ACCIDENT REPORT

MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

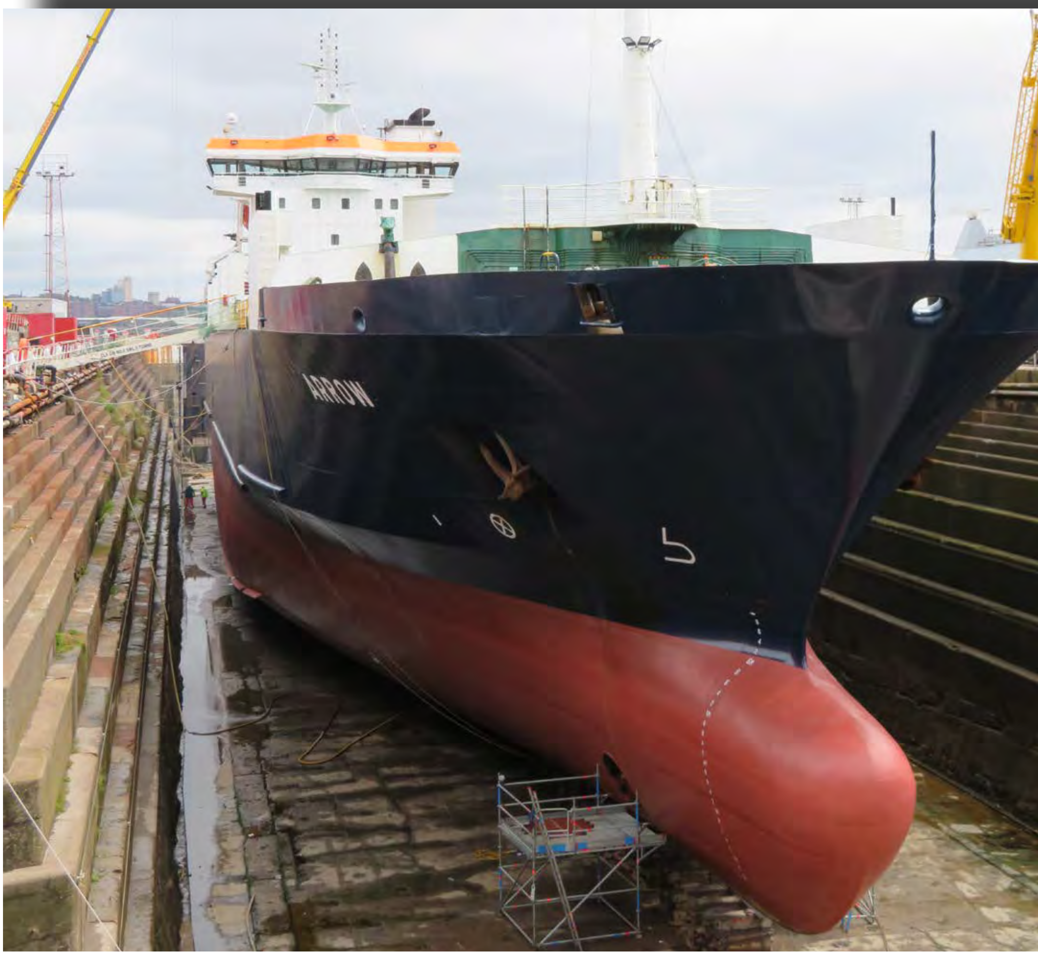
Report on the investigation of

the grounding of the ro-ro freight ferry

Arrow

in the approach channel of Aberdeen Harbour

on 25 June 2020



SERIOUS MARINE CASUALTY REPORT NO 8/2021 JULY 2021

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2012 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 14(14) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

2/O	-	Second Officer
3/O	-	Third Officer
AHB	-	Aberdeen Harbour Board
AIS	-	Automatic Information System
BA	-	British Admiralty
BRM	-	Bridge Resource Management
C/O	-	Chief Officer
CCTV	-	Closed-Circuit Television
CHA	-	Competent Harbour Authority
CoC	-	Certificate of Competency
COG	-	Course Over Ground
COLREGs	-	International Regulations for Preventing Collisions at Sea, 1972 as amended
con	-	The conduct of navigation of the vessel
CP	-	Controllable Pitch
DGPS	-	Differential Global Positioning System
DNV-GL	-	Det Norske Veritas-Germanischer Lloyd
DP	-	Designated Person
ECDIS	-	Electronic Chart Display and Information System
ECS	-	Electronic Chart System
ENC	-	Electronic Navigational Chart
GNSS	-	Global Navigation Satellite System
GPS	-	Global Positioning System
gt	-	gross tonnes
GtGP	-	Guide to Good Practice
IALA	-	International Association of Marine Aids to Navigation and Lighthouse Authorities
IMM	-	International Maritime Mobile
INS	-	Information Service
IoM	-	Isle of Man
ISM Code	-	International Management Code for the Safe Operation of Ships and for Pollution Prevention 1993, as amended

kts	-	knots
LOA	-	Length Overall
LPS	-	Local Port Services
m	-	metre
MCA	-	Maritime and Coastguard Agency
MGN	-	Marine Guidance Note
MPX	-	Master-Pilot Exchange
MSN	-	Merchant Shipping Notice
nm	-	nautical mile
OOW	-	Officer of the Watch
PEC	-	Pilotage Exemption Certificate
PI	-	Parallel Index
PMSC	-	Port Marine Safety Code
RA	-	Risk Assessment
RNC	-	Raster Navigational Chart
ro-ro	-	roll-on roll-off
Seatruck	-	Seatruck Ferries Limited
SMS	-	Safety Management System
SOLAS	-	International Convention for the Safety Of Life At Sea 1974, as amended
STCW	-	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended (STCW Convention)
S-VDR	-	Simplified Voyage Data Recorder
t	-	tonne
TOS	-	Traffic Organisation Service
UK	-	United Kingdom
UTC	-	Coordinated Universal Time
VDR	-	Voyage Data Recorder
VHF	-	Very High Frequency
VRM	-	Variable Range Marker
VTMIS	-	Vessel Traffic Monitoring and Information System
VTS	-	Vessel Traffic Service

VTSA	-	Vessel Traffic Service Assistant
VTSO	-	Vessel Traffic Service Officer
WBT	-	Water Ballast Tank

TIMES: all times used in this report are local unless otherwise stated.

Arrow

SYNOPSIS

At 0727 on 25 June 2020, after an overnight passage from Lerwick in the Shetland Islands, the ro-ro freight ferry *Arrow* grounded in thick fog while entering Aberdeen Harbour. There were no injuries or pollution, and the vessel was successfully re-floated 45 minutes later. There was significant damage to the port side of the underwater hull, including holing and splitting of several water ballast tanks and damage to the port propeller and rudder. Repairs required dry docking and the vessel was out of service for four weeks.

The investigation found that *Arrow*'s bridge team was not fully prepared for pilotage in restricted visibility and that Bridge Resource Management was poor. There was no effective shared mental model of the pilotage plan and the vessel's progress along it. A pilot exemption certificate holder provided by the vessel's charterer was navigating by radar and steering the vessel himself while receiving limited support from the remainder of the bridge team. He became overloaded in the fog that enclosed *Arrow* a few minutes before it entered Aberdeen's 70-metre-wide Navigation Channel and, while trying to correct a deviation to the north of the planned track, he over-corrected to the south. The over-correction was not noticed by the bridge team in time to avoid grounding.

The navigation techniques used did not provide *Arrow*'s bridge team with an accurate view of the available safe water in the Aberdeen approach channel. Poor bridge ergonomics and limited Electronic Chart System capabilities meant that the conning officer was navigating by use of radar alone.

After the grounding, *Arrow* began to list significantly in the falling tide and after 13 minutes the general alarm was sounded. Having verified that there were no internal ruptures and thus no ingress of water into the hull, *Arrow*'s master decided to attempt to re-float the vessel. Using *Arrow*'s engines and bow thruster and with the assistance of an Aberdeen Harbour pilot and a tug the vessel was re-floated, although pulling the ship off the bank probably caused some additional damage.

As a result of this accident, Seatruck Ferries Limited has undertaken a number of actions designed to improve the safe navigation of its vessels in pilotage waters, including, inter alia, implementation of effective Bridge Resource Management, clarifying its requirements for the conduct of pilotage by pilotage exemption certificate holders, navigation in restricted visibility and optimising the use of electronic navigation systems.

Aberdeen Harbour Board has reviewed its vessel traffic service procedures and introduced a graded pilotage exemption certificate system, together with enhancements to training.

SECTION 1 – FACTUAL INFORMATION

1.1 PARTICULARS OF *ARROW* AND ACCIDENT

SHIP PARTICULARS	
Vessel's name	*Arrow*
Flag	Isle of Man
Classification society	Det Norske Veritas-Germanischer Lloyd
IMO number	9119414
Type	Ro-ro cargo
Registered owner	CFCL Arrow LLC
Manager(s)	Seatruck Ferries Limited
Construction	Steel
Year of build	1998
Length overall	122.32m
Registered length	112.20m
Gross tonnage	7606t
Minimum safe manning	13

VOYAGE PARTICULARS	
Port of departure	Lerwick, Shetland
Port of arrival	Aberdeen, UK
Type of voyage	Short sea
Cargo information	Road freight trailers, commercial vehicles, cars
Manning	19

MARINE CASUALTY INFORMATION	
Date and time	25 June 2020, 0727 (UTC+1)
Type of marine casualty or incident	Serious Marine Casualty
Location of incident	Aberdeen Harbour approach channel
Place on board	Ship
Injuries/fatalities	None
Damage	Significant underwater damage to port side of hull including holing of water ballast tanks, deformation of hull plating, bilge keel, propeller, and rudder damage.
Ship operation	On passage
Voyage segment	Pilotage area
External & internal environment	Poor visibility in fog, light winds, sea state calm. Predicted height of tide 2.8m
Persons on board	19 crew

1.2 BACKGROUND

The roll-on roll-off (ro-ro) freight ferry *Arrow* was employed as a substitute for ferries in maintenance or repair and as such had no regular scheduled route. It was impractical for the ferry's deck officers to obtain and maintain pilotage exemption certificates (PECs) for all ports routinely visited, so a deck officer employed by the charterer, who held PEC's for the applicable ports, was frequently signed onto *Arrow*'s books for charter periods as an additional crew member.

The Aberdeen to Lerwick and Kirkwall freight services, operated by Serco Northlink Ferries, were normally delivered by *Helliar* and *Hildasay*, sister vessels of *Arrow*. The PEC holder on *Arrow* on 25 June 2020 was a chief officer (C/O) usually employed on *Helliar*.

1.3 NARRATIVE

At 1754 on 24 June 2020, *Arrow* sailed from Lerwick in the Shetland Islands, bound for Aberdeen, Scotland **(Figure 1)**, with 19 crew and an unaccompanied cargo of 51 freight trailers, three commercial vehicles and three cars. The passage plan had been used on three previous voyages in this charter period, had been updated to reflect conditions for the passage and took the ferry from berth to berth.

After departing Lerwick, *Arrow*'s master and the PEC holder discussed the following morning's entry into Aberdeen. They agreed that the PEC holder would handle *Arrow* for the approach and berthing, with the master supporting him. Both officers then had a ten-hour rest period.

At 0620 on 25 June, *Arrow*'s officer of the watch (OOW) confirmed the vessel's planned 0720 arrival time at the Aberdeen Fairway Buoy with Aberdeen Vessel Traffic Service (VTS) on International Maritime Mobile (IMM) very high frequency (VHF) channel 12. High water in Aberdeen was at 0441, it was two days after spring tides, and entry was scheduled for the middle of the ebb tide. The tidal stream was predicted to be setting across the harbour entrance to the north-west at about 0.8kts, reducing in the confines of the breakwaters. During ebb tides, a set to the north was expected in the Navigation Channel **(Figure 2)**, together with an outflowing tide that varied with the amount of recent rainfall. The weather had been dry, so the outflowing stream was about 1 to 2kts.

At 0650, *Arrow*'s third officer (3/O) took over the watch from the second officer (2/O) and started to complete the Pre-arrival checklist **(Annex A)** as the ferry closed the Fairway Buoy. Weather and sea conditions were calm, with light easterly winds. Visibility was 2-4nm with some patches of fog visible towards the coast. Vessel traffic was light; an offshore supply vessel, *Hermit Viking*, was waiting for a pilot to the east of the Fairway Buoy, and a small vessel was departing the harbour.

At 0705, *Arrow*'s 3/O reported to VTS that the vessel was 3nm from the Fairway Buoy. The PEC holder arrived on the bridge and began preparing to take over the conduct of navigation of the vessel (con) for harbour entry. He set up the ferry's S-Band and X-Band navigation radars, inserting a radar parallel index (PI) line on both displays on a course of 237º drawn at 0.05nm to the south to run on the Old South Breakwater **(Figure 3)**. After setting up the PI's on the 0.75nm range scale, he set the displays to the 1.5nm range scale, offset both displays to give a more detailed ahead look and set variable range markers (VRM) for the Turning Basin.

Reproduced from ARCS Chart 0002-0 by permission of HMSO and the UK Hydrographic Office

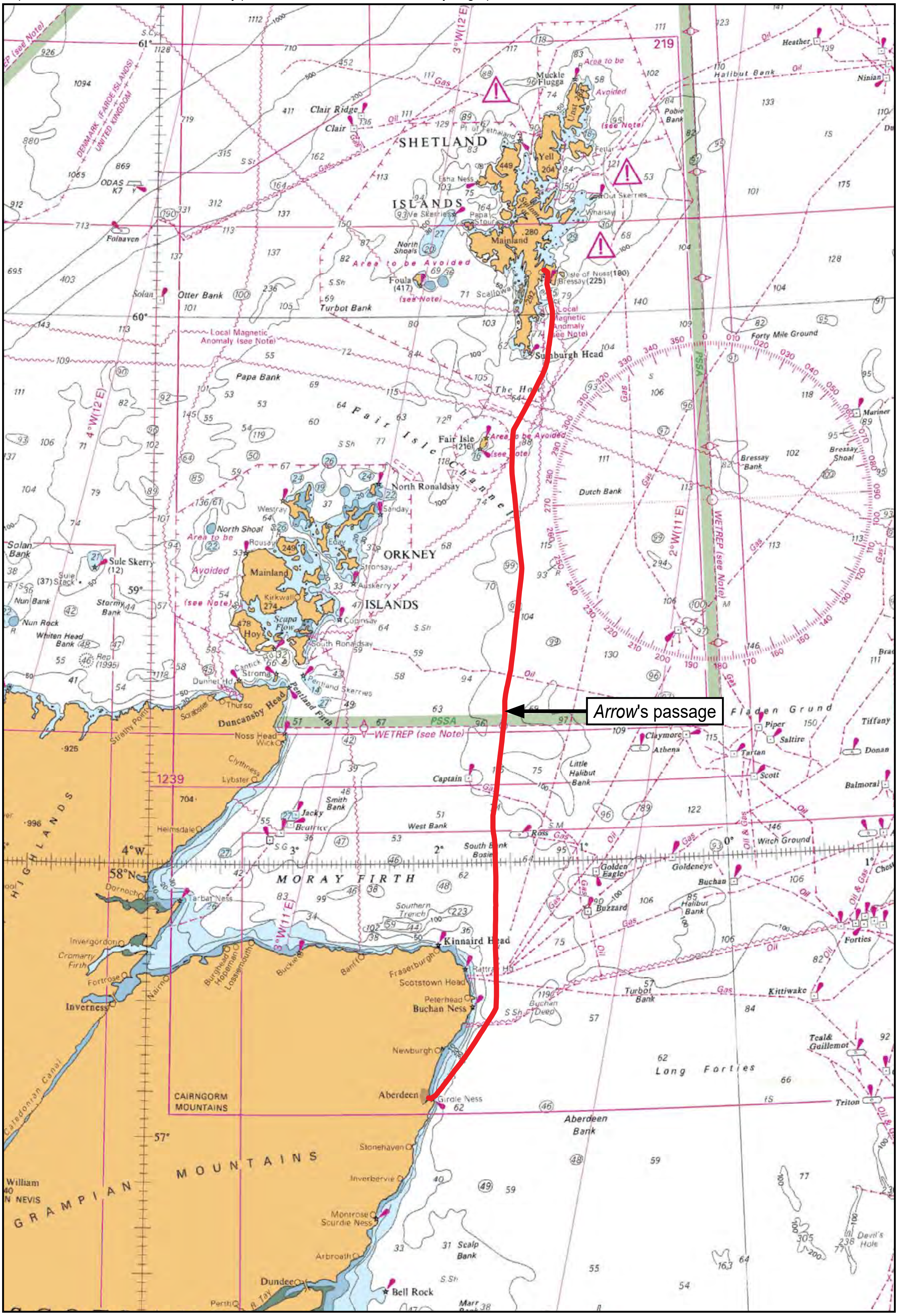

Figure 1: *Arrow*'s passage from Lerwick to Aberdeen

Image courtesy of Aberdeen Harbour Board (Crown copyright and database rights Ordnance Survey 100050351)

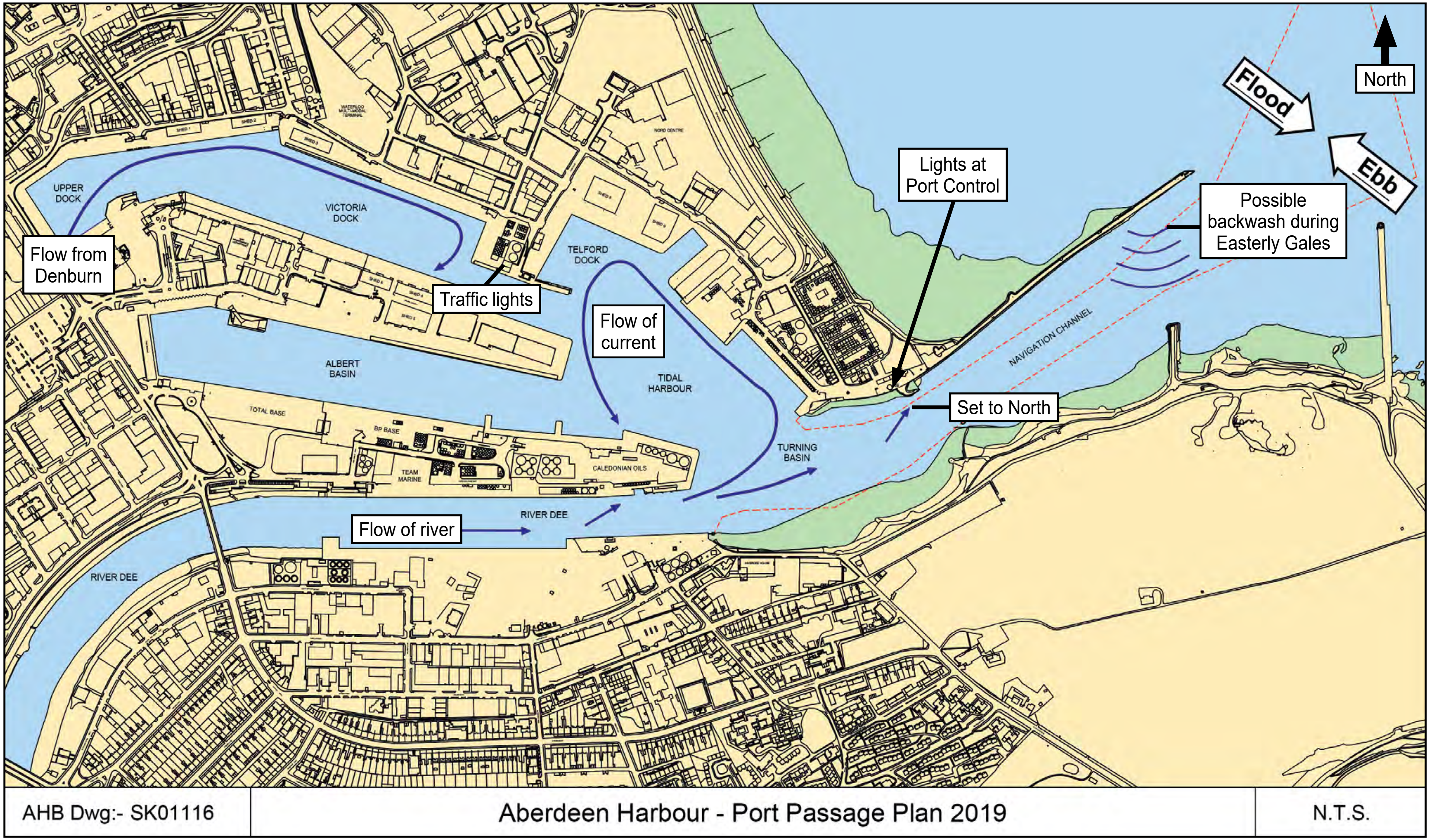

Figure 2: Aberdeen Port Passage Plan showing current effects

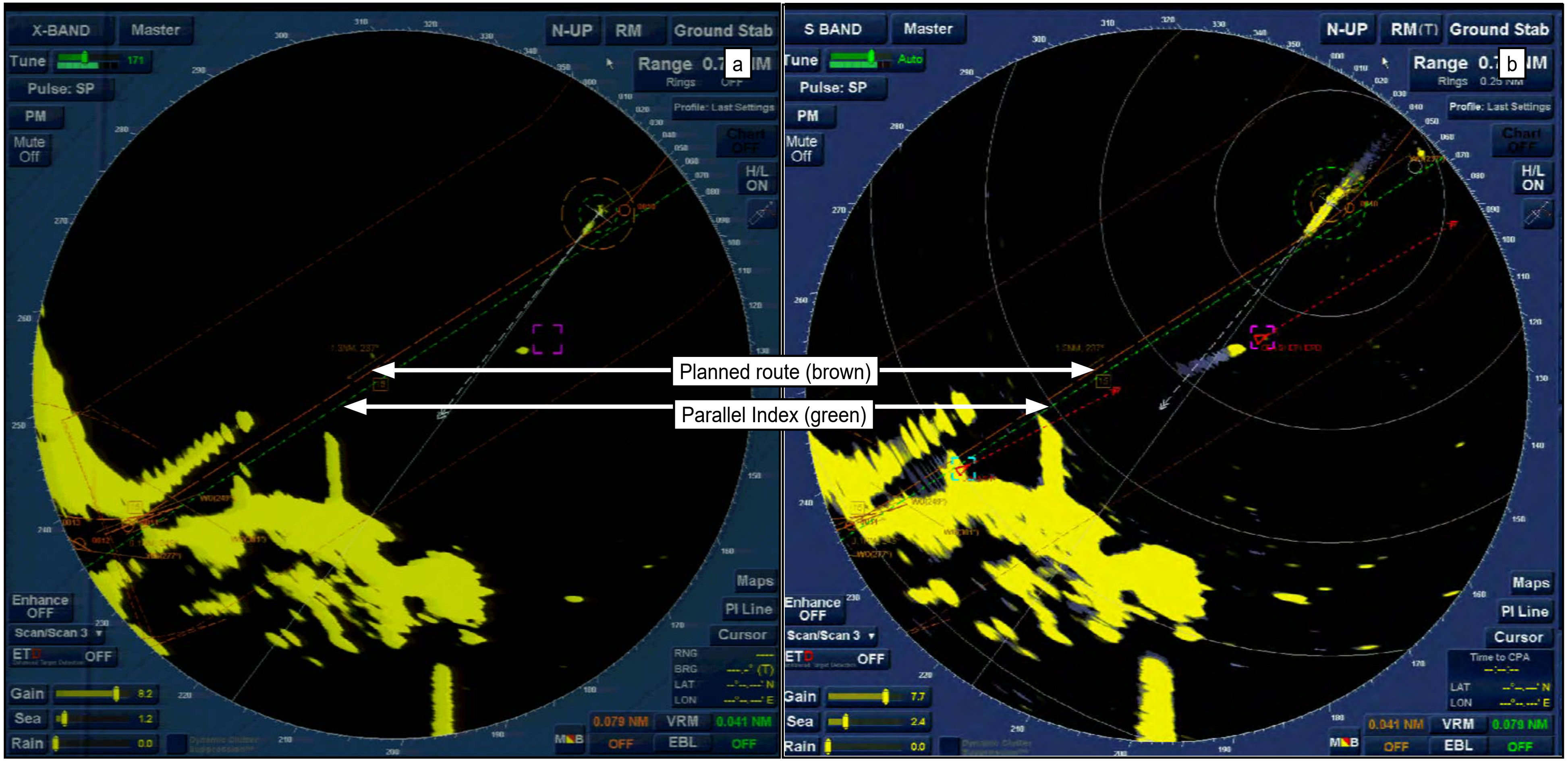

Figure 3: Radars set up for entry to Aberdeen. X-Band **(a)** and S-Band **(b)**
(Note: both displays offset to give maximum look ahead)

The ferry's planned route had been previously input into the Electronic Chart System (ECS), the display for which was located on the starboard side of the main console area **(Figure 4)**.

At 0712, *Arrow*'s master arrived on the bridge, checked the ferry's position and the current wind conditions and had a brief discussion with the PEC holder about the visibility. The PEC holder used images on his mobile phone from webcams situated to the west of the VTS station to demonstrate that the Turning Basin, at the western end of the entry Navigation Channel **(Figure 5)**, had clear visibility. Content that conditions were suitable for entry, the master made a cup of tea. *Hermit Viking*, still waiting for its pilot **(Figure 6)** at a range of 0.6nm, and the harbour entrance, about 1.5nm away, were not visible. The master and 3/O had a brief, informal toolbox talk to discuss mooring arrangements.

Arrow's speed was 13kts as it approached the Fairway Buoy and the PEC holder called VTS on VHF channel 12 to request permission to enter the harbour. Permission was granted at 0717:53, and the ferry passed the Fairway Buoy at 0718:42. The PEC holder engaged hand steering and used the tiller arm **(Figure 7)** to steer, which was located to the right of the X-Band radar that he was using for navigation. He also reduced *Arrow*'s speed to 10kts by adjusting the controllable pitch (CP) propeller levers. Initially, the PEC holder kept a relatively steady course, with the ferry slightly to the south of the Navigation Channel centreline **(Figure 8)**.

Recognising the decreasing visibility and having completed the Pre-arrival checklist **(Annex A)**, *Arrow*'s 3/O completed the Navigation in Restricted Visibility checklist **(Figure 9)**. Although all the items on the checklist were marked as being complete by 0720, a helmsman was not brought to the bridge and sound signals were not sounded as required by the International Regulations for Preventing Collisions at Sea (COLREGS) Rule 35[1]. *Arrow*'s 3/O continued to plot fixes on the paper chart, and the bosun, stationed on the forecastle, acted as a forward lookout.

As *Arrow* closed the harbour breakwaters, coastal fog began to reduce visibility. The master and PEC holder reduced the range scales on their radars to 0.75nm, and later to 0.5nm and then 0.25nm as the vessel passed the breakwaters. At 0721:57, VTS briefly discussed visibility with a pilot cutter on passage to *Hermit Viking*. The pilot cutter's skipper reported that they could just see the other side of the channel, implying visibility of about 150m. The conversation was heard by the PEC holder and master on *Arrow*, which was by then 0.3nm from the harbour entrance. The master asked the PEC holder if he was sure he wanted to continue, and the PEC holder answered that he was. There was no contact between VTS and *Arrow*.

As *Arrow* approached the harbour entrance, the PEC holder steered a heading of 250º, making good a course over the ground (COG) of 253º **(Figure 8)**, tracking to the north of the planned course of 237º along the centre of Aberdeen Harbour's Navigation Channel. Prompted by the master, who was using the S-Band radar and looking at the ECS display, the PEC holder altered heading to 225º. At 0724:51, *Arrow* came within 10m of the planned track as it passed the fog-obscured South Breakwater, and the PEC holder altered the ferry's heading to 234º.

[1] COLREGS Rule 35 requires a power-driven vessel making way in or near an area of restricted visibility, whether by day or night, to sound one prolonged blast at intervals not exceeding 2 minutes.

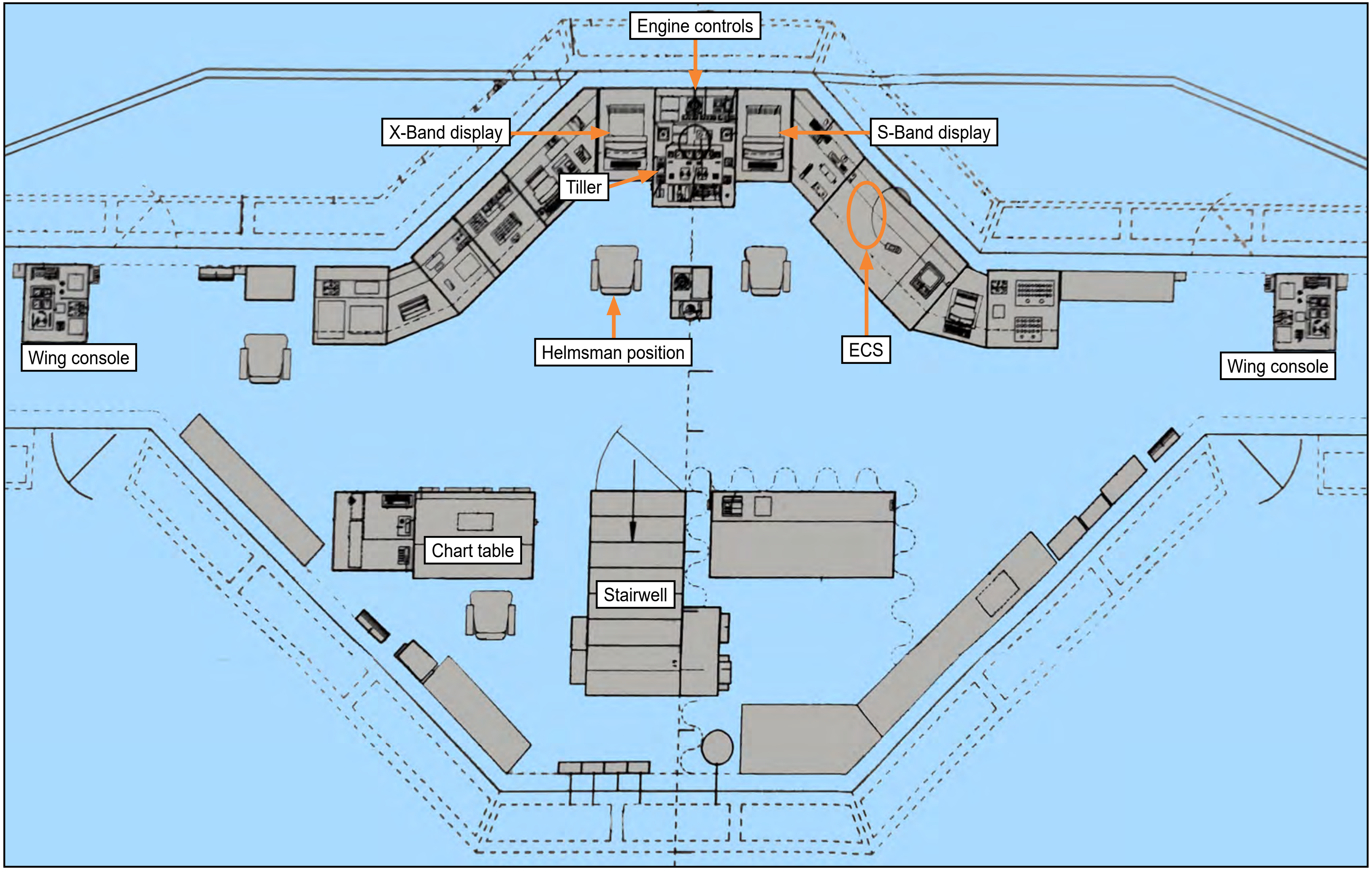

Figure 4: *Arrow* bridge layout

Reproduced from Admiralty Chart 1446 by permission of HMSO and the UK Hydrographic Office

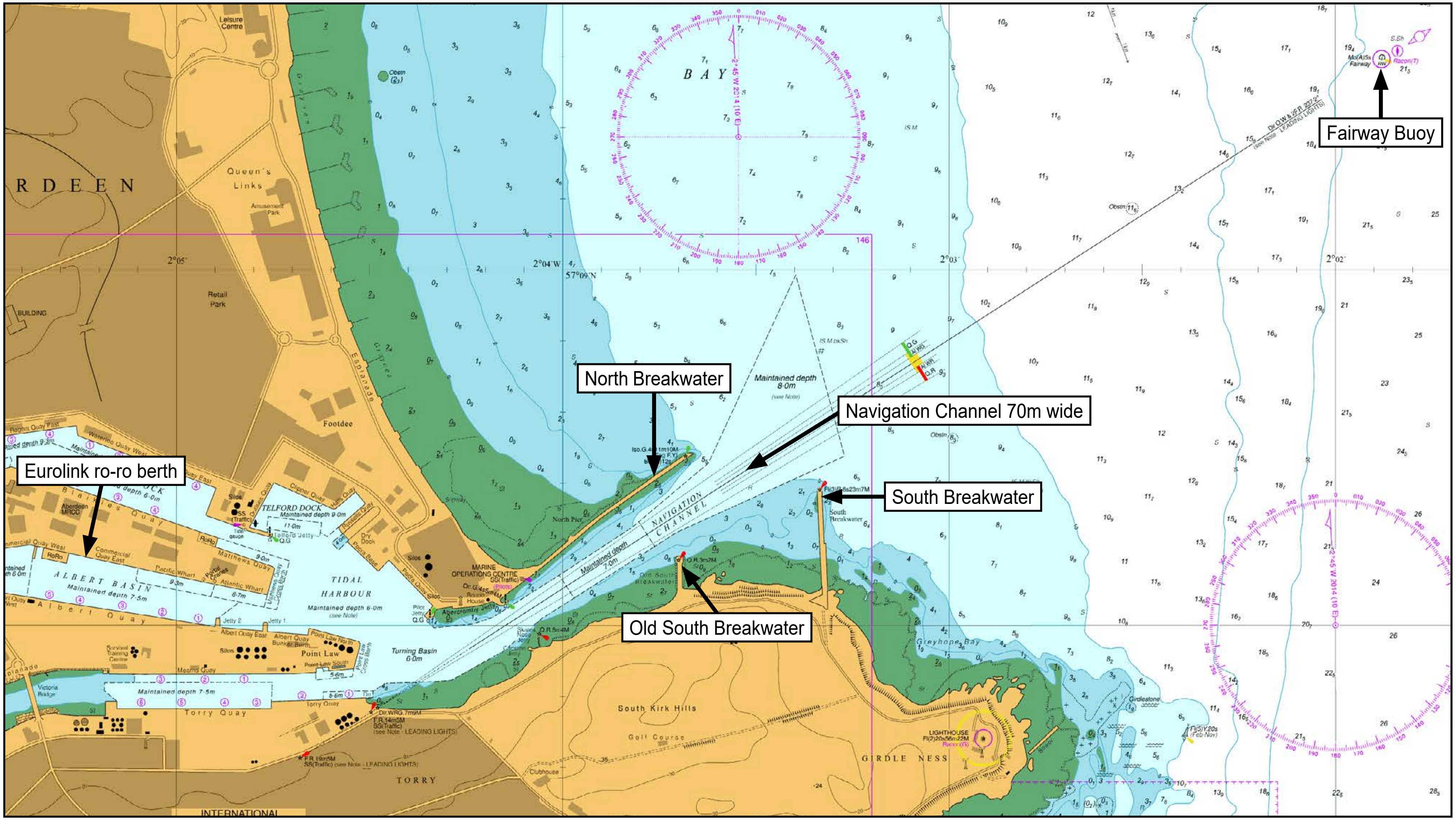

Figure 5: Extract from Admiralty Chart 1446 showing Aberdeen port and approach

Image courtesy of Aberdeen Harbour Board

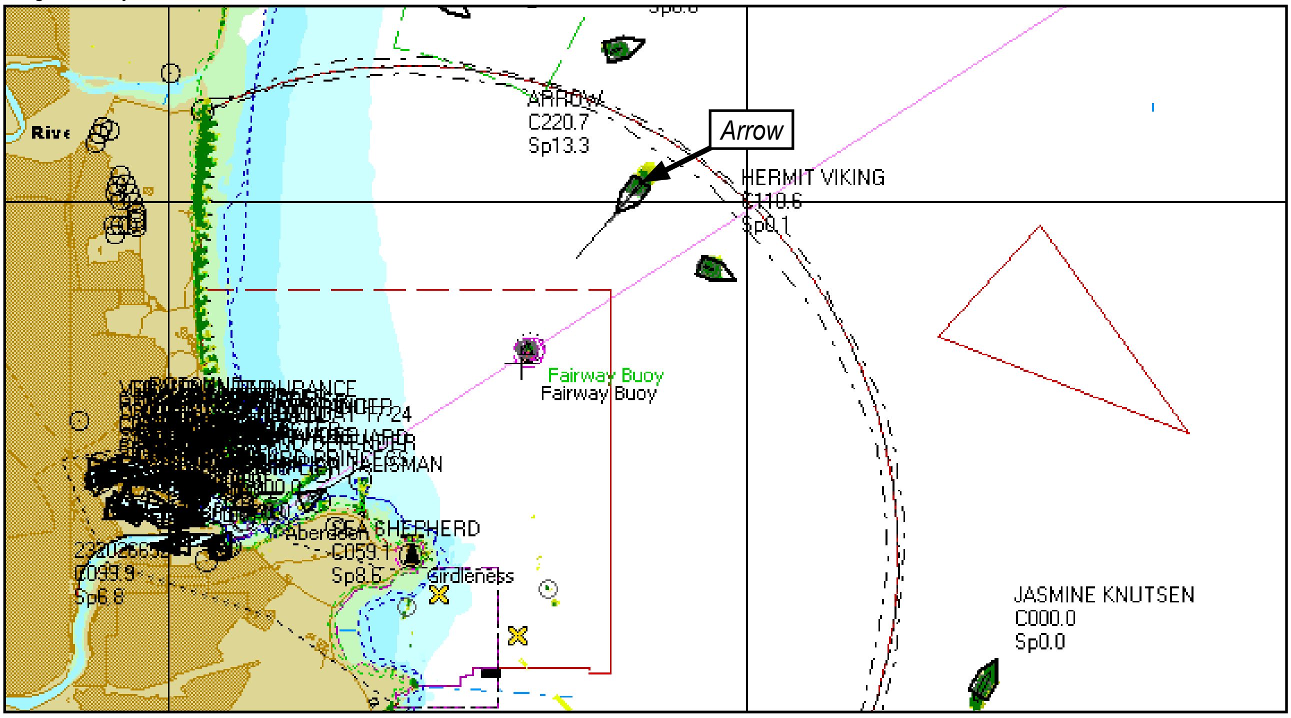

Figure 6: Screenshot from Aberdeen VTS equipment showing *Arrow*, *Hermit Viking* and the Fairway Buoy

Figure 7: Central bridge area layout

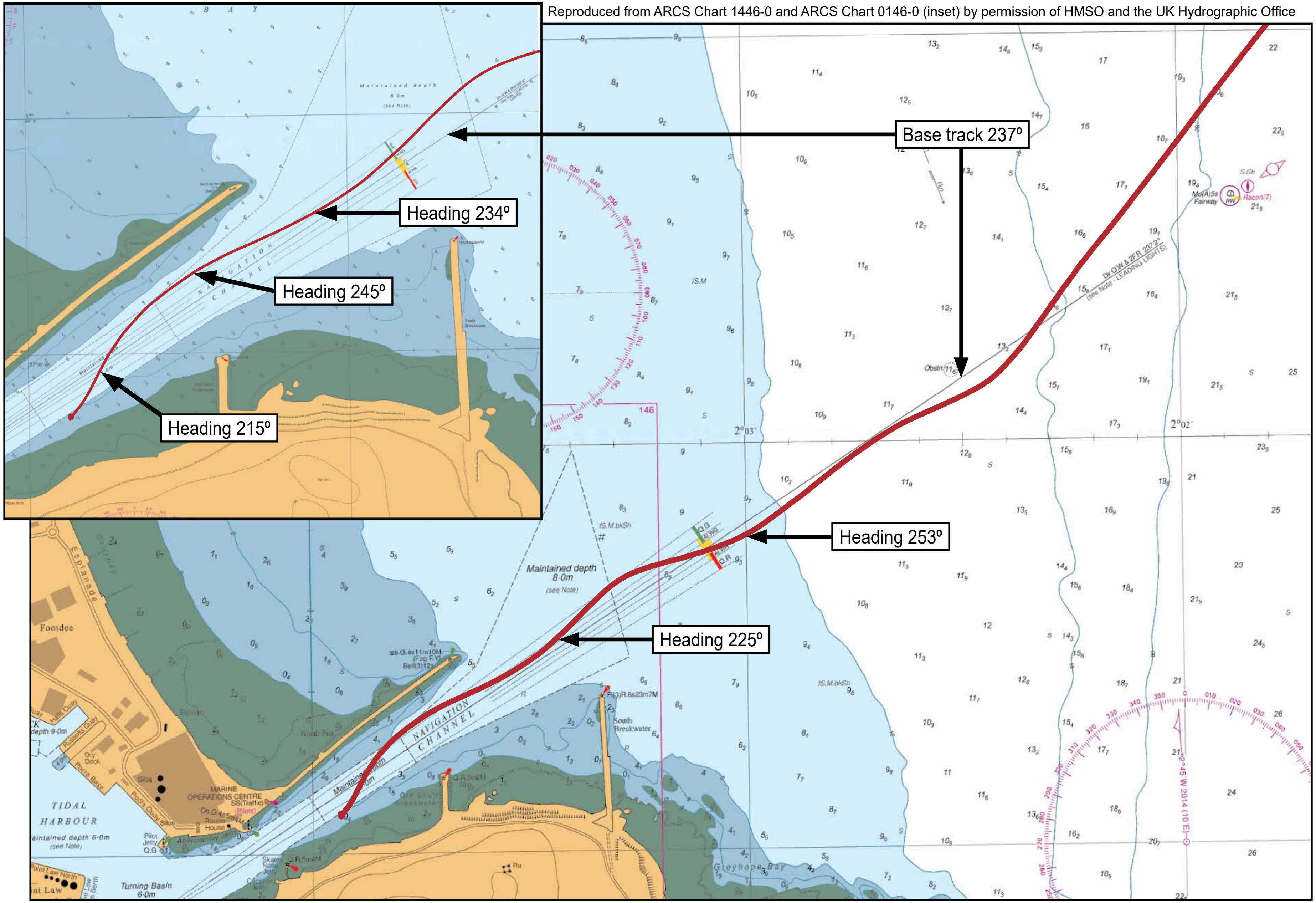

Figure 8: Plot of *Arrow*'s entry track on 25 June 2020

Image courtesy of Seatruck

SEATRUCK

Form 71

NAVIGATION IN RESTRICTED VISIBILITY

VESSEL	ARROW	DATE	25/06/2020	07.20
PASSAGE FROM	LERWICK	TO	ABERDEEN	

References:

- *International Regulations for Preventing Collisions at Sea (with particular reference to Rule 19)*
- *ICS Bridge Procedures Guide*
- *Bridge Team Management (NI)*
- *MGN 63 Use of electronic aids to navigation*
- *MGN 137 Look-out during periods of darkness and restricted visibility*
- *MGN 315 Keeping a safe navigational watch on merchant vessels*
- *MGN 324 Amendment 1 Navigation: Watchkeeping safety – Use of VHF radio and AIS*
- *MGN 369 Navigation: Navigation in restricted visibility*
- *SMS chapter 7.21 Navigation in restricted visibility*

Completion of this checklist is to be recorded in the deck log book

When in, or near an area of restricted visibility	
Inform the Master	✓
Inform the engine room	✓
Engines ready for immediate manoeuvre/SBE	✓
Proceed at a safe speed as defined by COLREGs Rule 6 and 19	✓
Post extra look-outs in accordance with SMS chapter 7.16.5.4	✓
Helmsman on standby	✓
Sound the appropriate sound signal as defined by COLREGs Rule 35	✓
Exhibit navigation lights	✓
Close watertight doors	✓
Monitor VHF Ch.16 and the nearest port channel	✓
Echo sounder on and set to appropriate scale	✓
Increase the frequency of position fixing	✓
Maintain effective communication throughout the bridge team	✓
Consider anchoring if the ship's position is in doubt	–
Monitor AIS for information but not for collision avoidance	✓
Ascertain tide information for height and set	✓
Navigate with extreme caution	✓
RADARS	
Maintain a constant RADAR watch	✓
Ensure both RADARS are correctly set up and functioning correctly	✓
Use clutter controls effectively and with caution	✓
Consider the effects of the weather on RADAR performance	✓
Monitor both long and short range scales	✓
Consider using sea stabilised modes for ARPA target details	✓
ARPA information is an aid to collision avoidance and not to be strictly relied upon	✓
COMMENTS:	

Figure 9: Seatruck Navigation in Restricted Visibility checklist

At 0724, *Arrow*'s 3/O plotted a Global Positioning System (GPS) position on the chart which was marked as 0725. The position indicated that the ship was north of the planned track **(Figure 10)**. A further fix was plotted at 0726, showing the vessel just to the north of the centreline. This position was not recorded in the log, and it is not clear if this was reported to the master and the PEC holder.

Extract from Chart 146 courtesy of Aberdeen Harbour Board and UK Hydrographic Office

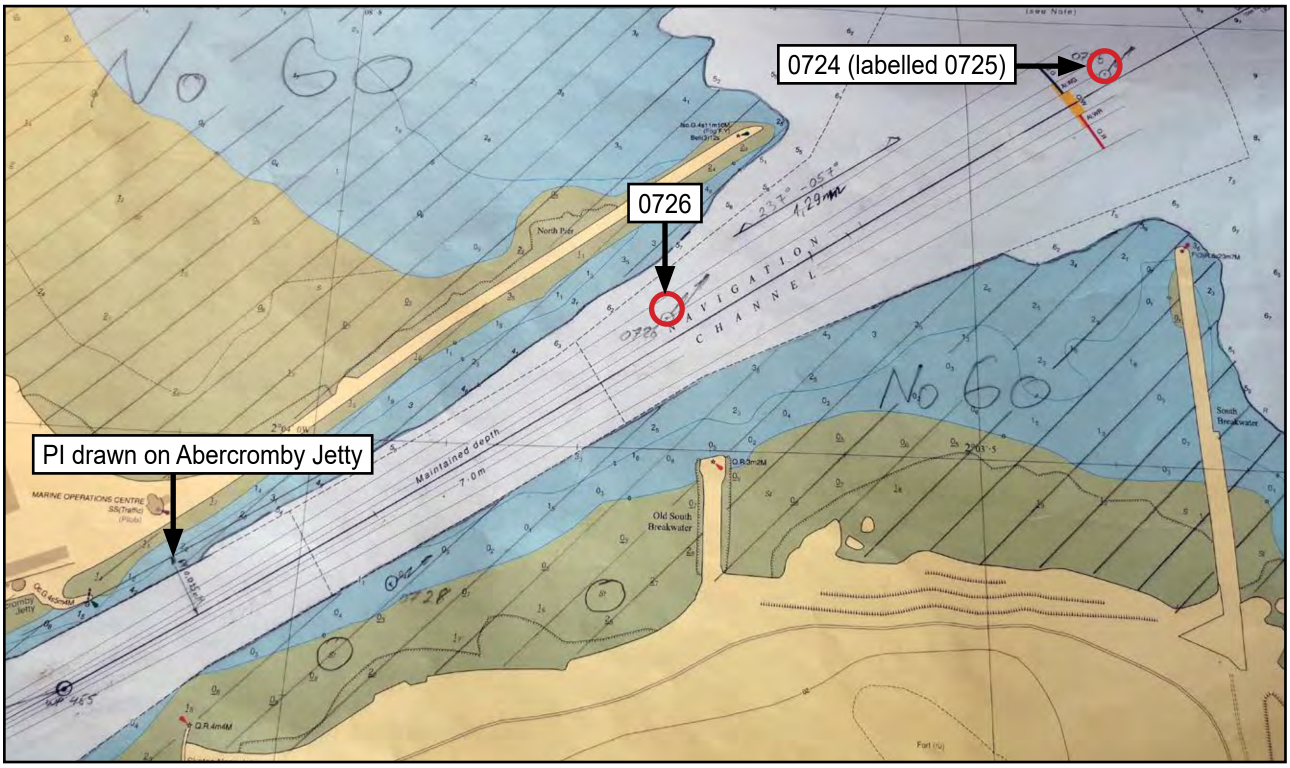

Figure 10: Extract from Chart 146 showing fixes at 0724 and 0726, both to the north of the centreline

Arrow was now fully in the Navigation Channel, and its PEC holder reduced the CP levers to dead slow. In response, the ferry's speed decreased to 6.5kts over the ground. The PEC holder altered *Arrow*'s heading to 245º, and the ferry again moved to the north of the centreline. This was not noticed immediately, and *Arrow* moved to the very edge of navigable water to the north. At about 0726, the master and PEC holder could see the North Breakwater and realised they were heading into danger.

Arrow's PEC holder applied about 10º of port rudder to bring the ship back towards the planned track. In response to prompting from the master, the PEC holder applied more helm until there was 30º of port rudder applied. The effect of the helm altered the vessel's heading to 215º, 22º off the 237º base track. *Arrow* rapidly crossed the narrow channel, and after 15 seconds, the PEC holder realised the new danger and applied maximum starboard rudder (35º) to turn the bows away from the channel edge. By now, *Arrow*'s bow was very close to the steep southern edge of the channel and while the bows turned to starboard, the alteration was too late. *Arrow* left the channel and grounded at 6.5kts, raking along its port bow and port side before coming to a stop on the southern edge of the Navigation Channel **(Figure 11)** at 0727:10.

Survey chart courtesy of Aberdeen Harbour Board

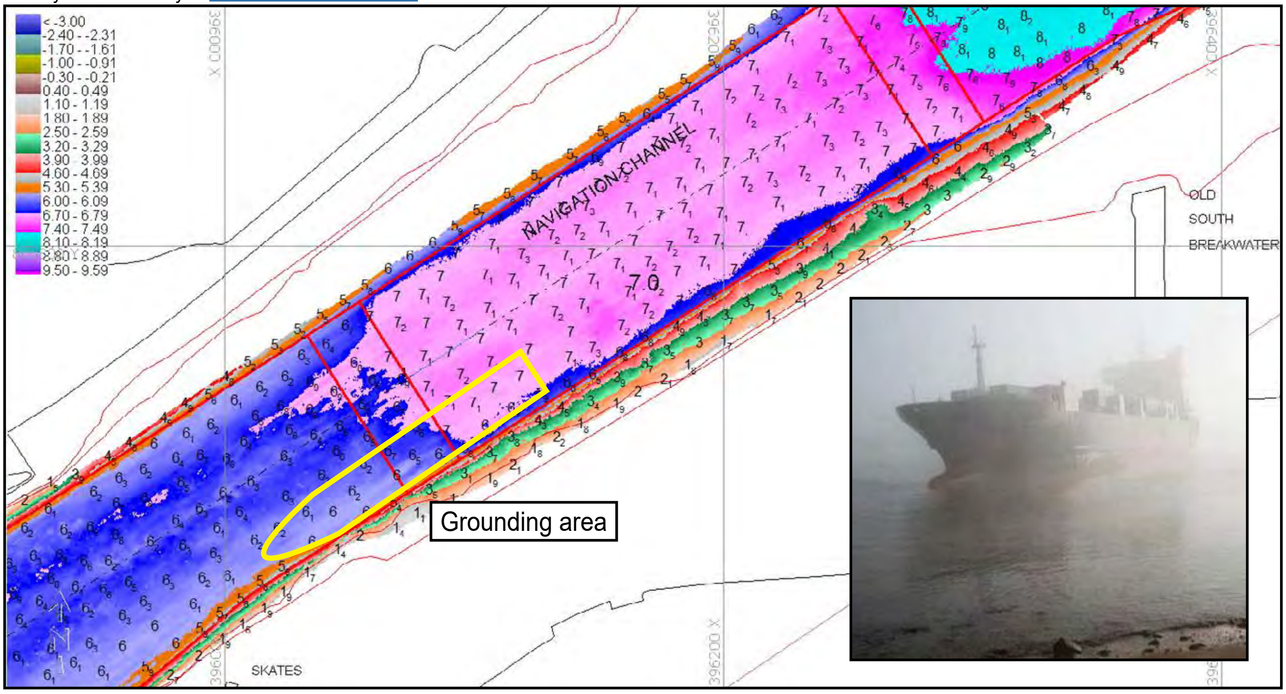

Figure 11: Aberdeen Harbour survey chart of Navigation Channel and *Arrow* aground

1.4 POST GROUNDING ACTIONS

Arrow's PEC holder brought the CP levers back to zero pitch, the master took the con and left the shafts turning but shut the idling bow thruster down. The PEC holder informed VTS that *Arrow* had grounded, and the master asked the 3/O to give him the Grounding/Stranding checklist **(Annex B)**. As *Arrow* settled, it took a list of about 2-3º to starboard. The master directed the crew to start internal checks for damage and water ingress, and for the 3/O and crew to go on deck to start sounding the ship's tanks, particularly forward. The deck crew were coordinated by the C/O, who also ordered the re-lashing of cargo trailers. With a reduction in draft forward and a slight increase aft, *Arrow*'s master concluded the ship was mainly aground by the bow and that the propellers were in sufficient water to safely turn. With no reports of any water ingress, and after contacting VTS, concerned by the increasing list, now 5-7º, and the falling tide, the master attempted to reverse off the bank. He worked the shafts up to 70% astern pitch, but *Arrow* did not move so he returned the CP levers to zero.

At 0740, the fog was clearing. *Arrow*'s list had increased to about 10º **(Figure 12a)** and the general alarm was sounded by the master. With no water ingress detected, the master decided not to send the crew to muster stations but directed them to remain at their posts. The alarm was intended to wake any off-watch personnel who were not yet aware of the grounding. After a short discussion with the master, the C/O went to the cargo control room to commence pumping forward ballast tanks to try to reduce the forward draft to assist in re-floating.

At about 0750, the Aberdeen harbourmaster informed *Arrow*'s master that a tug was underway, and that a pilot, required to control the tug, was also on his way. Once the tug arrived, it was connected to the starboard quarter. The pilot boarded at 0802, and after a brief discussion agreed with the master to attempt to tow the ferry off the bank. Power from the tug and thrust from the engines and bow thruster were gradually increased until at 0811 *Arrow* slowly moved off the bank and into the Navigation Channel **(Figure 12b).**

Photographs courtesy of Aberdeen Harbour Board

Figure 12: *Arrow* just before re-floating **(a)** and after re-floating **(b)**

There were no indications of water ingress or pollution and the ferry proceeded to its berth at the Eurolink ro-ro terminal. Once alongside, the cargo was safely unloaded. All members of the bridge team were breathalysed within two hours of the grounding; all results for breath alcohol were zero. Tests were conducted and witnessed by members of the crew, with the final test at 0912. No drugs testing was conducted.

A dive survey, conducted from 1115 that day, revealed significant damage to *Arrow*'s underwater hull on the port side. There was no compromise to watertight integrity of the inner hull, although the outer hull was pierced in several places. *Arrow*'s class certification was amended to allow a single voyage in ballast. The ferry was taken off-service and off charter and on 27 June departed Aberdeen for docking and repair in Birkenhead.

1.5 DAMAGE

Once docked, a full assessment of damage revealed holing to Water Ballast Tanks (WBT) 2 and 3 requiring new shell plating **(Figures 13** and **14)**, together with further shell repairs to cracks in several other areas on the port side. The port bilge keel was deformed in several places and there was significant scrape and dent damage to extensive areas of the port hull, which needed re-preserving, and in some areas, welding and flush grinding **(Figure 15)**. All four port propeller blades showed signs of damage and the port rudder and rudder stock required repairs. *Arrow* was out of service for four weeks.

1.6 ENVIRONMENTAL DATA

In the waters off Aberdeen, winds were easterly at about 5kts, there was a 0.5m swell offshore, and inshore waters were calm. Overnight, visibility was about 4nm, but some fog patches were observed along the coast, with thick fog reported on land. Sunrise was at 0414. From 0700, visibility at sea was reported as less than 2nm, and from 0711, it had dropped to less than 0.6nm in the vicinity of the Aberdeen Fairway Buoy and to less than 0.1nm in coastal areas by about 0720. When not affected by fog patches, the weather was clear and sunny.

Thirty-year climatological data indicated that Aberdeen had experienced an average of 46 days of fog, defined as when the visibility drops below 1000m, per year. Records for the month of June indicated fog on an average of 3.5 days per month. Coastal fog experienced in eastern Scotland is most common during spring and summer and is usually formed when relatively warm, moist air passes over a cool surface, causing the moisture to condense into tiny particles of water. In Aberdeen, this fog, known locally as ‘Haar’, is a regular summer occurrence. The fog produced can vary in density, is often patchy, and can develop and disperse quickly.

1.6.1 Forecasts

Serco Northlink Ferries provided *Arrow* with access to a contracted forecast provider. On 25 June, the forecast provided to *Arrow* indicated generally clear weather, with light to moderate easterly winds. Visibility was forecast to be poor at times, and UK Meteorological Office coastal and shipping forecasts concurred, indicating the possibility of fog patches.

1.7 *ARROW*

1.7.1 General

Arrow was a ro-ro freight ferry built in 1998 in Spain. Since 2007 *Arrow* had mainly operated around the UK as a replacement for similar sized scheduled ferries undergoing maintenance and repair. The vessel was Isle of Man (IoM) registered, owned by a holding company, CFCL *Arrow* LLC, operated by Condor Marine Services Limited and managed by Seatruck Ferries Limited (Seatruck). *Arrow*’s Safety Management Certificate, confirming that its Safety Management System (SMS) complied with the ISM Code[2], was issued by Det Norske Veritas-Germanischer Lloyd (DNV-GL) on 28 March 2018 and was valid until 28 March 2023. The vessel’s last internal audit took place in April 2019 with no navigational

[2] International Management Code for the Safe Operation of Ships and for Pollution Prevention.

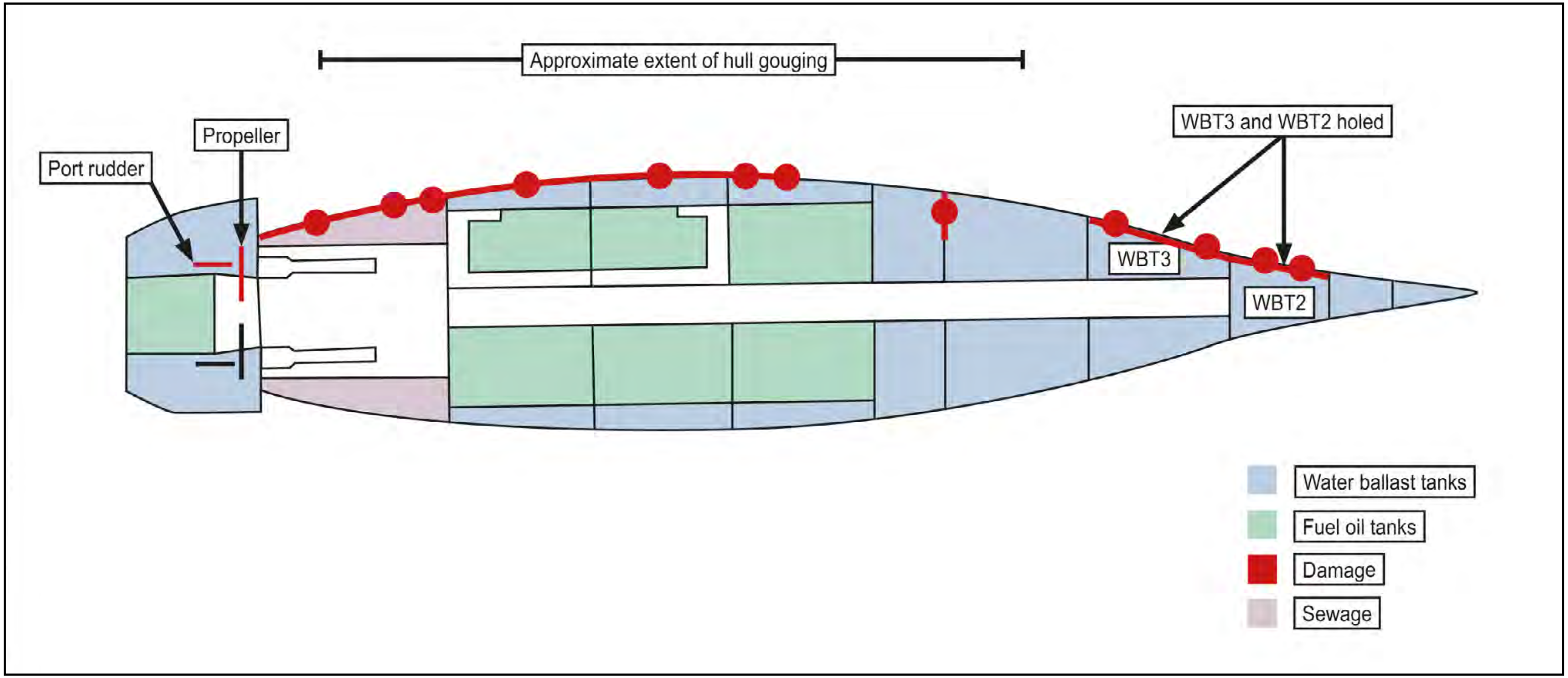

Figure 13: *Arrow*'s bottom tank arrangement showing areas of damage

Figure 14: Damage to *Arrow*'s water ballast tanks

Figure 15: Damage to *Arrow*'s hull, bilge keel, port rudder and propeller

non-conformances identified. An internal audit had been scheduled for April 2020 but had been delayed, with the approval of the flag state, due to the Coronavirus pandemic.

1.7.2 Construction

Arrow was of partial double-bottomed construction with the majority of the bottom spaces being water ballast tanks. A section of the central double-bottom area was given over to fuel oil tanks. At the time of grounding, most of the main ballast tanks were full or nearly full, with ballast at 75% capacity. Fuel tanks were at 27% on departing Lerwick, with the main tanks ranging from empty to 64% full. Draught on departing Lerwick was 5.2m forward and 5.4m aft.

1.7.3 Bridge layout and navigational equipment

Arrow's bridge was totally enclosed and contained three manoeuvring control consoles: a primary central console and two bridge wing manoeuvring consoles. The central console included the two main X-band and S-Band radar displays **(Figure 7)**, with slave repeats of the X-Band radar fitted on the wings.

Arrow's primary control console at the centre of the bridge forward included engine and bow thruster controls, together with a tiller arm rudder control lever to port and an emergency steering control to starboard. A gyro repeater was fitted in the upper central console area. Separate and slightly astern of the main console was a hand steering station, with a conventional wheel arrangement. A GPS receiver, VHF radio, Automatic Identification System (AIS) and echo sounder were fitted to the port of the main console, with the ECS display fitted to the starboard side.

Paper charts were *Arrow*'s primary source of navigational charting, with the ECS used to provide additional situational awareness. A full portfolio of corrected paper charts was available and were routinely used at a dedicated chart table towards the rear of the bridge **(Figure 4)**.

Arrow's installed navigational equipment included:

- Two Kelvin Hughes Manta radar systems; the port (smaller) display was linked to the X-Band (3cm) radar and the starboard display was linked to the S-Band (10cm) radar.

- An Anschutz Digital gyro compass.

- A Japan Radio Corporation JHS-182 AIS transceiver.

- Two GPS receivers – a Furuno GP-170 (Navigator) Differential GPS and a Samyung SPR-1400.

- A Koden CVR-010 Echo Sounder.

- A PC Maritime Navmaster ECS V.8.0.0.X loaded with fully corrected Admiralty Raster Charts supplied via C-MAP.

It was common practice on *Arrow* for the conning officer to use the X-Band radar and steer the vessel using the tiller arm fitted to the right of the radar display **(Figure 7)**. The S-Band radar and ECS were then monitored by either the pilot or PEC holder if the master was conning or the master if the pilot or PEC holder was conning. The ECS display was 2.5m from the X-Band radar display.

1.7.4 Propulsion system

Arrow was fitted with two Wartsila diesel engines, each driving a constant revolution outward turning CP propeller. Installed power was 7400kW, and a 600kW bow thruster was fitted. The vessel had twin rudders, each directly behind the respective propeller and ganged to operate in unison.

1.7.5 Radars

Both of *Arrow*'s radar displays had been similarly set up by the PEC holder prior to commencing pilotage **(Figure 3)**. Each was offset to the north-east to give a maximum look ahead as the ship entered the south-west-oriented Navigation Channel. Both displays were linked to either the GPS or DGPS receivers and had route waypoints input, shown as a red long-dashed line. A single PI, to run along the northern tip of the Old South Breakwater **(Figure 5)** was set up on each radar on a bearing of 237º and at a distance of 0.050nm to port. This PI was not noted on *Arrow*'s paper harbour approach chart although a PI was drawn on the chart, 0.025nm to starboard on Abercromby Jetty **(Figure 10)**. *Arrow*'s radars also had two VRMs set up to assist in clearing shoal patches in the Turning Basin. Each display was capable of displaying up to four PIs.

Arrow's radar displays were capable of displaying a scaled ship shape, offset according to the radar antenna position. This was not selected on either display for the duration of the entry to Aberdeen on 25 June 2020. However, the S-Band, and to a lesser extent the X-Band, displays did show radar returns from the bow, giving an indication of the length of the vessel.

Radar performance is a complex mix of pulse length, wavelength, antenna quality, installation, processing, atmospheric conditions, equipment set up and display system. On board *Arrow*, the radar's theoretical display accuracy on the 0.25nm range scale being used on the Manta X-Band radar at the time of the accident was 0.5m, limited by the number of pixels in the display. Realistically, a best-case whole system accuracy for a well-maintained system is of the order of +/ – 10m. This may be further degraded by the accuracy of the charting of the fixed objects being used for navigation and any effects due to the tidal height at the time.

1.7.6 Electronic Chart System

The ECS, although not *Arrow*'s primary means of obtaining navigational charting information, was routinely used to aid situational awareness. The system was interfaced to GPS, gyro heading and AIS, and the vessel's planned route was loaded. The system displayed a real-time plot of the vessel's position, together with a prediction of future movement based on past position updates. The ECS was loaded with raster navigational charts (RNCs), which are similar to scanned electronic copies of paper charts. When using RNCs, an ECS cannot display automatic warnings or alerts unless the user has manually input danger areas or lines. Although not type-approved, the ECS did have many of the capabilities of an electronic chart display and information system (ECDIS), including the ability to use vector electronic navigational charts (ENCs) and provide automatic warnings.

On 25 June, no additional information had been loaded into *Arrow*'s ECS and the system was displaying a simplified symbol **(Figure 16a**) to indicate the ship's position. Some versions of the Navmaster ECS were capable of displaying a ship outline **(Figure 16b**), provided it was enabled with the correct ship dimensions and antenna position. The shape scaled with the scale of the chart and the system reverted to a simplified symbol at smaller scales. The version of Navmaster ECS installed in *Arrow* did not have this capability. This had been identified by the crew, and enquiries with the manufacturer had been made early in 2020 to try to enable it but had not been successful.

Images courtesy of Navmaster and UK Hydrographic Office

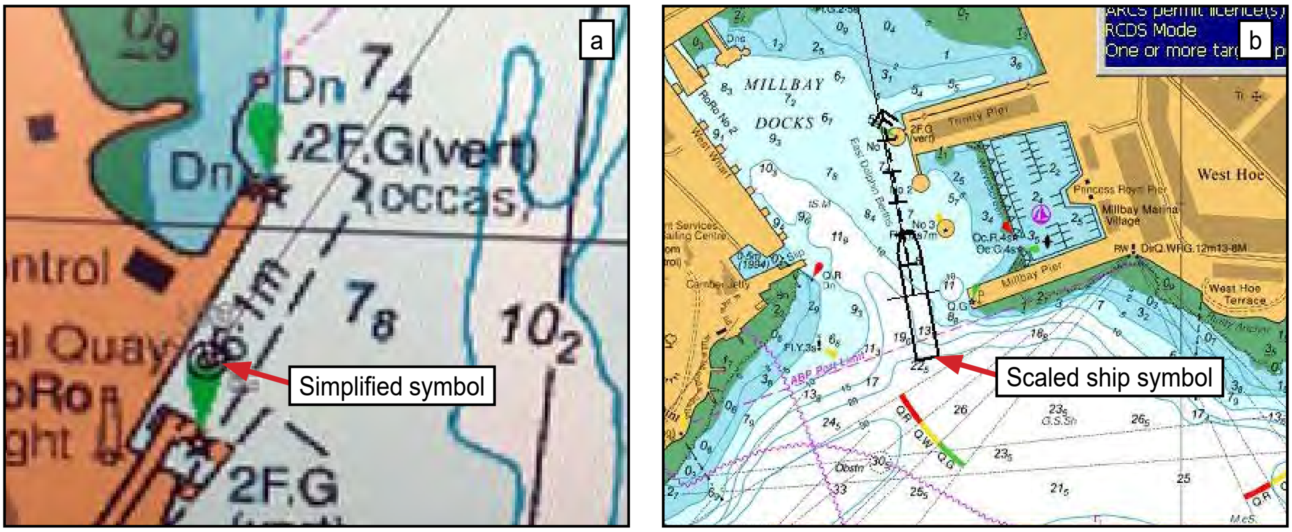

Figure 16: Navmaster ECS software with simplified symbol **(a)** and scaled ship **(b)**

1.8 CREW

Arrow's crew of 19 met the flag state's safe manning requirement. The crew comprised 11 Polish nationals, 7 Estonian nationals and 1 Lithuanian national. The main operational language was English, and all key officers spoke this fluently. Although affected by Coronavirus restrictions, crew changeovers had been continuing, and most key personnel were working four to six-week contracts, with a similar period of leave.

At the time of the grounding, the bridge team consisted of the master, the PEC holder, the C/O and the 3/O.

1.8.1 The master

The master was a 57-year-old Polish national, who had been employed by Seatruck since 2009. Initially employed as a 2/O, he was quickly promoted to C/O, serving mainly on *Clipper Ranger*, a sister ship to *Arrow*. Gaining his STCW[3] II/2 (Unlimited) Master's Certificate of Competency (CoC) in 2014, he was promoted to master on

[3] International Convention on the Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended.

Clipper Ranger in 2019, before moving to *Arrow* as master in August 2019. The master had completed Bridge Resource Management (BRM) training in November 2017. He joined *Arrow* on 14 May 2020.

1.8.2 The PEC holder

The PEC holder was a 32-year-old Estonian national, employed by Serco Northlink Ferries as a C/O, normally on *Helliar*. He joined Seatruck as a 3/O in 2015, was promoted to 2/O and then C/O after obtaining his STCW II/2 Chief Mate (Unlimited) CoC in 2018. When *Helliar* was taken on bareboat charter by Serco Northlink Ferries in 2017, he moved to employment with Serco Northlink Ferries via a crewing agency. He studied for and obtained PECs for Lerwick, Kirkwall and Aberdeen, being awarded the last, Aberdeen, in October 2019. He had logged 27 Aberdeen entries and exits in 2020 up to the grounding, including eight in January and seven in June on board *Arrow*. The PEC holder underwent BRM training in 2015 and again in 2017. He was signed onto *Arrow*'s books on 17 June 2020.

1.8.3 Chief officer and third officer

The C/O was a 48-year-old Estonian national with an STCW II/2 Master's (Unlimited) CoC. He had been employed by Seatruck since 2004, with most of his service as C/O of *Arrow* and had completed his most recent BRM training in 2016. He joined the vessel on 11 June 2020.

The 3/O was a 41-year-old Estonian national with an STCW II/2 Chief Mate's (Unlimited) CoC. He had been employed by Seatruck since 2013, exclusively as 3/O on *Arrow* and had completed BRM training in 2017. He also joined the vessel on 11 June 2020.

1.9 SEATRUCK FERRIES LIMITED

Owned by the Clipper Group, Seatruck was established in 1996 to operate Irish Sea freight services. Seatruck operated nine freight ro-ro vessels primarily on Irish Sea routes and took on the management of *Arrow* on behalf of its parent company in 2007. The eight vessels employed on scheduled routes were divided into two classes. Four 'FSG-class' vessels were registered in the Isle of Man and four 'P-Class' vessels were Cyprus-registered.

1.9.1 Safety management system

Seatruck's Document of Compliance, confirming that the company's SMS met the requirements of the ISM Code, was issued by the flag state on 26 May 2016 and was valid until 23 June 2021.

Seatruck's fleet of ships were issued with a generic SMS that provided general guidance common to the three classes of vessel, together with vessel and class-specific orders and checklists as annexes. It set out the company's policy for safety, quality management and environmental protection. Separate generic Fleet Risk Assessments were distributed to all vessels. These included *Fleet DK004 Manoeuvring the Vessel* and *Fleet DK007 Pilotage Waters* **(Annexes C** and **D)**. Neither risk assessment identified operations in restricted visibility as a specific hazard but made brief mentions of 'weather'.

The SMS provided guidance on shipboard operations, with Sections 7.16 to 7.26 covering navigation, pilotage and mooring operations. These sections gave outline procedures, referring crew to check-off lists and common publications including the *Bridge Procedures Guide*[4] and *Bridge Team Management - A practical guide*[5]. Passage planning, navigating with a pilot and navigation in restricted visibility were covered generically in the SMS but no specific guidance was given on operating in pilotage waters in restricted visibility or when operating with a PEC holder as opposed to a pilot.

The SMS provided guidance on the company's operational and engineering processes. It included Pre-arrival and Pre-departure checklists **(Annexes A** and **E)** that listed a requirement for arrival and departure briefs to take place under a voyage data recorder (VDR) microphone. The SMS also included a restricted visibility checklist **(Figure 9)** that stipulated a requirement to have a helmsman on standby, increase the frequency of position-fixing and sound appropriate sound signals.

Directions on the use of ECS or ECDIS (if fitted) were limited to ensuring systems were operational. Instructions for the use of such equipment relied on other manuals and documents including the *Bridge Procedures Guide* and *Bridge Team Management*.

1.9.2 Master's standing orders

In addition to generic navigational guidance, each ship maintained its own master's standing orders. These were included in the SMS document **(Annex F)**. The document detailed the master's directions to the OOW in open water and on actions when encountering restricted visibility. There were no directions on the use of the ECS.

1.9.3 Crew training and drills

The SMS requirement for drills and emergency training **(Annex G)** included Grounding and Damage Control exercises. A Grounding drill was recorded as having taken place on 13 May 2020 and a Damage Control drill took place on 14 April 2020. The Grounding drill was required at 4-monthly intervals, and normally took the form of rehearsing the actions detailed on the Grounding/Stranding check-off list **(Annex B)**.

There was no documented requirement for bridge team training or drills in conducting navigation or pilotage in restricted visibility.

1.9.4 Bridge Resource Management

BRM was not specifically referred to in the SMS, but bridge teams were directed towards the *Bridge Procedures Guide* and *Bridge Team Management*.

[4] International Chamber of Shipping *Bridge Procedures Guide* 5th Edition published by Marisec Publications, 2016.

[5] *Bridge Team Management - A practical guide* 2nd Edition by Captain A J Swift FNI published by the Nautical Institute, 2004.

1.9.5 Navigation in Restricted Visibility

Seatruck's SMS contained requirements for the safe operation of its vessels navigating in or near an area of restricted visibility **(Annex H)**. This included informing the master, posting extra lookouts, proceeding at a safe speed, having a helmsman on standby, sounding appropriate sound signals and completing Form 71, the Navigation in Restricted Visibility check-off list **(Figure 9)**. Both the SMS and Form 71 required position-fixing frequency to be increased and the vessel to be navigated with extreme caution.

1.9.6 Navigation with a pilot

Section 7.19 of the SMS covered the arrangements for navigation in pilotage waters. The section defined a pilot as:

> *Any qualified and licensed person who is engaged to assist in the safe navigation of vessels in confined waters and to facilitate port approach, berthing and departure.*

It re-iterated the master's ongoing responsibility for the safety of the ship, and their right to take over from the pilot in the event of a pilot's inexperience or misjudgement. The master was also directed to:

> *Ensure the bridge team are fully briefed in their duties and that all the support and co-operation necessary is given to the pilot.*

The section directed that time and space should be allocated to ensure a pre-pilotage information exchange with the pilot, referring to the *Bridge Procedures Guide* for more detail. The pilotage passage plan was to be agreed and the master was expected to receive details of how the navigation was intended to be conducted.

1.9.7 Bridge manning and use of hand steering

In SMS Section 7.16 Safe Navigational Watchkeeping, the OOW was directed to:

> *In areas of high traffic density, in conditions of restricted visibility and in all hazardous navigational situations ensure the vessel is in hand steering.*

and:

> *Station a person to steer the vessel and to put the steering into manual control in good time to allow any potentially hazardous situation to be dealt with in a safe manner.*

Further guidance was given on the required bridge manning levels for various situations and is summarised in **Table 1**.

	Master		OOW		Rating		Remarks
			II/1		II/4		
Visibility	Clear	Restricted	Clear	Restricted	Clear (1)	Restricted (2)	
Pilotage	1	1	1	1	1	2	
On passage		1	1	1	1	2	(1) See Lookout
At anchor			1	1	1	1	(2) Consider posting forward

Table 1: Seatruck's minimum bridge manning requirements

In notes accompanying the table, the SMS made clear that the duties of the lookout and the helmsman were separate, and that the helmsman was not to be considered as a lookout. The SMS was not explicit on who should be steering the vessel in pilotage waters.

1.10 SERCO NORTHLINK FERRIES

Serco Northlink Ferries operated passenger and freight ro-ro services from Aberdeen to Kirkwall in Orkney and Lerwick in Shetland. The company's freight services utilised two vessels, *Helliar* and *Hildasay*, both nearly identical sisters to *Arrow*, with the major differences being in navigation equipment fit. For the period of *Arrow*'s charter in June 2020, *Helliar* was off service for a routine docking.

The PEC holder on board *Arrow* on 25 June 2020 had worked under Seatruck's SMS for two years until the operation of *Helliar* moved to Serco Northlink Ferries. His period of training for duties as C/O and his experience while studying for his PECs were under the auspices of Serco Northlink Ferries's SMS.

C/Os on all Serco Northlink Ferries's vessels were expected to obtain and maintain PECs for all regular ports on their vessel's routes. New C/Os were allowed to settle into their primary role before starting PEC training and masters were consulted as to their suitability to act as a PEC holder.

1.10.1 Safety management

Serco Northlink Ferries's SMS covered the operation of both passenger and freight ro-ro ferries. The SMS was tailored to the company's requirements and described the level of operation expected from its employees, with limited reliance on external publications. BRM was specifically covered, with a direction that BRM briefings were to take place before arrival and departure from each port. The SMS made clear the responsibility of the master to ensure that bridge workload was shared, with no member given more duties than they could perform effectively.

1.10.2 Employment of PEC holders on other companies' vessels

As part of the arrangements to charter *Arrow*, Serco Northlink Ferries undertook to provide a PEC holder to the charter vessel if the crew did not already have a deck officer with the required certificates. The experience of *Arrow*'s master in operating the route was considered, with Serco Northlink Ferries providing a master holding a PEC for *Arrow*'s master's first charter working out of Aberdeen.

1.11 ABERDEEN HARBOUR

1.11.1 Background

Aberdeen Harbour was a trust port in the north-east of Scotland, which served the offshore oil, gas and windfarm industries, smaller cargo vessels, fishing vessels and passenger, car and freight ferries. Administered by a board of 12 appointees, day-to-day management was led by the chief executive. The board were collectively and individually the Duty Holders accountable for marine safety under the UK government Department for Transport's Port Marine Safety Code (PMSC)[6].

Aberdeen Harbour Board (AHB) was the statutory harbour authority for Aberdeen. It was also the competent harbour authority (CHA) under the provisions of the Pilotage Act 1987[7] and was responsible for the pilotage service within the Aberdeen harbour and pilotage area which extended out to 2.3nm from Girdleness Lighthouse. The harbourmaster was empowered to issue pilotage licences and PECs.

1.11.2 Safety management and risk assessments

Aberdeen Harbour operated an SMS based on the PMSC. To comply with the PMSC, port authorities had to, inter alia:

- *Ensure all risks are formally assessed and as low as reasonably practicable in accordance with good practice.*
- *Operate an effective marine SMS which has been developed after consultation and uses formal risk assessment.*
- *Use competent people (who are trained, qualified and experienced) in positions of responsibility for managing marine and navigational safety*[8]*.*

Once a port had implemented the requirements set out in the PMSC through its SMS, it could formally declare itself compliant to the Maritime and Coastguard Agency (MCA). This was a three-yearly requirement and AHB's latest declaration was made on 14 March 2018.

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6 The PMSC and its accompanying Guide to Good Practice (GtGP) sets out a national standard for port marine safety and applies to all harbour authorities and other marine facilities, berths and terminals in the UK.

7 As amended by the Marine Navigation Act 2013.

8 Competent people' is assumed to include PEC holders, who are certified by the CHA after undergoing an appropriate training, examination and revalidation regime. PEC holders are, in addition to providing services to their vessel, acting as a 'pilot' for their vessel, and thus are operating under the authority of the CHA, in this case, AHB.

AHB had appointed a designated person (DP) to independently audit its compliance with the PMSC. The DP's last full audit before the accident was completed in stages, with the final element of the report delivered on 19 January 2019. The audit indicated that AHB was broadly compliant with the PMSC. The 2020 DP audit was postponed due to illness and then Coronavirus. It was planned for completion by the end of 2020.

AHB's SMS contained risk assessments for its general port operations and was last updated in February 2020 as part of an exercise to investigate risks associated with the port's expansion project. The highest scoring hazard was assessed to be '*offshore support vessel contacting a vessel alongside the berth*', largely due to the higher frequency of reported incidents when compared to incidents such as grounding.

The remaining hazards were assessed as falling within the 'negligible' or 'low risk' regions and no further risk control measures were recommended.

In the period 2012-2020, the port's SMS recorded nine groundings. Of these, five were in the Navigation Channel, with one in restricted visibility. Some were due to control or engineering issues, but the majority were due to loss of situational awareness. Damage from these incidents was relatively minor, with all vessels able to proceed after assessment.

Grounding was identified as a port hazard, but due to historical minor consequences and a moderate frequency, grounding risk, for various types of vessel, was assessed as 'low'. The potential impact of adverse weather or restricted visibility had not prompted any additional risk control measures.

Port risk control measures in place included compulsory pilotage for larger vessels, VTS control of all vessels, aids to navigation and frequent surveys.

1.11.3 Aberdeen Navigation Channel

Vessels using the harbour were limited in size by the depth and width of the approach channel, known as the Navigation Channel, and the available turning room inside the harbour **(Figure 5)**. Operating constraints were detailed in the port's SMS, and in June 2020 were 166m LOA, 30m beam and 8.5m draught. The Navigation Channel was 0.5nm long from the South Breakwater to the Turning Basin and the minimum maintained depth in the Navigation Channel was 6m below chart datum. At its narrowest, from Old South Breakwater to Abercromby Jetty, the Navigation Channel was 70m wide. The sides of the channel shelved steeply **(Figure 11)**, particularly to the south. The seabed either side of the channel was stone and rock.

In clear visibility, the centreline was marked by lit transit marks and a sectored leading light. The port's diagrammatic 'Pilot's Handbook – Approach' **(Figure 17)** gave advice on three PIs – the seaward end of the North Pier at 0.06nm, Abercromby Jetty at 0.02nm and the Old South Breakwater at 0.05nm.

1.11.4 Pilots and pilot training

AHB employed 12 full-time pilots, who were graded according to their ability and experience, with Class 1 pilots authorised to pilot all vessels. Vessels were graded by LOA and propulsion machinery; *Arrow* required a Class 2 pilot.

Image courtesy of [Aberdeen Harbour Board]

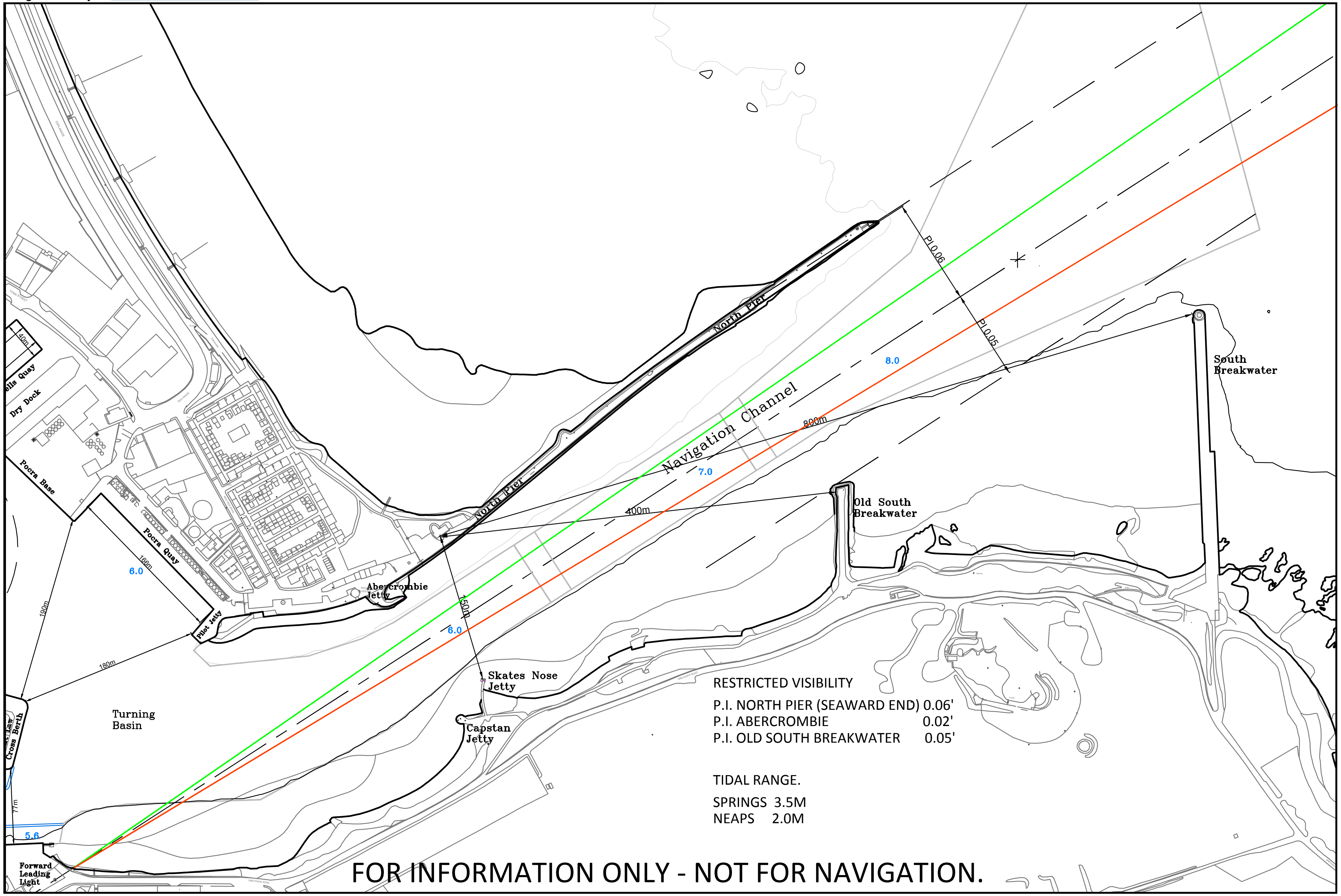

Figure 17: Pilot's handbook – Approach

The port had an established training programme to develop and train pilots, with practical, supervised sea going experience and training in AHB's own bridge simulator. The simulator could model most types of vessel using the port, and was, in addition to manoeuvring training, used for pilot restricted visibility and heavy weather training.

1.11.5 Pilotage directions and pilotage exemption certificates

Aberdeen Harbour's Pilotage Directions detailed the port's policy on pilotage and PECs, including a training and examination syllabus and procedures for the award and revalidation of PECs. Compulsory pilotage was imposed on all vessels over 60m in length, raised to 75m for vessels with an operational bow thruster.

In accordance with the provisions of the 1987 Pilotage Act, the directions allowed a bona fide[9] deck officer of a vessel (holding an appropriate CoC) to apply for a PEC. Award of a PEC was subject to the harbourmaster being satisfied:

> *That their skill, experience and local knowledge are sufficient for them to be capable of piloting the vessel of which they are a deck officer (or that and any other vessels specified in the certificate).*

For a vessel the size of *Arrow*, *Helliar* and *Hildasay*, the three vessels on the *Arrow*'s PEC holder's certificate, 12 arrivals to and 12 departures from the harbour were required, with at least half the voyages (including the first and last arrivals and departures) conducted with a pilot. The PEC applicant had to be in control of the vessel for these voyages, albeit supervised by a pilot or existing PEC holder, and complete them to an acceptable standard. The applicant was then formally examined by two appointed port examiners to ensure that they had sufficient knowledge and skill. Actions taken in response to emergencies were assessed by a pilot during one of the qualifying voyages.

The reverse of the PEC contained conditions for its use. Item 1 was:

> *The PILOTAGE EXEMPTION CERTIFICATE is **invalid**, where the bridge manning of the ship under pilotage falls below the following minimum levels:*
>
> *ii. Ships of over 95 metres registered length – the Master, one other officer, and a helmsman.*
>
> *In the event of violation of this rule, the certificate will be revoked without notice.*

PECs were valid for 12 months from award and a minimum of six arrivals and six departures were required for revalidation, including at least one arrival and one departure with a pilot. PEC holders were required to submit trip logs to the harbourmaster to support revalidation.

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[9] 'Bona fide' here is taken to mean that the PEC candidate is an official member of the crew of that vessel.

1.11.6 Vessel Traffic Services

Aberdeen Harbour operated its port control function via Aberdeen VTS, a VTS centre authorised by Merchant Shipping Notice (MSN) 1796 (M+F)[10]. The operation of VTS was in accordance with International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) standards, guidelines and manuals. The senior watchkeeper on watch, the VTS Officer (VTSO), was trained to IALA V103/1 VTS Operator standards, with the VTS Assistant (VTSA) locally trained and operating under the direction of the VTSO.

The primary functions of the VTS were to contribute to safety of life at sea, safety of navigation, efficiency of vessel traffic movement and to deputise for the harbourmaster. To support its functions, VTS maintained a constant listening watch on VHF channels 12 and 16 and operated a Vessel Traffic Monitoring and Information System (VTMIS) supplied by Transas. The VTMIS provided a traffic image, with data from surveillance radars, AIS, VHF radios and closed-circuit television (CCTV) cameras. Most of the data captured by the VTMIS was recorded.

Aberdeen VTS operated as an Information Service (INS) and a Traffic Organisation Service (TOS) under IALA Guideline 1089 – Provision of Vessel Traffic Services and Marine Guidance Note (MGN) 401(M+F)[11].

Participation in the VTS was mandatory for all vessels underway within harbour limits. The movement of all vessels required a 'traffic clearance' from Aberdeen VTS, and for entry into harbour, this was required before passing the Fairway Buoy. Vessels up to 24m LOA could pass each other in the Navigation Channel; only one-way traffic was permitted for all other vessels.

1.11.7 Procedures in restricted visibility

The SMS identified restricted visibility and/or severe weather conditions as hazards that required close liaison between the VTSO, Pilot and Duty Harbour Master.

Guidance to the VTSO and pilots included:

> *A state of visibility report should be given if the visibility changes. Visibility reports can be requested from vessels in the vicinity or through the use of visual markers around the harbour.*
>
> *The size and manoeuvrability of vessels is one of the many factors used by pilots and VTSOs in deciding whether a vessel is permitted to get underway during restricted visibility. Each decision is based on an individual assessment of the risks involved.*

In addition, towage operations were not permitted to take place in the port when visibility was less than 200m. A formal 'fog routine' was not established.

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[10] MSN 1796 (M+F) Vessel Traffic Services: Designation of Vessel Traffic Service (VTS) Centres in the United Kingdom

[11] MGN 401(M+F) Amendment 2 Navigation: Vessel Traffic Services (VTS) and Local Port Services (LPS) in the United Kingdom

1.12 BRIDGE RESOURCE MANAGEMENT

1.12.1 General

BRM is a requirement of the STCW code as amended in 2010 (the 'Manilla Amendments') for all masters and deck officers employed on ships of 500gt and above. At the heart of BRM is the concept of a 'shared mental model', where all team members understand the plan and, within their personal abilities, are able to effectively monitor and where necessary challenge both the plan and its progress during execution. The STCW code requires that officers have knowledge of BRM principles including:

- *Allocation, assignment and prioritisation of resources*
- *Effective communication*
- *Assertiveness and leadership*
- *Obtaining and maintaining situational awareness*
- *Consideration of team experience.*

More specifically, effective BRM requires that:

- *Responsibility for the safety of navigation is clearly defined at all times, including periods when the master is on the bridge and while under pilotage.*
- *Questionable decisions and/or actions result in appropriate challenge and response.*
- *Team members share accurate understanding of current and predicted vessel state, navigation path and external environment.*

This final point may be summarised as 'situational awareness', described in the *Bridge Procedures Guide* as:

> *…an appreciation of what is happening around the ship. This includes knowing where the ship is, where it is planned to be and whether any other vessel, event or conditions developing in the vicinity pose a risk to the safety of the ship. Situational awareness depends on the Bridge Team's ability to use information effectively to assess a situation accurately…*
>
> *Good situational awareness is essential for the safe conduct of navigation and protection of the environment.*

This point is also emphasised in *Bridge Team Management - A practical guide*:

An efficient bridge organisation will include procedures that:-

> *1. Eliminate the risk that an error on the part of one person may result in a disastrous situation.*

2. Encourage use of all means of establishing the ship's position so that in the case of one method becoming unreliable others are immediately available.

As an addition to the STCW code, officers who had not completed recognised BRM training as part of their formal college training were required to complete standalone training by 1 January 2017.

1.12.2 BRM with a pilot

The *Bridge Procedures Guide*, heavily referenced by Seatruck's SMS, provides guidance on working with a pilot. The publication advises a PEC holder to take on the duties and responsibilities of a pilot while providing local information and advice to the master and other members of the bridge team. A pilot will not always be familiar with the ship, and the master and bridge team will not always be familiar with the local area and conditions. To quickly integrate the pilot into the bridge team, an effective and thorough master/pilot information exchange (MPX) should take place. The MPX should be comprehensive and cover, among other aspects:

- *The pilotage plan and the circumstances when deviation from the plan may be required.*
- *Updates on local conditions such as the weather.*
- *Contingency plans should also be considered. These should identify possible abort points.*

The *Bridge Procedures Guide* provides a useful diagrammatic representation of how a bridge team should integrate with a pilot and the pilot's place in that team **(Figure 18)**. It also makes clear that a PEC holder should act as if they were a pilot. Effectively re-iterating the need for teamwork, the guide states:

The pilot should effectively communicate expert local knowledge, information and advice to the Bridge Team… Pilots should in turn be supported by all appropriate shipboard personnel in their execution of safe navigation.

The bridge team must be aware of the pilot's intentions to be able to adequately monitor the safety of the vessel and be empowered to communicate any concerns in sufficient time to allow the master to intervene if necessary.

1.12.3 Briefings

Team briefings are a fundamental part of BRM. Building and maintaining a shared mental model begins with all team members understanding the plan and their part in it. Briefings should reflect expected conditions and be updated if conditions change. Briefings are an important opportunity to share information and give team members the chance to ask questions and, if necessary, to challenge aspects of the plan they do not understand or are uncomfortable with. If a pilot is expected to be embarked, then an update briefing may be required after the MPX to reflect any changes to the pre-anticipated plan.

It is good practice to ensure the briefing is recorded. This can be simply achieved by holding briefs close to VDR microphones (where fitted). This was stipulated on Seatruck's Pre-arrival and Pre-departure checklists **(Annexes A** and **E)**.

Image based on diagram from Chapter 5 of *Bridge Procedures Guide,* courtesy of International Chamber of Shipping

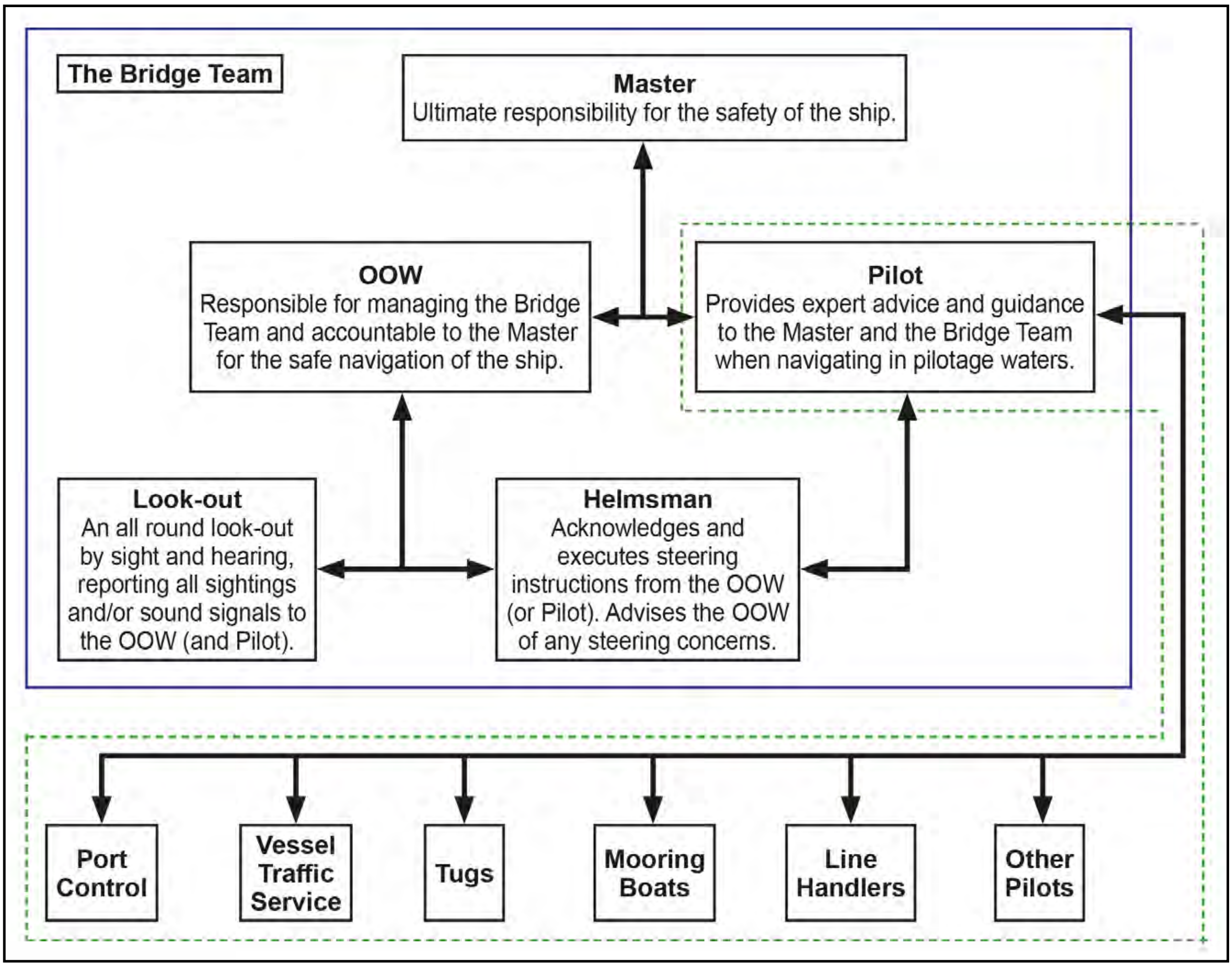

Figure 18: *Bridge Procedures Guide* guidance on the roles and responsibilities of the bridge team when a pilot is on board

1.13 POST ACCIDENT STEERING TRIALS

Restricted and clear visibility entries to Aberdeen were simulated by the MAIB using a commercially available 'desktop' bridge simulator. A computer model of a vessel with similar characteristics to *Arrow* was used, together with a replica tiller arm steering arrangement. A radar display was simulated, with one PI set in a similar manner to that used by the *Arrow* PEC holder. Runs were completed by experienced former mariners and the following was apparent:

- Steering and navigating at the same time took a high degree of concentration, but provided the vessel remained close to the planned track and corrections were small, safe entries were straightforward.
- Large deviations from the planned track were much harder to recover without oversteering.
- The alteration to 22° off base track to recover *Arrow*'s deviation to the north repeatably could not be recovered before running aground.
- Detection of drift off track was much harder with radar than with visual cues such as the transit marks.
- Separating the steering and navigation functions made control much more effective.

1.14 VOYAGE DATA RECORDER RECOVERY AND DATA

As a cargo vessel of over 3,000gt, in accordance with the International Convention for the Safety of Life at Sea 1974, as amended (SOLAS) Chapter V Regulation 20, *Arrow* was required to be fitted with a VDR to assist in casualty investigations. As *Arrow* was built before 1 July 2002, the regulations allowed this to be a Simplified VDR (S-VDR).

Arrow was fitted with a Netwave NW6000 series S-VDR. This was installed in 2016 and was interfaced to GPS, gyrocompass, speed log, both radar displays, AIS data and audio channels. The audio channels included four bridge microphones and an IMM VHF channel. *Arrow*'s most recent annual performance test before the accident took place on 10 January 2020, the equipment was assessed as operating within the required specifications.

To support the investigation, a full download of *Arrow*'s S-VDR data including the approach to Aberdeen, the accident, and the period up to and including berthing alongside was obtained. Most data was accurately captured, but two bridge microphones, the one on the starboard bridge wing and the microphone situated above the main central conning position, did not record correctly in the period leading up to the grounding.

The MAIB contracted industry specialists to attempt to remove background noise from the two operational bridge microphones to try to enhance the voice recordings. This work did enhance the audibility of the recordings, but it was not possible to discern details of all conversations on the bridge. There was very limited audible discussion in the two minutes immediately before the grounding and the exchanges identified were very short.

1.15 PREVIOUS ACCIDENTS

1.15.1 Seatruck Ferries Limited

This is the fourth accident since 2018 involving vessels managed by Seatruck Ferries Limited that has resulted in a published report.

On 17 December 2018, the assistant bosun on the ro-ro freight ferry *Seatruck Pace*[12] was found on the ramp between the main vehicle deck and the lower hold, having apparently fallen 4.5m. He was taken to hospital but died three days later. The investigation identified that the assistant bosun had probably crossed a temporary rope barrier onto a narrow section of deck. Seatruck took action to prevent similar accidents, to ensure safe working practices and to improve the safety culture among its crews.

On 15 May 2019, the 3/O of the ro-ro freight ferry *Seatruck Progress*[13] was fatally injured after being struck by a semi-trailer being pushed down the stern vehicle loading ramp. The 3/O was talking on his mobile phone, facing away from the advancing semi-trailer and was not visible to the driver of the tractor unit, whose view was obscured by the trailer. Recommendations were made to Seatruck aimed at improving the effectiveness of its procedures and improving the safety culture of its crews.

[12] MAIB report 9/2019

[13] MAIB report 10/2020

At 2243 on 8 May 2019, the IoM-registered ro-ro freight ferry *Seatruck Performance*[14] grounded while transiting the Greenore Channel in Carlingford Lough, Northern Ireland, shortly after departing Warrenpoint. The vessel was turning into a narrow, buoyed channel when it grounded. Damage included breaches in a tank and a void space requiring drydocking and the vessel was out of service for three weeks. There were no injuries and no pollution. The MAIB investigation identified that the ferry's passage had not been sufficiently planned and specifically the effect of squat had not been adequately considered. The vessel's electronic navigation system was not being used effectively by the newly appointed master, who was mainly navigating by eye as well as hand steering the vessel; he was also not being supported effectively by the other officers on the bridge.

Seatruck was recommended to: take further measures to enhance the safe navigation of its vessels by optimising its use of electronic navigation systems to provide real time positional information, and enhancing its Bridge Resource Management training.

1.15.2 *Red Falcon*[15]

On 21 October 2018, the ro-ro passenger ferry *Red Falcon* collided with and sank the yacht *Greylag* on its mooring in Cowes Harbour while visibility was severely reduced by fog. *Red Falcon* subsequently passed through other yacht moorings and ran aground on soft mud. *Red Falcon* was re-floated, was undamaged and there were no injuries or pollution. However, *Greylag* was a total constructive loss.

As *Red Falcon* entered Cowes Harbour, visibility significantly reduced. The helmsman, who was inexperienced at steering solely by digital compass, had difficulty in maintaining a steady course, leading to the master taking over control himself. The master rapidly became overloaded due to high stress, high workload, lack of visibility, poor bridge equipment ergonomics and a breakdown in support from the bridge team. This resulted in the master losing orientation in the fog; he drove the vessel in the wrong direction, with *Red Falcon* hitting *Greylag* and then running aground.

Red Funnel and Cowes Harbour Commission took steps to improve their own processes, equipment and training routines. Recommendations were made to both organisations aimed at reducing the likelihood of future collisions and risk to harbour users.

1.15.3 *Commodore Clipper*[16]

On 14 July 2014, the Bahamas registered ro-ro ferry *Commodore Clipper* grounded on a charted, rocky shoal in the approaches to St Peter Port, Guernsey. There were no injuries or pollution, but there was significant raking damage to the hull and flooding of double-bottom void spaces and the vessel was withdrawn for dry docking and repairs.

The investigation found that passage planning had been insufficient, and for the passage through an area known as the Little Russel, the extremely low tide and squat had not been properly considered. This meant that the bridge team were

[14] MAIB report 10/2020

[15] MAIB report 6/2020

[16] MAIB report 18/2015

unaware of the limits of safe water and, despite good positional awareness, headed into danger without appreciation of the risk. The operator's approved route through the Little Russel was not followed and the vessel's ECDIS was not used effectively because key safety features were either disabled or ignored. It was also established that Guernsey Harbours did not have an effective SMS for the conduct of pilotage within its statutory area.

Safety recommendations were made to Condor Marine Services Limited and the Government of Guernsey, designed to ensure appropriate levels of proficiency in the conduct of safe navigation.

SECTION 2 – ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future.

2.2 OVERVIEW

Arrow grounded because its bridge team lost situational awareness in thick fog. The PEC holder, who was conning and steering the vessel in a narrow channel, became overloaded by the complexity of the combined tasks and was not adequately supported by the rest of the bridge team. The PEC holder over-corrected in an attempt to recover position after being at the northern margins of the channel, resulting in the ferry grounding as it left the south of the channel. In this section of the report, the decision to enter Aberdeen Harbour in fog and the reasons why the PEC holder became overloaded will be analysed. Underlying factors that contributed to this accident, and issues related to the safety of navigation in Aberdeen Harbour will also be discussed.

2.3 DECISION TO ENTER ABERDEEN HARBOUR

Forecasts available to *Arrow*'s master indicated a chance of restricted visibility on the morning of 25 June. With fog patches sighted over the coast, and a historical June fog occurrence rate in Aberdeen of 3.5 days per month, this should have prompted the master and PEC holder to consider early preparations for a restricted visibility entry, especially as fog patches were visible on the coast. Alternatively, a plan to delay entry in the event of encountering fog could have been established. It is possible that a safe exit from Aberdeen in less thick fog a few days earlier may have led the team to believe that their arrangements for navigation in restricted visibility were adequate.

A formal abort point was not included in *Arrow*'s passage plan, and one was not drawn on the charts prepared for the entry. With a wide outer approach, *Arrow* could have safely aborted an entry at any time up to about 0.2nm from the South Breakwater. Fog closed in as *Arrow* was about 0.3nm from the South Breakwater, and after a brief discussion, the master and PEC holder agreed to continue. Had a formal abort position been established at the last safe point, it is possible that the bridge team would have given more thought to aborting the entry. As it was, with PIs on the radars and the PEC holder appearing confident, the master made the decision to continue the approach.

2.4 PREPARATIONS FOR NAVIGATION IN RESTRICTED VISIBILITY

Arrow was not fully prepared for pilotage in restricted visibility as it approached Aberdeen Harbour on 25 June 2020. Although the *Navigation in Restricted Visibility* checklist **(Figure 9)** had been completed, several tasks were not concluded effectively. Notably, navigation planning was not sufficiently detailed for pilotage into harbour without visual references, a dedicated helmsman was not present on the bridge, extra lookouts were not posted, sound signals were not made, and there was no shared mental model of the vessel's progress.

2.4.1 Passage planning

The passage from Lerwick to Aberdeen had been used several times by *Arrow* on this charter and took the vessel from berth to berth. The ship's paper British Admiralty charts 1446 and 146 **(Figure 10)** had been prepared for the entry, with 'no-go' areas clearly marked. The course marked for the route through the Navigation Channel was '237º – 057º' indicating that the chart was prepared for exits as well as entries. Beyond the 'no-go' areas, there were no clearing bearings or ranges or other safety calculations to indicate how close the vessel could get to danger, nor how far the vessel could be steered off base track and remain safe **(Figure 19)**.

Arrow's passage plan included one PI, drawn on Abercromby Jetty, but the PEC holder's plan relied on one drawn on Old South Breakwater, which was the only one used during the entry.

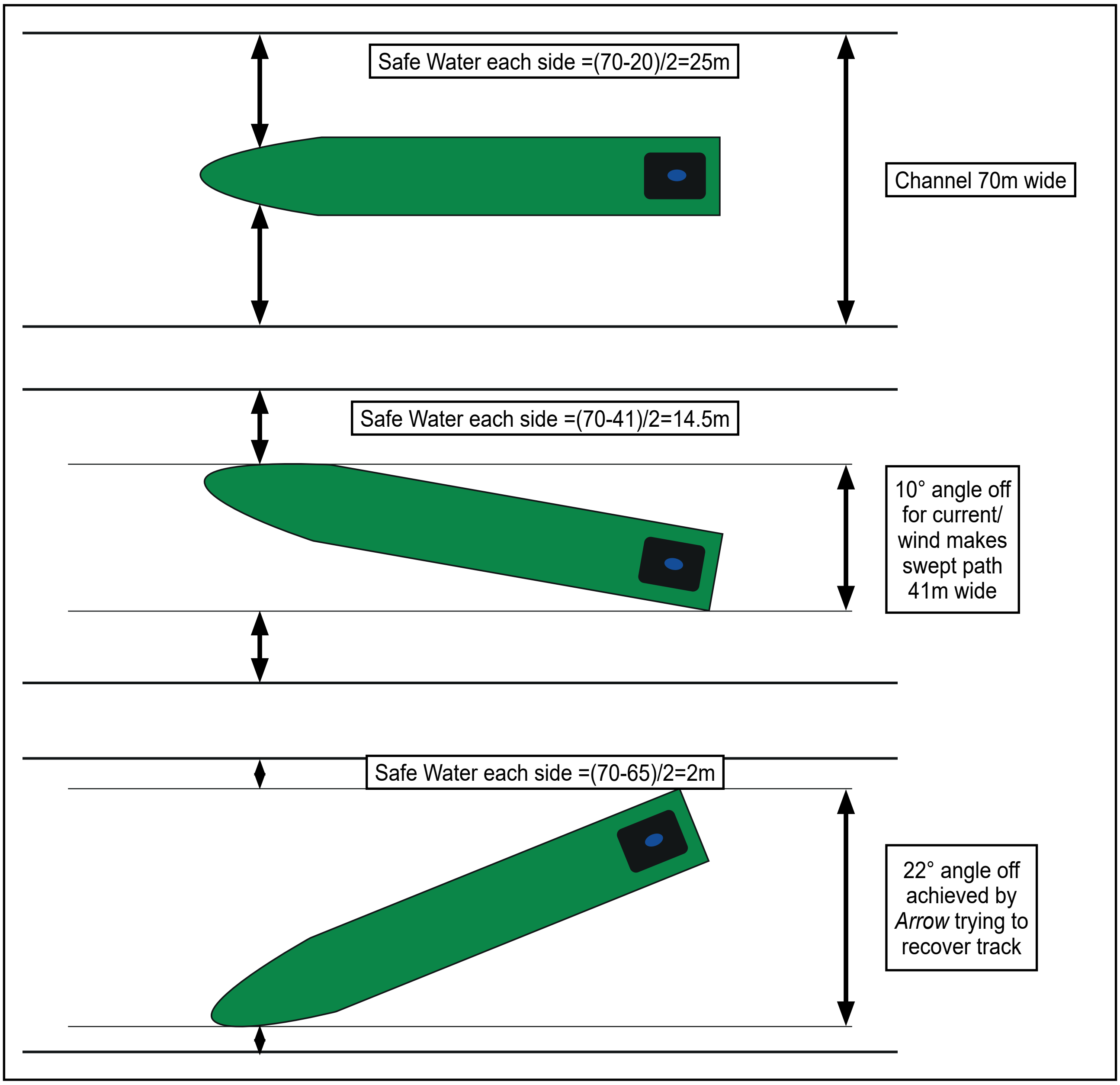

Figure 19: Diagrams showing effect on swept path of steering off the base track in a narrow channel

The use of one PI alone can only accurately give an indication of position if a measuring tool is used to determine distance off track. A more effective use of PIs would be to use multiple PIs to display safety limits, drawing a corridor down which the ship can be safely driven. The use of multiple PIs also allows more than one radar conspicuous mark to be used **(Figure 20)**. In this case, Old South Breakwater had disappeared from *Arrow*'s offset radar display **(Figure 21)**, which meant that immediately prior to the grounding the PEC holder had no real-time navigational information available. *Arrow*'s radar displays each had the capacity to store four PIs, and with only one track requiring precise navigation, two 'safety corridors' drawn on each display would have provided the bridge team with more information.

The passage plan for *Arrow*'s pilotage into Aberdeen relied heavily on the conning team being able to see visual references, and it was insufficient for safe navigation in severely restricted visibility.

2.4.2 Briefing

Discussion of the entry to Aberdeen had taken place the night before, when the master and PEC holder agreed who would handle the vessel. There was no discussion of expected conditions, and the other members of the bridge team were not engaged in this discussion. In the morning, while the master and PEC holder discussed conditions in the harbour, again, the whole team was not included and contingencies in the event of conditions deteriorating were not considered.

Even in a relatively small team and for a seemingly routine entry, a formal brief, as required by the SMS and detailed in the Pre-arrival checklist **(Annex A)** is a vital tool to ensure all team members are aware of the plan and their roles. It is an important opportunity to talk through contingencies, including the possibility of fog, and would have given the master and PEC holder the opportunity to cover the requirements of an MPX. The omission of a briefing meant this opportunity was missed, and possibly contributed to the poor BRM on *Arrow*.

2.4.3 Restricted Visibility checklist

The 3/O completed the Restricted Visibility checklist **(Figure 9)** as the visibility reduced to about 150m. The checklist was designed to cover offshore and pilotage restricted visibility conditions. While all actions were ticked off, sound signals were not made as required by COLREGSs Rule 35. Although the lack of sound signals had no direct impact on this accident, sound signals are mandatory in or near areas of restricted visibility and should have been made.

The checklist required a helmsman to be 'on standby' but did not direct their employment or positioning. Section 7.16 of Seatruck's SMS required the vessel to be in hand steering in restricted visibility (Section 1.9.7); to achieve this safely, a helmsman should have been stationed on the bridge.

2.5 EXECUTION OF PILOTAGE AND NAVIGATION

2.5.1 Required accuracy of navigation

Arrow was transiting a narrow channel with only 25m clearance either side when in the centre of the channel. Therefore, navigation accuracy must be repeatable and sufficient to inform the bridge team of a deviation from the planned track in time to

Reproduced from ARCS Chart 1446 by permission of HMSO and the UK Hydrographic Office

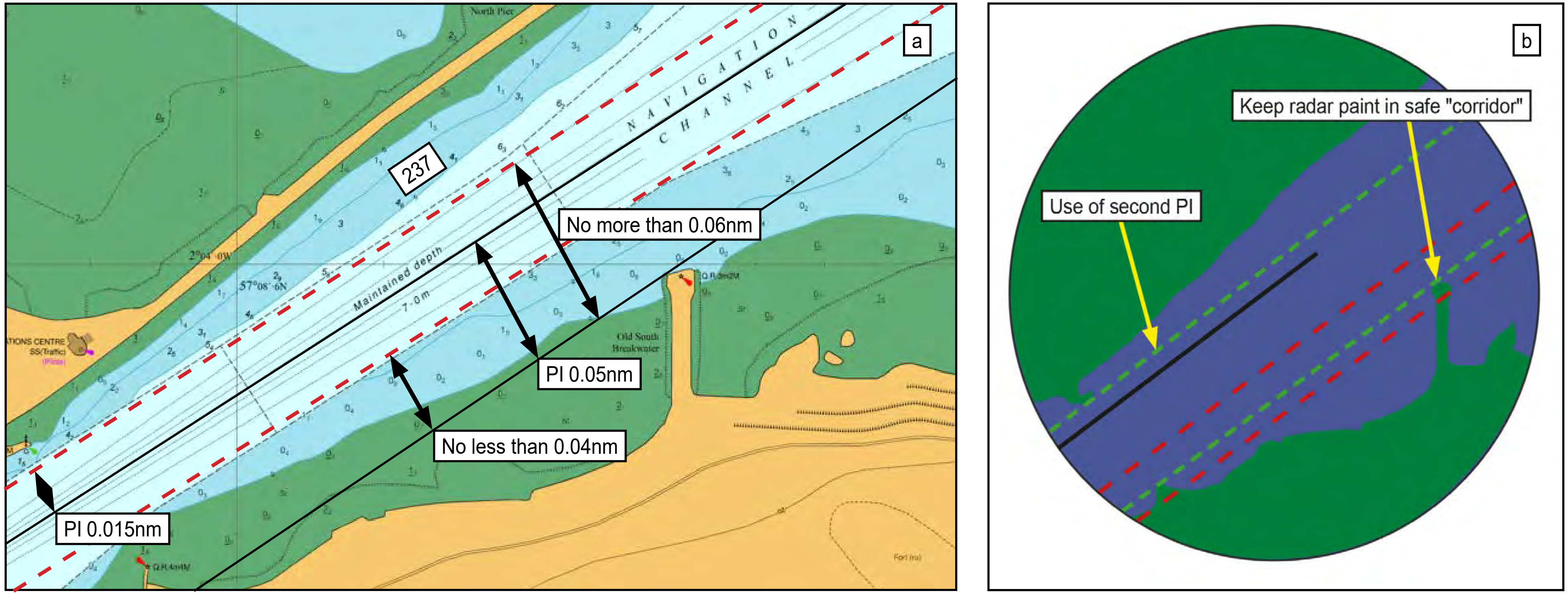

Figure 20: Parallel indexing techniques - showing use of two PIs and safe "corridor" **(a)** and radar display with additional PIs **(b)**

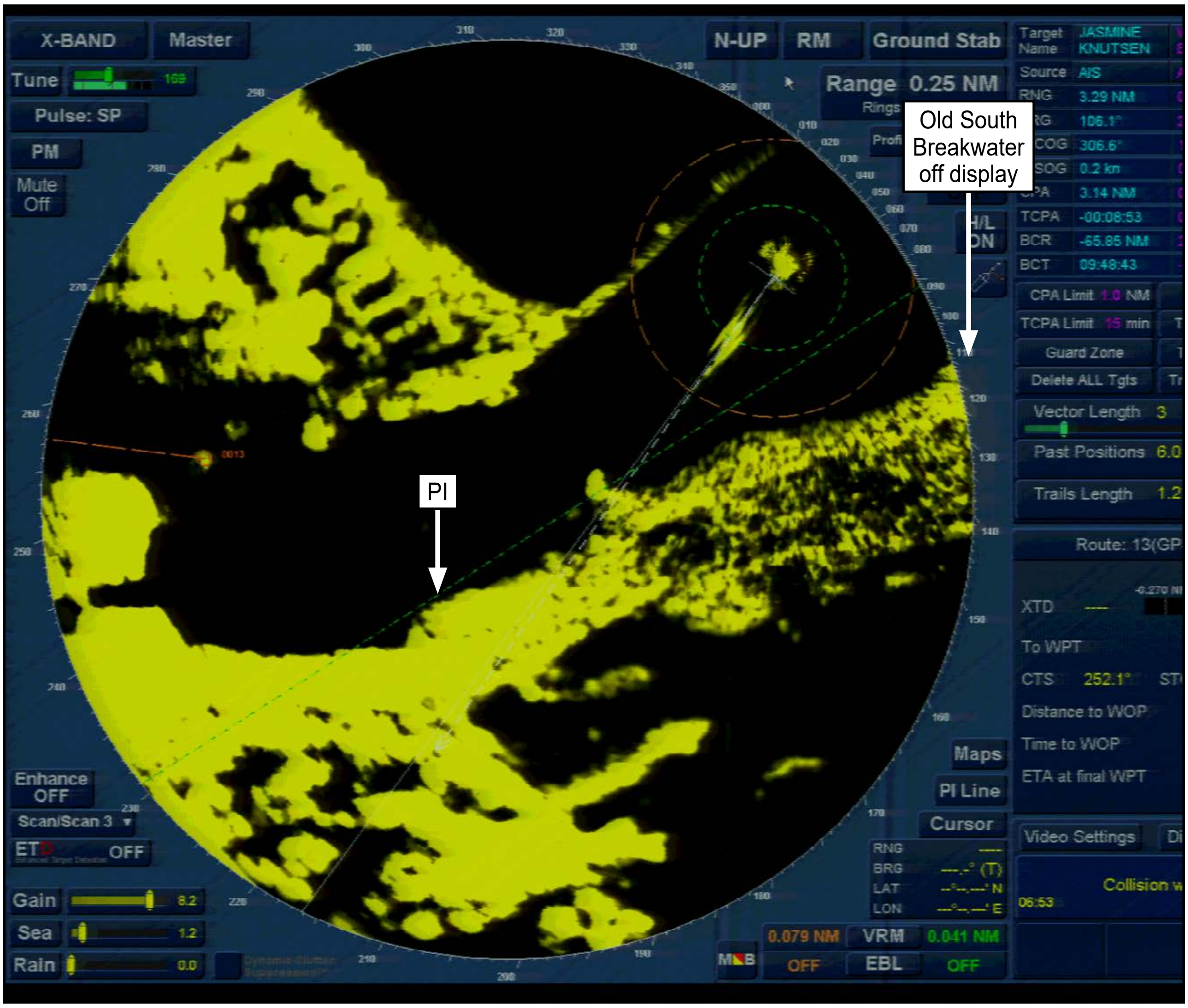

Figure 21: *Arrow*'s X-Band radar display just before the vessel grounded

allow the vessel to be maintained in safe water. In pilotage waters, this invariably requires accurate real-time positioning, able to instantly display the position of the vessel, in this case by use of a radar PI. Wherever possible, there should also be a secondary method. On *Arrow*, this could have been achieved by better use of the ECS or by use of additional PIs on each radar combined with careful monitoring by the master or another officer.

Detecting movement trends is much more difficult on a radar display than watching the movement of visual transit marks. Accurate radar navigation requires extremely close attention from the conducting officer. **Figure 22** shows previous entries and exits in good weather, together with the track on 25 June in red. It is highly likely that the PEC holder's ability to simultaneously navigate and steer was degraded to an unsafe level compared to entries and exits conducted in good visibility.

2.5.2 Use of *Arrow's* Electronic Chart System

Modern ECDIS systems, interfaced with Global Navigation Satellite System (GNSS) receivers, can achieve a similar or better real-time performance than radar, displaying information in a more accessible manner. *Arrow* was not fitted with an ECDIS but had a non-type-approved and less capable ECS. The vessel was using

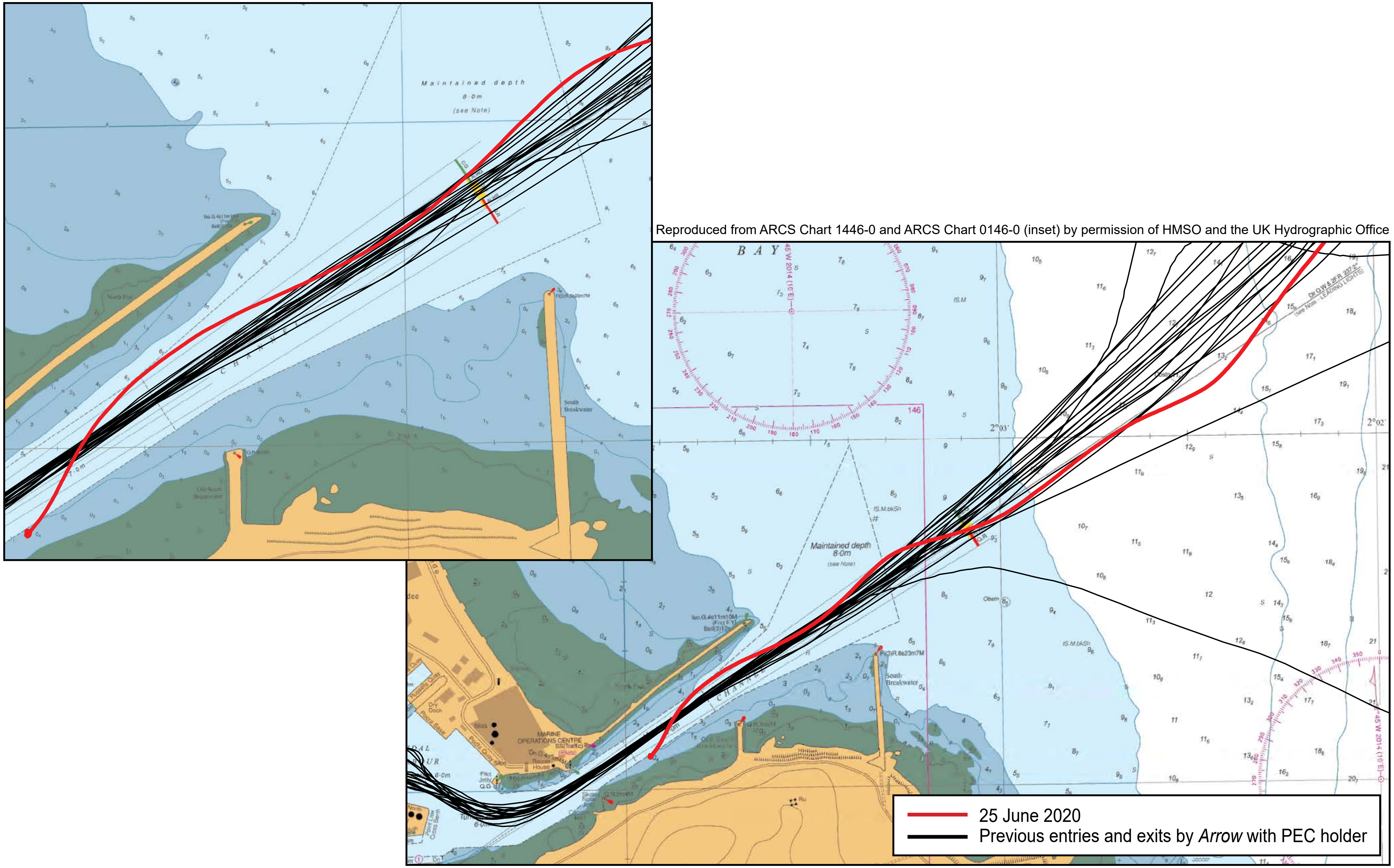

Figure 22: Plots of *Arrow*'s tracks into and out of Aberdeen Harbour January to June 2020

paper charts as the primary source of chart information, and the ECS was used to improve situational awareness. The ECS was well placed for the master to use but was 2.5m from the PEC holder's conning position **(Figures 4** and **7)** making the display of limited practical use to him.

The ECS was not able to display a representative scaled ship shape, only displaying the position of the antenna. On board *Arrow*, the antenna was approximately 100m from the bow, and in such a narrow channel, this can render the display less helpful **(Figure 23)**. To be useful in such confined pilotage situations, ECDIS and ECS should be configured to show the shape of the ship, with the correct antenna offsets input into the system. For operations close to navigational dangers, and particularly in restricted visibility, this feature can be valuable as it provides the mariner with a better representation of the position of the whole ship in relation to hazards.

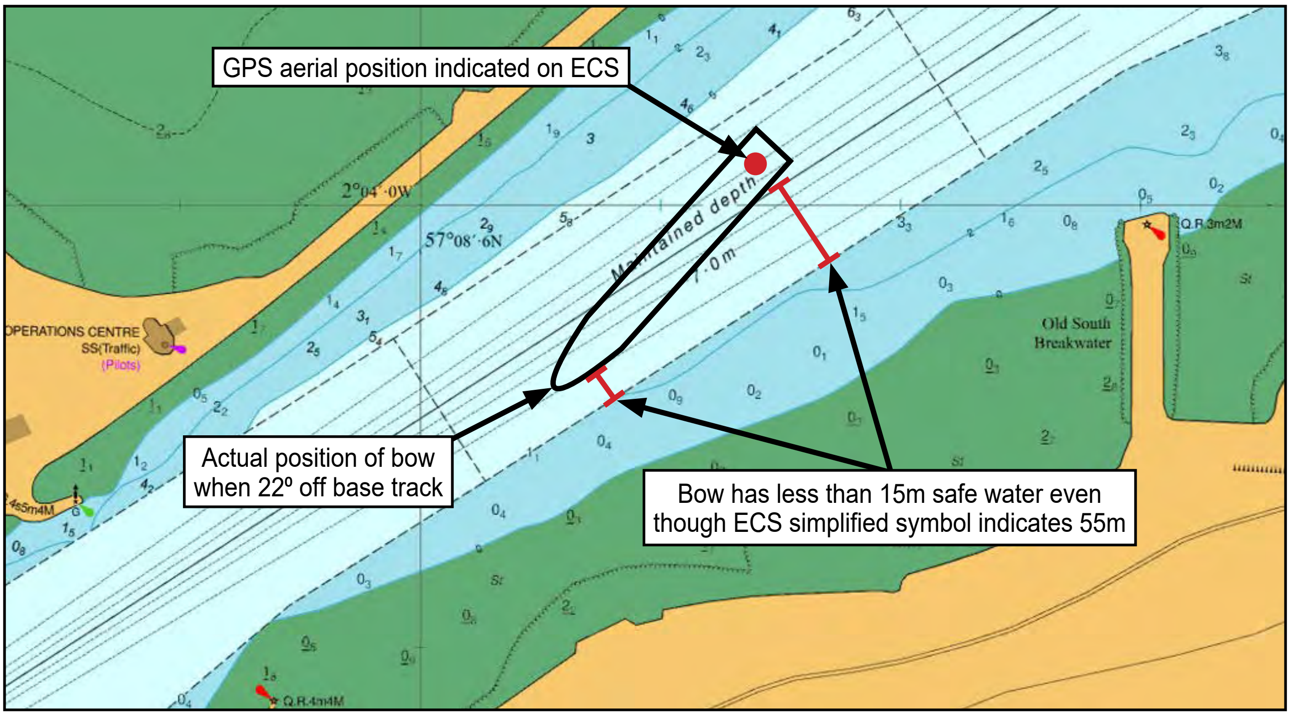

Figure 23: Diagram showing relative position of GPS and radar aerials compared to the bow of *Arrow* when 22° off base track in Aberdeen Navigation Channel

As the ECS was loaded with RNCs, the only warnings the system could give were cross-track errors unless manual danger lines were input to replicate some of the functionality available in an ECDIS using ENCs. No manual danger lines were input, and the cross-track error was not being monitored at the time of grounding. This meant that the ECS only provided limited assistance to the bridge team, denying them a considerable asset. A manual input of the edge of the channel, together with a look-ahead alarm set at an appropriate distance to make allowance for the GPS antenna position in relation to its distance from the bow could have provided a useful early warning. However, when navigating a narrow channel using such equipment, careful management of alarm overload is essential.

2.5.3 Navigation Channel width

At only 70m wide, Aberdeen's Navigation Channel is very narrow. The width of the channel means that navigators of larger vessels using the channel must take care to ensure all of the vessel remains safe at all times. This can limit the amount of course alteration available to regain or hold the planned track down the centreline as angles off the base course can increase the effective swept path[17] of water the vessel covers **(Figure 19)**. For a vessel of *Arrow*'s dimensions, at 10° off the base course, the swept path becomes 41m, and at 22° off the base course, the swept path is 65m of the available 70m of navigable water.

In practice, this means that in strong cross-currents or winds, a vessel's centre must be held very close to the centreline of the channel, so that both bow and stern remain within the channel at all times. As part of the pilotage planning process, pilots, PEC holders and bridge teams should understand how much the vessel can be steered off the base track and remain safe. Given the accuracy of radar navigation, in the case of *Arrow*, it is unlikely that any angle beyond 10° off the base track of 237° would have been reliably safe. It is not clear if any of *Arrow*'s bridge team understood this.

2.5.4 *Arrow*'s pilotage execution

With limited information available from the ECS, and feedback from the paper chart delayed, *Arrow*'s safe navigation depended on the single, identical PI on each radar display. Seconds before grounding, the PEC holder was navigating using the X-Band radar and steering the vessel. He and the master had realised the vessel was close to danger to the north, and the PEC holder altered to the south. At that moment, the Old South Breakwater slipped off both radar displays as it passed astern **(Figure 21)**. Thus, at the last possible opportunity to avoid grounding, *Arrow*'s bridge team had very limited radar-based real-time navigation information available to them. Changing the offset position of the radar display would have rectified this.

2.6 THE GROUNDING

2.6.1 Shallow water effects

Aberdeen's Navigation Channel is relatively steep-sided **(Figure 11)**, shelving more steeply to the south than the north. At mid-tide, with *Arrow*'s draught at 5.3m, there would have been about 3.5m below the keel, and at 6.5kts, squat would have been minimal. However, as the vessel approached the edge of the channel to the north, it is possible that there was a degree of bow cushion effect[18] between the bow area and the side of the channel. This may have accelerated the vessel's turn to port. Again, as the bow approached the steeper southern bank, bow cushion effect may have assisted in turning the bows away from the bank, but not sufficiently to avoid grounding.

[17] "Swept path" is used here to describe the total width of water a vessel covers as it moves through the water. If a vessel is having to steer to counter wind or current, the width will increase beyond the width of the vessel. See **Figure 19** for an explanation.

[18] 'Bow-cushion effect' refers to the tendency of a ship's bow to swing away from a nearby bank when operating in a restricted waterway.

2.6.2 Grounding

The PEC holder was navigating and steering *Arrow*, and reliant on radar information. He also had to take his eyes off the radar display to obtain heading information from the gyro repeat situated to the right of his position **(Figure 7)**. It is evident from the plot of the vessel's track **(Figures 8** and **22)** that the PEC holder struggled to hold *Arrow* on track while navigating in fog. East of the breakwaters, this was less important, but once in the confines of the Navigation Channel, accurate navigation and steering were essential.

Monitoring of progress along the channel by the remainder of the bridge team was limited and the vessel had deviated significantly from the planned track before the master noticed and the PEC holder reacted. The PEC holder's initial action to apply 10º of rudder. Given the confines of the channel **(Figure 19)**, this was probably sufficient to bring the vessel gently back towards the centreline. However, the master's prompting led to the PEC holder increasing this to around 30º, and coupled with the possible bow cushion effect, the vessel had altered to 215º before the PEC holder had stopped the turn. Immediately applying starboard wheel when the ship's head steadied might have recovered the situation, but by maintaining the heading for 15 seconds, during which time the ferry travelled a further 50m, there was no longer sufficient space to recover, despite applying full starboard rudder, and *Arrow* grounded.

It is possible that by utilising navigation information related to the stern of the vessel, where the radars and GPS aerials were situated, 100m from the bow **(Figure 23)**, the bridge team's awareness of the danger, first to the north and then to the south, was limited, reducing the available reaction time.

2.7 POST-GROUNDING ACTIONS

Initial reactions to the grounding were swift, but the Grounding Checklist **(Annex B)** was not fully completed, and it was 13 minutes before the general emergency alarm was sounded. It took several minutes to establish that there was no ingress of water into the hull, and that there was no immediate danger to life. However, had circumstances been different, the delay in raising the alarm, informing the crew of what had happened, and commencing an emergency response, might have proven costly. The use of the general alarm is an effective method of alerting all on board and should be instinctive.

Arrow was aground on its port side on the edge of a steep-sided channel **(Figure 11)** and immediately started to list to starboard. The master was aware that with a further 1.8m reduction in tidal height predicted, the list would increase, and that the ship's situation could quickly worsen. He decided that, with no or limited internal damage, an early attempt to re-float *Arrow* was the best course of action. Attempting to achieve this with engines alone proved unsuccessful, and so after de-ballasting forward tanks, he tried again once a tug and pilot had arrived.

In approximately 40 minutes and 0.5m fall of tide, *Arrow*'s list increased from about 2º to over 10º. With another 1.3m fall of tide, it is likely that the list would have increased further, with the worst case seeing the ferry turn onto its side. The risk of damage to ferry and cargo would have increased, with consequent risk to personnel. The master understood this risk and given the circumstances and no sign of water ingress or pollution, the decision to attempt to re-float *Arrow* was warranted. It is likely that this caused further damage but was justified given the risk to the vessel and cargo of remaining aground as the tide fell away.

2.8 BRIDGE RESOURCE MANAGEMENT

Effective BRM demands a planned and coordinated sharing of workload and a shared understanding of the plan and the current state of the vessel ('mental model'). This requires individual and team training, an effective plan, and a team brief in advance of all evolutions, with full consideration of possible emergencies and preparation for foreseeable contingency actions.

2.8.1 Master and PEC holder expectations

Although he had worked with the team on *Arrow* for several days, the PEC holder was used to operating in a more rigorous BRM environment and had probably become accustomed to more support when conducting pilotage. Without any full-team pre-entry brief, the PEC holder did not express any concerns he might have felt over the BRM in place and, as a relatively junior officer, did not feel able to challenge the organisation he found himself in. This led to the PEC holder conducting many of the key functions himself. In good visibility, this had not been an issue, but in poor visibility the workload was significantly higher.

The master retained responsibility for the safety of the ship, even with a pilot or PEC holder engaged, and should have ensured both effective workload distribution and monitoring of the passage by the remainder of the bridge team, including himself.

2.8.2 Training

Each member of the bridge team had been individually trained to the appropriate level for their role, and all had undergone BRM training. The PEC holder had completed sufficient assessed pilotage runs with Aberdeen pilots and had passed his PEC board in October 2019, including examination of his knowledge of restricted visibility navigation in Aberdeen Harbour. However, Seatruck's SMS did not require team training in restricted visibility **(Annex G)**.

Pilotage in restricted visibility is one of the most demanding ship navigation tasks, and for it to be conducted effectively it requires teamwork and mutual support. Each member of the bridge team must understand their role and fully contribute to the team. Changes in conditions will prompt changes in organisation, but this should be planned and familiar to all participants. This can only be successful if the team trains together and the navigation skills for restricted visibility are regularly practised.

2.8.3 Bridge manning

Seatruck's SMS required a bridge team for pilotage in restricted visibility of a master, an OOW, and two ratings. The SMS further implied that the helmsman should not also be tasked as a lookout. The SMS states that a helmsman should be on 'standby' in restricted visibility but does not state where this helmsman should be. With four officers on the bridge, it can be argued that *Arrow* fulfilled this remit. However, with no formal entry brief, the C/O arriving on the bridge at about 0715 as the vessel approached the Fairway Buoy and no dedicated lookout posted to the bridge, the effective bridge team was probably less than intended by the SMS.

2.8.4 Use of helmsmen

It was common practice on *Arrow* for the officer with the con during pilotage to also steer the vessel themselves, using the tiller arm located next to the port radar display, or on the two bridge wings during berthing or unberthing. While not explicitly in contravention of the current wording on AHB's PEC certificates, this goes against the spirit of the condition that requires bridge manning of a master, one other officer and a helmsman. *Arrow* had a bridge team of four at the time of grounding, the master, the PEC holder, the C/O and the 3/O. However, the PEC holder was conducting the pilotage in addition to steering the ship, and while the master was engaged in monitoring navigation, both the C/O's and 3/O's contribution were limited.

During final berthing manoeuvres, the conning officer taking direct control of engines, rudders and thrusters can make sense. However, during intensive periods of pilotage, such as in restricted visibility, use of a competent, well-trained helmsman can significantly reduce the loading on the conning officer, allowing them to concentrate on navigation.

Once the vessel was committed to the Navigation Channel, changing helm arrangements could have been dangerous, but early consideration of a change, at the first indication of restricted visibility, would have been prudent.

It is important that helmsmen are competent and familiar with the controls they are using. To allow masters to be confident in their abilities in high-pressure situations, they should be frequently employed during fair-weather pilotage and be part of drills and team training.

2.8.5 Grounding of *Seatruck Performance*

There are marked similarities between the grounding of *Seatruck Performance* in the Greenore Channel in Carlingford Lough on 8 May 2019 and this accident. Specifically, the pilotage plan lacked detail; there were shortcomings in the navigational practices employed; one officer was attempting both to navigate and steer the vessel in challenging conditions; and, the conning officer was insufficiently supported by the remainder of the bridge team. While this accident involved a PEC holder who had been signed on from another vessel, the conduct of navigation and pilotage onboard *Arrow* indicate that the learning of lessons from the earlier accident had not sufficiently improved BRM and navigational practices across the Seatruck managed fleet.

2.9 ABERDEEN HARBOUR BOARD

2.9.1 Safety management system

AHB had a comprehensive SMS and an updated RA covering most aspects of its operation. Due to the assessed relatively low severity of consequences, grounding was identified as a low-risk hazard for the port. However, while the risk to life of a grounding in the Navigation Channel was low, a grounded vessel, if not rapidly re-floated, could hamper or even stop harbour operations, and could pose a major risk of pollution should weather and tidal conditions cause increasing levels of damage. Risk control measures, such as a VTS and strict one-way traffic in the harbour reduced the risks, but the availability of the Navigation Channel depended largely on the standards of navigation of individual vessels by their crews, PEC holders and AHB's own pilots.

AHB had its own bridge simulator, which it used to train and assess its pilots. Use of this with PEC holders was limited, largely due to their numbers. Targeting ferry PEC holders, who as the most frequent visitors are most likely to operate in restricted visibility, could improve their competence and port confidence by matching their training and revalidation requirements to those of AHB's pilots. Visibility limitations on less frequent visitors, based on the ability to see the transit marks and leading light by the time the vessel reaches the Old South Breakwater **(Figure 5)**, approximately 0.6nm, could be considered. This would ensure such PEC holders are able to navigate the narrowest part of the Navigation Channel using the transit and light, as well as having sufficient visibility to navigate the narrow inner areas of the port.

2.9.2 Restricted visibility and VTS responsibility

The port did not have a formal 'Fog Routine' established in its pilotage and navigation directions. Given the total control of all vessel movements and one-way traffic, it can be argued that this was not strictly necessary. The restricted visibility was discussed with other vessels that morning and these conversations were overheard on *Arrow*'s bridge. However, AHB's SMS, in the event of adverse weather conditions, including restricted visibility, required that there should be a close liaison between VTS and the 'pilot'[19] to determine if it is safe to enter or depart.

The earliest recorded VTS VHF discussions concerning degraded visibility were at 0711, some 14 minutes before *Arrow* passed the South Breakwater. The PEC holder checked the visibility in harbour at 0714 and conditions probably worsened at the VTS station by about 0720. Fog enveloped *Arrow* at 0722, after *Arrow* had been given 'traffic clearance', at which point there was still time to abort the entry. Although VTS did not discuss the state of visibility with *Arrow*, given that *Arrow*'s PEC holder and master agreed to continue the entry at 0722, it is unlikely that a discussion would have prompted *Arrow*'s bridge team to abort the approach. However, a brief VHF call by VTS might have prompted *Arrow*'s bridge team to consider whether they were ready for the difficult conditions.

The purpose of a VTS is to contribute to safe navigation and control traffic; a VTS's function is not to navigate individual ships, although there is an obligation to inform vessels if they appear to be standing into danger. Given the narrowness of the Navigation Channel, there was probably less than 20 seconds for the VTSO to spot the danger and inform the vessel in time for it to react. As *Arrow* was a relatively regular harbour user, being piloted by an authorised PEC holder, it was reasonable for the VTSO to assume that the vessel, with no declared defects, would be safely navigated into harbour, and thus the VTSO did not question *Arrow*'s entry.

2.9.3 PEC holders' understanding of PEC conditions

AHB sets conditions on its PEC holders, among these is a bridge manning requirement; for *Arrow*, this is the master, one other officer and a helmsman. Although, the conditions do not make clear that the piloting officer should not be steering the vessel, it can be argued that this is implied. Industry practice varies, but

[19] This is assumed here to include a PEC holder, who is performing pilotage duties on behalf of his or her vessel, and also has a responsibility to AHB for the safe conduct of pilotage on their vessel.

some port authorities stipulate that the vessel is steered by a competent helmsman other than the master or pilot. While Aberdeen's Navigation Channel is relatively easy to navigate using the transits and leading light, in restricted visibility, the navigation workload is much higher, and the practice of combining the navigation and helming functions increases risk. Re-wording this section of the PEC certificate to make the port's expectation clear would remove any doubt.

SECTION 3 – CONCLUSIONS

3.1 SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. *Arrow* grounded on the southern side of the Aberdeen Navigation Channel because the PEC holder conning and steering the ship over-corrected the ship's heading after initially being on the northern side of the channel, and did not realise the error until it was too late to avoid the grounding. [2.2, 2.5.3, 2.6.2]

2. None of the bridge team spotted the danger in time to stop the grounding. [2.2, 2.5.3, 2.6.2]

3. The bridge team was not adequately prepared for pilotage in restricted visibility. A pre-arrival briefing had not been conducted; the passage plan lacked a formal abort position; which could have triggered a re-evaluation of the plan; and the restricted visibility check list has not been completed effectively. [2.3, 2.4]

4. Passage planning for the pilotage phase did not identify safety limits for the vessel that allowed for manoeuvring characteristics and the size of the vessel in relation to the available width of navigable water. The plan relied heavily on the conning team being able to see visual references, and it was insufficient for safe navigation in restricted visibility. [2.4.1]

5. More effective use could have been made of the radars and ECS. [2.4.1, 2.5.2, 2.5.4]

6. The PEC holder was probably overloaded by the combined duties of steering the vessel in addition to navigating it by the use of the radar. [2.5.1, 2.6.2]

7. The layout of the centre bridge console did not assist pilotage conning in restricted visibility from the port radar display as the ECS display was 2.5m away. [2.5.2]

8. The limits to which *Arrow* could safely be steered off the base track did not appear to be appreciated by the bridge team. [2.5.3]

9. Bridge Resource Management was poor and, as a result, the bridge team did not adequately support the PEC holder. [2.6, 2.8]

10. Seatruck's SMS did not require *Arrow*'s bridge team to practice pilotage in restricted visibility. [2.8.2]

11. There are marked similarities between the grounding of *Seatruck Performance* in the Greenore Channel in Carlingford Lough on 8 May 2019 and this accident. Specifically, the pilotage plan lacked detail; there were shortcomings in the navigational practices employed; one officer was attempting both to navigate and con the vessel in challenging conditions; and, the conning officer was insufficiently supported by the remainder of the bridge team. While this accident involved a PEC holder who had been signed on from another vessel, the conduct of navigation and pilotage onboard *Arrow* indicate that the learning of lessons from the earlier accident had not sufficiently improved BRM and navigational practices across the Seatruck managed fleet. [2.8.5]

3.2 OTHER SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT

1. Restricted visibility had been forecast, and fog patches were observed. Although the harbour was clear when checked, the chances of encountering fog were high and the vessel could have been much better prepared. [2.3]

3.3 SAFETY ISSUES NOT DIRECTLY CONTRIBUTING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. The general alarm was not sounded until 13 minutes after the grounding. [2.7]

2. The decision to attempt to re-float the vessel was probably correct, but it is highly likely this caused further damage. [2.7]

3.4 OTHER SAFETY ISSUES NOT DIRECTLY CONTRIBUTING TO THE ACCIDENT

1. Aberdeen Harbour Board could make better use of its bridge simulator facility to train and assess PEC holders' abilities to navigate in restricted visibility. [2.9.1]

2. Aberdeen VTS did not discuss the restricted visibility with *Arrow* before the vessel entered the harbour. [2.9.2]

3. Aberdeen Harbour Board's intended level of bridge manning for vessels piloted by PEC holders could be made clearer. [2.9.3]

SECTION 4 – ACTIONS TAKEN

Seatruck Ferries Limited has:

- Repaired defects in *Arrow*'s VDR and instituted an enhanced system monitoring regime.
- Upgraded *Arrow*'s current ECS system.
- Transitioned the remainder of its fleet to ECDIS as primary means of navigation (except *Arrow*).
- Defined the role of a PEC holder within the bridge team in its SMS.
- Revised its SMS procedure for navigating under pilotage to ensure that a PEC holder has the same responsibilities with regard to pilotage as those of a pilot.
- Conducted a review of Company Risk Assessment FLEET DK 007 – Pilotage Waters.
- Introduced VDR audits to verify compliance with company procedures and identify training weaknesses.
- Developed a bespoke Bridge Resource Management course incorporating company procedures and checklists.
- Updated its procedures to allow ECDIS as the primary means of navigation.
- Introduced a requirement for masters and PEC holders to conduct blind pilotage training.

Aberdeen Harbour Board has:

- Improved internal pilot blind pilotage training.
- Re-iterated the need for a dedicated helmsman as a condition of PEC to new PEC holders at award, and existing PEC holders at renewal.
- Established restricted visibility limitations for all vessels and uploaded fog protocols to their website.
- Instituted practical checks on PEC holders transferring to other vessels operating under a different SMS.
- Developed a training programme which includes a blind pilotage endorsement with Serco Northlink Ferries for ferry PEC holders to be trained to the same level as AHB's pilots.

SECTION 5 – RECOMMENDATIONS

As a result of the actions taken following this investigation no recommendations have been taken.

Marine Accident Report

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