Accident Investigation Board Norway

Defence Accident Investigation Board Norway

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PART ONE REPORT ON THE COLLISION ON 8 NOVEMBER 2018 BETWEEN THE FRIGATE HNOMS HELGE INGSTAD AND THE OIL TANKER SOLA TS OUTSIDE THE STURE TERMINAL IN THE HJELTEFJORD IN HORDALAND COUNTY

Accident Investigation Board Norway • P.O. Box 213, N-2001 Lillestrøm, Norway • Phone: + 47 63 89 63 00 • Fax: + 47 63 89 63 01
www.aibn.no • post@aibn.no

This report has been translated into English and published by the Accident Investigation Board Norway (AIBN) to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

Photo of ferry on the Norwegian west coast: Bente Amandussen

INTRODUCTION TO THE PART ONE REPORT

This part one report[1] contains the results of the Accident Investigation Boards Norway's investigation of the sequence of events up until the time when the collision occurred. Information relating to the sequence of events after the collision, will be included in the part two report.

The further investigation will focus on how the accident developed after the collision, up until the time when all crew had been evacuated and the frigate was deemed to have been lost. However, we cannot exclude the possibility that need to revise some parts of this part one report may arise when further information is collected and further analyses are conducted.

As a result of the scope and complexity of the investigation, it is not possible to estimate a date of completion for the part two report. The investigation will continue at a high level of activity.

[1] The report is published within 12 months of the accident in order to present the results of the investigation so far and to give the parties involved and the public an update on the status of the investigation. This is in accordance with the Act of 24 June 1994 No 39 (the Norwegian Maritime Code) Section 485 fifth paragraph.

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NOTIFICATION OF THE ACCIDENT

On the morning of Thursday 8 November 2018, the Accident Investigation Board Norway (AIBN) was informed that the frigate HNoMS Helge Ingstad and the Maltese-registered tanker Sola TS had collided outside the Sture Terminal in Øygarden municipality in Hordaland county (see Figure 1). The AIBN contacted the Defence Accident Investigation Board Norway (DAIBN) and it was decided to initiate a joint investigation into the accident, led by the AIBN. In the course of the afternoon and evening of 8 November 2018, 14 representatives of the AIBN and the DAIBN arrived in Bergen to initiate the investigation.

The investigation was conducted in accordance with the Act of 24 June 1994 No 39 (the Norwegian Maritime Code) Chapter 18. The Marine Safety Investigation Unit of Malta and the Spanish Standing Commission for Maritime Accident and Incident Investigations (CIAIM) have also participated in the investigation as 'substantially interested states'; see Section 474 of the Norwegian Maritime Code.

Hereinafter the investigation authorities (the AIBN and the DAIBN) are referred to as the AIB.

Figure 1: The vessels collided outside the Sture Terminal in the Hjeltefjord. Map: The NCA/AIBN

SUMMARY

The frigate HNoMS Helge Ingstad and the tanker Sola TS collided in the Hjeltefjord in the early hours of 8 November 2018. The frigate had 137 persons on board with a mix of conscripts and permanent crew. A total of seven watchstanding personnel were present on the bridge, including two trainees. The tanker Sola TS was operated by the Greek shipping company Tsakos Columbia Shipmanagement (TCM) S.A. There was a total of 24 persons on board. The bridge was manned by four persons, including the pilot.

HNoMS Helge Ingstad sailed south at a speed of approximately 17–18 knots with the automatic identification system (AIS) in passive mode, i.e. no transmission of AIS-signal. The frigate's bridge team had notified Fedje Vessel Traffic Service (VTS) of entering the area and followed the reported voyage. Sola TS had been loaded with crude oil at the Sture Terminal, and notified Fedje VTS of departure from the terminal. Sola TS exhibited navigation lights. In addition some of the deck lights were turned on to light up the deck for the crew who were securing equipment etc. for the passage.

In advance of the collision, Fedje VTS had not followed the frigate's passage south through the Hjeltefjord. The crew and pilot on Sola TS had observed HNoMS Helge Ingstad and tried to warn of the danger and prevent a collision. The crew on HNoMS Helge Ingstad did not realise that they were on collision course until it was too late.

At 04:01:15, HNoMS Helge Ingstad collided with the tanker Sola TS. The first point of impact was Sola TS' starboard anchor and the area just in front of HNoMS Helge Ingstad's starboard torpedo magazine.

HNoMS Helge Ingstad suffered extensive damage along the starboard side. Seven crew members sustained minor physical injuries. Sola TS received minor damages and none of the crew were injured. Marine gas oil leaked out into the Hjeltefjord. The Institute of Marine Research has ascertained the effect of the oil spill had little impact on the marine environment.

The AIBN's investigation has shown that the situation in the Hjeltefjord was made possible by a number of operational, technical, organisational and systemic factors:

- As a consequence of the clearance process, the career ladder for fleet officers in the Navy and the shortage of qualified navigators to man the frigates, officers of the watch had been granted clearance sooner, had a lower level of experience and had less time as officer of the watch than used to be the case. This had also resulted in inexperienced officers of the watch being assigned responsibility for training. Furthermore, several aspects of the bridge service were not adequately described or standardised. The night of the accident, it turned out, among other things, that the bridge team on HNoMS Helge Ingstad did not manage to utilise the team's human and technical resources to detect, while there was still time, that what they thought was a stationary object giving off the strong lights, in fact was a vessel on collision course. Organisation, leadership and teamwork on the bridge were not expedient during the period leading up to the collision. In combination with the officer of the watch's limited experience, the training being conducted for two watchstanding functions on the bridge reduced the bridge team's capacity to address the overall traffic situation. Based on a firmly lodged situational awareness that the 'object' was stationary and that the passage was under control, little use was made of the radar and AIS to monitor the fairway.

- When Sola TS set out on its northbound passage with the forward-pointing deck lights turned on, it was difficult for the frigate's bridge team to see the tanker's navigation lights and the flashing of the Aldis lamp, and thereby identify the 'object' as a vessel. The shipping company Tsakos

Columbia Shipmanagement SA had not established compensatory safety measures with regards to the reduction of the visibility of the navigation lights due to deck lighting. Furthermore, radar plotting and communication on the bridge did not sufficiently ensure the effect of active teamwork to build a common situational awareness. This could have increased the time window for identification and warning of the frigate.

- The Norwegian Coastal Administration (NCA) had not established human, technical and organisational barriers to ensure adequate traffic monitoring. The functionality of the monitoring system with regards to automatic plotting, warning and alarm functions, was not sufficiently adapted to the execution of the vessel traffic service. Lack of monitoring meant that the VTS operator’s situational awareness and overview of the VTS area were inadequate. Hence, Fedje VTS did not provide the vessels involved with relevant and timely information and did not organise the traffic to ensure the tanker’s safe departure from the Sture Terminal.

- On the southbound voyage, HNoMS Helge Ingstad sailed with AIS in passive mode. This meant that the frigate could not be immediately identified on the screens at Fedje VTS or Sola TS. None of the parties involved made sufficient use of available technical aids. It was a challenge for maritime safety that the Navy could operate without AIS transmission and without compensatory safety measures within a traffic system where the other players largely used AIS as their primary (and to some extent only) source of information.

The Accident Investigation Board Norway submits a total of 15 safety recommendations based on the investigation of the sequence of events leading up to the collision.

Information and any safety recommendations relating to the sequence of events after the collision up until the time that the frigate ran aground and sank, will be included in the part two report.

1. FACTUAL INFORMATION

1.1 Introduction

The description of the sequence of events is based on interviews with members of both vessel crews, the pilot and the Vessel Traffic Service (VTS) operators who were on duty during the night of the accident, in addition to technical/electronic information obtained from both vessels, Fedje VTS Centre, the Joint Rescue Coordination Centre's action log, the log from the Norwegian Coastal Administration's (NCA) automatic identification system (AIS), and radio and radar recordings from Fedje VTS.

The AIBN has furthermore conducted technical examinations on board HNoMS Helge Ingstad and carried out an observation voyage with one of the frigate's sister ship and Sola TS. A significant amount of information has also been obtained from the Norwegian Maritime Authority, the NCA, the police, the Royal Norwegian Navy, the Norwegian Defence Material Agency (NDMA) and Tsakos Columbia Shipmanagement S.A.

The AIBN has also used external consultants for input relating to human factors, situational awareness and military navigation, and for eyesight testing of the bridge crew on HNoMS Helge Ingstad.

1.2 Sequence of events

1.2.1 Sequence of events in the initial phase (00:00–03:40)

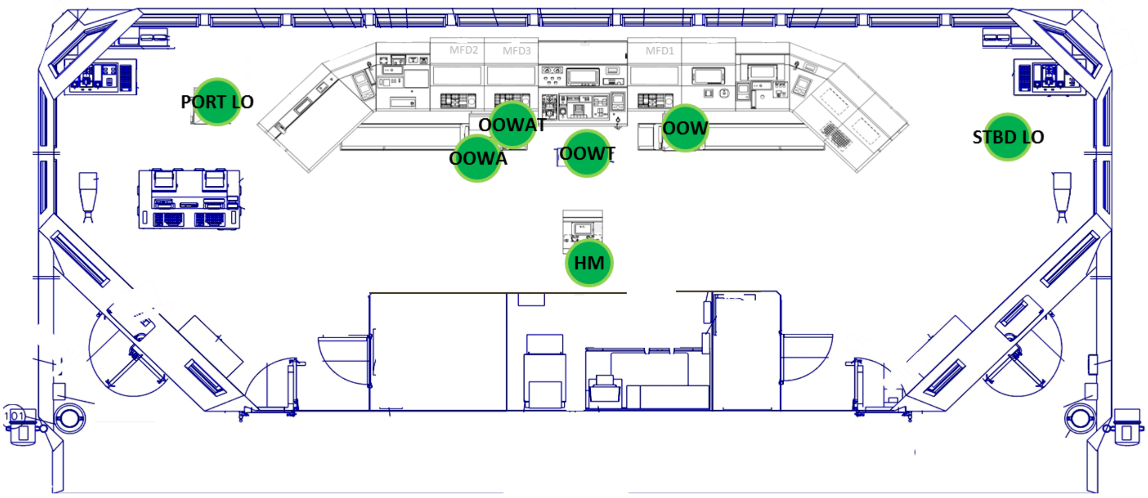
1.2.1.1 *HNoMS Helge Ingstad*

During the night leading up to Thursday 8 November 2018, HNoMS Helge Ingstad was on a southbound voyage from Måløy in Sogn og Fjordane county towards Sletta north of Haugesund (see Figure 2).

Figure 2: The Hjeltefjord is marked with a black circle. The red line shows the planned route of HNoMS Helge Ingstad through the area from the Krakhellesundet sound in the north. The shaded area shows the Fedje VTS area. Map: NCA/Royal Norwegian Navy/AIBN

The frigate's participation in the NATO[2] exercise *Trident Juncture 2018* had ended on Wednesday 7 November. The plan was to reach destination at Dundee in Scotland on Friday 9 November, and the voyage was being used for crew training in inshore navigation. The automatic identification system (AIS) was mostly[3] in receive mode (receive only, no transmission of own AIS information; see sections 1.7 and 1.9.3.7), and the frigate's navigation lights were on (two masthead lights, stern light and sidelights).

The bridge was manned as shown in Figure 3. The officer of the watch (OOW) was responsible for navigation of the frigate. There were another six crew on the bridge during the voyage: an officer of the watch trainee (OOWT), an officer of the watch assistant (OOWA), an officer of the watch assistant trainee (OOWAT) and a bridge watch team consisting of three conscripts rotating between the functions of helmsman (HM), port lookout (PORT LO) and starboard lookout (STBD LO) (for further details, see section 1.8.1). The training of the OOWT/OOWAT focused on checking the frigate's position on the electronic chart display (ECDIS[4]) using optical navigation aids.



OOW – Officer of the watch
OOWT – Officer of the watch trainee
OOWAT – Officer of the watch assistant trainee
OOWA – Officer of the watch assistant

Bridge watch team:
HM – Helmsman
STBD LO – Starboard lookout
PORT LO – Port lookout

Figure 3: Positions on the bridge of HNoMS Helge Ingstad. Illustration: The Royal Norwegian Navy/AIBN

The OOW on the 00–04 watch arrived on the bridge at around 23:40 on Wednesday 7 November and completed the handover procedure with the officer being relieved (20–24 watch). The frigate was a little way north of Florø at the time. The OOWT had been on duty since around 20:00 and was to continue to navigate until the frigate was south of Krakhellesundet.

During the southbound voyage, the Commanding Officer (CO) was present on the bridge when they sailed through areas of maritime traffic or narrow fairways. The CO made a final appearance on the bridge at approximately 01:30 on Thursday 8 November, before the frigate entered Krakhellesundet. At around 02:00, after passing through

[2] NATO – North Atlantic Treaty Organization – military alliance of 29 countries in Europe and North-America.
[3] On this particular voyage, HNoMS Helge Ingstad had last transmitted AIS information when passing through Skatestraumen in the evening before the accident.
[4] ECDIS – electronic chart display and information system that meets requirements set by the International Maritime Organization (IMO).

Krakhellesundet, the CO reminded the OOW to call Fedje Vessel Traffic Service (VTS) before reaching the northern boundary of the Fedje VTS area at Sognoksen. They were also told to wake up the executive officer (XO) when they reached the southern end of the Hjeltefjord, so that he could be present on the bridge when passing Bergen and through the Vatlestraumen straits. The CO then left the bridge.

At 02:00, the bridge watch team was relieved along with the OOWAT. A new bridge watch team arrived, and the starboard and port lookouts and helmsman were relieved. The relieving OOWAT arrived and went through the handover procedure with the OOWAT being relieved. The relieving OOWAT then took over the watch together with the OOWA on the 00–04 watch.

The plan was for the relieving OOWT to go on watch after they had sailed through Krakhellesundet and navigate the frigate from Sognesjøen to the southern end of the Hjeltefjord. The relieving OOWT arrived on the bridge at 02:18 and went through the handover procedure with the OOWT being relieved. The OOWT being relieved logged the watch change at 02:24 in the log book.

The OOW navigated the frigate while the relieving OOWT established night vision and got ready to navigate. As they continued south, the OOWT navigated the frigate and also performed course changes by issuing orders to the HM. The OOW oversaw the navigation (see section 1.8.1.3).

At 02:38, HNoMS Helge Ingstad was directly south of Ytre Steinsund, approximately 4 nautical miles (nm) north-east of the boundary of the Fedje VTS area (see Figure 4).

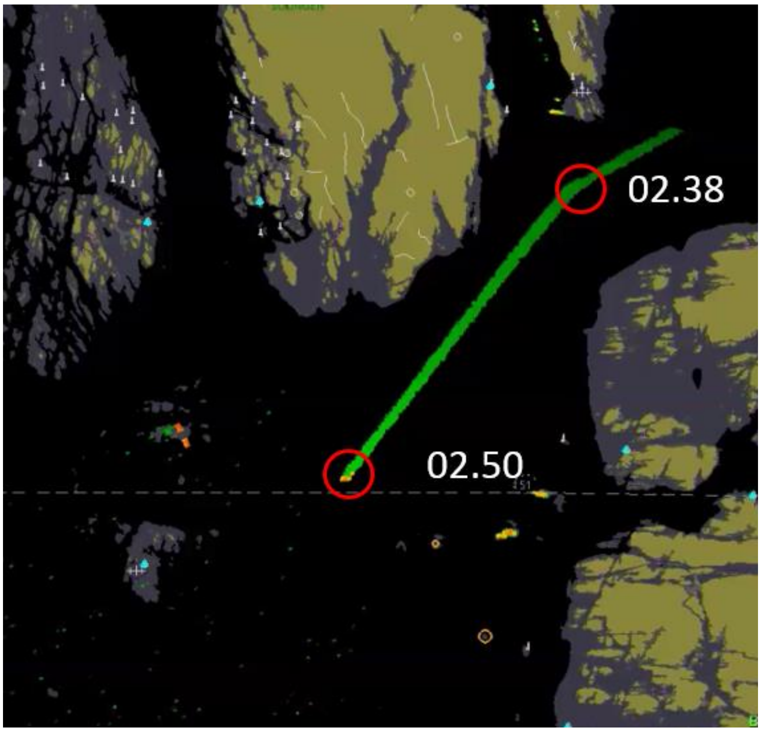


Figure 4: Screenshot of radar replay from Fedje VTS showing the position of HNoMS Helge Ingstad at 02:38 and 02:50, respectively. The broken line represents the boundary of the Fedje VTS area. Note: When preparing the radar replay after the accident, an artificially long afterglow was used to illustrate the frigate's voyage. Source: The NCA/AIBN

At 02.38, the OOW called Fedje VTS by mobile phone, with the information that they would enter the VTS area from the north. The OOW informed the VTS of the frigate's planned voyage route through the VTS area: the Holmengrå fairway, south through the Hjeltefjord and Vatlestraumen, leaving the area at Eldjarnet in the south.

In addition to VHF channel 16[5], HNoMS Helge Ingstad also established a listening watch on VHF channel 80, the VTS's working frequency for the area. The OOW had the responsibility for maintaining a listening watch (see chapter 1.13.2.2). The frigate sailed on at a speed of between 17 and 18 knots, which was normal transit speed when sailing with both diesel engines in 'cruise' mode.

The Fedje VTS operator (Area North), who was responsible for the area north of Jona light, confirmed receipt and logged the message in the VTS's log-keeping system at 02:40. The VTS operator saw a radar echo on the overview screen (see section 1.13.3.3) that was assumed to be the naval vessel.

At 02:50, HNoMS Helge Ingstad entered the Fedje VTS area from the north (see Figure 4). The VTS operator did not plot the vessel's movements on the radar. The VTS operator would normally, as a matter of routine, plot vessels when they passed into the traffic area, but did not do so this time. Because HNoMS Helge Ingstad was not transmitting AIS signals, information about the vessel's identity, course and speed vectors was also not transmitted automatically.

1.2.1.2 *Sola TS*

On Wednesday 7 November, the oil tanker Sola TS had been loaded with crude oil at the Sture Terminal, an oil and gas terminal in Øygarden municipality in Hordaland county. In the early hours of Thursday 8 November, Sola TS was getting ready to depart. The tanker was to be assisted by a pilot, and at 01:20 the pilot received the assignment to assist Sola TS on departure from the Sture Terminal.

The pilot boarded Sola TS at approximately 02:50, about the same time as HNoMS Helge Ingstad entered the Fedje VTS area from the north. The pilot and master completed the 'master-pilot exchange' (MPX), which consisted of exchanging information about the voyage route, ship particulars, weather and local conditions (see section 1.12.2.4). It was also agreed that the pilot would communicate with the tugboats and the VTS centre in Norwegian, but that the pilot would communicate all information of material importance to the master in English.

Just before 03:00, the master turned off the aft-pointing deck lights on Sola TS, while keeping the forward-pointing deck lights on to provide light for the work of clearing the forward deck. The two tugboats Ajax and Tenax arrived at Sola TS soon afterwards. Figure 5 shows the positions of Sola TS and HNoMS Helge Ingstad at 03:00.

At 03:05, the bridge on Sola TS was manned by the pilot, the master and the navigation officer on watch. The navigation instruments had been switched on and tested before the pilot arrived on board. The tanker's radars were switched on when the pilot confirmed that this could be done.

[5] International distress frequency.

At 03:12, the pilot on board Sola TS had established contact with the tugboats. Sola TS lay starboard side alongside the quay. The tugboat Ajax took up position midship on the port side, while Tenax was getting ready to pass its tow line through the stern centre lead on Sola TS (see Figure 6).

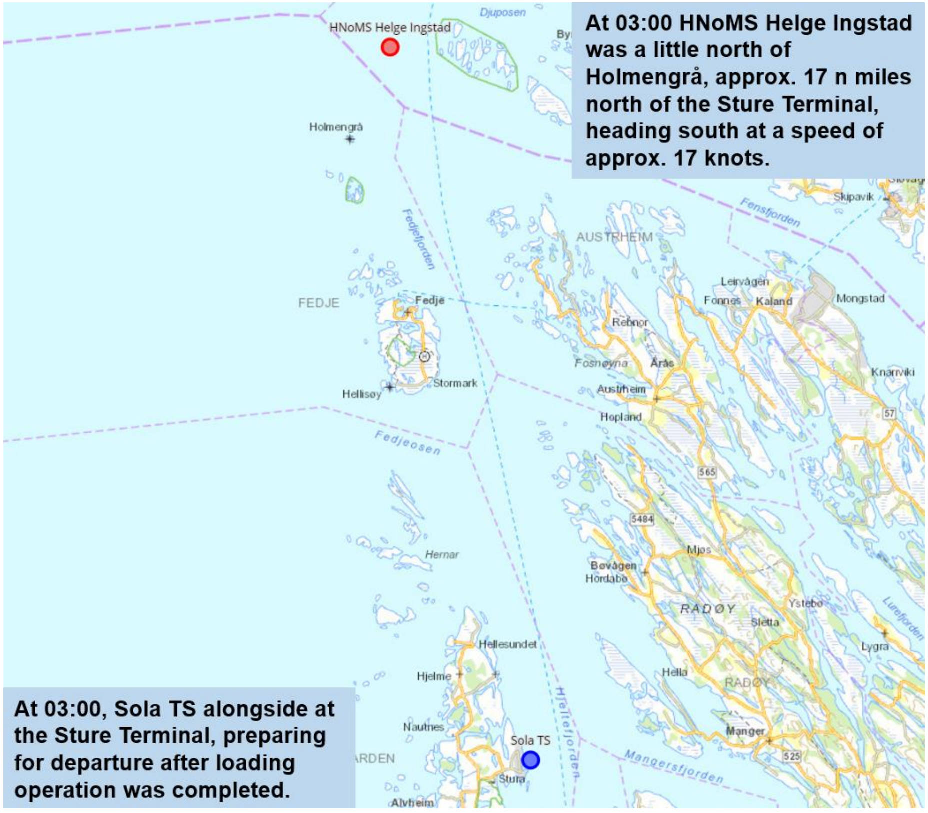


Figure 5: At 03:00, Sola TS (blue dot) lay alongside at the Sture Terminal, while HNoMS Helge Ingstad (red dot) was approx. 17 nm north of the Sture Terminal. Map: NCA/AIBN

Figure 6: The situation around Sola TS at 03:13, when the pilot informed Fedje VTS that they were ready to take in the mooring lines at the Sture Terminal. Illustration: AIBN

At 03:13, the pilot on board Sola TS called Fedje VTS on VHF channel 80 with the message that they were starting to take in the mooring lines and preparing to depart from the Sture Terminal. The VTS operator monitoring the area north of Jona light was downstairs getting some food at the time, so it was the VTS operator monitoring the southern area who confirmed receipt of the pilot's message. The Area North VTS operator returned shortly afterwards and was informed of this by the other operator. It was the Area North VTS operator who answered the subsequent VHF calls from vessels in the area north of Jona light.

Figure 7 shows the traffic situation in the Hjeltefjord at 03:13.

Figure 7: The traffic situation in the Hjeltefjord when HNoMS Helge Ingstad had passed Holmengrå (at 0313). There were one southbound and two northbound vessels in the area east of Fedje. There was one passing vessel by the Sture terminal, where Sola TS still was docked. Illustration: AIBN

At 03:13, none of the radars or the ECDIS on Sola TS were scaled to display the areas of maritime traffic to the north and south (see Figure 8). At 03:27, approximately 10 minutes before departure, the S-band radar was set to 3 nm and the X-band radar to 1.5 nm. There was still no indication of other vessel traffic on the radar displays, other than one southbound vessel ('Stril Herkules') that was just passing the Sture Terminal. See section 1.10.3.2 for a more detailed description.

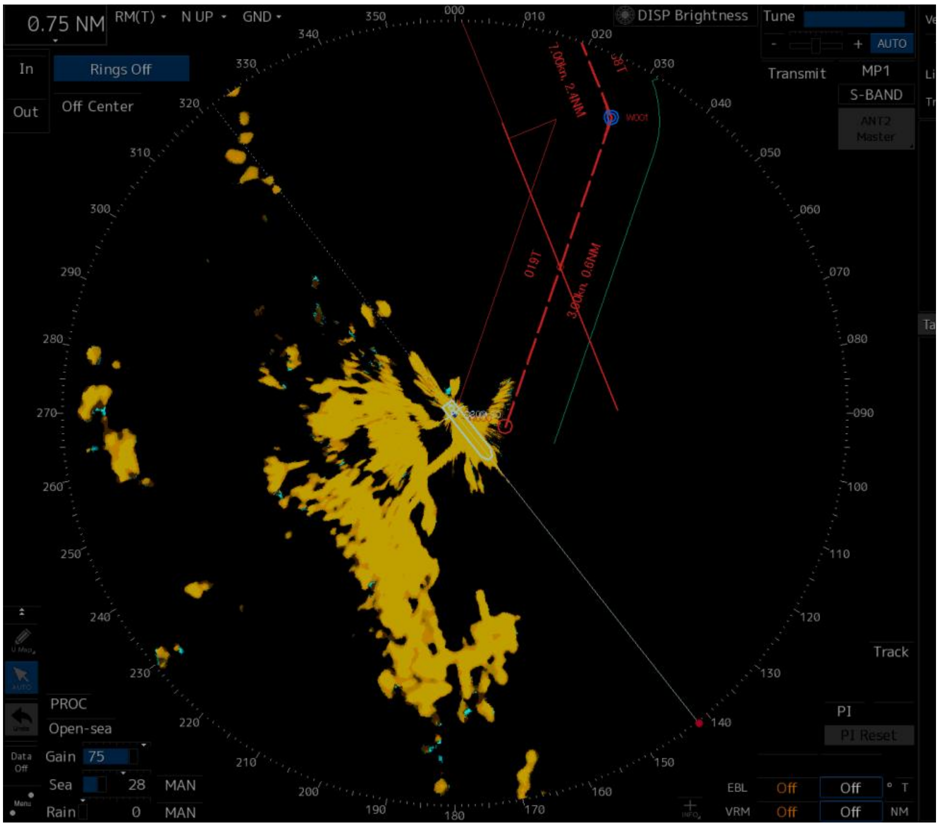


Figure 8: The S-band radar on Sola TS, set to a range scale of 0.75 nm, showed no other maritime traffic at 03:13. Source: Tsakos Columbia Shipmanagement S.A.

After reporting to Fedje VTS that they were taking in the moorings, the pilot and master went out on the starboard bridge wing to oversee the departure. As normal, the pilot was given the con of the vessel, while the master maintained command and monitored the actions of the pilot, the manoeuvring and navigation. There was a display on the bridge wing console that could be set to display either ECDIS or radar. Together with the view from the bridge wing, this enabled the pilot and the master to monitor the traffic in the nearby area. The bridge wing also had a VHF radio that enabled the pilot and master to also monitor radio communication. After the accident, it has not been possible to verify what was displayed on the bridge wing display or whether the VHF radio was set to the VTS centre’s channel. The pilot has explained that visibility was good, so that they were able to keep an eye on the traffic situation around the ship.

The navigation officer on watch and the helmsman remained inside the bridge on Sola TS and could monitor traffic by radar and ECDIS. They could also listen in on any communication with the VTS as long as the communication was in English.

Sola TS continued to prepare for departure. At 03:24, Tenax was made fast at the stern. At 03:36, all mooring lines had been retrieved, and Ajax, which had taken up position on the starboard side of Sola TS, started to push Sola TS from the quay. The pilot ordered slow speed ahead and they started manoeuvring away from the quay. The manoeuvring started with the aft tugboat pulling sideways towards the tanker’s port side at the same time as the forward tugboat pushed on the starboard side.

1.2.2 Sequence of events from 03:40 to 03:57

1.2.2.1 *HNoMS Helge Ingstad*

At 03:40, HNoMS Helge Ingstad was approximately 7 nm north of the Sture Terminal in the Hjeltefjord, still moving at a speed of between 17 and 18 knots. The OOW of the 04–08 watch arrived on the bridge to prepare for the onward voyage. The OOW first went into the chartroom at the aft end of the bridge to check the frigate's position and the voyage route. From 03:45 to 03:53, the relieving OOW and the OOW being relieved went through the handover procedure on the bridge. The OOWT was still navigating the vessel and did not take active part in the handover. The OOW being relieved was responsible for navigation of the frigate in this period.

The OOW being relieved informed the relieving OOW about what they had been doing on the watch, how the two OOWTs had performed and of the plans for the voyage during the hours ahead. The OOW being relieved pointed out that the XO was to be woken in approximately 30 minutes, about the time they would pass Jona light, at which time the OOWT would also be relieved. They talked about forecast weather conditions with rising winds and increasing wave heights into the day, and reviewed the bridge system, radar and communication settings.

The OOWs also discussed the traffic in the fairway. On the port side of the frigate's course line, three northbound vessels were approaching. These were acquired[6] on the frigate's radar along with one vessel heading in the same direction as the frigate. The navigation officers also discussed a stationary object at or near the Sture Terminal, which was giving off a great deal of light to starboard of the frigate's course line. The two OOWs stood around the radar (MFD[7] 1; see Figure 3) and discussed whether the 'object' could be the terminal's quay, or possibly a fish farm or rig/platform. The OOWs have stated that the 'object' transmitted AIS signals, but no speed vector, and that they assumed that it was stationary. The 'object' was therefore not tracked on the frigate's radar. The OOWs' statements differ somewhat: The OOW being relieved had observed two AIS signals and pressed one of them and read 'Sola TS'. The relieving OOW had seen a blue mark and interpreted this to be an AIS signal from a fixed installation and not from one or two vessels.

During the same period (03:38–03:56), the OOWT and the OOWAT performed several optical position determinations by taking bearings to verify the position in ECDIS. In practice, this meant that the OOWT took bearings of different objects using the pelorus at the centre of the bridge. The bearings were communicated to the OOWAT, who plotted them on the frigate's ECDIS to determine the frigate's position.

The OOWA was also relieved during the same period. The relieving OOWA arrived on the bridge at 03:49 and went through the watch handover procedure with the OOWA being relieved until 03:56. The OOWA being relieved informed the relieving OOWA about AIS mode, communication, navigation lights, ECDIS and radar settings, and where they were heading. The relieving OOWA got the impression that everything was in order. The OOWA being relieved could not remember seeing any vessels on the radar

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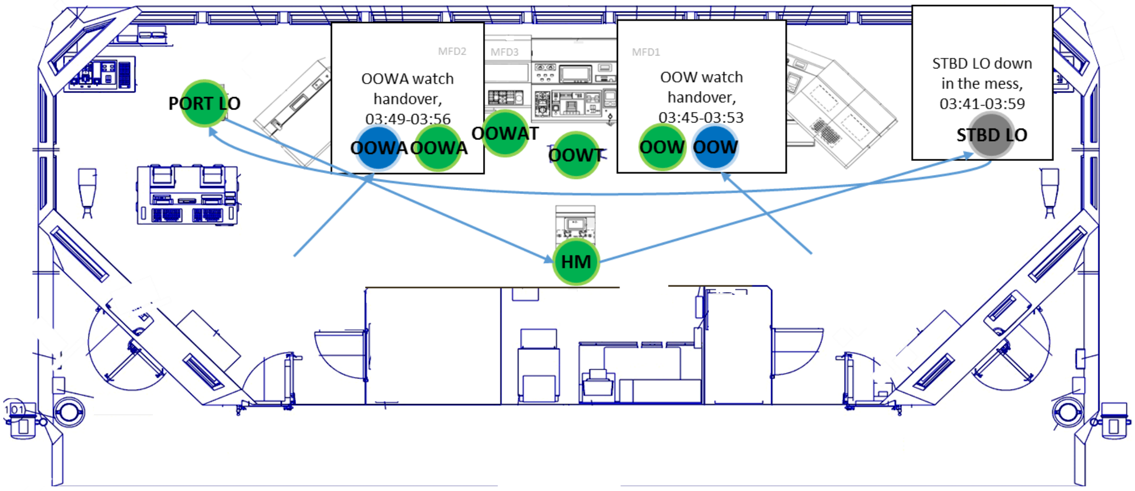
[6] Acquiring or tracking: A criterion for the navigation system to generate alarms according to set limit values for the closest point of approach (CPA) and time until CPA (TCPA). The navigation system will not generate alarms for vessels that are not being acquired.

[7] MFD – multi functional display

approaching from ahead when handing over the watch to the relieving OOWA. The radar (MFD 2) operated by the OOWA had been set to the 6 nm range scale and off centre since 02:50.

From 03:20, a night meal was being served in the mess, and it was agreed with the OOW being relieved that members of the bridge watch team could go down to get something to eat, one at a time. The STBD LO went down to the mess at 03:41 and was back on the bridge at 03:48. After that, the bridge watch team rotated their positions. The STBD LO took over as PORT LO. The PORT LO took over as HM. The HM, who was to take over as STBD LO, went down to the mess at 03:51 and returned to the bridge at 03:59.

Figure 9 shows the crew that were present on the bridge of HNoMS Helge Ingstad during the period from 03:40 to 03:59.



OOW – Officer of the watch
OOWT – Officer of the watch trainee
OOWAT – Officer of the watch assistant trainee
OOWA – Officer of the watch assistant

Bridge watch team:
HM – Helmsman
STBD LO – Starboard lookout
PORT LO – Port lookout

Figure 9: Crew on the bridge of HNoMS Helge Ingstad during the period from 03:40 to 03:59, a period of watch handovers and bridge watch team rotation, when the starboard lookout had gone down to the mess. Illustration: The Royal Norwegian Navy/AIBN

Once the handover was completed, the OOW who had been relieved went into the chartroom and logged the watch change at 03:53 in the log book. The relieving OOW stated out loud to everyone on the bridge that the OOW had taken over the watch and that the OOWT was navigating. Everybody on the bridge acknowledged.

At 03:53, HNoMS Helge Ingstad was keeping a course of 158° and moving at a speed of 16.9 knots.[8] The frigate caught up with and passed Dr. No on the port side, a yacht that was also heading south through the Hjeltefjord.

The OOW focused on the three vessels that were approaching from ahead on the port side. The OOW checked the radar and thought the three vessels had chosen a more easterly course than previously, which would increase the CPA.[9] The OOW did not check

[8] One knot is equivalent to one nautical mile (1,852 m) per hour. 16.9 knots = 31.3 km/h.
[9] CPA - closest point of approach

the names of the three approaching vessels. The OOW informed the bridge team of the three approaching vessels and asked them to notify of any further observations.

The OOW and the OOWT had a conversation during which the OOW asked the OOWT whether they had visual contact with the approaching vessels. The OOWT answered this in the affirmative. They did not discuss the flood-lit ‘object’ on the starboard side or examine it further on the radar or via AIS.

The PORT LO observed the three northbound vessels carrying navigation lights on the port side. The PORT LO also saw the yellow floodlights from the ‘object’ on the starboard side. The PORT LO had taken a quick look through the binoculars, but not seen any navigation lights. The PORT LO thought the floodlights came from a quay. The PORT LO continued to use the binoculars, focusing on the vessels on the port side.

The OOWA had observed a well-lit, big, square platform, but had not given it further thought or investigated it further. The OOWA focused on training the OOWAT.

The HM saw the floodlights after taking over the helm at 03:48 and understood that it was a vessel. The HM believed that the lookout had notified the bridge team of all the vessels, including the flood-lit vessel. The HM also assumed that the OOW and OOWA were aware of it being a vessel and could see it on the AIS. The HM thought that the vessel would pass HNoMS Helge Ingstad on the starboard side and that there was sufficient passing distance.

1.2.2.2 *Sola TS*

When Sola TS had moved far enough out and the stern was clear of the quay, the tanker continued to turn to port to set course for Fedjeosen. The pilot and master returned to the bridge shortly before 03:45.

At this time none of the vessels approaching from the north could be observed on the S-band radar, which had been set to a 3 nm range scale since 03:27 (see Figure 10).

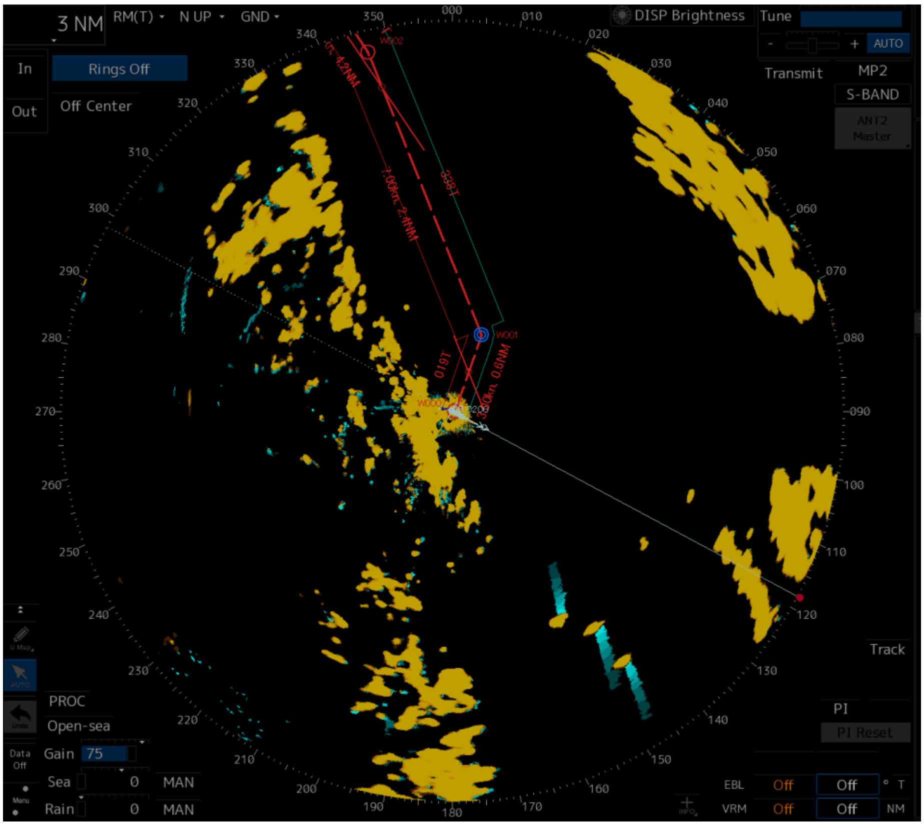


Figure 10: At 03:45, the S-band radar on Sola TS, set to a range scale of 3 nm, showed three vessels to the south and none to the north. Source: Tsakos Columbia Shipmanagement S.A.

To the south, the northbound Silver Firda and Vestbris were visible on the display, along with the southbound Stril Herkules. Both Silver Firda and Vestbris had notified the VTS in English of their entry into the VTS area from the south. None of these vessels were plotted on the radar on board Sola TS. The radar provided true trails which gave an indication of speed and heading of other vessels (see Figure 10). The vessels that were transmitting AIS signals, could be observed on the ECDIS on Sola TS as long as they were within the range scale to which the instruments had been set. The visibility was good and the bridge crew observed the surrounding vessels.

Sola TS had her lights on while moving away from the quay assisted by the two tugboats (see section 1.10.4). The tanker also had all forward-pointing deck lights on when leaving the Sture Terminal. Rough weather was forecast for the North Sea, and the master had ordered the crew to secure equipment etc. on deck after departure. This primarily consisted of putting blind flanges into place on the manifold, securing the gangway, oil spill and fire-fighting equipment, and securing the mooring hawsers and wrapping the hawser reels in tarpaulin.

At 03:45, as Sola TS moved further away from the lights on the Sture Terminal, the master turned off the deck lights in the midship masts (which were pointing forward). After that, the six forward-pointing yellow deck lights on the forward side of the superstructure and the three forward-pointing white lights in the foremast remained on (see section 1.10.5).

At 03:45, while the watch handover was starting on HNoMS Helge Ingstad, the pilot on Sola TS called Fedje VTS on VHF channel 80 with the message that the tanker was departing the Sture Terminal and heading west through Fedjeosen. The Area North operator at Fedje VTS confirmed receipt of the message.

The VTS operator then zoomed in on the Sture Terminal on the main work screen, in such a way that it showed a larger area to the south than to the north of the terminal. The operator observed three northbound vessels that were approaching and concluded that Sola TS had enough time to turn. The northbound vessels (Silver Firda, Vestbris and Seigrunn) were approximately 2 – 3.5 nm south of the Sture Terminal at 03:45. The two southbound vessels, Dr. No and HNoMS Helge Ingstad were directly to the east of Nordøytåna, 5.65 nm to the north of Sola TS, outside the range scale on the VTS operator's main work screen. Figure 11 shows the traffic situation in the Hjeltefjord at 03:45.

At 03:46, the pilot on Sola TS ordered rudder to port. At 03:49, the pilot dismissed the tugboat Ajax.

The second mate and helmsman who were taking over the watch on Sola TS arrived on the bridge at approximately 03:50 and 03:55, respectively. However, the handover procedure had not yet started when the situation with HNoMS Helge Ingstad arose.

At 03:52, the pilot ordered a course of 350°. Sola TS was then moving at a speed over ground (SOG) of 3.2 knots. The pilot had observed visually, probably slightly before this time, the two southbound vessels to the north of Sola TS. HNoMS Helge Ingstad and Dr. No in the north, and Silver Firda and Vestbris in the south, were now visible on the radar displays on Sola TS (see Figure 12), but they were not plotted on the radar.

After that, the tanker gradually built up speed. All was calm on the bridge on Sola TS, and the members of the bridge team were chatting while heading out to sea.

Figure 11: The traffic situation in the Hjeltefjord at approximately 0345. The frigate had one southbound vessel just ahead, and three northbound and one southbound vessels south of the Sture terminal. Sola TS and the tugs Ajax and Tenax had now left the quay and started a port turn to set a northbound course towards Fedjeosen. HNoMS Helge Ingstad was directly to the east of Nordøytåna, 5.65 nm to the north of Sola TS. Illustration: AIBN

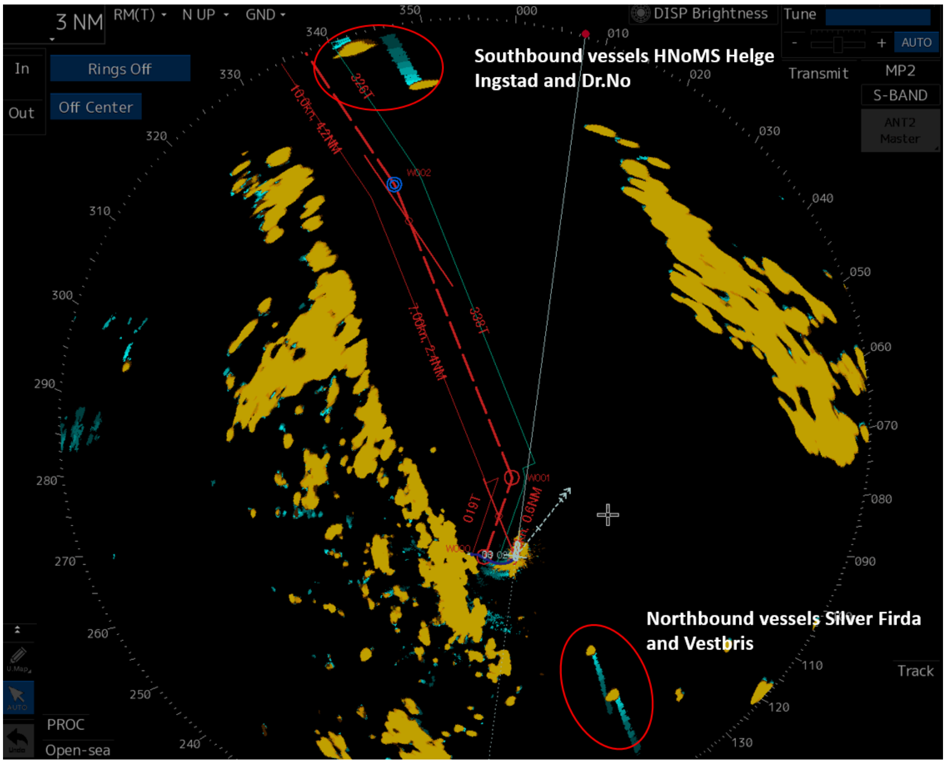


Figure 12: The traffic situation as displayed on the S-band radar on Sola TS at 03:51. Source: Tsakos Columbia Shipmanagement S.A.

1.2.3 Sequence of events during the collision phase (03:57–04:01)

At 03:57:25,[10] the speed of Sola TS had increased to 6.1 knots (SOG). At this point, there was a distance of approximately 2,720 metres between Sola TS and HNoMS Helge Ingstad (see Figure 13). The pilot was aware of the radar echo from a southbound vessel to the north in the fairway and had also observed the vessel's navigation lights visually. At that time, the southbound vessel was approaching at an angle of 10–12° on the port bow. The pilot saw only the vessel's green light and that the vessel would cross the tanker's course line. The pilot therefore requested AIS data about the vessel from the master on Sola TS, but the master replied that the vessel was not transmitting such data.

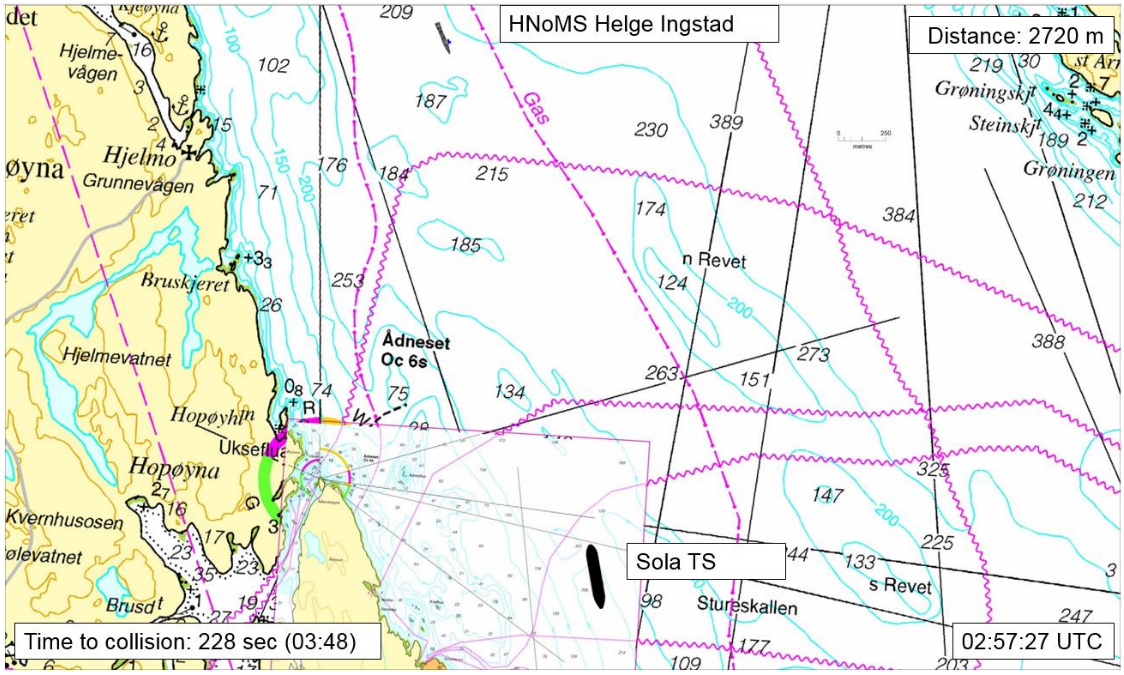


Figure 13: At 03:57:27, there was a distance[11] of approximately 2,720 metres between HNoMS Helge Ingstad and Sola TS. Illustration: Safetec/AIBN

At 03:58:03, the pilot on Sola TS called Fedje VTS on VHF channel 80. Fedje VTS responded immediately. The pilot requested information about the vessel: '*Yes, do you know the name, do you know what vessel is approaching on, towards us? She is slightly to port*.' The Area North operator at Fedje VTS replied at 03:58:30, stating that they had no information about the vessel: *'There is … have not received any information about it. It has not been reported to me, I only have an echo on the screen here*.'

The radar image from Fedje VTS (see Figure 14) shows that the vessels HNoMS Helge Ingstad, Sola TS with the tug Tenax, Silver Firda, Vestbris and Seigrunn were all present in the area around the Sture Terminal at 03:59.

[10] The specified times are taken from the sources of the information (Sola TS' Voyage Data Recorder (VDR), Fedje VTS' monitoring system, HNoMS Helge Ingstad's Integrated Platform Management System (IPMS) and navigation system).
[11] The calculation of the distances between the vessels (bow to bow) is based on VDR data from Sola TS and the frigate's navigation system. The sizes and antenna positions of the vessels have been taken into account.

At 03:58:54, after receiving the call from Sola TS, the Area North operator at Fedje VTS plotted the echo on the radar without AIS. He saw that a vector appeared on the screen indicating that Sola TS and the other vessel were on course to collide.

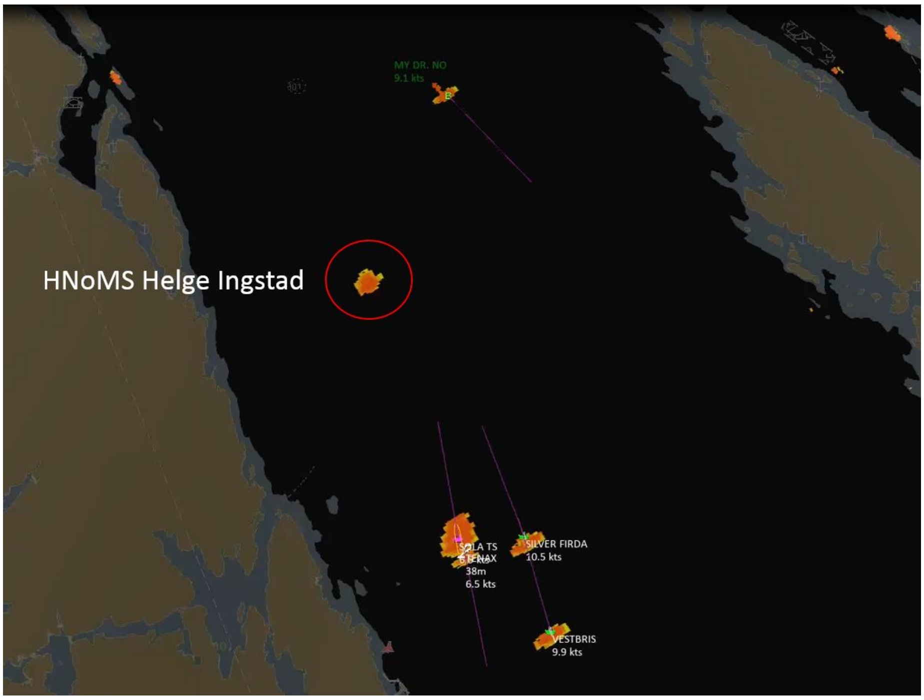


Figure 14: Screenshot of the radar replay from Fedje VTS, showing the traffic situation near the Sture Terminal at 03:59. Source: NCA

The OOW on HNoMS Helge Ingstad eventually noticed that the ‘object’ on the starboard side seemed to be closer to the frigate’s course line than first assumed, leaving less distance to the closest point of approach. The OOW has stated that the ‘object’ was primarily observed visually and that the OOW did not check the radar for details.

At 03:59:02, when there was a distance of approximately 1,510 metres between the vessels (see Figure 15), the pilot asked the master on Sola TS to use the Aldis lamp[12] to send out signals to the vessel. According to their statements, both the master and the pilot had, shortly after signalling with the Aldis lamp, observed both sidelights on HNoMS Helge Ingstad and thought that the vessel was turning to starboard. The master also observed that the two masthead lights on HNoMS Helge Ingstad were not in line and perceived the red sidelight to be clearer than the green sidelight. Shortly afterwards, they only saw the green light, and so they continued sending out light signals with the Aldis lamp.

The Area North operator at Fedje VTS has also stated that, on his screen, it briefly (at 03:59:16) appeared as if the vessels would go clear of each other, before they were observed to be on collision course shortly afterwards (at 03:59:25).

[12] An Aldis lamp is a signalling device used to send out light signals.

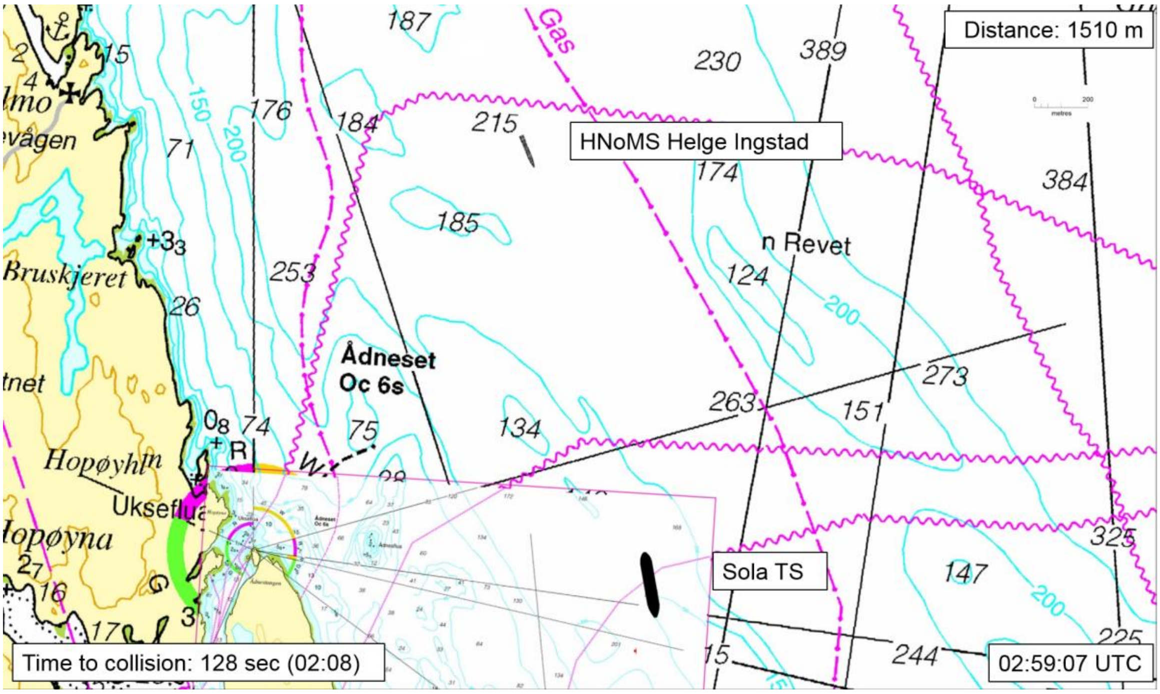


Figure 15: At 03:59:07, there was a distance[13] of approximately 1,510 metres between HNoMS Helge Ingstad and Sola TS. Illustration: Safetec/AIBN

At 03:59, Sola TS was moving at a speed of 6.7 knots (SOG) with the course set to 350°. At 03:59:21, the pilot on Sola TS asked the helmsman to change course from 350° to 000°, i.e. 10° to starboard to indicate to the approaching vessel that they were making an evasive manoeuvre.

At 03:59:26, HNoMS Helge Ingstad was keeping a course of 157° and moving at a speed of 17 knots. The OOW asked the OOWT to adjust the course by some degrees to port. The OOWT asked whether he should change course to port, which the OOW confirmed. The OOWT conveyed the message to the HM. At 03:59:30, HNoMS Helge Ingstad started to turn to port, ending up at 147° at 04:00:46 (see Figure 42 in section 1.15.1.2).

The HM focused on the rudder orders that were issued, but glanced around from time to time and saw that the vessel on the starboard side was getting closer. The vessel appeared to be on a parallel course with HNoMS Helge Ingstad, and the HM thought that it planned to pass HNoMS Helge Ingstad on the starboard side. When the vessel came even closer, the HM felt dazzled by the floodlights.

The STBD LO on HNoMS Helge Ingstad, who had returned to the bridge after a night meal at 03:59, observed a lot of light forward on the starboard side, thinking it was a quay or similar because of all the lights and the nearness of the 'object'.

Some time after receiving the first call from the pilot on Sola TS, the Area North operator remembered that HNoMS Helge Ingstad had previously (at 02:38) notified of entering the VTS area. The VTS operator immediately called the pilot on Sola TS on VHF channel 80:

- Fedje VTS called Sola TS at 03:59:40.

[13] See footnote 11.

- At 03:59:46, the pilot on Sola TS replied to the call.

- Fedje VTS to Sola TS at 03:59:47: '*It is possibly Helge Ingstad; he entered from the north a while ago. It could be that he is the one approaching*.'

The OOW on HNoMS Helge Ingstad became aware of the VHF call just after having asked the OOWT to change course. The OOW went over to the VHF radio (see section 1.9.4) to reply.

At this point (03:59:57), there was a distance of approximately 875 metres between the two vessels (see Figure 16).

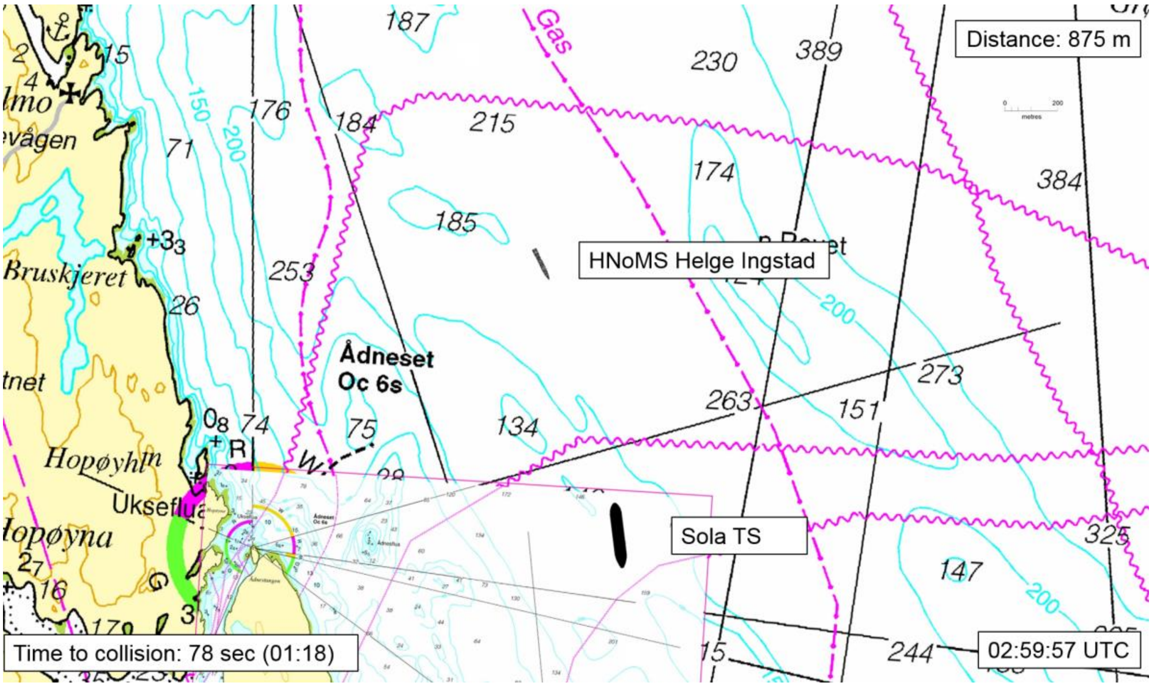


Figure 16: At 03:59:57, there was a distance[14] of approximately 875 metres between 'HNoMS Helge Ingstad' and Sola TS. Illustration: Safetec/AIBN

- At 03:59:56, the pilot on Sola TS called immediately HNoMS Helge Ingstad: '*Helge Ingstad, do you hear Sola TS?'*

- At 04:00:02, the OOW on HNoMS Helge Ingstad replied: '*Helge Ingstad*'.

- At 04:00:04, the pilot on Sola TS replied: *'Is that you approaching?'*.

- At 04:00:06, the OOW on HNoMS Helge Ingstad replied: *'Yes, it is'*.

- At 04:00:08, the pilot on Sola TS replied: *'You must turn to starboard immediately'*.

- At 04:00:11, the OOW on HNoMS Helge Ingstad replied: '*No, then we will sail too close to eh... blokkene/båkene'*.[15]

[14] See footnote 11.
[15] The exact word that is spoken is unclear and the OOW cannot explain it in retrospect, but the phrase is related to the illuminated 'object'.

- At 04:00:15, the pilot on Sola TS replied: *'Turn starboard if you are the one approaching.'*

- At 04:00:27, the OOW on HNoMS Helge Ingstad replied: *'I … a few degrees to starboard as soon as we have passed eh …, passed eh … the platform on our starboard side'*.

The OOW on HNoMS Helge Ingstad understood the call to be from one of the three northbound vessels that wanted the frigate to go further to starboard to increase the passing distance. The OOW still thought the 'object' on the starboard side was stationary and that they could not go further to starboard without getting too close to the 'object'.

At this point (04:00:27), there was a distance of approximately 500 metres between the two vessels (see Figure 17). At 04:00:20, Sola TS was steering to a course of 355°, still altering course to starboard, while the course over ground (COG) was 345.8°, and it was moving at a speed of 7.2 knots (SOG). At 04:00, HNoMS Helge Ingstad was moving at a speed of 16.9 knots. HNoMS Helge Ingstad had a course of 152.5° at 04:00:26 and of 149.7° at 04:00:36.

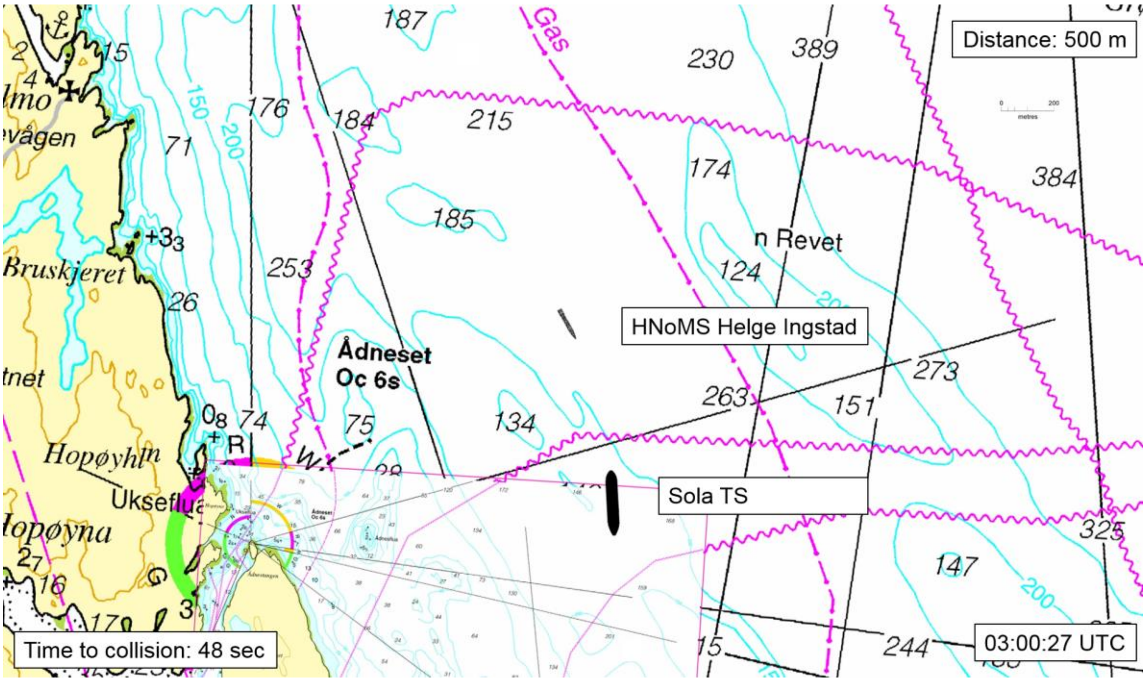


Figure 17: At 04:00:27, there was a distance[16] of approximately 500 metres between HNoMS Helge Ingstad and Sola TS. Illustration: Safetec/AIBN

The rest of the bridge team on HNoMS Helge Ingstad heard the OOW talking on the VHF radio, but did not catch all the details of what was being said. The lights on the starboard side were getting closer, but they believed that the OOW was in control of the situation. The helmsman (HM) who, so far, had been at the helm and steered using one of the tillers, has stated that the approaching vessel appeared to have altered course to starboard and that it was very close. The HM therefore got up from the chair and, from 04:00:36, steered using both rudder handles.

[16] See footnote 11.

At 04:00:30, the master on Sola TS called out *'stop engines'*. Sola TS was then moving at a speed of 7.2 knots (SOG).

The VTS operator at Fedje VTS had registered that there was radio contact between Sola TS and HNoMS Helge Ingstad and did not want to intervene. The operator has explained that the whole situation was incomprehensible. He did not understand why HNoMS Helge Ingstad replied that they could not go further to starboard. However, in the end, the VTS operator did call HNoMS Helge Ingstad at 04:00:44: *'Helge Ingstad, you must do something. You are getting very close*.' At this point (04:00:47), there was a distance of 250 metres between the two vessels (see Figure 18).

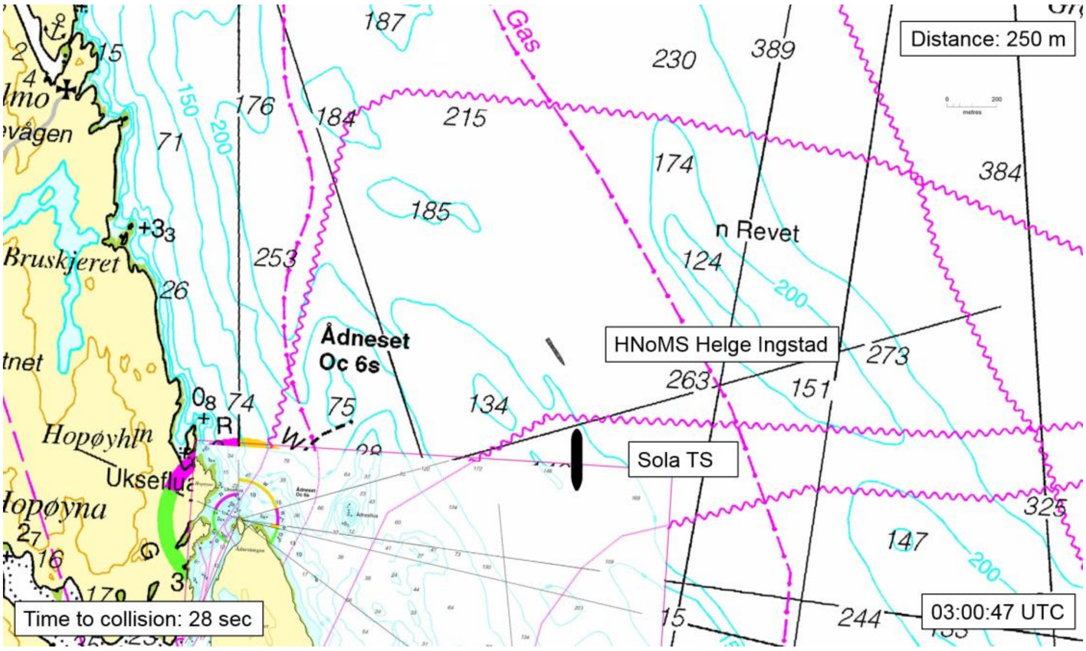


Figure 18: At 04:00:47, there was a distance[17] of 250 metres between 'HNoMS Helge Ingstad' and Sola TS. Illustration: Safetec/AIBN

The OOW on HNoMS Helge Ingstad was standing next to the VHF radio handset on the starboard side of the bridge. The OOW suddenly realised that the 'object' that was giving off light was moving and that they were on direct collision course. The others on the bridge also saw a lot of light on the starboard bow and realised that HNoMS Helge Ingstad was going to collide.

At 04:00:50, the pilot on Sola TS ordered full speed astern on the engines. At 04:01:03, the Area North operator made another call to HNoMS Helge Ingstad: '*Helge Ingstad, there will be a collision*.'

The OOW on HNoMS Helge Ingstad ordered rudder 20° to port, understanding that it was too late to turn to starboard. The HM moved both tillers to port, but the rudder had not moved more than 10° to port when the OOW issued a counter-order to set the handles to midship. This had the effect of changing the course of HNoMS Helge Ingstad from 147.2° to 145.7°.

[17] See footnote 11.

The two vessels collided outside the Sture Terminal in the Hjeltefjord at 04:01:15 (see Figure 19)

Figure 19: The point of impact when HNoMS Helge Ingstad and Sola TS collided outside the Sture Terminal in the Hjeltefjord at 04:01:15. Illustration: AIBN

1.3 The rescue operation

Additional information about the rescue operation will be published in the final investigation report. The following is mentioned here:

- After the collision, Fedje VTS notified the Joint Rescue Coordination Centre (JRCC), the NCA’s emergency response department and the VTS manager in accordance with a dedicated list.
- At 04:10, HNoMS Helge Ingstad sent a ‘DSC distress’ call[18], and notified verbally that they had run aground.
- At 04:15, the JRCC assumed responsibility for coordinating the rescue operation.
- At 04:23, HNoMS Helge Ingstad notified that all 137 persons on board had been accounted for.
- At 04:33, Sola TS notified that they had gained an overview of the situation.
- At 04:50, HNoMS Helge Ingstad notified that they had lost control of the frigate’s stability and would have to evacuate.
- At 05:05, HNoMS Helge Ingstad started to evacuate all but 10 personnel who still remained on the bridge.
- At 06:34, the final 10 were evacuated to the coast guard vessel NoCGV Bergen. The decision to do so was based on an overall assessment of the situation on board.

[18] Distress message via the VHF Digital Selective Calling system

1.4 Description of injuries/damage

1.4.1 Personal injuries

Seven crew members on HNoMS Helge Ingstad sustained minor physical injuries. None of the crew on Sola TS were injured in the collision.

1.4.2 Damage to the vessel

1.4.2.1 *HNoMS Helge Ingstad*

In the collision with Sola TS, HNoMS Helge Ingstad suffered extensive damage along the starboard side (see Figure 20). The damage caused flooding, a break in the starboard seawater line, severing of several electrical cables, extensive damage to the aft conscripts quarter, as well as damage to the torpedo magazine. Detailed information about the damage will be published in the final investigation report.

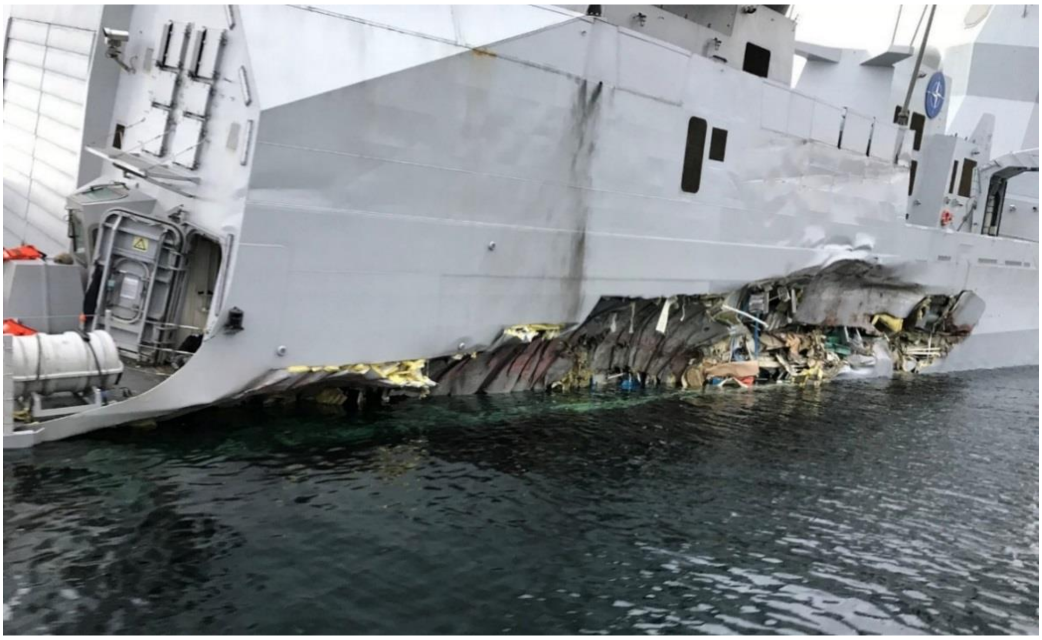


Figure 20: Damage to the hull along the starboard side of HNoMS Helge Ingstad after the collision. Photo: The Norwegian Coastal Administration

1.4.2.2 *Sola TS*

The tanker's starboard anchor was the first point of contact in the collision between HNoMS Helge Ingstad and Sola TS. The anchor and 20 m of the anchor chain were ripped out. The collision also caused damage to the hawsepipe and left a small hole in the hull just aft of the hawsepipe (see Figure 21). Parts of the bulwark above the anchor were indented.

Figure 21: The hawsepipe and the damage sustained by Sola TS in the collision. The hole in the hull is marked with a white circle. Photo: The Norwegian Maritime Authority

1.4.3 Spills and damage to the natural environment

The environmental surveys of farmed fish, shellfish and sediments in the area around the shipwreck of HNoMS Helge Ingstad were performed by the Institute of Marine Research on assignment for the NCA, which led the oil-spill response operation to limit the environmental damage after the accident. The NCA's final accounts after the accident show that HNoMS Helge Ingstad had 500 m^3 of oil on board, including 460 m^3 of marine diesel. In total, 284 m^3 of marine diesel leaked out into the Hjeltefjord. The following was stated in the report by the Institute of Marine Research (Boitsov and Klungsøyr, 2019):

> *(…) No traces of oil pollution were found in the salmon samples. In the mussel and sediment samples, oil pollution from the frigate was only found locally within a limited area from the shipwreck. The oil spill is therefore considered to have had little impact on the marine environment, and further environmental surveys relating to the incident are considered unnecessary.*

1.5 Weather and sea conditions

1.5.1 General information

Coinciding weather observations at the time of the accident were reported by the Meteorological Institute (Fedje weather station), Fedje VTS, Sola TS and HNoMS Helge Ingstad. A south-southeasterly wind was blowing at a speed of 7 m/s and the sea was calm. It was a starlit night and visibility was good. There was no rain in the area and no moonlight. See also Appendix A, which shows data from the weather stations in the area, provided by the Meteorological Institute.

1.5.2 Information about current conditions from the Meteorological Institute

The Meteorological Institute has not measured current conditions in the area. The AIBN has obtained calculations based on a numerical ocean model with a grid of approximately 800x800 m; see Appendix A. The model shows a northerly current moving at a speed of approx. 0.5 m/s in the accident location at the time of the accident. There is some uncertainty attached to model calculations of this kind. The Meteorological Institute assumes that the current direction in this case is correct, but that the speed is more uncertain.

1.6 The Hjeltefjord and the traffic situation

1.6.1 The Hjeltefjord

The accident occurred in the Hjeltefjord north of Bergen.

The Hjeltefjord belongs to the Fedje VTS area (see section 1.13.3.1). The Fedje VTS area is divided into Area North and Area South, with the boundary at Jona light near the southern end of the Hjeltefjord.

There are three major quay facilities in the Hjeltefjord serving the offshore oil and gas industry. In addition to the loading facilities at the Sture Terminal, there are maintenance and supply bases at Ågotnes and Hanøytangen, where several ships and oil rigs are normally docked for maintenance purposes.

The Directorate of Fisheries' map solution Yggdrasil shows that there are several different aquaculture locations along both sides of the Hjeltefjord. The perimeter of such facilities is normally marked with flashing lights, and the barges will also carry lights.

1.6.2 Traffic situation in the area

HNoMS Helge Ingstad sailed out the southern end of Krakhellesundet and continued in a south-westerly direction across Sognesjøen. At approximately 02:38, HNoMS Helge Ingstad was directly south of Ytre Steinsund, approximately 4 nm north-east of the boundary, and reported to Fedje VTS that they would enter the area from the north.

As HNoMS Helge Ingstad approached Holmengrå, the supply vessel Siem Pride was heading out to sea to the west of the frigate. The well boat Ronja Nordic was northbound and about to enter Brosmeosen. There were three vessels further south in the fairway between Fedje and Austrheim and Radøy: the southbound yacht Dr. No, and the northbound Odin and Kirsti H (see Figure 22). All of these vessels transmitted AIS-data, with the exception of HNoMS Helge Ingstad.

Figure 22: The traffic situation at Fedje at approx. 03:09 on 8 November 2018. Source: AIBN

At 03:34:30, HNoMS Helge Ingstad disappeared from Fedje VTS's radar display. At that time, the frigate was just east of Langøybukta. HNoMS Helge Ingstad reappeared on the radar display at Fedje VTS after 2 to 3 minutes[19].

When Sola TS departed from the Sture Terminal at approximately 03:45, HNoMS Helge Ingstad was directly to the east of Nordøytåna. They were about to catch up with and pass the yacht Dr. No. Maritime traffic further south in the Hjeltefjord consisted of three northbound vessels – Silver Firda, Vestbris and Seigrunn, and one southbound vessel – Stril Herkules. Figure 23 shows the traffic situation in the area at approximately 03:53. All these vessels transmitted AIS-data.

[19] The actual area was covered by the radar at Marøy, which had some technical issues the night of the accident. HNoMS Helge Ingstad disappeared from Fedje VTS's radar display only 2 – 3 minutes. The AIBN has not investigated this further.

Figure 23: The traffic situation at 03:52:55 on 8 November 2018. Source: AIBN

1.6.3 Traffic situation in the Fedje VTS area from 00:00 until 04:00

The AIBN has prepared an overview of the traffic situation in the Fedje VTS area during the night of the accident on the basis of radio communication on VHF channel 80 between Fedje VTS and the vessels in the area.

The traffic situation was normal for that time of night, and Fedje VTS communicated with a total of 20 vessels during this four-hour period. Seven vessels notified of entering the VTS area from the north at Sognoksen, one at Fedjeosen and four from the south. The other vessels notified of departure, of moving inside the VTS area or of leaving the area. In the period from HNoMS Helge Ingstad entered the area and until 0350, there were 11 calls between Fedje VTS and 9 vessels.

The three northbound vessels in the vicinity of the accident location reported entering the traffic area at 03:15:37 (Silver Firda in English), 03:16:32 (Vestbris in English) and 03:26:00 (Seigrunn in Norwegian), respectively.

1.7 Automatic Identification System (AIS)

1.7.1 General information

The International Maritime Organization (IMO) has introduced an amendment to the International Convention for the Safety of Life at Sea (SOLAS), whereby AIS is required on passenger and cargo ships of a certain size. The requirement has subsequently been extended to include other types of vessels. AIS is a supplement to radar-based information on board ships and at the VTS centres. Together, AIS and the radar tracking systems provide an almost complete picture of the maritime traffic situation in the coverage area.

The AIS system consists of transceivers on ships that transmit unique signals to other ships, land-based AIS base stations and satellites. The data from the base stations are then made available for VTS centres and other public agencies. Furthermore, the AIS image is made available to «the public» through *Kystinfo* and *BarentsWatch*[20]. The signals include information about the vessel, its position, speed and course. AIS transponders can also be used to transmit information from other installations, buoys, beacons and marks, and in search and rescue (SAR) helicopters and aircraft.

1.7.2 Rules and regulations

According to the Regulations of 5 September 2014 No 1157 on navigation and navigational aids for ships and mobile offshore units (Regulations on Navigational Aids for Ships etc.), AIS shall be carried by all passenger ships engaged on foreign voyages, passenger ships of 300 gross tonnage (GT) and upwards engaged on domestic voyages, passenger craft of 150 GT and upwards engaged on domestic voyages capable of a maximum speed of 20 knots or more, cargo ships of 300 GT and upwards, and mobile offshore units. Fishing vessels of 15 metres and more are also required to carry AIS. Recreational and other craft that are not obliged to carry AIS, may also install and use the system. AIS data can be integrated in the electronic charts (ECDIS).

All vessels required to use AIS shall use AIS Class A transceivers. AIS shall be in operation at all times, but may be deactivated when necessary for the safety and security of the vessel.

Naval vessels are not required to use AIS. It is clear from the Navy's regulations on inshore navigation (SNP-500, see section 1.11.6) that the Navy recognises that the original and most important function of AIS is anti-collision, and it is on this basis that AIS rules are issued. SNP-500 stresses that if the transmission and, if applicable, receipt of AIS data are deactivated, the navigation team must be particularly observant and vigilant in relation to approaching traffic, especially in the dark and in conditions of poor visibility. SNP-500 contains the following rules, among others, for the use of AIS:

- All military vessels shall comply with civil regulations concerning the use of AIS.
- Deviations from civil regulations shall be based on conscious decisions and be known to all members of the navigation team. In such cases, special vigilance must be exercised in relation to other vessels.

1.7.3 Coverage and update frequency

The AIS base stations along the coast and AIS equipment on board the vessels are based on VHF radio signals. These have a limited range, which means that some parts of the fjords in Western Norway have poor or no AIS coverage. AIS coverage in the Hjeltefjord is good.

[20] *Kystinfo* is the NCA's online map service.
BarentsWatch is a Norwegian management and information system for the northern coastal and sea areas.

The AIS transponders depend on reliable positioning systems. Any inaccuracies in the global positioning system (GPS) will be reflected in the AIS position. Inaccuracies can arise as a result of atmospheric conditions, but can also be a result of conscious manipulation/blocking (GPS jamming). The investigation found no interference in GPS signals or inaccuracies in the GPS system at the time of the accident.

AIS Class A transceivers transmit dynamic information at intervals of between 2 seconds and 3 minutes, depending on the vessel's speed, course changes or requests from the base station.

1.7.4 Warship AIS (W-AIS)

Warship AIS, also called Blue Force AIS, encrypted AIS or secure AIS, is a mode selectable on compatible AIS transponders, which broadcasts the vessel's AIS information in an encrypted format. The encryption keys used for W-AIS are generated with commercially available encryption algorithms. W-AIS information can be displayed by compatible AIS units with the correct encryption key installed. For NATO vessels that use W-AIS, the system requirements are given in the NATO standard STANAG[21] 4668 (Edition 2). W-AIS may also be used in accordance with this STANAG, by other government authorities.

1.8 Personnel information

1.8.1 HNoMS Helge Ingstad

1.8.1.1 *General information*

HNoMS Helge Ingstad had 137 persons on board. The mix of conscripts and permanent crew was normal. There was no rotation of the crew. The crew earned time off in lieu per voyage day, which was to be taken out when the vessel lay alongside or in other appropriate situations. The frigate only had one crew.

1.8.1.2 *Crew and bridge watch system on the night of the accident*

A total of seven watchstanding personnel were present on the bridge of HNoMS Helge Ingstad during the night leading up to 8 November: the officer of the watch (OOW), the officer of the watch trainee (OOWT), the officer of the watch assistant (OOWA), the officer of the watch assistant trainee (OOWAT), and the bridge watch team consisting of two lookouts and a helmsman.

The OOWs and OOWTs were qualified officers, while the remaining personnel on the bridge were conscripts or undergoing apprenticeship[22] to become, for example, able seamen.

Table 1 shows the hours worked by the bridge personnel during this particular voyage.

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[21] NATO Standardization Agreement 4668 – *Warship – Automatic Identification System (W-AIS)*

[22] The apprenticeship scheme is organised by the Navy's personnel department. The purpose is to give apprentices an opportunity to complete their national service and the apprenticeship period at the same time, in the course of two years' service on board.

Table 1: Watch systems worked by the bridge personnel during the voyage

Position	Watch
Officer of the watch (OOW)	4 hours on – 8 hours off
Officer of the watch trainee (OOWT)	6 hours on – 6 hours off
Officer of the watch assistant (OOWA)	4 hours on – 8 hours off
Officer of the watch assistant trainee (OOWAT)	6 hours on – 6 hours off
Bridge watch team	3 hours on – 9 hours off

On HNoMS Helge Ingstad, three cleared officers of the watch were present on the bridge during the day, along with three officer of the watch trainees. The OOW and the OOWA had worked ordinary sea watches during the NATO exercise *Trident Juncture,* i.e. 4 hours on, 8 hours off. On this particular day, the OOWT and the OOWAT were working to a 6 hours on/6 hours off watch system to earn as much navigational practice time as possible. On this particular watch, the training goal for the OOWT was to gain more independence in the role of navigator.

The bridge watch team, which consisted of conscripts, had worked 6 hours on/6 hours off during *Trident Juncture*, but had been back on normal sea watches since the night leading up to Wednesday 7 November 2018. HNoMS Helge Ingstad had enough personnel on board to form four bridge watch teams, and they could therefore work three-hour watches in daytime and during the night. The bridge watch team rotated between the positions of port lookout, helmsman and starboard lookout at one-hour intervals.

Figure 24 shows the personnel present on the bridge around the time of the accident, including how long each of them had been on watch and the bridge watch team’s change of positions. The average age of the members of the bridge team was 22.4 years.

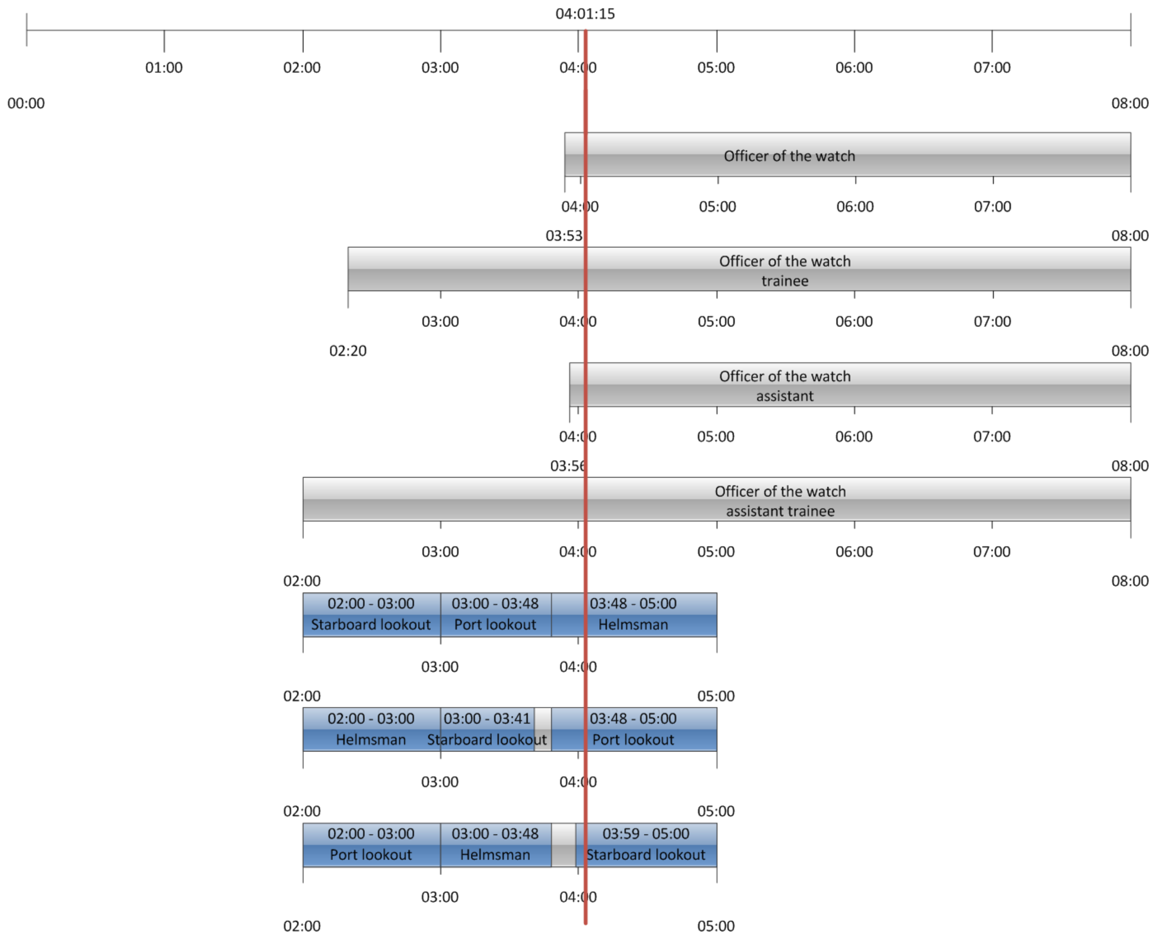


Figure 24: Personnel on the bridge at the time of the accident, at 04:01:15. Illustration: AIBN

1.8.1.3 *Duties and responsibilities on the bridge*[23]

The officer of the watch (OOW) was responsible for the safe and secure navigation of the vessel and for all training activities on the bridge, approved the OOWT's decisions and had a duty to take over navigation at any time, should this prove necessary.

The officer of the watch trainee (OOWT) navigated the vessel and performed all duties normally assigned to the OOW (except for VHF communication), including monitoring traffic, monitoring the vessel's position in the fairway and issuing orders to the helmsman.

The duty of the officer of the watch assistant (OOWA) was to monitor the voyage on the ECDIS and radar. The assistant is required to assist the OOW/OOWT and may get questions related to navigation, can inform about any upcoming course changes if these have been plotted and about beacons etc. It was the OOWA's duty to train the OOWAT on this voyage.

The duty of the officer of the watch assistant trainee (OOWAT) was to plot optical bearings on the ECDIS display.

The frigate always used a helmsman and manual steering during inshore voyages.

[23] Reference is also made to section 1.11.7.2 for a more detailed description of the bridge manual.

The duty of the helmsman (HM) was to execute orders from the OOW/OOWT. Executing orders at the helm means to steer a steady course or set the rudder to a specific position (number of degrees to starboard or port) on the orders of the navigator.

The lookouts were tasked with looking out for relevant information, vessels and other potential dangers to navigation, and with notifying the OOW/OOWT of their observations in accordance with established procedures.

It was normal practice for the Commanding Officer (CO) and the executive officer (XO) to spend a great deal of time on the bridge and in the operations room during inshore navigation. The CO and the XO have no specific duties on the bridge during voyages, other than to provide support as needed and to ensure that the navigators and bridge crew navigate safely and tend to their duties. Both the CO and the XO were present during part of the training of new navigators to form an impression of how they were doing. The CO and/or the XO were always present on the bridge when passing through areas of maritime traffic and/or narrow fairways, and in conditions of poor visibility. On the night in question, the CO had been on the bridge several times during the southbound voyage in inshore waters.

1.8.1.4 *Commanding officer (CO)*

The CO had held the position of commanding officer on board HNoMS Helge Ingstad for 2 years and 3 months when the accident occurred. After completing education at the Royal Norwegian Naval Academy, the CO served for 15 years in different officer positions and as commanding officer on board the navy`s fast patrol boats. From 2013, the CO held the position as operational officer on board several of the navy's frigates, and from 2014 as executive officer.

1.8.1.5 *Officer of the watch (OOW)*

The OOW being relieved (00–04 watch) had been a navigator on several of the Navy’s frigates and had a civilian degree in navigation. The OOW had also served on board Skjold-class corvettes for three years and on a merchant vessel operating along the Norwegian coast for about one year.

The relieving OOW (04–08 watch) had held clearance as officer of the watch for about eight months when the accident occurred. The OOW was a graduate of the Norwegian Naval Academy and had been cleared as officer of the watch after nine months’ training on HNoMS Helge Ingstad. The OOW had held the position as Navigation Officer 1 for three months (see section 1.11.5.2).

The night before the accident, the relieving OOW had gone to bed at around 22:00. After approximately 5.5 hours’ sleep, the OOW got up around 03:30 to go on watch, arrived on the bridge at approximately 03:40 and took over the watch at 03:53. The OOW sometimes slept an hour in the middle of the day, but had not slept during the day on 7 November 2018.

1.8.1.6 *Officer of the watch trainee (OOWT)*

The OOWT was an English-speaking exchange officer from another NATO country. The OOWT had worked on Norwegian frigates since 2017. The OOWT was seeking to gain navigational experience and to prepare for the theoretical exam, the first step in the qualification process for OOWs.

The OOWT normally worked the 00–04 watch. In connection with the navigational training on this particular day, the OOWT worked 6-hour watches. The day before the accident, the OOWT had gone to bed at around 21:30 and slept for about 4.5 hours. The OOWT arrived on the bridge at 02:18.

1.8.1.7 *Officer of the watch assistant (OOWA)*

The OOWA being relieved (00–04 watch) was in the process of completing the period of national service and had previously acquired an able seaman's certificate. The OOWA was part of the Seamanship section[24] on HNoMS Helge Ingstad, working on ship maintenance and serving as an OOWA during voyages.

The relieving OOWA (04–08 watch) had begun an apprenticeship as an able seaman after completing the period of national service and had served on board HNoMS Helge Ingstad for 14 months.

The day before the accident, the relieving OOWA had gone to bed at around 21:30–22:00 and slept for about 5.5–6 hours. The OOWA arrived on the bridge at approximately 03:45.

1.8.1.8 *Officer of the watch assistant trainee (OOWAT)*

The OOWAT was in the process of completing the period of national service and was undergoing apprenticeship as an able seaman on board HNoMS Helge Ingstad. The OOWAT had completed an IMO 60 safety course and basic maritime courses and had signed on HNoMS Helge Ingstad about two weeks before the accident.

The OOWAT was normally on the 04–08 watch. In connection with the navigational training on this particular day, the OOWAT worked 6-hour watches. The day before the accident, the OOWAT had worked the 14:00–20:00 bridge watch, before going back on watch at 02:00.

1.8.1.9 *Helmsman (HM)*

The HM was completing the period of national service and had signed on HNoMS Helge Ingstad four months before the accident. The HM served as gunner on board, in addition to being part of the bridge watch team during voyages.

The HM came on watch together with the rest of the bridge watch team at 02:00. The HM served as starboard lookout for the first hour, then as port lookout and took over at the helm at 03:48.

[24] The Seamanship section on a frigate consists of the boatswain (OR 5-6), two boatswain assistants (OR 2-4), two to four able seaman apprentices and a number of conscripts. Members of this section have many functions on board a frigate, including on the bridge team, where they serve as lookout, helmsman and officer of the watch assistant.

1.8.1.10 *Starboard lookout (STBD LO)*

The STBD LO was completing the period of national service and worked as a logistics/supplies assistant on HNoMS Helge Ingstad, in addition to being part of the bridge watch team during voyages.

The STBD LO came on watch together with the rest of the bridge watch team at 02:00. The STBD LO first served as port lookout for an hour and then as helmsman. The STBD LO went down to the mess for a night meal at 03:51 and was back on the bridge at 03:59, taking over as starboard lookout.

1.8.1.11 *Port lookout (PORT LO)*

The PORT LO was completing the national service and had signed on HNoMS Helge Ingstad eight months before the accident. The PORT LO held the position of gunner, served on the bridge watch team and was a qualified breathing apparatus (BA) firefighter. The PORT LO had completed an IMO 60 safety course as well as basic maritime courses and firefighting courses.

The PORT LO came on watch together with the rest of the bridge watch team at 02:00, serving as helmsman for the first hour, then as starboard lookout. The PORT LO went down to the mess for a night meal at 0341, before taking over as port lookout at 03:48.

1.8.2 Sola TS

1.8.2.1 *General information*

Including the pilot, there were a total of 24 persons on board Sola TS.

1.8.2.2 *Crew and bridge watch system*

There were four deck officers on board Sola TS. Three of them worked four-hour shifts followed by eight hours off, regardless of whether they were on sea watches or loading/offloading watches. The chief mate followed loading and offloading operations while the vessel was alongside, but did not work navigational watches on the bridge.

During the departure from the Sture Terminal, the bridge was manned by the master, pilot, navigation officer on watch and helmsman. The relieving navigating officer arrived on the bridge at approximately 03:50, while the able seaman who was taking over as helmsman arrived at approximately 03:55. At the time of the collision, a total of six persons were present on the bridge. The average age of the members of the bridge team was 42 years.

1.8.2.3 *Duties and responsibilities on the bridge*

According to the shipping company’s navigation procedures manual (see section 1.12.2.3), while sailing along the coast or with a pilot, the master (or chief mate) shall be in command and control of the vessel’s movements in accordance with the International Regulations for Preventing Collisions at Sea (COLREGs). The commanding officer shall make course and speed adjustment, monitor the navigation and coordinate the activities of the bridge watch team.

The navigation officer on watch shall follow the master's instructions. The navigation officer's primary responsibility is collision avoidance and monitoring of the ship's position. The navigating officer's duties include:

- operating the radar/ARPA[25] and other navigational equipment capable of plotting targets within a range;
- monitoring the vessel's course, speed and position;
- reporting navigation information to the master as necessary and ensuring correct acknowledgement by the master;
- acknowledging rudder and engine orders received and executing them;
- maintaining the bridge log and other records.

1.8.2.4 *Master*

The master was employed by the shipping company in 2017 and had previously served as master on three of the company's vessels, including Sola TS. The master had served as master on tankers since 2005. The master signed on Sola TS four months before the accident. The master has also made two subsequent calls at this terminal. The captain did not speak or understand Norwegian.

1.8.2.5 *Navigation officer*

The navigation officer on the 00–04 bridge watch was the tanker's second mate. The second mate signed on Sola TS about four months before the accident. The second mate has worked for the shipping company for almost 9 years, including as second mate for the past 7.5 years. The second mate was the vessel's navigating officer with special responsibility for voyage planning, among other things. Before signing on Sola TS, the second mate had served on board one of her sister ships for 8.5 months. The second mate did not speak or understand Norwegian.

The navigating officer on the 04–08 watch, who arrived on the bridge at approx. 03:50 to relieve the second mate, had served on board Sola TS for one month and worked for the shipping company for more than six years. The navigating officer did not speak or understand Norwegian.

1.8.2.6 *Helmsman*

The helmsman on the 00–04 watch was an able seaman and had worked for the shipping company for 11 years. The helmsman had served on nine of the shipping company's vessels, including a sister ship of Sola TS. The helmsman signed on Sola TS about two and a half months before the accident. The helmsman did not speak or understand Norwegian.

The helmsman on the 04–08 watch, who arrived on the bridge at approximately 03:55 to take over from the helmsman being relieved, was an able seaman who had worked for the shipping company for six years. The helmsman had served on eight of the shipping

[25] ARPA – Automatic Radar Plotting Aid

company's vessels, including two sister ships of Sola TS. The helmsman signed on Sola TS about two and a half months before the accident. The helmsman did not speak or understand Norwegian.

1.8.3 The pilot

The pilot on Sola TS got his pilot license in 2008 and had worked 15 years at sea before that. The pilot is employed by the NCA's pilotage service (see section 1.13.4). The pilot was qualified for large tonnage at Sture since 2011. The pilot had been on board Sola TS on several previous occasions. On 7 November, the pilot had a pilotage assignment from 14:25 to 17:10. He departed for the assignment on Sola TS at 01:50 on 8 November.

1.8.4 Fedje VTS

1.8.4.1 *Area North operator*

The Area North operator started as a VTS operator ten years ago. The operator had several years of experience of working on board international ferries, both as navigator and able seaman. The operator had also worked as an express boat navigator in Western Norway for a period of about 11 months.

The VTS operator had just returned to work after a free period of approximately one week. The operator had gone on duty at approximately 23:45 on Wednesday 7 November 2018 and was scheduled to be relieved at 08:00 the following day. Everything appeared normal and it had been a quiet night with little traffic up until the accident occurred. The operator had not slept since the morning on the day preceding the night shift. He felt well rested in the operator's own opinion and generally did not find working night shifts problematic.

1.8.4.2 *Area South operator*

The Area South operator started as a VTS operator about ten years ago. The operator had several years of experience, working as an officer in various positions, including on large chemical tankers for 20 years, and at the Mongstad terminal for 2.5 years.

1.9 The frigate HNoMS Helge Ingstad

1.9.1 General information

HNoMS Helge Ingstad (see Figure 25) was a Norwegian Fridtjof Nansen-class frigate, based at the Haakonsvern naval base in Bergen. The frigate was owned by the Norwegian State Ministry of Defence, and managed on behalf of the owner, by the Norwegian Defence Materiel Agency (NDMA). The Norwegian Navy was the operator of the frigate. The frigate was built by Navantia in Ferrol in Spain. HNoMS Helge Ingstad was the fourth in a line of five frigates built and handed over to the Norwegian Navy between 2006 and 2011, and was delivered in 2009.

The vessel had a length overall of 133.25 m and breadth of 16.8 m. The propulsion system consisted of two BAZAN BRAVO 12V diesel engines and one GE LM2500 gas turbine, with an engine power of 2 x 4.5 MW and 1 x 21.5 MW, respectively.

The Navy's frigates were not equipped with voyage data recorders (VDR), and there are therefore no audio records of the situation on the bridge on the night of the accident (see also section 1.11.10).

Figure 25: The frigate HNoMS Helge Ingstad. Photo: Anton Ligaarden/Norwegian Armed Forces

1.9.2 Bridge design and layout

The bridge on HNoMS Helge Ingstad was largely equipped and designed in the same way as the bridge on the sister frigates. Most of the navigation equipment was placed in consoles along a more or less straight transverse line; see Figure 26. The bridge team were positioned next to each other, except for the helmsman, who stood midship a little further aft, to allow movement transversely between the helm and the control console.

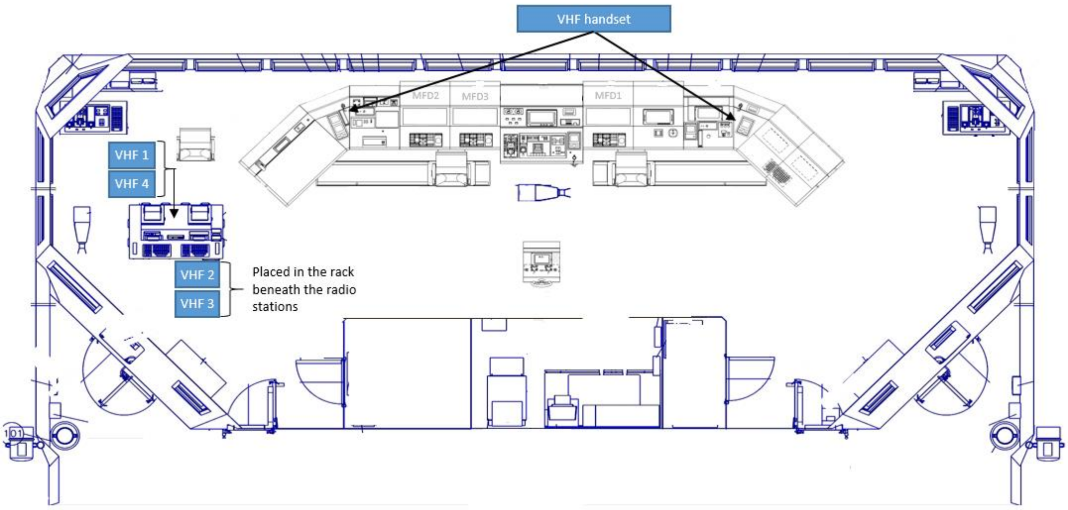


Figure 26: Bridge design on HNoMS Helge Ingstad. Position of VHF radios. See Figure 3 for information about the bridge team's positions on the night of the accident. Illustration: The Royal Norwegian Navy/AIBN

The bridge had 22 windows in total, of which 11 faced forward; all separated by robust dividing bars (see Figure 27). The lookouts had to keep watch from inside the bridge at all times, since the frigate lacked traditional bridge wings, and they were therefore positioned at the far corners.

The following comment was made concerning the noise level on the bridge in connection with DNV GL's classing (24 November 2014) of the frigate:

> *Bridge ventilation system is so noisy that it is difficult for the bridge team to communicate in a normal manner. Excessive levels of noise interfering with voice communication, causing fatigue and degrading overall system reliability, shall be avoided. (noted during visit on-board)*

The Norwegian Defence Logistics Organisation[26] (NDLO) did not implement any measures or changes based on DNV GL's comment:

> *The noise levels on Bridge is within the limit of RAR[27] regulations, and no further actions are considered by NDLO.*

Figure 27: The bridge on HNoMS Helge Ingstad was near identical to the bridge on HNoMS Thor Heyerdahl shown in the photo. The officer of the watch's chair can be seen in the foreground. Photo: AIBN

[26] Norwegian Defence Materiel Agency (NDMA) at the time of the accident and today.
[27] Rules and Regulations of the Royal Norwegian Navy

1.9.3 Navigational aids[28] – function and use

1.9.3.1 *K-Bridge Integrated Bridge System*

The navigation system on Fridtjof Nansen-class frigates is based on the K-Bridge Integrated Bridge System from Kongsberg Maritime, with additional software functionality to support military navigation. K-Bridge is a commercially available navigation system, type-approved for paperless (electronic) navigation in accordance with current rules and regulations. The additional functionality, including the possibility of plotting optical bearings on the electronic chart, was implemented by Kongsberg Defence and Aerospace (KDA), the supplier of the system to the Navy.

The K-Bridge system consists of five multifunction displays (MFD), where different applications (ECDIS, Radar, Planning and Conning) can be selected according to the navigator's need for information (see Figure 28).

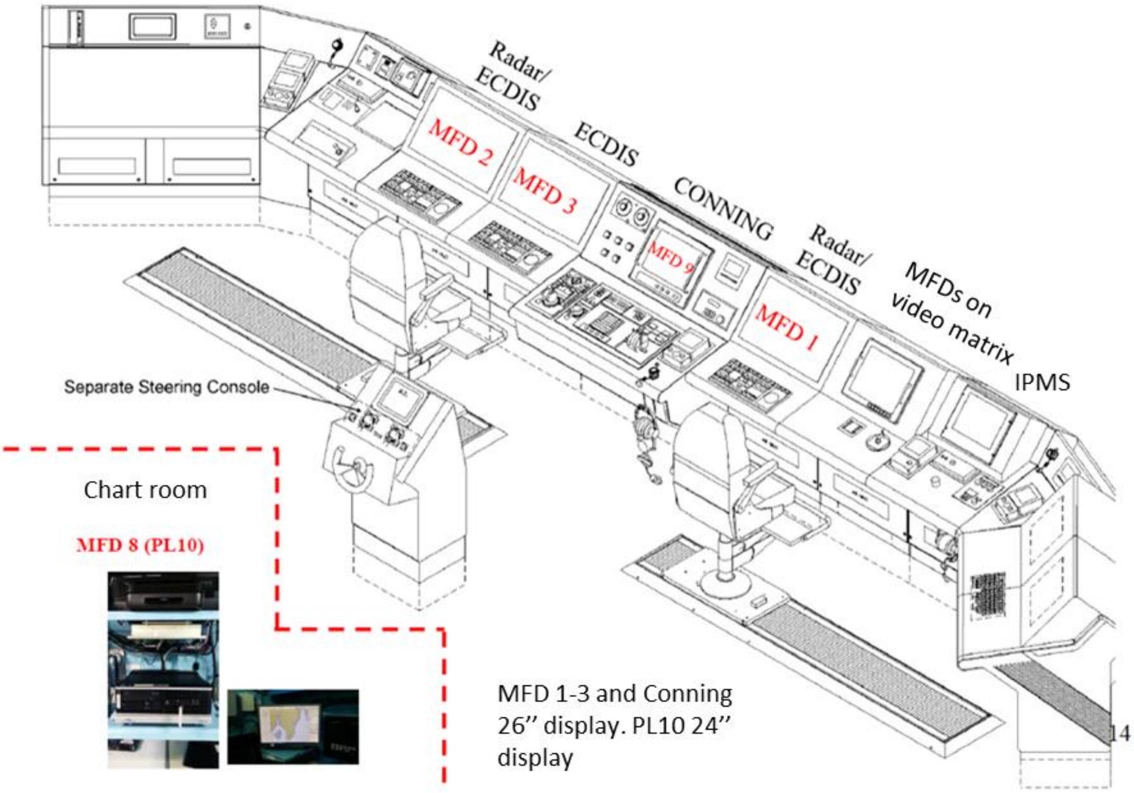


Figure 28: K-Bridge Integrated Bridge System. Illustration: The Royal Norwegian Navy/AIBN

[28] Some parts of the system description in this section have been reproduced from the report of the Norwegian Navy's internal investigation team, who analysed data from the navigation system and integrated platform management system (IPMS) on 'HNoMS Helge Ingstad' on 8 November 2018 (see section 1.15.1).

Table 2 shows the applications that were implemented on HNoMS Helge Ingstad and selected on the day of the accident:

Table 2: The K-Bridge Integrated Bridge System on HNoMS Helge Ingstad. Source: The Norwegian Navy

MFD	Applications implemented on HNoMS Helge Ingstad	Applications selected 08 November 2018
MFD 1 (normally the OOW's operating station)	ECDIS and Radar, both X-band and S-band.	X-band radar
MFD 2 (normally the OOWA's operating station)	ECDIS and Radar, both X-band and S-band	S-band radar
MFD 3 (normally the OOWA's operating station)	ECDIS	ECDIS
MFD 8	Planning (planning application – can also be used for voyage monitoring)	Planning
MFD 9	Conning (overview showing information collected from technical sensors)	Conning
MFD 16	Laptop with planning application that can be connected to the network on the bridge.	Whether it was connected to the network on the bridge is unknown.

1.9.3.2 *DINA system*

There is also a DINA[29] system, which was not part of the delivery from KDA, but is integrated with K-Bridge and distributes signals from the navigation system to the Integrated Platform Management System (IPMS) and other technical systems. The DINA system also transmits signals to separate displays showing navigation information adapted for use by the various positions on board. For example, within the helmsman's field of vision is a separate display that is normally set to 'Helmsman', so that it shows rudder angle and speed, among other things.

1.9.3.3 *Data from the navigation system*

The Navy's internal investigation team has performed an analysis of data from the navigation system and made a reconstruction of what was shown on the displays of MFD 1–3 (see sections 1.15.1 and 1.15.2).

1.9.3.4 *Radar*

HNoMS Helge Ingstad had two radars that were switched on and in use. The OOW had master control of the X-band (3 cm) radar on MFD 1. The OOWA had master control of the S-band (10 cm) radar on MFD 2.

[29] DINA - Distribution of Navigation Signals

The OOW had a video image of the S-band radar on the tactical console (on the starboard side of MFD 1), without the possibility of changing any radar settings.

1.9.3.5 *Electronic Chart Display and Information System (ECDIS)*

On the day of the accident, the MFD 3 with Electronic Chart and Display Information System (ECDIS) was used by the OOWT, among other things to plot bearings on the electronic chart to verify the frigate's position in relation to the chosen sensor.

The OOW also had the possibility of operating ECDIS on MFD 1, but was then unable to operate the X-band radar at the same time.

According to the bridge manual, there were plans to show ECDIS on the conning display at the centre of the bridge console. This would enable the OOW to make both radar and ECDIS observations at the same time from his/her normal position on the bridge:

> *Furthermore, ECDIS software must be installed and a new licence purchased to display ECDIS on the conning display, but this is something that must be considered so as to be able to display 2xRadar and 2xECDIS in front of the navigators at all times. Having an ECDIS at the centre, immediately in front of the officer of the watch, will also be an advantage in connection with navex.*

HNoMS Helge Ingstad did not have ECDIS installed on the conning display.

1.9.3.6 *Automatic identification system (AIS)*

HNoMS Helge Ingstad was equipped with an automatic identification system (AIS) of the type Kongsberg Seatex AIS-200 Blue Force Warship AIS (WAIS). AIS-200 received position and time data from GPS2.[30] Three modes could be selected on the AIS: Mode 1 – standard AIS (active), mode 2 – receive only (passive) or mode 3 – encrypted AIS (active).

1.9.3.7 *Use of AIS*

For operational reasons, it is sometimes desirable for military vessels not to disclose their own position and data. Military regulations, and tactical factors that the CO of a naval vessel choses to take into account, will always take precedence over rules issued under the Norwegian Navy's navigation regulations (SNP-500).

The AIBN has been informed that the operational framework plan from 2014, which was developed after the security policy situation had changed, contained guidelines on transmission that changed priorities relating to AIS. The naval vessels were then increasingly engaged in operations in nearby areas, and there was a growing need for keeping information about the movement of Norwegian vessel concealed. According to the framework plan, AIS should, as a rule, be kept in passive mode (mode 2) from then on, and only set to active mode (mode 1) when considered necessary for reasons of navigational safety.

[30] No information has been found to indicate that there was any form of interference in GPS signals in the Hjeltefjord on 8 November 2018.

In 2018, the operational framework plan was updated without any mention of AIS. Normal procedure was still to set the AIS in passive mode and to switch to active mode when passing through areas of maritime traffic and if the navigator thought that other vessels needed to observe the naval vessel more closely.

At the time of the accident, HNoMS Helge Ingstad was part of the NATO force SNMG1 (see section 1.9.7.5), and the instructions for the period in question specified that AIS was to be kept in passive mode. On this particular voyage, HNoMS Helge Ingstad had last transmitted AIS information when passing through Skatestraumen in the evening before the accident. The AIS was in passive mode (mode 2) prior to and at the time of the collision with Sola TS. It was set to active mode (mode 1) after the collision.

Warship AIS (mode 3) was not used during the voyage through the Hjeltefjord.

The Navy had no guidelines for the use of W-AIS when sailing in the service area of Fedje VTS. W-AIS was a relatively new technology in the Navy in 2014, and the Navy realised that equipping Fedje VTS with W-AIS could be helpful in reducing the need for communication. Thus, they contacted the NCA, and the NCA acquired and installed W-AIS at the VTS centre in 2015.

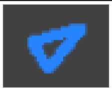
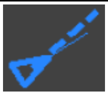
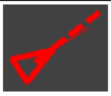
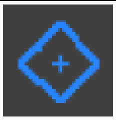
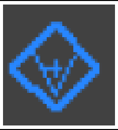
The investigation has shown that there was minimal communication about the use of W-AIS in the service area of Fedje VTS after the spring of 2016. Based on the information the AIBN has obtained, it was mostly unknown that Fedje VTS had W-AIS installed with the correct encryption key. On 8 November 2018 there was still no agreed upon procedures for the use of W-AIS between Navy vessels and Fedje VTS.

1.9.3.8 *AIS symbols*

In accordance with the functions described in the supplier’s manuals, all vessels with AIS transmission within range were represented by symbols on the ECDIS and radar displays on HNoMS Helge Ingstad. It has not been possible to reconstruct the AIS targets plotted on MFD 1-3 during the voyage, because this information is not stored in the navigation system, nor was the vessel equipped with a VDR.

The relevant symbols displayed for different objects are described in the bridge system supplier’s AIS operator manual. A selection of symbols is shown in Table 3.

Table 3: AIS symbols Source: K-Bridge Radar – Operator Manual, release 7.0.x

AIS symbol	Meaning
	By a sleeping AIS target is meant a target that is not being tracked. The target's orientation will vary with the vessel's course.
	A tracked AIS target. The symbol's vector represents the vessel's speed and direction.
	A tracked AIS target that has generated a CPA or TCPA alert.
	Navigation object, landmark or buoy with AIS transponder.
	Virtual navigation object. The symbol is shown on the radar or ECDIS display only and does not represent the presence of any physical object.

1.9.3.9 *Tracking of radar and AIS targets*

Both radars had ARPA functionality enabling them to track radar echoes and calculate course, speed, closest point of approach (CPA) and time to closest point of approach (TCPA). To track an echo/radar target, it was necessary to place a marker manually on top of the target on the display and press the 'ACQ' (acquire) button on the MFD.

If a given vessel is represented by both AIS and radar echo, both AIS and radar tracking is possible. When the 'ACQ' button is pressed, the system will then choose between the radar and AIS target according to which is closer to the marker's position. The system will then automatically continue to follow the target as long as it is within radar or AIS range.

Both radars on HNoMS Helge Ingstad (MFD 1 and MFD 2) were set to give both sound and text alerts if a tracked radar echo would pass HNoMS Helge Ingstad with CPA less than 0.5 nm in the course of 6 minutes (TCPA). The AIS would generate similar alarms if it was estimated that a tracked vessel would come closer than 0.5 nm in the course of 6 minutes. In both cases, alarms would only be generated if the vessels were being tracked.

Each MFD has a common alarm dialogue box (for both AIS and ARPA) where it is possible to change the alarm limits for collision danger (CPA and TCPA) and proximity violation. Any changes in the settings will apply to both AIS and ARPA targets, but only for the MFD on which the change was made.

The 'DATA' function shown in Figure 29 is used to present data about a radar or AIS target. By placing the marker on the target and pressing 'DATA', a pop-up window will appear with information about the target's name, bearings, distance, course, speed etc. (see Figure 30). If a vessel is being tracked by both AIS and radar, both AIS and radar information can be viewed simultaneously by expanding the window. AIS contacts do not have to be targeted to display information when pressing 'DATA'.

The supplier's operator manual describes how to start AIS tracking, but does not include any details on how long it takes to establish tracking.

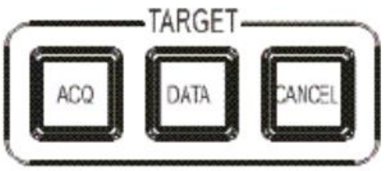


Figure 29: AIS target functions. Source: The Norwegian Navy

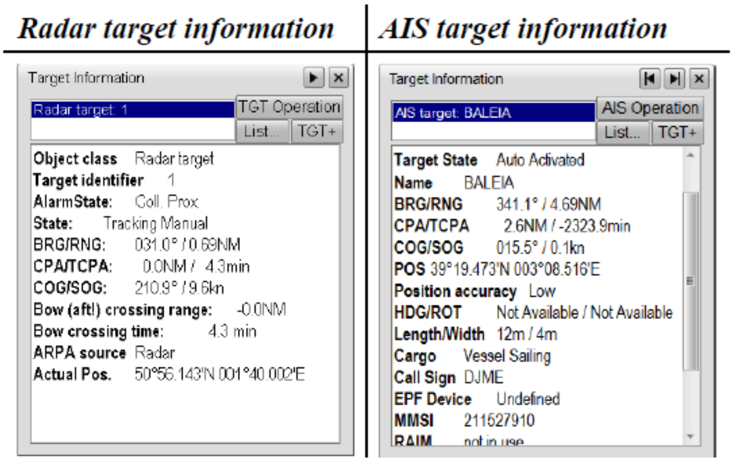


Figure 30: By placing the marker on the target and pressing 'DATA', a pop-up window will appear with information about the target's name, bearings, distance, course, speed etc. Source: K-Bridge Radar – Operator Manual, release 7.0.x

1.9.3.10 *Integration of radar, AIS and ECDIS*

The OOWA had ECDIS on MFD 3 and could select radar or ECDIS (normally radar) on MFD 2. AIS targets could be tracked on both ECDIS and radar.

The OOW could select radar or ECDIS on MFD 1. Radar was normally selected on MFD 1. According to the bridge manual, radar should be set up to display AIS contacts and planned route. In the case of pure radar navigation, the shoreline in the electronic chart (chart outline) and sea marks (aids to navigation) shall be presented. Both MFD 1 and MFD 2 were set up as described. On changing from radar to ECDIS on MFD 1 and MFD 2, ARPA tracking would not be transferred. This is described in the manufacturer's operator manual, but not in the bridge manual. Changing the other way, from ECDIS to radar, is described in the bridge manual:[31]

> *On changing back from ECDIS to RADAR on MFD 1 and MFD 2, the chart overlay needs to be switched on and all AIS tracks need to be re-tracked (ARPA tracks are maintained). This is not practical as it should be possible to switch between the displays at frequent intervals.*

1.9.3.11 *Handling alerts*

A single vessel being tracked will generate alarms for collision danger (CPA and TCPA) and proximity violation. In total, a single vessel will generate six alarms if it is being tracked using all available systems (MFD 1-3).

A total of 12 alarms for collision danger and proximity violation were generated between 03:47 and 04:01 during the night leading up to 8 November 2018. The vessels were tracked on MFD 1 and 2. The final alarms that the bridge team had to handle were: a) 'collision danger' with 'Seigrunn' at 03:58:07 on MFD 1 and at 03:58:59 on MFD 2, the latter being acknowledged at 03:59:09, and b) 'proximity violation' in relation to Silver Firda at 04:00:20 on MFD 1 and at 04:00:21 on MFD 2, the latter being acknowledged at 04:00:31.

[31] V-200 Bridge Watch Guidelines, section V-210.03. Experience of K-Bridge

On acknowledging an alarm, the person who does so shall state loudly and clearly which alarm has been generated, for example: '*Collision Danger on the southernmost of three approaching vessels, planned passing distance xx*'. This is to ensure information flow as necessary between the OOW and the OOWA, at the same time as the information is also conveyed to the CO if he/she is present on the bridge.[32]

The Navy has summed up how the alert system works as follows:

1. Alarms are indicated both optically and acoustically on all MFDs, regardless of which MFD generates the alarm.

2. Individual settings are made on each MFD, among other things for Grounding, Collision Danger and Proximity Violation.

3. Some alarms (for example the alerts for Grounding, Collision Danger and Proximity Violation) can only be acknowledged on the MFD by which they were generated.

4. Alarms relating to routine monitoring cannot be acknowledged on ECDIS when the latter is in Browse mode.

5. CPA/TCPA and Proximity alarms will only be generated for objects where tracking has been established.

1.9.3.12 *Automatic warning functions*

Automatic tracking

HNoMS Helge Ingstad had a radar function for initiating automatic tracking of radar and AIS targets (automatic acquisition of targets), but this function was not activated during the voyage. The function for automatic target acquisition did not distinguish between AIS and radar targets. The function was based on the radar operator indicating an area around the vessel, for example a corridor of X nautical miles to either side of it and Y nautical miles ahead. All radar echoes and AIS contacts within this area would then be tracked automatically and the operator would be notified it the target came within a distance of 0.5 nautical miles of the vessel in the course of 6 minutes. The alarm limit can be adjusted. The function tracks and issues warnings of all radar targets, regardless of whether the radar signals were reflected from shore, vessels or other objects. On inshore voyages, the function will to a large extent track and warn of targets without any operational value, and, for that reason, it would normally be deactivated.

Sleeping target warnings

HNoMS Helge Ingstad also had an AIS function that could warn of sleeping AIS targets (see Figure 31), that is AIS contacts not being tracked. The function would issue alerts for sleeping AIS targets at the same CPA and TCPA as tracked AIS contacts. According to the Navy, the function was normally deactivated on inshore voyages since the system would otherwise generate many alarms of vessels alongside quays.

[32] P-200 Bridge Watch Procedure (REV 1606), section P-212

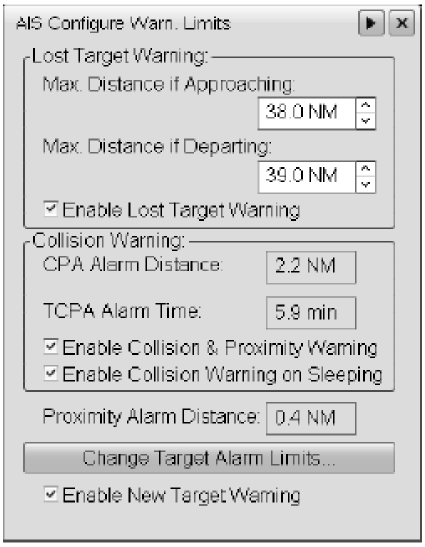


Figure 31: The function for warnings about sleeping AIS targets is activated by ticking the box 'Enable Collision Warning on Sleeping'. The settings for receiving warnings can also be changed. Source: The Norwegian Navy

1.9.4 VHF radios

The bridge on HNoMS Helge Ingstad was fitted out with four VHF radios with built-in loudspeakers and associated handsets (see Figure 26). One of the handsets, the one used by the officer of the watch when HNoMS Helge Ingstad received the call from the pilot on Sola TS, was located next to the IPMS on the starboard side of the bridge console, approximately 1.5 metres from the radar display (MFD 1). The AIBN has been informed that this VHF radio has been moved closer to MFD 1 on HNoMS Roald Amundsen and HNoMS Otto Sverdrup, and that there had been plans to do the same on HNoMS Helge Ingstad.

1.9.5 Navigation lights

During the night leading up to Thursday 8 November 2018, the navigation lights on HNoMS Helge Ingstad were switched on. The frigate exhibited two white masthead lights, sternlight and sidelights.

1.9.6 Voyage planning

As prescribed in the bridge manual (I-202.06.01) for the frigate squadron, a navigation brief shall be carried out for relevant personnel before departure. This is a general brief that, among other things, addresses the programme for the voyage, tides, weather, narrow sounds, communications, navigation warnings, traffic and any other military activity. No such brief was carried out for the inshore voyage in question. This voyage was planned when the vessel already was under way.

The AIBN has received the vessel's voyage plan. The planning of the voyage in question was based on a standard route, it was planned and validated in ECDIS and approved by the CO. Validation of the route took place in ECDIS the day before the voyage. Validation involves checking the route against information available in the electronic chart. According to the voyage plan for the area in question, the frigate's planned speed was 17 knots.

ECDIS checks and notifies whether the planned route means that the vessel will pass any shallow areas or geographical areas subject to limitations. If the system detects conflicts between the planned route and the electronic chart data, it will give a warning (for example ‘Grounding’). The navigator can change the route or enter a comment about why the warnings occurred. These comments can either be linked to the route and automatically give the navigator warnings (‘critical points’) or be entered as comments relating to turns (‘waypoints’). The navigator needs to retrieve these comments in each individual case to enable them to be presented on the screen.

The comments relating to the validated, approved route included warnings about fish farms and shallows that would be passed. There was also a comment about notifying Fedje VTS and listening to VHF channel 80, and a comment about changing to VHF channel 71 when passing Jona light. None of these comments were entered as ‘critical points’, and were therefore not automatically presented.

On the electronic chart, a ‘Safety Zone Sture’ was also marked around the Sture Terminal. Figure 32 shows the safety zone as marked on the ECDIS on HNoMS Helge Ingstad. HNoMS Helge Ingstad planned to pass this safety zone at a CPA of 700 m to the safety zone. The planned route in this area, slightly to starboard in the fairway, was in accordance with the Navy’s principles for voyages in inshore waters (SNP 500).

Figure 32: Map section showing the safety zone (marked with a pink broken line in the lower right corner) around the Sture Terminal. Photo of the ECDIS/MFD 3 on HNoMS Helge Ingstad taken after the accident. Photo: Crew member of HNoMS Helge Ingstad

The safety corridor for the voyage in question, on the basis of which the system had validated the route, was set to 500 m on either side of the vessel. The safety corridor is visible in ECDIS, but not on the radar, and the system would give alarm if the vessel left this corridor.

The passage through inshore waters was divided between the three OOWTs so that each of them would get to navigate a route adapted to their level of experience. In addition, as described in section 1.8.1.3, the CO and/or XO were always present on the bridge when the vessel was to pass through demanding narrow waters and/or areas of maritime traffic, and in conditions of poor visibility. The passage through the Hjeltefjord was not considered particularly demanding, as the fairway is open and offers a good view all around.

A captain's night order book was not kept on 'HNoMS Helge Ingstad', but the Commanding Officer (CO) gave instructions both during the planning phase and en route (see section 1.2.1.1), which were communicated in connection with the officer of the watch handovers. No joint review of the route (fairway review) was carried out with all the navigators before the inshore voyage commenced. The relieving OOW and the OOWT had both reviewed their part of the voyage route the night before the accident.

1.9.7 Frigate operation and sea training

1.9.7.1 *General information*

After it had been decided that the Navy would increase the number of operative frigates from three to four HNoMS Helge Ingstad was taken out of a lay-up period and put into operation in August 2016.

1.9.7.2 *The sea training concept*

The frigates are assessed every four years. The actual sea training period is of six months' duration. The crew are evaluated as they follow a structured practical safety training path in accordance with the Navy's training concept OPUS. To start with, the focus is on safety and basic skills, leading up to a final safety review. The frigates also train in aspects of tactical warfare and handling damage situations and are subject to a general evaluation[33] by Flag Officer Sea Training (FOST), a UK body for evaluation of naval units.

The Navy is the owner of the sea training programme and appoints a team to go on board and evaluate the crew's skills in different areas. The Navy's Navigation Competence Centre (NavKomp), represented by HNoMS Tordenskjold, tests the level of navigation on board the vessel. NavKomp representatives normally spend two days on board together with the bridge team to evaluate their performance. In addition to evaluating navigation skills and teamwork on the bridge, they seek to observe each officer of the watch when navigating with reduced sensors, at high speed, in daylight, darkness etc. The bridge team and navigators are checked out and cleared by demonstrating that they have attained the requisite level of skills, and general feedback is given to the vessel.

1.9.7.3 *Safety review, HNoMS Helge Ingstad, 2016*

NavKomp conducted an evaluation of navigation competence in connection with the safety review of HNoMS Helge Ingstad. The following are relevant excerpts from the summary, recommended priorities and proposals for further training mentioned in the report (dated 20 October 2016):

[33] General evaluation: testing the entire vessel's capabilities against the requirements of a fully operational frigate.

...Proposed further training:...- The OOW's thoughts and intentions must be more apparent. - Better knowledge of the structure of the navigation system. - Greater attention to using binoculars (the whole bridge team) and use of radar in the dark. This should be linked to the phases, of which the control phase is particularly important. The lookout should learn to use the binoculars after every turn – Read the COLREGS regularly and pay particular attention to the rules that apply under different visibility conditions.

The overall conclusion from the safety review was that HNoMS Helge Ingstad had a satisfactory level of sea training. The Navy has informed the AIBN that it is up to the CO on each individual vessel to follow up the recommendations from the safety review.

1.9.7.4 *Flag Officer Sea Training (FOST), 2017*

In the FOST evaluation in 2017, HNoMS Helge Ingstad was awarded the grade 'Very satisfactory'. Among other thing, the vessel achieved a higher score than any Norwegian vessel had previously achieved in tackling exercises with water ingress in multiple compartments.

1.9.7.5 *Participation in SNMG1 and Trident Juncture, 2018*

HNoMS Helge Ingstad had joined the Standing NATO Maritime Group One (SNMG1) in the Baltic Sea on 13 September 2018 and remained there until the start of the *Trident Juncture* exercise off the Norwegian coast on 25 October 2018.

1.9.7.6 *Bridge Resource Management (BRM) training*

The following practice for BRM training was established in the Navy:

- All Norwegian naval officers have completed courses and training in BRM as part of the STCW[34] training required to obtain their certificates.

- Since 2001, the Navy (through NavKomp) has provided instruction in BRM and engine resource management (ERM) and issued certificates of competence to cadets at the Naval Academy, accredited by the Norwegian Maritime Authority.

- The Navy assumes that able seaman apprentices on board 'HNoMS Helge Ingstad' had been instructed in BRM as part of their STCW training in line with normal practice, but lacks an overview of the facts.

- The Navy's bridge teams are assessed in relation to BRM and teamwork during safety reviews. According to the Navy, it is highly probable that individual members of the bridge team on 'HNoMS Helge Ingstad' had been assessed while serving on board, but it cannot be documented whether such an assessment of the practical teamwork of the bridge team in question, had been carried out.

[34] STCW - Standards of Training, Certification and Watchkeeping for Seafarers

1.10 The oil tanker Sola TS

1.10.1 General information

The tanker Sola TS (see Figure 33) is operated by the Greek business group Tsakos Columbia Shipmanagement (TCM) S.A. The vessel was built at the Romanian shipyard Daewoo Mangalia Heavy Industries (DMHI) and delivered to the owners in May 2017.

The vessel is a double hull tanker for carrying crude oil, with a length overall of 250 m, breadth of 44 m and moulded depth of 21.2 m. The vessel's deadweight tonnage is 112,948.8 tonnes. Sola TS is fitted out with a MAN-type main engine. Type D&T 6G60ME-C9.5 X1, with an output of 11820 kW and a fixed four-bladed propeller. The vessel also has a spade rudder with a maximum rudder angle of 35°.

Sola TS is registered in Malta and classified by DNV-GL with the class notation +1A1 as 'tanker for oil'. The vessel has also been assigned ice class 'ICE-1B'.

Sola TS has 12 cargo tanks (6 on either side) with an aggregate volume of 123,933 m^3, and two slop tanks (one on either side). The vessel is double-hulled with the ballast tanks located outside of the cargo tanks.

'MT Sola TS' was under a charter with Equinor, along with several other tankers from TCM's fleet.

Figure 33: The tanker Sola TS. Photo: Tsakos Columbia Shipmanagement S.A.

1.10.2 Bridge design and layout

Figure 34 shows the bridge on Sola TS.

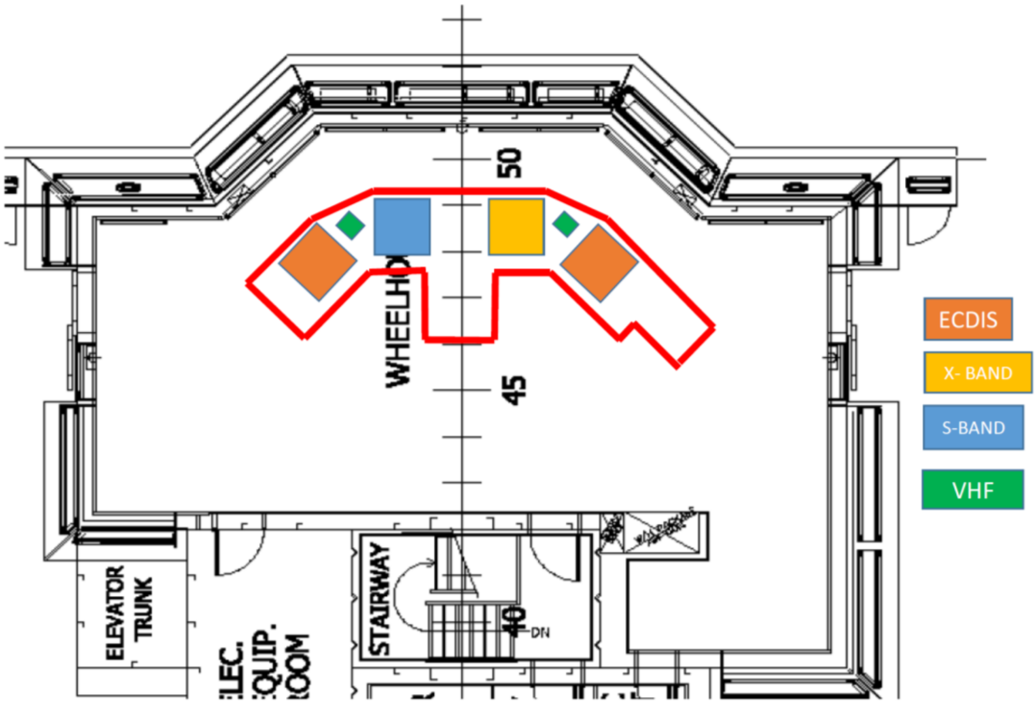


Figure 34: Bridge design of Sola TS. Illustration: Tsakos Columbia Shipmanagement S.A.

1.10.3 Navigational aids

1.10.3.1 *Description*

The vessel was fitted out with two approved ECDIS, in addition to one JMR-9230 S-band radar and one JMR 9225 X-band radar. Sola TS carried normal radio equipment consisting of two VHF radios in the forward bridge console and one VHF radio in the GMDSS station at the aft end of the bridge.

Sola TS was equipped with AIS Class A transceivers. The vessel transmitted AIS signals as normal, and AIS information from other vessels was automatically displayed on both ECDIS displays. While sailing through the Hjeltefjord, the crew used AIS in addition to radar with true trails and visual observations as sources of information about other maritime traffic in the area.

1.10.3.2 *Data from the navigation system*

At 03:13, both radars on Sola TS were set to a range of 0.75 nm. The scale was set to 1:10,000 and 1:12,500, respectively, on the two displays showing ECDIS. This meant that the instruments did not cover the area further south, where there were three northbound vessels (Silver Firda, Vestbris and Seigrunn). The vessels approaching from the north (HNoMS Helge Ingstad and Dr. No) were also not within the range scale of the instruments on Sola TS at this point in time.

The tanker’s VDR recorded images of the ECDIS displays every 30 seconds and of the radars every 15 seconds.

The range scale on the tanker’s S-band radar was increased to 1.5 nm at 03:27:05 and to 3.0 nm at 03:27:20. The range scale on the X-band radar was increased to 1.5 nm at

03:27:33 and to 3 nm at 03:57:48. At 03:47:18 the S-band radar was off-centred. Variable range marker (VRM) was switched on at 03:57:12 and placed on the echo of the frigate.

The scale of the tanker's ECDIS 1 was changed to 1:12500 at 03:54:18. The scale of ECDIS 2 was changed to 1:20000 at 03:54:07 and reduced to 1:12500 again at 03:54:38. The scale of ECDIS 2 was changed to 1:20000 at 03:58:35 and was not rescaled before the collision.

1.10.4 Navigation lights

1.10.4.1 *Use of lights on Sola TS during the night leading up to 8 November 2018*

When leaving the Sture Terminal, Sola TS exhibited the following lights: two masthead lights, sidelights and sternlight. The tanker's sidelights were located near the main deck under the bridge wings. In addition, the vessel exhibited three red all-round lights in a vertical line in the mast and on the roof of the bridge. Above the topmost of these lights, the vessel displayed a flashing red light. Figure 35 shows the lights exhibited abaft midship on Sola TS, with the same navigation lights as on the night of the accident, seen from starboard during the observation voyage (see section 1.15.3).

According to the NCA, it has become established practice for tankers approaching and leaving the Sture Terminal to exhibit the same lights as tankers calling on Mongstad: three red all-round lights in a vertical line. Concerning the flashing red light, according to the NCA, vessels carrying dangerous or polluting cargo are required to exhibit such lights in Japanese waters. Normal practice in the rest of the world is to exhibit a fixed red all-round light.

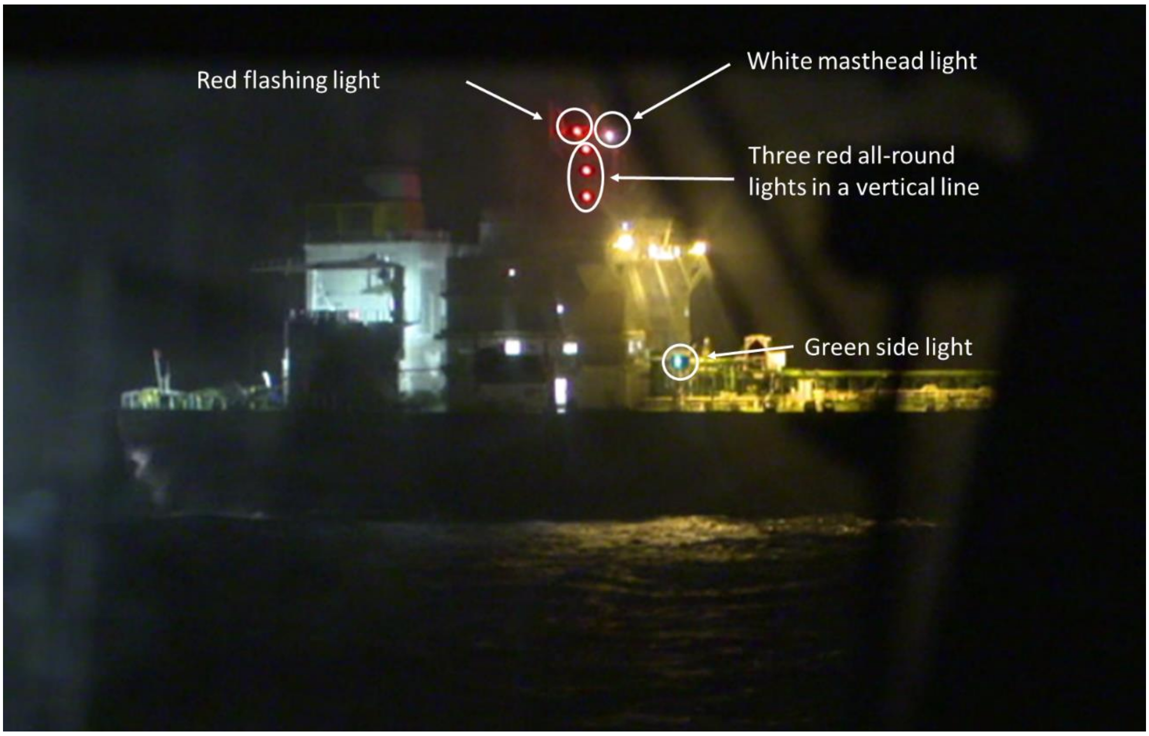


Figure 35: The lights exhibited abaft midship on Sola TS, viewed from the starboard side during the observation voyage. Photo: The police

1.10.4.2 *Regulations concerning navigation lights*

The Regulations of 01 December 1975 No 5 for preventing collisions at sea (COLREGs) include provisions concerning navigation lights. Rule 20 b) is quoted below:

> *a) The Rules concerning lights shall be complied with from sunset to sunrise. During such times no other lights shall be exhibited, except such lights as cannot be mistaken for the lights specified in these Rules and do not impair their visibility or distinctive character, or interfere with the keeping of a proper look-out.*

1.10.5 Deck lighting

Sola TS had a total of 21 deck lights on the foredeck: 13 throwing the light forward and 8 throwing the light aft.

The forward-pointing deck lights were on when Sola TS left the quay at 03:36 (see Figure 36):

- On the bridge deck, approximately 21 m above the waterline, there were six deck lights of the type Flood Light HPS.
- In the foremast, approximately 19.5 metres above the waterline, Sola TS carried three LED lights. One of these light was mounted at the centreline and pointing forward. The other two were mounted slightly to the side of and pointed at an angle of approximately 45° from the centreline.
- In the starboard and port deck masts midship on Sola TS, were mounted a total of four floodlights of the type Flood Light HPS, approximately 18.5 metres above the waterline.

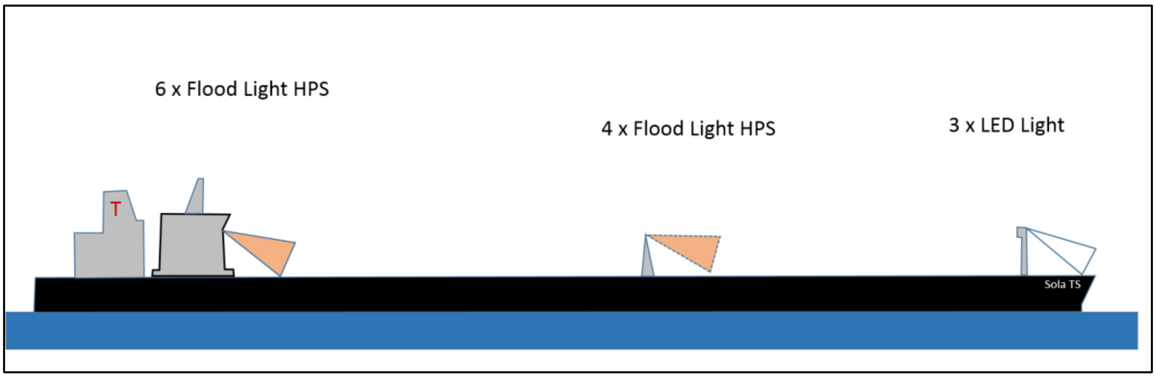


Figure 36: Simplified drawing of the forward-pointing deck lights that were lit on departure. Shortly after departure, the four midship lights were turned off. Illustration: Tsakos Columbia Shipmanagement S.A./AIBN

In addition, the vessel was equipped with the following aft-pointing deck lights: four deck lights in the foremast and four in the starboard and port deck masts midship. The latter lights had all been turned off just before 03:00.

1.11 The Royal Norwegian Navy

1.11.1 In general

The Royal Norwegian Navy consists of the Naval Staff, the Fleet, the Coast Guard, the naval bases, the Navy's Medical Corps and the HNoMS Harald Hårfagre Basic Training Establishment at Madla in Stavanger (see Figure 37). The Fleet is the Navy's operative force.

The Fleet and Coast Guard's vessels are continually on assignment or preparing for assignments – both in national territorial waters and abroad. The Fleet is a standing combat organisation having the Navy's materiel and coastal craft at its disposal, including the Fridtjof Nansen-class frigates. The Fleet's primary function is to be capable at all times of defending Norway's territorial waters by military means if necessary. The Fleet shall ensure that its vessels and departments are provided with state-of-the-art equipment and trained and motivated personnel.

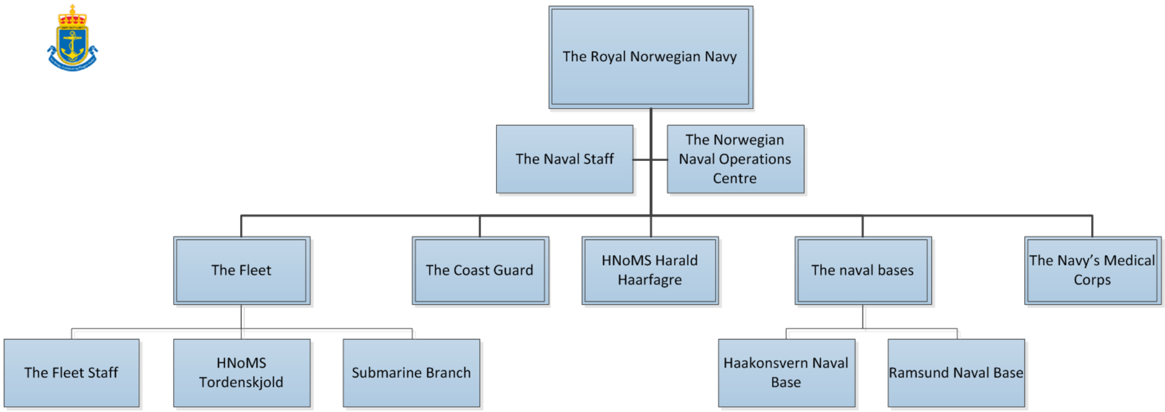


Figure 37: Organisation chart of the Royal Norwegian Navy 2018. Illustration: The Royal Norwegian Navy

1.11.2 Long-term plan for the defence sector

A new long-term plan for the defence sector 'Combat force and sustainability' (Proposition to the Storting No 151 S (2015-2016)), prepared by the Ministry of Defence, was adopted by the Storting in November 2016. The plan entails a combination of increased funding, continued rationalisation and structural changes. The following is quoted from section 5.3 on the Navy:

> *(…) The current situation, with few crews, lack of maintenance and spare parts, means that the vessels are not being put to optimum use. Priority is therefore given to increasing the frigates' level of activity in the upcoming four-year period. Furthermore, the number of crews will be increased from 3.5 to 5, which means that the Navy will be able to operate four frigates simultaneously. Among other things, this will be achieved by rationalising the land-based staff and administration to prioritise shipboard crews. (...)*

1.11.3 Safety management and application of the Ship Safety and Security Act to vessels belonging to the Armed Forces

The Act of 16 February 2007 No 9 relating to ship safety and security (the Ship Safety and Security Act) Section 7 regulates the shipowners' duty to establish, implement and further develop a safety management system. The Chief of the Royal Norwegian Navy has been established as owner and the Chief of the Fleet as responsible for operations, in accordance with Section 2 *Owner and operationally responsible* of the Regulations of 29 June 2017 No 1668 relating to the application of the Ship Safety and Security Act by the Ministry of Defence's subordinate agencies. The Regulations also regulate exemptions from the Act for vessels belonging to or serving the Armed Forces. Among other things, the Regulations state that the Armed Forces' vessels are exempt from Sections 23 (Working hours) and Section 24 (Rest periods) of the Ship Safety and Security Act.

A directive on requirements for safety management in the Armed Forces (*Direktiv – Krav til sikkerhetsstyring i Forsvaret*) contains generally applicable provisions on safety management and attention to safety in the Armed Forces. Further operationalisation is found in a set of instructions for the requirement for safety management in the Navy (*Instruks for krav til sikkerhetsstyring i Sjøforsvaret*).

The Navy has interpreted the requirement for risk assessments in the Ship Safety and Security Act in relation to its own safety regime and operations, and uses the risk management tools in the operation of its vessels.

1.11.4 Education, competence and career path for navigators

1.11.4.1 *Education*

A navigator degree from the Norwegian Naval Academy is the start of the career path as an operational officer on board the Navy's vessels. Admission to the Armed Forces' academies is granted by the Armed Forces' admissions section (FOS) using a selection scheme under which candidates assessed as being most fit for service are offered training in the Armed Forces.

During the first 3.5 years at the Naval Academy, the students specialise in nautical subjects, receiving theoretical instruction as well as extensive practical training on board the Navy's school ships. Compared with civilian maritime vocational and higher education, the Naval Academy's educational programmes provide for more practical training on board school ships.

Naval navigation is traditionally more challenging than ordinary civil navigation as a result of the operational requirements that apply to the vessels. The biggest differences between instruction in civil navigation and military navigation largely relate to the use of optical principles, basic use of the clock and logs, in addition to system understanding and use of the navigation system without input from the GPS. Furthermore, while training and instruction in the use of pelorus devices is generally not offered at civil navigation schools, these are essential aids in military navigation. Navigational warfare is another subject not taught at civilian schools.

Following the restructuring of the Navy in 2016, vessel-specific courses are largely left to the vessels in the form of on-the-job-training.

1.11.4.2 *Practice and career path*

According to the Navy's career and service plan, dated 7 July 2017, there will normally be greater focus on technical skills early on in a person's career, while this is less prominent at a later stage – overall understanding and management become more important in higher-ranked officer positions. On Fridtjof Nansen-class frigates, officers start as trainees in the department corresponding to their field of specialisation, with the focus on gaining ‘clearance’ for their various functions. On being cleared, the candidate will normally advance to the next level in his or her section.

In the career map for officers on frigates, one of the positions is designated ‘Navigation Officer 1-3’. The recommended minimum period of service in this position is set to 2-4 years.

During the first year of practical training as navigation officer on board an operational naval vessel, the trainee is a novice in navigational skills. In that year, much time will be spent on becoming familiar with the vessel’s procedures and on translating the theoretical learning acquired at the Naval Academy into practical navigation and operation.

After a year of practical training, the trainee will usually be familiar with the relevant procedures and have acquired an understanding of his/her function on board. The candidate will also have tried his/her hand at using all navigational aids. Depending on the vessel’s sailing pattern, as navigator, the trainee will also get some experience of inshore voyages as well as navigation in open waters.

The career path from navigation officer to CO is normally completed in about 12–15 years, where it is natural for officers to serve in other departments of the Armed Forces along the way.

1.11.4.3 *Qualification and clearance of bridge officer of the watch*

The process for clearing bridge officers of the watch differs between the different types of vessels. On some vessel types, the clearance process is based on own courses and checkouts under the auspices of the operating organisation. On frigates, it is the CO who decides at what time a navigation officer has gained a sufficient level of competence to be cleared as officer of the watch. On board a frigate, it normally takes 1–2 years to receive training and clearance as officer of the watch in accordance with the checklists in the manuals.

Based on the information the AIBN has received through interviews with representatives of the Navy’s navigational competence environments, an officer should have 3–4 years’ experience in order to be considered an experienced officer of the watch. A cleared officer of the watch should have 2–4 years’ experience before being charged with training other navigators.

1.11.4.4 *Practical experience and certificates*

On completing their education, candidates must have 360 days of service on board before they can be issued with a first certificate as Deck Officer Class 4/3 (D4/D3). All working hours are reckoned to be hours of sea duty, whether at sea, alongside or on guard duty.

When a first certificate has been issued, service time is earned as a factor of 0.8 of the number of days the deck officer holds the position on board. To be issued with a Deck Officer Class 2 certificate, the candidate must have completed 24 months of service on board (i.e. 30 months in the position on board) after the date of issue of the D3/D4 certificate. To be issued with a D1 certificate, the candidate must have completed 36 months of service on board (i.e. 45 months in the position on board) after the date of issue of the D3/D4 certificate. One month is reckoned as 30 days. Service time is recorded by the Navy Staff (SST/P) at Haakonsvern.

To become an officer of the watch on a Fridtjof Nansen-class frigate, a Deck Officer Class 4 (D4) certificate or better is required.

1.11.5 Job descriptions

1.11.5.1 *Commanding Officer*

According to the job description for captains on Fridtjof Nansen-class frigates, the CO's duties and responsibilities are as follows:

> *The CO is responsible for all operation of the vessel and for training and education of subordinate personnel. The CO is responsible for financial dispositions, control and follow-up in accordance with allocated budgets, and for applicable directives and regulations.*

The CO on board is responsible for qualification and clearance of new officers of the watch.

The following is stated the Navy's Service Manual SAP-1(D), Chapter 3 'The CO', section 335:

> *1: The CO shall seek to arrange the service so as to motivate and engage interest, develop a feeling of responsibility, the will and strength to act independently…*
>
> *4: Young officers should be given as much independence as possible to carry out some part of the service and lead drills and work operations so that they assume responsibility and are afforded the chance to exercise own judgement and act of their own accord.*

1.11.5.2 *Navigation Officer 1*

According to the job description for Navigation Officer 1 on Fridtjof Nansen-class frigates, the officer is charged with the following duties and responsibilities:

> *The position as Navigation Officer 1 on board a Fridtjof Nansen-class entails responsibility for passage planning in cooperation with the Executive Officer (XO) and Operations Officer. Arranging navigation training, including instruction for students and own crews. Navigation Officer 1 shall ensure that all personnel standing watch on the bridge have received necessary training. Assisting the CO with navigational information. Watch standing in accordance with the vessel's watch bill.*

1.11.6 Regulations for exercising navigation on the Navy's vessels (SNP-500)

These regulations on practical navigation, issued in 2013, apply to the whole Navy. The purpose is described as follows:

> *The document describes how the Navy's traditional principles for inshore navigation shall be upheld when using modern electronic aids such as electronic charts, global*

> *positioning systems and integrated bridge systems. The purpose is to promote safe navigation and support the vessels' work on navigation.*

SNP-500 is an official approved document forming the basis for the governing bridge service documents (bridge manual) for Fridtjof Nansen-class frigates. NavKomp is responsible for the content.

Optical navigation is defined in the regulations (p. 8) as *'navigation without the use of electronic aids'*. The regulations (p. 9) state that *'The optical principles and techniques form the basis for navigation in the Navy.'*

The reason why the Navy continues to rely on optical navigation in a time when electronic navigational aids are extensively used both in civil and military navigation is stated as follows (p. 9):

> *The Navy wants to uphold the principles and techniques that form the basis for optical navigation for reasons of safety and security, for tactical reasons and for educational reasons. Developments in technology have introduced electronic aids, however, that affect the navigator's working environment and tasks. One reason for this is that vessel steering and positioning have largely been automated through the use of electronic charts, automatic steering and global positioning systems. By using traditional principles and techniques for optical navigation in combination with more recent electronic aids, the Navy will maintain the skills of navigators and at the same time be capable of evaluating the quality of the data presented by electronic aids.*

This is why all navigators receive practical training in optical navigation on board the vessels as part of the process of being cleared for the officer of the watch position.

In order to check the position that is being presented by the navigation system at any time, the navigators use different modes, or methods of sailing the vessel (p. 10)

> *It will always be one of the following three modes:*
> - *Optical mode*
> - *Radar mode*
> - *A combination of the two*

The following concerns principles for voyage planning (p.32):

> *All route planning is carried out with all available aids that are relevant to the voyage and the waters. During the voyage itself, both optical and radar control methods can be used. Most voyages are carried out in optical control mode, which is why this is the starting point for route planning.*

When the accident occurred, training in optical control principles was being conducted. The following is reproduced from section 3.1.2.1 Rule – Use of control methods on a voyage: *'In the course of a bridge watch, the vessel's position should be checked and training should be provided in available methods of checking the vessel's position.'*

1.11.7 The bridge manual

1.11.7.1 *Introduction*

I-200 *Instruks for brotjenesten* ('Bridge service instructions'), V-200 *Veiledning for brotjenesten* ('Bridge service guidelines'), P-200 *Prosedyrer for brotjenesten* ('Bridge service procedures') and L-200 *Sjekklister for brotjenesten* ('Bridge service checklists') for Fridtjof Nansen-class frigates were the governing bridge service documents (the bridge manual) that applied to HNoMS Helge Ingstad at the time of the accident. SNP-500 (see section 1.11.6) forms the basis for these documents.

1.11.7.2 *The bridge team's tasks and responsibilities*

According to I-202.03, the officer of the watch (OOW) reports directly to the CO and is in command of the vessel on behalf of the CO. This applies unless the OOW in the operations room is in command. It also applies when the vessel is being navigated by the OOWT.

The following is reproduced from I-202.06 on bridge service execution:

> *06.03 Prioritisation and assessment*
>
> *Safe navigation shall always be emphasised and, during peacetime operations, always take priority over other considerations. The officer of the watch shall navigate safely and effectively by fully utilising available aids at all times. The question of 'what if' shall be a recurring theme in the continuous assessments made by the officer of the watch when serving on the bridge.*

The officer of the watch trainee (OOWT) is described in I-203. The following is stated in the general part of the OOWT instructions (I-203.01):

> *The training of new navigators is a continuous process, where the purpose of the training is to instil in the candidates necessary knowledge about the officer of the watch's duties and responsibilities, the vessel's manoeuvring characteristics, equipment on the bridge, safety rules relating to the use of weapons and special exercises, the vessel's organisation, good work routines and correct attitudes. As a rule, a plan for the watch shall be in place for the training to be as effective as possible, and the officer responsible for the training shall have perused the plan for officer of the watch clearance. The officer of the watch in question shall also have a clear understanding of the training goals for the watch.*

The following three points are reproduced from the specifying part of the OOWT instructions (I-203.02):

> *c. …The OOW shall know the vessel's positions at all times, for example by visually observing GPS pos fix on his/her console so that it can be compared with the position calculated by the OOWT.*
>
> *e. Proper preparation is a precondition for serving as OOWT. The OOWT is expected to prepare the watch in the same way as the OOW, including to participate in all relevant briefs and read signals of relevance to the watch.*
>
> *f. The OOWT shall talk while negotiating the fairway/performing manoeuvres, so that the OOW/CO is informed about the assessments made at all times. Any doubt*

on the part of the OOWT shall be communicated to the OOW and acted on as necessary.

g. The OOWT is expected to demonstrate willingness to learn, inquisitiveness and active information seeking.

The primary task of the officer of the watch assistant (OOWA) is defined as follows in I-204.01:

The officer of the watch assistant shall assist the officer of the watch with the navigation. The officer of the watch assistant's position is on the port side of the bridge. His primary task is to operate MFD 3, where he is responsible for monitoring and correcting the voyage by continually informing the officer of the watch about time and distance to turn, next course, headings, turn objects, passing distances etc. in accordance with applicable procedures. His secondary task is to operate and monitor MFD 2 with the emphasis on information about other vessels, including to help with surface image construction in the operations room.

The manual does not contain any formal or specific requirements for the OOWA's competence and training in relation to the execution of primary and secondary tasks.

The lookout's duties are described as follows in I-208:

All vessels have a duty to maintain active lookout in order to be able to detect and identify any vessels, floating objects, navigational marks and lights at the earliest possible time, at the same time as visual contributions to image construction/identification are important on a warship.

The lookout is required to be constantly vigilant. The lookout is responsible for immediately reporting any observations of importance within his/her range of vision to the officer of the watch, who will communicate any relevant information to the operations room.

…

If only one lookout is present on the bridge, she/he shall be positioned on the starboard side.

The instructions do not mention the use of binoculars specifically. The reason why the starboard lookout position must be manned is to monitor any need to give way to starboard, and the starboard lookout is also tasked with assisting to launch the dinghy in a man-overboard situation.

The helmsman was not responsible for maintaining lookout or reporting about vessels. The helmsman's duties and responsibilities are described as follows in I-209.01:

A helmsman shall be available on the bridge at all times, alternatively as one of two lookouts when automatic steering is used. His task is to stand at the wheel, and to man the emergency steering system should this be necessary.

The division of responsibility between the helmsman and navigators is described as follow (I-209.02):

The helmsman is part of the bridge watch team and reports directly to the officer of the watch. He shall be present on the bridge and ready to take the wheel all times, including when automatic steering is used. Under normal circumstances, the vessel will be navigated by either an officer of the watch or an officer of the watch trainee, who will issue rudder orders and permit the helmsman to be relieved. In some cases, rudder orders may be issued directly by the officer of the watch, the XO or the CO, according to what they consider necessary. The helmsman shall always comply with orders received from these three persons.

1.11.7.3 *Control of position using radar and optical aids*

During the night leading up to 8 November 2018, HNoMS Helge Ingstad was being navigated in a mode known as 'electronic positioning with combined optical and radar control', which in V-230.04 is described as follows:

- *This mode utilises all available equipment to perform an overall and at all times most appropriate control of the voyage.*

- *If optical control is not possible on account of visibility conditions, electronic positioning with radar control will apply.*

When electronic positioning is active, the vessels real-time position is transmitted from the GPS via the inertial navigation system (INS) to the electronic chart (ECDIS), and updated every second.

Radar control of the vessel's position uses the chart outline on the radar display. This is described in V-210.09:

Radar charts: The chart outline and aids to navigation shall be displayed. The purpose of this is to quickly ascertain whether the GPS pos tallies with the radar image and to help to identify vessels versus fixed objects. As long as the chart outline is in accordance with the shore contours on the radar, and the vessel is travelling along a validated route displayed on the radar, it is unnecessary to use parallel indexes.

V-230.03 specifies the following principles for optical control: Steering towards objects (bow and stern bearings, turn bearings in relation to objects, cross bearings, navigation by half lines, four-line bearings and displaced lines of position (LOP). The bridge manual goes on to describe how radar control shall be carried out using parallel index techniques, turn by index or bow distance, positioning by multiple radar distances and/or radar bearings and control of chart outlines on the radar display.

1.11.7.4 *Control of traffic situation*

The control methods listed for optical and radar control are all based on principles for determining the vessel's own position. With respect to detecting other vessels and avoiding proximity situations, the bridge manual I-202.06.04 states that proper lookout must be kept at all times regardless of waters and conditions. At least one navigator (OOW, OOWT or OOWA[35]) shall look out at all times.

[35] Previously, in connection with ECDIS being phased in on board the Fridtjof Nansen-class frigates, the OOWA function was manned by navigators.

V-202.04 Methodology for radarnavex (radar navigation exercise) describes that in order to divide the tasks between the two radars, it is expedient that the radar dedicated to the OOWA uses a range scale of 3 nm or more for early detection of other maritime traffic. The OOW mainly works in range scales of 3 nm and lower. When sailing in narrow fairways and in connection with vessels passing, use of the lowest possible range scales is expected in order to get as accurate a picture as possible of the closest dangers.

1.11.7.5 *The combat information centre*

The combat information centre (CIC), which possess capabilities and expertise that can help to discover and identify contacts on demand from the bridge, was not part of the navigation team during the current voyage. Besides one general comment, the bridge manual does not mention how the CIC can support navigation. The AIBN has understood that such support is to a limited extent trained and practiced. The AIBN does not consider the CIC further in this part of the investigation.

1.11.7.6 *Cooperation and communication*

V-201.02 contains a general observation that concerns everybody on the bridge:

> *It is important that everybody on bridge watch is aware of the responsibility for safety and security that the bridge watch entails, and that the bridge crew work well as a team. The threshold for alerting if anything is observed or otherwise perceived to be wrong shall be low, and the officer of the watch shall motivate and involve his crew to ensure that all crew members perform their best within their respective areas of responsibility.*

The following is reproduced from P-202.02.04 concerning the officer of the watch assistant:

> *…Orders issued and information exchanged between the officer of the watch and the assistant shall be brief, concise, loud and clear. Loose assumptions and the use of relative parameters should be avoided. Information that is clearly not relevant or clearly known to the officer of the watch shall not be stated. The information shall nonetheless be conveyed if in doubt.*
>
> *Everybody with navigational tasks works in a team, that can only function optimally if everybody is aware of their roles and duties, follows procedures, shows initiative and where all members of the bridge team know each other well.*

Communication between members of the bridge watch team shall be in accordance with procedures. Closed-loop communication shall be used, i.e. orders shall be issued by the officer of the watch and acknowledged by the helmsman, who then reports on having executed the order and has this acknowledged by the officer of the watch.

The procedures also state that the noise level on the bridge should not be so high that the officer of the watch must shout to be heard by the lookout and helmsman.

I-201.04.03 clarifies the following as a general rule:

> *The navigation officers are responsible for ensuring that own crews on board the vessel are informed about the applicable revision of the regulations and for ensuring that the regulations are complied with in the performance of their service.*

1.11.7.7 *Watch handovers*

L-200 in the bridge manual includes a checklist for handovers between officers of the watch (L-201-2 *Sjekkliste – Vaktsjefoverlevering*), which is to be completed before the relieving officer arrives on the bridge:

> *The relieving officer reviews the list while acquiring night vision/preparing the watch, and asks questions if anything in the handover is unclear. This reduces the time that the handover takes, at the same time as the officer of the watch being relieved is not prevented from focusing on the vessel's safe passage when nearing the end of his or her watch.*

The *Sjekkliste – Vaktsjefoverlevering* mainly contains a summary of the vessel's configuration, including the status of machinery, vessels and navigation systems. Aspects related to navigation and traffic situations are discussed between the officers of the watch in the handover.

L-200 also includes a checklist for handovers between officer of the watch assistants (L-203 *Sjekkliste – Vaktsjef assistent overlevering*).

1.11.8 Working environment, working hours and rest periods

1.11.8.1 *Background*

Personnel serving in the Navy are exempt from the Ship Safety and Security Act's provisions on working hours and rest periods pursuant to separate exemption regulations (see section 1.11.3). Based on the above, the Ministry of Defence (MoD) and the Fleet (Navy) shall adopt separate provisions to ensure that requirements for rest periods as provided for in laws and regulations are met overall.

1.11.8.2 *Procedure for rest and restitution in the Navy*

Excerpt from the procedure on rest and restitution in the Navy (*Prosedyre for hvile og restitusjon i Marinen*), dated 2 October 2016:

> *2.1 The CO's responsibility:*
>
> *The Navy is engaged in force production for the purpose of being able to deliver combat force in situations of war or crisis. Force production requires endurance training. This will affect the possibility of having optimum hours of rest. The CO is responsible for the safe and secure operation of the vessel. This means that the CO must continually assess the risk associated with inadequate rest, and take action when the risk becomes excessive. The need for rest hours must be considered in relation to the nature of the work. Special focus must be given to sleep deprivation in personnel performing critical functions.*
>
> *2.2 The responsibility of each individual:*
>
> *Many individual circumstances have an impact on sleep deprivation. It is therefore difficult for the CO to assess the risk unless somebody blows the whistle. Those who feel the effects of sleep deprivation therefore have a special responsibility to notify their superiors.*
>
> *(…)*

1.11.8.3 *Protection provisions in the Navy*

The work on regulating how the Ship Safety and Security Act should be applied to the Armed Forces has been going on for a period of more than 11 years, from work on the new Regulations was initiated in 2006 until they were adopted in 2017. Internal rules and a system of supervision have not yet been established or implemented for ships used by Ministry of Defence's subordinate agencies as described in Sections 4 and 5 of the Regulations relating to the application of the Ship Safety and Security Act by the Ministry of Defence's subordinate agencies.

The work on the regulations for ship safety includes rules on working hours and rest periods. Protective provisions for sea-going personnel in the Navy, to replace Section 1 of the exemption regulations, limited to considering provisions to make up for the special exemption provided for in Sections 23 and 24 of the Ship Safety and Security Act, are part of the requirements included in this work.

The Ministry of Defence is responsible for drawing up such protection rules. On the Naval Staff's initiative, the Navy's competence environments became involved in this work and the Navy was assigned the task of preparing a set of draft provisions to meet the requirements set out in the Regulations to the Ship Safety and Security Act. The draft internal rules were made available by the Navy on 30 September 2019.

1.11.9 Lean manning concept (LMC)

The Fridtjof Nansen-class frigates were built with a view to being operational with a minimum crew, approximately half the crew needed on comparable vessels. This concept is known as the lean manning concept (LMC).

The following is reproduced from section 1.5 of the crewing plan 3.0, dated 1 July 2016:

> *LMC entails optimisation of the crew with a view to performing the primary tasks on board and does not include redundancy. Instead, many positions cover several functions and are assigned additional tasks.*
>
> *This multi-functionality, combined with marginal crewing, means that the vessel's operational combat capacity is directly based on qualitative as well as quantitative personnel production, where motivation, attitudes, and levels of competence and experience are all critical factors. Multi-functionality places strict requirements on education, instruction and training, and entails a high workload and extensive effort. This may mean that individuals may be pushed to the limits of their capabilities. The concept is therefore basically neither personnel-friendly nor family-friendly.*

1.11.10 Voyage Data Recorder (VDR) on the Navy's vessels

In 2009, the Ministry of Defence approved a procurement solution for Project (P6005) Voyage Data Recorder (VDR) for the purpose of installing S-VDR/VDRs on several of the Navy's vessels. The following requirements were described in the assignment:

> *Under the Ship Safety and Security Act, all vessels are required to be able to present data after an incident at sea. The work on implementing the Ship Safety and Security Act and its regulations in the Navy is based on compliance with both statutory requirements and the intentions of the Act. This will help to prevent any*

lack of clarity in connection with the exercises and drills the Navy conducts nationally or internationally, regarding ship safety and security, and form a basis whereby the Navy can be treated on a par with other maritime activity.

The following year, in 2010, the Armed Forces were awarded the assignment, with the Ministry of Defence as project owner, the Norwegian Defence Logistics Organisation (NDLO) as project manager and the Navy as the party responsible for implementation. As it turned out, work on the procurement never started, and the project was eventually terminated without VDRs having been installed on any vessels.

After an accident involving one of the Navy's vessels in 2013, the Armed Forces appointed an internal investigation board. One of the factors highlighted by the head of the Armed Forces' operative headquarters, the investigating authority at the time, in the summary report (2015) to the Defence Staff, was the need for VDRs on the Navy's vessels:

Had VDR data from the incident been available, the [] would have had access to unique data to document the sequence of events more exactly, and to better understand the situation on board the [vessel]

The following recommendation was issued by the head of the Armed Forces' operative headquarters:

The investigating authority recommends that the Ministry of Defence, in cooperation with the Armed Forces, consider the possibility of installing and using VDR on various military vessels, for the purpose of improving the follow-up of safety on board after accidents and incidents.

1.12 The shipping company Tsakos Columbia Shipmanagement (TCM) S.A.

1.12.1 General information

Tsakos Columbia Shipmanagement (TCM) S.A. was formed in 2010 and has offices in Athens in Greece. TCM is responsible for technical and other operations and for crewing a varied fleet of approximately 80 vessels.

1.12.2 Navigation manual

TCM has prepared a 'Navigation Procedures Manual' (NPM), with guidelines for how its vessels are to be navigated. Relevant parts of the manual are cited below.

1.12.2.1 *NPM Section NPM-01: Navigation Procedures*

The purpose of the procedure is to specify safe practices and to ensure that necessary precautions are observed by the master and officers on bridge watch for the vessel's safe navigation. The section on responsibility states, among other things, that the master shall remain on the bridge when the vessel is approaching/leaving port and when in the vicinity of other vessels. The master shall ensure that the bridge is manned as necessary and that a safe distance to other vessels in the vicinity is maintained at all times.

Chapter 3 of the procedure describes 'Pre-sailing preparations', intended to ensure that all necessary checks and preparations on the bridge are carried out before departure. The pre-sailing preparations include drawing up a passage plan.

1.12.2.2 *NPM Section NPM-02: Voyage planning*

The purpose of this procedure is to prepare a pre-sailing plan, which shall provide for the safety of vessel, crew and cargo and for environmental protection during the whole passage.

The plan is prepared by the vessel's navigation officer and approved by the master. Prior to departure, the master shall have discussed the whole plan with the rest of the bridge team. All navigation officers must review and sign the plan to acknowledge that they have read and understood it.

The plan for the voyage from the Sture Terminal to Tetney in the UK was described using 'Form NAV-009A: Passage Plan'. Under 'Special navigation safety requirements', the navigation officer had, among other things, drawn attention to there being a high danger of collision on account of dense vessel traffic in the area they were passing after leaving the Sture Terminal.

1.12.2.3 *NPM Section NPM-03: Bridge Watchkeeping*

The purpose of this procedure is to set out requirements for an effective bridge organisation and watchkeeping, in order to ensure safe navigation of the vessel. It also describes how the bridge on all TCM's vessels is organised as a team so as to safeguard against and correct possible errors. Relevant parts of the procedure are described below.

While sailing, the bridge officer of the watch (OOW) shall monitor and be fully aware at all times of the vessel's position, and the position, course and CPA of other vessels in the vicinity.

Section 3.1 of the procedure entitled 'Bridge Team Management' (BTM) points out the following, among other things:

BTM refers to the management of the human resources available to the Master (OOW, helmsman, lookout, duty engine officer etc.) and how to ensure that all members contribute to the goal of a safe and efficient voyage. The primary goal of BTM is to eliminate 'one-person errors'.

There must be a free exchange of information between the bridge team members. The officer in command (conning officer) must keep the other bridge team members apprised of intended manoeuvres, as fully as the circumstances permit. It is important to keep bridge team members up to date with a developing situation.

Even if not recognised as part of the watch team, the pilot plays an important role on the bridge, and it is the responsibility of the bridge watch team to assist the pilot to work within the team.

According to the manual, the circumstances when sailing out from the Sture Terminal indicated that the bridge should be manned in accordance with 'Elevated Condition 2'. The bridge team shall consist of the master (or chief mate), the navigation officer of the watch, one able seaman at the helm and one able seaman or ordinary seaman as lookout. The navigating officer's primary responsibility is collision avoidance and monitoring the vessel's position. Among other things, the navigating officer shall operate the radar/ARPA and other navigational aids, and plot all targets within a range, as ordered by the master.

Section 3.8 of the manual addresses 'Watchkeeping controls at sea' and points out that the OOW must not rely solely on one source to determine whether there is a risk of collision, but use the ARPA in conjunction with visual bearings, and any other means, to establish if a risk of collision exists. Furthermore, reliance solely on AIS information displayed on the ECDIS as an aid to collision avoidance must be avoided. AIS information must be compared with the information from the ARPA, radar or visual observations.

1.12.2.4 *NPM Section NPM-03 Chapter 4: Pilotage*

Section NPM-03 of the manual also contains a separate chapter on pilotage (Chapter 4). The master retains full responsibility for the safety of the vessel, while the pilot assists by providing navigational advice.

The master-pilot exchange (MPX) is an important tool for including the pilot as a resource for the bridge team. MPX is intended to inform the pilot about vessel particulars, including draft, engines, navigational aids, manoeuvring characteristics and any special conditions or characteristics that may affect the pilot's ability to understand how the vessel should be handled. The goal of the MPX is to establish a rapport with the pilot and to agree on the plan for the transit, in order to ensure that everyone responsible for navigating the vessel shares the same plan.

The procedure also points out that English should always be established as the common communication language between the pilot and the bridge team, and that English shall be used for all internal and external exchange of information about the vessel's operations.

1.12.3 <u>The use of deck lights</u>

The owners had established procedures specifically relating to the use of deck lights with regards to the crew's safety while working on deck. The use of deck lights is dependent on the operation of the vessel at the time and at the discretion of the master or the officer of the watch.

The owners refer to the Code of Safe Working Practices for Merchant Seafarers (COSWP) published by the Maritime and Coastguard Agency (MCA) of the UK, Sections 26.3.6 and 31.3.3. Chapter 26.3.6 points out, among other things, that the work areas during mooring operations must be adequately lit when work is done in the dark part of the day. Chapter 31.3.3 points out that at nighttime there should be lighting in areas where work is going on. It is further pointed out that this lighting should not affect the prescribed navigation lights.

1.13 The Norwegian Coastal Administration (NCA), VTS centres and pilot services

1.13.1 <u>The NCA</u>

The NCA is a national agency for maritime transport, maritime safety and acute pollution response. The NCA is headed by the Director General and the head office is the agency's highest governing body. The regions perform operative and common tasks on behalf of the Director General. The NCA has nine operating units: five regions, the shipping company, the Pilot Service, the Centre for Emergency Response and the head office (see Figure 38).

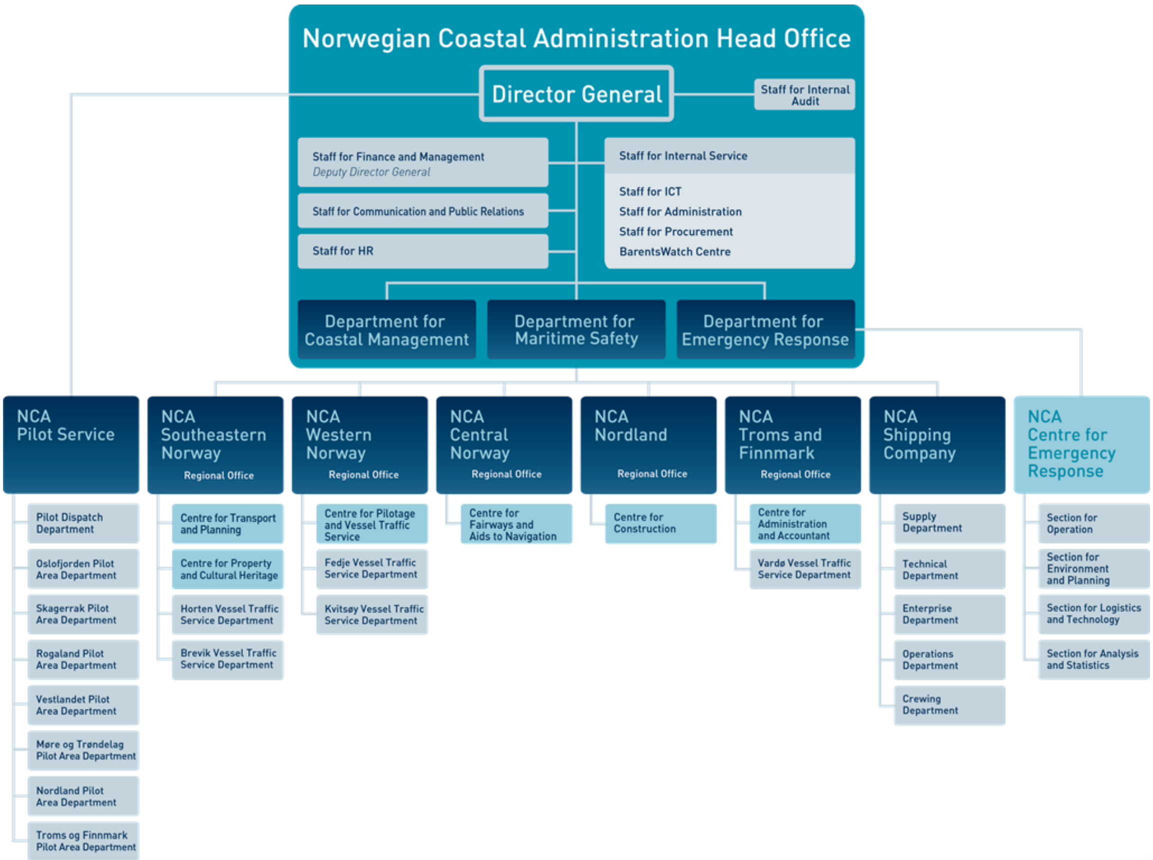


Figure 38: The NCA's organisation chart. Illustration: The NCA

1.13.2 <u>Vessel Traffic Services</u>

1.13.2.1 *General information*

The Vessel Traffic Service is an international service, which, in Norway, is operated by the NCA to improve safety at sea and protect the coastal environment. The NCA's five VTS centres monitor and organise maritime traffic 24/7 in defined service areas along the Norwegian coast. Their work is regulated by the Regulations of 23 September 2015 No 1094 relating to use of vessel traffic service areas and use of specific waters (the Maritime Traffic Regulations).

1.13.2.2 *Regulations related to communication and duty to listen*

Section 7. in the Maritime Traffic Regulations concerning Communication in the VTS area:

> *Communication between a vessel traffic service centre and a vessel must take place over the VTS centre's VHF working channels. Communication between vessels concerning passing or other coordination of voyages must take place over the VTS centres' VHF working channels. The master of the vessel or whoever is in command in his place must be able to communicate in a Scandinavian language or English if the vessel is not using a pilot. Vessels under military command may communicate with the VTS centre via mobile telephone when necessary.*

Section 11. in the Maritime Traffic Regulations concerning Duty to listen and duty of disclosure:

> *Vessels that use a VTS area have a duty to listen to the VTS centre's VHF working channels. Vessels that use a VTS area must inform the VTS centre about any matters that may be of significance to safe passage and efficient traffic flow, including that the vessel is departing from the dock or anchorage site or is making changes to its cleared sailing route.*

1.13.2.3 *The tasks of the VTS centres*

The VTS centres are tasked with the following:

- traffic monitoring with the aid of monitoring and communication systems such as radar, land-based and satellite-based AIS, VHF radios, meteorological sensors and video cameras;
- granting sailing permission to vessels before they enter the VTS area and before they leave port;
- providing information and organising maritime traffic;
- intervening to enforce the Maritime Traffic Regulations as necessary;
- monitoring and immediately contacting vessels on suspecting engine problems, incorrect course or anything else that is out of the ordinary;
- summoning, issuing orders and providing assistance to vessels as necessary;
- being part of the NCA’s first-line acute pollution response organisation.

1.13.2.4 *The services of the VTS centres*

The Vessel Traffic Service (VTS) offers three types of services, based on international regulations and recommendations[36]:

1. Information Service (INS)
   This service shall provide important information at the right time to support nautical decision-making processes on board. A vessel may request information, and the VTS centre may provide unsolicited information and request clarification from the vessel as required.

[36] http://www.kystverket.no/Maritime-tjenester/Sjotrafikkovervaking/VTS-tjenester/ [read 22 October 2019].

2. Navigation Assistance Service (NAS)
   Navigation assistance is established either on the request of the vessel or when the VTS operator observes irregular navigation and deems it necessary to intervene. The vessel and the VTS centre will agree on when the navigation assistance service starts and stops. This service entails close assistance to the vessel in question.

3. Traffic Organisation Service (TOS)
   TOS is exercised to prevent the occurrence of dangerous traffic situations and to contribute to the safe and efficient management of shipping traffic in the service areas of the VTS. The service includes operational organization and planning of ship movements and is particularly relevant when there is high traffic density. Vessels of a certain size must apply for a permit before sailing or anchoring in the service areas of the VTS and must further report before entering the VTS area or before departure from the quay or anchorage.

Appendix C contains excerpts from the instructions for these three services for Fedje VTS.

1.13.2.5 *Competence requirements for VTS operators*

To be employed as a VTS operator by the NCA, the candidate must have a maritime nautical background, including holding a Deck Officer Class 2 (D2) certificate, and have passed the Deck Officer Class 1 (D1) exams. The appointed candidates must complete various work psychology tests, conduct a common central agency training in addition to a local training at the VTS centre where they are to work. They will then be authorised to serve as VTS operators at the VTS centre in question. The VTS operators attend refresher courses and are recertified every five years.

1.13.2.6 *VTS operator training – the NCA’s training regime*

The AIBN has received documentation from the NCA, including about training and refresher courses for VTS operators. Reference is made to the NCA’s certification course for VTS operators.

The following are among the goals for the course, which also include communication training:

The candidate shall:

- *Be capable of clear, concise, correct, timely and meaningful communication through repeating, dividing up and rewording messages.*
- *Be capable of speaking clearly and accurately on a VHF radio.*
- *Be capable of using a VHF radio for emergency communication, among other things.*
- *Be capable of using message markers, information-informasjon, question-spørsmål, answer-svar, warning-advarsel, advice-råd, request- x and instruction-instruksjon. (English and Norwegian)*
- *Be capable of issuing result-oriented messages*
- *Know how to issue information to maritime traffic about the various rules that apply within a VTS area.*

Every five years, personnel from the different VTS centres attend courses in Copenhagen together with the pilots. The purpose is to gain a better understanding of each other's roles.

1.13.2.7 *Follow-up of the VTS centres*

The procedure for operation of the service (*Drift av tjenesten*), issued by the NCA's Department for Maritime Safety, sets the premises for internal reviews by each individual VTS centre. Internal reviews shall be carried out annually by each individual VTS centre, relating to, among other things, training, competence, procedures and practice. The purpose of the internal review is to identify specific improvement measures through dialogue, observation and reviewing documents and technical systems. The reviews are organised by the quality coordinator at the centre for pilotage and vessel traffic service (SLVTS).

An internal review of Fedje VTS was carried out on 18 and 19 June 2018. According to the report from the review, there was little that warranted attention concerning the observations that were made in the tower during the review. The following comments were made, however, concerning the review of the audio recording that were obtained prior to the internal review:

> *Some comments on the manner of communication. Little use of message markers. Some unnecessary use of politeness phrases. Most things are done according to the book at times, but occasionally there is too much chatter etc. One important question is how to get everybody to work as uniformly as possible and in accordance with applicable procedures and instructions.*

Among other things, the report raised the question of how it can be ensured that VTS operators act in accordance with the instructions for brief and concise communication. One measure was that the NCA should organise an e-learning programme to be completed by all VTS operators.

1.13.3 Fedje VTS

1.13.3.1 *Responsibility and guidelines*

Fedje VTS belongs to NCA Western Norway (see Figure 38). Fedje VTS is responsible for the traffic area between Marstein in the south, Sognesjøen in the north and Bergen in the east (see Figure 39). All vessels of 24 m or more must have permission from Fedje VTS before entering the service area; see the Maritime Traffic Regulations.

Figure 39: The Fedje VTS area and overview of working channels to be used for VHF radio communication. Map: The NCA

Fedje VTS has a total of 14 VTS operators working eight-hour shifts throughout the day and night. In addition, there is one VTS manager and three employees who service technical equipment and buildings.

Traffic is at all times monitored from two workstations in the control room at Fedje VTS by two VTS operators covering different parts of the VTS area. In the northern part, the main focus is on tankers crossing the fairway, and in the southern part, special attention is paid to the potential for conflicting traffic in the narrow waters at Vatlestraumen and Kobbeleia, to avoid unfavourable head-on situations. In addition, Fedje VTS has special focus on vessels requesting pilotage in the challenging waters around Marstein.

The internal instructions for traffic organisation for Fedje VTS (see Appendix C) points out that the Grimstadfjord (Haakonsvern)/Raunefjord/Vatlestraumen areas are sometimes heavily trafficked by military vessels, which often sail without AIS or VHF radio notification. The VTS operator must pay special attention to this. Fedje VTS has no further instructions or procedures for handling naval vessels.

Most of the maritime traffic being monitored and organised from Fedje VTS consists of ships in transit along the coast, ships calling on the Sture and Mongstad oil terminals and at the CCB Ågotnes and CCB Mongstad supply bases, in addition to inbound and outbound traffic from Bergen. Ships bound for and leaving Sløvåg are also monitored. Approximately 400 large crude oil tankers, 1,100 smaller product tankers and 270 gas tankers pass through the VTS area annually.

According to the NCA's solution for statistical monitoring of vessel traffic, Havbase.no, statistics are kept of the number of vessels passing defined lines along the coast. One such passing line is defined a short distance to the north of the Sture Terminal. According to the database, the number of vessel passages across this line totalled 12,579 in 2018. The records are based on active AIS transmission by the vessels. In practice, this means that the figures do not reflect all vessel traffic (many pleasure craft and other vessels of less than 24 m are, for example, not included)

1.13.3.2 *Equipment and system for monitoring maritime traffic*

There is full AIS coverage throughout the Fedje VTS area, but some areas lack radar coverage (blind zones). Fedje VTS also has two cameras – one covering Vatlestraumen and the other covering the area near the mouth of the Fensfjord and the approach to Mongstad. It does not have any cameras covering the area near the Sture Terminal where the accident occurred.

The Norwegian Coastal Administration's VTS centres use the system C-Scope as a support tool for monitoring and handling maritime traffic. C-Scope uses AIS, radar and other sensors (for example cameras and VHF direction finders) as sources of information about maritime traffic.

C-Scope is a system that integrates and processes the data transmitted from sources and sensors. The image that is generated and displayed to the VTS operators is filtered and intended to provide an overview of the traffic situation, thus alleviating their tasks and putting less pressure on the operators.

The VTS centre's operational support system (OSS) gives VTS operators access to vessel and voyage information registered in *SafeSeaNet*[37], and the system includes tools that can be used to assist the operators in emergency situations.

AIS and radar are the most important information sensors in C-Scope. Plotting/tracking can be automatic, manual or a combination of the two. A plotted target is normally not generated from a single source of information, but is a product of information from the available sensors. Information about a single vessel is often obtained from several sensors, with slightly varying time stamps. Two course/speed lines are only displayed very occasionally (when using both AIS and radar inputs) for one and the same vessel. The information will usually be unambiguous, regardless of whether the target is being tracked by one or more sensors.

[37] *SafeSeaNet* Norway is an online notification system used by the shipping companies to submit mandatory information about arrivals and departures to Norwegian authorities and ports.

For various reasons, AIS transponders may occasionally give incorrect indications of position and speed. Radar information is generally more reliable than AIS information with respect to position and course/speed. The information that users enter in AIS may also be inadequate, and misinformation can be entered intentionally or unintentionally. As a result of the C-Scope function for quality assessment and integration of information from the various input sensors, the reliability of the various plots is considered to be high.

Vessels that can only be observed on the radar display can be identified through direct communication between the vessel and the VTS. The operator can then obtain more information about the vessel on the OSS.

Since August of 2015, the monitoring system at Fedje VTS has been able to receive and display encrypted Warship AIS. The system was tested in August of 2015 and allegedly functioned properly. A test in September of 2019 did confirm that Fedje VTS could receive and display W-AIS on their monitors. The monitoring system does not differentiate between standard AIS (mode 1) and encrypted AIS (mode 3); it displays encrypted and unencrypted AIS with identical symbols.

1.13.3.3 *The VTS operator's workstation*

The traffic operators' workstation is set up with three main screens and three overview screens up above (see Figure 40). The screens are a part of C-Scope. The terminals are called C-Scope Operator Client (C-SOC). The settings on C-SOC are mainly controlled by the VTS operator, and most VTS operators have a start screen to which they log on when they go on duty. There are only slight variations between the start screens used by the different VTS operators.

The main screens normally also cover some of the area bordering on the VTS area, so any vessel notifying of its entry just before crossing the border can also be observed by the operator. The operator is able to move freely between the screen and within the area in C-SOC. The operator's screen layout was centered as normal to cover around 1-1.5 nm outside the VTS area.When 'HNoMS Helge Ingstad' notified of entering the area at 02:38, the VTS operator (Area North) did not see the vessel's radar echo on the main work screens because it was outside this area. The VTS operator saw an echo on the overview screen, which was assumed to be the naval vessel.

The AIBN understands from interviews with personnel at Fedje VTS that it can be difficult for operators to keep the total picture in view while focusing on a particular location. The VTS centres have routines to monitor the VTS areas to detect vessels sailing into the areas or leaving quay or anchorage.

Figure 40: Workstation for the VTS operator monitoring the northern part of the Fedje VTS area. The three 'main screens' are marked with a red circle. The overview screen is placed above the main screens. Photo: AIBN

1.13.4 <u>The pilotage service</u>

1.13.4.1 *General information*

The NCA is responsible for Norway's national pilotage service. By pilotage is meant guidance relating to vessels' navigation and manoeuvring. The pilotage service helps safeguard traffic at sea and protect the environment by providing vessel crews with necessary knowledge of the fairways. The service comprises around 285 pilots with local knowledge who have special training in navigating the Norwegian coastal area for which they hold a certificate.

A pilot is a person employed by the pilotage service who holds a pilot licence issued in accordance with the Act of 15 August No 61 relating to pilotage (the Pilotage Act). The Act does not entail any change of rules relating to the master's responsibility. The pilot is responsible for the pilotage. The master may surrender control of the vessel's propulsion, navigation and manoeuvring to the pilot.

1.13.4.2 *Pilotage instructions*

The purpose of the NCA's pilotage instructions (*LOS 09.04 – Utførelse av losingen*) is to ensure that pilotage assignments are carried out in a safe and efficient manner. The following is stated in section 3.1 of the instructions on 'Allocation, preparations for and execution of the assignment':

- *The pilot shall plan the pilotage assignment, in collaboration with the master and the bridge crew.*
- *Regardless of the manner in which the master or the officer in charge announces that the pilot shall be take over the control or being replaced, the pilot shall indicate this by saying, respectively: 'Pilot has the con' or 'Captain has the con'.*
- *The pilotage shall be communicated accurately so that misunderstandings do not arise.*
- *During pilotage, the pilot shall continuously monitor and check the vessel's position, heading and speed.*
- *A pilot is considered to be part of a ship's bridge team and shall help the team to cooperate and communicate optimally (good BRM).*
- *If, during a pilotage assignment, the pilot finds that the prerequisites for good BRM are not present, the pilot shall make the best of the situation in order to carry out the assignment safely. In such instances, the situation shall be reported to the head of the pilot services along with the nonconformity, so that the shipping company or shipping agent can be notified.*
- *In situations entailing a risk of personal injury, environmental damage or major material damage, the pilot may act on the principle of necessity if such harm cannot be otherwise prevented. The damage risk in the emergency action must be far less than the damage risk in the event you want to avert.*
- *The pilot shall communicate with the VTS operator in the language that has been clarified with the ship's captain / bridge crew for bridge communication.*
- *Communication with VTS operator about passing or conflicts with vessels communicating in English shall take place in English. This is to ensure that the vessels involved understand all communication so that misunderstandings do not arise.*
- *If the vessel is within an area covered by a VTS centre, the pilot may contact the VTS, which is authorised to issue orders to the ship as necessary.*

1.13.4.3 *Compulsory pilotage and pilot exemption certificates*

Compulsory pilotage is regulated by the Regulations of 17 December 2014 No 1808 on compulsory pilotage and use of pilot exemption certificates (the Compulsory Pilotage Regulations). The Regulations stipulate which vessels are subject to compulsory pilotage and the waters where the requirement applies. The general rule is that all vessels with a length of 70 metres or more are subject to compulsory pilotage when operating in waters within the baseline.

Pursuant to Sections 3 and 4 of the Compulsory Pilotage Regulations, Sola TS was subject to compulsory pilotage when heading out from the Sture Terminal and sailing through Fedjeosen. The Regulations do not apply to military vessels or other vessels under military command.

The Compulsory Pilotage Regulations permit sailing without a pilot on certain conditions stipulated in the provisions on pilot exemption certificates (PECs).

The following is retrieved from the NCA's website [translated from Norwegian] concerning pilot exemption certificates:

> *Vessels of a certain size are subject to compulsory pilotage when operating inside Norway's baseline (applies to the mainland and Svalbard). A navigator with a valid exemption certificate can often meet the requirement without using a pilot. Pilot exemption certificates are based on control by the authorities of the navigator's experience, competence and skills on a specific vessel in specific waters.*

1.13.5 Traffic from the Sture Terminal

From the AIBN's interviews with personnel at Fedje VTS, it appears that the VTS operators perceived Sola TS as departing in the normal manner from the Sture Terminal and in line with how this is often done. This is largely confirmed by data retrieved from the NCA's Havbase.no (see Figure 41). Tankers and LPG tankers arrive approximately every other day to the Sture Terminal.

There was no specific discussion at Fedje VTS on this point. The alternative would be to cross the fjord a little further and make a wider turn, but this is not seen as an option in the case of big tankers. It is also evident from the interviews that the part of the voyage from departure until the tanker passed Fedjeosen was handled by the on-board pilot, and that the VTS did not find it natural to oversee this.

It was furthermore evident from the interviews that the times at which the different pilots notify Fedje VTS of departure varies. When the pilot notifies of a vessel taking in the mooring lines, this is an indication to the VTS that the vessel will leave the quay within the next hour. There are also differences as to where the pilot is in the departure procedure when the VTS is called for the second time. Some pilots call Fedje VTS when the mooring lines have been retrieved, while others call when they have left the terminal and are about to turn.

The VTS operators have told the AIBN that, after the introduction of AIS and electronic sea charts, vessels generally operate differently from what they did before. They now take the shortest route when heading out through the fjord, as opposed to what was previously the case, when the vessels steered by light sectors and to starboard of the middle of the fairway.

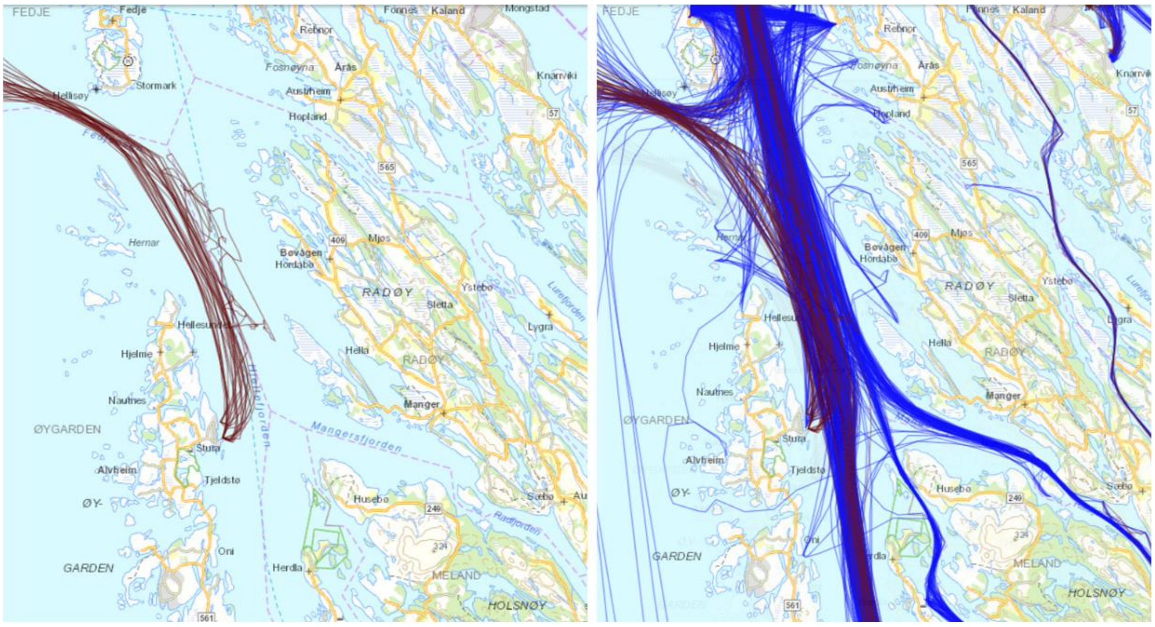


Figure 41: The chart on the left shows the routes taken by tankers of between 50,000 and 100,000 GT in November 2018. The chart on the right shows all traffic of tankers and mixed cargo vessels of all sizes during the same period. The tankers operate along the western side of the Hjeltefjord so as to minimise the length of the approach/departure passage from the Sture Terminal. Other traffic is spread across the width of the fjord, depending on vessel destinations. Map: The NCA, havbase.no

1.13.6 Communication between the VTS centre and vessels

Resolution A.918(22) IMO Standard Marine Communication Phrases (SMCP), states in A.857(20) that the phraseology used in the communication between the VTS centre and the vessel should clarify the message content and prevent misunderstandings. In any VTS message directed to a vessel, it should be made clear whether the message contains (1) *Information*, (2) *Advice*, (3) *Warning* or 4) *Instruction*.

How the communication between the VTS centre and vessels should be conducted is regulated by a procedure issued by the NCA's Department for Maritime Safety. The following is stated in section 3.1 'Communication':

> *Within the VTS area, the VTS operator will, as a rule, communicate with vessels by VHF radio, using terminology as described in 'IMO STANDARD MARINE COMMUNICATION PHRASES'. The VTS operator will communicate with the Armed Forces' vessels in public service by mobile phone when this is necessary for the vessel to complete its assignment. The VTS operator will seek to keep communication by VHF radio brief and concise.*

The procedure also includes a chapter regulating the VTS operators' use of message markers.

Concerning the language of communication, the procedures states:

> *The VTS operator communicates with vessels in the language the vessel uses for communication with the VTS. Communication with any vessel about overtaking or conflicts with vessels that communicate in English takes place in English. This is intended to ensure that the vessels involved understand all the communication and*

> *thus prevent misunderstandings. If conflicts arise between vessels that clearly communicate in different languages, the VTS operator will ensure that any necessary information, advice, warning or instruction is communicated in both Norwegian and English.*

The AIBN has been informed that there have been discussions in the NCA concerning what language the VTS centres should use. At present, the VTS operators speak Norwegian to navigators who speak a Scandinavian language and English to non-Scandinavian speakers. The VTS operators have been reluctant to use English for all communication, because the crew on smaller vessels sometimes have a limited grasp of the English language. They have held that, by communicating in English only, they will lose more in relation to navigators who speak a Scandinavian language than they will gain in relation to those who do not. When dealing with a situation that involves both those who speak a Scandinavian language and those who do not, the VTS operators follow the practice of issuing information in both languages.

1.14 Medical and personal considerations

1.14.1 Generally

The AIBN has not found that any of the personnel involved were affected by alcohol and/or other drugs/medications at the time of the accident. Nor has the investigation revealed any personal conditions or distractions that are relevant to the accident, other than aspects related to visual function and fatigue (see sections 1.14.2 and 1.14.3).

1.14.2 Examination of visual quality for the bridge crew on HNoMS Helge Ingstad

1.14.2.1 *Introduction*

The Department of Occupational Medicine (Helse Bergen health trust), has, on assignment for the AIB, performed eye tests on the seven crew members who made up the bridge team at the time of the accident. The AIBN has received a specialist report with assessment of the crew's eyesight. The report describes the methods used to test the crew's vision and the regulations under which vision is assessed (see extract in Appendix D). The Department of Occupational Medicine has been presented with photos and video recordings from the observation voyage that took place on the night leading up to 2 April 2019.

1.14.2.2 *Findings in the vision tests*

The examination and assessment of vision and the medical information the AIBN received from the Navy, gave the following findings:

- One of the bridge team members should, according to the specialist report, under the regulation on military health service and medical assessments (*Bestemmelse for militær helsetjeneste og legebedømmelse – FSAN P6*) and the instructions concerning medical requirements for the Navy (*Instruks om helsekrav for Sjøforsvaret*), be assessed as fit for service in the Armed Forces but not for service in the field or at sea.

- One bridge team member was, according to the specialist report, unfit for service in the Armed Forces under the regulations, including for sea duty and bridge duty, also unfit for service on Norwegian vessels for work requiring a certificate. The assessment in the specialist report does not correspond to the medical information from the Navy. The military doctor considered the person in question as fit for sea duty, but unfit for bridge duty. According to the Department of Occupational Medicine, the military doctor gave the wrong diagnosis of the condition. There are deviating findings in the examination, and the regulations have not been complied.

- Two of the bridge team members had, according to the specialist report, reduced to low contrast sensitivity[38], especially in twilight conditions and twilight with glare. According to the specialist report both persons were fit for service in the Armed Forces under the regulations, including for sea duty and bridge duty. The current regulations do not contain mechanisms for identifying personnel with low contrast sensitivity in the absence of predisposing factors. The Navy was not aware of the person having reduced contrast sensitivity.

- In the case of one bridge team member, the requisite report, specialist assessment and examination by a military doctor after corrective eye surgery, were not available as required by the regulations.

- Several of the reduced visual functions were unknown to both the Navy and the individuals themselves.

- The remaining three members of the bridge team had normal visual.

Furthermore, the following is cited from the specialist report by the Department of Occupational Medicine:

> *Several members of the bridge team had reduced vision, as a result of this two did not fulfil the formal requirements for bridge watchkeeping in the Navy. In the actual situation it was local light pollution involving glaring lights and negative contrasts*[39] *during parts of the sequence of events.*
>
> *Local light pollution in combination with reduced vision could mean that ordinary visual stimuli such as navigation lights and other lights were difficult to detect. It is, however, considered that bridge crew's total visual competence was sufficient for safe naval navigation in the current situation. When considered the effect of reduced vision for individuals, the function of each member and how work was organised on the bridge is essential. It is therefore not possible based on the results from the tests by the Department of Occupational Medicine alone to say anything specific about the degree to which reduced qualities of vision for the persons can be considered a contributing factor to the incident.*

[38] Contrast vision is the eye's ability to perceive different light intensity. A person with reduced contrast vision sees less than normal when the contrasts in the surroundings are reduced. There is no widely accepted first choice of standard for measurement of contrast sensitivity, and the various methods are only to a limited extent validated in relation to each other (see Appendix D). There is no minimum threshold value for contrast sensitivity in relation to approval as bridge crew.

[39] Navigation lights and other lights had lower light intensity than the deck lights, thus the threshold for object detection will increase.

1.14.3 Fatigue, sleep deprivation and circadian rhythm

Appendix B describes theory relating to fatigue, sleep deprivation and circadian rhythm.

1.15 Special investigations

1.15.1 Analysis of data from the navigation system

1.15.1.1 *Introduction*

The Navy's internal investigation team has analysed the data from the navigation system and IPMS for HNoMS Helge Ingstad as of 8 November 2018. The analysis considered objective findings and related professional assessments.

1.15.1.2 *The headings of HNoMS Helge Ingstad*

Based on information from the navigation system, the graph in Figure 42 shows the headings of HNoMS Helge Ingstad in the period from 03:58:06 to 04:01:36.

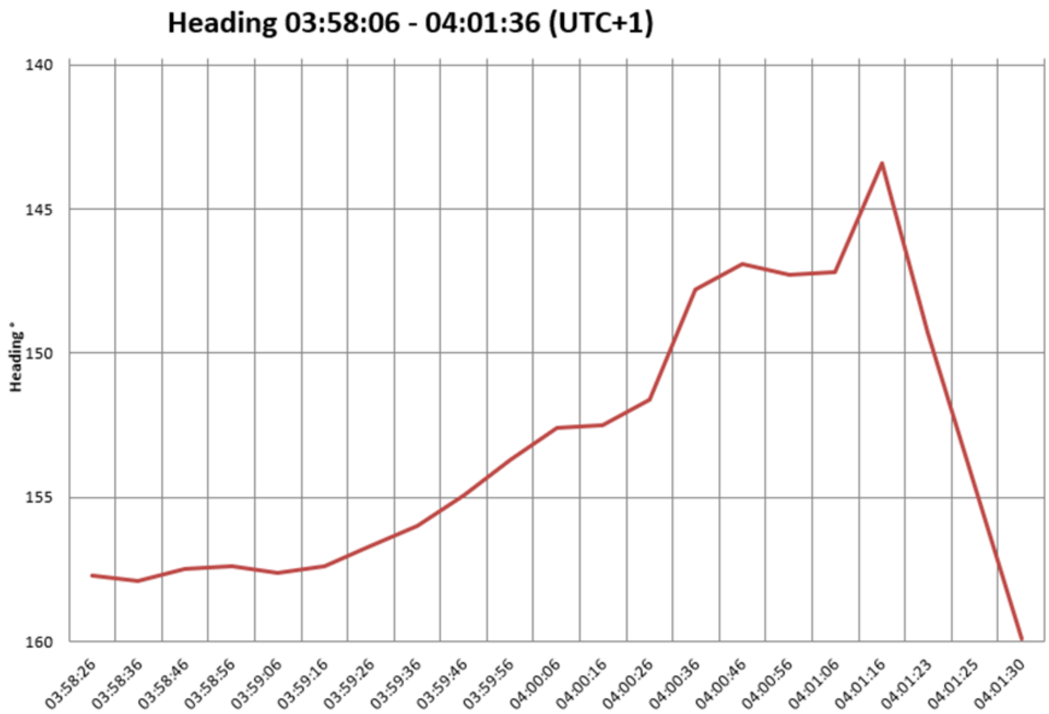


Figure 42: The headings of HNoMS Helge Ingstad in the period from 03:58:06 to 04:01:36. Illustration: AIBN

1.15.1.3 *Summary of navigation data*

Main analysis findings relating to the sequence of events prior to the collision:

> - *There is no evidence of there having been any fault or defect in the navigation system or connected sensors with the exception of occasional faults in GPS 2 that had consequences for active AIS transmission* [after the collision]
>
> - *The navigation system settings were in accordance with the standard for Fridtjof Nansen-class frigates. It is therefore highly probable that Sola TS and Tenax were visible as AIS contacts on all MFDs on the bridge.*

- Sola TS and Tenax were not tracked by radar and/or AIS, and did not therefore generate any alarm for 'Collision Danger' or 'Proximity Violation'

- It is highly probable that Sola TS could be seen on the radar, given that Dr. No, Seigrunn, Vestbris and Silver Firda were tracked and generated alarms.

- HNoMS Helge Ingstad did not reduce her speed before the collision

- Data from IPMS show that, at 04:01:17, the starboard and port rudders on the steering console were both approximately 30 degrees to port of zero degrees. The actual rudder angle was 10° on both rudders. It is therefore highly probable that full rudder to port[40] was ordered immediately prior to the collision.

1.15.2 Reconstruction of information shown on the navigation console displays on HNoMS Helge Ingstad

1.15.2.1 *Introduction*

The Navy's internal investigation team has made a reconstruction of what was shown on the displays on the different navigation consoles (MFD 1–3) on HNoMS Helge Ingstad on 8 November 2018. The reconstruction is based on the log files from HNoMS Helge Ingstad showing a reference position every time the chart section on the ECDIS (MFD 3) is moved away from the vessel (Browse) or the centre of the radar image is moved on MFD 1 and MFD 2 (offset/off-centred).

The log files from HNoMS Helge Ingstad do not give information about radar tuning, i.e. which settings were chosen in order to minimize noise, gain or any other functions in use. Furthermore, it is not possible to recreate the magnitude of the radar echo from Sola TS or whether there were trails on the echoes.

The reconstructed displays do not provide exact replicas of what was shown on board HNoMS Helge Ingstad. According to the Navy's internal investigation team, they can be deemed to have an accuracy of 0.1–0.2 nm (185–370 m) depending on the chart/radar range scale.

1.15.2.2 *Settings on MFD 1 and MFD 2 during the voyage*

Table 4 and Table 5 show the settings on the OOW's radar display (MFD 1) and the OOWA's radar display (MFD 2), respectively. Note that the orientation and presentation mode on both radars were constantly in North UP/True Motion (NUP/TM)[41].

[40] This does not tally with the information the AIBN received through interviews with the bridge crew.
[41] From the radar manual: *North Up (NUP): The orientation of the screen becomes northwards. The direction of the heading line changes during manoeuvres. TM (True Motion): In true motion, the own-ship symbol moves across the Radar picture while the picture remains fixed.*

Table 4: Settings on the OOW's radar display (MFD 1 = X-band radar)

From (time):	Radar range scale:	Chart scale:
02:52:26.	6 nm	1:77293
03:03:04.	3 nm	1:38646
03:21:48.	6 nm	1:77293
03:21:51.	3 nm	1:38646
03:36:49.	6 nm	1:77293
03:37:01.	3 nm	1:38646
03:46:58.	6 nm	1:77293
03:47:01.	12 nm	1:154586
03:47:26.	6 nm	1:77293
03:47:59.	3 nm	1:38646
03:50:16.	6 nm	1:77293
03:50:28.	3 nm	1:38646
03:55:04.	6 nm	1:77293
03:55:16.	3 nm	1:38646
03:59:00.	1.5 nm	1:19323

Table 5: Settings on the OOWA's radar display (MFD 2, S-band radar)

From (time):	Radar range scale:	Chart scale:
02:50:50.	6 nm	1:77293
03:57:44.	3 nm	1:38646

1.15.2.3 *Optical bearings during the voyage*

The MFD 3 display (ECDIS/chart display) was in Browse mode up until the time of the collision. On this display, optical bearings are used to check the vessel's position. Data from the bridge console indicated that optical bearings were taken several times between 03:30 and 04:00 on 8 November 2018:

At 03:38:40 Position Line, Onglesundet light in bearing 125.0°
At 03:42:17 Position Line, Onglesundet light in bearing 108.5°
At 03:44:19 Position Line, Onglesundet light in bearing 094.0°
At 03:44:59 Position Line, Flesi light in bearing 146.5°
At 03:46:10 Position Line, Flesi light in bearing 117.7°
At 03:46:58 Position Line, Onglesundet light in bearing 070.6°
At 03:53:13 Position Line, Flesi light in bearing 084.4°
At 03:55:42 Position Line, Ådneset light in bearing 182.0°

When optical bearings are to be used to find the vessel's position, a work sequence is started during which the OOW and the OOWA work together. On this particular voyage, the OOWT and the OOWAT worked on this together. The sequence starts with the OOW/OOWT deciding which objects to take bearings of and communicating this to the OOWA and the OOWAT. The OOWA/OOWAT finds these objects in ECDIS, opens the 'Position Line' dialogue box on the display and scales the chart as necessary. If the OOWA/OOWAT has problems finding the objects on the chart, the OOW/OOWT can explain or point out where the object is on the chart.

The OOW/OOWT takes bearings of the objects with the optical pelorus, and announces the bearings in three digits, which are then entered in the 'Position Line' dialogue box by the OOWA/OOWAT. This part of the sequence is repeated for each object.

The bearing lines of each object are presented on the ECDIS display, and the vessel's position is in the intersection between the lines. The OOWA/OOWAT then informs the OOW/OOWT of whether the vessel's position is to starboard or port of the planned route. The OOW/OOWT assesses the vessel's position and whether it is necessary to correct the course to revert to the planned route.

If the OOW/OOWT is uncertain of the accuracy of the positioning, or whether it was done correctly, the work sequence is restarted. That is why data from MFD 3 show that bearings were taken of the same object several times within a short time interval.

During the positioning process, the OOW/OOWT will focus on what is going on outside the vessel and on the use of the pelorus, while the OOWA/OOWAT will focus on the ECDIS display.

1.15.2.4 *Summary of reconstruction*

The following is reproduced from the Navy's summary of the findings made during the reconstruction:

> *The reconstructed displays indicated that the scaling and offsetting of X-band and S-band radars were in accordance with normal practice. The investigation team has no information to indicate that there were any technical problems with the radar or AIS. It is therefore natural to assume that that Sola TS was visible on the radars.*
>
> *It is normal practice to choose presentation of AIS targets on both the radar and ECDIS displays. Since data from the navigation system do not indicate whether this was the case, AIS targets were not plotted on the reconstructed displays.*[42]
>
> *It is also normal for ECDIS to be set to BROWSE mode when looking for objects to take optical bearings of, checking sounding depths etc. Note that route monitoring continues in the background on MFD 3 even if the chart shown on the display is off centre in relation to the vessel's position. The route was also monitored on both radars.*

1.15.3 Observation voyage

1.15.3.1 *Introduction*

In order to get a better picture of the situation as it might have been perceived by the bridge team on HNoMS Helge Ingstad, a voyage was conducted on 2 April 2019 with the frigate HNoMS Roald Amundsen at the same time as Sola TS left the Sture Terminal, under conditions that were as similar as possible to the night leading up to 8 November 2018. The voyage covered the period from when Sola TS started manoeuvring until shortly before the collision. A set of positions that the two vessels were to occupy at

[42] It has not been possible to reconstruct the AIS targets plotted on MFD 1–3 during the voyage, because this information is not stored in the navigation system, but, in accordance with the functions (default settings) described in the supplier's manuals, all vessels with AIS transmission that are within range will be represented by symbols on the radar and ECDIS displays.

given times, had been agreed in advance. The purpose was to ensure that course/speed, bearings and distances between the two vessels would resemble the sequence of events on 8 November as much as possible.

1.15.3.2 *The voyage*

The wind was slightly stronger and more than on the night of the accident. It was also a cloudy day, but the light and visibility conditions were deemed to be relatively similar to those on the night of the accident (see Appendix A).

During the southbound voyage from Fedje towards the Sture Terminal, the bearing of Sola TS relative to the heading of HNoMS Roald Amundsen was gradually reduced from 161.4° to 159.0°. On the night of the accident, the bearing of Sola TS relative to the heading of HNoMS Helge Ingstad was gradually reduced from 162.7° to 160.8°.

Because of the prevailing wind conditions on the observation voyage during the night leading up to 2 April 2019, Sola TS set a more northerly course sooner than it did on the night of the accident.

Video recordings were also made from the bridge of HNoMS Roald Amundsen and Sola TS to document what things might have looked like on the night of the accident. The observers on the bridge of HNoMS Roald Amundsen had two sets of binoculars available, identical to those that were available on HNoMS Helge Ingstad during the night of the accident. An observer from the AIBN was also present on board Sola TS during the voyage.

Appendix F shows images from the observation voyage based on video recordings made from the bridge on HNoMS Helge Ingstad by the police.

1.15.3.3 *Observations made during the voyage*

When Sola TS lay alongside with all deck lights switched on (including those that pointed aft), the vessel’s lights were distinct from the terminal lights. The vessel’s deck lights had a more yellow glow than the terminal’s lights. The terminal’s lights were perceived as having less luminous intensity and a whiter hue than the vessel’s deck lights. Without knowing what you were looking for, it was difficult to ascertain that the lights came from a vessel.

Without the use of binoculars, the vessel became one with the terminal’s lights when the crew on Sola TS switched on the aft-pointing deck lights. With the aid of the Navy’s binoculars, it was nonetheless possible to discern a vessel alongside when conducting an active search among the lights.

When Sola TS started to turn her bow seawards from the quay, this was done so slowly that it was difficult to see any movement from the frigate’s position. The lights exhibited by the vessel were also not visible to the naked eye. Other lights on the vessel appeared to be an extension of the terminal’s lights and of similar hue (light/yellow/white). It was not possible to spot the forward-pointing yellow deck lights to start with. Only with the aid of binoculars and being conscious of what one was looking for, was it possible to perceive this as a vessel. During one period, the lights from the escorting boat could be observed between the stern of Sola TS and the quay at the Sture Terminal. When the vessel had moved away from the quay, it was no longer observed as an extension of the quay and the background lighting.

As Sola TS turned her bow northwards and in the direction of the observers on the frigate's bridge, the yellow deck lights became visible. As Sola TS continued to turn and establish a northerly course (opposite course to HNoMS Roald Amundsen), the forward-pointing deck lights gave off more light and finally became very sharp and clearly observable from HNoMS Roald Amundsen.

For observers on the frigate bridge it was almost tempting to 'hide the deck lights from Sola TS' behind one of the window bars so as not to be dazzled. The lights from the tanker gave the impression of something square-shaped. As the vessels drew closer to each other, the lights appeared to increase in intensity, but it was difficult to estimate the distance or ascertain what was behind the lights.

Estimating the distance was challenging because of the lack of reference points within the field of vision. When HNoMS Roald Amundsen broke the voyage approximately1 nm from Sola TS and the vessels passed each other port to port, the contours of the tanker started to appear when the observers were no longer dazzled by the floodlights. If observed from the side or from any angle abaft of midship, Sola TS was quite visible.

During the observation voyage, the side lights of the tanker could be distinguished through the binoculars; especially if you knew what you were looking for. The observers had slightly varying opinions on this point. Some were able to see the three all-round red lights and the flashing red light on Sola TS through the binoculars.

When the vessels were getting closer to each other and Sola TS signalled with the Aldis lamp, the flashes could only just be discerned between the yellow deck lights without the aid of binoculars, but this required looking straight into the strong yellow lights. Through the binoculars, the Aldis lamp could be seen more easily.

As Sola TS moved further away from the Sture Terminal and the 'effect' of the forward-pointing deck lights increased, the vessel stood more and more out as a separate object that was unrelated to the Sture Terminal. The distance between Sola TS (with strong yellow deck lights) and the Sture Terminal became considerable and could be more easily observed as the two vessels came closer to each other. The strong yellow deck lights from Sola TS became clear and could easily be seen from all positions on the bridge of HNoMS Roald Amundsen.

1.15.4 Simulation of last chance for anti-collision manoeuvre

The AIBN has been provided with information about the manoeuvring characteristics of HNoMS Helge Ingstad and Sola TS in relation to the vessels' engine configuration and speed during the time leading up to the collision.

HNoMS Helge Ingstad was significantly more manoeuvrable than Sola TS, and the AIBN therefore requested an opinion/simulation from Safetec Nordic AS of the potential effect on the sequence of events of a 'crash-stop' and full-rudder-to-starboard manoeuvre, respectively, on the part of HNoMS Helge Ingstad. The purpose of the assessment was to identify the 'point of no return', that is the last chance to make a manoeuvre to avoid the collision.

The simulation has shown that a crash-stop manoeuvre on the part of HNoMS Helge Ingstad must have been carried out approximately 68 seconds before the collision when there was a distance of approximately 750 m between the vessels.

Had a manoeuvre as shown in Figure 43 with full-rudder-to-starboard on the part of HNoMS Helge Ingstad, been carried out when 38 seconds remained before the collision and the distance between the vessels was approximately 375 m, the collision could have been avoided, but the CPA would have been 0–25 m.

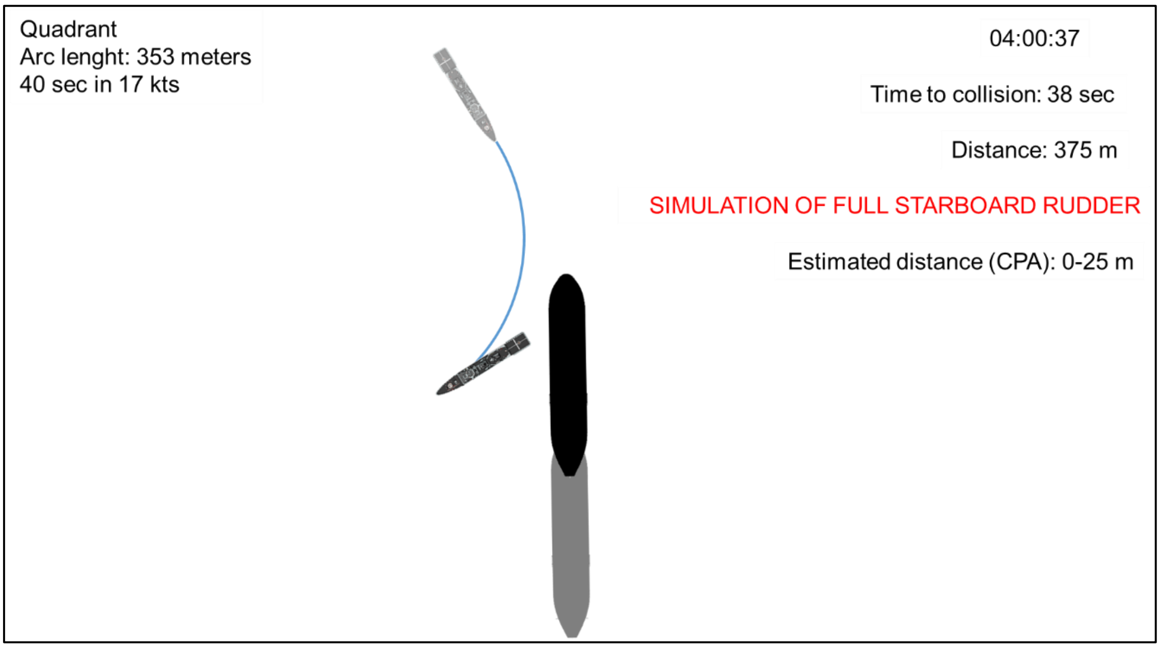


Figure 43: Had HNoMS Helge Ingstad made a manoeuvre to starboard 38 seconds before the collision, the collision would probably have been avoided. The vessels would then have passed each other port to port with a CPA of approximately 0 - 25 m. Illustration: Safetec/AIBN

1.15.5 Use of external consultants

In addition to the simulation in 1.15.4, the AIBN commissioned Safetec Nordic AS, among others, to review and evaluate the functionality and use of the navigation equipment on HNoMS Helge Ingstad.

The AIBN also commissioned the consultants Hærem, Andersen and Kost to map theoretical perspectives so as to be able to understand what cognitive and organisational challenges a navigation team is faced with. Their report (see Appendix G) considers different forms of common perceptual and cognitive limitations, how these can interact in a bridge team, and how this can be identified and dealt with.

1.15.6 DNV GL – Mapping of the safety culture in the Fleet and in the Navy's executive staff

As part of the Armed Forces' internal investigation of the accident involving HNoMS Helge Ingstad, DNV GL was commissioned by the Norwegian Defence Logistics Organisation (NDLO) to conduct a survey of the safety culture in the Fleet and among the Navy's executive staff. The survey was initiated to be able to understand and describe the safety culture of the Fleet in general and among the Navy's executive staff, regardless of the specific circumstances under which the accident occurred. DNV GL's survey of the safety culture consisted of questionnaires (a total of approx. 500 respondents) and interviews (a total of 160 interviews).

Based on the questionnaire survey, DNV GL identified nine fundamental assumptions that express the prevailing culture in the Fleet/Navy. These assumptions can reflect strengths in the culture, but also challenges. In total, DNV GL identified 17 challenges relating to competence and manning, cooperation and involvement, alertness, conflicting goals, incentives, compliance, robustness and organisation learning. The findings are described in Appendix E.

1.16 Other information

1.16.1 The BRM concept

Bridge Resource Management (BRM) is a maritime adaptation of the aviation concept Crew Resource Management (CRM). BRM is used to describe important principles for optimum utilisation of available resources (human and technological) to ensure a safe voyage. Important principles include teamwork, communication, leadership, decision-making and resource allocation, as well as how tasks are performed and affected by factors like stress, attitudes and understanding of risk. The BRM principles apply to the preparation and planning of the voyage, the voyage itself and the evaluation of the voyage on arriving at the destination (Wahl & Kongsvik, 2018, Swift, 2004 and Adams, 2006).

The main objective of a well-functioning bridge team is to ensure that individual team members' undesirable actions or inaction are registered by the team, so that the team can take necessary action to maintain control of the vessel. This reduces the risk of exposing the vessel and crew to danger. IMO has made BRM training a formal requirement for navigation officers on the bridge and in the engine room (IMO, 2011).

1.16.2 COLREGs

The Regulations of 12 January 1975 No 5 for preventing collisions at sea (COLREGs), are international rules that apply to all vessels. In addition to the requirements mentioned in section 1.9.5 relating to the use of lights, the COLREGs also contain provisions on keeping a lookout, safe speed, collision danger and collision avoidance manoeuvres.

1.16.3 Previous accidents involving pilots

1.16.3.1 *Grounding of 'Federal Kivalina' at Årsundøya on 6 October 2008*

The AIBN's investigation into the grounding of 'Federal Kivalina' (Report Marine 2010/01) revealed that the ship's bridge crew were not sufficiently prepared for the five-hour voyage from the pilot boarding place to the quay, and that the bridge team and pilot did not function together as intended. The ship's bridge crew and pilot had not deemed it necessary to work as a bridge team, and the pilotage service had also not stipulated sufficient requirements for the pilot to act as part of the bridge team. In practice, there was just one person, the pilot, who performed active navigation, and no one checked the voyage after having arrived at the pilot boarding place. The bridge crew paid less attention to the navigation of the ship after the pilot's arrival.

1.16.3.2 *Grounding of 'Crete Cement' in the Oslofjord on 19 November 2008*

In the AIBN's investigation of the grounding of 'Crete Cement' (Report Marine 2010/04), it was found that barriers that should have been in place when the pilot did not change course in time, were weak or absent. The navigation officer on watch was required to deal with other tasks that distracted him from navigational tasks, and no additional bridge resources were mobilised for the passage through the narrow fairway. During the voyage, communication between the pilot and the navigation officer on watch was limited to practical issues and the details of the passage were not discussed.

1.17 Implemented measures

1.17.1 The Navy

The Navy has conducted its own investigation of the accident. The report was not completed at the time this preliminary report was published. The AIBN has received information about measures taken by the Navy after the accident (see Appendix H).

In addition to the measures implemented as described in Appendix H, the AIBN has received information about the following:

- The Navy has developed a BRM training programme adapted to frigate bridge teams. Three frigate crews have completed the programme in connection with sea training.

- The Navy has established a dedicated CRM instructor course in cooperation with the US Navy. The course is intended for seagoing personnel on the Navy's vessels for the purpose of raising CRM competence on board. This will allow the vessels to conduct dedicated CRM training of its teams. The first CRM instructor course was held in March 2019.

- The Navy is in the process of establishing a working group tasked with evaluating, and if applicable, revising the instructions concerning medical requirements for the Navy (*Instruks om helsekrav i Sjøforsvaret*), including eyesight requirements by summer 2020.

- The organisation as a whole is reviewing and improving the system to ensure that personnel on the Navy's vessels are fit for service in their respective functions.

1.17.2 Tsakos Columbia Shipmanagement S.A.

The AIBN has received information on the measures the company has taken following its initial investigation of the accident. As implemented measures, the company points out the following:

- *Notified all vessels in our fleet operating in the Sture region as follows*:

    - *To exercise extra caution when ordered to the Sture due to potential fast moving military craft operating in the region which may not be transmitting AIS signals or maintaining a proper lookout*

- *A reminder to all crew to contact VTS prior to arrival and departure from the Sture terminal to establish if there are any reported or unidentified vessels in the area*

- *Exercise caution in reliance on VTS in the region for the purpose of monitoring and safe navigation, until there has been an enquiry into the actions of VTS in relation to this incident and corrective actions implemented by VTS*

- *The shipping company has participated in a full reconstruction of the incident using a sister Navy frigate and the Sola TS to confirm that the navigation lights of Sola TS remained visible at adequate/sufficient distance with the Sola TS deck lights on and that the Sola TS was clearly visible and identifiable as a vessel distinct from the lighting arrangement of the Sture terminal.*

- *The shipping company has used the data from the VDR for training purposes*.

In addition to the above-mentioned points, the shipping company conducted a review of the use of deck lights on the Sola TS in light of this incident and on other vessels in their fleet during departure and arrival operations at night, concluding that:
Sola TS use of deck lights during the incident was appropriate and in accordance with industry best practice in order to ensure the safety of the crew working on the deck.

The shipping company also concludes that the use of deck lights is not considered to have contributed to the incident given the two ships' positions relative to each other and to the terminal.

1.17.3 The NCA

The Norwegian Coastal Administration has conducted its own investigation of the accident. The report was not completed at the time this preliminary report was published.

The Norwegian Coastal Administration's (NCA) internal report on the Vessel Traffic Service (VTS) identified the following measures:

1.17.3.1 *(A) Guidelines for voyages with the Armed Forces' vessels in VTS areas*

It is sometimes necessary to operate the Armed Forces' vessels without transmitting AIS information and without the vessels identifying themselves on the VTS centres' working channels. Because the VTS centres' monitoring is largely based on AIS and because full radar coverage is not available in the VTS areas, more detailed guidelines need to be drawn up for voyages with the Armed Force' vessels in the VTS areas.

The NCA and the Navy have started on this work together.

1.17.3.2 *(B) Testing of functionality for automatic plotting of vessels not transmitting AIS information*

The VTS centres' monitoring is largely based on AIS. Functionality for automatic plotting of vessels is needed in cases where vessels do not transmit AIS information. The radar system's existing functionality has previously been tested locally by a VTS centre, and the conclusion was that the functionality was not sufficiently adapted for operational use. On this basis, tests and analyses need to be conducted in order to identify how this functionality can be improved and adapted to the VTS centres' monitoring tasks and the respective VTS areas' geography and weather conditions.

The NCA has initiated controlled testing of this functionality in cooperation with the equipment supplier.

1.17.3.3 *(C) Improvement of functionality for dead reckoning*

The VTS centres' monitoring system includes functionality for dead reckoning a vessel's onward voyage in cases where sensor data from radar and AIS are not available. Operational use of the system has shown that this functionality needs to be further developed before it can be used in the VTS centres' operational monitoring.

The NCA is in dialogue with the equipment supplier on improvement of this functionality.

1.17.3.4 *(D) Criteria for safe passing distance*

The VTS areas consist of narrow and open fairways and are used by a number of different types of vessel. In order to ensure that sufficient margins have been established in the different VTS areas to avoid undesirable proximity situations, the VTS centres started a review in spring 2018 of criteria for safe passing distance. The purpose was to assess whether the criteria take sufficient account of different vessel types and fairways.

The revised criteria are to be described in internal quality documents before the end of 2019.

1.17.3.5 *(E) Criteria for information in connection with voyages involving tankers and other large vessels*

In connection with the work on revising criteria for safe passing distances between vessels, an assessment will also be carried out of the need for revising or drawing up more specific criteria and procedures for information in connection with voyages involving tankers and other large vessels. The purpose is to ensure that all vessels have the same situational awareness in connection with voyages that may require special considerations by vessels.

1.17.3.6 *(F) Requirement for use of English in the VTS areas*

The Maritime Traffic Regulations set out as a requirement that the ship's master or the officer of the watch as the master's deputy must be able to communicate in a Scandinavian language or in English, if the vessel is not under pilotage. The existing arrangement whereby communication is done in either Scandinavian languages or English, increases the likelihood of the information being issued in a language that is not understood by all the navigators involved. Experience from the VTS centres suggests that consideration should be given to requiring that all communication in the VTS areas is done in English.

The NCA will propose an amendment of the language provision in connection with the next revision of the Maritime Traffic Regulations. This must be seen in the context of the international guidelines for the VTS centres' VHF communication which will be established in 2020.

1.17.3.7 *(G) Strengthening of local training*

In recent years, the NCA has strengthened central courses and training in the Vessel Traffic Service and introduced requirements for VTS operators to undergo simulator training at least twice every five years. A requirement has also been introduced for annual testing of VTS operators in connection with local authorisation. For the purpose of further improving training, follow-up and testing of VTS operators, the NCA intends to strengthen local training resources at the VTS centres, including by reviewing the structure of local training and follow-up of VTS operators.

During the period January to April 2019, all personnel responsible for local training at the VTS centres have undergone instructor training.

2. ANALYSIS

2.1 Introduction

2.1.1 Investigation methods and structure of the analysis

The accident and circumstances surrounding it were investigated and analysed in line with the AIBN's framework and analysis process for systematic safety investigations (the AIBN method). The sequence of events, from the time that HNoMS Helge Ingstad notified Fedje VTS of entering the VTS area until the accident occurred, was mapped using a sequential presentation in a STEP[43] diagram.

A key question in the investigation has been how and why it was possible for the two vessels HNoMS Helge Ingstad and Sola TS to collide outside an oil terminal in an area monitored by a VTS centre. Based on the information that was available immediately after the accident, the crew and pilot on Sola TS had seen HNoMS Helge Ingstad and tried to warn of the danger and prevent a collision. Despite this, the crew on HNoMS Helge Ingstad had not realised that they were on collision course until it was too late. It was also possible for the VTS centre, Fedje VTS, to influence the situation through traffic monitoring, information service and traffic organisation.

The analysis in section 2.2 starts with a review and assessment of the sequence of events from the perspective of the three parties that were directly involved (HNoMS Helge Ingstad, Sola TS and Fedje VTS), with special focus on the operational and technical factors that led to each of them being unable to prevent the collision.

Based on its assessment of the sequence of events, the AIBN has investigated and analysed each of the three parties' role in and contribution to the situation that arose. The purpose of the investigation and the analysis has been to ascertain why the accident occurred, to identify systemic safety problems[44] and to report on how safety can be improved.

2.1.2 Assumptions and reservations relating to the analysis

2.1.2.1 *Lack of VDR data for HNoMS Helge Ingstad*

There was no VDR on board HNoMS Helge Ingstad, which means that no recording is available of the communication that took place between the bridge team members on HNoMS Helge Ingstad. The AIBN therefore points out that the part of the sequence of events that concerns HNoMS Helge Ingstad is based on a combination of what emerged in interviews with the personnel involved and data from the frigate's navigation system, VDR data from Sola TS and recordings of radio communication.

The AIBN's assessment concerning VDR coincides with the Armed Forces' own conclusion in its investigation of a previous accident (2013) involving a naval vessel (see section 1.11.10). Had VDR data from HNoMS Helge Ingstad been available, the AIBN would have had access to unique data to document the sequence of events more exactly,

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[43] STEP – Sequentially timed events plotting.

[44] A systemic safety problem can be described as the investigation's most important finding with a bearing on safety. It constitutes a risk factor that the organisation or authorities have some degree of control over and responsibility for, and which will increase the risk of accidents in the future unless it is dealt with.

and to better understand the situation on board the frigate. The absence of VDR data did not contribute to the accident, but it is a factor of such great importance to safety that the AIBN issues a safety recommendation to the Navy.

2.1.2.2 *Limitations of interviews*

Information obtained through interviews will necessarily reflect human limitations, particularly as regards our sensory and memory capacity. People also do not fully perceive their surroundings all the time, nor do they remember all they have seen, heard and understood. Interviews are conducted within a limited time period, and sometimes this can also limit the transfer of information. Furthermore, as time passes, our memory is affected by who we are and the situation we find ourselves in. The AIBN takes account of these involuntary limitations of interviewees, and seeks to interview the people involved and witnesses as soon as possible after the incident, in addition to using data from different types of sources to confirm or refute information that is based on human memory.

2.1.2.3 *Evaluation of the observation voyage*

The observation voyage conducted on board Sola TS and HNoMS Roald Amundsen during the night leading up to 2 April 2019 (see section 1.15.3) was an important contribution to the AIBN's description and understanding of the sequence of events leading up to the accident.

It is important to keep in mind that night vision and contrast sensitivity may vary from one individual to the next. The background, training and experience of the observers varied. They also knew what they were looking for. The quality of the images from the observation voyage can also result in different and subjective perceptions of the material being studied.

On the observation voyage, the sky was overcast, humidity was high, and the wind was strong (moderate gale). The wind blew humidity from the air and smoke from the funnel on Sola TS forward and downwards, across the tanker's bridge and onto the floodlights. Light refraction in the humid air and smoke from the funnel, combined with light reflection from the cloud cover, may have meant that Sola TS and the surroundings (the Sture Terminal and the sea's surface) were seen in a slightly different light than during the night of the accident.

The manoeuvring performed when leaving the quay and the wind conditions caused Sola TS to turn towards a northerly course more quickly than the night of the accident (see Figure 44). This meant that Sola TS was a little closer to HNoMS Roald Amundsen than planned throughout the observation voyage. The time at which the forward-pointing deck lights on Sola TS started to stand out more clearly when viewed from HNoMS Roald Amundsen was probably earlier in the sequence of events than on the accident voyage.

With the exception that Sola TS turned more rapidly to a northerly course, the vessel followed the same route as on 8 November 2018. HNoMS Roald Amundsen also followed the same route as HNoMS Helge Ingstad had taken in the early hours of 8 November. During the accident voyage and the observation voyage, the bearings of Sola TS taken from the frigate were relatively stable and relatively similar. The bearings changed by approximately 2 degrees in the course of 7–8 minutes of the voyage.

On the observation voyage, the vessels did not come close enough to each other to enable observations of what the view from the frigate may have been shortly before the collision.

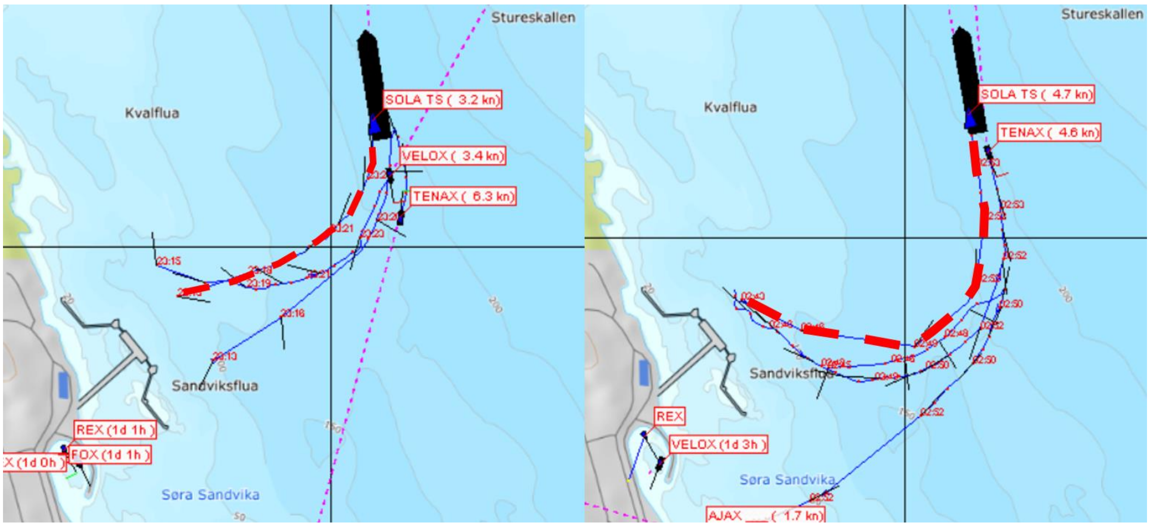

Figure 44: Left: Sola TS manoeuvring out from the quay on the observation voyage. Right: Sola TS manoeuvring out from key the night of the accident. Source: NCA/AIBN

Despite the above-mentioned differences between the two voyages, the AIBN is of the opinion that the observations made in the early hours of 2 April 2019 were representative and applicable to the analysis part of the investigation.

Nonetheless, the experience gained during the observation voyage cannot be directly transferred to the situation on board HNoMS Helge Ingstad prior to the accident. Since the frigate’s bridge team had not identified Sola TS as a moving object, the ‘object’ was not subject to the same concentrated observation by the bridge team as by the observers on the observation voyage. None of people involved in the accident were present during the observation voyage, and they could thus not confirm to what degree the voyage was representative of the conditions during the night of the accident.

2.2 Assessment of the sequence of events

2.2.1 Introduction

A discussion follows below of the sequence of events from the perspective of the three players (HNoMS Helge Ingstad, Sola TS and Fedje VTS), and of the factors that contributed to each of them being unable to prevent the collision.

2.2.2 From the perspective of HNoMS Helge Ingstad

2.2.2.1 *Introduction*

Navigation training was carried out as usual during transit voyages (this is discussed further in section 2.3.3.3). The OOWT, who had been on watch since 02:24, had navigated the frigate from Sognesjøen and was to continue to navigate until they reached the southern end of the Hjeltefjord. The passage through the Hjeltefjord was not considered particularly demanding, as the fairway is open and offers a good view all around. The OOW monitored and controlled the voyage and reported the vessel and voyage plan to Fedje VTS. The frigate followed the reported voyage plan on the onward voyage.

2.2.2.2 *03:36–03:53*

Sola TS started manoeuvring out from the quay at 03:36, exhibiting navigation lights and with some of the deck lights turned on to light up the deck for the crew who were securing equipment etc. for the passage (see section 1.10.4 and 1.10.5). Figure 45 shows what the situation looked like on the observation voyage when Sola TS started to manoeuvre out from the quay.

Figure 45: Screenshot of video recording on the bridge of 'HNoMS Roald Amundsen' on the observation voyage in the early hours of 2 April 2019, when Sola TS started to manoeuvre out from the quay. This corresponds approximately to the situation at 03:36 on the night of the accident. Sola TS marked with yellow circle. Photo: The police

Until 03:45, all the forward-pointing deck lights were on. At 03:45, the lights in the midship masts were turned off. After that time, the deck lights just under the bridge deck and the lights in the foremast remained on Sola TS. The use of deck lights by Sola TS is discussed further in section 2.4.3.

In daylight, you can see that a vessel is moving in that its position shifts relative to the shore. Waves from the bow and stern and smoke from the funnel are all observable indications that a vessel is moving. In contrast to the well of information that is available to the navigator in daylight, a vessel's movements at night must largely be ascertained by observing the vessel's navigation lights or that the vessel has changed position.

On the observation voyage, the initial manoeuvring out from the quay took place so slowly that no movement could be observed. It was very difficult to observe the vessel against the background lights from the terminal, unless binoculars were used and you knew what you were looking for. The lights from the vessel appeared to be an extension of the lights from the terminal. Figure 46 shows what the situation looked like on the observation voyage as Sola TS was moving away from the quay.

Figure 46: Screenshot of video recording on the bridge of HNoMS Roald Amundsen on the observation voyage in the early hours of 2 April 2019, seven minutes after Sola TS started to manoeuvre out from the quay. This corresponds approximately to the situation at 03:43 on the night of the accident, at which time Sola TS had a more southerly course, however. Sola TS marked with yellow circle. Photo: The police.

On the observation voyage, Sola TS only stood out clearly as she turned her bow northwards towards Fedjeosen, so that the forward-pointing yellow deck lights became visible (see Figure 47). It was difficult, even through binoculars, to discern the vessel's navigation lights due to the deck lighting. It was probably during this period that the relieving OOW and the OOW being relieved on HNoMS Helge Ingstad were discussing traffic in the fairway. This was when they observed an object giving off masses of light to starboard of the frigate's course line, located alongside or near the Sture Terminal. The 'object' was observed both visually and on the radar display in the form of a radar echo and AIS symbol.

Figure 47: Screenshot of video recording on the bridge of HNoMS Roald Amundsen on the observation voyage in the early hours of 2 April 2019, when Sola TS had turned to a north-northeasterly course (035°). This corresponds approximately to the situation at 03:49 on the night of the accident. Sola TS marked with yellow circle. Photo: The police

The two OOWs stood around the radar together (MFD 1) and observed an AIS signal from the ‘object’, but no speed vector. Between 03:46 and 03:50, the OOWs changed the radar settings (by zooming in and out on the display) six times (see section 1.15.2.2).

The OOW being relieved has described that there were two AIS signals. The OOW being relieved had pressed ‘Data’ and read Sola TS, but saw no other information, such as SOG/COG (ref. section 1.9.3.9). It is possible that the OOW being relieved made this observation before the watch handover and before Sola TS moved away from the quay; the AIBN has been unable to ascertain the time. The observation was in any case not discussed or mentioned during the OOW handover, or, alternatively, the relieving OOW did not take note of it. The relieving OOW has described a blue mark, which the OOW interpreted to be an AIS signal from a fixed installation and not from one or two vessels. The relieving OOW could not remember having seen or heard the name Sola TS before receiving the VHF radio call from the pilot on Sola TS.

The OOW being relieved and the relieving OOW discussed whether the lights could come from a fish farm, a platform or some offshore-related object. This may be related to the fact that there are fish farms in the area, and that the Hjeltefjord has three major quay facilities serving the offshore oil and gas industry (see section 1.6.1). The two OOWs did not clarify the issue. Both OOWs had formed the clear perception that the ‘object’ was stationary near the shore and thus of no risk to the safety of the frigate’s passage. During the watch handover, they did not make use of the possibility offered by AIS to obtain more information about the ‘object’. The OOWs’ statements indicate that, then and there, they were not aware that there is no vector for sleeping AIS targets. This may have to do with how AIS symbols are presented on the display (see section 2.3.2.2).

Since the ‘object’ was assumed to be stationary, it was not tracked on the OOW’s radar (MFD 1). Nor was it tracked on the radar (MFD 2) by the OOWA. As a result of this, further into the sequence of events, the bridge system did not generate any alarms to indicate that the vessel was on collision course with Sola TS.

When HNoMS Helge Ingstad entered the Fedje VTS area from the north at 02:50, the VHF radio was set to channel 80, the VTS centre’s working frequency for the area. But nobody on board HNoMS Helge Ingstad registered that the pilot on Sola TS notified Fedje VTS on channel 80 at 03:45 that the tanker would depart the Sture Terminal and set course for Fedjeosen in the west. This meant that the OOW missed an opportunity to obtain important information about the traffic situation in the area.

That the radio communication at 03:45 was not registered could be explained by the following:

- The OOWs had just started the handover procedure and the OOWT was focusing on navigating the vessel. The OOWT has also stated that it was the OOW who usually monitored the VHF radio, as the communication was most often conducted in Norwegian (see section 2.5.5).
- The traffic information was not provided by Fedje VTS (see section 2.5.3).
- As far as the AIBN has found, none of the messages from Sola TS to the Maritime Traffic Center over VHF channel 80 were registered at HNoMS Helge Ingstad. This may be related to how an operator registers and filters the communication that takes place on the radio (see section 2.3.2.7).

2.2.2.3 *03:53–03:59*

After the watch handover on the bridge at 03:53, the relieving OOW’s further decisions and actions relied on the situational awareness that the ‘object’ at the Sture Terminal was stationary. The investigation has demonstrated that it was difficult to rectify this awareness based on visual input alone.

Viewed from HNoMS Helge Ingstad, the deck lights on Sola TS did not give the impression of a moving vessel. On the observation voyage, the lights appeared to increase in intensity as the vessels came closer to each other, but it was nonetheless difficult to judge the distance. Furthermore, the intensity of the lights was dazzling, and it was unpleasant to look straight at them.

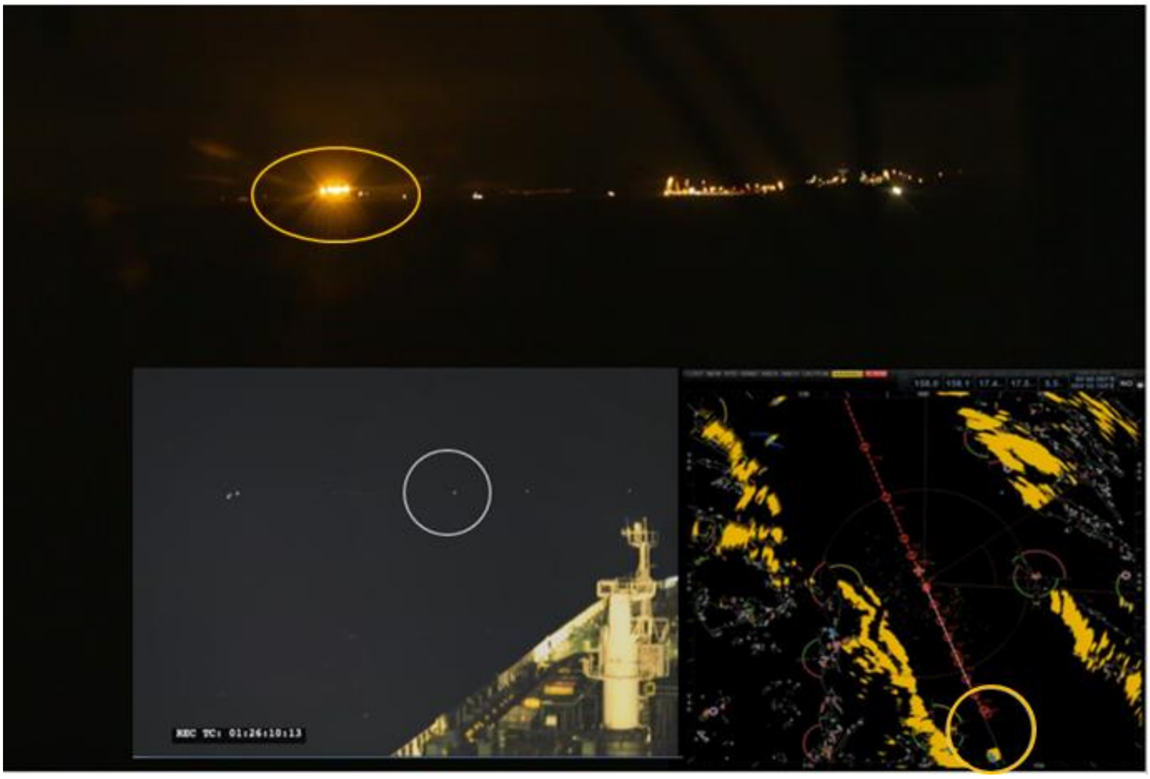

Figure 48: Top: Screenshot of video recording on the bridge of HNoMS Roald Amundsen on the observation voyage in the early hours of 2 April 2019. This corresponds approximately to the situation at 03:53 on the night of the accident. Bottom left: Screenshot of video recording on the bridge of Sola TS on the observation voyage. Bottom right: Screenshot of video recording of the radar display on HNoMS Roald Amundsen on the observation voyage, marked with white circle. Sola TS marked with yellow circle. Illustration: The shipping company/police/AIBN

The photo in Figure 48 shows what Sola TS may have looked like from the bridge of HNoMS Helge Ingstad at around 03:53 on the night of the accident. The figure also shows what HNoMS Helge Ingstad may have looked like from the bridge of Sola TS, marked with a white circle. As evident from the image in the bottom right corner, Sola TS was visible on the radar on board HNoMS Helge Ingstad at this time.

The OOW was focusing on the three vessels approaching in the opposite direction on the port side of HNoMS Helge Ingstad, which had been observed visually and tracked in the bridge system.

Data from the bridge system show that the settings on the OOW's radar (MFD 1) were changed from 3 nm to 6 nm and back to 3 nm at 03:55 (see section 1.15.2.2). It was probably the OOW whom at this time checked whether there were more vessels further ahead. Figure 49 shows the radar display on HNoMS Roald Amundsen on the observation voyage, at a time approximately corresponding to 03:55 on the night of the accident, with the range scale set to 3 nm on the left and to 6 nm on the right.

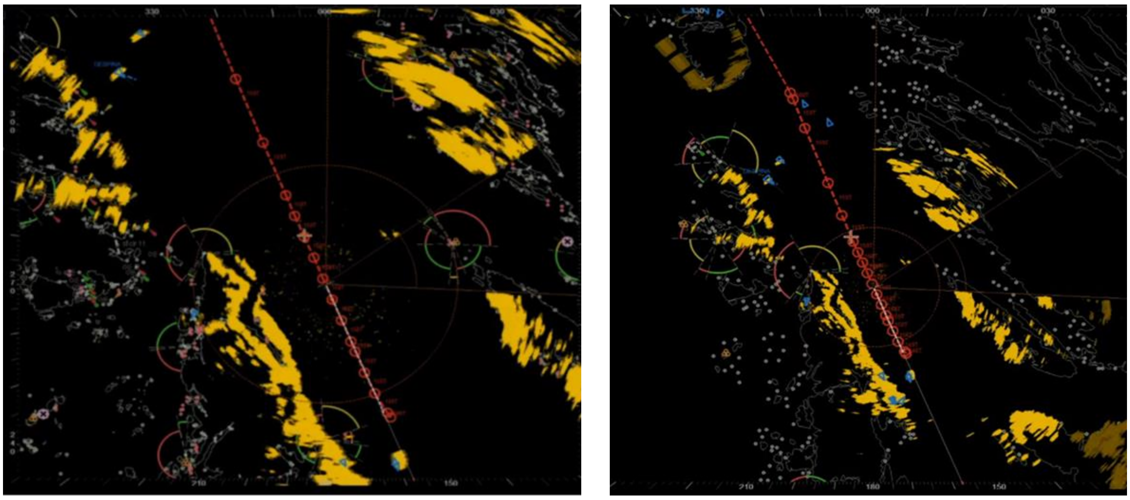

Figure 49: Screenshot of video recording of the radar display on HNoMS Roald Amundsen during the observation voyage in the early hours of 2 April 2019, with the range scale set to 3 nm on the left and to 6 nm on the right. This corresponds approximately to the situation at 03:55 during the night of the accident. Photo: The police

After having checked the radar, the OOW informed the bridge watch team that they would pass three vessels approaching in the opposite direction, and asked them to notify of any further observations. The OOW did not mention the 'object' at the Sture Terminal since the two OOWs had assumed that it was stationary. The OOW did not have an overview of the names of the three approaching vessels. A little later, on receiving a call from the pilot on Sola TS, the OOW thought it came from one of the vessels approaching in the opposite direction that was requesting them to change course to starboard.

In the period 03:56-03:59, a total of five alarms on MFD 1 and MFD 2 related to vessels on the frigate's port side were acknowledged. This probably contributed to draw the bridge crew's focus towards these vessels (see section 2.3.7.2).

During the period leading up to the collision, the position of starboard lookout (STBD LO) was unmanned (see section 2.3.2.4). At the same time (03:52–03:57), the two trainees (OOWT and OOWAT) were engaged in optical positioning. There was also a watch change for the OOWAs during this same period. Hence, during the decisive period leading up to the collision, there was reduced capacity in the bridge team to monitor the traffic situation. The organisation of the bridge team is discussed further in section 2.3.8.2.

2.2.2.4 *03:59–04:00*

The OOW on HNoMS Helge Ingstad eventually noticed that the 'object' on the starboard bow seemed to be closer to the frigate's course line than first assumed, leaving less distance to the closest point of approach. The OOW has stated that the 'object' was primarily observed visually, but the OOW had also seen on the radar that there was a little distance between the shore and the 'object'. The AIBN's understanding is that the OOW was still under the impression that this was a stationary object close to the Sture Terminal, that there was no room to pass between the 'object' and the terminal, and that the distance between the shore and the 'object' could be explained by the frigate having come closer to the point at which the 'object' lay alongside.

The OOW thought that the course would have to be adjusted slightly to port to increase the passing distance to the 'object'. The OOW could not make a wide turn to port, however, as this would create a proximity situation with the vessels approaching in the opposite direction on the port side of the frigate.

Data from the bridge system show that the settings on the OOW's radar (MFD 1) were changed from 3 nm to 1.5 nm at 03:59 (see section 1.15.2.2). This was probably done by the OOW to check that there was room to adjust the course towards port without conflicting with the three approaching vessels. The OOW instructed the OOWT to adjust the course by some degrees to port. During the period up until the time of the collision, the course of HNoMS Helge Ingstad was adjusted by a total of 10 degrees to port through a series of small course changes (see section 1.15.1.2).[45]

Figure 50 shows a screenshot of a video recording of the radar display on HNoMS Roald Amundsen on the observation voyage, with the range scale set to 1.5 nm at a time approximately corresponding to 03:59 during the night of the accident.

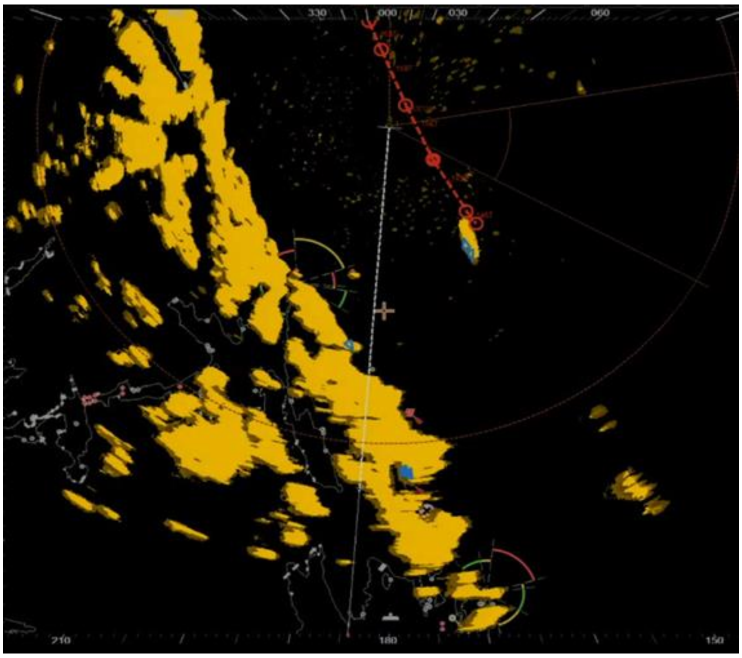

Figure 50: Screenshot of video recording of the radar display on HNoMS Roald Amundsen during the observation voyage in the early hours of 2 April 2019, with the range scale set to 1.5 nm. This corresponds approximately to the situation at 03:59 on the night of the accident, when the distance between Sola TS and shore (Ådnesflua) was approximately 950 meters. Photo: The police

[45] According to the COLREGS one shall go starboard of approaching vessels and avoid a series of small course changes. The OOW did not relate to this, since the 'object' to starboard was perceived as being stationary near the shore, rather than a vessel.

As shown in Figure 50 at this time the distance between land and the 'object' was 950 m. The distance between the 'object' and the first of the three northbound vessels was approximately half of this. The OOW's situational awareness, radar use, experience and competence are discussed further in sections 2.3.2.2 and 2.3.3.2.

On the observation voyage, as Sola TS turned towards a northerly course, it was observed that the yellow floodlights stood out clearly as representing a separate entity not connected to the Sture Terminal, but that it was difficult to discern the contours of a vessel behind the deck lights. Other lights or navigation lights on the vessel were not visible to the naked eye. On the other hand, it proved possible on the observation voyage to distinguish the sidelights though the binoculars when concentrating on looking for them. The AIBN has not found that the bridge team used binoculars to study the 'object' during this period of the night of the accident.

Nobody on the bridge of HNoMS Helge Ingstad reported having seen the navigation lights or the three red top lights on Sola TS. They only observed the strong deck lights on Sola TS. Of those present, only the HM reported having identified the 'object' giving off light as a vessel. This is discussed further in section 2.3.2.6.

2.2.2.5 *03:59–04:01*

The OOW on HNoMS Helge Ingstad answered the direct call on VHF channel 80 from the pilot on Sola TS immediately. On hearing HNoMS Helge Ingstad being mentioned by name on the VHF radio, the OOW moved approximately 1.5 m to the VHF radio to answer the call (see section 2.3.7.4).

When the OOW, at 04:00:11, responded by saying that they could not turn to starboard, this was based on the firm perception that the floodlights observed by the OOW came from a stationary object close to shore and that it was not a vessel, that there was not enough room to pass on the shore side of the 'object'. Furthermore, the OOW assumed that it was one of the three northbound vessels approaching to port that was requesting the frigate to alter course to starboard, as the OOW had just adjusted the course to port. The OOW did not recognise the name Sola TS, and, as mentioned above, had not checked the names of the three vessels approaching in the opposite direction on the radar.

The manner in which the OOW replied to the VHF call indicates that the OOW felt certain of the situation and was under the impression that they were steering a good middle course between the 'stationary object' and the approaching vessels. However, the OOW's reply that they could not turn to starboard before they had passed what the OOW referred to as the 'blocks/sea marks' and subsequently the 'platform' indicates that the OOW was not sure what the frigate was passing.

Since it was perceived as being stationary, neither the OOW nor the OOWA had tracked the 'object' on their respective radar displays. No alarm was therefore generated to indicate that they were too close to Sola TS. Since automatic vessel detection would generate many pointless and distracting alarms in inshore waters, this function was normally deactivated. This meant that no technical barrier had been activated to warn of or prevent collision.

The OOW received the call from Sola TS with the request to change course approximately one minute before the vessels collided. Had the OOW become aware of the situation, assessed it correctly, decided how to manoeuvre and ordered full rudder to starboard no later than 38 seconds prior to the time of the collision, the collision could have been prevented (see section 1.15.4). However, the OOW had not become aware of the situation by that time.

When the OOW understood that the ‘object’ giving off light was moving and on direct course to collide, it was too late to avoid the collision. The only option left to the OOW was to try to manoeuvre around the bow of Sola TS. Realising that it was too late to turn to starboard at the time, the OOW therefore ordered rudder 20 degrees to port, and then rudder midship immediately afterwards. Given the available time this was probably a reasonable manoeuvre, since a turn to starboard must have been carried out earlier.

2.2.3 From the perspective of Sola TS

Sola TS started manoeuvring out from the quay at 03:36. From approximately 03:50, Sola TS set the planned course towards Fedjeosen. At this point in time, there was a distance of approximately 4 nm between the vessels. Neither HNoMS Helge Ingstad nor any other vessels were plotted on the radar on Sola TS. The bridge team did not raise any questions about or discuss the other vessels in the vicinity. The bridge team cooperation under pilotage is discussed further in section 2.4.2.

Shortly before Sola TS had turned to a northerly course, the pilot observed the southbound vessels without being aware at the time that one of them was HNoMS Helge Ingstad. The pilot reacted when the vessel was getting closer without indicating that it would give way. This was approximately four minutes before they collided, at which point the distance between the vessels was approximately 1.5 nm. At 03:57:25, the pilot requested AIS data about the southbound vessel from the master on Sola TS. However, HNoMS Helge Ingstad did not transmit AIS-data (see section 2.3.9). The vessel’s name was therefore not displayed to the master on Sola TS. This probably raised the threshold for contacting the vessel directly.

At 03:58:03, the pilot on Sola TS called Fedje VTS on VHF channel 80, requesting information about the vessel. At 03:58:30, Fedje VTS answered that they were also unable to identify the vessel (see section 2.2.4).

From 03:59, Sola TS tried to establish contact with the vessel using the Aldis lamp. The visibility of the flashes was reduced by Sola TS deck lights, however, and were therefore not perceived by the bridge team on HNoMS Helge Ingstad. Both the master and the pilot have stated that, shortly after signalling with the Aldis lamp, they were briefly able to observe both sidelights on HNoMS Helge Ingstad and thought that the vessel was turning to starboard, which was also what they expected. Technical information from the navigation system at HNoMS Helge Ingstad, indicates that the vessel was keeping a stable course during this period. Measurements conducted by the Navy, of the lanterns at HNoMS Helge Ingstad and HNoMS Roald Amundsen indicates that it cannot be excluded that both lanterns may have been visible in this period the night of the accident. However, the Accident Investigation Board considers that this has not changed the sequence of events and therefor does not discuss this further.

The option of using other means to establish contact with the frigate, such as the fog horn or a general call to all southbound vessels in the Hjeltefjord, is discussed further in section 2.4.4.

At 03:59:21, Sola TS initiated a course change from 350° to 000°, i.e. 10° to starboard, to indicate an evasive manoeuvre to the approaching vessel. The pilot on Sola TS also had to take account of there being vessels on the starboard side of the tanker. The ordered course change turned the bow of Sola TS 10 degrees to starboard, but the tanker's course over ground had in reality not changed much before the two vessels collided. At the same time as Sola TS altered course to starboard, HNoMS Helge Ingstad made several small course changes to port.

A period of 2.5 minutes passed from the time that the pilot requested AIS data of the approaching vessel from the master until contact was established with HNoMS Helge Ingstad. When the pilot on Sola TS was told by the VTS operator on VHF channel 80 that the approaching vessel was HNoMS Helge Ingstad, the pilot immediately called the frigate. The OOW on HNoMS Helge Ingstad answered the call immediately, at 04:00:02, a little over a minute before the collision occurred.

The fact that HNoMS Helge Ingstad could not be identified by means of AIS and the lack of monitoring on the part of Fedje VTS caused valuable time to be lost – time during which the frigate could have been warned of the vessels being on collision course.

The OOW on HNoMS Helge Ingstad was not aware that the illuminated 'object' up ahead was Sola TS, the vessel the OOW was communicating with. Nor did the communication between Sola TS and HNoMS Helge Ingstad help to change the OOW's situational awareness. This will be discussed in more detail in section 2.4.5.

When HNoMS Helge Ingstad did not change course, the master on Sola TS ordered '*stop engines'* and, 20 seconds later, the pilot ordered full speed astern on the engines. These two measures were carried out a short time before the collision and were therefore without material effect. The escorting tugboat was not ordered to assist in reducing the tanker's speed or changing her course. So close to the time of collision, such measures would probably also have been without material effect.

2.2.4 From the perspective of Fedje VTS

At 02:38, the OOW on the 00–04 watch notified Fedje VTS that HNoMS Helge Ingstad was entering the VTS area from the north, and informed of the planned onward route. The VTS operator at Fedje VTS logged HNoMS Helge Ingstad, but did not plot the frigate on the radar. Nor was HNoMS Helge Ingstad plotted on the radar after it had crossed the boundary to the Fedje VTS area at 02:50, and the time of entering the traffic area was not logged. The VTS centre's practice relating to the plotting and monitoring of vessels is discussed further in section 2.5.2.

At 03:13, the pilot on Sola TS called Fedje VTS on VHF channel 80 with the message that they were starting to take in the mooring lines and preparing to depart from the Sture Terminal. Fedje VTS acknowledged receipt of the message. There was little vessel traffic in the vicinity of the Sture Terminal, and the VTS operator saw no need to inform other vessels in the area at the time. The three northbound vessels were 6.5 nm south of the Sture terminal. HNoMS Helge Ingstad was approximately 14 nm north of the terminal. Furthermore, the VTS operator did not know when the tanker would leave the Sture Terminal. This is discussed further in section 2.5.3.

At 03:45, the pilot on Sola TS notified Fedje VTS on VHF channel 80 that the tanker was departing from the Sture Terminal and heading west out Fedjeosen. By this time, traffic was becoming denser in the area off the Sture Terminal. Fedje VTS confirmed receipt of the information, but did not organise traffic in any way or issue information to vessels in the area relating to the departure of Sola TS (see section 2.5.4). The radio communication was in Norwegian (see section 2.5.5).

Fedje VTS had not monitored the passage of HNoMS Helge Ingstad after the frigate notified of entering the area. When Fedje VTS received a call from the pilot on Sola TS on VHF channel 80 approximately 3 minutes before the collision, requesting information about the vessel that was approaching head on, the operator at Fedje VTS was unable to answer immediately. HNoMS Helge Ingstad was not transmitting AIS signals and had not been plotted on Fedje VTS's radar. The VTS operator only saw the frigate as an echo on the radar screen, without direction/speed vector. The VTS operator immediately plotted the frigate and became aware of the collision danger. The VTS operator did not remember, however, that HNoMS Helge Ingstad had notified of entering the area from the north earlier that night (at 02:38). This, in turn, meant that valuable time for notifying HNoMS Helge Ingstad that they were on collision course was lost.

Approximately 1.5 minutes later, the VTS operator remembered HNoMS Helge Ingstad. The VTS operator passed this information on to the pilot on Sola TS over VHF channel 80. Once the vessels had established contact, the VTS operator assumed that they would resolve the situation between themselves, and left it to the pilot on Sola TS to clarify the situation (see section 2.5.4).

2.3 The frigate HNoMS Helge Ingstad and the Navy

2.3.1 Introduction

The following topics are addressed in this section on HNoMS Helge Ingstad and the Navy: the bridge team's situational awareness, level of experience, training and competence, the organisation of and BRM in the bridge team, fatigue and functional capacity, reduced visual functions, the frigate's navigation aids, the bridge manual and bridge design, and the Navy's use of AIS.

Among other things, our assessment is based on the sequence of events, interviews with the bridge personnel, the Navy's governing documents for Fridtjof Nansen-class frigates, the frigate's navigation aids, and research and theory related to human functioning/limitations and situational awareness.

2.3.2 The bridge team's situational awareness at the individual level

2.3.2.1 *General observations about situational awareness*

In order to assess the bridge team's functioning, the AIBN has used the situational awareness of each individual member prior to the collision as a point of reference. Situational awareness is defined in Appendix G and can be broken down into three levels: Level 1 – perception of the elements in the environment, Level 2 – comprehension of the relationship between these elements, Level 3 – projection of future developments and events (Endsley, 1995).

2.3.2.2 *The officer of the watch (OOW)*

In addition to safe navigation, the OOW was responsible for organising the bridge team and for satisfactory training of the OOWT and the OOWAT. The OOW's actions while present on the bridge during the minutes before the collision were based on the available information, which primarily consisted of:

- The watch handover between the OOWs: As described in section 2.2.2.2, both OOWs were under the clear impression that the 'object' at the Sture Terminal was stationary, and that it was something other than a vessel and therefore did not pose any risk to the frigate's passage. They therefore did not use the possibility offered by AIS to obtain more information about the 'object'. The OOW being relieved had read Sola TS at some point, but either did not pass on this information or the relieving OOW did not take note of it.

- Presentation of AIS symbols: The relieving OOW has described a blue mark. This was interpreted to be an AIS signal from a fixed installation and not from one or two vessels. Since HNoMS Helge Ingstad had not tracked Sola TS, the tanker will have been represented by the symbol for a sleeping AIS target (see section 1.9.3.8). The tugboats assisting Sola TS will also have been presented as sleeping AIS targets. Since the symbol orientation depends on the bow orientation, Sola TS and the tugboats may have been entangled on the MFD display on HNoMS Helge Ingstad, so that they appeared to represent a navigation object or a virtual navigation object (see Figure 51).

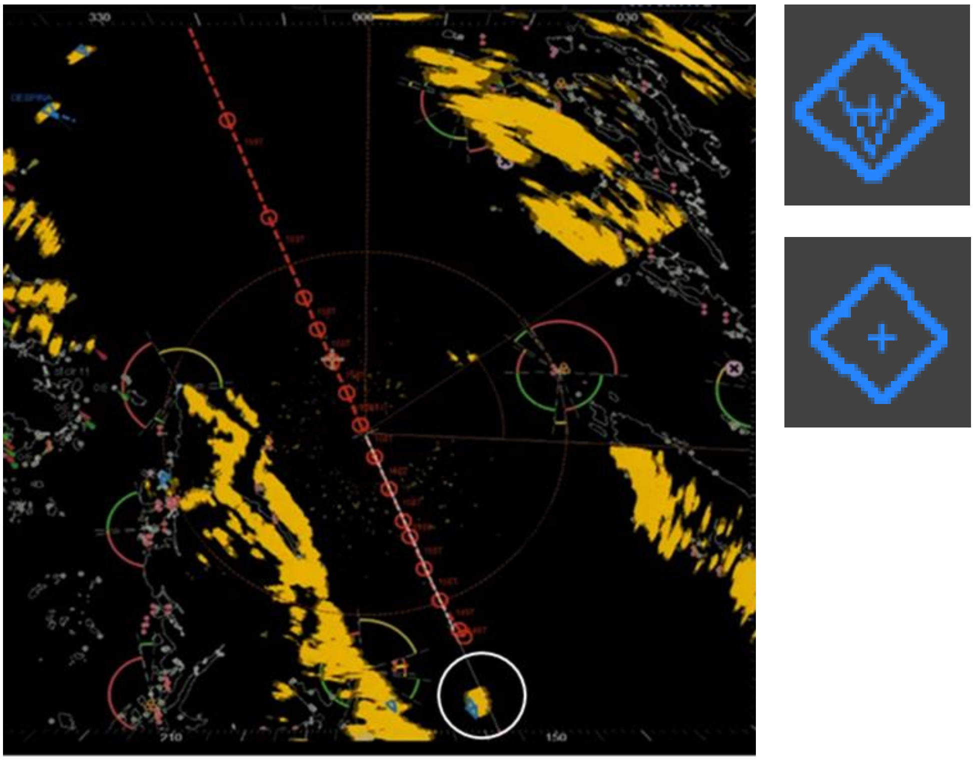

Figure 51: On the left: Screenshot of video recording of radar display on HNoMS Roald Amundsen on the observation voyage. Sola TS with escorting tug marked with a white circle. Virtual navigation object in the top right corner. Navigation object, landmark or buoy with AIS transponder in the lower right corner. Illustration: AIBN

- Optical information observed by the OOW through the bridge windows after taking over the watch: The forward-pointing deck lights on Sola TS made it difficult, even through a pair of binoculars, to discern the vessel's navigation lights. The visual impression was that the 'object' was not a vessel, but an object giving off light close to the Sture terminal. As the tanker moved into the fjord and the distance between Sola TS and the terminal gradually increased, VS had shifted their attention to ensuring a good passage of the three vessels up ahead that were approaching to port, monitoring of the training activity on the bridge and otherwise following up that the voyage took place according to plan. The OOW therefore did not detect the movement of Sola TS visually, and did not rectify the misperception of a stationary 'object' near the shore. The OOW eventually thought that the course would have to be adjusted slightly to port to increase the passing distance to the 'object'. It was difficult to estimate the distance to the 'object' due to the darkness and the tanker's lights. The AIBN considers it likely that the OOW estimated the distance to the 'object' based on perceived distance from the flood lights. The bow of the tanker, which was approximately 200 m closer to the frigate than the strongest deck lights, was probably not perceived by the OOW until just before the collision.

- Information from the bridge system: The OOW has stated that the situation after the watch handover did not appear to warrant any active radar use. After the watch handover, the OOW used the radar to verify what the OOW observed through the bridge windows and the OOW did not study the radar thoroughly during the sequence of events. Primarily, the OOW used the radar to verify the movements of the three vessels up ahead that were approaching to port. The alarms also contributed to draw the attention towards these vessels (see section 2.3.7.2). The radar echo from Sola TS on MFD 1 (see Figure 49) was probably filtered away in the OOW's registration and prioritisation of sensory inputs, as the OOW's focus was elsewhere. The OOW eventually noticed that the 'object' on the starboard side seemed to be closer to the frigate's course line than the OOW had first assumed, leaving less distance to the closest point of approach. The OOW has stated that the 'object' was primarily observed visually, but the OOW had also seen on the radar that a little distance had appeared between the shore and the 'object' (see Figure 50). The OOW was still under the impression that this was a stationary object outside the Sture Terminal, and that the distance between the shore and the 'object' on the radar screen could be explained by the frigate having come closer to the point at which the 'object' lay alongside the shore. Hence, the OOW interpreted the information in a way that upheld the OOW's situational awareness.

- Information received by the OOW over the VHF radio: When the pilot on Sola TS was told by the VTS operator that the approaching vessel was HNoMS Helge Ingstad, the pilot immediately called the frigate. The pilot's communication was not sufficiently detailed, however, to rectify the OOW's prevailing situational awareness. This is discussed further in section 2.4.5.

- Information from the previous day's voyage planning: The electronic chart did not contain any information in the form of comments on the possible presence of tankers approaching or leaving the oil terminal or on dangers to keep in mind when passing through the area. Voyage planning is discussed further in section 2.3.8.3.

- The information received from the rest of the bridge team gave no indication to the OOW that the ‘object’ had moved away from shore and was on collision course with the frigate. This is discussed further below.

The OOW was under the clear impression of being in control of the onward voyage and focused on ensuring that the three vessels approaching to port in the opposite direction could be passed safely. The OOW did not give priority to monitoring the ‘object’, having decided that it did not constitute a threat to the frigate.

In the beginning of the watch, the visual distance, seen from the frigate’s bridge, between the approaching vessels and the Sture terminal was approximately 1200 m. The OOW had the clear perception that the illuminated ‘object’ was stationary near the shore and the situation, as perceived by the OOW, gave no reason to reduce the frigate’s speed. This situational awareness was maintained by the OOW until just before the collision.

Research shows that, intuitively and without being aware of it, people often tend to seek confirmation of their own initial situational awareness. Although it cannot be verified, this may have contributed to the OOW not detecting the danger of collision in time. It may be that the OOW interpreted the visual input through the bridge windows as confirmation that the frigate had three approaching vessels to port and one stationary ‘object’ near the shore to starboard. The OOW has explained that the lights growing slowly stronger was completely in line with the perception that the frigate was drawing closer to the ‘stationary object’. This type of confirmation bias can easily arise in a complex situation like the one being considered here; see the research described in Appendix G.

The investigation has shown that the information received and sought by the OOW (Level 1) was not sufficient to help the OOW get a correct understanding of the situation (Level 2) in the space of time that the OOW was on the bridge before the collision. Hence, it was not possible for the OOW to predict the danger of collision (Level 3) and take action to prevent collision.

2.3.2.3 *Officer of the watch trainee (OOWT)*

The mode of navigation on HNoMS Helge Ingstad on this voyage was ‘electronic positioning with a combination of optical and radar control’. On this particular night, the OOWT had been set the specific task of practising checking the vessel’s position on the electronic chart (ECDIS) using optical navigation aids. At the same time, the OOWT was to carry out all the tasks normally seen to by an OOW. The OOWT was to navigate the frigate, including in relation to other vessels in the fairway, and to perform course changes by issuing orders to the helmsman. The role of the OOW was to ensure a safe voyage, and to guide and correct the OOWT as necessary. Even though the frigate was being navigated by the OOWT, it was the OOW who was responsible on the bridge.

During the OOW handover between 03:45 and 03:53, the OOWT was navigating the vessel and did not pick up on the OOWs’ discussion about the ‘object’. The OOWT had observed the lit object and seen it as being one with the shore at the Sture Terminal, but had neither identified it as a vessel nor checked it out on the radar. During the same period (03:38–03:56), the OOWT and the OOWAT performed several optical position determinations to verify that the ECDIS positions were good. In practice, this meant that the OOWT took bearings of different objects using the pelorus at the centre of the bridge.

The bearings were communicated to the OOWAT, who plotted them on the frigate's ECDIS to determine the frigate's position (see section 1.15.2.3).

It seems clear to the AIBN that, during the period leading up to the collision, optical positioning and operating the bridge equipment took most of the OOWT's attention. This meant that less attention was given to other OOW tasks, such as keeping an overview of the traffic situation.

2.3.2.4 *The lookouts (STBD LO and PORT LO)*

The bridge watch team, which consisted of three conscripts, had a supporting role in relation to the OOW and OOWT. The lookouts are tasked with looking out for relevant information, vessels and other potential dangers to navigation, and notifying the OOW of their observations. They must also carry out any orders issued by the OOW.

The starboard lookout position was unmanned from 03:41 until 03:59 as a consequence of the bridge team, by agreement with the OOW being relieved, taking turns to go down for a night meal. This meant that a barrier was weakened during a period when Sola TS could have been identified as a vessel on collision course. I-200 *Instruks for brotjenesten* ('Bridge service instructions') states that '*When only one lookout is present on the bridge, the lookout shall look out on the starboard side*'. In this case one cannot say for certain whether it would have made any difference whether the lookout had been standing on starboard side, as visibility in the fairway ahead was good from both lookout positions on the frigate. Based on the PORT LO's statement, the PORT LO focused mainly on the port side and the three vessels approaching in the opposite direction, after having taken a quick look at the surroundings through the binoculars and assumed that the 'object' on the starboard side was a quay. Immediately after the collision, the PORT LO still thought that the frigate had collided with a quay.

On returning to the bridge at 03:59, the STBD LO also did not see any navigation lights and thought the 'object' giving off light might be a quay. It was not until the strong lights came even closer and the STBD LO heard it being said on the radio that they must do something that the STBD LO understood that it was a vessel on collision course. It is difficult to determine exactly when the STBD LO understood this, but it may have been around the same time that the OOW realized that the illuminated 'object' was moving. Hence, it was too late for the STBD LO act upon the situation.

2.3.2.5 *The officer of the watch assistant (OOWA) and officer of the watch assistant trainee (OOWAT)*

It seems clear to the AIBN that, during the period leading up to the collision, both the OOWA and the OOWAT, like the OOWT, directed most of their attention to optical positioning.

The relieving OOWA, who took over the watch at 03:56, has stated that there was a lot of light on the starboard bow from something that the OOWA thought was a square platform. The OOWA did not consider it a danger to the frigate and therefore did not check it out on the radar (MFD 2). Much of the OOWA's attention was focused on training the OOWAT in primary tasks, which, according to the watch plan, were '*to operate MFD 3, where he is responsible for monitoring and correcting the voyage by continually informing the officer of the watch about time and distance to turn, next* *course, headings, turn objects, passing distances etc. in accordance with applicable procedures*'.

The AIBN believes that, since the OOWAT was a novice to bridge duty, most of the OOWAT's attention was taken up with operating MFD 3 and cooperating with the OOWT on optical positioning. The OOWA focused on ensuring that the OOWAT learnt as much as possible.

The training activity competed for attention with the OOWA's secondary tasks, which were to '*operate and monitor MFD 2 with the emphasis on information about other vessels*'. This meant that the safety function that the OOWA could have constituted through operating important systems and assisting the OOW/OOWT was not in place.

2.3.2.6 *The helmsman (HM)*

The interviews conducted by the AIBN indicated that the helmsman realised before anybody else in the bridge team that the lights ahead on the starboard side of HNoMS Helge Ingstad belonged to a moving vessel.

The HM assumed that the OOW and OOWA were aware of it being a vessel as they would have been able to observe it on AIS and radar, in other words that they were in control of the situation through having access to the bridge system. The HM also thought that the rest of the bridge team had likewise understood that this was a vessel. At the time, the HM also thought that the lookout had notified of this vessel as well as the three vessels approaching to port.

The HM's attention was directed at the HM's primary tasks, see the helmsman's instructions (I-209.01), which were to man the wheel and receive and act on the orders of the OOW/OOWT. The HM focused on the rudder indicator and the frigate's heading, and on keeping a steady course. The HM only glanced out through the window occasionally and did not have a complete overview of the traffic situation. The HM had not been instructed to warn of any vessels the HM detected that several other members of the bridge team were tasked with detecting; the lookouts have this as their primary task, and the OOWA has it as a secondary task, something that the HM was aware of.

The HM has described that it was difficult to see what course the vessel had, both because it was very dark and because the HM only briefly glanced up from the rudder indicator. According to the HM, when the vessel came closer, it appeared at first to be a straight-forward starboard-to-starboard passing. The HM assumed at the time that this was what the OOW/OOWT planned to do. But just before they collided, the HM realised that the vessel was on collision course with the frigate. At that point, the HM became worried, stood up and was ready to take rudder orders from the OOW. The HM did not have the same professional skills as the OOW in navigating and manoeuvring a vessel, and, according to the HM, this was another reason why the HM did not request a clarification of the situation from the OOW. The AIBN considers that the HM performed the HM's duties in accordance with what can be expected of a conscripted member of the bridge team.

2.3.2.7 *Attention, filtration of sensory inputs and change blindness*

That neither the OOW, the OOWT nor the OOWA took note of the radar echo from Sola TS may have to do with the way the human sensory system is built up and functions. Our capacity to register and understand sensory inputs is limited. This means that many situations, particularly under challenging operational circumstances, can only be tackled if you focus on the information perceived as important there and then, and filter from your awareness information that is irrelevant to the performance of the task at hand. These are necessary and everyday processes in human functioning.

We know from research into road safety that drivers are often blind to unexpected road users. This is often described in the literature as ‘looked, but failed to see’. Chabris and Simons (2011) coined the phrase ‘inattentional blindness’ to describe this blindness to the unexpected.

The phenomenon can be explained by selective attention control (see Appendix G). Those involved do not notice special or unexpected events because their attention is focused on one task in such a way that other situational elements are filtered from their awareness. The overall picture, and any changes to the overall picture, do not become part of their continuously updated situational awareness.

The perception of new visual information from the environment will largely depend on awareness of the actual change. The size and speed of the new element will determine whether the shift is great enough to make us aware of the change. A slow change in a small part of the field of vision is difficult to detect, while a quick shift in a large part of the field of vision is naturally easier to detect. There is a lower threshold for becoming aware of such changes, which varies from one person to the next.

When Sola TS first started manoeuvring away from the quay, this was done so slowly that it was difficult to register any movement. It was demonstrated on the observation voyage that, for a relatively brief period (03:49–03:51), it was possible to observe how the deck lights changed when the tanker turned northwards. During that period, the bridge team’s attention was probably directed at optical positioning and the OOW handover. After Sola TS came on a course towards HNoMS Helge Ingstad, the distance to the ’object’ became smaller, without the ‘object’s’ movement being easy to detect. At the same time, the distance slowly increased between the ’object’ and the shore. The OOW had observed this, but was unable to interpret it correctly (see section 2.3.2.2).

The OOWT was largely concentrating on cooperating with the OOWAT on optical positioning. The OOW had a clear impression of being in control of the onward voyage and focused on ensuring that the three vessels approaching to port in the opposite direction could be passed safely. Neither officer gave priority to monitoring the ‘object’ at the Sture Terminal. This meant that they both depended on a shift in awareness from what they were focusing on to the radar echo of Sola TS, or a rapid change in the environment relating to Sola TS of a magnitude great enough to attract their attention. As we know, there was no such event or warning. On the contrary, the alarms that went off contributed to maintaining focus on the vessels on the port side (see section 2.3.7.2).

During the watch handover, the OOW being relieved and the relieving OOW did not use the possibility offered by AIS to obtain more information about the ‘object’. There may have been an element of economising on mental capacity when the OOW ‘decided’ that the ‘object’ was stationary, and did not consider ‘what if’ or ask anyone to pay particular attention to the ‘object’ until they had passed it. Even when we have surplus capacity, we continue to employ economising mechanisms as long as possible, even if the utility value and quality of our choices are sub-optimal (see Appendix G).

The OOW's location on the bridge was for the most part close to the VHF radio and radio communication could be heard from this location. In the AIBN’s opinion, communication on VHF radio is something an operator will register, but may not always process further if the message does not matter or is not addressed to the vessel. Clear message markers (for example, "warning" or "mayday") and calls to your own vessel, on the other hand, will catch your attention. When the OOW heard HNoMS Helge Ingstad mentioned, the OOW responded immediately.

2.3.3 Level of experience, training and competence

2.3.3.1 *Introduction*

Research by Endsley et al. has shown that situational awareness is affected by experience and expertise. Research also indicates that less experienced people clearly have less capacity than experienced people for picking up on weak signals of danger (Hærem & Rau, 2007).

The relieving OOW had held clearance as officer of the watch for eight months when the accident occurred. The OOW led a team consisting of young conscripts with limited maritime experience, at the same time as training was in progress for two watchstanding functions (OOWT and OOWAT).

The question can be raised as to whether a more experienced OOW might have been able to draw on a wider repertoire for recognising signs that Sola TS was moving, and perhaps also been more persistent in the effort to clarify the ‘object’s’ status. This is discussed further in section 2.3.3.2.

The investigation has shown that the training activity that was being conducted on the bridge on the voyage in question, took a lot of the bridge team’s attention. The Navy’s guidelines for such training activity are discussed in section 2.3.3.3.

The OOW had advanced on the career ladder relatively fast and had little experience in relation to the responsibility associated with the position on board. This is discussed in connection with the career path and experience level for OOWs in general and the Navy’s need for vessel crews in section 2.3.3.4. A discussion of the quality assurance of the navigation team’s competence follows in section 2.3.3.5.

2.3.3.2 *Assessment of the level of experience as a factor in the accident*

In the AIBN’s opinion, the level of experience in navigating inshore waters at night had a bearing on the ability to assess the situation with Sola TS correctly based on optical information alone. That the HM, who was not a navigator, nonetheless recognised the ‘object’ as a vessel may have been a matter of chance, for example that the HM was the only person on the bridge who observed the ‘object’ during the period when it was easier to recognise it as a vessel. This is difficult to verify after the event.

A more experienced navigator would have been better equipped to recognise the ‘object’ alongside the Sture Terminal that night as a tanker, and would probably have had more experience of encountering big outbound oil tankers leaving oil and gas terminals, both in daylight and at night. In the AIBN’s opinion, an experienced navigator would have been more capable of interpreting radar images and AIS symbols correctly and, if applicable, to use the bridge system more effectively.

All in all, the sequence of events suggests that the level of experience had a bearing on the accident. As mentioned by way of introduction, research indicates that less experienced people clearly have less capacity than experienced people for picking up on weak signals of danger. A more experienced navigator would have been better equipped to suspect that his/her own situational awareness was inaccurate, based on having more experience of similar situations (the recognition effect). A possible and natural reaction would then be to reduce the speed, and thus have more time to analyse the situation and take action.

2.3.3.3 *Training activity on the bridge*

Operative personnel without OOW clearance are always present on board and navigation training therefore takes place whenever an opportunity arises. Several of those who were interviewed by the AIBN considered that voyages were safer with than without an OOWT on the bridge. It gives the OOW a better overview and more control of the situation, as well as an extra pair of eyes and an extra person to monitor the radar. The OOW has explained, however, that it can also make the OOW more distant in relation to the systems, since the OOWT can concentrate fully on the tasks and tends to adopt a more hands-on approach to the radar and chart.

The AIBN's review of the sequence of events shows that the navigation training involving two trainees on the voyage under consideration drew parts of the bridge team's attention away from the overall traffic situation. As a result of the training activity, the OOW/OOWT lacked assistance from the OOWA to operate important bridge systems. It also meant that there was less direct communication between the OOW and the OOWA. The OOW also used some capacity to monitor the training activity. At the same time, attention was directed at the three vessels approaching to port in the opposite direction, among other things on account of the alarm system as described in more detail in section 2.3.7.2. The combined effect was to reduce the capacity for checking for nonconformities and weak signals of unexpected events.

The AIBN cannot see that the Navy has conducted risk assessments of or had enough focus in its procedures and guidelines on how training activity on the bridge affects the functioning of the bridge team. For example, there is no description of or expressly stated requirement for compensatory measures to be put in place while such training is in progress, nor any requirement for risk assessments to be approved by the CO when planning such activity. There is also no specification of competence or what should be required of instructors. Generally, this becomes particularly critical when such training activity takes place in combination with navigators who have a low level of experience. In the present case, the training of two persons probably caused a shift in the bridge team's attention and affected their performance of primary and secondary tasks.

2.3.3.4 *Level of experience, career path and crewing needs*

It emerged from the AIBN's interviews with representatives of the Navy's navigational competence environments that, based on a professional assessment, a cleared OOW should have completed 2–4 years' of sea duty, depending on experience, before being put in charge of training other navigators, and should only be considered an experienced OOW after 3–4 years' experience. The investigation indicates that this level of experience is seldom attained by OOWs on frigates.

The position of navigation officer is a recruitment position for following a career path on board Fridtjof Nansen-class frigates. In the case of operative personnel on frigates, it is a natural career goal to advance to the top position in the operations room and then become CO. Navigator education and sea practice as OOW on the bridge are necessary in order to gain a good understanding of safe navigation of the vessel. Younger officers therefore spend more time working bridge watches than more experienced officers, who spend more time in the operations room. As a consequence of this, OOWs on frigates generally have a low level of experience and stand a relatively short time in the position, which means that responsibility for training is assigned to OOWs with limited experience.

The investigation has shown that the relieving OOW was cleared as OOW after nine months' training, which was sooner than what is normally the case for navigation officers. After four months of being cleared as OOW, the OOW was also assigned responsibility for voyage planning and for taking charge of navigation training on board, in addition to working sea watches on the 04–08 watch.

The low level of experience of the OOWs in general and the extensive training that was being conducted on the bridge are also based on the Navy's shortage of qualified labour and the need for new personnel to man the frigates. The following was found, among other things, in DNV' survey of the safety culture (see section 1.15.6): '*One challenge is therefore that there seems to be an increasing tendency to clear personnel sooner than used to be the case'*. This is mentioned in particular with respect to navigators.

Despite the frigates being manned in accordance with the lean manning concept (LMC, see section 0), until the reorganisation in autumn 2016, the frigate branch was only able to operate three of five frigates concurrently because of personnel budget constraints. The reorganisation entailed transferring many land-based functions to operative functions on board the Armed Forces' vessels. Hence, it gradually became possible to operate four of five frigates concurrently from mid-2017. The Armed Forces have described that the level of competence and experience is a critical factor for the multi-functionality and marginal crewing that LMC entails. In the AIBN's view, the competence and experience which the bridge team on HNoMS Helge Ingstad had, did not enable the team members to mitigate the dynamic context in which they were operating this night.

Based on the above, the AIBN believes that the Navy's need for having more frigates in operation, combined with the LMC crewing, without having sufficiently considered the level of competence and experience of personnel, contributed to the accident. As a consequence of the career ladder for fleet officers in the Navy and the shortage of qualified navigators to man the frigates, officers of the watch are granted clearance sooner and with a lower level of experience than used to be the case.

2.3.3.5 *Quality assurance of competence*

Navigators on frigates have good navigational competence on having completed their education at the Naval Academy. They acquire this through theoretical learning, combined with simulator training and extensive practical training on board the Navy's school ships. It is a condition for acquiring sufficient fairway knowledge on the path to obtaining clearance as officer of the watch that the vessel on which they serve offers them varied training in different areas along the coast.

Practice on board the frigates has been for the CO to grant clearance as officer of the watch when the candidate has convinced and earned the CO's trust as necessary, without involving the rest of the operating organisation. The OOW's role as instructor for the OOWT was also not defined or linked to formal competence requirements. Hence, it was not ensured that the person charged with training new navigators had sufficient competence and experience for taking on such a role.

The relieving OOW had received OOW training for nine months before obtaining clearance, and then served as a cleared OOW for eight months. However, leave of absence, holidays and periods alongside meant that little time had actually been spent at sea during that period. Compared with this, a civilian navigator who will navigate a vessel of corresponding size in the same area has to pass a PEC exam to convince a local pilot that s/he is familiar with the fairway and the challenges it presents (ref. section 1.13.4.3). In the AIBN's opinion, the Navy had assigned the OOW a role as instructor that the OOW did not have a sufficient level of competence and experience to fill. This relates in particular to responsibility for the ongoing training of two people on the bridge while also being responsible for safe navigation.

In the Navy, the function of OOWA is not based on any documented training path. Any able seaman apprentice with a user course in ECDIS can start a course of training as an OOWAT, without any formal or specific requirements being defined with respect to the competence that an OOWA must finally possess to fulfil the OOWA's primary and secondary duties as described in the bridge manual. In connection with the accident being considered here, the OOWA could have constituted an important safety barrier in the sequence of events through operating important bridge systems and assisting the OOW/OOWT. It appears that the OOWA had not received sufficient training and did not have the requisite competence to fill this function while at the same time administering training to the OOWAT.

Given the absence of specific competence requirements, it is difficult to document that candidates have received correct and adequate training. Clearance without involvement of the operating organisation, opens up for granting clearance based on a subjective perception of trust and competence. In combination with press to achieve and deliver operative capacity this can lead to clearance being granted faster and with less experience and competence than desired.

The AIBN issues two safety recommendations to the Navy concerning training, competence and experience level.

2.3.4 The bridge team's situational awareness at team level

2.3.4.1 *Introduction*

This section addresses the bridge team's situational awareness at team level and functioning compared with what would have constituted optimum teamwork and bridge resource management (BRM). Cultural aspects that may have affected the functioning of the bridge team are also discussed.

2.3.4.2 *Situational awareness at team level and BRM*

Situational awareness at the individual and team level are linked. If a team member perceives new information about the surroundings and communicates it to the rest of the team, situational awareness is also developed at team level (Salas et al., 1995). Information sharing also works as a control mechanism. By the team members sharing or coordinating their individual understanding of the situation, it is possible to make corrections to the team's situational awareness.

It is not a goal that all members of the bridge team on the frigates shall have the same detailed situational awareness. According to the procedures, information shall be passed on from the lookouts and the OOWA to the OOW. It is the navigation officer who shall consider the information from lookouts and assistants, own observations, information obtained from charts, radar, VHF etc. together, and compile it to get a correct understanding of the situation the frigate finds itself in.

In principle, the bridge team on HNoMS Helge Ingstad had clearly defined roles and responsibilities related to their tasks. The OOW is responsible for conveying a clear and authoritative picture of the situation. When the OOW has reached a decision and wants to implement it, orders are issued to the helmsman and assistants, and if applicable to the lookouts, stating who must do what. This is reflected in the interviews with conscripts in the bridge team in statements like *'I do what the officer of the watch tells me to do', 'I don't keep track of it, as it's not my job', 'I don't have the competence that the officers have'*, etc.

These internal differences in the bridge team and consideration of competence, time at sea, duties and responsibility, can easily become factors that impede communication and teamwork. A more homogeneous and coordinated bridge team would have been more likely to detect the tanker at an earlier time. More information sharing could also have made it easier for the HM to realise that the other members of the bridge team had not understood that the 'object' giving off light was a vessel on collision course. On board HNoMS Helge Ingstad, it was left to the OOW to realise this and take corrective action, as the other members of the team were not experienced enough to undertake such deliberations.

Achieving good teamwork (BRM) is particularly challenging in the case of bridge teams whose members are constantly being replaced. Each member of the bridge team had been trained on board HNoMS Helge Ingstad, and some had also attended FOST in 2017 (see section 1.9.7.4). Naval officers and able seaman apprentices have completed courses and training in BRM as part of their STCW training. According to the Navy, it is highly probable that individual members of the bridge team on 'HNoMS Helge Ingstad' had been assessed with respect to BMR and teamwork while serving on board, but it cannot be documented whether such an assessment had been carried out of the practical teamwork of the bridge team in question.

The Navy has established a navigator project (*Prosjekt Navigatøren*; see Appendix H) to strengthen navigation skills. It is pointed out that the ability for effective collaboration in the bridge teams is given importance in this work, including the implementation of a more systematic training in Crew Resource Management. The AIBN issues a safety recommendation supporting this.

The conclusion from the safety review in November 2016 was that, overall, HNoMS Helge Ingstad had a satisfactory level of sea training (see section 1.9.7.3). The observations relating to navigation had several features in common, however, with the findings made in the investigation of the accident considered here. This suggests that the improvement process may have been inadequate compared to what should be expected over a two-year period. The Navy has informed the AIBN that it is up to the CO on each individual vessel to follow up the recommendations from the safety review. Such follow-up will, in turn, depend on prioritisation of time, availability and interests on board each individual vessel. The Navy's navigator project should also look more closely at whether the system for following up safety reviews works so that improvement measures are initiated and implemented.

2.3.4.3 *Cultural aspects*

It is apparent from interviews that the crew on HNoMS Helge Ingstad had a high degree of confidence in each other's skills.

The AIBN's findings are in line with the findings made by DNV GL in its survey of the Navy's safety culture (see section 1.15.6), where the following was documented, among other things:

- The culture is characterised by mutual confidence and trust in each other's knowledge, skills and ability to carry out the job in a good and safe manner.

- The culture is characterised by a fundamental assumption of being in 'full control'. According to DNV GL, this can result in lack of necessary cooperation and involvement during operations. It entails that individuals will tend to be overconfident in others doing everything right, which is hardly realistic.

- DNV GL also found that many were of the view that 'safety is maintained through procedures and good preparedness', and points to the risk that this entails of neglecting ordinary/known risks.

As part of the crew on HNoMS Helge Ingstad, the bridge team was a part of the same culture. In the AIBN's view, the bridge team's perception of being in control of the situation may have contributed to them lowering their shoulders too much and becoming less alert and sensitive to weak signals of danger (see Appendix G). In the case of the OOW, it may have resulted in less use of the radar to ensure navigational safety.

2.3.5 Fatigue and functional capacity

2.3.5.1 *Assessment of the bridge team*

In the investigation, the AIBN has obtained information about the bridge team working three different watches (4 hours on/8 hours off, 3 hours on/9 hours off, 6 hours on/6 hours off), and some information about the individual bridge team members' hours of rest and sleep during the final 24 hours before the accident. The AIBN has used that information as well as research on sleep and functional capacity to assess whether the bridge team's functional capacity may have been influenced by fatigue.

The interviews with the crew suggest that the exercise they had just completed had not been particularly hectic or tiring, and exhaustion has therefore not been investigated further. On the other hand, the AIBN has considered certain aspects relating to fatigue and the need for sleep.

On the basis of the gathered information concerning sleep and rest, the AIBN considers that the OOW and OOWA may have been somewhat affected by fatigue, particularly considering the time of day (according to the circadian rhythm, fatigue is most prominent in the early hours of the morning) when the accident occurred. The AIBN considers that the rest of the bridge team may also to some degree have been affected by fatigue. This may have affected the functional capacity in important areas such as problem solving and flexibility of thought, for example in the form of reduced ability to challenge and, if applicable, adjust the original situational awareness (see Appendix B).

Research has shown that the negative effects of fatigue (see Appendix B) can be difficult to detect for those who suffer from sleep deprivation. None of the bridge team members told the AIBN that fatigue was a problem at the time of the accident, though one member stated not being ‘as up to the mark’ after two weeks of working sea watches as when being ashore.

In the absence of systematic logging of working hours and hours of rest etc., it has not been possible to further investigate the degree to which the bridge team may have been affected. There are also individual differences in how well people are able to function despite sleep deprivation and fatigue. Hence the AIBN cannot, based on the facts of the case, be more accurate in its estimation of the effect of this factor on the sequence of events.

2.3.5.2 *Follow-up and control of hours of rest*

The procedure for hours of rest and restitution in the Fleet (see section 1.11.8.2) clarifies responsibility and guidelines. According to the procedure, ‘*Those who experience sleep deprivation have a special responsibility for notifying their superiors’*, and ‘*The CO is responsible for ensuring safe operation of the vessel. This means that the CO must continually assess the risk associated with inadequate rest, and take action when the risk becomes excessive.*’

LMC entails a form of optimisation whereby many positions cover several functions and are assigned additional tasks. The Fridtjof Nansen-class frigates are built for this concept and manned accordingly. According to the Armed Forces, this multi-functionality *‘entails a high workload and requires effort’*, and *‘This can mean that individuals may be pushed to the limits of their capabilities’* (ref. section 0).

In the AIBN’s opinion, it should not be up to each individual to assess the impact of sleep deprivation on safety-critical functions. In the absence of a system of registration, the CO has no real possibility of keeping an overview of the crew’s hours of rest, except insofar as individual crew members report feeling deprived of sleep or it is observed by the CO. Research has shown that sleepiness impairs the capacity for self-assessment and that individuals will tend to overestimate their own fitness (see Appendix B). In addition, LMC also puts pressure on the crew’s capabilities and work performance, which may in turn lead to further under-reporting.

The Ministry of Defence has initiated the process of establishing protective provisions for sea-going personnel in the Navy. The regulatory framework is not fully drafted at the time of publishing this report, but the work so far shows that the Navy’s vessels need permission from the Ministry of Defence to use fewer hours of rest per day than what is provided for in Section 24 of the Ship Safety and Security Act.

The AIBN understands the Navy’s needs by virtue of the special nature of its activities, but calls for a requirement for compensatory measures to be put in place when activities don`t comply with the framework provided for in the civilian protective provision (at least 10 hours of rest during every 24-hour period). To achieve a greater understanding and acceptance in the Navy of the need for provisions on hours of rest, a system should be introduced, particularly relating to critical functions, to give the Navy a systematic overview and positive control of hours of rest.

Based on this, the AIBN issues a safety recommendation to the Ministry of Defence.

2.3.6 Reduced visual function

The Department of Occupational Medicine has performed vision tests of the involved bridge personnel (see section 1.14.2). The specialist report concludes that it is not possible based on the results from the vision tests alone to say anything specific about the degree to which reduced visual qualities of the bridge personnel can be considered a contributing factor to the accident. The consequences of reduced visual function must be considered concerning the task each member of the bridge team was to fill, and to how work on the bridge was organised.

Based on the investigation the AIBN cannot exclude that reduced visual quality for the bridge team members has influenced on the accident. The AIBN is however of the opinion that other factors, for example little use of the radar and AIS to monitor the fairway, was of much greater importance for the accident.

The tests showed that two members of the bridge team, who were performing a duty when the accident happened in which good visual function was necessary to perform the persons' primary tasks, had reduced contrast sensitivity. According to the Department of Occupational Medicine, one must assume the two individuals in question was functionally impaired in the situation that arose compared with personnel without such reduced contrast sensitivity. However, the findings regarding reduced contrast sensitivity must be interpreted with some caution, as there is some uncertainty related to the measurement method and threshold values.

In the AIBN's opinion, contrast sensitivity as a possible medical criterion in the selection and follow-up of civil and military bridge crews in the future is an important issue, with the potential for improving maritime safety. However, the possible implementation of introducing contrast sensitivity as a criterion on a general basis seems to depend on further research and development in the field.

Two other members of the bridge team did not meet the formal requirements for keeping bridge watch. Still, but they had sufficient visual function so that the duties they carried out during the period in question did probably not suffer.

The findings relating to the four members of the bridge team are, however, all relevant concerning the adequacy of the Navy's barriers against medical factors causing incidents and accidents. Medical selection and follow-up is meant to ensure that everybody who serves in a given position, for example as bridge crew on a frigate, are medically fit to perform such service safely and effectively. Naval navigation is traditionally more challenging than ordinary civil navigation as a result of operational requirements that apply to the vessel and crew. That is why stricter visual requirements apply to personnel on naval ships than those reflected in the civil regulations.

The bridge team members were less capable of optical navigation in the dark than they and the Navy were aware. As a consequence, the bridge team was not correct composed with regards to meet the requirements for eyesight in current regulations, see Appendix D. This gives reason to question whether the Navy's system for medical selection and follow-up is satisfactory.

Based on this, the AIBN issues a safety recommendation to the Navy to review and improve its system for medical selection and follow-up with regards to vision.

2.3.7 The frigate's navigation aids and bridge design

2.3.7.1 *Introduction*

This section addresses technical factors on the frigate that may have affected the bridge team's functional abilities. It starts with a discussion of the frigate's alarm systems and possible limitations of the navigation aids used by HNoMS Helge Ingstad on the voyage. Finally, it discusses bridge design and the position of the radio equipment.

2.3.7.2 *The alarm system*

The bridge system's two warning functions (automatic tracking and warning of sleeping AIS targets; see section 1.9.3.12) that did not require advance detection and tracking by an operator were normally deactivated in inshore waters. This was because they would involve automatic tracking of a large number of targets, and many pointless and distracting alarms that would put excessive strain on the user.

The AIBN has assessed the relevant voyage route from Florø and through the Hjeltefjord with regards to the use of automatic tracking on AIS. The function could have been an additional barrier, but probably not without an operator directing much attention to the system, regularly monitoring and adjusting alarm settings, and acknowledging unnecessary alarms. The AIBN is of the opinion that the bridge crew would have been better equipped to avoid the collision by directing their attention to, for example, more active use of radar and AIS on the relevant voyage route, and have therefore not analyzed this issue further.

In addition, since neither the OOW nor the OOWA was tracking the 'object' on their respective radar displays, the bridge system did not issue any alarms to indicate that they were on collision course with Sola TS. The OOW may have chosen not to track the stationary 'object' at the Sture Terminal, since it would have generated pointless alarms relating to something that did not entail any danger to the frigate's safe passage.

As described in section 1.9.3.11, a single vessel being tracked on MFD 1, MDF 2 and MDF 3 will give a total of six alarms. The OOW and OOWA on HNoMS Helge Ingstad were tracking four vessels during the period from 03:47 to 04:01, which generated a total of 12 alarms. The alarms were presented with lights and red symbols on the display. Because the alarms are also audio alarms, they compete with other sound information, for example communication on the bridge, VHF radio communication etc. According to the bridge manual, all alarms shall be expressly acknowledged on the bridge to ensure information flow as necessary.

According to accepted definitions, alarm systems are meant to draw the operator's attention to conditions that require action,[46] the point being to transfer and focus the user's attention on the cause of the alarm. In this case the alarms probably shifted the OOW's attention to the meeting situation with the vessels approaching to port – vessels that the OOW had already identified and in relation to which the situation was under control.

Since the tanker was not acquired, no alarms were generated to indicate that HNoMS Helge Ingstad was on collision course with Sola TS and thereby draw the bridge team's attention to this. The OOW focused on being in control of the situation with the vessels approaching to port in the opposite direction and did not see that a vessel (Sola TS) was outbound from the Sture Terminal on the western side of the fjord.

2.3.7.3 *Limitations of the bridge system*

On realising that the 'object' to starboard was closer than first assumed, the OOW had to deviate from the planned route. This meant that the OOW had to compare radar, tracking and chart information. However, the OOW did not have ECDIS immediately available at all times while the OOWT and the OOWAT used MFD 3 for optical positioning.

According to the bridge manual, checking coast contours against the radar display is a method that can be used to control navigation with the aid of radar. The bridge system worked in such a way that, on changing from ECDIS to radar on MFD 1, the coast contours had to be restored manually by the OOW. This meant that, if the navigator switched from radar to ECDIS and back to radar, he/she would lose the method used to verify the vessel's position. The navigator would also lose any AIS tracking.

The bridge manual also pointed out that the current MFD 1 solution was 'inexpedient' and that the OOW should have access to both ECDIS and radar on separate displays, and it was described that a new licence must be purchased to be able to display ECDIS on the conning display.

These limitations of the bridge system may have contributed to the OOW not detecting the collision danger before it was too late to avoid collision.

2.3.7.4 *Bridge design and position of the radio equipment*

The handset, which was used by the OOW when HNoMS Helge Ingstad received the call from the pilot on Sola TS on VHF channel 80, was located next to the Integrated Platform Management System (IPMS) on the starboard side of the bridge console, approximately 1.5 metres from the radar display (MFD 1). This had two unfortunate consequences:

1. The OOW did not have immediate access to a radar display when having to move to the handset to answer the call. At this point in time, the OOW had not yet identified or understood that the 'object' was in fact a moving vessel. Being in control of the meeting situation with the three vessels approaching to port, the OOW did not see any reason to move along the bridge console to be able to consult the radar display at the same time.

[46] EEMUA Publication 191 Alarm Systems – a guide to design, management and procurement, Third Edition. www.eemua.org

2. When the OOW spoke with the pilot on Sola TS on the VHF radio, the other members of the bridge team did not register what exactly was being said. Only the HM assumed that it was the vessel to starboard that was calling and asking the frigate to change course. During an inspection of the sister vessel HNoMS Thor Heyerdahl, the AIBN registered that messages over the loudspeakers were audible, while what was being said by the OOW/internally on the bridge was more difficult to catch. It is an important principle of good BRM that communication/information on the bridge shall be understood by everybody.

The AIBN has been informed that, on two of the other frigates (HNoMS Roald Amundsen and HNoMS Otto Sverdrup), the handset had been moved closer to MFD 1 and that there were plans to do the same on HNoMS Helge Ingstad.

The bridge design also meant the individual members of the bridge team were relatively statically positioned next to each other along most of the width of the bridge (approx. 16 m). All communication thus had to take place sideways, and communication may have been somewhat impeded by this. The AIBN is also aware that low-frequency fan noise can pose certain challenges for verbal communication on the bridge, for example between the OOW and the lookout.

The aforementioned characteristics of the bridge design may have been a hindrance to obtaining and sharing information in the bridge team, and may thus to some extent have reduced the possibility of developing a good, shared situational awareness on the bridge.

2.3.8 Organisation, voyage planning and governing documentation

2.3.8.1 *Introduction*

This section addresses structural factors that may have affected the bridge team's functional abilities. It starts with a discussion of the organisation of the bridge team. Then voyage planning and risk assessments is addressed. Finally, the bridge manual and the guidelines for the bridge team are discussed.

2.3.8.2 *Organisation of the bridge team*

The fact that, as chance would have it, the watch changes between the OOWs and OOWAs, the night meal and the rotation of positions between the bridge crew team took place at the same time as Sola TS was leaving the Sture Terminal, may have increased the likelihood that important information and observations were not registered. It may to some extent have obstructed the development of a common situational awareness (see Appendix G). That all this took place at the same time as the OOWT, OOWAT and OOWA were engaged in optical positioning leads the AIBN to conclude that the organisation of the bridge team was not expedient.

In principle, a watch change can help to improve situational awareness in that the person being relieved must review the status together with the relieving person, and through a 'well-rested' person arriving on the bridge. Furthermore, job rotation is important to break the monotony of some jobs, which could otherwise lead to poorer concentration. In the present case, the bridge team did not succeed in detecting that Sola TS was leaving the Sture Terminal, while the watch changes and job rotation were in progress. Based on the interviews conducted, it did not emerge that the OOW expressed any clear expectation that the bridge team was to cover both primary tasks of optical positioning and traffic monitoring, despite the ongoing training of two trainees and with only one lookout.

In the AIBN's opinion, factors relating to leadership, organisation and teamwork on the bridge contributed to the tanker not being detected in time to avoid the collision.

2.3.8.3 *Voyage planning and risk assessments*

The planning of the voyage was based on a standard route. In the AIBN's view, the choice of route through the Hjeltefjord follows what is normal for southbound voyages through this area, with sufficient (700 m) distance to the safety zone around the Sture Terminal. The route contained comments, but no 'critical points' concerning the possible presence of tankers approaching or leaving the oil terminal or any other dangers it was important to be aware of along the route.

The frigate sailed south through the Hjeltefjord at a transit speed of 17 knots, which, in the AIBN's view, is not uncommon when visibility is good and control is maintained of other vessel traffic.

The fact that the Navy frequently sails in this area does not mean that all navigators have the same knowledge or experience of traffic to and from the Sture and Mongstad terminals. The use of 'critical points' in the planning stage can help to increase awareness of dangers, such as other traffic, along the route.

A notation on the electronic chart concerning the potential presence of tankers approaching or leaving the oil terminal would provide valuable information, especially for less experienced navigators, which could be used in the planning and execution of the voyage through the VTS area. On this specific voyage, this might have provided information that could have contributed to correcting the OOW's understanding of what the 'object' was. It should also be natural, especially when navigation training is to be carried out, to conduct a joint fairway review prior to the voyage.

The AIBN cannot see that governing documentation for the bridge service focuses to any great extent on risk assessments of the voyage in the route planning.

2.3.8.4 *The bridge manual*

The bridge manual described that the radar must be used in conditions of poor optical visibility. The manual made no particular mention of nocturnal voyages, however, which can be seen as a grey area between navigation in daylight and in conditions of poor visibility, or in connection with training activity.

The bridge manual described specific methods for checking the vessel's position, but not what methods to use for detecting other vessels. It was thus left to the judgement of the OOW to combine the use of optical principles, radar, ARPA and AIS. The bridge manual described AIS as an aid to navigation, but said nothing specific about how AIS was to be used to ensure navigational safety. It did not describe any settings for warning of AIS targets.

Furthermore, the bridge manual did not mention that vessels must be tracked to generate an alarm. It neither mentioned the possibility of automatic tracking and defining criteria for automatic alarm indication of radar and AIS targets, nor the option of setting the system to give alarm indication of sleeping AIS targets. The bridge manual did not describe what method should be used for detection of vessels and tracking, or whether the preferred method of tracking should be radar or AIS.

Nor was the bridge manual updated with respect to the fact that the function of OOWA was no longer carried out by navigators in training. The bridge manual referred to the OOWA as navigator, and referred to the primary and secondary tasks of the OOWA as requiring a certain level of navigation skills, but the person in question would lack both the education and experience required of a navigator. The requirement set out in the bridge manual for one navigator to look out at all times (see section 1.11.7.4) was unrealistic, as there are situations in which the navigator(s) must consult the chart, for example to identify objects for taking optical bearings. Furthermore, the instructions for the lookouts did not mention the use of binoculars.

The bridge manual failed to make clear how the OOW was to quality assure that all important bridge team tasks were covered when personnel were being trained on the bridge.

Overall, the AIBN's review of the bridge manual showed that the manual provided insufficient job support for the navigator and the rest of the bridge crew with respect to ensuring a safe passage. This may have contributed to sub-optimal use of the bridge system, and to the fact that nobody in the bridge team detected the collision danger before it was too late to avoid it.

The AIBN issues a safety recommendation to the Navy related to the governing bridge service documents.

2.3.9 The Navy's use of AIS in connection with inshore navigation

HNoMS Helge Ingstad sailed south through the Hjeltefjord with AIS in passive mode. In practice, this means that no information was transmitted about the vessel's identity or movements in the form of course/speed factors.

The consequence of not using AIS transmission is that information about the vessel is not made automatically available to other vessels in the area equipped with AIS. Nor will vessel identity and movement data be automatically displayed on the VTS operator's screens. In the same way as navigators on other vessels in the area, the VTS operators have to use radar to view information about vessel movements, and they must identify and plot the vessel themselves when necessary.

It was evident from the analysis of the sequence of events that active AIS transmission could have contributed to Sola TS and HNoMS Helge Ingstad establishing contact before they did. Such extra time to communicate could have helped to clarify the situation that was developing.

The AIBN acknowledges the Navy's special situation compared with other maritime traffic, in its role as the nation's power at sea, which entails that it must strike a balance between different concerns. On the one hand, the Navy will sometimes need to avoid AIS transmission on account of operational requirements and the need to conceal naval vessels' sailing patterns, including in the future. On the other hand, there is a constant need to exchange AIS data with other vessels for anti-collision purposes in the interest of safety, particularly in conditions of darkness and poor visibility.

The investigation indicates that the introduction of AIS and electronic charts has contributed to establishing a general expectation among seafarers and the VTS centre that all vessels have a complete overview of the traffic situation. As a consequence of digitalisation on board ships and increased use of ECDIS and thus also AIS, it has become generally expected that a vessel’s own navigation system will automatically display other vessels and information about them. This affects navigation practice and the relationship between those involved, and, in the AIBN’s opinion, it further adds to the Navy’s responsibility for the safety of naval and other vessels when electing not to use AIS transmission on own vessels.

It was a challenge for the maritime safety that the Navy was able to operate without open AIS transmission and without compensatory safety measures within a traffic system where the other players largely used AIS as their primary (and to some extent only) source of information. It was found in the investigation that the Navy had, and still has, rules for the use of AIS (see section 1.7.2), which have been drawn up for the purpose of ensuring safety with and without AIS transmission. However, since 2014, the Fleet’s vessels have generally used AIS in passive mode as a rule rather than by way of exception. This practice has been established in accordance with the operational framework plan for the vessels, which, in turn, is based on an increasingly demanding security policy situation. No established practice, procedures or risk assessments are available that address the need to be particularly vigilant in connection with the use of AIS in passive mode.

The Navy’s operational framework plan has led to a practice relating to the use of AIS in inshore waters that sets aside applicable rules and thereby also the barrier that was intended to ensure safety. The AIBN is therefore of the opinion that the Navy should review the relevant regulations and consider all aspects of the Navy’s use of AIS. Since the need for use of passive or encrypted AIS mode will continue to be present in the time ahead, compensatory measures must be implemented to ensure the safety of naval and other vessels.

At the time of the accident, the Navy did not have procedures for the use of W-AIS when sailing in the Fedje VTS area. The investigation has found that the dialogue between the NCA and the Navy about the use of W-AIS in the Fedje VTS area, faded away before guidelines for such use were in place. Procedures for use of the system were not established between the parties involved, seemingly in part due to a misperception that the VTS centre did not have the correct encryption key. Thus, there has been no particular reason for Navy vessels to select mode 3 AIS in the Hjeltefjord, even if some military vessels may have done it for other reasons.

The investigation has found that if the frigate had set AIS to mode 3 for the voyage, it’s highly likely that the VTS monitoring system would have displayed the AIS information. The AIBN considers use of W-AIS in VTS areas to potentially be a valuable safety barrier in situations where use of AIS mode 1 is not appropriate. The Navy and the NCA should resume and formalise their cooperation to develop and implement guidelines for such use, including establishing an arena for exchange of experience and safety learning.

The use of mode 3 will not broadcast AIS information to other vessels in the area, and compensatory measures for not sailing in mode 1, will still be required. One such measure could be to inform the VTS centre that the vessel is using mode 3, allowing the traffic controller to take this into account.

The AIBN issues two safety recommendations to the Navy concerning use of AIS, one of which concerns the use of W-AIS in collaboration with the NCA. In addition the AIBN issues a safety recommendation for the Navy to review their own operating concept and ensure that safety management and operational needs are compared as management parameters.

2.3.10 Assessment of measures taken by the Navy

The AIBN has received information about measures initiated by the Navy after the accident (see 1.17.1 and Appendix H). The Navy has chosen to focus on safety culture, navigation, technical safety, documentation, competence management and handling of nonconformities, as well as teamwork training, medical requirements and fitness. The AIBN considers these areas to be relevant in relation to the safety problems identified in this investigation.

2.4 The tanker Sola TS with the pilot and the shipping company Tsakos Columbia Shipmanagement S.A.

2.4.1 Introduction

The following topics are discussed in this section on Sola TS, the tanker’s pilot and the shipping company Tsakos Columbia Shipmanagement (TCM) S.A.: Cooperation between the pilot and bridge team, use of deck lights, use of available warning aids and VHF communication between Sola TS and HNoMS Helge Ingstad.

Our assessment is based on the sequence of events, interviews with the bridge personnel, the shipping company’s navigation procedures manual and the tanker’s navigational aids, among other things.

2.4.2 Cooperation between the pilot and the bridge team

The bridge team and the pilot on Sola TS experienced good control of the voyage and the other ship traffic in the area. The radar provided true trails which gave a good indication of speed and heading of the other vessels (see Figure 10). The crew explained that they therefore did not consider it necessary to plot the vessels on Sola TS’ radar. Nevertheless, the AIBN finds that there are areas of improvement also concerning Sola TS’ practice, especially with regards to the cooperation between the pilot and the bridge crew.

The shipping company’s navigation procedures manual describes how the bridge crew is organised as a team so as to safeguard against and correct possible errors. Even if not recognised as part of the watch team, the pilot plays an important role on the bridge, and it is the responsibility of the bridge team to include the pilot in the team. The NCA’s pilotage instructions also point out that the pilot shall make efforts to establish good BRM and take active part in the vessel’s bridge team.

While sailing north towards Fedjeosen, communication between the pilot and the rest of the bridge team was limited to trivial matters. There was little communication about the voyage and about the other vessels that were approaching.

The navigation procedures manual also points out that English should always be established as the common communication language between the pilot and the bridge team, and that English shall be used for all internal and external exchange of information about the vessel's operations. For this particular departure, the master and pilot had agreed that the pilot could speak Norwegian on the VHF radio when communicating with Fedje VTS and the tugboats. Norwegian was also used in the subsequent communication between the pilot on Sola TS and the bridge watch team on HNoMS Helge Ingstad. The pilot retold what the pilot considered relevant information to the master on Sola TS. It was not found in the investigation that any essential information was lost as a consequence of this, but the AIBN is of the opinion that this type of practice can entail that the bridge team lose out on the possibility of understanding the situation and of intervening, if applicable, at an earlier point in time.

The first mention of HNoMS Helge Ingstad was when the pilot (at 03:57:25) asked the master if there was any information about the vessel that was approaching from the north. That was just under four minutes before the collision was a fact.

The master and the pilot on Sola TS had experience of taking tankers out from the Sture Terminal. The tanker was also sailing within the Fedje VTS area. In addition, the master and pilot had good visual control over all the traffic in the area. This can explain why those manning the bridge on Sola TS did not consider it necessary to exchange much information. The AIBN's general opinion is that not establishing communication about vessel traffic on the bridge may increase the threshold for notifying of any uncertainty.

According to the bridge procedures manual, the navigating officer shall, among other things, operate the radar/ARPA and other navigational equipment, and plot all targets within a range as decided by the master. It was pointed out in the relevant passage plan that there was a high danger of collision on account of there being much traffic in the area they were passing through after leaving the Sture Terminal. However, the investigation has shown that none of the other vessels in the Hjeltefjord the night of the accident were plotted on any of the tanker's radars. This indicates that the crew on Sola TS found it natural to use AIS information on the ECDIS display as their source of information about other maritime traffic. It is also the AIBN's opinion that the lack of plotting may indicate that the bridge team took a less active role with the pilot on the bridge.

By letting the pilot play the most active role on the tanker's bridge, while the bridge team assumed a more standby role, the corrective effect of active teamwork to build up a common situational awareness can be reduced; see Appendix G. This is to some extent in line with findings from previous investigations of accidents involving vessels under pilotage[47]. The AIBN has previously issued a safety recommendation[48] on this subject to the Norwegian Coastal Administration.

The AIBN issues a safety recommendation to the shipping company in order to review and revise practice for bridge teamwork and safe navigation with pilot on board.

2.4.3 Use of deck lights

Sola TS left the quay with the forward-pointing deck lights on. The AIBN's experience on the observation voyage showed that it was difficult, even through binoculars, to discern the tanker's navigation lights from the deck lighting (see Figure 52). This implies that it cannot have been easy for the bridge crew on HNoMS Helge Ingstad to observe the

[47] Ref. AIBN reports Report Marine 2010/01 and Report Marine 2010/04, among others.
[48] Safety Recommendation Marine no 2010/04T in Report Marine 2010/01.

navigation lights on Sola TS. As a consequence of the deck lights it was visually challenging for the bridge crew on the frigate to identify the tanker as a vessel.

Figure 52: Photos from the observation voyage taken at a time corresponding to approximately 03:55 the night of the accident. On the left: the view from the bridge on Sola TS, with HNoMS Roald Amundsen marked with a white circle. The photo on the right shows what Sola TS may have looked like from the bridge on HNoMS Helge Ingstad. The distance between the vessels was approximately 2.3 nm at the time. Photo: The police/the shipping company/AIBN

As described in section 1.12.3, the company had established procedures relating to the safety of the crew while working on deck. However, the company had not established compensatory safety measures with regards to the reduction of the visibility of the navigation lights due to deck lighting.

It is a known fact and normal practice that the tankers on their way to the terminal need to start preparing for mooring and loading, and that the vessels on their way out prepare for the ocean-going voyage. The use of deck lights during mooring operations is according to what the shipping company considered best practice. To work safely on deck while securing for sea, the deck crew depends on good lighting.

The AIBN sees the company’s need to safeguard the working environment, but at the same time the use of deck lighting must not be at the expense of maritime safety. The AIBN issues a safety recommendation to the shipping company to establish measures for the use of deck lighting, which ensures that the lighting does not conflict with the visibility of navigation lights.

The AIBN does not have an overview of other cases where the deck lighting has reduced the visibility of the vessel’s navigation lights, but to the extent that the visibility of the navigation lights is reduced this may pose a risk. The AIBN issues a safety recommendation to the Norwegian Maritime Authority to address the industry in general in this regard.

2.4.4 Use of available warning aids

Sola TS did not have access to AIS information about HNoMS Helge Ingstad. When the need arose to establish contact with the vessel, the pilot called Fedje VTS. Fedje VTS did not know the identity of the vessel either. The pilot did not attempt to make a call for example directed to all ‘southbound vessels just north of the Sture terminal, which the AIBN believes would have been a good option. The frigate was not plotted on the radar on Sola TS, whereby more specific information could have been provided about the frigate's course and speed had such a call been made.

The pilot considered other options for establishing contact with the vessel. At 03:59:02, the pilot asked the master on Sola TS to use the Aldis lamp to send out signals to the vessel and get her attention. Given the view that the bridge team on Sola TS had of HNoMS Helge Ingstad (see Figure 52), the AIBN can understand the assumption that the flashes from the Aldis lamp would be observed by the approaching vessel.

Experience on the observation voyage showed that the flashes from the Aldis lamp could only just be discerned between the yellow lights without using binoculars. This depended on looking straight into the deck lights, which the bridge team on HNoMS Helge Ingstad probably felt was unnatural, as they were focused on maintaining their night vision.

Sola TS did not use sound signals in the attempt to call on the attention of HNoMS Helge Ingstad. Any attempt by Sola TS to establish contact with 'HNoMS Helge Ingstad' by sounding the fog horn would probably have failed, because the frigate's lookouts and other bridge team members were inside the enclosed bridge. On the observation voyage, the fog horn of Sola TS was audible on the bridge of HNoMS Roald Amundsen when the door to the bridge deck was open, but not when it was closed[49]. On the basis that the personnel on the bridge of Sola TS were convinced that the tanker was highly visible to the approaching vessel, the AIBN understands why they did not consider using the fog horn.

The course of events might have been different had the flashes from the Aldis lamp and the navigation lights not been concealed by the forward-pointing deck lights on Sola TS. In the AIBN's opinion the members of the bridge team on Sola TS could not have been aware of the effect of the deck lights on the visibility of both flashing lights and navigation lights, and hence, they did not consider turning off the lights to achieve greater visibility.

2.4.5 VHF radio communication between Sola TS and HNoMS Helge Ingstad

When the pilot on Sola TS was told by the VTS operator that the approaching vessel was HNoMS Helge Ingstad, the pilot immediately called the frigate. The OOW on HNoMS Helge Ingstad answered, and the pilot on Sola TS asked: *'Is that you approaching?'*, and gave the message: *'You must turn to starboard immediately'*. This communication did not provide the OOW on HNoMS Helge Ingstad with information that enabled the OOW to change the prevailing situational awareness.

Had the pilot stressed that it was the tanker Sola TS calling, outbound from the Sture Terminal and on collision course with the HNoMS Helge Ingstad, and asked the frigate to turn to starboard, the OOW/bridge team on HNoMS Helge Ingstad would probably have detected the collision danger before they did.

The pilot was probably convinced that HNoMS Helge Ingstad observed Sola TS both visually and by AIS and radar. The pilot therefore found it unnecessary to inform HNoMS Helge Ingstad of their relative positions. The AIBN believes that, with the introduction of ECDIS and AIS, a general expectation has gained foothold among

[49] VSS Sound Reception System intended to capture audio signals in fog or in poor visibility, was not switched on during the observation voyage and probably not at HNoMS Helge Ingstad on the night of the accident.

seafarers that all vessels in the vicinity have a complete overview of the traffic situation, and this also affects how seafarers communicate with each other.

2.4.6 Assessment of measures implemented by the shipping company

The AIBN has received information about the measures implemented by the shipping company after the accident. The AIBN cannot see that the shipping company has implemented changes in connection with any of the possible areas of improvement relating to its vessels that have been identified by this investigation. This concerns use of deck lights and the shipping company's own navigation procedures with pilot on board. The shipping company states that use of deck lights is normal and safe practice, and does not see that the deck lights can make the navigation lights less visible. The AIBN does not share this view.

2.5 Fedje VTS and the Norwegian Coastal Administration (NCA)

2.5.1 Introduction

This section addresses the VTS centre's tasks relating to traffic monitoring, information service and traffic organisation. Consequences of the choice of language used for communication between seafarers and the VTS, as well as traffic separation and position in the fairway, are also discussed in this section.

Our assessment is based on the sequence of events, interviews with the VTS operators, the VTS centre's procedures and systems, and information obtained from the NCA's Department for Maritime Safety, among other things.

2.5.2 Traffic monitoring

Fedje VTS shall continuously monitor its service area for the purpose of detecting situations in which there is a danger of collision or grounding. The AIBN considers traffic monitoring to be of the utmost importance in enabling the VTS centre to carry out its information, traffic organisation and navigation assistance services. The VTS shall give special priority to vessels carrying hazardous or noxious cargoes between the oil terminals and pilot boarding ground, among others.

Lack of monitoring meant that the VTS operator's situational awareness and overview of the VTS area were inaccurate. For instance, the VTS operator at Fedje VTS was unable to identify HNoMS Helge Ingstad immediately on the request from the pilot on Sola TS. The investigation has shown that HNoMS Helge Ingstad was not plotted on the VTS's radar when the frigate notified of entering the VTS area.

According to the NCA the general routine at the VTS centre is that vessels are plotted when they are within the screen layout on the operator's main screens (see Figure 40). This was also normal for the VTS operator who was on duty, but in this case, it was forgotten.

C-Scope includes functions whereby a zone can be defined for automatic plotting of vessels without AIS transmission. The system can be set to generate warnings and alarms on these plots, to draw the VTS operator's attention to the vessel. According to the NCA the functionality has been tested locally by the first VTS centre who started utilizing the system, but since it was not sufficiently adapted to the execution of the vessel traffic service the functionality was not chosen. The NCA has in cooperation with the equipment supplier initiated testing and analysis in order to identify how the automatic plotting, warning and alarm functions can be improved (see section 1.17.3.2). Furthermore, the testing of the system has shown that the functionality for 'dead reckoning' needs to be further developed before it can be used operationally. The NCA has informed the AIBN that a dialogue with the equipment supplier on improvement of this functionality, has been initiated (see section 1.17.3.3).

Because HNoMS Helge Ingstad did not transmit AIS signals, the monitoring system did not automatically display the vessel with identity and speed/course vectors. This means that, in a critical phase of the sequence of events leading up to the collision, the VTS centre was unable to assist the pilot with information about the approaching vessel. This further delayed the time at which the pilot on Sola TS established contact with HNoMS Helge Ingstad.

This was the first night shift worked by the VTS operator after returning from a long free period, and the operator had not slept since the morning on the preceding day. The AIBN considers it probable that the time of day (circadian rhythm), and the transition from staying awake in the day to staying awake at night, may have affected the VTS operator's level of attention (see Appendix B), and the number of hours of continuous wakefulness may have been a contributing factor to HNoMS Helge Ingstad not being plotted and monitored. Furthermore, the work as a VTS operator entails a lot of screen use and the job is somewhat repetitive and sedentary, which can cause a gradual weakening of the ability to concentrate.

It is important that organisations establish human, technical and organisational barriers to compensate for the risk that follows from human limitations. In the present case, there were not sufficient barriers in place at the VTS centre. The AIBN considers that the monitoring system's functionality should be improved so that it can be utilized by the VTS centers.

Concerning Warship AIS, discussed in section 2.3.9, today it is not possible on the C-SOC monitors to see the difference between a W-AIS and a standard AIS. The symbol on the screen will not tell the traffic controller whether a naval vessel is transmitting AIS in encrypted or open mode. A traffic controller who is not aware that the system may be displaying W-AIS, will assume that other vessels in the area are also able to see AIS information on the naval vessel. This can potentially lead to misunderstandings that affect safety. It seems reasonable to assume that a technical modification of the system can address this limitation. At least such a solution is worth pursuing.

There is no specification in the NCA's procedures/instructions of what sensors to use for traffic monitoring, other than that the NCA describes AIS as a supplement to radar. As described before (see section 2.3.9 and 2.4.5), the investigation indicates that the introduction of AIS and ECDIS has contributed to establishing an expectation that everybody has a complete overview of the traffic situation. It has also contributed to less manual radar plotting of vessels on the part of the VTS. In the present case, this contributed to the frigate being forgotten and thus not monitored while passing through the area.

The AIBN recommends that the NCA review and improve how traffic monitoring is conducted.

2.5.3 Information Service (INS)

Monitoring and adequate situational awareness are basic conditions for the VTS centre's ability to operate an efficient and correct information service.

The NCA has drawn up a set of instructions for the VTS operators at Fedje VTS, describing how and when information shall be provided. The instructions state that the VTS operators shall provide information services so as to make relevant information available to vessels in time for navigational decisions to be made on board. Particular mention is made of informing about vessels leaving their moorings within the VTS area. Communication of such information by the VTS shall be preceded by the message marker *Information*.

The pilot on Sola TS notified Fedje VTS that they were starting to take in the mooring lines at the Sture Terminal at 03:13. At that time, there was little maritime traffic in the vicinity of the terminal. The three northbound vessels were 6.5 nm south of the terminal. HNoMS Helge Ingstad was approximately 14 nm north of the terminal.

Based on the pilot's message that the tanker was preparing for departure (taking in the mooring lines) at 03:13, Fedje VTS could not know exactly when the tanker would be leaving the terminal. The preparations can take a shorter (20 minutes) or longer time (1 hour) as circumstances can arise that delay the departure. Given that there was uncertainty about the actual time of departure, the AIBN understands why the VTS operator did not convey the message to other vessels in the area at this point in time.

The AIBN finds that Fedje VTS did not adequately inform other traffic in the area of Sola TS leaving the Sture Terminal. Other than the conversation between the pilot and the VTS centre, which took place in Norwegian, the VTS centre did not provide any specific information to vessels in the area about the tanker that was leaving the Sture Terminal at 03:45. This part of the investigation also indicates that a general impression has formed among seafarers that AIS and ECDIS entail that everybody has a complete overview of the traffic situation. In turn, this has given rise to the view that there is less need for the VTS centre to provide information.

In the AIBN's opinion, it is important to contribute to making all vessels aware of the situation when tankers operate within the VTS area. Due to the lack of traffic information the frigate's bridge team missed an opportunity to catch that a tanker was leaving the Sture terminal.

On that basis, the AIBN issues a safety recommendation to the NCA in order to revise the current practice and routines relating to traffic information. Furthermore, information from the VTS centre must be communicated in a way that ensures that it can be understood by all navigators on watch in the relevant area. See also section 2.5.5.

2.5.4 Traffic Organisation Service (TOS)

As mentioned in section 2.5.1, the VTS centre shall monitor the service area continuously for the purpose of detecting situations that entail a danger of collision or grounding. The VTS centre shall seek to facilitate that large tankers can complete their planned passage without being obstructed by other traffic.

Sola TS notified of her departure at 03:45 and started on the outbound passage towards Fedjeosen. The VTS operator has stated that, then and there, a lot of resources were spent on addressing the situation near the Sture Terminal. The VTS operator zoomed in on the area near the Sture Terminal on the main work screen to check whether Sola TS had sufficient time and space to manoeuvre in relation to other vessels in the area, and concluded that this was the case. The three northbound vessels were approximately 2 – 3.5 nm south of the Sture Terminal. HNoMS Helge Ingstad was 5.8 nm north of the Sture Terminal, and outside the area that the VTS operator had zoomed in on, and was thus not part of the traffic situation being considered by the VTS operator. Based on the VTS operator's situational awareness, the operator decided that there was no need for traffic organisation or for issuing information to vessels in the area.

Following the departure of Sola TS, the VTS operator's main work screen remained zoomed in on the area near the Sture Terminal. In the combination with the lack of radar plotting, this contributed to the VTS operator not remembering HNoMS Helge Ingstad in the subsequent sequence of events.

Traffic monitoring is essential in order to provide the VTS centre with the necessary scope of action for early, effective and safe traffic organisation. The AIBN finds that this scope of action had largely been lost when the VTS centre once again became aware of the presence of 'HNoMS Helge Ingstad' after receiving the call from the pilot requesting information about the vessel.

Once Sola TS and HNoMS Helge Ingstad had established contact, the VTS operator felt that the situation would be resolved. At that point in time, the two vessels were so close that it was natural that the VTS operator left communication and clarification of the situation to the two vessels' bridge teams.

However, a navigator passing through the VTS area would probably perceive a call from the VTS operator as more authoritative than a call from what the OOW on HNoMS Helge Ingstad understood to be a navigator on one of the three vessels approaching in the opposite direction. It is possible that the OOW on HNoMS Helge Ingstad had acted differently had the OOW received a VHF radio call from the VTS operator and had the VTS operator used clear message markers and ordered the OOW to turn to starboard or bring the frigate to an immediate stop.

The VTS operator could not be absolutely certain, however, that the vessel was HNoMS Helge Ingstad, since there had been no plotting or tracking of the vessel. Furthermore, the VTS operator did not have the same possibility of making visual observations as the two vessels involved. The VTS operator probably also assumed that the two vessels were aware of each other based on both visual observations and radar/AIS information. When the OOW on HNoMS Helge Ingstad answered that they were unable to turn to starboard, the VTS operator did not understand why. The VTS operator did not want to intervene in a situation of which the VTS lacked an overview and did not understand.

2.5.5 Language

The navigation officer on watch and the helmsman on Sola TS, who were both from the Philippines, remained inside the bridge when the master and pilot went out on the bridge wing. On the bridge, it was possible to listen in on communication with the VTS as long as the communication was in English.

The bridge team on Sola TS did not speak Norwegian, and the OOWT on HNoMS Helge Ingstad was not fluent in Norwegian. However, the pilot spoke only Norwegian when communicating by VHF with Fedje VTS, the tugboats and, later on, also with HNoMS Helge Ingstad. The pilot retold what the pilot considered to be relevant information from the VTS to the master on Sola TS. It was not found in the investigation that any essential information was lost.

The OOWT on HNoMS Helge Ingstad did not usually listen actively to the VHF radio, since the communication was usually in Norwegian. It was the OOW who followed up the radio communication, but the OOW’s attention was on the watch handover when Sola TS notified of her departure from the Sture Terminal at 03:45.

The AIBN considers that, as a result of the language barrier, both the captain on Sola TS and the OOWT on HNoMS Helge Ingstad may have lost out on the possibility of understanding the situation and taking appropriate action at an earlier point in time. Two of the northbound vessels approaching to starboard of Sola TS also had English-speaking navigators who did not understand what was happening prior to the collision.

The VTS operators consider that many others (Norwegian-speaking) would lose out on the communication if only English was used for VHF radio communication. On being notified of entry into the VTS area by vessels exceeding 24 m, the VTS operators learn what languages the various vessels use. For this group of vessels, the VTS operators will thus be aware of what languages are relevant to use.

In the AIBN’s opinion, the choice of language was in this case unfortunate, but it was not a factor that contributed to the accident. The AIBN considers it important to safety, however, that everybody understands what is being communicated on the bridge and by VHF radio. It should be possible to issue brief safety messages in both English and Norwegian. According to the NCA they will propose an amendment of the language provision in connection with the next revision of the Maritime Traffic Regulations (see section 1.17.3.6).

2.5.6 Traffic separation, positioning in the fairway and use of ECDIS with AIS

The outbound route of Sola TS from the terminal was planned on the tanker’s ECDIS. During the master-pilot exchange before departure, the passage was discussed by the pilot and master, who agreed to follow the planned outbound route to the pilot disembarkation area. According to Fedje VTS’s instructions for traffic organisation, vessels of more than 30,000 GT carrying hazardous or noxious cargo shall use the shortest fairway from Fedjeosen to/from the Sture Terminal. The planned outbound passage of Sola TS from the Sture Terminal and through Fedjeosen was in line with normal practice for tankers calling at the terminal (see Figure 41).

The alternative for Sola TS would have been to head across the fjord a little further and make a wider turn. This can be a challenge for big tankers. Heading straight towards the eastern shore of the fjord with a fully loaded tanker while building up speed would not be the natural course of action for the navigators on board. The pilot on Sola TS considered it important to turn the bow northwards as soon as possible. This would provide more open water ahead, which is important for a fully loaded tanker that is difficult to bring to a stop and that has limited manoeuvring capabilities.

No traffic separation scheme has been established in the Hjeltefjord. Both Sola TS and the tree northbound vessels were on the port side of the fairway. The investigation has also shown that it was normal for vessel traffic in the area (see section 1.13.5) to take the shortest route when heading north, even if this meant that they were on the port side of the fairway. The VTS operators have stated that, after the introduction of AIS, vessels generally operate differently from what they did before. They now take the shortest route when heading out through the fjord, as opposed to what was previously the case, when the vessels steered through sectors and to starboard of the middle of the fairway.

The investigation indicates that seafarers have too much confidence in electronic charts with AIS information providing a complete overview of the traffic situation. This probably contributed to Fedje VTS and Sola TS making insufficient use of available technical aids, particularly radar plotting. The AIBN does not have an overview of other cases where this have been a safety issue. Therefore the AIBN does not have sufficient basis for issuing a safety recommendation. It could nevertheless be of interest, both for the Norwegian Maritime Authority and the Norwegian Coastal Administration, to look closer at how the use of electronic charts with AIS information has affected the navigation safety in Norwegian waters.

Based on the information available to the AIB, the vessel traffic in the Hjeltefjord has not been discussed by the VTS operators at Fedje or by their superiors in the NCA. In 2014, it was concluded in a study by DNV GL, commissioned by the NCA, that safety at sea would benefit from the introduction of a traffic separation scheme (TSS). The risk-reducing effect of traffic separation schemes and recommended fairways is also mentioned in the white paper on preventive maritime safety and preparedness against acute pollution (Report to the Storting No 35 (2015–2016) *På rett kurs*).

Based on the AIBN's assessment, the introduction of traffic separation in the Hjeltefjord will not necessarily improve maritime safety for the area as a whole. Any introduction of traffic separation in the fairway must also be considered in relation to what challenges it can create for traffic entering and leaving other fairways to and from Bergen, and in relation to whether traffic organisation by Fedje VTS can provide the same degree of safety.

2.5.7 Assessment of measures implemented by the NCA

The AIBN has received information about measures initiated by the NCA after the accident. The NCA has identified several areas for improvement, see section 1.17.3. The AIBN considers these areas to be relevant in relation to the safety problems identified in this investigation.

3. CONCLUSION

3.1 Introduction

The AIBN’s investigation has clarified the sequence of events, as well as how and why the two vessels collided outside an oil terminal in an area monitored by a VTS centre. The investigation has shown that the situation in the Hjeltefjord was made possible by a number of operational, technical, organisational and systemic factors.

3.2 The sequence of events, operational and technical factors

During the night leading up to 8 November 2018, HNoMS Helge Ingstad sailed south from Sognesjøen to the Hjeltefjord at a speed of approximately 17–18 knots with AIS in passive mode. The frigate’s bridge team had notified Fedje VTS of entering the area and followed the stated voyage. The passage through the Hjeltefjord was not considered particularly demanding, as the fairway is open and offers a good view all around. The VTS operator at Fedje VTS logged HNoMS Helge Ingstad, but did not plot the vessel in the monitoring system.

Navigation training was being conducted on board HNoMS Helge Ingstad as usual during a transit voyage. The officer of the watch trainee (OOWT) was navigating the frigate and was to carry out all tasks normally performed by the officer of the watch (OOW). The OOW was in charge on the bridge. The OOW, who had not held clearance as officer of the watch for very long, led a team consisting of young conscripts with limited maritime experience, at the same time as training was in progress for two watchstanding functions. During the night in question, the OOWT and the officer of the watch assistant trainee (OOWAT) were receiving training in optical positioning in particular.

During the same period, the tanker Sola TS was preparing to leave the Sture Terminal. Sola TS had some of the deck lights turned on to light up the deck for the crew who were securing equipment etc. for the passage. Sola TS also exhibited navigation lights.

The pilot on Sola TS notified Fedje VTS by VHF radio of departure from the Sture Terminal at 03:45. The VTS operator acknowledged receipt of the message. The VTS operator zoomed in on the area near the Sture Terminal on the main work screen to check whether Sola TS had sufficient time and space to manoeuvre in relation to other vessels.

The three northbound vessels were approximately 2 – 3.5 nm south of the Sture Terminal. HNoMS Helge Ingstad was 5.8 nm north of the Sture Terminal, and outside the area that the VTS operator had zoomed in on, and was thus not part of the traffic situation being considered by the VTS operator. The VTS operator saw no need for traffic organisation or for issuing information to vessels in the area. Following the departure of Sola TS, the VTS operator’s main work screen remained zoomed in on the area near the Sture Terminal. In the combination with the lack of radar plotting, this contributed to the VTS operator not remembering HNoMS Helge Ingstad in the subsequent sequence of events.

At the same time as Sola TS notified of her departure from the Sture Terminal, the watch handover between the OOWs started on HNoMS Helge Ingstad, while the OOWT continued to navigate the frigate. During the watch handover, the OOW being relieved and the relieving OOW observed an object at the Sture Terminal, to starboard of the frigate’s course line. The ‘object’ was observed both visually and on the radar display in the form of a radar echo and AIS symbol. The two OOWs discussed, but did not clarify, what the ‘object’ might be. Both OOWs had formed the clear perception that the ‘object’ was stationary near the shore and thus of no risk to the frigate’s safe passage.

Once Sola TS had manoeuvred out from the quay, the tanker set the planned course towards Fedjeosen and increased the speed to around 6–7 knots. At this point in time, there was a distance of approximately 4 nm between the vessels.

After the watch handover on HNoMS Helge Ingstad, the relieving OOW’s further decisions and actions relied on the situational awareness that the ‘object’ at the Sture Terminal was stationary. The investigation has demonstrated that it was difficult to rectify this situational awareness based on visual input alone.

As far as the AIBN has found, none of the messages from Sola TS to Fedje VTS over VHF channel 80 were registered at HNoMS Helge Ingstad. This can be related to the watch handover between the OOWs, that traffic information was not provided by Fedje VTS, and how an operator registers and filters the communication that takes place on the radio.

When Sola TS first started manoeuvring out from the quay, this was done so slowly that it was difficult to register any movement from the bridge on HNoMS Helge Ingstad. The lights from the tanker appeared to be an extension of the lights from the terminal. Sola TS was more clearly away from the terminal when the tanker turned her bow northwards towards Fedjeosen, so that the forward-pointing yellow deck lights became visible. The navigation lights on Sola TS were then difficult to discern because of the deck lights. The tanker appeared to be an object giving off light, and it was difficult to judge the distance in the dark.

On the bridge of the frigate, the training activity took parts of the bridge team’s attention. Hence, during the decisive period before the collision, the bridge team had reduced capacity to monitor the traffic situation. In addition, the starboard lookout position was unmanned, and this meant that a barrier was weakened during a period when Sola TS could have been identified as a vessel on collision course.

Furthermore, certain of own situational awareness, the relieving OOW on HNoMS Helge Ingstad did not see any need to carefully monitor the fairway on the radar. Since the ‘object’ was assumed to be stationary, it was not investigated further or tracked on the radars on board HNoMS Helge Ingstad. The OOW was focusing on the three vessels approaching in the opposite direction to port of HNoMS Helge Ingstad, which had been observed visually and tracked in the bridge system. Since the tanker was not acquired, no alarms were generated to indicate that HNoMS Helge Ingstad was on collision course with Sola TS and thereby draw the bridge team’s attention to the collision danger.

The OOW eventually realised that the ‘object’ giving off light on the starboard bow was closer to the frigate’s course line than first assumed. The OOW has stated that the ‘object’ was primarily observed visually, but the OOW had also seen on the radar that a little distance had appeared between the shore and the ‘object’. The OOW was still under the impression that this was a stationary object close to the Sture Terminal, that there was no room to pass between the ‘object’ and the terminal, and that the distance between the shore and the ‘object’ on the radar screen could be explained by the frigate having come closer to the point which the ‘object’ lay alongside.

A more experienced OOW would probably have had greater capacity to pick up on weak signals of danger and be better equipped to suspect that his/her own situational awareness suffered from misconceptions. The OOW thought, however, that the course had to be adjusted slightly to port to increase the passing distance to the 'object'. The course was then adjusted by a total of 10 degrees to port through a series of small course changes.

Neither HNoMS Helge Ingstad nor any other vessels were plotted on the radar on Sola TS, this may indicate that the bridge team took a less active role with the pilot on the bridge. Furthermore, there was little communication between the bridge team and the pilot about the passage and the general traffic situation in the fairway. This meant that the effect of active teamwork to build a common situational awareness, was not sufficiently ensured.

A while after setting course towards Fedje, the pilot reacted to the approaching vessel drawing closer without any indication of giving way. That was approximately four minutes before the collision, at which point the distance between the vessels was approximately 1.5 nm. As a consequence of HNoMS Helge Ingstad not transmitting AIS signals on this voyage, the name of the vessel that was approaching in the opposite direction was not presented on the displays on Sola TS.

The pilot requested information about the approaching vessel from Fedje VTS. The VTS operator had not monitored the passage of HNoMS Helge Ingstad after the frigate notified of entering the area, and was therefore unable to identify the vessel immediately.

The crew on Sola TS tried to establish contact with the vessel by flashing the Aldis lamp. The flashes from the Aldis lamp were concealed by Sola TS deck lights, and were therefore not perceived by the bridge team on HNoMS Helge Ingstad. The bridge team and pilot on Sola TS were probably not aware of the effect of the deck lights on the visibility of both flashing lights and navigation lights. Sola TS altered course 10 degrees to starboard, to indicate an evasive manoeuvre to the approaching vessel.

When the pilot on Sola TS was told by the VTS operator at Fedje VTS that the meeting vessel was HNoMS Helge Ingstad, the pilot immediately called the frigate. A total of 2.5 minutes passed from the time the pilot reacted to the approaching vessel until they got in contact with HNoMS Helge Ingstad.

At that point in time, the vessels were so close to each other that the VTS centre's scope of action had become very limited. Furthermore, the VTS operator did not have the same possibility of making visual observations as the two vessels involved. The VTS operator also assumed that the two vessels could see each other on the bridge instruments. Therefore the VTS operator left the further communication and clarification of the situation to the two vessels' bridge teams.

The OOW on HNoMS Helge Ingstad answered the call from the pilot on Sola TS immediately. The pilot asked HNoMS Helge Ingstad to turn to starboard. The OOW responded by saying that they were unable to turn to starboard. This was based on the firm perception that the floodlights came from a stationary object close to shore and not from a vessel. Furthermore, the OOW assumed that it was one of the three northbound vessels approaching to port that was requesting the frigate to alter course to starboard, as the frigate had just adjusted the course to port.

An avoidance manoeuvre to prevent collision would still have been possible at this point in time, had a correct decision been made and correct action taken. However, the communication between the pilot on Sola TS and the OOW on HNoMS Helge Ingstad did not provide the OOW with information that enabled the OOW to rectify the situational awareness. The pilot was convinced that HNoMS Helge Ingstad could see Sola TS both visually and on the bridge instruments.

When HNoMS Helge Ingstad did not alter course, the master on Sola TS ordered ‘stop engines’ and, shortly afterwards, the pilot ordered full speed astern on the engines. These two measures were carried out only short time before the collision, and were therefore without material effect. Any use of the escorting tugboat to change course or bring the tanker to stop would probably also have been ineffective at this late stage of the sequence of events.

When the OOW on HNoMS Helge Ingstad understood that the ‘object’ giving off light was moving and on direct course to collide, it was too late to avoid the collision.

At 04:01:15, HNoMS Helge Ingstad collided with the tanker Sola TS. The first point of impact was Sola TS’ starboard anchor and the area just in front of HNoMS Helge Ingstad’s starboard torpedo magazine. HNoMS Helge Ingstad suffered extensive damage along the starboard side.

3.3 Organisational and systemic factors

3.3.1 The frigate and the Navy

a) Organisation, leadership and teamwork on the bridge of HNoMS Helge Ingstad were not expedient during the period leading up to the collision. The watch changes between the officers of the watch and the officer of the watch assistants, the night meal and the rotation of positions between the bridge crew team coincided with the training in optical positioning.

b) The Navy lacked procedures to ensure the functioning of the bridge team while administering training. The training activity being conducted for two watchstanding functions reduced the bridge team’s capacity to address the overall traffic situation, and the officer of the watch lacked assistance for operating important bridge systems.

c) The Navy lacked competence requirements for instructors. The Navy had assigned the officer of the watch a role as instructor which the officer of the watch had limited competence and experience to fill. Furthermore, the Navy had not given the officer of the watch assistant sufficient training and competence to operate important bridge systems while training the officer of the watch assistant trainee at the same time.

d) As a consequence of the clearance process, the career ladder for fleet officers in the Navy and the shortage of qualified navigators to man the frigates, officers of the watch had been granted clearance sooner, had a lower level of experience and had less time as officer of the watch than used to be the case. This had also resulted in inexperienced officers of the watch being assigned responsibility for training. The level of competence and experience required for the lean manning concept (LMC), was apparently not met.

e) A more coordinated bridge team with more information sharing would have been more capable of detecting the tanker sooner. Achieving good teamwork is particularly challenging in the case of bridge teams whose members are constantly being replaced. Furthermore, the bridge team was part of a culture characterised by great confidence in each other's skills, and this may have contributed to the perception of them being in full control of the situation and thus less vigilant and sensitive to weak signals of danger.

f) The governing bridge service documents (the bridge manual) provided insufficient job support with regards to risk assessment and ensuring a safe voyage. The navigational aids, the bridge design and the bridge manual were not optimised to ensure the best possible situational awareness on the bridge.

g) The bridge team was not correctly put together with regards to the requirements for vision in current regulations. It may be questioned whether the Navy's system for medical selection and follow-up was satisfactory.

h) The bridge team on HNoMS Helge Ingstad may have been somewhat affected by fatigue, particularly considering the time of day. The Navy lacked systematic logging of working hours and hours of rest. The Ministry of Defence has initiated the process of establishing protective provisions for sea-going personnel in the Navy.

i) According to the Navy's regulations for the use of AIS, AIS shall, as a rule, be in transmission mode and special vigilance shall be exercised when deviating from the rule. After 2014, the use of AIS in passive mode had generally become more of a rule than an exception on the Fleet's vessels, as a consequence of an ever more demanding security policy situation, without any specific guidance being provided on compensatory measures.

j) If the frigate had set AIS to mode 3 for the voyage, it's highly likely that the VTS monitoring system would have displayed the AIS information. The investigation has found that the dialogue between the NCA and the Navy about the use of W-AIS in the Fedje VTS area, faded away before guidelines for such use were in place.

k) After the accident, the Navy has implemented relevant measures relating to safety culture, navigation, technical safety, documentation, competence management and handling of nonconformities (see Appendix H), as well as teamwork training, medical requirements and fitness.

3.3.2 The tanker and the shipping company

a) It is a known fact and normal practice that tankers approaching the terminal need to start preparing for mooring and loading, and that vessels leaving the terminal work on securing for sea. The shipping company had not established compensatory safety measures with regards to the reduction of the visibility of the navigation lights due to deck lighting, and claims that the current practice is safe. The AIBN is of the opinion that to the extent that the visibility of the navigation lights is reduced this may pose a risk.

b) Radar plotting and communication between the bridge crew and the pilot on the bridge did not sufficiently ensure the effect of active teamwork to build a common situational awareness. This could have increased the time window for identification and warning of the frigate.

c) After the accident, the shipping company has not implemented changes in connection with any of the possible areas of improvement relating to its vessels that have been identified by this investigation. This concerns use of deck lights and the shipping company's own navigation procedures with pilot on board.

3.3.3 The Norwegian Coastal Administration, the VTS and the pilot services

a) When the pilot has the most active role on the bridge, while the bridge team assumes a more standby role, the corrective effect of active teamwork to build up a common situational awareness, can be reduced. This is to some extent in line with findings in previous investigations. The AIBN has previously issued a safety recommendation[50] on this subject to the Norwegian Coastal Administration.

b) Lack of monitoring meant that the VTS operator's situational awareness and overview of the VTS area were inadequate. In combination with night work, the VTS operators' duties can cause a weakening of the ability to concentrate. The functionality of the monitoring system with regards to automatic plotting, warning and alarm functions, was not sufficiently adapted to the execution of the vessel traffic service. The NCA had not established human, technical and organisational barriers to ensure adequate traffic monitoring.

c) Traffic monitoring is necessary to ensure that the VTS centres have sufficient scope of action to operate an early, effective and safe traffic organisation and information service. The night of the accident, the VTS centre's scope of action had largely been lost when the VTS once again became aware of the presence of HNoMS Helge Ingstad.

d) Fedje VTS did not adequately inform other traffic in the area of Sola TS leaving the Sture Terminal. An efficient and correct information service is an important contribution to situational awareness on all vessels when tankers operate within the VTS area. Due to the lack of traffic information the frigate's bridge team missed an opportunity to register that a tanker was leaving the Sture terminal.

e) The introduction of AIS and electronic charts may have contributed to establishing a general expectation among seafarers that other vessels have a complete overview of the traffic situation. In turn, this might have given rise to the view that there was less need for the VTS centre to provide information. It might also have contributed to less manual radar plotting of vessels on the part of VTS.

f) It is not given that the introduction of a traffic separation scheme in the Hjeltefjord will improve maritime safety for the area as a whole. Any introduction of traffic separation in the fairway must also be considered in relation to what challenges it can create for traffic entering and leaving other fairways to and from Bergen, and in relation to whether traffic organisation by Fedje VTS can provide the same degree of safety.

[50] Safety Recommendation Marine no 2010/04T in Report Marine 2010/01.

4. SAFETY RECOMMENDATIONS

The investigation of this marine accident has identified 15 areas in which the AIBN deems it necessary to submit safety recommendations for the purpose of improving safety at sea.[51]

Safety recommendation MARINE No 2019/05T

On the southbound voyage in the early hours of 8 November 2018, training was being conducted for two watchstanding functions on the bridge of HNoMS Helge Ingstad. The training activity meant that the bridge team's capacity to address the overall traffic situation was reduced. The Navy lacked competence requirements for instructors and procedures to ensure the functioning of the bridge team while administering training.

The Accident Investigation Board Norway recommends that the Royal Norwegian Navy establish competence requirements and procedures for training activity on the bridge, attending to both the training function and safe navigation.

Safety recommendation MARINE No 2019/06T

On the southbound passage through the Hjeltefjord in the early hours of 8 November 2018, while training activity was being conducted on the bridge of HNoMS Helge Ingstad, the navigator in charge did not pick up on the signals of danger or that the navigator's own situational awareness was inaccurate. A more experienced navigator would have been better equipped to realise this. As a consequence of the clearance process, the career ladder for fleet officers in the Navy and the shortage of qualified navigators to man the frigates, officers of the watch had been granted clearance sooner, had a lower level of experience and had less time as officer of the watch than used to be the case.

The Accident Investigation Board Norway recommends that the Royal Norwegian Navy consider the career path and the clearance process for officers in the Fleet in relation to the Navy's manning concept for frigates, with a view to ensuring that bridge teams have a sufficient level of competence and experience.

Safety recommendation MARINE No 2019/07T

On the southbound passage through the Hjeltefjord in the early hours of 8 November 2018, a more coordinated bridge team on HNoMS Helge Ingstad would have been more capable of detecting the tanker sooner. Achieving good bridge resource management (BRM) is particularly challenging in the case of bridge teams whose members are constantly being replaced.

The Accident Investigation Board Norway recommends that the Royal Norwegian Navy establish systematic bridge resource management (BRM) training for the whole bridge team.

Safety recommendation MARINE No 2019/08T

On the southbound passage through the Hjeltefjord in the early hours of 8 November 2018, the tanker was not detected in time to avoid the collision. Organisation, leadership and teamwork on the bridge of HNoMS Helge Ingstad were not expedient. In addition,

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[51] The investigation report is submitted to the Ministry of Trade, Industry and Fisheries, which will take the necessary steps to ensure that due consideration is given to the safety recommendations.

the governing bridge service documents (the bridge manual) provided insufficient job support with regards to risk assessment and ensuring a safe voyage.

The Accident Investigation Board Norway recommends that the Royal Norwegian Navy review and revise the governing bridge service documents.

Safety recommendation MARINE No 2019/09T

The investigation of the collision in the Hjeltefjord in the early hours of 8 November 2018, has found that the personnel on the bridge on HNoMS Helge Ingstad was not correctly put together with regards to the requirements for vision in current regulations. Medical fitness assessment and follow-up is meant to ensure that everyone who serves in a given position, is medically fit to perform such service safely and effectively.

The Accident Investigation Board Norway recommends that the Royal Norwegian Navy review and improve its system for medical fitness assessment and follow-up with regards to vision.

Safety recommendation MARINE No 2019/10T

On the southbound passage through the Hjeltefjord in the early hours of 8 November 2018, HNoMS Helge Ingstad sailed with AIS in passive mode. This meant that the vessel could not be immediately identified on the screens at Fedje VTS and Sola TS. It was a challenge for maritime safety that the Navy was able to operate without AIS transmission and without compensatory safety measures within a traffic system where the other players largely used AIS as their primary source of information.

The Accident Investigation Board Norway recommends that the Royal Norwegian Navy review the use of AIS and ensure that adequate compensatory measures are put in place when using AIS in passive or encrypted mode.

Safety recommendation MARINE No 2019/11T

If HNoMS Helge Ingstad had set AIS to mode 3 (Warship AIS) for the voyage in the early hours of 8 November 2018, it’s highly likely that the VTS monitoring system would have displayed the AIS information. The investigation has found that the dialogue between the NCA and the Navy about the use of W-AIS in the Fedje VTS area, faded away before guidelines for such use were in place. The AIBN considers use of W-AIS in VTS areas to potentially be a valuable safety barrier in situations where use of AIS mode 1 is not appropriate.

The Accident Investigation Board Norway recommends that the Royal Norwegian Navy, in cooperation with the Norwegian Coastal Administration, resume and formalise their combined effort to develop and implement guidelines for the use of Warship AIS in the Fedje VTS area, as well as in other Norwegian VTS areas as required.

Safety recommendation MARINE No 2019/12T

On the southbound passage through the Hjeltefjord in the early hours of 8 November 2018, HNoMS Helge Ingstad sailed with AIS in passive mode. This meant that the vessel could not be immediately identified on the screens at Fedje VTS or the displays on Sola TS. When operational demands led to a change of practice to more use of AIS in passive mode, the applicable rules in the navigation requirements were set aside.

The Accident Investigation Board Norway recommends that the Royal Norwegian Navy review the operating concept and ensure that safety management and operational needs are compared as management parameters.

Safety recommendation MARINE No 2019/13T

The access to factual information in order to map the sequence of events in the collision in the Hjeltefjord in the early hours of 8 November 2018, has been somewhat limited by the lack of Voyage Data Recorder (VDR) on board HNoMS Helge Ingstad. Had VDR data from HNoMS Helge Ingstad been available, the AIBN would have had access to unique data to document the sequence of events more exactly, and to better understand the situation on board the frigate.

The Accident Investigation Board Norway recommends that the Royal Norwegian Navy install VDR on the Navy’s vessels.

Safety recommendation MARINE No 2019/14T

The investigation of the collision in the Hjeltefjord in the early hours of 8 November 2018, has found that the bridge team on HNoMS Helge Ingstad may have been somewhat affected by fatigue, particularly considering the time of day. In the absence of systematic logging of working hours and hours of rest etc., it has not been possible to further investigate the degree to which the bridge team may have been affected by fatigue. The Ministry of Defence has initiated the process of establishing protective provisions for sea-going personnel in the Navy.

The Accident Investigation Board Norway recommends that the Ministry of Defence introduce, particularly relating to critical functions, a system to give the Navy a systematic overview and positive control of hours of rest. In addition, a requirement for compensatory measures should be put in place when non-compliance with the provided hours of rest in the civilian protective provision.

Safety recommendation MARINE No 2019/15T

When leaving the Sture Terminal in the early hours of 8 November 2018, Sola TS had the forward-pointing deck lights turned on to light up the deck for the crew who were securing equipment etc. for the passage. The deck lights reduced the visibility of both the navigation lights and the flashes from the Aldis lamp. This contributed to the bridge team on HNoMS Helge Ingstad not managing to visually identify Sola TS as a vessel.

The Accident Investigation Board Norway recommends that the shipping company Tsakos Columbia Shipmanagement S.A. establish safety measures for the use of deck lights on vessels, which ensures that the deck lights do not reduce the visibility of the navigation lights.

Safety recommendation MARINE No 2019/16T

During the voyage from the Sture Terminal in the early hours of 8 November 2018, neither HNoMS Helge Ingstad nor any other vessels were plotted on the radar on Sola TS. Furthermore, there was little communication between the bridge team and the pilot about the voyage and the general traffic situation in the fairway. This meant that the effect of active teamwork to build a common situational awareness was not sufficiently ensured.

The Accident Investigation Board Norway recommends that the shipping company Tsakos Columbia Shipmanagement S.A. review and improve its practice relating to cooperation on the bridge and safe navigation on vessels under pilotage.

Safety recommendation MARINE No 2019/17T

The investigation of the collision in the Hjeltefjord in the early hours of 8 November 2018, has found that Sola TS' deck lights reduced the visibility of both the navigation lights and the flashes from the Aldis lamp. This contributed to the bridge team on HNoMS Helge Ingstad not managing to visually identify Sola TS as a vessel. It is a known fact and normal practice that the tankers on their way to the terminal need to start preparing for mooring and loading, and that the vessels on their way out prepare for the ocean-going voyage.

The Accident Investigation Board Norway recommends that the Norwegian Maritime Authority address the industry in general with regards to the use of deck lighting which could reduce the visibility of the vessel's navigation lights.

Safety recommendation MARINE No 2019/18T

In the early hours of 8 November 2018, the VTS centre did not monitor the southbound voyage of HNoMS Helge Ingstad through the Hjeltefjord. The NCA had not established human, technical and organisational barriers to ensure adequate traffic monitoring. The functionality of the monitoring system with regards to automatic plotting, warning and alarm functions, was not adapted to the execution of the vessel traffic service.

The Accident Investigation Board Norway recommends that the Norwegian Coastal Administration review and improve how traffic monitoring is conducted, with regards to manning, tasks and technical aids.

Safety recommendation MARINE No 2019/19T

In the early hours of 8 November 2018, Fedje VTS did not adequately inform other traffic in the area of Sola TS leaving the Sture Terminal. An efficient and correct information service is an important contribution to situational awareness for all vessels when tankers operate within the VTS area. Due to the lack of traffic information the frigate's bridge team missed an opportunity to register that a tanker was leaving the Sture terminal.

The Accident Investigation Board Norway recommends that the Norwegian Coastal Administration review and improve its procedures and practice for traffic information.

Accident Investigation Board Norway
Lillestrøm, 7 November 2019

5. FURTHER INVESTIGATIONS

The AIBN will continue the investigation into how and why HNoMS Helge Ingstad ran aground and sank.

The main areas for the AIBN's further investigation are (this list is not complete):

- Mapping of the battle damage repair.
- Investigation of how the systems for propulsion and steering were functioning after the collision.
- Investigation of cooperation and internal communication in the accident situation on board HNoMS Helge Ingstad.
- Investigation of possible connections linked to design criteria/choices for the Fridtjof Nansen-class frigates. This includes e.g. an investigation of the design with hollow propeller shafts.
- Detailed stability calculations for HNoMS Helge Ingstad.
- Further examination of the bilge system on HNoMS Helge Ingstad.
- Investigation of what decision-making support was available to the crew in the accident situation and cooperation with dedicated onshore organisation.

This work presumes continued good collaboration with the responsible organisations, primarily the frigate manufacturer Navantia, the Navy and the Norwegian Defence Materiel Agency, and that the AIBN is being given unhampered access to relevant information.

As a result of the scope and complexity of the investigation, it is not possible to estimate a date of completion for the part two report. The investigation still has a high priority.

DETAILS OF THE VESSELS AND THE ACCIDENT

Vessel 1	
Name	HNoMS Helge Ingstad
Flag state	Norwegian
Classification society	DNV-GL, put into class 24 November 2014
Call signal	LABI
Type	Frigate
Build year	2009
Owner	Norwegian State Ministry of Defence
Operator	Royal Norwegian Navy
Construction material	Steel
Length	133.25 m
Port of departure	
Destination port	Dundee, Scotland
Persons on board	137
Vessel 2	
Name	Sola TS
Flag state	Malta
Classification society	DNV-GL
IMO Number/Call signal	9737383/9HA4475
Type	Crude oil tanker
Build year	2017
Owner	Tsakos
Operator / Responsible for ISM	Tsakos Columbia Shipmanagement (TCM) S.A.
Construction material	Steel
Length	249.9 m
Gross tonnage	62,557 tonnes
Port of departure	The Sture Terminal
Destination port	Tetney, UK
Cargo	Oil
Persons on board	24
Information about the accident	
Date and time	8 November 2018, 04:01:15 local time
Type of accident	Collision
Location/position where the accident occurred	The Hjeltefjord, N 60°38.5, E 004°51.9
Place on board where the accident occurred	The bow of Sola TS and the starboard side of HNoMS Helge Ingstad aft of midship
Injuries/deaths	Minor injuries to 7 persons on board HNoMS Helge Ingstad
Damage to vessel/the environment	Minor foreship damage on Sola TS. On HNoMS Helge Ingstad, approximately 46 m of the ship’s starboard side was torn open.
Ship operation	Inshore voyage
At what point of the voyage was the vessel	Under way
Environmental conditions	Southerly breeze, good visibility, night darkness

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ABBREVIATIONS

AIBN	Accident Investigation Board Norway
AIS	Automatic Identification System
ARPA	Automatic Radar Plotting Aid
BRM	Bridge Resource Management
BTM	Bridge Team Management
COSWP	Code of Safe Working Practices for Merchant Seafarers
COG	Course Over Ground
CPA	Closest Point of Approach
CSOC	C-Scope Operator Client
DAIBN	Defence Accident Investigation Board Norway
DINA	Distribution of Navigation Signals
DSC	Digital Selective Calling
ECDIS	Electronic Chart Display and Information System
ERM	Engine Resource Management
FOS	Armed Forces’ admission section
FOST	Flag Officer Sea Training
GPS	Global Positioning System
GT	Gross tonnage
HM	Helmsman
HNoMS	His/Her Norwegian Majesty’s Ship
IMO	International Maritime Organization
INS	Information Service
IPMS	Integrated Platform Management System
ISM	International Safety Management
JRCC	Joint Rescue Coordination Centre
KDA	Kongsberg Defence and Aerospace
LMC	Lean Manning Concept
MFD	Multi Functional Display
MPX	Master Pilot Exchange
NAS	Navigation Assistance Service
NATO	North Atlantic Treaty Organization
NavKomp	The Navy’s Navigation Competence Centre
NDMA	Norwegian Defence Material Agency
NDLO	Norwegian Defence Logistics Organisation

nm	Nautical mile (1 nm = 1,852 m)
NPM	Navigation Procedures Manual
OOW	Officer of the watch
OOWA	Officer of the watch assistant
OOWAT	Officer of the watch assistant trainee
OOWT	Officer of the watch trainee
OPUS	Operational periodical qualification sea
OSS	Operational Support System
Port LO	Port lookout
SLVTS	Centre for pilotage and vessel traffic service
SMCP	Standard Maritime Communication Phrases
SNMG1	Standing NATO Maritime Group One
SOG	Speed Over Ground
SOLAS	Safety Of Life At Sea
STANAG	NATO Standardization Agreement
STBD LO	Starboard lookout
STCW	Standards of Training, Certification and Watchkeeping for Seafarers
TCM	Tsakos Columbia Shipmanagement S.A.
TCPA	Time to Closest Point of Approach
TOS	Traffic Organisation Service
VDR	Voyage Data Recorder
VHF	Very High Frequency (30-300 MHz)
VTS	Vessel Traffic Service
XO	Executive officer

APPENDICES

Appendix A: Data from the Norwegian Meteorological Institute

Appendix B: Fatigue, sleep deprivation and circadian rhythm

Appendix C: Excerpts from key instructions for Fedje VTS

Appendix D: Eyesight tests – methods and regulations

Appendix E: DNV GL – Survey of the safety culture in the Fleet and among the Navy's executive staff

Appendix F: Photos from the observation voyage

Appendix G: Cognitive and organisational challenges in a navigation team

Appendix H: Measures implemented by the Royal Norwegian Navy

APPENDIX A – DATA FROM THE NORWEGIAN METEOROLOGICAL INSTITUTE

Observasjoner 8. november 2018 fra Flesland, Bergen-Florid og Fedje Kl: 02 til 05 LT								m/s		m/s
						Temperatur	Vindretning	Middel	Middel	Kast
Stnr	Dato-Time(NMT)		Sikt			TA	DX_1	FX_1	FX_1	FG_1
			Visuelle Observasjoner	Visuelle observasjoner						
Flesland			Sikt	Skydekkeil 8-deler	Skyhøyde	TA	DX_1	FX_1	FX_1	FG_1
	08.11.2018-02:00		mer enn 10 km	ingen skyer		7,1	189	4,4	lett bris	4,8
	08.11.2018-03:00		mer enn 10 km	1-2 åttendedeler	4600ft	10,1	129	5,1	lett bris	6,8
	08.11.2018-04:00		mer enn 10 km	3-4 åttendedeler	4500ft	12,4	127	5,6	laber bris	7,7
	08.11.2018-05:00		mer enn 10 km	5-7 åttendedeler	4200 ft	12,3	109	4,4	lett bris	6,6
Bergen - Florida		Nedbør				TA	DX_1	FX_1	FX_1	FG_1
	08.11.2018-02:00	0				6,4	131	1,6	svak vind	2,2
	08.11.2018-03:00	0				6,3	115	3,1	svak vind	4,4
	08.11.2018-04:00	0				11,8	117	6,8	laber bris	11,3
	08.11.2018-05:00	0				13,7	132	7,5	lett bris	13,3
Fedje						TA	DX_1	FX_1	FX_1	FG_1
	08.11.2018-02:00					9,4	121	4,1	lett bris	5,3
	08.11.2018-03:00					9,6	118	6,7	laber bris	8
	08.11.2018-04:00					10,9	121	9,5	frisk bris	11
	08.11.2018-05:00					11	118	10	frisk bris	11,3

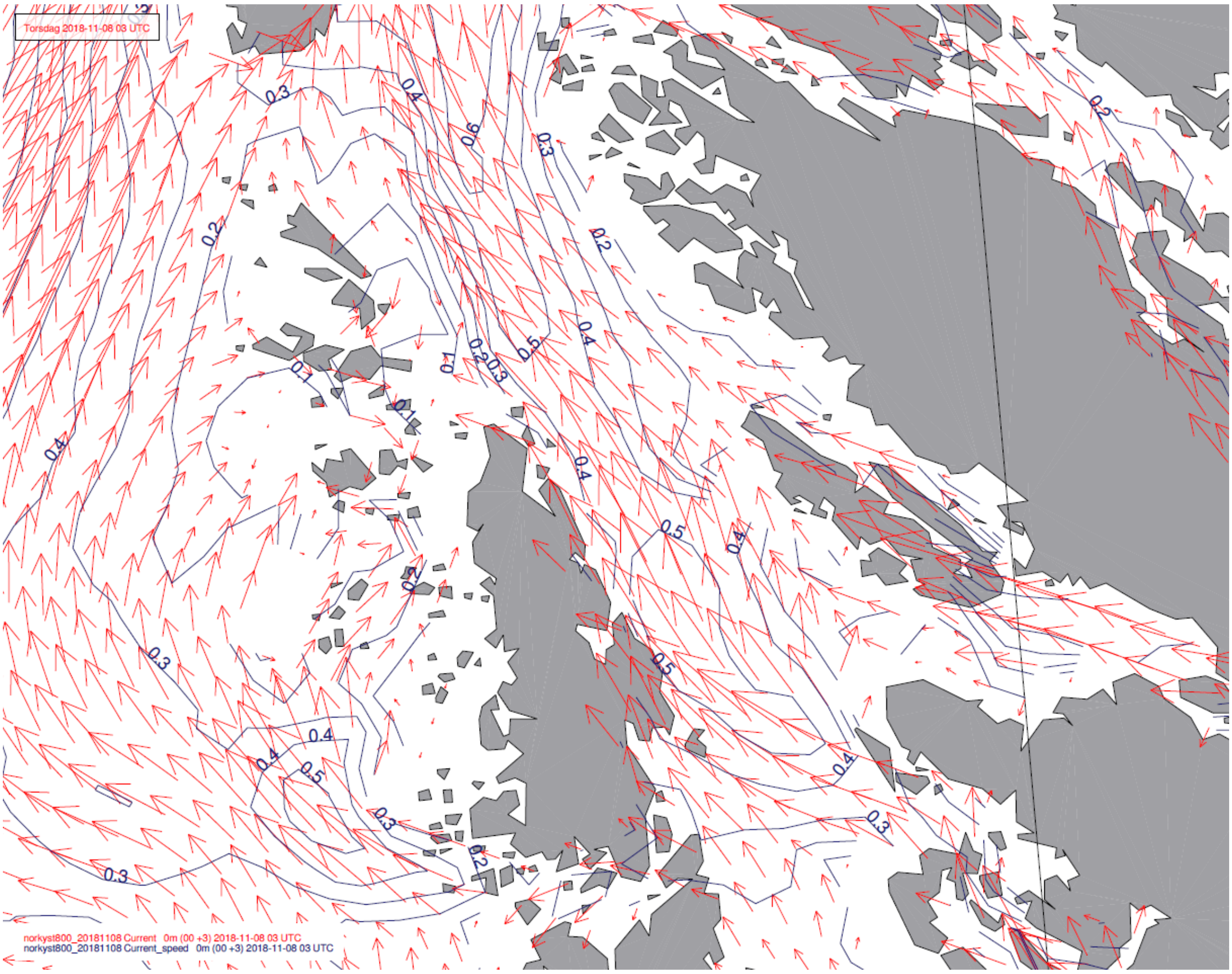
Observations from weather stations in the area around the time of the accident on 8 November 2018. Source: The Meteorological Institute

Observasjoner 2. april 2019 fra Flesland, Bergen - Florida og Fedje kl 00-05 lokal tid

Stnr	Navn	I drift fra	Hoh	Kommune	Fylke
50500	FLESLAND	okt.55	48	Bergen	Hordaland
50540	BERGEN - FLORIDA	nov.49	12	Bergen	Hordaland
52535	FEDJE	aug.04	19	Fedje	Hordaland

			Visuelle observasjoner		Temperatur	Retning	Middelvind	Middelvind	Kast
Stnr	Dato-Time(NMT)	Nedbør	Sikt	Skydekke 8-deler og skyhøyde ft	TA	DX_1	FX_1 m/s	FX_1	FG_1 m/s
Flesland	02.04.2019-00:00	0	mer enn 10 km	2-åttendedeler i 3000 ft og 5 åttendedeler i 4000 ft	3,5	164	10,5	frisk bris	15
	02.04.2019-01:00	0	mer enn 10 km	2-åttendedeler i 3300 ft og 5 åttendedeler i 4000 ft	3,4	159	11	liten kuling	14,8
	02.04.2019-02:00	0	mer enn 10 km	2-åttendedeler i 2500 ft og 5 åttendedeler i 4000 ft	3,3	157	10,8	liten kuling	15
	02.04.2019-03:00	0	mer enn 10 km	2-åttendedeler i 3000 ft og 5 åttendedeler i 4300 ft	3,2	151	9,9	frisk bris	14
	02.04.2019-04:00	0	mer enn 10 km	2-åttendedeler i 3000 ft og 5 åttendedeler i 4200 ft	3,5	147	8,9	frisk bris	13,2
	02.04.2019-05:00	0	mer enn 10 km	2-åttendedeler i 3000 ft og 5 åttendedeler i 4300 ft	3,8	152	8,8	frisk bris	13
Bergen	02.04.2019-00:00	0			4	149	8,2	frisk bris	14,3
	02.04.2019-01:00	0			3,9	148	10	frisk bris	15,8
	02.04.2019-02:00	0			3,9	151	8,7	frisk bris	15
	02.04.2019-03:00	0			3,9	148	9	frisk bris	15
	02.04.2019-04:00	0			4,3	142	9,4	frisk bris	15,8
	02.04.2019-05:00	0			4,6	139	9,3	frisk bris	15,8
Fedje	02.04.2019-00:00				3,6	170	14	stiv kuling	18,6
	02.04.2019-01:00				3,9	156	15	stiv kuling	18,6
	02.04.2019-02:00				3,9	161	14,3	stiv kuling	17,6
	02.04.2019-03:00				4	155	15,7	stiv kuling	20,4
	02.04.2019-04:00				4,2	158	15,5	stiv kuling	19,4
	02.04.2019-05:00				4,4	152	14,9	stiv kuling	18,3

Observations from weather stations in the area around the time of the observation voyage on 2 April 2019. Source: The Meteorological Institute



Numerical ocean model of current conditions in the Hjeltefjord at the time of the accident. Source: The Meteorological Institute

APPENDIX B – FATIGUE, SLEEP DEPRIVATION AND CIRCADIAN RHYTHM

General observations on fatigue

How tired we get and human cognitive functions such as observation, assessment, planning and taking action depend on two fundamental neurobiological processes in the body (Satterfield and Killgore, 2019):

1. The homoeostatic process, an automatic regulation mechanism whereby the need for sleep increases with the period of wakefulness (sleep deprivation). Sleep will once again reduce the need for sleep.

2. The circadian process, which has to do with how the body's biological clock (the body's natural 24-hour rhythm) affects the need for sleep. Our body temperature follows a circadian rhythm. It reaches its lowest point (nadir) in the early hours of the morning, normally between 04:00 and 06:00. After that, our body temperature rises until sometime between 13:00 and 15:00, and remains at a stable high level until sometime between 20:00 and 22:00, when its starts to drop towards nadir. We usually sleep from approximately six hours before until approximately two hours after body temperature nadir. It is difficult to stay awake around nadir. The ability to sleep is low just after nadir, somewhat higher between 14:00 and 17:00 and then drops again until it normally starts to rise between 21:00 and 01:00 (Pallesen & Bjorvatn, 2009).

For an individual to get enough quality sleep over time, these two processes must function well – both separately and in relation to each other. This means that fatigue is the combined result of the homoeostatic and circadian processes.

The need for sleep

The amount of daily sleep needed to avoid running a sleep backlog will vary from one individual to another (the National Competence Centre for Sleep Disorders[1]):

> *The need for sleep varies considerably from one individual to another. When considering our own sleep pattern, it is therefore important to look beyond the number of hours of sleep that we get. The quality of sleep, i.e. the number of hours of deep sleep, is even more important than the total number of hours of sleep. The general rule is that we get enough sleep if we feel rested during the day. This applies regardless of the number of hours of sleep we get during the night.*
>
> *For some individuals, less than six hours of sleep can be enough, while others need nine hours or more to function well the following day. Both can be seen as normal, even if such sleeping hours are uncommon. It is important to remember that people differ in many ways, in height, weight and appearance as well as their need for sleep. Looking at the population as a whole, adults sleep an average of between 7 and 7.5 hours, and the vast majority sleep between 6 and 9 hours.*

[1] See https://helse-bergen.no/nasjonal-kompetansetjeneste-for-sovnsykdommer-sovno/normal-sovn

In the USA, the National Sleep Foundation[2] keeps abreast of research into the need for sleep in different age groups. For adults aged 18 and above, they now recommend 7–9 hours of sleep and that consideration be given to the quality of sleep and not just the number of hours of sleep.

How long it takes to recover after running a sleep backlog varies. Sleep during the day is generally of poorer quality than regular sleep at night, and is therefore not equally suited for restitution from sleep deprivation. Studies by Åkerstedt et al. (2000) show that a good night's sleep is seldom enough to make up for sleep deprivation, two nights is usually enough to feel rested and up to the mark, while three or four nights are needed to recover after a period of material disruption of the circadian rhythm.

Fatigue also varies with the time of day. The most important time sensor in the circadian rhythm is light. Much light reduces melatonin levels and the need for sleep, while dark surroundings increase melatonin production and the need for sleep (Stehle et al., 2011). For most people, the need for sleep increases around 22:00 and reaches a peak between 03:00 and 06:00. In the daytime, the need for sleep increases slightly sometime in the early afternoon, and then drops again until the next night cycle begins.

The following is stated in a review by the Institute of Transport Economics of studies of fatigue in seafarers on civilian vessels (Phillips, 2014):

> *The sleep patterns of seafarers are relatively well documented, and both sleep quantity and quality are poor, especially for those working the popular 6/6 watch. Average total sleep lengths per day seem to center around 6 to 7 hours for many crew, but this sleep is often taken in two or more spells. Continuous sleep periods of desired length are rare.*

Fatigue and functional capacity

It is documented in a number of studies that operators who are affected by sleep deprivation clearly have a higher risk of accidents than others. For example, a study among road users showed that less than six hours of sleep before starting work entailed a fourfold increase in the accident risk, and less than four hours of sleep multiplied the risk by 19. Less than 12 hours of night-time sleep in the course of the last two days before starting work increases the probability of a fatigue-related accident (Philips & Sagberg, 2010).

Research has shown that individuals who stay awake for more than 16 hours or get less than 6 hours of sleep per night tend to show persistent and profound impairment in sustained attention (Satterfield & Killgore, 2019). Trials have also shown that reducing sleep by one hour per night for a week had adverse effects that it took more than three days of normal sleep to remedy. In one study, it was found that two weeks of four hours' sleep per night led to an inattentiveness that was comparable to 88 hours without sleep. Several studies have also demonstrated that 18 hours of wakefulness can be compared with a blood alcohol content of 0.05 per cent.

Studies (Satterfield and Killgore, 2019) also show that the circadian rhythm has an impact on the effect of long periods of wakefulness. In the early afternoon, the circadian rhythm will have the positive effect of reinforcing the feeling of being awake, while it will have the negative effect of reinforcing the feeling of sleepiness during the early hours of the morning.

VanLeuwen et al. (2013) conducted a trial by simulating the maritime watch system and measuring the degree of fatigue after exposing the subjects to both sleep deprivation and circadian disruptions.

[2] www.sleepfoundation.org

One third of the participants in the trial fell asleep on at least one watch in the course of the simulated week-long structure. The highest number of subjects fell asleep on the 00–04 watch, and the number of subjects who fell asleep increased after overtime work and restricted possibilities of sleep. The trial documented how the circadian rhythm and a need for sleep accumulated over time had the combined effect of increasing fatigue and heightening the risk of accidents within the framework of the simulated maritime watch system.

The Bridge Watchkeeping Safety Study (2004) by the UK Marine Accident Investigation Board (MAIB) reviewed in detail the evidence of 66 collisions, near collisions, groundings and other incidents investigated by the MAIB between 1994 and 2003. One of the findings in the study was that a third of all the groundings involved a fatigued officer alone on the bridge at night.

Characteristic effects of fatigue

Fatigue, i.e. the combined effect of wakefulness and the time of day, has three characteristic effects (Satterfield and Killgore, 2019):

1. Sleepy individuals are unstable and unpredictable. It is to some degree possible to compensate for the lack of sleep, but often for only part of the work at hand. Satterfield and Killgore (2019) describe this as follow:

   Together, these data illustrate that performance instability is a hallmark of sleep loss. It is this unstable and unpredictable nature that makes fatigue so dangerous, especially in safety-critical operations.

   Doran et al. (2001) made similar findings:

   Cognitive impairment due to sleep loss does not constitute a gradual performance decline or a complete failure to perform, but rather takes the form of performance instability.

2. Sleepy individuals pay less attention to changes in their surroundings and less attention to the quality of their own work.

3. Wakefulness over time impairs physical and mental resources.

Based on the available research, it appears to be quite clear that fatigue leads to unpredictability and instability, particular in executive functions. These functions are located in the frontal lobe, an area of the brain that, among other things, helps us to handle multiple thoughts and ideas simultaneously, think before we act, handle unexpected situations and stay concentrated.

The following effects of fatigue are also documented:

- Fatigue impairs the capacity for self-assessment and individuals will tend to overestimate their own fitness (Satterfield and Killgore, 2019).

- They will tend to pay attention to what they assume to be the most important factors in a situation, and thus apply a top-down strategy. They will lack flexibility and will not take much note of new factors, and they will have a high threshold for doing anything other than planned tasks (Whitney et al., 2018).

- Individuals affected by fatigue are able to maintain quality in the performance of some tasks, but they have to put more effort into the work (Gould et al., 2009). This reduces their ability to perform tasks other than their primary tasks, i.e. secondary tasks. They take less note of nonconformities in their own performance, and will to a greater extent deviate from procedures without being aware of it.

APPENDIX C: EXCERPTS FROM KEY INSTRUCTIONS FOR FEDJE VTS

The instructions for the Information Service (INS) at Fedje VTS state the following, among other things:

> *The VTS operator shall provide an information service that ensures that information that is deemed to be relevant for the transit becomes available in time for on-board navigational decision-making. Procedures should be in place at minimum to ensure that the VTS issues transit-related information as necessary when:*
>
> - *vessels enter the VTS area;*
> - *vessels start to move within the VTS area;*
> - *vessels anchor in the VTS area;*
> - *the VTS operator deems it necessary;*
> - *a vessel requests information.*
>
> *The VTS operator shall perform the information service so as to give vessels an overview of traffic that could affect their transit (message marker 'Informasjon' /'Information'), including vessels that can be expected to approach from the opposite direction, cross the course line, overtake or be overtaken by the vessel. It is particularly important that vessels approaching, catching up with or crossing each other's course lines are informed of this when visibility is poor.*
>
> *Such information shall be limited to a factual description of the observations made. Information about traffic that can affect the transit should be relevant, and for example consist of the position, identity, intention and destination of a vessel. When the information concerns several vessels/ conflicts, only the number of vessels should be stated. When there is a lot of information to be conveyed, it should be broken down into several messages and made available in time for on-board navigational decision-making.*

The instructions for the Navigation Assistance Service (NAS) at Fedje VTS state the following, among other things:

> *Navigational assistance shall be given when situations arise in which:*
>
> - *a moving vessel requests navigational assistance;*
> - *the VTS operator deems it necessary.*
>
>   *Examples:*
> - *Risk of running aground or collision*
> - *Vessel deviating from the passage plan*
> - *Technical failure of a vessel's navigational equipment*
> - *Vessel uncertain of its position*
>
> *When a situation arises in which the VTS operator deems it necessary to provide navigational assistance, the VTS operator shall provide information, recommendations and instructions as necessary to ensure safe transit. The VTS operator shall continually monitor the vessel's transit and the effect of the information, recommendations and instructions given.*

The VTS operator shall continually assess factors that may have an impact on how the navigational assistance is performed. When a VTS operator considers that a vessel is at risk of collision or grounding or otherwise poses a threat to fairway safety, the VTS operator may instruct the vessel to change course or speed (message marker 'Instruksjon'/'Instruction') to prevent a situation of distress. Such instructions may be used when the VTS operator finds it necessary to prevent loss of human life or injuries, or damage to the environment or property. A VTS operator who considers the time aspect to be particularly critical in a situation may, for example, instruct a vessel to steer to a particular course when that is considered necessary to avoid a situation of distress.

The instructions for the Traffic Organisation Service (TOS) at Fedje VTS state the following, among other things:

2.1 Monitoring of the areas covered by Fedje VTS

Fedje VTS shall continuously monitor traffic within its VTS area for the purpose of detecting situations in which there is a danger of collision or grounding.

In the monitoring of the VTS area, priority shall be given to the following in particular:

- *navigationally challenging areas where, based on experience, the risk of incorrect navigation is particularly high;*
- *narrow fairways with approaching or passing traffic, including fairways where the Maritime Traffic Regulations contain provisions on passing in the same or opposite direction;*
- *areas of crossing traffic where, based on experience, there is a risk of proximity situations/collision, for example the Hjelteskjær area, Fedjeosen and Holmengrå/Grimeskjæret;*
- *vessels carrying hazardous or noxious cargo between Sture, Mongstad and the pilot embarkation areas;*
- *continuous monitoring of vessels in transit subject to traffic organisation or navigational assistance, including monitoring of the traffic situation and the effect of the information, recommendations and instructions given;*
- *continuous monitoring of situations of approaching or crossing traffic under conditions of poor visibility, for example at Brosmosen, Fedjeosen, Vatlestraumen and Kobbarleden.*

Monitoring of the Fedje VTS area shall also detect vessels that:

- *enter the VTS area or leave a quay or anchorage site;*
- *move in contravention of the permissions given by the VTS centre;*
- *whose navigation markedly or persistently deviates from the expected/instructed route;*
- *come into a proximity situation / risk collision;*
- *are moving in contravention of the provisions of the Maritime Traffic Regulations;*
- *are drifting at anchor.*

The VTS operator shall ensure that vessels carrying hazardous or noxious cargo use the mandatory fairway in accordance with Section 124. Vessels carrying hazardous or noxious cargo with a gross tonnage of more than 30,000 tonnes shall normally use the shortest *fairway (Fedjeosen to/from Sture, Holmengrå to/from Mongstad). The VTS operator shall normally grant vessels carrying hazardous or noxious cargo with a gross tonnage of less than 30,00 tonnes permission to choose where to navigate within the mandatory fairway.*

In general, the VTS operator shall seek to facilitate that large tankers can complete their planned passage without being obstructed by other traffic. This means that the VTS operator shall seek to keep other traffic at a safe distance from the tanker.

...

2.5.3 The Grimstadfjord (Haakonsvern) / the Raunefjord / Vatlestraumen

This area is at times heavily trafficked by military vessels, which often sail without AIS or VHF radio notification.The VTS operator must pay special attention to this.

APPENDIX D: EYESIGHT TESTS – METHODS, REGULATIONS, SELECTION

Method

The eyesight tests were carried out by the Norwegian Centre for Maritime Medicine (NSMM), a section of the Department of Occupational Medicine, University Hospital of Bergen, based on the following methods:

Visual acuity

Optec 6500 with ETDRS charts, luminance 85 candela/m^2 (cd/m^2)[1] for the right eye, left eye, and both eyes, respectively, at a simulated distance of 6 metres. Visual acuity is presented in decimal Snellen fractions, in line with the notations used in the regulations. For candidates wearing glasses, corrected visual acuity was also measured. ETDRS charts are in everyday use. The charts have limitations when assessing eyesight quality other than visual acuity, and no strong correlation is found between visual acuity and functional ability in day-to-day tasks or specific maritime tasks.

Colour vision

Colour vision was assessed by the CIE 143-2001 standard (International Recommendations for Colour Vision Requirements for Transport). The assessment includes use of Ishihara-24 plates with interpretation of plates 2–13, the Hardy-Rand-Rittler Pseudoisochromatic Plate Test 4th Edition (HRR4), the Farnsworth D15 dichotomous test, and the Optec 900 lantern test.

The candidates were also assessed using the computer-based Colour Assessment and Diagnosis (CAD) test method. The CIE colour vision standard is based on the consensus of an international panel of experts in 2002. The test instruments used alone are not sufficient to diagnose and quantify colour vision defects, but, combined, they provide a basis for determining the candidate's level of functioning. The Ishihara test, which is used by most maritime doctors, has a high negative predictive value for red-green colour vision impairments. CAD has a high negative predictive value for red-green and blue-yellow colour vision defects and is suitable for determining the candidate's level of functioning and for use in diagnostics.

Contrast sensitivity (contrast vision)

Contrast sensitivity is assessed by Optec 6500, using sine-wave gratings at 1.5 to 18 cycles per degree of visual angle (cpd) for light levels of 3 cd/m^2 (twilight), 3 cd/m^2 (twilight with glare) and 85 cd/m^2 (daylight), respectively.

The findings are assessed at individual spatial frequencies and an index of contrast sensitivity (ICS). No generally accepted standard is available as the first choice for measuring contrast sensitivity.

Still, the applied method is preferred for evaluation of contrast sensitivity, both for scientific and empirical reasons. The various frequency bands are responsible for different parts of image formation in the brain. Low frequencies cover image formation of large, rough structures, while higher frequencies provide detail to the image. The index of contrast sensitivity was developed to simplify the interpretation of frequency data; threshold values of individual frequencies and their importance concerning the quality of vision are not well established. No absolute minimum threshold values for any measurement of contrast sensitivity has been determined concerning occupational requirements. Normative data exists for ICS and frequency data for the relevant group in connection with the use of OPTEC 6500.[2] ICS observed for each candidate is presented as a percentile of the ICS for normal data. And the frequency data are discussed for each candidate. No normative data are available for ICS or frequency measurements for twilight glare exposure (3cd/m^2). This exposure is, therefore presented with the normal data for twilight conditions. ICS and contrast sensitivity is expected to be slightly reduced under glare conditions.

Refraction

Refraction was measured in dioptre (D) using a NIDEK autorefractor based on the average of three measurements per eye. The method indicates refractive disorders but is not fully adequate as the basis for producing optimum corrective glasses or contact lenses.

Rules and regulations

Minimum medical fitness standards exist for personnel who perform specific services in the Armed Forces. The standards are intended to ensure that the personnel have the health qualifications required to work with adequate safety. Medical fitness requirements can be broken down into two main categories: requirements relating to the absence of any illness that might reduce the quality of the service, and standards for sufficient competence (in terms of eyesight, hearing etc.) to perform the service.

Regulations on medical examination of employees on ships

The Regulations on medical examination of employees on Norwegian ships and mobile offshore units, state that any person working on a Norwegian ship must be medically fit for service onboard and not endanger the health and safety of other persons on board. In the regulations, the Ministry of Trade, Industry and Fisheries has stipulated specific eyesight requirements for the different categories of employment onboard ships.

The regulations set out requirements for assessment of visual acuity (distance vision/near vision), colour vision, reading vision, visual angle, night vision, double vision and contrast sensitivity (on indication). The Armed Forces' vessels are not exempt from these regulations.[3]

A specialist assessment is required if reduced night vision is suspected. Following refractive eye surgery and other ophthalmological procedures, which may potentially impair eyesight, an examination by a specialist shall be carried out after the vision is presumed to have stabilised. The aim is to map any occurrence of reduced contrast vision, reduced night vision, halo, starburst or similar effects.

Provisions on military health service and medical assessments (FSAN P6)

In addition to the Regulations on medical examination of employees on ships, Regulation on military health service and medical assessments (*Bestemmelse for militær helsetjeneste og legebedømmelse* – FSAN P6) apply to the selection and follow-up of Armed Forces personnel. The Regulation has been drawn up by the Armed Forces' medical service to ensure uniform classification and selection of military personnel, to safeguard the health of personnel and thereby ensure the Armed Forces' combat capacity.

Regulations restrict the possibility of performing military service with illnesses and functional impairments. FSAN P6 guides the medical fitness standards issued by the different branches of the

Armed Forces. FSAN P6 stipulates normative restrictions in fitness for service in a specified list of diseases of the eye and visual acuity.

Instructions concerning medical requirements for the Navy

The guidelines concerning medical fitness standards for the Navy (*Instruks om helsekrav for Sjøforsvaret*) apply to all personnel serving in the Navy or participating directly in the Navy's activities. The purpose is to ensure that personnel do not suffer from any illness, injury or handicap whereby situations could arise that pose a risk to their own or other personnel's health and safety. The instructions specify medical requirements for the different services based on FSAN P6 and the given assessment figures.

The instructions state that personnel serving onboard a ship shall meet the requirements in the regulations. The guidelines set out specific standards for eyesight and colour vision based on FSAN P6. For officers, the corrected visual acuity shall be at least 1.0 for each eye, and the uncorrected visual acuity shall be at least 0.5 for the best eye and 0.3 for the poorest eye (assessment figure: 7). Colour vision shall be normal.

Personnel who have undergone refractive eye surgery shall present specialist documentation of preoperative and postoperative visual acuity, including contrast vision, and information about the procedure, before they can be assessed as fit for service at sea by a military doctor.

[1] Candela (cd) is the unit of measure for luminance.
[2] Koefoed, VF (2015): *Contrast sensitivity measured by two different test methods in healthy, young adults with normal visual acuity*.
[3] Regulations relating to the application of the Ship Safety and Security Act by the Ministry of Defence's subordinate agencies.

APPENDIX E: DNV GL – SURVEY OF THE SAFETY CULTURE IN THE FLEET AND AMONG THE NAVY'S EXECUTIVE STAFF

Competence and manning:

> *The main impression is that the Navy has robust competence in the different discipline areas. The main challenges associated with competence and manning are first and foremost characterised by issues relating to a shortage of the right resources and a strong perception of safety being ensured through procedures and good preparedness. In addition to professional competence, a mature safety culture requires that all employees in the organisation have sufficient safety competence based on an overall system perspective. This is found to be somewhat weak in the Navy.*

Cooperation and involvement:

> *In general, the Navy is good at cooperating. People work towards common operational goals and are well aware of each other's competencies and responsibilities. The most important challenges identified in the area of teamwork and involvement have to do with the assumption that others are in control and carry out tasks in the best possible manner, and that individual crew members find it challenging to signal that an operation should be stopped or changed. These assumptions can cause an individual to refrain from communicating signals to other officers or the vessel's management. In addition, it is left to the willingness of the vessel's management to respond to the signals. The ability to signal and the willingness to act on signals can both constitute challenges to safety.*

Alertness:

> *The combination of good education, belief in oneself and others, respect for rank (as regards competence) and experience of success (including with a view to safety) can contribute to a high level of complacency. This can impede the ability to stay alert. The need to look out for the unexpected or to continuously use new information to adjust one's own and others' decisions is not always assigned enough importance.*

Conflicting goals:

> *The Navy has generally been observed to have few safety goals in place for its vessels and operations. Weak and few safety goals for the vessels and operations mean that there are often no conflicting goals (which is not always a good thing). This weakens any counter-pressure from the safety culture (see section 2.2.6 Conflicting goals in a safety perspective, 'drift to danger') to strike a balance between operational goals and efficiency goals. If the pressure from the need to perform/complete operations becomes too great, the safety margins can be 'eaten up', which can lead to undesirable incidents and accidents.*

Incentives:

> *There are clear incentives in place for operational success and for advancing one's career in the organisation. At the same time, there are few formal and uniform*

incentives relating to safety. Low status of risk assessment qualifications and safety competence can result in little motivation to focus on risk assessments in general or on incident reporting and improving own competence relating to safety. The organisation has few incentives in place for cultivating certain disciplines and the critical roles of, for example, navigators, and this results in navigation officers serving for a short time and quickly advancing to other roles.

Compliance:

No specific challenges have been defined relating to compliance, but certain impairments exist as a consequence of challenges relating to other dimensions (Incentives and Robustness), which are analysed and discussed under those headings.

Robustness:

Lack of clarity about how to observe and apply rules and regulations can impair the development of robustness in the organisation in the form of building robustness through systems and processes. As a result of the possibility of using exceptions under current regulations, together with lack of clarity on the part of the Navy about how to observe and apply rules and regulations, many people feel that 'the rules and regulations do not apply to us'. This cultural aspect can affect the safety of personnel and vessels in that it underpins the perception that 'it is acceptable to push the limits to deliver on our commitments', and thereby, without being aware of it, exceed what would have been the acceptance limits or tolerance criteria for risk had such criteria been established. The perception that safety is maintained through procedures and good preparedness also undermines the demand for safety goals and impedes the development of safety management.

Organisational learning:

Organisational learning refers to systematic reflection on improvement potential, and thus changing performance. The challenge here is the perception that the work often consists of taking risks, at the same time as it is believed that safety is maintained through procedures and good preparedness. In addition, there is a perception that safety is maintained at vessel level. Underreporting of near-misses and inconsistent handling of reported non-technical incidents mean that the organisation misses out on an important source of learning. Furthermore, distribution and feedback on reported incidents varies from one vessel to another and between the different types of vessel.

APPENDIX F: PICTURES FROM THE OBSERVATION VOYAGE

As stated in Chapter 1.15.3.2 of the report, an observation voyage took place with Sola TS and HNoMS Roald Amundsen on the night of 2 April 2019. The voyage was accomplished by the frigate being in a series of waypoints "Romeo 1" to "Romeo 13". The table below shows the waypoints the frigate sailed through and the approximate corresponding time of the accident voyage.

Planned distance and bearing from HNoMS Roald Amundsen to Sola TS also appear in connection with each waypoint. In the pictures that are from each of the waypoints, the Sola TS is highlighted with a yellow circle.

The voyage was planned so that HNoMS Roald Amundsen should be in the position that HNoMS Helge Ingstad was in the night of the accident while Sola TS should be in the points the vessel was in when it departed from the quay at the accident night. As stated in Chapter 2.1.2.3 of the report, the sea current and wind conditions on the night of April 2 meant that Sola TS came somewhat faster around to a northerly course and was therefore somewhat closer to the frigate than was the case the night the accident took place.

Waypoint	Corresponding time the night of the accident (approx. time hour, minute)	Bearing/range HNoMS Roald Amundsen - Sola TS
Romeo 1 (Fig.1)	03.38	163/7.66
Romeo 2 (Fig.2)	03.41	163/6.91
Romeo 3 (Fig.3)	03.46	163/5.49
Romeo 4 (Fig.4)	03.48	163/4.72
Romeo 5 (Fig.5)	03.50	161/4.02
Romeo 6 (Fig.6)	03.51	161/3.70
Romeo 7 (Fig.7)	03.52	161/3.36
Romeo 8 (Fig.8)	03.53	161/3.02
Romeo 9 (Fig.9)	03.54	161/2.67
Romeo 10 (Fig.10)	03.55	161/2.21
Romeo 11 (Fig.11)	03.56	161/1.92
Romeo 12 (Fig.12)	03.57	161/1.55
Romeo 13 (Fig.13)	03.58	161/1.35

Figure 1. HNoMS Roald Amundsen passing waypoint "Romeo 1". Source: Police/Navy

Figur 2. HNoMS Roald Amundsen passing waypoint "Romeo 2". Source: Police/Navy

Figur 3. HNoMS Roald Amundsen passing waypoint "Romeo 3". Source: Police/Navy

Figur 4. HNoMS Roald Amundsen passing waypoint "Romeo 4". Source: Police/Navy

Figur 5. HNoMS Roald Amundsen passing waypoint "Romeo 5". Source: Police/Navy

Figur 6. HNoMS Roald Amundsen passing waypoint "Romeo 6". Source: Police/Navy

Figur 7. HNoMS Roald Amundsen passing waypoint "Romeo 7". Source: Police/Navy

Figur 8. HNoMS Roald Amundsen passing waypoint "Romeo 8". Source: Police/Navy

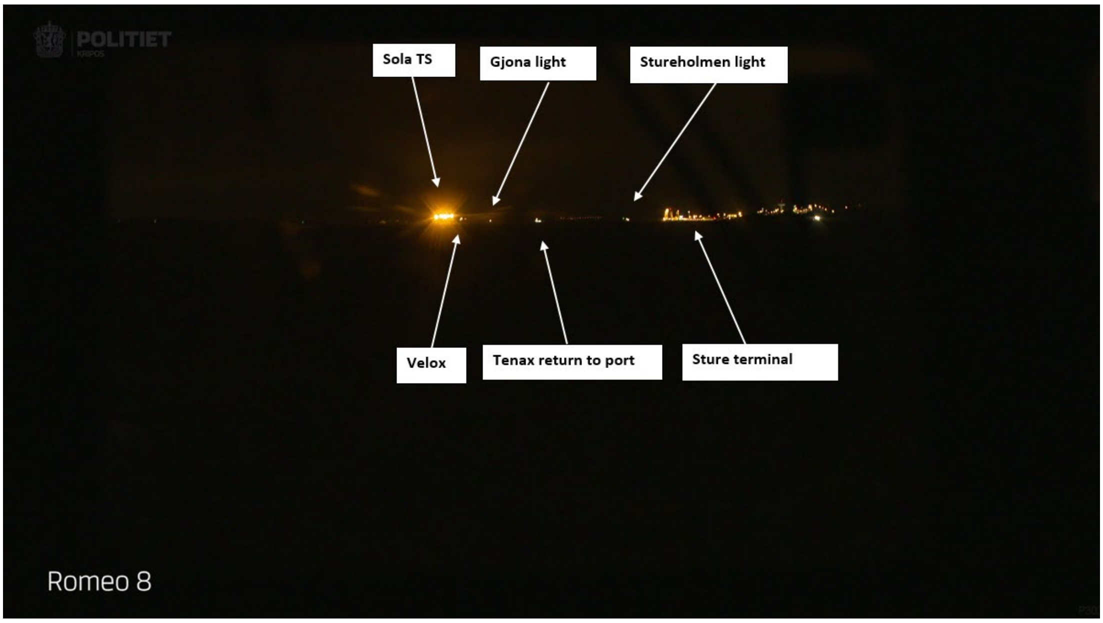
Figur 9. HNoMS Roald Amundsen passing waypoint "Romeo 9". Source: Police/Navy

Figur 10. HNoMS Roald Amundsen passing waypoint "Romeo 10". Source: Police/Navy

Figur 11. HNoMS Roald Amundsen passing waypoint "Romeo 11". Source: Police/Navy

Figur 12. K HNoMS Roald Amundsen passing waypoint "Romeo 12". Source Police/Navy

Figur 13. HNoMS Roald Amundsen passing waypoint "Romeo 13". Source: Police/Navy



Figur 14. Visible objects that could be observed from the bridge of HNoMS Roald Amundsen during the observation voyage. Source: Police/AIBN

APPENDIX G: COGNITIVE AND ORGANISATIONAL CHALLENGES IN A NAVIGATION TEAM

Report to the Accident Investigation Board Norway

By Svein S Andersen, Thorvald Hærem and Dominique Kost

(The authors are listed alphabetically, but have contributed equally.)

About the authors

Svein S Andersen is a professor of organisational studies at BI Norwegian Business School. He has previously been head of the Department of Leadership and Organizational Behaviour and Dean for BI's PhD programmes. He earned his PhD degree at Stanford University based on a dissertation on the organisation of petroleum activities in the North Sea. One of the main topics was how to organise activities so as to leave no room for serious incidents and errors. Theoretical perspectives are mindful organisations and reliable experiential learning. This touches on key challenges in modern organisations, which have to cope with uncertainty and change. One of his main interests in terms of methods is case studies. He has published a vast number of international articles and books. In the last few years, he has taught BI's management programme 'Organizing for the unexpected' together with Thorvald Hærem.

Thorvald Hærem is a professor of organisational psychology at BI Norwegian Business School, and wrote his PhD on how experts and novices solve problems in organisations. He teaches organisational theory and how people make decisions at the individual, team and organisation level. His areas of research cover the same topics. The results of his research have been published in leading international journals such as Academy of Management Review, Journal of Applied Psychology, Organization Studies, Journal of Behavioral Decision Making, Leadership Quarterly, Management of Information Systems Quarterly and Organization Science.

Dominique Kost is an associate professor of organisation and management at OsloMet – Oslo Metropolitan University. She presented her PhD thesis in 2016 at BI Norwegian Business School. Before she started on her PhD, she worked as a personnel management consultant. Her areas of research are virtual teams, communication in crisis situations and digital work. Dominique's PhD thesis concerned performance and coordination of knowledge in virtual teams. She also studies digitalisation and new work methods. Dominique's areas of teaching are management, personnel management and digital management.

Contents:

Purpose and structure of the report

The point of departure are the priorities emphasised in the letter of assignment. The purpose is to contribute a set of theoretical premises for understanding how the bridge team on 'KNM Helge Ingstad' functioned during the period leading up to the accident. The incident was complex and multi-faceted and diversely perceived by those involved. The AIBN's interviews, factual description and mapping of the sequence of events have identified safety problems arising from mistakes and misconceptions, and a lack of barriers. This report sheds light on mechanisms that can help to explain how these types of mistakes and misconceptions arise, and how they can be rectified.

The theoretical perspectives described in this report entail various supplementary approaches. They can be used as the point of departure for further analyses of important human and organisational factors that affect perceptions, assessments and the actions chosen at both the individual and team level. The weighting of perspectives and different explanatory mechanisms provided in the report reflects actual events as described in the available data material.

The first part concerns the question: *What is a team*? It provides a framework for understanding the importance of the factors that can affect a bridge team's capacity for establishing and updating a reliable situational awareness. Factors such as experience, age and fatigue can affect several of the factors discussed.

The second part, *Attention, perception and selection,* highlights factors that affect our ability to pick up on different stimuli, or signals, in our surroundings. What is attention? What characterises inattentiveness and change blindness? What are the human limitations when it comes to judging distances to lights/objects in the dark?

The third part covers the literature on *mental models and situational awareness (SA)*. What is a mental map? What is situational awareness at the individual and team level? How can certain mental schemas and models lead to a rigid situational awareness?

The fourth part, *Sensemaking*, explains some key factors relating to how mental models work. How can individuals in interaction with other team members strengthen their capacity for picking up on and interpreting weak signals that are inconsistent with established expectations? This is important in relation to people's ability to update and develop their situational awareness.

The fifth part, *Routines as a carrier of knowledge and teamwork competence*, explores topics such as the interaction between internalised routines and non-internalised routines, and how internalised routines can be processed to free up cognitive capacity to search for signs of possible deviations from expected patterns.

What is a team?

Teams as organisation

In traditional organisation theory, roles were designed based on the tasks to be performed – and individuals filled predefined roles. This way of thinking was characterised by a hierarchical organisation and clearly defined lines of command. This tradition completely dominated both industrial and military organisations for a long time. Based on this way of thinking, social psychology developed an interest in how to create dynamic and efficient organisations (e.g. Katz & Kahn, 1966). In addition, team theory gradually gained a firmer foothold in organisational theory, especially the part of organisational theory that concerned non-standardised tasks; tasks that demand active attention, situational awareness and fresh thinking. The literature on organisations that cannot afford to fail, known as high reliability organisations (HRO), combines insight from social psychology with organisational theory. Although the HRO perspective does not include a specific team perspective, it emphasises challenges relating to reliable perception, interpretation and learning in situations characterised by complexity and ambiguity. A main focus is how to recognise and manage the unexpected through mindful interaction and sharing of knowledge and information (Weick & Sutcliffe, 2015).

Teams are different from both groups and formal organisational entities. Teams have been defined in different ways (Bass, 1982; Baum et al. 1981; Denson, 1981; Dyer, 1984; Hall & Rizzo, 1975). In a comprehensive study of team behaviour in the US Navy, a team was defined as a set of two of more individuals who interact interdependently and adaptively to achieve specified, shared and valued objectives (Morgan et al., 1986). The study pointed out that the interaction between individuals was partly determined by interaction with machines and machine procedures, leaving too little room for communication and cooperation between the team members, both during training and in the performance of their tasks. This has enabled the performance of tasks to become standardised and routinised. At the same time, it can weaken the mechanisms that create the very dynamics and flexibility that strengthen a team's capacity to handle uncertainty and ambiguity. This weakens the team's ability to pick up on situational elements that fall outside known patterns of variation.

Team structure and sharing of information

How do procedures affect teams working in situations characterised by complexity and ambiguity? In a team, team members have a primary responsibility for specific roles, while roles are performed in interaction, taking account of both the primary responsibility of other team members and the team's overriding objective. A team that works this way creates dynamics that strengthen teams' capacity to continuously pick up on nuances and deviations in ambiguous situations and thereby deal with unexpected incidents before they become critical. This way of thinking is based on the belief that neither the leader alone nor any individual member of the team can be absolutely certain that they have perceived all important factors in the situation correctly. Sometimes, it can be useful to establish teams within the team in order to attend to core tasks. Research into teams also recognises that people are fallible. This is a key point in research into bounded rationality and capacity for reliable learning (March & Simon, 1958; Kahneman, 2011; Weick, 1979). Such a basic view is clearly reflected in research on aviation safety (Helmreich, 2000) and is also an underlying assumption in the theory of reliable organisations (Weick & Sutcliffe, 2015).

Normally, misconceptions will sometimes arise about situational elements, which could undermine the bigger picture and the team's shared situational awareness. A study of aviation safety showed that, on average, such situations arose twice during a flight, but that they usually were corrected (Helmreich, 2000). Active interaction and sharing of information increase the possibility of clearing up misconceptions and identifying signals of danger at an earlier stage (Weick, 1990; Weick & Sutcliffe, 2015). What is special about communication that leads to accidents is not that misconceptions arise but that they are not corrected.

Stasser and Titus (1985) started a stream of research into team communication. They discovered that it is fairly common for critical information not to be shared, precisely because people assume that others have the same information or that the information is unimportant. A meta study on information sharing shows that sharing of unique information is particularly critical to the outcome when the exchange of information is highly structured (Mesmer-Magnus & DeChurch, 2009).

An accident that illustrates the phenomenon of not sharing information and difficulties in perceiving approaching light signals is described by Perrow in the book 'Normal Accidents' (1986). The master of a coast guard vessel misinterpreted a ship's lights as lights from a vessel they were catching up with, while the lookout correctly perceived the lights to be from a ship approaching in the opposite direction. The lookout thought the master shared this perception and did not say anything. As the master thought he was about to overtake the ship they were catching up with, he decided to provide more room for manoeuvring as they were approaching the mouth of the Potomac River, and made a sudden turn to port. As a result of this, the coast guard vessel collided with an approaching cargo ship.

A team that is part of a hierarchical structure required to be capable of handling complexity and ambiguity in dynamic environments can give rise to challenges. The contrast between maintaining a robust focus and being susceptible to signals that can refute or modify the established situational awareness is particularly challenging.

Attention, perception and selection

Distinguishing between foreground and background

Attention, perception and selection of information in organisations have been widely elucidated in studies on cognitive limitations and bounded rationality (Neisser, 2014; Weick, 1979; Simon & March, 1958; Tversky & Kahneman, 1974; Kahneman, 2011). Perception is about whether and how individuals perceive and process external stimuli (see e.g. Schacter, Gilbert & Wegner, 2009). Sensitivity to different stimuli reflects general human characteristics, but can be affected by experience, training, organisational culture and routines. Essential in this context is the ability to identify and understand changes that may significantly affect the interpretation of situations. This ability has received considerable attention in studies of military personnel, and also in the transport sector. Keywords are attentional limitations and change blindness. Since the late 1940s, it has been common knowledge that some types of change are sometimes overlooked because they are camouflaged by familiar and easily recognisable main patterns.

A classic example is Bruner and Postman's (1949) experiment, in which the colours of playing card suits – such as hearts and spades – were switched. It turned out that there was a strong tendency for the card suit shape to be more dominant than colour, so that, for example, red spades were identified as spades. Mazza and Turato (2005) show that changes can be camouflaged by 'drowning' in foreground or background patterns, so that it becomes difficult to distinguish objects from the foreground or background. One explanation is that automated cognitive processes relating to the recognition of main patterns are less demanding than extracting information from variations within such a pattern.

We know from research into road safety in the USA that drivers are often blind to unexpected road users. For example, the most frequent accident situation encountered by motorcyclists is when a car crosses the opposite lane to turn left. Car drivers check whether the road is clear by looking for cars approaching in the opposite direction. If no cars are approaching, they make the turn, failing to detect and recognise any oncoming motorcycles (Hurt, Ouellet & Thom, 1981, quoted in Simon & Chabris, 2011). This was and continues to be a dangerous situation for motorcyclists. A total of 65% of accidents involving motorcyclists occur in situations where the other vehicle violates the motorcyclist's right-of-way (Simon & Chabris, 2011). Simon and Chabris coined the phrase 'inattentional blindness' to describe this blindness to the unexpected.

Another classic example of inattentional blindness is Simon and Chabris's (2011) 'invisible gorilla test'. The participants in an experiment were asked to watch a video of two teams of students passing a basketball around. They were asked to count the number of passes made between players wearing white. At one point in the video, a person wearing a gorilla suit appears between the players, beats his chests and leaves the area. After watching the video, the participants were asked whether they noticed anything out of the ordinary. Alternatively, they were asked directly whether they noticed a gorilla in the video. It turned out that 46% of the participants failed to notice the gorilla. Simon and Chabris explain this as a manifestation of 'inattentional blindness'.

The problem is not that the gorilla is difficult to see – quite the contrary. It is an example of a phenomenon called selective attention control. Those involved do not notice special or unexpected events because their attention is focused on one task in such a way that other situational elements are filtered from their awareness. The overall picture, and any changes to the overall picture, do not become part of their continuously updated situational awareness.

Changes in situational awareness

There are several mechanisms that can contribute to maintaining a gradually more incorrect situational awareness. The focus on training specific skills can draw attention away from weak signals of danger, in the same way as counting basketball passes distracts attention from signals that the gorilla is moving through the group of players.

Even in, for example, a well-known training situation, training in specific skills can distract from more actively seeking information to confirm or adjust the overall picture of the situation. This is in line with findings by Chen (2008) and Chen and Treisman (2008), which have shown that the likelihood of not registering a change object increases with the object's distance from the focus of attention.

One type of study on attention concern people's perception of the size and speed of changes. Big and rapid changes are, naturally, easier to identify. Small, gradual changes can be associated with change blindness, however. The likelihood of detecting objects increases if the object is moving *towards* rather than *away* from the observer (Cole & Liversedge, 2006). In cases where the observer moves relatively quickly towards the object, however, this may camouflage the object's movement. The above example from Perrow (1984) illustrates precisely the fact that moving towards an object giving off light can make it more difficult to determine the movement of that light.

Another factor relating to awareness at the individual level is that, even when we have surplus cognitive capacity, we continue to employ economising mechanisms as long as possible, even if the usefulness and quality of our choices become sub-optimal. Research has shown that, using heuristics, we make choices where simple reflection or calculation could give us a better range of choices (Gigerenzer, 2000 and Kahneman, 2011).

Team level

In organisations, attention is a scarce resource. Organisations economise on attention. Basic organisational theory (Simon & March, 1958) claims that people often make endeavours to think and act rationally, but that they only manage to do so to a limited degree. Our capacity and ability to search for, process, store and retrieve information is limited. Organisations therefore develop routines and procedures to rationalise the processing of information, for example to select and deselect both relevant and irrelevant signals, interpretations and options for action. Organisations are required to steer attention towards certain things, at the same time as other situational elements become less important. Strong programming of this type has major advantages when the tasks and surroundings are stable and well understood. Given variable tasks and surroundings, however, situational awareness requires more active, open searching for and updating of information. Extensive research shows that striking a good balance can be challenging (March & Simon, 1958; Scott, 2015).

Newby and Rock (1998) distinguish between two paths to attentional focus and situational awareness. One main path is top-down processing of observations. This is characterised by active search for certain stimuli and patterns that match the internalized expectations of the organisation's members. To varying degrees, such individual expectations may be overlapping reflecting education, training and experience. This type of search mode is sensitive to weak stimuli, as long as such stimuli are consistent with expectations. Inconsistent stimuli or signals are more easily overlooked, and there is thus a tendency to perceive what is seen as confirmation of having understood the situation correctly.

Another path to situational awareness is bottom-up processing of observations. This means that the search process is triggered by stimuli or signals that are not automatically understandable, but that activate a search for pattern recognition. Ensuring that signals are not ignored requires a certain signal strength and information richness on which further identification and interpretation can be based.

Both perception and interpretation can be more demanding in such situations. The capacity to detect the unexpected can be overruled by routines, but can be strengthened through exercise at the individual and team level.

Psychology is not the only discipline that has studied such mechanisms. Sociologist Thorstein Veblen (1914) introduced the term 'trained incapacity' to describe how professional knowledge can limit people's perspective: 'that state of affairs in which one's abilities function as inadequacies or blind spots'. This means that training and experience can lead people down the wrong path when faced with new situations or new elements that can challenge their established conceptions. Rochlin (1991) uses the term 'scenario fulfilment' to describe the misconceptions that caused the US Navy vessel 'Vincennes' to accidentally shoot down an Iranian passenger plane in 1988.

Limited attention can be seen as economising with scarce resources, and is the first phase of the perceptual cycle (Neisser, 2014; Weick, 1979). It entails a selection of signals or indicators for further processing. Specific and targeted reporting (communication) between roles entail economising with one's own and others' time and attention. Rationalising the use of time drives rationalisation of attention in other areas.

Challenges relating to attention and the ability to detect critical factors in a situation can be reinforced, but also impeded, through organisational measures. This is well documented in research, but the documented effects are not absolute. It is a question of propensities or probabilities, and may vary from person to person and from one situation to the next. This means that individuals in a team can perceive stimuli in different ways. Some will perceive and interpret critical signals correctly, while others will misperceive such signals and some will ignore them completely.

In a well-functioning team, characterised by open and honest sharing of observations, the effect of mistakes and misconceptions by individuals can be corrected (Helmreich, 2000, pp. 781–784). Even if someone misunderstands or ignores important signals, the team can develop a realistic situational awareness. Furthermore, a hierarchical context and lack of communication training can give rise to expectations and create barriers to the utilisation of diversity in observations and approaches. Rochlin (1991:116–17) points to organisational challenges relating to the perception and integration of different situational elements in dynamic and ambiguous situations. In the study of 'USS Vincennes', he describes what the officers on the bridge refer to as 'having the bubble', meaning to establish and maintain an overall reliable situational awareness. It was clearly communicated who had 'the bubble' at any time.

Another general challenge in teams is to develop and maintain shared models for understanding situations. Perception is about placing stimuli in mental models and thus generating observations that, in turn, form the basis for situational awareness. The ability to create a realistic, nuanced situational awareness depends on which models are mobilised and how nuanced they are. This makes creating a correct common situational awareness a complex and challenging task. This is addressed in the section below.

Situational awareness (SA) and transactive memory systems (TMS)

There are many different forms of mental models in teams, but two in particular are important to shedding light on individuals and teams' role comprehension, cooperation and adaptive ability, namely situation awareness (SA) and transactive memory systems (TMS), or shared information about own and others' knowledge and expectations.

Situational awareness

Endsley (1995) originally studied situational awareness among air traffic controllers and was interested in explaining how they were able to retain control of the situation, with the air full of planes scheduled for landing and the airport full of planes scheduled for take-off. The term has later been used in organisations engaged in land, sea and air operations, and in all organisations involved in crisis management and defence tasks. Both Endsley and others have subsequently taken an interest in how this situational awareness is handled by teams. What is their shared situational awareness?

Situational awareness (SA) is defined as: 'the perception of environmental elements and events with respect to time or space, the comprehension of their meaning, and the projection of their future status' (Endsley, 1995, p. 36, 2015). As indicated by the definition, the model can be broken down into three levels: Level 1 – perception of the elements in the environment, Level 2 – comprehension of the relationship between these elements, Level 3 – projection of future developments and events (Endsley, 1995).

A recent study looked at the relationship between Level 1, 2 and 3 SA, and team performance (Valaker, Hærem & Bakken, 2018). It found that Level 2 and 3 SA are more important in explaining performance than Level 1 SA, while Level 1 SA is related to the building of Level 2 and 3 SA.

The same study also found that it is more difficult to integrate Level 2 and 3 SA (directly critical to the result) when communication takes place in a distributed setting – in other words not co-localised and face to face.

At the individual level, role comprehension, knowledge and job performance skills are important factors in developing situational awareness. Experience and expertise influence what information we seek, how it is interpreted and, finally, our situational awareness (Endsley, 1997; Endsley, 2006).

At team level, it is important to distinguish between shared situational awareness, i.e. the degree to which the team has a shared understanding of the surroundings, and accuracy, i.e. whether this shared understanding of the surroundings is correct (Salmon et al., 2008). In other words, a team's shared understanding of the surroundings is not necessarily an accurate understanding. The teams situational awareness covers not only an understanding of the tasks to be carried out, but also the coordination processes between the team members (Salas, Prince, Baker & Shrestha, 1995).

Situational awareness at the individual and team level are linked. If a team member perceives new information about the surroundings and communicates it to the rest of the team, SA is also developed at team level (Salas et al., 1995). Information sharing also works as a control mechanism. When team members share or coordinate their individual understanding of the situation, it is possible to make corrections to the team's situational awareness. If critical elements of information are missing, the whole team can develop a shared, but incorrect understanding of the situation. Critical elements of information are related to the dynamic elements of information that are necessary to performing the task. Situational awareness is not an accurate picture automatically created by individuals who play a role in a team. Many factors contribute to this.

Rigid situational awareness

An incorrect situational awareness on the part of the team has in fact been a factor in many of the accidents that have occurred in the Navy. Often one or a few individuals are in possession of critical information that could have contributed to a more accurate situational awareness. In 13 of 21 groundings with Norwegian MTBs that occurred in the period 1989–2007, members of the navigation team possessed critical information about the situation that they failed to share (Neverdal, 2017). The reason why such information is not shared can be the assumption that the information is already know to everyone, or an expectation that everyone with greater authority would correct any errors in the shared understanding. That team members fail to share unique information is a well-established finding in what is known as 'hidden profile' research (see Lu, Yuan & McLeod, 2012, for an overview of relevant literature).

Critical events or situations require teams to acknowledge and communicate changes in the environment (Burke et al., 2006). In other words, the team must first acknowledge that an assumption about the environment is incomplete or incorrect. This will cause the team to look for new information to form an updated or new understanding of the situation (Waller & Uitdewilligen, 2009).

Research into the relationship between communication media and the ability of information to change people's understanding (in the course of a given time interval) has been conducted since the late 1970s and is known as media richness theory (Daft & Lengel, 1986; Dennis & Kinney, 1998; Valaker, Hærem & Bakken, 2018). A more recent version is called media synchronicity theory (Dennis, Fuller & Valacich, 2008; Brown, Dennis & Venkatesh, 2010; Valaker, Hærem & Bakken, 2018). The core finding is that the ability to convey rich information varies between different communication media. Face-to-face communication is rich because of its high capacity to provide synchronised feedback, to send multiple signals, to adapt the information to the receiver etc. At the other end of the scale we find written information, which is considered leaner (less rich) in relation to these properties.

Research on media richness theory and situational awareness (SA) is relevant in this context. Fundamental to media richness research is the difference between 'conveyance' (transmission) and 'convergence' (integration) (Dennis, Fuller & Valacich, 2008). It has been established that these two processes are necessary to achieving a shared understanding. Leaner media such as radio and morse code are effective for transmitting unequivocal information, but not for integrating equivocal information into a shared understanding. Face-to-face communication is most effective for integration.

Transactive memory systems (TMS)

TMS consists of shared knowledge or a shared understanding of who is an expert, plus unique knowledge that only the expert possesses, as well as the coordination process through which team members use and update each other's knowledge. In other words, as a team member, you know who you must ask to get help. This makes TMS an important part of the coordination of knowledge and tasks in a team (see e.g. Lewis & Herndon, 2011; Lewis, 2003). A well-functioning team is one where the team members have different but overlapping cognitive schemas. This applies to teams composed of domain experts. It will also be the case where team members have different roles – they will develop specialised schemas for specialised tasks. This will entail a differentiation of schemas – and a differentiation of TMS. TMS is often confused with the notion of a shared understanding, but it will often be differentiated with only certain parts shared by the whole team.

Extensive research shows that TMS is important to the team's performance, learning, creativity and efficiency (for an overview, see e.g. Ren & Argote, 2011). TMS also stimulates coordination in teams, a phenomenon that has been studied in e.g. special police forces (Marques-Quinteiro, Curral, Passos

& Lewis, 2013). At the same time, research has also identified a dilemma for TMS: Too much specialisation in a team can prevent effective coordination, while a too high degree of coordination between the team members prevents specialisation of the different roles (Reagans, Miron-Spektor & Argote, 2016).

Team theory states that individuals with different roles, knowledge and information can develop different assessments that can make it difficult for the team to establish a shared understanding of the problem. This research is based on teams characterised by close, binding cooperation on problems that require fresh thinking and flexibility (see e.g. Majchrzak, Jarvenpaa & Hollingshead, 2007). In a team with a hierarchical structure, reinforced by some members being experts while others are novices, the challenges are somewhat different. Research has shown that active information sharing about each other's roles helps teams to develop TMS (Pearsall, Ellis & Bell, 2010). Research in this area also underlines that TMS covers not only the understanding of tasks, but also cooperation and coordination that is not inherent in the formal roles (Lewis, Lange & Gillis, 2005).

Research into TMS has demonstrated that teams in which members are replaced continue to interact in the same way as before they were replaced. In other words, new team members are not actively included in the team's coordination process and communication, which hampers the team's performance and the updating of the TMS (Argote, Aven & Kush, 2018; Lewis, Belliveau, Herndon & Keller, 2007).

Furthermore, even in a normal watch change between two team members, the handover does not necessarily include any clarification of role expectations or coordination of information with the rest of the team, which would help to form the TMS (Pearsall et al., 2010). A new team member may have a slightly different situational awareness and other assumptions concerning roles and coordination than the rest of the team, who have just worked with another team member. If the new team member has a different understanding of roles, expertise and knowledge than the rest of the team, this may undermine the team's TMS. This means that it is not sufficient to have routines for or written information about expertise and roles. This is especially the case in teams whose members change (Majchrzak et al., 2007).

TMS is a precondition for shared SA, but nonetheless not a guarantee for the SA being accurate and resulting in good decisions. Below we will take a closer look at how errors and misconceptions in SA and decisions can arise and how they can be prevented.

Sensemaking and decision-making biases

Information richness and selective perception

Forming an understanding of one's surroundings is more than a simple physiological process where signals are received by sensory organs and generate an accurate picture of the situation. Often, perception will be partly based on weak, ambiguous signals that need to be interpreted and compiled to form a picture of the situation. The nature of the situation can change if just one or a few signals are misinterpreted or ignored (Weick, 1995). Sensemaking is an ongoing retrospective rationalisation process in which individuals seek and give meaning to their observations and experiences. Active, mindful updating of one's situational awareness is critical in environments characterised by change, uncertainty and ambiguity. A key contributor to the understanding of such processes is Karl Weick (2001). His model includes three sub-processes: 1) a variation in the surroundings, 2) a selection process, and 3) a retention process. Each of these sub-processes leaves room for misconceptions, but also reliable learning:

1) There are vast numbers of elements of information that people can potentially notice – it is invariably a question of whether all the elements are perceived.

2) Existing cognitive maps activate a selection process in which the signals marked as relevant or important are selected for further processing. The critical question is whether the importance of the signals is correctly assessed.

3) This is also how we remember the signals that match our existing cognitive maps. Signals not marked as relevant are often not stored, in other words ignored – despite the fact that they may have been selected in the first round.

An important topic that complements research on sensemaking is related to intuitive processing and decision-making biases (Tversky & Kahneman, 1974; Russo, Schoemaker & Russo, 1989; Kahneman, 2011). A key insight from this research is that people can switch between intuitive and analytical information processing. Intuitive processing is rapid, parallel, automatic, associative, context-dependent, and affected by extensive learning and experience. Analytical processing is slower, sequential, controlled, more context-independent, cognitively challenging, but can be learned quicker through explicit rules and algorithms (Stanovich & West, 2000).

Many studies find that, after cognitive exertion and mental fatigue, the processing of information will be more intuitive (see e.g. Pocheptsova, Amir, Dhar & Baumeister, 2009) and less analytical. The strive for complete analytical processing of all information is reduced in step with the depletion of cognitive resources. It is not realistic to expect decision-makers to be able to carry out an extensive, complete analysis of all elements of information in every situation.

The expression ‘switching cognitive gears’ is used in literature to describe how people’s cognitive capacity also depends on their ability to switch between different types of cognitive processing, i.e. from automatic to conscious and analytical processing. People’s ability to understand what type of processing is required is decisive in critical situations (Louis & Sutton, 1991).

It is a well-established fact that people act as if they use simple rules of thumb to simplify situations and seek information. Research on decision-making biases draws an important distinction between simplification heuristics and recognition heuristics (Kahneman & Klein, 2009). Both types are central to intuitive information processing. They represent different qualities and biases in relation to routines and interaction (Pentland & Hærem, 2015). Simplification heuristics are the main focus of Tversky and Kahneman’s research on decision-making biases. It is a common phenomenon and has a central place in the extensive literature on bounded rationality. Recognition heuristics was one of Herbert Simon’s interests in seeking to understand the differences between experts and novices’ processing of information (1987, 1992).

Several areas in the psychology of decision-making have built on and further developed this research. There is widespread agreement that people handle or reduce this complexity in two main ways (Kahneman & Klein, 2009; Pentland & Hærem, 2015); through simplification logics and recognition logics. Simplification logics reduce the complexity, while recognition logics also manage the complexity to a greater extent.

Simplification mechanisms entail selecting signals in situations that match broad, coarse categories, or categories that are easily accessible because they are clear or have been extensively or recently activated. This type of categorisation can activate a third type of simplification mechanism, whereby information is sought to confirm that the signals are not critical and that the search process can be concluded.

Recognition mechanisms are to a larger extent based on experience and expertise, where the reflection is more conscious and goal-oriented. The quality of the pattern recognition is based on extensive experience, conscious reflection and training in strong expert environments where challenges are ensured through sufficient variation in the situations that arise. In summary, we can say that recognition heuristics counteract the tendency towards intuitive simplification.

Excessive confidence in own knowledge, and confirmation bias

Researchers find that one of the most detrimental cognitive biases is overconfidence. Overconfidence in one's own knowledge is the belief that you possess more accurate and reliable knowledge than you actually do (Kahneman, 2011; Moore & Healy, 2008). Consequently, your belief in the correctness of your judgements is greater than the objective accuracy of those judgements (Kahneman, 2011; Moore & Healy, 2008). Overconfidence has a number of effects in addition to the effect of being wrong. It can reduce information seeking and the analytical processing of information, and thus lead to misjudgement based on intuitive misconceptions. At the group level, however, the effects seem to be even greater.

Overconfidence can undermine open communication and thus limit other people's possibility of developing good situational awareness. Recent research shows that elaboration of information, providing increased detail on the core of messages, improves communication and team performance (Mesmer-Magnus & DeChurch, 2009; Hærem, Valaker & Bakken, 2014). Individuals who have excessive confidence in their own situational awareness seem to engage less in elaboration – this becomes especially clear when the communication takes place through rich media, such as face-to-face communication (Hærem, Valaker and Bakken, 2014).

Kruger, Epley, Parker and Ng (2005) found that overconfidence was driven by, among other things, egocentrism – i.e. referring to one's own perspective while neglecting the fact that the rest of the world does not necessarily share that perspective. Egocentrism is also related to what is referred to as the fundamental attribution error – i.e. attributing what is going on to ourselves. It is well known from research on navigation that egocentrism in the design of bridge consoles and instruments affects situational awareness (Wickens & Prevett, 1995). Wickens and Prevett found that, with an egocentric design, in other words a design based on the navigator's perspective on the surroundings, the navigator would keep a more steady course, while an exocentric design made it easier for the navigator to identify dangers along the adopted course. Egocentrism and overconfidence can prevent a good development of situational awareness at the individual level, in addition to affecting communication (Kruger, Epley, Parker & Ng, 2005) and potentially having a major impact on the team's situational awareness.

Strong confidence in own knowledge increases the search for affirmative information. This is called the confirmation bias. This means that new observations and active searches for new information are made with a view to confirming the established situational awareness.

One of the most commonly used strategies in information searches is to search for confirmation that one is right. This is also the strategy that results in the highest number of decision errors (Nickerson, 1998). Kray and Galinsky (2003) investigated effective strategies for avoiding the confirmation bias and found that introducing what are known as counterfactual mind-sets – or, in simpler terms, asking 'what if...' – was highly effective. When asked 'What if...', decision-makers generated alternative hypotheses that refuted their original hypothesis. This does not happen automatically – but hypothetical questions will trigger an analytical processing that can generate alternative interpretations of the situation. Those with high confidence in their own knowledge are not likely to ask 'what if I'm wrong and it's actually this way or that way …'.

Mindful interaction

Inspired by Ludwig Neisser's (2014) studies of perception as a perceptual cycle, Karl Weick (1979) developed a model for organisations' sensemaking processes. One of the main conclusions in that research was that avoiding confirmation bias is difficult. Individuals and organisations are largely self-referential systems. Thinking outside our own web of existing knowledge is as difficult as it is to discredit our own assumptions. A key topic in Karl Weick's research was how organisations and teams can avoid being trapped by their initial assumptions by making organisations engage in more mindful information processing.

Much of the research into human factors and interaction in demanding situations originates in the US Armed Forces. One officer describes the environment on an aircraft carrier as follows:

> *Imagine it's a busy day, and you shrink San Francisco airport to only one short runway and one ramp and one gate. Make planes take off and land at the same time, at half the present time interval, rock the runway from side to side and require that everyone who leaves in the morning returns that same day…Turn off the radar to avoid detection, impose strict controls on the radio, fuel the aircraft in place with their engines running, put an enemy in the air and scatter live bombs and rockets around. Now wet the whole thing down with seawater and oil, and man it with 20-year-olds, half of whom have never seen an aircraft close up…'* (Rochlin, LaPorte & Roberts, 1987)

'Although naval aircraft carriers represent a million accidents waiting to happen, almost none of them do' (Wilson (1986) in Weick & Roberts (1993). In a classic study of interaction on board an aircraft carrier, Weick and Roberts (1993) describe how the collective consciousness required by a mindful organisation is created through heedful interrelating whereby shared mental models are developed. They describe how shared mental models, the team's 'collective mind', contribute to the formation of reliable opinions in teams and organisations. A key point in this research is that interaction and

interactive norms are not primarily formed by written rules and routines – they arise as a result of observed actions and interaction with others.

The theory on mindful interaction links theories about SA (interpretation of situations) with routines (patterns of interaction). Together, they point out that mindful interaction can identify early signs that something has been misconceived, that the situational awareness needs to be adjusted, and that interaction has taken a wrong course. As previously discussed, it is normal for misconceptions to arise, but it is also normal for such misconceptions to be corrected.

Interaction and exchange of information are largely controlled by formal roles and rules. In a military organisation, this basic structure needs to be clear and unambiguous. This provides clarity in complex, stressful situations. The challenge is that it also limits the possibility of utilising the diversity of information that individual team members can pick up on.

In organisations with stringent hierarchical and structural elements, interpretation of signals will have to take place within a fixed framework (Weick, 2001). Behavioural patterns set clear limits for who is to say what to whom. Communication often goes one way. There will be less room for doubt and for speaking out if something is perceived as ambiguous, and perhaps wrong, in relation to the situation being responded to. Research from military and civil aviation shows that active exchange of information and articulation of doubt can modify the effect of a hierarchy. Such sharing of information leads to increased vigilance and openness to detecting weak signals before they become a serious problem. Mistakes will occur, but the capacity for correcting mistakes increases.

Sharing of information and weak signals

Weick and Sutcliffe (2015) talk about how weak signals of danger become strong and clear through a crystallisation process, but this process requires a certain amount of time. Mindful interaction involves questioning both individual and shared interpretations. This ensures that assumptions are not taken for granted. Some degree of uncertainty – not certainty – will therefore often be present in organisations that have the capacity to handle unexpected situations.

In other words, we intuitively seek information that will confirm our existing mental image. Such confirmation bias can also be reinforced by overconfidence in one's own situational awareness, as discussed above. As a result of these mechanisms, people do not actively consider alternative explanations. Hærem, Valaker and Bakken (2014) also found that this confidence in own situational awareness on the part of a team member also spreads to the rest of the team. This applied to both overconfidence and underconfidence. Such groupthink is a phenomenon partly driven by the search for sources of certainty rather than uncertainty. Most of the initial research on groupthink was conducted in the 1970s (Janis, 1972). It has subsequently been followed up in organisational research on a regular basis, but it is overconfidence, i.e. people's ability to develop excessive confidence in their own abilities, that has received the most attention. A main point in theories on mindful organisations (Weick & Sutcliffe, 2015) is that people and organisations must systematically cultivate a certain amount of doubt as to whether they have understood everything correctly. This stimulates vigilance, which counteracts lack of updating or rigidity in situational awareness.

Routines as carriers of knowledge and interaction competence

Routines as practice

Routines are often defined as repetitive, recognisable patterns of interdependent actions (Feldman & Pentland, 2003). Routines can be understood at both the individual and organisational level. Here, we will primarily discuss routines at the organisational level, where the pattern of action is partially carried out by different individuals. How this takes place in a team is closely connected to the concepts of mental models and transactive memory systems.

Routines are also important carriers of organisational knowledge. Since efforts are continuously made to update norms to align them with practice, the interaction between norms and practice is a key aspect. Norms and practice inform each other. It is not always the case that norms update practice – it should perhaps just as often be the other way round. Confusion may arise in the interaction between ideals and practice about the right way to perform a task.

Routines are internalised in different interpretations at the individual level. They are formulated in ways that enable the development of mutual expectations of behaviour. This makes it possible to observe deviations and clarify misconceptions and align patterns of behaviour over time. It is often an advantage for individual routines to be based on a shared understanding of goals and responsibilities, especially in a closely connected system.

Routines thus comprise both a formal idealised component and a practice-related component. Examples are idealised descriptions of how jobs are to be performed. How the tasks are actually performed will often differ from the idealised norm (Feldman & Pentland, 2003). Usually, this discrepancy will be functional and practice will be more expedient than the idealised norm. The routine as described seldom matches the situations that arise. Unexpected events require adaptation and experienced decision-makers who are capable of adapting the routines to the situations that arise (Suarez & Montes, 2019).

Mindful and mindless information processing

The point of well-learned routines is that actions can be performed quicker and that it is easier to keep up with changes in the surroundings. Routinised tasks mean that tasks can be performed automatically and thereby take up less information processing capacity (March & Simon, 1958). In organisational psychology, this is often called mindless processing (Pentland & Hærem, 2015; Laureiro-Martinez, 2014). Mindless processing does not mean that the decision-maker fails to think, but leaves room for devoting attention to more important factors, such as scanning the surroundings for signs of deviations from the expected pattern.

More training and experience means that routine tasks take up less attention and free up capacity for mindful processing of weak signals of potential dangers (March & Simon, 1958; Weick & Sutcliffe, 2014), Mindful processing means to use one's cognitive capacity to question interpretations of intuitively accepted information and to conduct activities to detect weak indications that a nonconformity could be about to arise.

Laureiro-Martinez (2014) defines the degree of mindful processing as the degree of cognitive control skills employed. The concept stems from neuroscience research and covers cognitive functions of an 'executive' kind that allocate attention, control short-term memory, planning and the generation of options for action, and govern the capacity for reflection (Bargh & Chartrand, 1999; Barkley, 2001; Laureiro-Martinez, 2014). A practised team strikes a balance between mindless and mindful processing so that a minimum of cognitive resources are spent on routine tasks and awareness is allocated to scanning the surroundings and to internal processes to detect threats to continued safe operation.

Simultaneous training and regular operation is trying for the balance between mindful and mindless processing. The fact that normal routine tasks are not conducted automatically distracts attention from other requisite tasks – and occupies the attention of team members who are charged with ensuring that the training is conducted as planned. This can reduce the capacity that would normally be spent on looking out for nonconformities and weak signals of unexpected incidents.

Having to review something again reduces the amount of attention available to detect potentially important signals. Team members get thrown off their routines when things do not go according to plan, and novices need time to get back into the routine. Experts rarely get thrown off their routine – and will in any case get back into the routine more quickly (Perrow, 1967; Hærem & Rau, 2007). This means that novices have much less capacity to look out for weak signals of danger (mindful processing) than experts. Specific training is particularly important in the case of novices. The training should also address how to interpret unclear or ambiguous signals that may be important and relevant. This requires that the training includes communication and mindful interaction between all members of the team.

Brief summary and discussion

The purpose is to contribute a theoretical framework that can inform the understanding of how the bridge team on 'KNM Helge Ingstad' functioned during the period before the accident. The report sheds light on mechanisms that can explain how errors and misconceptions arise and how they can be corrected. The report outlines several approaches to further analyses of central human and organisational factors.

The first part concerns how structures, division of labour and procedures govern and limit information sharing in a team. What challenges create a high degree of structuring in relation to ambiguous and unexpected elements in the situation.

The second part discusses how attention, perception and selection can give rise to particular challenges in situations where it is difficult to distinguish foreground from background and detect weak signals of changes in the situation.

The third part discusses how situational awareness is created at individual and team level. It addresses challenges associated with developing the three levels of situational awareness at team level, and how this relates to communication through rich and lean communication media. The second half of this part discusses how a transactive memory system (TMS) in the team can compile knowledge for mindful interaction, and points to known challenges in achieving this.

The fourth part discusses how a team interprets weak signals in relation to adjusting or not adjusting their situational awareness. It also contains a discussion of how people process information intuitively and analytically – and how intuition can potentially lead to misinterpretations. Two decision-making biases relevant to establishing situational awareness are also discussed.

The fifth part addresses how routines are translated into practice and how the resultant practice can be functional or dysfunctional in different settings. It also addresses how learning new routines can absorb cognitive capacity, thereby reducing the capacity for more active, mindful processing of weak signals.

In total, we can say that the different parts of the document address different forms of common perceptual and cognitive limitations and the potential interplay between them in a team. It is a challenge for any organisation to deal with human fallibility by strengthening mechanisms that can clarify mistakes and misconceptions that can arise in situations not fully covered by established action routines.

All members of the team are required to assume a more offensive, exploratory role in situations characterised by unclear and ambiguous signals than in familiar situations of little uncertainty and confusion. All members must be assigned more clearly defined responsibility for contributing to the overall situational awareness. This also requires a low threshold for sharing and for requesting supplementary information. Training is needed to maintain efficient, concise communication. Such training will stimulate both individual and collective capacity while raising each team member's awareness of their own and others' weaknesses and strengths in such situations.

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FORSVARET
Marinen

Vår saksbehandler	Vår dato	Vår referanse
Orlogskaptein Eivind Engelsen +47 93211301	2019-08-30	2019/032256-001/FORSVARET/ 481
	Tidligere dato	Tidligere referanse

Til	Kopi til
Statens Havarikommisjon for Transport Sophie Radichs vei 17 2003 LILLESTRØM	FMA/MARKAP SJØ/MAR/MARSTAB SJØ/SJ S SJØ/SST

Statusrapport fra Marinen til Statens Havarikommisjon for Transport

1 Innledning

Marinen viser til kollisjonen mellom KNM Helge Ingstad og Sola TS, 8. november 2018 og den forestående rapporten fra Statens Havarikommisjon for Transport (SHT). Hensikten med dette skrivet er å gi en status for de tiltak som er iverksatt i etterkant av ulykken, samt arbeid som pågår for å sikre varig og bedret sikkerhet for våre fartøy og besetninger.

Vi har iverksatt tiltak på områder hvor svakheter har blitt avdekket, og etterarbeidet er nå over i en systematisk fase for å identifisere forbedringsområder og sikre varig styrking av sikkerhetsnivået. De kommende rapportene fra Statens Havarikommisjon, den interne undersøkelses nedsatt av Sjef Sjøforsvaret og Forsvarsmateriell Maritime kapasiteters (FMA MARKAP) tekniske undersøkelse, vil gi avgjørende bidrag til dette arbeidet. Inntil disse foreligger har Marinen har valgt å fokusere på sikkerhetskultur, navigasjon, teknisk sikkerhet, dokumentasjon, kompetansestyring og avvikshåndtering. Dialogen med overordnede myndigheter for å klarlegge og forbedre de overordnede rammebetingelsene for sikkerhet håndteres av Sjøforsvarsstaben, herunder klargjøring av roller, ansvar og myndighet ift skipssikkerhetsloven med tilhørende forskrifter.

Sjøforsvaret har en samhandlingsavtale med Sjef FMA MARKAP hvor det er det gitt at FMA MARKAP er ansvarlig for teknisk sikkerhet i medhold av skipssikkerhetsloven med tilhørende forskrifter.

For Marinen vil arbeidet fremover ta utgangspunkt i de styrkene Marinen allerede har på sikkerhetsområdene, med vekt på systematisk trening og sertifisering av fartøyene og seleksjon av personell til sikkerhetskritiske stillinger, men samtidig være realistisk og selvkritisk i måten vi avdekker og utbedrer forbedringsområder innenfor sikkerhetsstyringssystemet.

2 Sikkerhetskultur

Sikkerhet skal ha høyeste prioritet i militære operasjoner i fredstid. Samtidig løser Marinen oppdrag som impliserer risiko og har målsetting om realistisk trening for krise og krig. Vi har derfor behov for en velutviklet sikkerhetskultur slik at medarbeidere på alle nivå evner å balansere operativ risiko og sikkerhet i operasjoner. Ulykken har aktualisert behovet for å kontinuerlig arbeide med de kulturelle forutsetningene for sikkerhet i Marinen.

Umiddelbart etter ulykken ga jeg føringer om å utvise aktsomhet og legge inn ekstra marginer inntil årsaksforholdene var kartlagt. Dette er kommunisert til alle skipssjefer i Marinen skriftlig og i en rekke samlinger vi har hatt. Vi har gjennom året tilrettelagt for gode diskusjoner mellom alle skipssjefer for å utveksle erfaringer og harmonisere praksis. Rapportering på sikkerhet har fått en styrket posisjon på agendaen i ledermøter og risikovurderinger har fått en større plass i planlegging av kommende operasjoner og øvelser. Ledelsens oppfølging av dette vil vedvare.

Sjøforsvarets sikkerhetspolicy er dekkende for alle deler av virksomheten. For å kunne gi føringer som er mer konkret rettet mot Marinens virksomhet vil det utarbeides en sikkerhetspolicy spesifikt for Marinen. Kurs og utdanningsopplegg skal gjennomgås for å sikre at sikkerhet og dilemmatrening blir en integrert del av all kompetansebygging. Arbeid med sikkerhetskultur er et langsiktig arbeid. Den interne undersøkelsesgruppen har gjennomført en studie av sikkerhetskultur med støtte av DnVGL som viser at sikkerhetskulturen på flere områder er god, men også pekt på tydelige forbedringspotensial. Nye studier av samme type de kommende år vil danne grunnlag for å måle progresjon.

3 Navigasjon

Umiddelbart etter hendelsen ble det innført to strakstiltak relatert til navigasjon på Marinens fartøyer. Retningslinjene for bruk av AIS ble presisert og det ble innført en ekstra sikkerhetsbarriere i forbindelse med opplæringsaktiviteter for navigatører. For en mer bred og gjennomgang og varig styrking av fagområdet navigasjon har jeg etablert «Prosjekt Navigatøren». Arbeidet ledes av Sjøforsvarets Navigasjonskompetansesenter (NAVKOMP) og deres mandat er vedlagt. Hensikten er å utrede og implementere tiltak raskt og effektivt innenfor hovedområdene regelverk, kompetanse og erfaringslæring. Å sikre at «best practice» på enkelte fartøystyper gjøres gjeldende for alle vil være et sentralt mål, herunder å sikre at vi har rett erfaringsnivå og klareringskriterier for alle navigatører og broteam. Evnen til effektiv samhandling i broteamene på alle Marinens fartøyer tillegges vekt i dette arbeidet, herunder implementering av en mer systematisk trening i «Crew Resource Management».

4 Dokumentasjon

Marinen opererer avanserte fartøyer med komplekse systemer og har derfor et omfattende system for dokumentasjon av instrukser, prosedyrer og rutiner. Disse inngår i et større dokumenthierarki med felles bestemmelser for Forsvaret, Sjøforsvaret og Marinen, samt teknisk dokumentasjon fra FMA MARKAP. Fregattenes dokumentasjon ble sist oppdatert i 2016. Første halvår 2019 har det vært gjennomført en større revisjon av fregattenes interndokumentasjon som vil bli sluttført medio september.

I lys av hendelsen med Helge Ingstad vil det nå bli iverksatt en revisjon av hele dokumenthierarkiet for alle Marinens fartøyer for å sikre at dette er oppdatert, harmonisert, forenklet og lett tilgjengelig. Dette vil også styrke vår evne til å gjøre kontinuerlige oppdateringer basert på erfaringer. En hovedmålsetting er å sikre større grad av felles retningslinjer på tvers av fartøystypene. Arbeidet er omfattende og favner alle faginstanser i Marinen samt en rekke eksterne instanser, og vil bli organisert som et prosjekt med prioritet på dokumentasjon som er relatert til operasjonell og teknisk sikkerhet, herunder navigasjon, sjømannskap, brann og havari, samt sanitet.

5 Kompetansestyring

En forutsetning for sikker drift av marinens fartøy er at personellet innehar rett kompetanse og at avvik i forhold til kompetansekrav blir identifisert, risikovurdert og nødvendige tiltak iverksatt. Marinen har i første halvår 2019 gjennomgått gjeldende kompetansekrav og verifisert personellets faktiske kompetanse. Kompetansekrav omfatter kvalifikasjoner, erfaring, kurs, utdanninger og klareringer. Videre er Marinens kurs gjennomgått, kontrollert og blir nå registrert i den enkeltes rulleblad. Kodifisering av erfaringsnivå innenfor de spesifikke funksjoner er utarbeidet og implementert i Forsvarets felles kompetansestyringsverktøy. I tiden fremover vil det være behov for å kvalitetssikre datagrunnlaget som er etablert og etterregistrere all sjømilitær kompetanse på den enkelte medarbeideren.

Dette grunnlagsarbeidet vil vi benytte til å styrke våre rutiner og verktøy for monitoriering og rapportering av den enkeltes og fartøyets kompetanse, med vekt på å kunne identifisere avvik. Det vil bli vurdert justeringer av både prosesser og organisering av Sjøforsvarets HR-apparat for å sikre en tydeligere involvering i driften av Marinens fartøyer.

6 Teknisk sikkerhet

Teknisk sikkerhet avhenger av leveranser fra flere aktører i og utenfor Forsvarssektoren. FMA MARKAP er ansvarlig for fartøyenes tekniske sikkerhet og sertifisering. Fregattene er klasset av DnV-GL. Forsvarets Logistikkorganisasjon utfører tyngre vedlikehold. Marinen legger det økonomiske premisset for vedlikehold og det er avgjørende med gode samhandlingsprosesser med aktørene slik at riktige prioriteter blir gitt.

FMA MARKAP har i etterkant av Ingstad-havariet gjennomgått den tekniske sikkerheten for fregattene og oppgir følgende tiltak som gjennomført:

- Det er gjennomført en intern teknisk undersøkelse i FMA MARKAP med flere funn som er under saksbehandling.
- Det ble umiddelbart etter varsling om manglende vanntett integritet (hul aksling) mellom aktre generatorrom og girrom gjennomført midlertidig tiltak for å opprette vanntett skille mellom de to rommene. Det er nå gjennomført en varig reparasjon på de fire gjenværende fartøyene og saken er lukket.
- Det er gjennomført ny krengeprøve på KNM Fridtjof Nansen som har verifisert dataene for stabiliteten på fregattene og de gitte anbefalingene hva gjelder handling ved skadet skrog. Det er ikke avdekket feil i stabilitetshåndboken og den har ikke avvik fra klasse
- Vedlikeholdsrutinen for lensesystemet er oppdatert for å verifisere at dette er funksjonsdyktig.
- Det er utgitt en presisering av konfigurasjon på hovedtavler for å redusere risiko for å miste strømforsyningen om bord (svart skip).
- Det er utgitt nye prosedyrer for operering av navigasjonslanterner som skal motvirke at de slukker hvis fartøyet får svart skip.

Sjef FMA MARKAP har utstedt flere Materiellsikkerhetspåbud (MSP) som ivaretar sikkerhetskritiske avvik. Fra Marinens side er det etablert rutiner slik at en oversikt over alle gjeldende påbud relatert til materiellsikkerhet sendes fartøyene regelmessig. I tiden fremover vil vi i samarbeid med FMA MARKAP arbeide med å styrke den helhetlige oversikten og prioriteringen av tekniske avvik og oppfølgingen av teknisk sikkerhet.

Sjef FMA MARKAP har etter ulykken satt ned et prosjekt for å gjennomgå materiellforvaltningen spesielt relatert til fregattene. Sentrale elementer i dette prosjektet er:

- Konfigurasjonskontroll og endringsbehandling
- Avviksbehandling og kontroll
- Oppdatering av teknisk dokumentasjon
- Oppdatering av fartøyenes vedlikeholdssystem og reservedelsforvaltning

7 Avvikshåndtering

Marinen har etablerte rutiner for rapportering og behandling av avviksrapporter. Rapporteringskulturen anses på de fleste områder for å være relativt god og skal danne grunnlag for organisatorisk læring ved å iverksette tiltak. Avvikshåndteringen på alle områder har siden ulykken fått økt ledelsesfokus ved at kritiske avvik relatert til HMS og teknisk sikkerhet skal rapporteres uten opphold til ledelsen for å sikre riktige prioriteringer. Status gjennomgås rutinemessig på ledermøter.

Rapportering av erfaringer og nesten-uhell innenfor navigasjonshendelser har vært for svak og det ble i 2017 tatt grep for å bedre dette, men det er fortsatt behov for bedring. Avviksrapportering av navigasjonshendelser vil nå bli fulgt grundig opp i rammen av «Prosjekt Navigatøren» hvor vi skal ha på plass bedre insentiver og en styrket læringssløyfe.

I tiden fremover vil vi styrke feed-back sløyfen. Relevante erfaringer innenfor navigasjon skal samles, redigeres og publiseres av NAVKOMP. Opprydning i dokumenthierarkiet vil legge til rette for mer effektiv oppdatering av rutiner og deling av «best practice» basert på erfaringer.

8 Tiltak iverksatt av Sjøforsvarsstaben

Marinen har driftsansvaret for egne fartøyer, men noen av forutsetningene for sikker drift hviler også på systemer og verktøy som er felles for hele forsvarssektoren, og samhandling med andre etater, i særdeleshet Forsvarsmateriell. Behov for endringer på overordnede systemer og forholdet til eksterne er adressert av Sjøforsvarsstaben (SST), men myndighet til å gjøre endringer ligger utenfor Sjøforsvaret. SST har identifisert mangler relatert til IKT-verktøy for understøttelse av sikker drift av vår maritime virksomhet. Funksjonalitet og tilpasning av proprietære systemer er ikke optimalisert for kontroll på avvikshåndtering, risikovurderinger, kompetansestyring og dokumentasjonsstyring av en maritimt rettet virksomhet. Sjøforsvaret har anmodet Forsvarsstaben om å kartlegge behov for- og anskaffe tilpassede verktøy som vil gi avdelinger og fartøyer tilfredsstillende funksjonalitet og kapasitet til å ivareta sikker drift i henhold til gjeldende krav i lovverket.

Utover dette har Sjøforsvaret anmodet Forsvarsdepartementet (FD) om å klargjøre roller, ansvar og myndighet ift skipssikkerhetsloven med tilhørende forskrifter. Dette er iverksatt av FD og aktuelle etater er involvert og støtter arbeidet.

På teknisk side ble de umiddelbare vurderingene gjort av FMA MARKAP som beskrevet over, og tiltak implementert. For å sikre en grundig gjennomgang av alle mulige avvik på tekniske systemer har SST derfor bedt FMA MARKAP om en teknisk granskning av valgte løsninger i forhold til gjeldende regelverk, teknisk dokumentasjon, operasjonsmanualer samt en gjennomgang av løsningene om bord på fregattene. Formålet er å sikre at systemene på de gjenværende fartøyene er i samsvar med spesifikasjoner og gjeldende regelverk.

9 Konklusjon

Marinen, Sjøforsvaret og FMA MARKAP har etter kollisjonen mellom KNM Helge Ingstad og Sola TS iverksatt en rekke tiltak for å bedre sikkerheten på Marinens fartøyer. Arbeidet er over i en mer systematisk fase for å sikre varig styrking av sikkerhetsnivået og har høyeste prioritet i hele organisasjonen. Vi tilstreber å gjennomføre tiltak som gir varige effekter og konkrete resultater, både innen grunnleggende sikkerhetsaspekter og fra et ledelsesperspektiv. Arbeidet skal bygge videre på vårt system for trening, øving og kvalitetssikring av sikkerhetsnivået, men også en forståelse for at den alvorlige hendelsen avdekker forhold som kan ta oss et vesentlig skritt videre. Arbeidet som allerede er iverksatt skal forberede oss på omsette de funn og anbefalinger som fremkommer av rapportene fra Statens Havarikommisjon og Sjøforsvarets interne undersøkelse.

Rune Andersen
Flaggkommandør
Sjef Marinen

Vedlegg: Mandat for prosjekt navigatøren

Dokumentet er elektronisk godkjent, og har derfor ikke håndskreven signatur.

AIBN's translation of Appendix H

Status report from the Fleet to the Accident Investigation Board Norway

1 Introduction

Reference is made to the collision between 'KNM Helge Ingstad' and 'Sola TS' on 8 November 2018 and the report that is soon to be released by the Accident Investigation Board Norway (AIBN). The purpose of this communication is to describe the status with respect to measures that have been implemented in the wake of the accident, and the ongoing effort to ensure lasting and better safety for our vessels and crews.

We have implemented measures in areas where weaknesses have been identified, and have now entered a phase of systematically working to identify areas for improvement and ensuring a higher safety level on a lasting basis. The upcoming reports from the AIBN, the internal investigation initiated by the Chief of the Royal Norwegian Navy and the technical investigation by the Norwegian Defence Material Agency's Naval Systems Division (FMA MARKAP) will constitute important contributions to our efforts. Pending the above reports, the Fleet has chosen to focus on safety culture, navigation, technical safety, documentation, competence management and handling of nonconformities. The dialogue with competent authorities to map and improve the overall framework conditions for safety is being handled by the Naval Staff, including the clarification of roles, responsibility and authority relating to the Ship Safety and Security Act and its regulations.

The Navy has a cooperation agreement with the Chief of FMA MARKAP under which FMA MARKAP is responsible for technical safety pursuant to the Ship Safety and Security Act and its regulations.

As far as the Fleet is concerned, our work in the time ahead will be based on the Fleet's current strengths in the safety area, with the emphasis on systematic training and certification of vessels and selection of personnel to positions critical to safety, while at the same time being realistic and self-critical in the way we identify and make improvements where there is a potential for improvement in our safety management system.

2 Safety culture

Safety shall have the highest priority in military operations in times of peace. At the same time, the Fleet carries out assignments that entail risk and aims to provide realistic training for situations of crisis and war. We therefore need a well-developed safety culture so that staff at all levels are able to strike a balance between operative risk and safe operation. The accident has highlighted the need to continuously address the cultural conditions for safety in the Fleet.

Immediately after the accident, I issued guidance on exercising vigilance and operating with additional margins until the causal factors were identified. This has been communicated to all captains on board the Fleet's vessels, both in writing and at a number of gatherings. Throughout the year, we have facilitated good discussions between all captains of our vessels for the purpose of exchanging experience and harmonising practice. Safety reporting has been given a more prominent position on the agenda at management meetings and more time is spent on risk assessments when planning upcoming operations and exercises. Management will continue to follow up these matters.

The Navy's safety policy applies to all parts of the Navy's activities. In order to provide more particular guidance for the activities of the Fleet, a safety policy will be prepared specifically for the Fleet. Courses and educational schemes will be reviewed to ensure that safety and dilemma training become an integral part of all competence-building. Establishing a safety culture is long-term work. Supported by DnVGL, the internal investigation team has carried out a study of the safety culture, which shows that, while the safety culture is good in several areas, there is clearly improvement potential in others. Repeating studies of this type in the years ahead will enable us to measure what progress we make.

3 Navigation

Immediately after the incident, two immediate measures were introduced relating to navigation of the Fleet's vessels. The guidelines for use of AIS were clarified and an additional barrier was introduced in connection with training activities for navigators. I have established a navigator project (*Prosjekt Navigatøren*) to ensure a broader review and strengthen the navigation discipline on a lasting basis. The project is headed by the Navy's Navigation Competence Centre (NavKomp), whose mandate I have enclosed. The purpose is to elaborate on and implement measures quickly and effectively in the primary areas regulations, competence and experiential learning. A key goal will be to ensure that best practice on certain vessel types is made generally applicable, including that all navigators and bridge teams have the requisite level of experience and are subject to the right clearance criteria. This work focuses on the ability of all bridge teams on the Fleet's vessels to cooperate effectively, and includes the implementation of systematic training in crew resource management.

4 Documentation

The Fleet operates state of the art vessels with complex systems and therefore has a comprehensive system for documentation of instructions, procedures and routines. These are part of a document hierarchy containing common provisions for the Norwegian Armed Forces, the Navy and the Fleet, as well as technical documentation from FMA MARKAP. The frigate documentation was most recently updated in 2016. A major revision of the frigates' internal documentation has been carried out during the first half of 2019 and will be completed in mid-September.

In light of the incident with 'KNM Helge Ingstad', a revision will be conducted of the document hierarchy for all the Fleet's vessels as a whole, to ensure that it is updated, harmonised, simplified and easily accessible. This will also strengthen our ability to introduce continuous updates on the basis of experience. It is a main objective to ensure more common guidelines across the different vessel types. This is an extensive task and involves all professional bodies in the Fleet as well as a number of external bodies; it will be organised as a project giving priority to documentation relating to operational and technical safety, including navigation, seamanship, fire and accidents, and the medical service.

5 Competence management

The safe operation of naval vessels depends on crews having the right competence and on identifying any nonconformities relating to competence requirements, conducting risk assessments and implementing necessary measures. During the first half of 2019, the Fleet has reviewed current competence requirements and verified the actual competence of personnel. Competence requirements include requirements for qualifications, experience, courses, education and clearances. Furthermore, the Fleet's courses have been reviewed and records are now kept for each employee. The level of experience relating to specific functions has now been codified and incorporated in the Armed Forces' common competence management tool. In the time ahead, we need to quality-assure the established data basis and register all the naval competence of individual employees.

We will use this fundamental work to strengthen our procedures and tools for monitoring and reporting the competence of individuals and vessels, with the emphasis on being able to identify nonconformities. Consideration will be given to adjusting both processes and the Navy's HR administration, in order to ensure clearer involvement in the operation of the Fleet's vessels.

6 Technical safety

Technical safety depends on deliveries from several parties, both inside and outside the defence sector. FMA MARKAP is responsible for the technical safety and certification of our vessels. DnV-GL is responsible for the classification of the frigates. Heavy maintenance is carried out by the Norwegian Defence Logistics Organisation. The Fleet sets the financial premises for maintenance, and good processes for cooperation with the parties involved are decisive for making the right priorities.

Following the accident with 'KNM Helge Ingstad', FMA MARKAP has reviewed the technical safety of the frigates and reports that the following measures have been implemented:

- An internal technical investigation has been conducted by FMA MARKAP, resulting in several findings that are now being processed.
- Immediately after the lack of watertight integrity (hollow axle) between the aft generator room and the gear room had been reported, temporary measures were implemented to establish a watertight division between the two compartments. Permanent repairs have now been carried out on the four remaining vessels, and the case has been closed.
- A new inclining test has been carried out on 'KNM Fridtjof Nansen', verifying the stability data of the frigates and the recommended handling of the vessels in connection with hull damage. No errors have been found in the stability handbook and it contains no nonconformities related to the class of vessel.
- The bilge system maintenance procedure has been updated for the purpose of verifying that it is in working order.
- A more precise description has been issued of the main switchboard configurations on board, in order to reduce the risk of loss of power (blackout).
- New procedures have been issued for operating the navigation lights to prevent them from being extinguished in the event of a blackout.

The head of FMA MARKAP has issued several safety orders relating to materiel (*Materiellsikkerhetspåbud – MSP*) addressing safety-critical nonconformities. The Fleet has established procedures whereby the vessels regularly receive an overview of all MSP orders. In the time ahead, we will collaborate with FMA MARKAP to improve our overview and prioritisation of technical nonconformities and strengthen our follow-up of technical safety.

After the accident, the head of FMA MARKAP has initiated a project to review materiel management, particularly of the frigates. Key elements of this project include:

- Configuration control and change management
- Handling and control of nonconformities
- Updating technical documentation
- Updating the vessels' maintenance systems and spare parts management

7 Handling of nonconformities

The Fleet has procedures in place for reporting nonconformities and handling nonconformity reports. The reporting culture is considered to be fairly good in most areas, and is meant to form the basis for organisational learning through the implementation of measures. Since the accident, there has been more management focus on nonconformity reporting in all areas in that critical nonconformities relating to HSE and technical safety are to be reported to management without delay to ensure correct prioritisation. Status is reviewed at management meetings as a matter of routine.

There is still some under-reporting relating to incidents and near-misses in the area of navigation, and even though measures were taken to improve this in 2017, there is still a need for improvement. Nonconformity reporting of navigation incidents will now be followed up thoroughly within the framework of the navigator project (*Prosjekt Navigatøren*), which aims to establish better incentives and a stronger learning loop.

In the time ahead, we aim to strengthen the feedback loop. Relevant empirical experience of navigation shall be collected, edited and published by NAVKOMP. Tidying up the document hierarchy will facilitate more effective updating of procedures and sharing of best practice on the basis of experience.

8 Measures implemented by the Naval Staff

The Fleet is responsible for the operation of its own vessels, but some of the conditions for safe operation also depend on systems and tools that are common to the whole defence sector, as well as on cooperation with other public agencies, particularly the Norwegian Defence Materiel Agency. The need for changes to governing systems and the relationship with external parties have been addressed by the Naval Staff, but the authority to make changes lies elsewhere. The Naval Staff has identified shortcomings relating to ICT tools for supporting the safe operation of our maritime activities. The functionality and adaptation of proprietary systems have not been optimised for control of the handling of nonconformities, risk assessments, competence management and document control in a maritime undertaking. The Navy has requested the Naval Staff to map the need for and procure suitable tools that will provide departments and vessels with satisfactory functionality and the capacity to ensure safe operation in accordance with applicable statutory requirements.

In addition to this, the Navy has requested that the Ministry of Defence clarify roles, responsibility and authority in relation to the Ship Safety and Security Act and its regulations. The Ministry of Defence has acted on this and relevant public agencies are involved in and support the work.

On the technical side, the immediate assessments were carried out by FMA MARKAP as described above, and measures were implemented. In order to ensure a thorough review of all possible nonconformities in the technical systems, the Naval Staff has therefore asked FMA MARKAP to conduct a technical investigation of the chosen solutions in relation to applicable regulations, technical documentation and operating manuals, as well as a review of the solutions on board the frigates. The purpose is to ensure that the systems on the remaining vessels are in accordance with the specifications and applicable regulations.

9 Conclusion

After the collision between ‘KNM Helge Ingstad’ and ‘Sola TS’, the Fleet, the Navy and FMA MARKAP have implemented a number of measures to improve safety on board the Fleet’s vessels. The work has entered a more systematic phase to ensure a lasting heightening of the safety level and is given top priority throughout the organisation. We seek to implement measures that will have lasting effect and give concrete results, both in terms of basic safety aspects and from a management perspective. This work will be a further development of our system for training, exercises and quality assurance of the safety level, but will also be based on an understanding of the serious incident having brought to light circumstances that enable us to take a material step forward. The work that has been done already will prepare us for the findings and recommendations made in the AIBN’s reports and the Navy’s internal investigation report.