above 60 KIAS and radar altitude is below 150 feet. 2. Gear down: At 120 KIAS, alert will sound at 100 feet. As airspeed decreases, the alert altitude also decreases down to 80 KIAS and 10 feet. See diagram in EGPWS manual. Yellow caution on PFD. Aural alert will initially sound twice and will sound twice again each time the radar altitude decreases by 20%. Aural alert is silenced when the conditions no longer exist or the VOICE CNCL button is pushed. Aural alert suppressed by selecting AUD INHB.
TRAFFIC "TRAFFIC"	TCAS traffic alert. Set by TCAS when separation from another transponder equipped aircraft is cause for concern. There are two sensitivity levels. Below 2000 feet AGL a traffic alert will be displayed when: If current closure rate is maintained, separation of less than 600 feet in altitude will occur in 20 seconds. Current separation is less than 600 feet and 0.2 nautical miles in range.

WARNING "AURAL ALERT"	EXPLANATION
	A non-altitude reporting intruder is within 15 seconds or 0.2 nautical miles. Above 2000 feet AGL a traffic alert will be displayed when: If current closure rate is maintained, separation of less than 800 feet in altitude will occur in 30 seconds. Current separation is less than 800 feet and 0.55 nautical miles in range. A non-altitude reporting intruder is within 20 seconds or 0.55 nautical miles. Yellow caution on PFD. Aural alert will sound twice. Aural alert is inhibited when below 400 feet AGL.
"ONE HUNDRED FEET" or other selectable altitudes.	Hardwired altitude alert. Set when radar altitude first goes below the set radar altitude. These alerts are selected by the customer prior to delivery and cannot be adjusted by the customer. It is possible to have none, one, or several of these alerts. Aural alert will sound once and will not sound again until reset by climbing 50 feet above the selected altitude and then descending through it again.
"TAIL TOO LOW"	Tail strike warning. Set by the EGPWS based on pitch attitude, radar altitude, pitch rate, and barometric rate of descent. See EGPWS manual for diagram. Aural alert will sound continuously until the conditions no longer exist or the VOICE CNCL button is pressed. Aural alert suppressed by selecting AUD INHB. 64
"HOVER ALTITUDE"	Hover altitude too low. Set when both of the following occur: 1. Coupled hover or approach to hover mode engaged. 2. Radar altitude descends below 30 feet. Aural alert will sound continuously until radar altitude increases above 30 feet, the aircraft is decoupled, or the VOICE CNCL button is pressed.
"AIRSPEED"	Velocity never exceed. Set when airspeed is 3 knots greater than computed V_{ne}. Portions of airspeed gauge turn red. Aural alert will sound continuously until airspeed is decreased below V_{ne} or the VOICE CNCL button is pressed.
CHECK POWER **"CHECK POWER"**	Coupled flight director collective limiting. Set when altitude or vertical speed is coupled to the collective channel and continuous power limits will not maintain the selected altitude or airspeed. Yellow caution on PFD. Aural alert will sound once.
"MINIMUMS"	Set when barometric altitude first goes below the selected minimum barometric altitude.

WARNING "AURAL ALERT"	EXPLANATION
	Aural alert will sound once and will not sound again until reset by climbing 50 feet above the selected altitude and then descending through it again.
"ALTITUDE"	Set when radar altitude first goes below the selected radar altitude. Aural alert will sound once and will not sound again until reset by climbing 50 feet above the selected altitude and then descending through it again.
"GLIDE SLOPE"	Deviation below glideslope. Two levels of alert set by EGPWS. Both alerts require the gear down and the aircraft established on a front course ILS. The "soft" alert is set when more than 1.3 dots below the glideslope. The "hard" alert is set when more than 2 dots below glideslope and below 300 feet AGL. The hard alert is louder than the soft alert and takes precedence. The soft aural alert will initially sound twice and will sound twice again each time the aircraft descends an additional 20% below glideslope. The soft alert is cancelled when the conditions no longer exist, the hard alert takes over, or the VOICE CNCL button is pressed. The hard aural alert will sound continuously until the conditions no longer exist or the VOICE CNCL button is pressed. Yellow caution on PFD. Both aural alerts are suppressed by selecting AUD INHB or G/S CNCL.
"BANK ANGLE"	Excessive bank angle at low altitude. Set by EGPWS based on bank angle and radar altitude. See EGPWS manual for diagram. Aural alert will initially sound twice and will sound twice again each time the bank angle increases by an additional 20%. Aural alert is silenced by the VOICE CNCL button. Aural alert suppressed by selecting AUD INHB.
"LEVEL OFF"	Level off. Set when both of the below occur: 1. Altitude preselect is engaged. 2. Aircraft altitude is 300 feet from the selected altitude. Aural alert will sound once and will not sound again until reset by deviating 330 feet from the selected altitude and then climbing/descending to 300 feet from the selected altitude.
"CHECK ALTITUDE"	Check altitude. Set when altitude hold is engaged (either coupled or uncoupled) and actual aircraft altitude deviates more than 200 feet from the selected altitude. Aural alert will sound once and will not sound again until reset by climbing/descending to within 20 feet of the selected altitude and then deviating by 200 feet again.
"DECOUPLE"	Flight director decouple. Set when the flight director is decoupled either intentionally by the pilot or unintentionally due to a malfunction. Aural alert will sound once.
"BE ALERT TERRAIN INOP"	EGPWS look ahead function not available. Set by EGPWS when GPS reception is degraded.

-END-

Appendix P — HUMS Parameters



Graphic No. P1: HUMS Data Recorder Parameters

-END-

Appendix Q — Inspection of Recovered Lifejackets

General

The first three lifejackets recovered were two RFD Beaufort Mk44 Lifejackets worn by the two Pilots and one RFD Beaufort Mk15 Lifejacket carried as a spare on the aircraft. The fourth and fifth lifejackets to be recovered were identified as Mk15 Lifejackets worn by the two Rear Crewmen of the Helicopter.

The initial inspections of the occurrence lifejackets found that:

i. Mk44 Lifejacket worn by the Commander

Recovered with the Commander, 14th March 2017

The Commander's lifejacket was found to have been manually inflated. The stole inflation bottle was pierced and the stole deployed. A SARBE 6-406G was found in the PLB pocket of the lifejacket with the GPS antenna installed in the same pocket. The strobe light fitted to the lifejacket was found selected to 'ON'. The lifejacket was found without a HEED bottle. The Operator's maintenance records show that a HEED bottle was installed to the lifejacket.

ii. Mk44 Lifejacket worn by the Co-pilot

Recovered with the Co-pilot, 26th March 2017

The Co-pilot's lifejacket was found with the stole packed and not deployed. On examination, the stole inflation bottle was found not to be discharged. A SARBE 6-406G was found in the PLB pocket of the lifejacket with the GPS antenna installed in the same pocket. This lifejacket was also found without a HEED bottle.

iii. Helicopter Spare Mk15 Lifejacket

Recovered by ROV, 23rd March 2017

This lifejacket was found with the stole packed and not deployed. On examination, the stole inflation bottle was found not to be discharged. A SARBE 6-406G was found in the PLB pocket of the lifejacket with the GPS antenna installed around the stole of the lifejacket. There was no STASS bottle in the lifejacket and the HEED bottle retaining cord was found sheared.

iv. Mk15 Lifejacket worn by the Winchman

Recovered from shallow water at Elly Bay, Clogher, Ballina, Co Mayo, 30th September 2017.

This lifejacket was found with the stole deployed and some of the fabric mesh of the jacket torn. The stole inflation bottle was discharged and the manual activation handle was missing from the jacket.

A SARBE 6-406G was found in the PLB pocket of the lifejacket. The PLB pocket itself was damaged with approximately ¼ of the stitches missing. The strobe light and HEED bottle were missing. The flares box was found intact with all flares inside.

v. Mk15 Lifejacket worn by Winch Operator

Recovered in a fishing vessel’s nets, 12th July 2018, 1 NM northwest of Achill Head.

This lifejacket was found badly damaged, with large tears to pockets, and with significant corrosion on the inflation bottle. The inflatable stole was unpacked but the inflation bottle was not pierced indicating that the lifejacket had not been inflated. A light was found still attached to the lifejacket, but other accessories such as the SARBE 6-406G and the HEED bottle were missing.

-END-

Appendix R — SARBE Inspections

General

The four SARBE 6-406G units underwent an external visual examination, a battery test, self-test[27] and a test of the TX/RX antenna. In all cases, the self-test was carried out with a known 'good' battery as the batteries fitted to the units were not serviceable. The internal seals and circuits of the first three units were not examined as this would compromise further planned testing by the SARBE 6-406G manufacturer.

SARBE 6-406G installed in Commander's Lifejacket

Inspection

The Commander's SARBE 6-406G was recovered from the Commander's lifejacket at the sea surface on the day of the accident, installed in the Commander's Mk44 Lifejacket. The SARBE 6-406G was found armed but the activation pin was not pulled. The activation lanyard was wrapped around a D-ring in the SARBE pouch. The saltwater activation switch was set to 'ON'. Both the GPS and the TX/RX antennas were in good condition, but the connectors on both antennas were loose with salt deposits around them.

The body of the SARBE 6-406G was in good condition with some signs of wear on the buttons. Black marks were noted on the base of the SARBE 6-406G next to the battery terminal. This may have been from an electrical short but it was not possible to confirm. The battery expiry date was marked on the battery as November 2018.

Initial testing

The conclusion of the initial testing of this unit was:

- SARBE 6-406G was unserviceable.

- The battery was marginally unserviceable i.e. it had a small amount of power remaining.

- The TX/RX antenna was serviceable.

SARBE 6-406G installed in Co-pilot's Lifejacket

Inspection

This SARBE 6-406G was recovered from a water depth of 40 m, 12 days after the accident. The SARBE 6-406G was armed but the activation pin was not pulled. The saltwater activation switch was set to 'ON'.

[27] The self-test or BIT (Built-in Test) is initiated by pushing a button on the outside of the unit. If successful, two LEDs on the body of the unit begin to flash and the unit emits an audible siren. In order to preserve battery life, the manufacturer recommends carrying out a self-test twice, and no more than four times per year.

Both the GPS and the TX/RX antennas were in good condition, but the connector on the GPS antenna was loose. There were salt deposits around both antenna connectors.

The body of the SARBE 6-406G was in good condition with some signs of wear on the buttons. Salt deposits were noted around the gasket seals of the main body of the unit. The battery of this unit had an expiry date of January 2017 indicating that the battery had expired at the time of the accident.

Initial testing

The conclusion of the initial testing of this unit was:

- SARBE 6-406G was unserviceable.
- The battery was marginally unserviceable i.e. it had a small amount of power remaining despite being beyond its expiry date.
- Both antennas appeared to be physically sound.

SARBE 6-406G found in Helicopter Spare Mk15 Lifejacket

Inspection

This SARBE 6-406G was recovered from a water depth of 40m, several days after the accident. The SARBE 6-406G was armed and the switch was seized in the 'ON' position. The saltwater activation switch was set to 'ON'. The TX/RX antenna was broken but the GPS antenna looked physically sound. Both antennas were loose on their mountings. The battery was intact and had an expiry date of August 2018.

Initial testing

The conclusion of the initial testing of this unit was:

- SARBE 6-406G was unserviceable.
- The battery was unserviceable.
- The TX/RX antenna was broken.

SARBE 6-406G installed in the Winchman's Lifejacket

Inspection

This SARBE 6-406G was recovered from the shoreline of the Mullet peninsula, County Mayo six months after the accident. It was found with the GPS antenna broken off.

The activation pin was out of its housing on the SARBE 6-406G but the manual activation toggle was not pulled from the lifejacket.

Initial Testing

The conclusion of the initial testing of this unit was:

- SARBE 6-406G was unserviceable.
- The battery was unserviceable.
- The GPS antenna was found broken.

Inspection and Test by SARBE 6-406G Manufacturer

Following the initial testing of the SARBE 6-406G units described above, the first three units to be recovered were taken to the original manufacturer for a detailed examination and test. A detailed examination and test was not carried out on the fourth unit to be recovered. This was because the significant level of damage observed at the initial examination indicated that nothing further could be learned by a more detailed examination. In addition, as the unit had been in the sea for several months, it would not be possible to ascertain when the damage occurred.

Description of Inspection and Testing Carried out By Manufacturer

The SARBE 6-406G manufacturer carried out the following tests on each SARBE 6-406G:

1. General external inspection
2. Self-test
3. Battery test
4. Pressure test to determine if the seals of the units were intact. In this test the manufacturer replicated the pressure conditions at 10m water depth by introducing air at 15 psi into the unit via a pressure test screw located on the base of the unit.
5. General inspection of the internal circuits and the main seal.
6. Antenna test to determine if the units were capable of radiating the correct frequencies and at the correct power. In this test the antennas were connected to a slave PLB, activated and placed inside a screened enclosure. The frequency and power of the output was then measured.

Results of Examination and Testing

Table No. R1 below shows the results of the SARBE 6-406G Testing. In summary:

1. The exterior of all three units showed signs of saltwater immersion.
2. The batteries of all three units had been discharged or were inoperative.
3. Two of the units passed the manufacturer's standard production pressure test.
4. The antennas for all three units passed a live activation test using a known good PLB and battery.
5. There was no damage to the main seal on any of the units.
6. All three units showed evidence of internal flooding (**Photo No. R1**).

		SARBE 6-406G		
		Commander	**Co-pilot**	**Spare**
Initial External Survey	**Body Work**	**Pass**	**Pass**	**Fail**
	Antenna TNC Connectors	**Fail**	**Fail**	**Fail**
	Arming Switch	**Pass**	**Fail**	**Fail**
	Keypad	**Fail**	**Pass**	**Pass**
	Labels	**Pass**	**Pass**	**Fail**
Battery Test	**Visual Condition**	**Fail**	**Fail**	**Fail**
	Voltage Test	**Fail**	**Fail**	**Fail**
	Operational Test	**Fail**	**Fail**	**Fail**
Test Regime	**Program Read**	**Fail**	**Fail**	**Fail**
	Self-Test	**Fail**	**Fail**	**Fail**
	Pressure Test	**Pass**	**Fail**[28]	**Pass**
	Tx Antenna Live Test	**Pass**	**Pass**	**Pass**
	GPS Antenna Live Test	**Pass**	**Pass**	**Pass**
	Antenna Extension Test	**Pass**	**Pass**	**Pass**
Internal Survey	**Heel Plate Removed**	**Pass**	**Pass**	**Fail**
	Front & Rear Case Separated	**Pass**	**Pass**	**Pass**
	Internal Inspection	**Fail**	**Fail**	**Fail**

Table No. R1: Results of SARBE 6-406G Testing

[28] When tested, this unit exhibited a leak on the right-hand side of the unit's self-test button

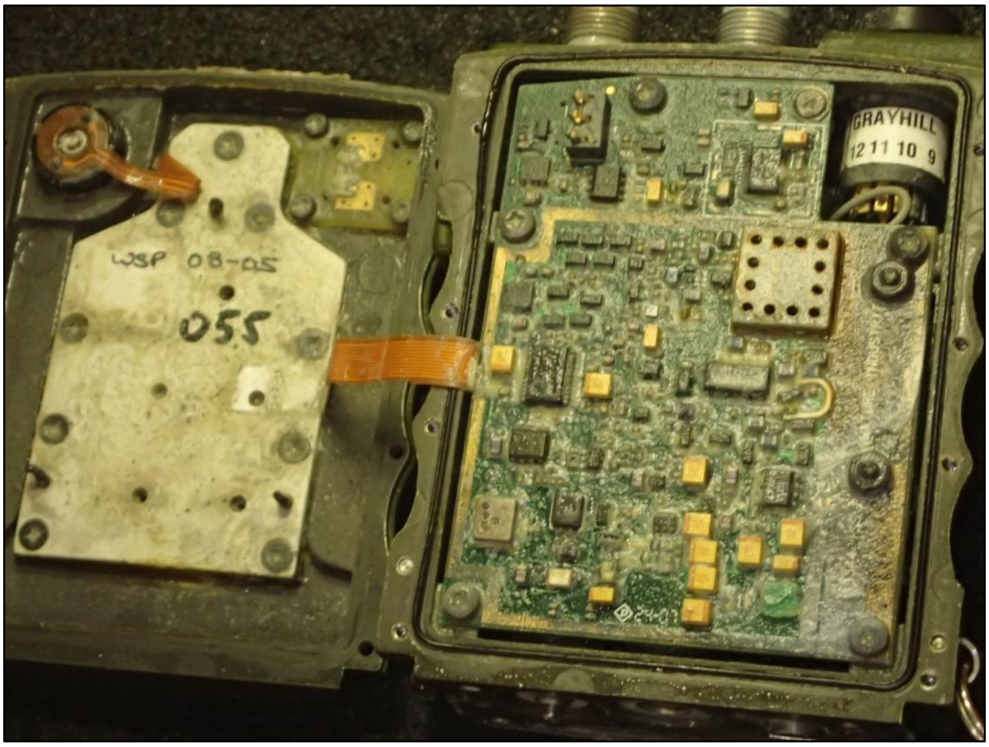


Photo No. R1: Internal Water Damage to Commander's SARBE 6-406G

Conclusions of Examination and Testing

73 Following the examination and testing the PLB Manufacturer produced a test report which concluded that:

> *'All the PLBs investigated appear to have suffered a similar significant ingress of water. This water ingress could short circuit internal componentry and cause damage to the batteries, sufficient to cause the PLB to fail to operate.*
>
> *During the survey and test, it was noted that despite the extent of water ingress the case seals appeared to be in good condition. The results of the described pressure tests indicated that the seals continued to perform as designed, and therefore were likely to have been in good condition prior to the accident event.*
>
> [The PLB manufacturer] *were advised that at least two of the PLBs* [the Co-pilot's and the spare] *had been immersed to a depth of about 40m for an extended period. The immersion depth of the third [*the Commander's*] was unknown. The results found are consistent with this information.*
>
> *The SARBE 6-406G PLB has not been tested for immersion in depths greater than 10 metres, and the results of immersion to greater depths are therefore unknown. However, it is considered likely that during the period that the PLBs exceeded this depth the PLB sealing was breached, causing the PLBs to fail. There is no evidence to suggest that the PLBs were not fully serviceable at the time of the accident event, although it appears that at least one of the tested PLBs was fitted with a life expired battery.*

Presuming that the PLBs functioned as designed through activation of the salt water switch, and were therefore transmitting, the PLBs may have been underwater at this point. The antennas are not designed to transmit underwater, but must rather have a clear view to the sky. This would have prevented any signals being radiated by the PLB, or received by the satellite. The subsequent dive beyond the specified immersion depth and ingress of water would probably have caused the PLBs to fail; this would result in any transmission stopping. The ingress of water would have prevented any further operations of the PLBs even following a return to the surface and visibility of the sky for the antennas.

NOTE: *Life jacket integration is outside the scope of this* [the PLB] *investigation. However, it was noted that the configuration of two of the life-vests did not provide the recommended separation of the two antennas (TX and GPS) and did not provide a clear view of the sky without manual intervention. The operation of the GPS antenna, especially in this configuration, may be compromised.'*

-END-

Appendix S — PLB Installed Performance - Mk44 and Mk15 Lifejackets

General

In response to Safety Recommendation IRLD2017006 the Lifejacket Manufacturer with assistance from the PLB Manufacturer and the Operator carried out a two phase investigation into the installation and performance of the SARBE 6-406G PLB as installed in both the Mk44 and Mk15 Lifejacket. Phase 1 was a table-top examination of both types of lifejacket with PLB and antennas installed.

Phase 2 assessed the performance of the SARBE 6-406G in the sea when installed in both Mk44 and Mk15 Lifejackets. In each performance test the test subject entered the water whilst wearing an industry standard immersion suit and one of the two lifejackets. The test subject adopted a floating position. Observers noted the position of the beacon pocket, antenna and GPS antenna relative to the waterline. The Marine Rescue Coordination Centre (MRCC) of the Irish Coastguard monitored the signal emitted/collected from the PLB. A handheld device capable of receiving the transmitted signal was also located on the shoreline. The test was repeated with each lifejacket in the un-inflated and inflated configurations.

PHASE 1

The table-top review of the two lifejacket types concluded that:

Mk44 Lifejacket:

- The beacon pocket is located on the right-hand side of the jacket, as worn and is orientated in a vertical position.
- The SARBE 6 406G locator beacon is stored in the pocket but without a fixed tether point.
- The SARBE 6 406G beacon fitted includes a fixed antenna and GPS antenna. The antenna is directly attached to the base unit and the GPS antenna is stowed within the beacon pocket alongside the beacon.
- The fixed antenna and GPS antenna are therefore immediately adjacent to the subject's torso when the lifejacket is worn.
- The PLB manufacturer noted the standard antenna being used was of an older revision that is now obsolete. A new '*blade*' type antenna was introduced in May 2013 as an improvement. The GPS antenna was of the current standard.

Mk15 Lifejacket:

- The beacon pocket is located on the left-hand side of the jacket, as worn and is orientated in a horizontal position.

- The SARBE 6 406G locator beacon is stored in the pocket, but without a fixed tether point.

- The SARBE 6 406G fitted includes a standard type antenna and GPS antenna. The standard type antenna is remotely attached to the base unit via an extension cable. The antenna is mounted on the inflatable lifejacket stole. The GPS antenna cable is routed along the periphery of the lifejacket stole and is attached to a patch on the stole.

- The standard type antenna and GPS antenna are therefore positioned away from the subject's torso when the lifejacket is worn and would be positioned prominently on the stole above the water line.

- The connector from the GPS antenna to the base unit was loose and was hand tightened prior to the in-water assessment. If the connection points are loose, connectivity could be compromised and the risk for water ingress is increased.

- The PLB Manufacturer noted that the standard type antenna, extension cable and GPS antenna were of the current standard.

PHASE 2

The table below describes the results of the Phase 2 testing of the PLBs installed in Mk44 and Mk15 Lifejackets:

Lifejacket	Mk44 Un-inflated	Mk44 Inflated	Mk15 Un-inflated	Mk15 Inflated
Position of PLB	Below waterline	Below waterline	Below waterline	Below waterline
Position of Antenna	Below waterline	Below waterline	Above waterline	Above waterline
Position of GPS Antenna	Below waterline	Below waterline	Above waterline	Above waterline
Hand-held device	No signal detected	No signal detected	Signal detected	Signal detected
MRCC	No signal detected	No signal detected	Signal detected	Signal detected
Standing at water's edge	Test not carried out	Signal detected – no positional information	Test not carried out	Test not carried out

Conclusions and Recommendations

The investigation of PLB performance carried out by the lifejacket manufacturer concluded that:

- The installation of the SARBE 6 406G PLB in the Mk44 Lifejacket was unsatisfactory because although the beacon would be activated by the water activation switch, the full range of signals were not detected from the locator beacon when the test subject adopted a floating attitude, regardless of whether the lifejacket was inflated or un-inflated.

- The installation of the SARBE 6 406G in the Mk15 Lifejacket was satisfactory because the beacon was activated by the water activation switch and the full range of signals was detected when the test subject adopted a floating attitude and regardless of whether the lifejacket was inflated or un-inflated.

In light of these conclusions the lifejacket manufacturer decided that:

a) The Mk44 Lifejacket would be modified to adopt the same standard antenna and GPS antenna mounting methods and positioning as the SARBE 6 406G installation on the Mk15 Lifejacket.

b) The Lifejacket manufacturer would carry out initial assessments of a modified Mk44 prototype to demonstrate functionality. These initial assessments would be carried out in a swimming pool and would ensure that the stole deployed correctly and that the antennas were correctly positioned.

c) Formalised trials would then be carried out with MRCC and the Operator to validate the modification and to provide user confidence.

d) Once the trials were completed successfully a service bulletin would be raised to introduce the modification.

e) A review of all SARBE 6 406G beacons installed in the lifejacket manufacturers product portfolio would be carried out to ensure correct installation, function and operation. Acceptance of each installation would be sought from the PLB manufacturer.

f) A wider review of all lifejackets with integrated beacons in the portfolio would be carried out to ensure the correct function and operation of the equipment. Acceptance from the relevant PLB manufacturer would be sought.

-END-

Appendix T — Differentiation SAR vs HEMS

The definitions and regulations relating to HEMS missions are covered in OMG.

SAR flight:

All taskings to incidents at sea, cliffs, inland waterways, mountainous areas or locations where access to, and extraction of, the casualty is not safe by an ambulance crew shall be classified as SAR and remain so until the mission has been completed. This shall be based on the best available information as provided by the SAR mission controller (SMC) at the time of tasking.

If, upon arriving on-scene, the casualty is in, or has been moved, to a location where an ambulance crew can safely access and extract the casualty, the following restrictions shall apply:

a. *For day operations:*
i. *Landing: Site shall have a minimum dimension of 2D x 2D*
ii. *Hoisting: Only permitted if a suitable 2D x 2D site is not available and significant delays would result in positioning to such a site.*

b. *For night operations:*
i. *Landing: Only permitted at CHC approved surveyed sites, on beaches or licensed airfields*
ii. *Hoisting: Only permitted where the aircraft can safely approach over the water, and remain on the shoreline. An unobstructed flyaway shall be maintained at all times.*

Note:

For the purposes of night off-airport operations on both SAR and HEMS missions, night shall be deemed to begin 15 minutes prior to CET and end 15 minutes after CMT.

c. *Offshore islands:*

i. *Missions to offshore islands, where in the opinion of the paramedic or other suitably qualified medical personnel that the casualty's condition is life threatening, or where the casualty needs to be winched into the helicopter, will be operated as a SAR flight.*
ii. *If the best available information at the time of tasking indicates that the casualty does not need to be winched and the condition of the casualty is not life threatening, then it will be conducted in accordance with OMG.*

In certain circumstances, missions to incidents which are not at sea, cliffs, inland waterways, mountainous areas or areas which are inaccessible to ambulance crews may also be designated SAR. However, the following criteria must be applied:

- ***a.*** *In the opinion of the paramedic, or other suitably qualified medical personnel, the condition of the casualty is life threatening.*
- ***b.*** *Where it is obvious that a casualty is likely to expire if not facilitated by immediate air transport, even when a road ambulance is available.*
- ***c.*** *Weather minima and performance shall be in accordance with OMG limits.*
- ***d.*** *For day operations, the operating site shall have a minimum dimension of 4D x 2D. (In certain circumstances this may be reduced to 2D x 2D.) See section 'Site dimensions' in OMG chapter 2 for site dimensions.*
- ***e.*** *Hoisting is not permitted.*
- ***f.*** *For night operations, land at CHC approved surveyed sites only.*

Note:

- ***a.*** *The above conditions are not mutually exclusive.*
- ***b.*** *CHC shall record and report to the IAA all such situations where this discretion has been exercised.*
- ***c.*** *CCS shall continuously review (through a follow-up process) all post-flight medical case, based on the medical information available to the paramedic (or suitably qualified medical personnel) at the time of the airlift.*
- ***d.*** *This discretion may be used for inter facility transports where the condition of the casualty is life threatening.*
- ***e.*** *This discretion may be used for the transport of organ patients or organs, when the organs could potentially become unusable if not facilitated by immediate air transport*'.

OMG defines a HEMS flight as:

'A flight by a helicopter operating under a HEMS approval, the purpose of which is to facilitate emergency medical assistance, where immediate and rapid transportation is essential, by carrying:

- *a. Medical personnel, or*
- *b. Medical supplies (equipment, blood, organs, drugs), or*
- *c. Ill or injured persons and other persons directly involved'.*

OMG defines an Air Ambulance flight as '*A flight, usually planned in advance, the purpose of which is to facilitate medical assistance, where immediate and rapid transportation is not essential, by carrying:*

- *a. Medical personnel, or*
- *b. Medical supplies (equipment, blood, organs, drugs), or*
- c. *Ill or injured persons and other persons directly involved'.*

-END-

Appendix U — Measures outlined by the Minister for Transport, Toursim and Sport following the accident and in response to the Investigation's Draft Final Report

Following the accident and in response to the Investigation's Draft Investigation Report, the Minister advised the following on 12 November 2019 (de-identified where appropriate):
[…]

[In summary: Several measures were undertaken which were grouped under six headings and that much of these measures anticipated findings and safety recommendations contained in the draft report]:

1. Development of a new National SAR Plan following extensive review
2. Enhancing safety and oversight across the SAR system
3. Addressing SAR aviation oversight – nationally and internationally
4. Review and revision of all relevant Standard Operating Procedures (SOPs) and training for the IRCG personnel, particularly SAR Mission Coordinator (SMC) training with a focus on aviation tasking
5. Development of an externally accredited safety management system in the IRCG
6. Review of governance arrangements in relation to [the Operator], enhancing aviation expertise in critical areas and legislative reform of the IAA

[…]

1. **Development of a new National SAR Plan following extensive Review**

[Cross-reference Table removed]

On foot of a recommendation in the AAIU's interim report (March 2018), I commissioned an independent review of oversight arrangements for SAR aviation operations in Ireland. Following publication of the [independent consultant's] Report in September 2018 (hyperlink here), I committed to implement in full and without delay the 12 recommendations contained in that report. A key element to this was a review of the National SAR Framework (referenced at various points in the AAIU draft report) to take account of the [independent consultant's] report's findings. This review was led independently by [the former] CEO of the UK's Maritime Coastguard Agency, commenced work in November 2018 and completed its report to me in June 2019. It was published along with the new National SAR Plan in July having been noted by Government.

The first output from this review was a new National SAR Plan (NSP). This new NSP provides for a re-balancing of the previous maritime-centric SAR Framework to encompass both aeronautical and land SAR more comprehensively; it provides for more explicit governance, assurance and oversight roles across the SAR system; it reconfigures and re-names the previous Irish Aeronautical and Maritime Emergency Advisory Committee as a more strategic National SAR Committee with a leaner, more coherent set of sub-committees. It also provides for a clearer description of the National SAR system including roles, inter-relationships and responsibilities from strategic through tactical to operational levels; and it sets out guidance to develop a common approach to managing SAR incidents across all three domains.

The NSP is being delivered on a phased basis over 18 months to enable a managed and integrated approach to the revised SAR structures and to the development of the necessary MoUs and SLAs between SAR stakeholders, both horizontally and vertically, within the system.

The second output was an implementation plan for the recommended model for a Joint Rescue Coordination Centre (JRCC). This '*virtual*' JRCC will capitalise on the strengths of the current ARCC/ARSC and MRCC/MRSC model, while minimising disruption and exploiting the potential of enhanced technology, closer cooperation and revised operating procedures. It will also address vulnerabilities identified in the existing model, and provide for stronger oversight arrangements.

The SAR report also sets out revised arrangements for overseeing the international SAR agreement between the IRCG and UK's MCA [Maritime and Coastguard Agency]. It also addresses aspects of SAR relevant to the 2018 MCIB report into the tragic Kilkee accident in September 2016.

The SAR review was assisted by […] Consultants, who provided independent expertise and supporting analysis. Their submissions underpin the findings of this report and the direction taken in developing the new NSP and selecting the most appropriate JRCC model for Ireland.

Following the conclusion of the SAR Review Report in June, [independent consultancy] were asked to review the follow-up actions taken since their report was published on SAR Aviation Oversight the previous September. [The independent consultancy] completed this review which was broadly positive and concluded that 8 of its 12 recommendations have been fully addressed with the remaining 4 either '*partly*' or '*initially*' addressed with some further work required to complete. A copy of this report has been provided to the AAIU.

A major theme covered by the SAR Review which is addressed in the NSP relates to roles and responsibilities within the SAR system, particularly the governance and oversight roles. This issue is also mentioned in the draft AAIU report. A new chapter in the National SAR Plan captures how SAR policy is set, responsibilities are assigned, performance is monitored and managed and how the primary SAR stakeholders are overseen, including from a regulatory perspective where relevant. This includes a definition of 'oversight' itself. This goes very directly to the issues raised in the AAIU's draft report in relation to bringing clarity to state oversight, not just in the aviation area, but across the entire SAR system, at strategic, tactical and operational levels. Furthermore, the new NSP identifies SAR regulatory roles more explicitly – including those of the IAA, the Marine Survey Office and the Road Safety Authority.

2. **Enhancing safety and oversight across the SAR system**

[Cross-reference Table removed]

Also of clear relevance to the AAIU's draft report, the new National SAR Plan introduces a new element to provide assurance in relation to the performance and safety of the SAR system. This is described under the '*Assurance, Risk Management and Safety Culture*' section of the NSP.

This approach is adapted from the New Zealand SAR model of '*system assurance*' and places an onus on all participants to provide annual assurances across key areas. While this does not obviate or supplant any statutory or other formal requirements, it provides a mechanism for routinely assuring a minimum set of requirements are in place in relation to safety management and oversight across the SAR system. Essentially, it requires all SAR stakeholders to implement a range of measures along the principles of risk assessment, safety management and continuous system improvement. Collectively, these measures represent an improved level of assurance in relation to the overall system. A key principle embedded in this assurance mechanism is that it should be proportionate to the scale and complexity of the organisations involved – so that smaller voluntary SAR units are not subject to the same degree of administrative scrutiny as a larger, professional SAR stakeholder.

As a support mechanism to the new SAR assurance system, the NSP establishes a new SAR Regulators' Forum and a new Health and Safety Forum. The Regulators' Forum is intended to sit along-side the National SAR Committee and act in an advisory capacity. It will review the SAR system assurance reports, share regulatory best practice and inform further enhancements of this system. It will report to me as necessary in relation to regulatory compliance matters arising and offer advice when requested. This Forum is now up and running, with membership drawn from the IAA, the Marine Survey Office and the Road Safety Authority with the Chair of the National SAR Committee in attendance.

The new Health and Safety Forum aims to encourage a collaborative and cooperative approach among the primary SAR stakeholders and service providers to health and safety issues in the SAR sector. Its membership has been agreed by the National SAR Committee to include experts in health and safety management within the main SAR service providers. This model exists and works well in other jurisdictions but is new to the Irish system.

Finally, the National SAR Committee has also been assigned a role to monitor and review the adequacy of this enhanced mechanism for assurance. In that context, it will ensure the following activities are carried out:

- Regular reviews and updates of SAR agreements internationally;
- Regular reviews of MoUs / SLAs between SAR system participants;
- Provision of submissions (as appropriate) to the ICAO / IMO Joint Working Group on SAR to share lessons learned and experiences with other States for the continuous improvement of the worldwide SAR system;
- Regular analysis of SAR operational data to identify trends and areas of improvement and a commitment to make this information available to the wider SAR system through the National SAR Committee;
- Annual review of the SAR system to identify any specific gaps in capability and /or areas for improvement against minimum requirements of relevant international conventions and guidelines (including Annex H of IAMSAR manual) (IAMSAR);
- Other initiatives to promote system assurance through consultation with the Regulatory Forum and/or the Health and Safety Working Group.

This new SAR assurance mechanism places an onus on the IRCG to conduct an annual Annex H assessment. This voluntary self-assessment tool is specifically mentioned in the AAIU draft report. The first of these assessments was conducted in the context of the SAR Review process in June 2019. This identified a number of minor areas for improvement in what was found to be a fundamentally compliant and soundly administered SAR regime. This self-assessment will now be undertaken annually under the auspices of the National SAR Committee. For clarity, this a system-wide review rather than aviation specific. It is designed to assess the entire system and its components, and is not confined to SAR aeronautical operations nor indeed, considers the presence/absence of an SMS.

As regards external assessments, the NSP provides greater clarity in relation to regulation, involving external audits, of the SAR system. For example, oversight of the ARCC, MRCCs and the new Virtual JRCC is set out clearly, as follows. The ARCC continues to be overseen by the IAA's Safety Regulation Division as the national aviation safety regulator. MRCC/MRSC operator training in relation to tasking SAR aviation assets is being conducted by an aviation Approved Training Organisation (ATO) which is subject to certification and oversight by the IAA. MRCC/MRSC operations generally will be overseen by the IRCG enhanced internal audit regime (in support of its new Safety Management Systems) and reinforced by periodic external audit by an independent and suitably experienced entity.

All of these elements are designed to bring clarity in terms of oversight at all levels in the SAR system, make roles and responsibilities more explicit than previously and ultimately, provide adequate reassurance in relation to how the SAR system operates and builds in a stronger and systematic commitment to continuous improvement and developing a '*just culture*' across the entire system.

3. **Addressing SAR aviation oversight – nationally and internationally**

[Cross-reference Table removed]

As outlined above, the new National SAR Plan sets out more clearly the roles and responsibilities in relation of oversight. The SAR Review Report (published July 2019) also describes the measures undertaken by the IAA as the national aviation regulator to address recommendations arising from the [independent consultant's] review of SAR aviation oversight which are clearly relevant to those aspects of the AAIU's draft Report. The implementation of these specific recommendations is also addressed in the [independent consultant's] 2019 Report on implementation. I expect the IAA's response to [the AAIU's] draft report will provide the latest state of play in this regard.

One of the recommendations from the [independent consultant's] SAR oversight review report, which is picked up in the draft report [recommendation No. removed], relates to engagement with European bodies concerning on an EU-wide framework for SAR regulation and the '*opt-in*' provision for SAR under the European Aviation Safety Regulation EC 2018/1139. The Department has, on 4 November 2019, engaged in discussion with relevant counterparts in European Commission and the European Aviation Safety Agency (EASA) in this regard.

With regard to a possible future EU-wide SAR regulation framework, the European Commission and EASA have confirmed that EASA does not have competence under the European Aviation Safety Regulation to develop such a framework, rather this is a European Commission responsibility in consultation with the Member States. The European Commission will respond directly to the AAIU in this regard as named parties of the draft Report. However, my Department understands that the development of an EU-wide SAR regulation framework by the European Commission would involve a long-term assessment of surveys and trend data over time, as well as political will by Member States.

It is also noted that the SAR opt-in under the European Aviation Safety Regulation was proposed by the EU and agreed by the member states, with flexibility to select some and not all of the specific regulatory requirements to opt in to. This indicates perhaps that a number of Member States may not support an EU-wide aviation safety oversight framework for SAR. Within this context there are limits to which Ireland can ensure the bringing about of such an EU-wide SAR framework.

Notwithstanding, taking account of the recommendation of the [independent consultant's] SAR oversight review report and the AAIU recommendation, my Department has sought and received legal advice that primary legislation is required for Ireland to exercise the EASA opt-in under Article 2(6) of the European Regulation 2018/1139. The Department is seeking further Counsel advice concerning a possible draft Heads of Bill for this purpose. Subject to Government agreement this could be considered within the Air Navigation and Transport Bill 2019. EASA has, in the recent discussion, advised my Department officials that an analysis should be undertaken of the requirements of the European Regulation which apply to the SAR opt-in against the National requirements for SAR oversight, in order to assess any potential gaps which may need to also be provided for under National legislation.

4. **Review and revision of all relevant SOPs and training for the IRCG personnel, particularly SMC training with a focus on aviation tasking**

[Cross-reference Table removed]

The Coast Guard, in its role as a helicopter tasking authority, has identified and addressed a series of measures that provide for more robust and clear cut decision making by IRCG Rescue Coordination Centre (RCC) staff, and more explicitly incorporate risk assessment procedures to be followed.

A key document in this context is the IRCG's Heli OPs SOP (Standard Operating Procedure). This document captures the operating criteria under which CG helicopters can be tasked by IRCG RCCs, for different mission types and the associated constraints and limitations that apply. The key audience for this document are RCC staff. [The Operator's] primary engagement with this document is to ensure that it complies with the applicable, IAA-overseen [Operator's] Operations Manual (OM-G). This engagement with [the Operator] is critical in ensuring that the IRCG as the tasking authority and [the Operator] as the recipient of such requests have a shared understanding of the IRCG's operating criteria as it impacts on them. The SOP was re-issued in 2018 following an extensive review between IRCG and [the Operator]. Technical advice on IRCG input into the document was provided by the retained IRCG Aviation consultant.

This document is kept under constant review. Future iterations of the document will also include IAA input in accordance with arrangements prescribed in the recently agreed Advance Arrangement (referred to elsewhere in this letter). Any internal operational notices issued by IRCG must conform with the Heli Ops SOP.

Internal IRCG procedures referred to as Coast Guard Operations Notices are kept under ongoing review and are managed under a document control procedure. These documents are driven by a lessons identified and lessons learned process with input from key stakeholders and address some important matters identified in the AAIU [draft] report – three in particular:

i) IRCG reviewed and updated the internal operational notice on the procedure to be followed when considering a request for a MEDEVAC and sourcing medical advice. MEDICO Cork as a key stakeholder participated in the drafting of this document. The latest version contains very specific guidance to assist IRCG watch officers determine more explicitly the views of MEDICO personnel on the medical necessity and options, in responding to a particular incident.

ii) Similarly revised procedures for determining the requirements for, and coordination of, air support for long range SAR operations, including Fixed Wing or Helicopter options, have been issued. [The Operator] participated in the drafting of this document – again to ensure compliance with their regulatory and / operational parameters.

iii) Revised arrangements governing operational criteria for the conduct of HEMS operations were also published in 2018 following consultation involving IAA, [the Operator], IRCG and Dept of Health / HSE. This Operations Notice reflects a clear delineation of HEMS as a Commercial Air Transport activity as opposed to SAR.

The establishment of a Safety, Quality and Compliance Section within the Coast Guard at a structural level provides for significant improvement in its internal oversight and risk assessment procedures. All Coast Guard RCC and Operations staff undergo a SAR Mission Coordinator course at the NMCI [National Maritime College of Ireland]. This syllabus reflects IMO Model Course for SMC training and the Coast Guard has completed a review and update of its syllabus. The course attracts international students and the Coast Guard in conjunction with NMCI/CIT [Cork Institute of Technology] is working towards securing formal third level recognition for this training.

In October 2019 the Coast Guard rolled out a new course entitled SAR Aviation Tasking and Coordination (SATaC). This course, delivered by an IAA Approved Training Organisation (ATO) provides in-depth theoretical knowledge on Aviation coordination to Coast Guard operational personnel. Risk assessment procedures are an integral element of this course.

The Coast Guard has reviewed the provision of aviation expertise by identifying technical capabilities to oversee and review all activities associated with SAR aviation operators. The Coast Guard has received sanction to recruit a new aviation manager who will improve technical capabilities in relation to activities associated with the SAR aviation operator.

Following a review of the IRCG's SOPs for Boat Launching and Search and Recovery as part of the SAR Review completed in June last, the IRCG is undertaking a programme of review of all its extant SOPs. This will aim at greater clarity and uniformity in the style and presentation of such SOPs, taking account of the intended audience and how such documentation is used in practice. The deadline for completion of this review as part of the implementation of the NSP is March 2020. In addition, improved document control will form part of the IRCG's roadmap to an accredited Safety Management System based on rigorous quality management.

The Coast Guard has an established '*lessons learned /lessons identified*' process which is embedded in its Operations logging system (SILAS). The IRCG has enhanced its in-house resourcing to conduct regular analysis across SILAS and other data sources available to the IRCG to better interrogate how incidents have been carried out.

The advent of a new Volunteer Information Management IT System will ease the promulgation of new SOPS and associated guidance material across the IRCG volunteer population. Together with the existing Incident Logging System (SILAS), this will provide for more consistent and comprehensive approaches to dynamic decision-making and risk assessment.

5. **Development of an externally accredited safety management system in the IRCG**

[Cross-reference Table removed]

87 In support of Continuous Improvement of the SAR system, Coast Guard has established a Safety and Quality Compliance (SQC) Section, and within which includes a dedicated Health and Safety Officer to provide oversight of the SMS, and work in conjunction with the Department's safety officer(s) in pursuit of Health and Safety Policy, Procedures, Goals and Objectives.

IRCG has also committed to the development and implementation of an effective and functioning Safety Management System, applicable to the specific needs of the IRCG and in adherence with the requirements of ISO 45001:2018 - Occupational Health and Safety Management Systems.

Per the recommendations of [the independent consultant's] Review, and specifically concerning the necessity to implement a Total System Approach (TSA) regarding safety management, Coast Guard and [the Operator], have drafted an interface agreement to link their respective Safety Management Systems. Doing so provides a structure in which to facilitate more open communication on identified safety issues, aids joint hazard identification and mitigation activities, defines safety responsibilities and supports the continuous improvement of safety performance.

The administrative integrity and operational performance of the MRCC/MRSCs are also now overseen and assured by the IRCG's internal compliance and audit regime, led again by the recently established SQC section and to be reinforced by periodic external audit by an independent and suitably experienced entity, in accordance with the new NSP.

In the context of delivering its part of the SAR assurance mechanism as prescribed in the new National SAR Plan, the IRCG has commenced a review of all its Memoranda of Understanding / Service Level Agreements to ensure respective roles and responsibilities are articulated clearly and understood by the respective parties. Such MoUs and SLAs are particularly important in determining where the risk lies when organisations are being requested to respond to an incident. This review will include the existing SLA with the Department of Defence / Air Corps in relation to issues such as top cover to ensure a common understanding of the terms used and operational implications. This review will be completed by March 2020 as part of the implementation of the new NSP.

6. **Review of governance arrangements in relation to [the Operator], enhancing aviation expertise in critical areas and legislative reform of the IAA**

[Cross-reference Table removed]

Contacts between the IRCG and [the Operator] happen at various levels and follow the contractual arrangements set out in the 2012 contract with [the Operator]. As such, day to day operational matters – including tasking, incident management etc - are handled through the Rescue Coordination Centres directly with their [Operator] base contacts. These are governed by the IRCG SOPs – primarily the Heli –Ops SOP – which is kept under constant review by both IRCG and the external aviation consultant when requested. As noted already, Coast Guard has reviewed its Heli SOPs in particular the SAR/HEMS decision tree in close consultation with the operator and the aviation consultant. Future updating of SOPs will incorporate enhanced risk assessment processes. As mentioned already, specific aviation training is underway for RCC staff complete with explicit risk assessment training for tasking of aviation assets i.e. rotary and fixed wing.

SAR Operation management issues, including more strategic issues such as availability issues, Hospital Landing sites, etc - are managed by the CG Operations Manager with his counterpart in [the Operator], Manager of Flight Operations (MFO). Safety related matters are managed between the Health and Safety personnel of both – under the terms of the aforementioned SMS bridging document with input from the external aviation consultant contracted by the IRCG.

Broader governance issues – in terms of contract performance issues, contract changes, high level safety matters and any financial issues - are managed through regular Contract Liaison meetings between IRCG and [Operator] management personnel. These meetings cover a broad range of issues and are facilitated by the IRCG's aviation consultant who prepares the paperwork, agenda, identifies and monitors appropriate follow-up actions, etc.

Through these structures, there is a very clear delineation in the day to day operational engagement and the more strategic governance arrangements with [the Operator], which are inter alia, intended to avoid any perception that IRCG may be exerting undue pressure – commercial or otherwise - on day to day decision-making of [the Operator's] crews. These arrangements would have pertained at the time of the accident.

In order to further strengthen the IRCG as an '*intelligent customer*', a recruitment of a full time Aviation Manager position is underway. This individual will have, inter alia: technical aviation qualifications and aviation safety management background particularly ICAO Annex 19 Safety Management and European Aviation Safety Agency Requirements for Air Operations. Gen 200 Management System. It is expected that the post will be filled by end 2019.

The Department itself conducted a review of governance in relation to roles and procedures in relation the [the Operator] contract changes in February 2018. This was intended mainly as a hygiene check in relation to how contract changes were managed and to ensure that language within the contract was consistent with practice as it had evolved over the initial term of the contract itself. Subsequent to this, some changes were made to the manner in which IRCG – [Operator] contract meetings were held, adding greater focus to safety related matters and encouraging a more robust engagement on issues around contract compliance.

The use of the external aviation consultant (currently [named auditing company] Ltd) has also been enhanced – within the existing parameters of the contract – to enable a more robust engagement with [the Operator] in terms of the performance of its contractual obligations. The audit approach applied by the external contractor is rigorous in terms of safety compliance. [named auditing company] reports are narrative accounts of the audit and the evidence examined (rather than simply being checklists) and accompanied by typically half a dozen relevant photographs. They are a written record of the major pieces of evidence reviewed (such as taskings, Technical Log pages, documents etc). They are typically 2000+ words. The emphasis varies between audits. While each looks at the SAR capability of that base, deeper audits are conducted on specific areas during individual audits, which are spread out over the year, with all 4 bases examined. For example the safety function and flight ops / flight training is examined more deeply in Dublin and the CAMO (continuous airworthiness management) and base maintenance in Shannon. The 2018 and 2019 audits at Dublin have featured two auditors, with different backgrounds, as a team. Two auditors have examined Sligo during the period and one auditor Waterford and Shannon so far. This gives a useful mix of diversity and consistency.

The Flight Safety Foundation BARS [Basic Aviation Risk Standard] Offshore Helicopter Operations standard, which included high level reference to regulations and a framework of operational, technical and equipment requirements for offshore, SAR and MEDEVAC, is used to code findings which may be against regulations, the contract, [the Operator's] own policies and procedures and industry good practices that deserve consideration.

The contractor holds a debrief after each audit with [the Operator] who typically send the Safety and Compliance Manager or another manager to provide some liaison. The reports are supplied to IRCG for comment before being issued to [the Operator]. Audit feedback is given jointly to [the Operator] and IRCG at Contract Ops Meetings. A spreadsheet of all findings and responses is maintained by [the named auditing company] and is now on a secure SharePoint site accessible between Contract Ops Meetings by IRCG and [the Operator].

A mid-term review of the overall contract was commissioned through [the named auditing company]. They were tasked to identify lessons learned, any areas of non-compliance and areas for future improvement. The report was finalised in May 2019 and made a series of 10 recommendations – all of which are being followed up as appropriate. The review forms an important input into on-going deliberations in relation to the next SAR aviation contract.

On the regulatory aspects of the contract, the [independent consultant's] Report made a specific recommendation in relation to how IRCG and IAA interact in this context. Throughout the recent SAR review process, the IAA and IRCG engaged very constructively in relation to the wider regulatory aspects of SAR aviation. It was agreed that a formal mechanism should be found to ensure this engagement continue in a way that facilitates constructive interaction and avoids encroaching on IAA-SRD's regulatory responsibilities in relation to [the Operator]. It was agreed that the mechanism will take the form of an Advance Arrangement between IAA and IRCG. The text for this arrangement has been agreed. [The independent consultant organisation], in its review of the follow-up to its report, found that this arrangement met the requirements of that particular recommendation.

IAA Oversight of SAR

As regards oversight of the IAA's role in regulating SAR, the Department does not retain specialist aviation expertise (pilot or engineering) but contracts expertise for the purposes of the discharge of the Minister's statutory function pursuant to section 32 of the IAA Act, 1993. Section 32(3)(a) of the Irish Aviation Authority Act 1993 requires me as the Minister for Transport, at least every three years, to appoint a person to carry out an examination of the performance by the company of its functions in so far as they relate to the application and enforcement of technical and safety standards in relation to aircraft and air navigation.

The current Section 32 examination is being carried out by the Independent Consultants [another consultant organisation]. The Department is engaging with [the other consultant organisation] about the possibility of including in its examination a review of the IAA regulatory oversight, i.e. that it is sufficiently robust, and that there is a clear understanding of responsibility with regard to functions of the IAA, both which fall within or outside of the International and European regulatory competence (but with a particular focus on operations under IAA national competence such as aerial firefighting) (Recommendation 30 refers).

The previous Section 32 examination noted that while functional separation existed between the IAA safety regulation functions and air navigation service functions, that this needed to be kept under review by the Department. This was addressed through work under the action (2.5.1) of the National Aviation Policy 2015, to ensure that the organizational arrangements and structures for economic and safety regulation of the Irish aviation sector are effective and appropriate.

Finally, the AAIU should be aware that I have been given Government approval for wholesale reform of aviation regulation in Ireland, which will separate out the regulatory and commercial functions of the Irish Aviation Authority. The rationale behind the initiative is to provide much clearer lines of responsibility and accountability in relation to aviation regulatory oversight and, at the same time, to invest in strengthening regulatory capacity. A general scheme of a Bill to give effect to this regulatory overhaul has been considered and approved by the Joint Oireachtas Committee under its pre-legislative scrutiny process, and in September the Government included this legislation in its priority list. The Department has prioritised this legislation and is working with the Office of the Attorney General on drafting a Bill or publication. In the meantime, all of the necessary administrative arrangements are being made in preparation for the new arrangements.

-END-

Appendix V — Extracts from the National SAR Framework

National SAR Framework

The IRISH NATIONAL MARITIME SEARCH AND RESCUE (SAR) FRAMEWORK, published by the Department of Transport on 2 March 2010 states, inter alia:

> *'Search and Rescue (SAR) comprises the search for and provision of aid to persons who are, or are believed to be, in imminent danger of loss of life.*
>
> *…*
>
> *This National Maritime Search and Rescue Framework is the standard reference document for use by all Irish Search and Rescue authorities working in the maritime domain and promulgates the agreed methods of coordination through which search and rescue operations are conducted within Ireland's SAR Region.*
>
> *…*
>
> *In providing a search and rescue response, nothing in the content of the Framework precludes properly qualified officers from using their initiative in providing a SAR response in circumstances where these procedures are judged to be inappropriate. In so doing, however, officers' actions should conform as closely as possible to those instructions contained in the Framework most closely pertinent to the circumstances and they should keep all other parties involved informed.*
>
> *…*
>
> *1.1.3 Where applicable this Framework encompasses the national aviation SAR Framework where the aircraft frame lands into the sea or a major inland lake.*
>
> *…*
>
> *1.6.1 The Department of Transport (DoT) exercises overarching responsibility for maritime and aviation SAR services and for maritime and aviation safety through its Divisions, agencies, the IAA, airport, port and harbour authorities.*
>
> *1.6.2 The Irish Coast Guard, as a Division of DoT, has responsibility for the 24/7/365 coordination of maritime SAR emergency response at sea and along the coasts and cliffs of Ireland, and on major inland lakes. It maintains its Coast Guard national Maritime Operations Centre (MOC) incorporating Irelands Marine Rescue Co-ordination Centre (MRCC) at Dublin and Marine Rescue Sub-Centres (MRSC) at Malin Head in Co. Donegal and Valentia Island in County Kerry. It has a comprehensive Marine Communications Network covering Irish offshore and inland waters. It maintains a network of strategically located Coastal Units equipped to deal with local marine emergencies.*
>
> *1.6.3 The Irish Aviation Authority (IAA) is a semi-state agency responsible to the DoT for the provision of Air Traffic Services including Air Traffic Control and the coordination of Aeronautical SAR emergency response. The IAA maintains an Aviation Rescue Co-ordination Centre (ARCC) at Shannon Airport and an Aviation Rescue Sub-Centre (ARSC) at Dublin Airport. The Safety Regulation Division of the IAA is the body responsible for the regulation and oversight of aircraft operations, including aeronautical Search and Rescue, within the State.…*

1.6.8 The HSE through Medico Cork in Cork University Hospital provides Irelands 24/7 Radio Medical Advice Service to seafarers through the Coast Guard radio network to sick or injured seafarers on a 24-hour basis.

The HSE also provide a Marine Ambulance Response Team for major emergencies. If medical advice requires the casualty to be taken off the vessel then the MRCC/MRSC providing the link will arrange for the casualty to be transported from the vessel to a hospital.

…

1.8.1 Maritime SAR

Within the Department of Transport (DoT), which has overall responsibility as Lead Government Department for maritime and aviation SAR. Primary responsibility has been delegated for Marine Emergency Management within Irelands various responsibility Regions to the Irish Coast Guard. The Coast Guard co-ordinates maritime SAR services within the Irish SRR and will lead and co-ordinate national participation in the SAR and safety related initiatives of the International Maritime Organisation (IMO).

...

1.8.3 Aviation SAR

The Department of Transport (DoT) while retaining overall responsibility for Aviation SAR has determined that the Irish Aviation Authority shall operate the ARCC requirements of ICAO Annex 12. The Safety Regulation Division of the IAA is the body responsible for the regulation and oversight of aircraft operations, including aeronautical Search and Rescue, within the State.

…

1.12 FUNCTIONS COVERED BY THIS FRAMEWORK

1.12.1 The efficient operation of the Maritime components of the co-ordinated SAR system.

1.12.2 The provision of SAR services for aircraft at the request of the IAA or An Garda Síochána.

1.12.3 The establishment, maintenance and operation of a maritime operations centre and maritime rescue co-ordination centres capable of adequately discharging the responsibilities for the efficient detection, co-ordination and rescue of persons in distress or potentially in distress and that have adequate and resilient means of communications, equipment and properly trained and resourced staff.

1.12.4 The provision of assistance to the relevant authorities in the event of natural disasters.

1.13 FUNCTIONS NOT COVERED BY THIS FRAMEWORK

1.13.1 Air Ambulance service not resulting from maritime or aeronautical SAR operations. National Maritime SAR Framework version final 2010 Publish date: 2nd March 2010 Pg 17 of 61.

1.13.2 Helicopter Emergency Medical Services (HEMS).

1.13.3 Civil Disturbance, insurrection, terrorist or other emergencies, which endanger citizens or property.

1.13.4 Salvage and aircraft recovery operations.

1.13.5 Pollution operations.

1.13.6 Ship Casualty incidents where live [life] *is not at risk.*

…

1.16.5 No provision of this Framework is to be construed as an obstruction to prompt and efficient action to relieve distress whenever and wherever found.

1.16.6 SAR Co-ordinators shall arrange for the receipt of distress alerts originating within the Irish SRR, and ensure that the MRCC/MRSC can communicate with the persons in distress, and with the SAR facilities.

…

1.17.2 The Marine Rescue Sub Centre (MRSC) Valentia is the contact point for routine operational matters in the area between Ballycotton and Clifden. MRSC Malin Head is the contact point for routine operational matters in the area between Clifden and Lough Foyle. MRCC Dublin is the contact point for routine operational matters in the area between Carlingford Lough and Ballycotton.

…

1.18.3 SAR Authority

1.18.3.1 A SAR Authority is the authority within a national Administration with overall responsibility for establishing and providing SAR services and ensuring that planning for those services is properly coordinated. The national SAR authority in Ireland is the Irish Coast Guard in respect of maritime SAR and the IAA in respect of aviation SAR. The SAR Authority takes on the roles of the SAR Coordinator as described in the IAMSAR Manual.

1.18.3.2 A SAR Authority shall ensure that a SAR operation can be promptly initiated and prosecuted with the efficient use of available SAR resources, until rescue has been completed or until chance of success is no longer a reasonable possibility. An operation may thereafter continue if appropriate to effect recovery of deceased persons.

1.18.3.3 The Coast Guard on behalf of the Department of Transport has the overall responsibility for establishing, staffing, equipping and managing the SAR system, including providing appropriate legal and funding support, establishing RCC's, providing or arranging for SAR assets, coordinating SAR training and developing SAR policies. The SAR authority, where applicable, shall:

- *establish a Rescue Coordination Centre (RCC) to coordinate all participating search and rescue assets and facilities;*

- *ensure that the RCC conforms to the SAR procedures contained in this manual or local SOPs and manuals;*

- *establish close liaison and formulate agreements with other authorities and organisations having SAR potential;*

- *establish liaison with SAR authorities of adjacent areas to ensure mutual cooperation and coordination in combined operations;*
- *ensure that a comprehensive and current SAR Framework is prepared and distributed;*
- *establish and supervise communication facilities and assign SAR frequencies from those authorised to assets designated for SAR tasks;*
- *establish communications with adjoining RCC's and appropriate organisations to ensure two-way alerting and dissemination of SAR information;*
- *ensure immediate action is taken to provide assistance, advising the appropriate SAR authorities and passing all information received concerning the distress incident and any action taken;*
- *ensure that the operating authority or agency of any craft, aviation asset or land party in need of assistance has been advised of initial actions taken, and they are kept informed of all pertinent developments;*
- *designate an SMC for a specific SAR incident;*
- *ensure that each incident is prosecuted until assistance is no longer necessary, rescue has been completed or chance of success is no longer a reasonable possibility;*
- *ensure that if the scope of the operation exceeds the authority's capacity to plan and execute the operation, it shall seek advice and assistance from, or by mutual agreement, hand over coordination, to an appropriate authority;*
- *maintain and preserve adequate records; and*
- *develop new and improved techniques and procedures.*

1.19.1 The staff of a RCC performs duties in the conduct of search and rescue events and in addition they have responsibility for maintaining the RCC in a continuous state of preparedness. The RCC staff consists of personnel who are experienced and/or trained in SAR operations. When a period of heavy activity is anticipated or during major SAR incidents, the regular staff may be supplemented as required or workload may be shared between Coordination Centres. Each centre will be able to link landline or marine communications in and out of the Tetra network.

1.19.2 Each SAR operation is carried out under the coordination of a SAR Mission Coordinator (SMC) designated for the purpose by the Coast Guard. The SMC is responsible for efficiently prosecuting a SAR incident using the assets available. The SMC is responsible for all stages of the SAR system. Their responsibilities include the prompt dispatch of appropriate and adequate SAR assets and the prosecution of SAR operations until rescue has been completed, or chance of success is no longer a reasonable possibility.

The SMC is responsible for ensuring that the following duties are carried out depending on the SAR incident and local circumstances:

- *Obtaining and evaluating all information pertaining to the incident, including emergency equipment carried by the person or craft in distress.*
- *Classifying the SAR incident into the appropriate emergency phase (Uncertainty, Alert/Urgency, or Distress).*
- *Alerting appropriate SAR assets and SAR organisations that may be of assistance during the incident.*
- *Conducting a risk assessment.*
- *Dispatching initial SAR Units if situation warrants.*
- *Conducting initial communications checks. If unsuccessful, making an extended communications search to obtain additional information on the incident, personnel involved and equipment carried by the vessel, aircraft or party in distress.*
- *Calculating the search area. Preparing optimum plans and promulgating attainable plans.*
- *Obtaining past/present/forecast weather, drift information and oceanographic conditions if applicable.*
- *Providing for SAR crew briefing, dispatching of appropriate SRU's, or other assets.*
- *Organising logistical support for all SAR assets including fuel, food and accommodation, through to the completion of the incident.*
- *Making arrangements for appropriate communications.*
- *Maintaining a continuous, chronological plot showing sighting and hearing reports, DF bearings, air plot, radar plot, fixes, reports of debris, areas searched or not searched and other intelligence.*

- *Maintaining a continuous, chronological record or log of the search effort, including actions taken in relation to intelligence, SRU's employed, sorties, hours flown/underway, sightings, leads, results obtained, message traffic, briefing notes, telephone calls, daily evaluation of progress and probability of detection.*
- *Initiating marine distress broadcasts or marine information broadcasts and initiating the alerting of enroute aircraft.*
- *Arranging communication schedules when and if needed.*
- *Requesting additional SAR assets, as required.*
- *Exercising overall coordination of SAR assets.*
- *Maintaining liaison with the next of kin, owner, agent or management of the missing craft or persons.*
- *Liaise, and brief as appropriate, the Minister for Transport and the Government Information Service.*
- *Keeping all authorities involved fully advised of SAR incident progress with timely and regular situation reports (SITREPs).*
- *Making recommendations and decisions in relation to the continuation or suspension of searches.*
- *Issuing news media releases on the progress of incidents in accordance with the procedures and policies.*
- *Providing debriefs of SRU's, cancel alerts, release SAR assets and organisations involved, and issuing the final SITREP to all concerned.*

- *Acting as required coping with any unique, unusual or changing circumstances of the emergency.*

1.19.3 Where a maritime incident requires an aviation response, the Coast Guard shall liaise directly with agencies that may supply such resources. IRCG's MRCC/SC shall be responsible for the provision of such services as fuelling, accommodation, security and any such additional services. Where aviation resources are required in response to an aviation incident, the IAA's RCC shall be responsible for the provision of resources and any such support services as are required. Where airport facilities for marine related incidents are required outside the normal hours of availability of such facilities, MRCC/SC shall be responsible for the call-out of such services as required.

1.23.2 The Department of Transport while retaining overall responsibility for Aviation Search and Rescue Operations (ICAO Annex 12) has determined that the Irish Aviation Authority (IAA) will operate the ARCC requirements of ICAO Annex 12 as an agent of the Department of Transport (Ref. ICAO Annex 12; S.I. No. 171 of 1995; S.I. No. 172 of 1995). The Aviation Search and Rescue Region covers an area coincident with the Shannon FIR/UIR

1.23.3 In the event of an aviation emergency over a maritime or littoral area, ARCC/ARSC will co-ordinate the incident in close liaison with MRCC/MRSC. Should an aircraft force land in a maritime area, ARCC/ARSC will be responsible for determining the initial search area, but co-ordination will then transfer to MRCC/MRSC with continued close co-operation and back-up services from ARCC/ARSC.

1.23.4 In the event of an emergency meeting at the Marine Emergency Room, requiring an aviation input, the Head of ARCC Shannon will decide on the appropriate representation. The AAIU may also consider a need for representation at this meeting where appropriate or where requested by the IRCG.

1.23.5 Routine communication shall take place by means of documentary, electronic or verbal transfer. ARCC/ARSC will be included as information addressee in routine Sitreps issued by MRCC/MRSC where the incident may require or include an aviation response. The AAIU will be included as information addressee in routine Sitreps issued by MRCC/MRSC where the incident may require a response and investigation by the AAIU.

1.23.6 Where a maritime incident requires an aviation response, it is the MRCC/MRSC who will liaise directly with agencies, which may supply such resources. MRCC/MRSC are responsible for the provision of refuelling, accommodation, security and any additional related services.

…

2.1.2 IRCG provide medical link calls from ships at sea to the vessel's national medical centre and evacuation of the casualty from the vessel by helicopter or lifeboat if required. If medical advice requires the casualty to be taken off the vessel then the MRCC/MRSC providing the link will arrange for the casualty to be transported from the vessel to a hospital. IRCG Responders or aircrew dealing with patients in remote locations can be linked live through a Coordination centre on marine communications to Medico Cork or any foreign Medico Centre.

2.2.4 Helicopter tasks include:

- *The location of marine and aviation incident survivors by homing onto aviation and marine radio distress transmissions, by guidance from other agencies, and by visual, electronic and electro-optical search.*
- *The evacuation of survivors from the sea, and medical evacuees from all manner of vessels including high-sided passenger and cargo vessels and from the islands.*
- *The evacuation of personnel from ships facing potential disaster.*
- *Search and/or rescue in mountainous areas, caves, rivers, lakes and waterways.*
- *The transport of offshore fire fighters or marine ambulance teams and their equipment following a request for assistance.*
- *The provision of safety cover for other SAR units including other Marine Emergency Service helicopters.*
- *Inter-agency training in all relevant aspects of the primary role.*
- *Onshore emergency medical service, including evacuation and aero-medical tasks carried out with specific Approvals issued in accordance with Joint Aviation Requirements JAR OPS 3.005(d).*
- *Relief of the islands and of areas suffering from flooding or deep snow.*

The secondary roles of the helicopter include:

- *The exercise of the primary search, rescue and evacuation roles in adjacent Search and Rescue regions. • Assistance to onshore emergency services in accordance with IAA approvals.*

…

2.3.1 The IAA is a semi-state agency responsible to the Department of Transport for the provision of Air Traffic Services (ATS) including Air Traffic Control (ATC). This includes the provision of an Aeronautical Rescue Coordination Centre (ARCC) at Shannon Airport and an Aeronautical Rescue Sub Centre (ARSC) at Dublin airport. The Aviation Search and Rescue Region covers an area coincident with the Shannon FIR/UIR.

2.3.2 ARCC/ARSC shall be the co-ordinating agency for establishment of Temporary Restricted Areas when so required for SAR purposes. Clearance to enter, operate in or leave any of the above mentioned areas should be obtained from the appropriate ATS units.

2.3.3 Where aviation resources are required in response to an aviation incident, ARCC will request resources and any support services as are required.

2.3.4 The Safety Regulation Division of the Irish Aviation Authority has the function with regard to aviation legislation and regulatory oversight of all civilian aircraft operations, including in this case Search and Rescue.

IRCG Standard Operating Procedures For Helicopter Operations, IRCG Helicopter SOPs, Issue 4 dated 25 April 2016 state, inter alia:

7.1. SAR flight:
All taskings to incidents at sea, cliffs, inland waterways, mountainous areas, or locations where access to, and/or extraction of the casualty is not safe by land ambulance or its crew, shall be classified as SAR and remain so until the mission has been completed. This shall be based on the best available information at the time of tasking.
…
10.1. Call-Out Authority.
The authority to call-out the aircraft is delegated by the Director IRCG to the Divisional Controller at the local RCC. To avoid the pitfalls of dual control and possible conflict of priorities, the aircraft shall in no circumstances respond to any call-out other than from its RCC, the Designated Officer or the Director IRCG.
…
10.4. Additional Night Callout Procedures.
When the state of readiness changes to 45 minutes each night, each base is to notify its local RCC of the names and telephone numbers of the Duty Aircraft Commander and Duty Winch Operator. In the event of a call-out the following standard actions will be taken unless different procedures are agreed for a specific base and promulgated in CHCI Local Staff Instructions and an Operational Notice to the relevant RCC.
…
11. Briefing Information.
Prior to launching, the RCC Controller should provide the crew with as much of the information listed at ANNEX H - MISSION BRIEFING as possible, and equivalent information for overland rescues.
…
12.1. A doctor at Medico Cork is constantly available to both IRCG and CHCI duty personnel to assess the urgency of the medical condition of injured survivors, to contribute to decisions on whether and when to launch, and to provide advice on the treatment of patients. CHCI crews can obtain the advice before launch or when airborne by requesting a link-call to Medico Cork through the co-ordinating or local RCC.
…
15.1. If the scene is more than 80 miles from shore, the Duty Controller should attempt to arrange Top-Cover by an IAC Casa or French Coastguard fixed-wing. The Top-Cover's greater height improves communications with the RCC, reduces the workload on the helicopter crew, and reduces search time by directing the rescue helicopter to the scene. The Top-Cover should be designated as OSC; […] see para 14.4 above.

15.2. If a fixed-wing aircraft will not be available in time, the rescue helicopter commander may request the RCC to launch a second S92 helicopter to shadow the rescue helicopter.

15.2.1. The decision to request the Shadow Helicopter will be based on the urgency of the operation, current and forecast conditions (daylight, cloud base, visibility, temperature and sea-state) and mitigations including waiting for the target vessel to steam closer, back-up by UK or French fixed wing and ships in the area.

15.2.2. The Shadow Helicopter will be positioned by the Rescue Helicopter in the optimum location to provide a communications link and to assist in the event that the rescue helicopter is ditched.

15.2.3. The Shadow Helicopter will be launched from the most appropriate base – probably Shannon for Waterford and Sligo rescues, Waterford for Shannon rescues south of N52, and Sligo for Shannon rescues north of N52.30. The Shadow Helicopter will launch with maximum fuel and fly for maximum endurance.

…

16.3. CHCI helicopters are to report their positions, status and endurance (to dry tanks) every 15 minutes to the Co-ordinating RCC which will maintain a continuous safety watch on aircraft movements. Position reports are to be by magnetic bearing and range from a significant point out to a range of 30 miles from the coast; at greater distances position is to be reported by latitude and longitude.

…

16.5. RCCs will track the helicopters on AIS and SkyTrac when it does not interfere with other RCC duties. Helicopters' 15-minute ops normal checks (as para 16.3) are the primary means of RCC monitoring.

101

ANNEX H - MISSION BRIEFING

MISSION BRIEFING		
1	Name/type of vessel and/or incident outline:	
2	Location/position: or grid reference: or bearing and distance from:	Lat: Long: at time: Carrickfin: Sligo: Blacksod: Shannon: Kerry: Castletownbere: Cork: Waterford: Dublin: Belfast International:
3a	Ship's course and speed:	
3b	Ship description/winching area:	
3c	Visual markings / description of LS:	
4a	Details of casualty(s) and injuries:	
4b	Medico Cork advice:	
5	Top cover/cooperating units:	
6	Radio frequency/call sign:	
7a	English speaking?	
7b	Deck crew briefed or experienced with hi-line:	
8a	Weather en-route:	
8b	Weather on scene:	

-END-

Appendix W — Technical Details Black Rock Light

Black Rock Mayo Marine Aid to Navigation Light: A Technical Review

The present marine aid to navigation light at Black Rock Mayo is a Tideland TRB-220 revolving beacon, shown here. The light character is created by an always ON (at night) 35W lamp within a rotating carousel containing 6 lens panels. The carousel rotates once every 72 seconds which creates a 0.3 second flash every 12 seconds.

Each of the 6 lens panel focuses the light coming from the lamp into a ‘pencil beam’ such that there are 6 ‘pencil beams’ rotating at night. The passing of the ‘pencil beam’ across the observer creates the flash of light. The red flash (in the red sector) is created by the beam passing through red filter material installed at the lantern room glazing. This is illustrated below in **Figure No. V1**.

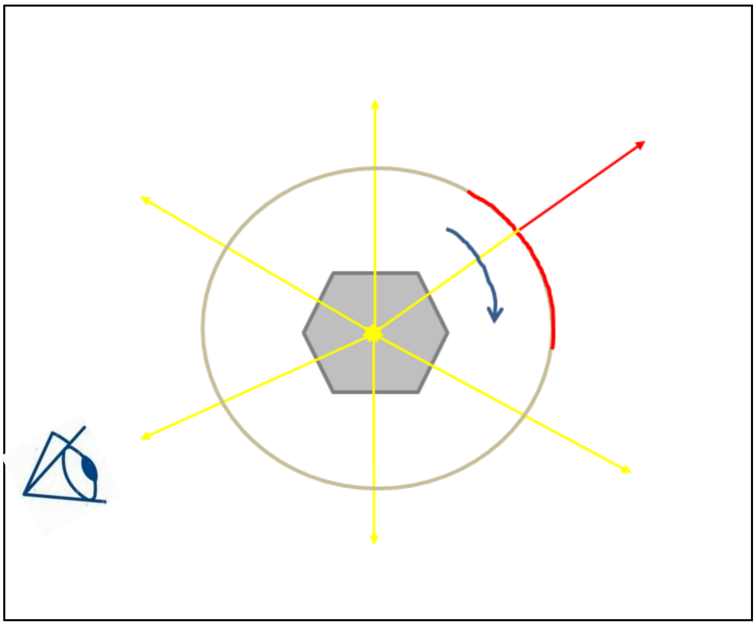


Figure No. V1: Illustration of white and red ‘pencil beam’ rotating through observer position (not to scale)

Peak Intensity and Effective Intensity

When an observer sees a flashing light, the intensity that is perceived is not the actual intensity of the light (the peak or stationary intensity), but a lower intensity based on the shape and length of the flash. This lower intensity is known as the ‘*Effective Intensity*’ and is used to calculate the nominal range of a light.

There are a number of mathematical formulas to calculate the ‘Effective Intensity’ when the Peak Intensity and flash length are known. IALA recommends the Modified simple Schmidt-Clausen formula is a very close approximation:

$$Ie = \frac{Io \times t}{(0.2+t)}$$

where Ie = Effective Intensity
Io = Peak Intensity
t = flash length

Tests on the Vertical Beam Profile of a 35W lamp in the TRB-220 is shown in **Figure No. V2** below. The peak intensity of 92,000cd (candelas) calculates to an 'Effective Intensity' of 55,200cd at a flash length of 0.3 seconds, which is an 18 NM light according to IALA figures (49,000cd – 73,000cd = 18 NM range).

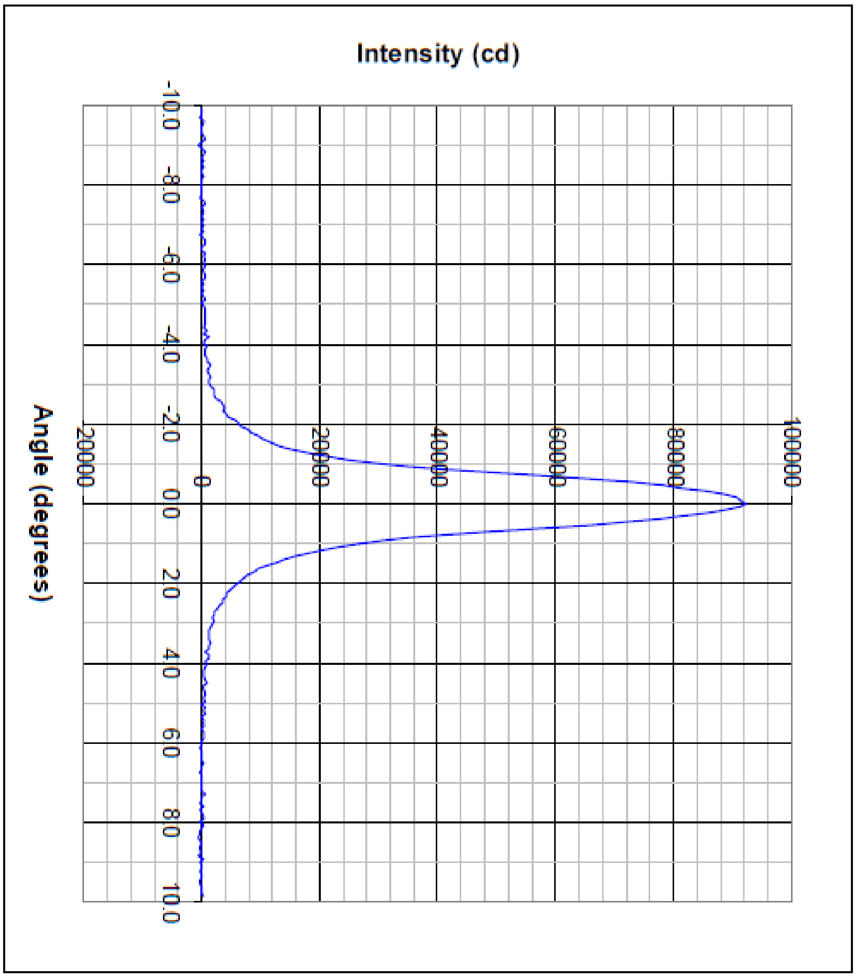


Figure No. V2: Vertical Beam Profile

Divergence

As already noted, the beam of light is referred to as a 'pencil beam'. This is a highly focused beam of light which the manufacturer states as having a horizontal divergence of 1.9^{o} (+/- 0.95^{o}) to 10%. The Vertical Beam Profile tests noted above show that the Tideland TRB-220 lantern has a vertical divergence of about 3.5^{o} (+/- 1.75^{o}) to 10%. This means that the intensity of the beam reduces to 10% of its maximum intensity at 1.75^{o} above and below the beam centre.

This means that if the observer is 1.75° below or above the beam centre, they will only see a light 10% as intense or as bright as if they were in the beam centre. At angles greater than 1.75°, the intensity of the light further reduces and, in effect, the observer can be said to be either above or below the beam.

Data shows that Rescue 116 was flying towards Black Rock over the last 1.5 NM (2,778m) on a steady heading at 200 ft ASL or approximately 100 ft (30 m) below the level of the light. Calculations show (**Table No. V1**) that if an observer were 30 m below the level of the light, the angle between the observer and the light is greater than 1.75° when closer than 1,000 m from the light. Effectively the observer is below the beam of light when closer than 1,000 m. At a distance greater than 1,000 m, the angle between the observer and the light will be less than 1.75° but will still be in the reduced intensity portion of the beam. It is not until approximately 2,000 m from the light that a reasonable intensity of light (44% of peak) would be expected. However, at this point, the distance from the light, especially in poor visibility, has a greater influence on whether the light can be seen or not than the divergence.

Metres below light	**30 m (100 feet)**									
Distance from light (metres)	100	200	300	400	500	600	700	800	900	1000
Angle to light (degrees)	16.7	8.5	5.7	4.3	3.4	2.9	2.5	2.1	1.9	1.7
Intensity percentage (estimated from Beam Profile graph)	0	0	0	0	1.5%	2.5%	4.4%	6.3%	7.5%	9%
Distance from light (metres)	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
Angle to light (degrees)	1.6	1.4	1.3	1.2	1.1	1.1	1.0	1.0	0.9	0.9
Intensity percentage (estimated from Beam Profile graph)	9.4%	10%	15%	20%	25%	28%	31%	31%	44%	44%

Table No. V1: Intensity of light at various ranges and angle to light

Nominal Range and Luminous Range

The International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) has the following definition:

'The nominal range of a light used as an aid to marine navigation is its luminous range in a homogeneous atmosphere in which the meteorological visibility is 10 sea-miles (nautical miles)'.

In the case of Black Rock Mayo, the nominal range published at 18 NM (white) and 14 NM (red) is valid only when the meteorological visibility is 10 NM i.e. in clear weather.

IALA publishes a Luminous Range Diagram (**Figure No. V3**), which shows how the Luminous Range of a light varies in different meteorological visibility. This shows for example that for a nominal range of 18 NM, in meteorological visibility of 1,000 m, the luminous range of the light is 3,000 m.

The local visibility on 14 March 2017 @ 00.45 UTC is noted as being 2-3 km (1 – 1.6 NM) with mist and drizzle. **Figure No. V3:** shows that a light of 18 NM ***nominal range*** will only have ***luminous range*** of approximately 3 NM when the meteorological visibility is 1 NM (poor visibility).

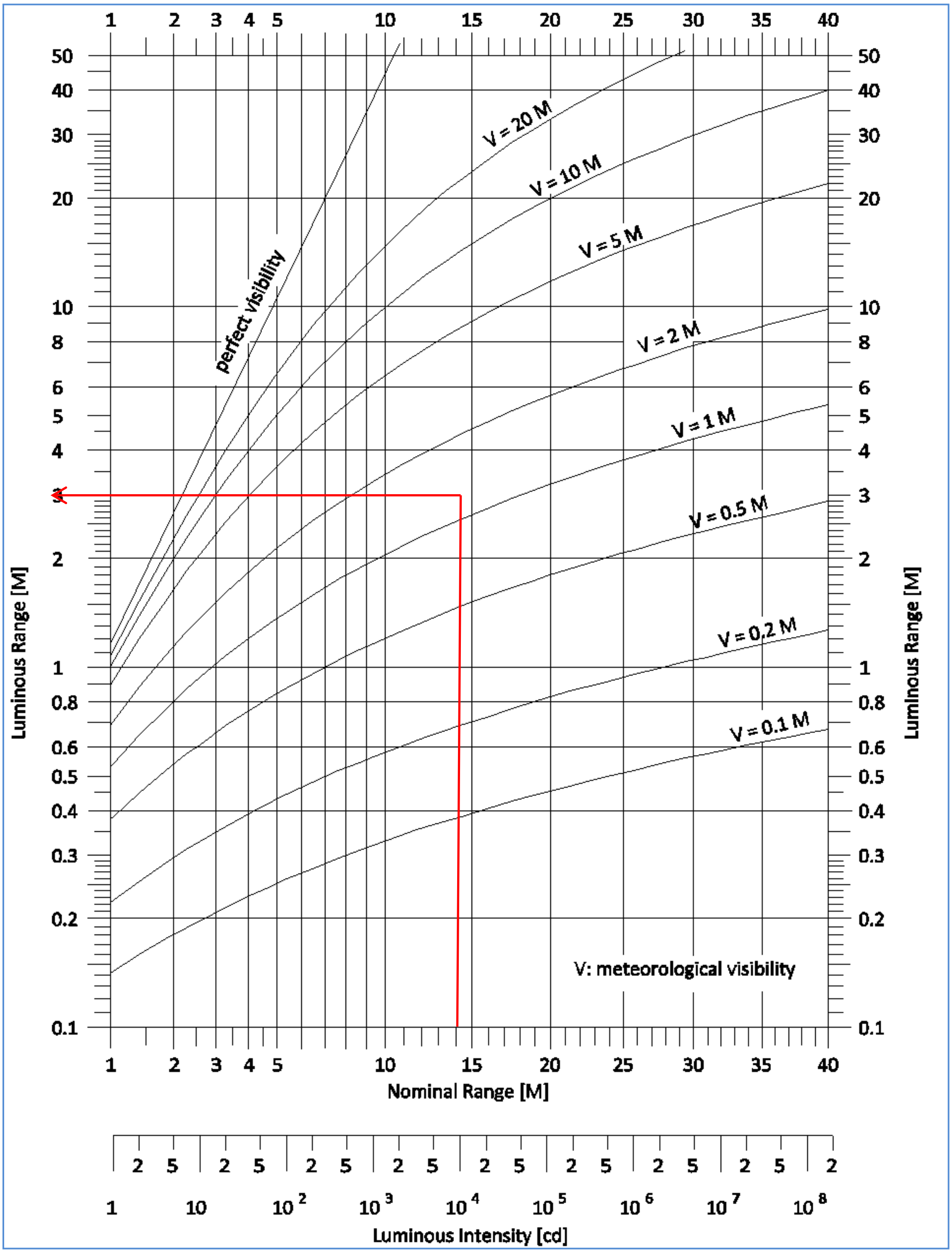


Figure No. V3: Luminous Range Diagram

Character of Light

The character of the light at Black Rock Mayo is published as Fl WR 12s (0.3 + 11.7). This translates to a 0.3 second White or Red flash every 12 seconds, i.e. a very short flash of light with a relatively long eclipse or dark period between the flashes.

Rescue 116 was travelling at a speed of 85 kts (160 km/hr) after turning and when heading eastwards towards Black Rock. At this speed, the Helicopter will travel 433 m in 12 seconds, i.e. will have travelled 433 m between each flash from the lighthouse. Over the last 1.5 NM (2,778 m), while heading towards Black Rock at that speed, only 6 of the short flashes would have been potentially visible, notwithstanding the beam divergence and visibility limitations.

Geographical Range

The Geographical range is defined by IALA as the maximum distance at which light from a light or other aid to navigation can reach an observer, as limited only by the curvature of the earth and refraction in the atmosphere and by the heights of the observer and of the light or aid. For Black Rock Mayo, the light is published as being at an elevation of 86m above water. The horizon (0 m above water) is calculated as being 18.8 NM distant. The beam of light from Black Rock was directed towards the horizon.

Red Sector

The red sector alerts mariners to the dangers of the Inishkea and Duvillaun More Islands to the east and north-east of Black Rock Island. The characteristics of the red flash are identical to the white flash as described above in terms of divergence, flash length etc. but the nominal range of the red flash is less than the white flash. The reduction in luminous range due to poor visibility would be more pronounced in the red sector.

Rescue 116 passed just to the north of Black Rock when travelling from East to West, at an altitude of 1,300 ft. At this altitude, the Helicopter would be well above the beam of light. Furthermore, the cloud base was estimated to be 300 - 400 ft, therefore, it is likely that the Helicopter and light were in cloud and thus they would not have seen the light as it manoeuvred in proximity to the red sector.

-END-

Appendix X — Extracts from OMB and OMF (Visibility and Weather Limits)

OMB says:

‘***2.12.9 Night and DVE visual approaches offshore***

DVE is defined as visibility less than 4000 metres or no distinct natural horizon. Circuits shall be flown at 500 feet with reference to the RADALT with speed at least V_Y[29]. Once established on the final approach track inside 2 nm at 500 feet, couple or remain coupled to RALT, HDG and IAS and beep down to 300 feet (or deck elevation plus 50 feet, whichever is the higher), to be level by around 1 nm to run. Aim for gate positions on final approach at 1 nm from the destination with a groundspeed of no more than around 60 knots, and at 0.5 nm from the destination with a groundspeed of no more than 50 knots. Confirm the approach is stabilised at 0.5 nm to run. As the aircraft approaches the descent point, or as IAS is reduced to 55 knots, if sooner, request PM to deselect airspeed, then set a nose up attitude to decelerate the aircraft further. When at the descent point, decouple and descend to the helideck.’

OMF provides the following definitions:

‘Airborne radar approach
A radar approach flown using a combination of aircraft radar, AFCS and FMS for horizontal / vertical course guidance and lateral separation from obstacles’

‘SAR distress / SAR immediate
An imminent threat to life exists, or may exist under slightly different circumstances.’

‘SAR operational flight
This is a flight to retrieve persons in distress from a hostile environment and deliver them to a place of safety. Initial medical care may be provided if specified by the contracting agency. In some jurisdictions, the flight may use a rescue call sign.’

OMF says:

‘Commanders are reminded that the application of weather minima should be based on the urgency of each particular mission. At the commander's discretion, higher weather minima may be applied to any particular mission with the decision passed, if required, to the contracting agency. The aim of the weather limitations as set out below is to allow maximum flexibility to aircraft commanders while also providing an appropriate degree of safety.

The intent is to focus the decision to launch on whether or not the meteorological conditions are suitable for the particular task in hand. Secondary tasking limitations are specified in EASA OPS for normal CAT flights.

[29] ***V_Y***: Best rate of climb speed; equivalent to V_{BROC}.

SAR distress / medevac immediate and medevac urgent limits are defined in this section. SAR training limitations are defined in the next section (see section 2.9 Weather limits – SAR training flight).

2.8.1 Departure

2.8.1.1 SAR distress / medevac immediate

Commander's discretion: Cloud base and visibility / RVR should normally be for the class of profile flown.

2.8.1.2 Medevac urgent

Minimum cloud ceiling 100 feet and minimum RVR is 200 m.

2.8.2 En route VMC

2.8.2.1 SAR distress / medevac immediate

a) *Clear of cloud and in sight of the surface. Aircraft is to be operated at an appropriate speed for the prevailing conditions and airspace.*
b) *Certain alleviations and exemptions are contained within the CHC Ireland National SAR approval.*
c) *Night overland: Minimum operational height of 500 feet AGL (reduced to 200 feet offshore if autopilot coupled to RALT).*

2.8.2.2 Medevac urgent

Day:

a) *COCISS (250 feet and 800 m) or visibility 5 km and clear of cloud (1000 feet vertically and 1500 m horizontally)*

b) *Clear of cloud (1500 m horizontally and 1000 feet vertically).*

Night:

a) *Minimum visibility 5 km.*

b) *Aircraft to remain clear of cloud.*

c) *Night overland: Minimum operational height of 500 feet AGL (reduced to 200 feet offshore if autopilot coupled to RALT).*

2.8.3 En route IMC

Comply with the IFR requirements in OMA.

2.8.4 Low-level offshore night or IMC.

AWSAR: Minimum height 200 feet with collective axis coupled to RALT and absolute minimum of 50 feet aircraft hover with collective coupled to an AFCS SAR mode height hold. If the SAR mode auto-hover system is unserviceable, the RADALT limit of 200 feet applies. If the RALT hold is additionally unserviceable, the aircraft may only descend to 300 feet AMSL on the ALT hold provided it is serviceable. If no height hold is serviceable, the aircraft should remain at 500 feet AMSL or above. If the RALT itself is unserviceable, the aircraft may only descend below 500 feet in accordance with any restrictions placed in the type-specific MEL.

Visibility sufficient for the requirements of the task and to satisfy any OMB requirements for system modes being used.

Minimum lateral clearance: An absolute minimum of minimum radar range using permitted navigational radar modes[30] *should applied to all obstacles not visually identified / correlated by eye and / or by FLIR if available.*

Consideration should also be given to the following factors:

a) Increasing the absolute minimum stated above to allow sufficient margin for escape headings and contingency procedures such as OEI.
b) Selection of appropriate airspeeds and / or groundspeeds given the prevailing environmental conditions to provide maximum reaction times and options.
c) If the radar is unserviceable, then descent may be allowed to 500 feet AMSL provided that the let-down is conducted at a minimum of 5 nm from any known obstruction (such as coastlines or an oil and gas platform) into a clear area, confirmed by latitude and longitude from a current chart or by appropriate radio navigation aids. Continued operation at 500 feet AMSL over water may be conducted provided the aircraft can be kept 2 nm clear of contacts / obstructions by FLIR or by FMS correlated with one other system. If at 500 feet AMSL, VMC can be maintained, then further closure or lower operation may continue under these rules.

As a general working guideline, separation from unidentified radar contacts should be at least 0.5 nm by radar unless the mission requirement / profile mandates closer proximity.

2.8.8.3 Offshore or coastal approach AWSAR

SAR distress / medevac immediate:

[30] **Permitted Navigational Radar Modes**: The Investigation asked the Operator what is/are the permitted navigational radar mode(s) and where is this permission laid down? The Operator informed the Investigation that it was not aware of any permissions as such and that it was not sure that such a permission existed. OMF also speaks about '*Radar, serviceable in approved navigation modes*'.

Let down using autopilot SAR modes is permitted to a minimum auto-hover height of 50 feet. Under no circumstances should the aircraft approach within ¼ nm of any target unless the PM is visual with the surface, clear of cloud, and travelling at a height and speed commensurate with being able to stop (if appropriate), initiate a climb, or execute the pre-briefed go-around procedure within the limits of the visibility at that time.

Without the SAR modes of the autopilot available, the missed approach point is 200 feet and ½ nm (radar). Visibility is to be assessed by the aircraft commander as sufficient for the task. Radar must be serviceable in the permitted navigational mode.

Medevac urgent:

Using SAR modes of the autopilot, the missed approach point is 100 feet and ½ nm (radar). Without SAR modes, the missed approach point is 200 feet and ¾ nm (radar).

[…]
3.3 Guidance for operations without AFCS SAR modes

While both LIMSAR and AWSAR helicopters can successfully reach a point in space 200 feet AMSL and ¾ nm at minimum safety speed from an offshore target, a successful winch rescue depends on the ability of the crew to manoeuvre the helicopter from this relatively safe position to a stabilised hover over the target.

Such a manoeuvre can be safely accomplished with minimal visual reference in an auto-hover equipped helicopter. With an AFCS LIMSAR helicopter, the deceleration and transition down to a circa 50-foot hover height requires adequate visual references. Such visual references cannot be easily quantified and a commander's assessment of what may be achievable prior to launch will be based on many variables such as:

a. Forecast or reported ambient light. Such light may be natural or artificial, for example, moon light, light from coastal towns, light from adjacent vessels / installations or indeed flares deployed by top cover aircraft.

b. Restricted vision from the cockpit caused by rain and / or salt spray

c. The nature of the target floating on the water. This includes size, configuration and stability in the prevailing sea state.

d. The likely winching position in relation to potential visual cues, such as a large stable ship under power and able to provide the optimum relative wind over its stern winching area, with full deck lighting, is much more likely to provide adequate visual references than a small fishing vessel which is unable to manoeuvre and which has little or no deck lighting.

While it is impossible to give precise guidance as to what is achievable by a an AFCS LIMSAR helicopter at night owing to the vast number of inter-related variables, some of which are indicated above, commanders are to give full consideration to the safety aspects of the operations particularly the likelihood of a loss of visual references (for example, boats less than 60 feet).

If tasked with a mission while AFCS LIMSAR, in which the lack of adequate visual cues are likely to be a factor, it may be opportune to suggest the tasking of the nearest AWSAR-capable aircraft.

[…]

3.19.1 SARA procedure

[…]

At the conclusion of the approach, the aircraft can continue to close the target until visual under FLIR or radar con or the decision point or appropriate SAR approach limits (whichever comes first), are reached.

3.19.3.1 Decision point

It is imperative that no doubt exists on whether collision avoidance is being provided visually, or by radar. Under no circumstances should the aircraft approach within 0.25 nm of any target unless the PM is visual with the surface, clear of cloud and travelling at a height and speed commensurate with being able to stop (if appropriate), initiate a climb, or execute the pre-briefed go-around procedure within the limits of the visibility at that time.

The decision point is nominated by the commander based on the following considerations:

- *a) Minimum effective radar range and actual visibility.*
- *b) Radar picture quality and contact density.*
- *c) Sea surface in visual contact (but possibly not with target)*
- *d) Medical category of casualty.*
- *e) Location of obstacles / hazards and high terrain in landing zone area.*

Although it may be appropriate for the PF to remain on instruments if adequate visual cues are available when reaching the decision point or SAR approach limits, it must be clearly understood that collision avoidance responsibility remains with the PM throughout, and continues once he takes control and becomes the PF. The aircraft can be positioned for landing or visual hover as required.

*If adequate visual cues are available when reaching the decision point or SAR approach limits, the PM must clearly state, **"Visual, I have control"**. The aircraft can then be positioned for landing or visual hover as required, although it may be appropriate for the PF to remain on instruments and continue to be conned into the target by either the PM or winch operator using RADAR or FLIR as applicable. In this case the PM will call **"Visual, continue"**. It must be clearly understood that collision avoidance responsibility remains with the PM throughout, and continues once he takes control and becomes the PF.*

*If visual cues are not available, then the PM will call **"Go-around"** and the pre-briefed go-around shall be flown.*

After a go-around, repeat approaches may be flown as fuel endurance allows'

-END-

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No 996/2010, and Statutory Instrument No. 460 of 2009, Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulation, 2009, the sole purpose of this investigation is to prevent aviation accidents and serious incidents. It is not the purpose of any such investigation and the associated investigation report to apportion blame or liability.

A safety recommendation shall in no case create a presumption of blame or liability for an occurrence.

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