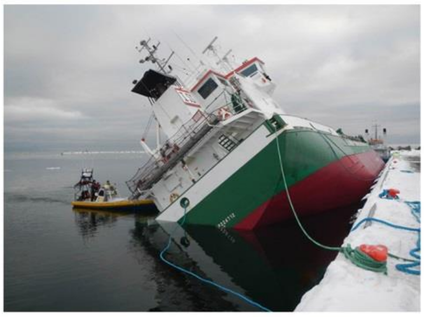
Statens haverikommission
Swedish Accident Investigation Authority



Final report RS 2016:05e

STENA JUTLANDICA/TERNVIND – collision in Gothenburg's archipelago on 19 July 2015

File no. S-127/15

30/06/2016

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The report is also available on SHK´s web site: www.havkom.se

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Content

General observations

The Swedish Accident Investigation Authority (Statens haverikommission, SHK) is a central government authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations aim to, as far as possible, determine both the sequence of events and the cause of the events, along with the damage and effects in general. An investigation shall provide the basis for decisions which are aimed at preventing similar events from happening in the future, or to limit the effects of such an event. At the same time the investigation provides a basis for an assessment of the operations performed by the public rescue services in connection with the event and, if there is a need for them, improvements to the rescue services.

SHK accident investigations thus aim to answer three questions: *What happened? Why did it happen? How can a similar event be avoided in the future?*

SHK does not have any inspection remit, nor is it any part of its task to apportion blame or liability concerning damages. This means that issues concerning liability are neither investigated nor described in association with its investigations. Issues concerning blame, responsibility and damages are dealt with by the judicial system or, for example, by insurance companies.

Furthermore, SHK's remit does not include, aside from that part of the investigation that concerns the rescue operation, an investigation into how people transported to hospital have been treated there. Nor does it include public actions in the form of social care or crisis management after the event.

The investigation

SHK was informed on 19 juli 2015 that a collision had occurred the same morning between the vessels STENA JUTLANDICA and TERNVIND in the outer reaches of the fairway into Gothenburg.

The accident has been investigated by SHK, represented by Jonas Bäckstrand, Chair until 9 September 2015, Helene Arango Magnusson, Chair thereafter, Jörgen Zachau, investigator in charge, Dennis Dahlberg, operational investigator and Alexander Hurtig, behavioural sciences investigator.

SHK has been assisted by Baltic Navigator with the reconstruction of the course of events and with computerised bridge simulations.

Interviews have been conducted with the crew members concerned from both vessels, the pilot, the VTS operator, the person responsible for VTS operations in Gothenburg, the SAR Mission Coordinator at the JRCC and with the safety managers from each of the shipping companies. Both vessels have been visited.

Patrik Jönsson has participated as the coordinator for the Swedish Transport Agency, Ulf Holmgren for the Swedish Maritime Administration and Tore Eriksson for the Swedish Civil Contingencies Agency.

A fact finding presentation meeting with the interested parties was held on 1 December 2015. At the meeting SHK presented the facts discovered so far during the investigation.

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Information about STENA JUTLANDICA	
Flag state/register of shipping	Sweden
Identity	
IMO number/call sign	9125944/SEAN
Vessel data	
Type of vessel	Ro-ro/train/passenger vessel
Builder/year of build	Van der Giessen de Noord, NL /1996
Gross tonnage	29,691[1]
Length overall	184.3 m
Beam	28.4 m
Draught, max.	6.00 m
Deadweight at max. draught	6,542 tonnes
Main engine, output	4 x MAN, totalling 25,920 kW (40,380 hp)
Propulsion system	2 x variable-pitch propellers
Lateral propeller	2 in the bow, 1,580 kW
Rudder system	2 Becker FKSR 70°, possible to split when manoeuvring in port
Max. speed	22.5 knots
Registered owner and manager	Stena Line Scandinavia AB
Classification society	Lloyd’s Register

Voyage particulars	
Ports of call	Sailing between Fredrikshavn, Denmark and Gothenburg, Sweden
Type of voyage	International
Cargo information/number of passengers	Vehicles/531 passengers
Crew	89

[1] Measure of volume that does not have units.

Fig. 1. STENA JUTLANDICA. Photo: Igor Dilo/Stena Line

Fig. 2. TERNVIND. Photo: Terntank.

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Information about TERNVIND	
Flag state/register of shipping	Denmark DIS[2]
Identity	
IMO number/call sign	9425356/OWTQ2
Vessel data	
Type of vessel	Chemical tanker
Builder/year of build	Dearsan Shipyard/2008
Gross tonnage	7,321
Length overall	129.5 metres
Beam	19.8 metres
Draught, max.	8.15 metres
Deadweight at max. draught	11,258.9 tonnes
Main engine, output	MAN B&W, 4,500 kW (6,120 hp)
Propulsion system	1 x variable-pitch propeller
Lateral propeller	1 in the bow, 530 kW
Rudder system	High-efficiency rudder 70°
Service speed	14 knots
Registered owner and manager	Terntank Ship Management
Classification society	DNV GL

Voyage particulars	
Ports of call	Gothenburg–Halmstad
Type of voyage	International
Cargo information	9,660 tonnes marine diesel and petrol
Crew	14

Marine casualty information	
Type of marine casualty	Serious marine casualty
Date and time	2015-07-19 02.17
Position and location	57° 36.4 N, 011° 39.9 E 1.2 M NE of Trubaduren
Weather	Wind around SW 14 m/s
Consequences	
Injuries to persons	No physical injuries
Environment	None known
Vessel	Hull damage

[2] Denmark's open register.

SUMMARY

In the early morning of 19 July 2015, the tanker TERNVIND, loaded with oil products, departed Gothenburg on a voyage to Halmstad. Just before the pilotage line, the pilot left the vessel and the master, who was alone on the bridge with the helmsman, discovered that STENA JUTLANDICA was closing faster than he had anticipated. He then proposed that the vessels should pass starboard to starboard.

STENA JUTLANDICA, which was on its way in from Fredrikshavn, had already begun a slight turn to port ahead of TERNVIND in order to position herself in the fairway. As a result of a misunderstanding in the radio communications between the vessels, those in command of the vessels developed different understandings of how the meeting would be conducted. The master of TERNVIND got the impression that it had been agreed that they would pass starboard to starboard. However, on STENA JUTLANDICA, the officer intended to have the vessels to pass port to port. As TERNVIND was turning to port in order to, as the crew believed, provide more space for STENA JUTLANDICA, a collision occurred.

In summary, SHK is of the opinion that the accident was caused by improper planning of the vessels' meeting, combined with a misunderstanding in the communication concerning this meeting. Together, both vessels' respective turn to port also constituted a prerequisite for the collision to take place.

SHK is also of the opinion that inadequate lookout on TERNVIND and the pilotage ending too early probably constituted contributory causes of the accident. Another contributory cause may have been that the officers of the watch on the vessels probably were affected by fatigue.

In terms of raising the alarm, SHK concludes that internal reporting within Stena Line was prioritised ahead of reporting to the public rescue services. Nevertheless, the investigation has shown that in this respect the crew acted in accordance with the internal check-list for collisions that is in force within the shipping company. As an evacuation of a passenger vessel of STENA JUTLANDICA's size requires advance planning and preparation, SHK is of the opinion that there are grounds for Stena Line to revise the vessels' procedures, and those of the shipping company, with regard to what priority contact with the JRCC is to have.

With respect to the public rescue services, SHK is of the opinion that the JRCC should have classed the event as more serious than they did, and in the absence of an alarm from the vessel, should have taken the initiative to obtain more information about the event.

Safety recommendations

It is recommended that the Swedish Maritime Administration:

- Fully implement the measures that have been initiated in order to ensure that pilotage is conducted within the areas that are defined in applicable regulations and monitor that this is taking place (see Section 3.1). (*RS 2016:05 R1*)

- Take action to ensure, monitor and continuously follow up that the communication within the VTS areas is conducted in accordance with applicable regulations (see 3.2). (*RS 2016:05 R2*)

- Implement measures in order to ensure that operations in the JRCC are undertaken in accordance with applicable instructions and monitor that the clarifications that have been made in these instructions have the intended effect (see 3.7). (*RS 2016:05 R3*)

It is recommended that Stena Line Scandinavia AB:

- Check that VDRs on the shipping company's vessels save the data required by the regulations (see Section 3.3.3). (*RS 2016:05 R4*)

- Review working schedules or in some other way compensate for the risks of fatigue that may arise in its operations (see 3.3.4). (*RS 2016:05 R5*)

- Consider revising on-board instructions with the intention of giving a higher priority to reporting to the JRCC (see 3.6). (*RS 2016:05 R6*)

It is recommended that Terntank Ship Management AB:

- Ensure that lookout is kept on board its vessels in accordance with the applicable regulations (see 3.3.1). (*RS 2016:05 R7*)

- Check that VDRs on the shipping company's vessels save the data required by the regulations (see 3.3.3). (*RS 2016:05 R8*)

1. FACTUAL INFORMATION

1.1 Narrative

All VHF[3] conversation referred to in this section has taken place on channel 13, which is the traffic channel for Gothenburg's VTS area, VTS Göteborg[4]. The communication that has taken place on the bridges has been taken from VDR[5] recordings from the vessels.

1.1.1 The planning phase

The chemical tanker TERNVIND, left Skarvikshamnen from berth 521 on the night of 19 July 2015. TERNVIND had a pilot on board. The pilot reported in English to VTS Göteborg at 01:32 (see also Appendix 1) over VHF radio that the vessel had passed reporting point 3. During this report, the pilot stated that the vessel would take the southern route (the Böttö fairway), before continuing in a westerly direction.

Present on the bridge, in addition to the pilot, were the vessel's master, an officer of the watch and an apprentice deck officer. The crew had initially turned on the automatic steering system, but as it was steering badly, they switched over to manual steering again. Manual steering was undertaken by the apprentice deck officer on board. The apprentice thus acted as helmsman with instructions provided by the pilot or the master. The officer of the watch acted as lookout on the bridge.

Twenty minutes later, 01:52, the pilot on TERNVIND talked with the pilot boat PILOT 746 SE over the VHF radio and agreed with the crew there at what position the pilot would leave TERNVIND in order to transfer to the pilot boat. The conversation was conducted in Swedish. Immediately thereafter, the pilot informed the master of TERNVIND of their intentions and, at the same time, asked whether TERNVIND would continue in a westerly direction. The master responded that they would head south, as the destination was Halmstad.

A minute or so later, STENA JUTLANDICA entered the VTS area on her voyage from Fredrikshavn in Denmark. The officer of the watch, who was on the bridge together with the one of the two able seamen of the watch who was acting as lookout, announced the vessel's entry into the area over VHF in accordance with the regulations that apply to entry into a VTS area. The VTS acknowledged STENA JUTLANDICAS entry with information about the current trafficsituation, including that the vessel B GAS LYDIA was at Ekeskärsbådan and TERNVIND at Böttö and that both would head west. The communication with the VTS in Gothenburg took place in English. Following this conversation, the pilot on TERNVIND interrupted and, in English,

[3] VHF (very high frequency): communication radio system.
[4] VTS (vessel traffic service). The Swedish Maritime Administration's traffic information centre.
[5] VDR: voyage data recorder.

corrected the information that TERNVIND would head west and announced that TERNVIND would head south. The VTS confirmed the correction and then announced that STENA JUTLANDICA had entered the VTS area. This communication also took place in English.

At this time, STENA JUTLANDICA sailed with its automatic steering system engaged. The officer thus programmed a course and turn radius into the system, after which the vessel automatically turned to the given course using the set turn radius and then kept the programmed course. The speed was approx. 20 knots.

At 01:59, the officer on STENA JUTLANDICA called B GAS LYDIA in order to find out where the vessel intended to go. The response was that they would head south. STENA JUTLANDICA responded that they intended to go in between Trubaduren and Gamla Gumman (see Fig. 3) and the response was that this would probably be fine. This communication between STENA JUTLANDICA and the other vessel took place in Swedish. It has subsequently been established that the person who responded to the call to B GAS LYDIA was actually the pilot on TERNVIND, who did this by mistake.

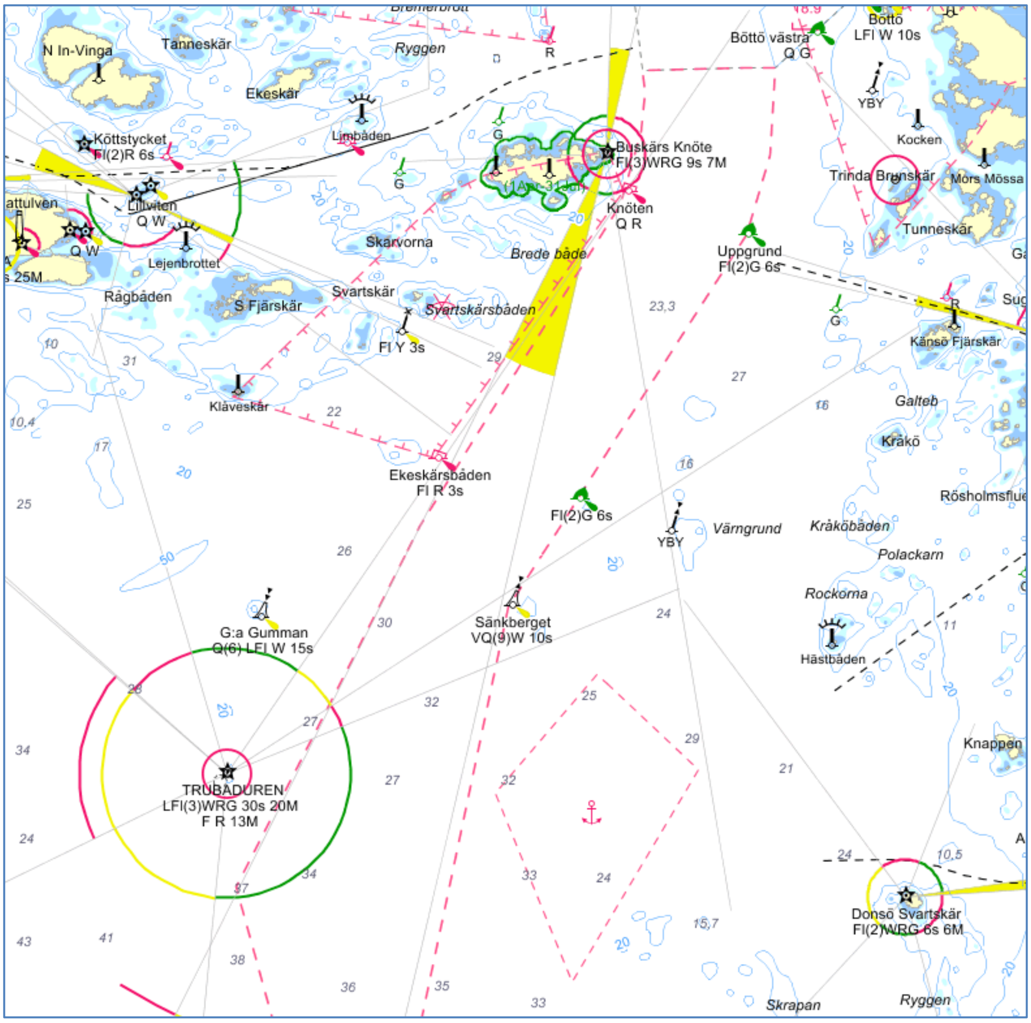


Fig. 3. Excerpt from the nautical chart of the area in question. The collision occurred just to the west of Sänkberget (a little below the centre of the image). See also Fig. 14. Image: Swedish Maritime Administration no.: 10-01518.

The pilot from B GAS LYDIA, who had already left the vessel and was now on the pilot boat following conclusion of the pilotage operation, called STENA JUTLANDICA immediately after this conversation and said that B GAS LYDIA was now proceeding without a pilot and was heading west at Ekeskärsbådan. STENA JUTLANDICA acknowledged this message. This conversation also took place in Swedish and the time was now almost 02:01.

Just after this, the pilot and the master on TERNVIND discussed the forthcoming meeting with the incoming STENA JUTLANDICA (this information comes from TERNVIND's VDR).

– There is one passenger… (Pilot) 02:01:45
– *(Inaudible)* (Master)
– *(Inaudible, indeterminate origin)* … south-west… 02:02:15
– She will go in between the lighthouse and… (Pilot)
– …here? (Master)
– Yeah, and Gamla Gumman.
– *(Inaudible)*
– … and quite fast, 18 knots. (Pilot)

The VDR recording from STENA JUTLANDICA also indicates that the officer discussed the traffic situation with the able seaman five minutes after the radio call with the pilot boat (02:06). They noted that a gas boat, which had already turned west, came first and that TERNVIND came in a southerly direction after that. The officer concluded that they could pass starboard to starboard, but that the pilot on TERNVIND would have to disembark first. Following this, the officer woke up the master, who has to be on the bridge when entering the pilotage area since it was the master who had the pilot exemption certificate. The officer on STENA JUTLANDICA had set the course a few degrees further south, closer to Trubaduren, than was originally intended and planned to proceed a little further east in order to give more space to TERNVIND on her port side. According to the officer, the radar plot in this situation showed a CPA[6] of just over 0.3 M[7].

At the same time, the pilot had left TERNVIND and transferred to the pilot boat, which turned around and headed towards Gothenburg. The time was now 02:08. The officer, who had supervised the pilot's disembarkation, had, in conjunction with this, left the bridge. The bridge was therefore temporarily manned by only the master and the helmsman. Once the pilot had left the vessel, the master returned to concentrating on the ongoing voyage and established then that STENA JUTLANDICA had closed faster than expected on TERNVIND's starboard side. TERNVIND's speed has increased somewhat and was now up at 8–9 knots. The master plotted STENA JUTLANDICA and that the CPA in this situation was approx. 0.3 M, passing astern of STENA JUTLANDICA.

[6] CPA (closest point of approach): the minimum distance between two vessels in a meeting situation.
[7] M: Nautical mile, approx. 1,852 metres.

1.1.2 The collision phase

At 02:14:44 , STENA JUTLANDICA initiated a slight turn to port with a turn radius of 1.4 M in order to head towards Böttö on the eastern side of the fairway and pass TERNVIND port to port. According to the officer the turn radius increased to 1.6 or 1.7 M just after this in order for the turn to be slower. At 02:15:12, TERNVIND called STENA JUTLANDICA on the VHF radio:

– STENA JUTLANDICA. TERNVIND. 02:15:12
– Ja, här är vi. [Yes, we're here.][8]
– Sir, can we pass starboard to starboard?
–Nä, jag har precis lagt min [No, I've just put my]… port side, so I'm turning to port now.
– Copy that, thank you.

The master of TERNVIND acted as if a passage starboard to starboard would take place and ordered the helmsman to turn more to port, i.e. more to east. At the same time as this internal communication on TERNVIND, STENA JUTLANDICA called again.

– Port to port if that is ok with you. I will keep as close to the green side as possible.

However, this call was not answered by the crew of TERNVIND, but can be heard on TERNVIND's VDR.

At 02:15:46, the bridge on STENA JUTLANDICA began to suspect something given the actions of TERNVIND. Just over ten seconds later, the officer decided to set course to starboard, which was carried out using the automatic steering system:

– [Is he going to turn left now?] (Lookout) 02:15:57
– [Yes … he can't really … I'm changing course to starboard.] (Officer)

– [This doesn't work.] (Lookout) 02:16:07
– [What's he doing?] (Officer)
…
– [I'm turning to starboard.] (Officer)

The course was then set, according to the officer, in the direction of Sänkberget, with the autopilot still turned on.

At 02:16:09, the helmsman on TERNVIND also began to suspect that something was not right:

– Where is she going, what's happening? (Helmsman) 02:16:09
– It's ok. Steady the course ... Steady the course (*heard indistinct-*

[8] Square brackets indicate translation of what was originally said in Swedish.

ly). (Master)
– You said go to port. (Helmsman)
– Going to the … (unclear). (Master)

On the masters orders, TERNVIND's course was changed at the same time more to port in order to, as they understood it, keep out of the way of STENA JUTLANDICA. At some point while this was going on, the officer of the watch came back onto the bridge following the pilot's hand-over. Just after this, the master realised that something was wrong and TERNVIND turned more to port, at the same time as the master, according to his own statement, put the engine into reverse.

At 02:16:15, the lookout on STENA JUTLANDICA is heard to say to the officer to turn the steering to manual, but this took a moment longer.

– [Turn off the pilot[9] I'm going to turn here.] (Lookout) 02:16:15
…
– [What's he doing? (Lookout)] 02:16:27
– [Yes, we … I …] (Officer)
– [Turn it off so I can turn the helm here.] (Lookout)
– [Yes, yes, yes.] (Officer)
– [Turn it off so we can turn the helm.] (Lookout)
– [Yes, there. Starboard, starboard!] (Officer)

The rudder was switched over to manual steering at 02:16:32. Following this, approx. 02:16:37, the able seaman, now acting as helmsman, steered with full rudder to starboard, before changing at 02:16:43, on the orders of the officer, to full rudder to port in order to lift the stern away from the approaching vessel. The officer had then moved to the port bridge wing in order to monitor TERNVIND.

At 02:16:51, TERNVIND's course was 145°. A few seconds later, a noise is heard on the VDR that can be connected temporally to shaking and vibration caused by the collision or the reverse manoeuvre. The collision occurred just under a cable[10] west of Sänkberget, immediately outside of the pilotage line[11]. TERNVIND's speed was somewhat reduced to between 7 and 8 knots. STENA JUTLANDICA's speed was still just under 20 knots.

Approx. 30 seconds prior to the collision, the VTS operator, who had noticed that there was a risk of collision, called both STENA JUTLANDICA and TERNVIND without receiving a response.

[9] Internal name for the automatic steering system.
[10] A cable length is one tenth of a nautical mile, i.e. approx. 185 metres.
[11] The pilotage line denotes where compulsory pilotage begins and ends in a pilotage fairway.

1.1.3 The aftermath

Just after the collision, within a minute, both vessels confirmed to the VTS that a collision had occurred. The officer on STENA JUTLANDICA says that TERNVIND had turned right into the side of STENA JUTLANDICA. The VTS's conversation with TERNVIND took place in English, while the communication with STENA JUTLANDICA took place in Swedish. The VTS operator informed STENA JUTLANDICA that they were in the process of "calling around".

A few minutes later, the pilot boat called the VTS in Swedish and informed them that they were on the way into the city (i.e. the pilot station in Gothenburg) as they had "not heard anything". They asked at the same time about the status of TERNVIND. There was also a request from the pilot boat for confirmation that they could continue towards the city, but the VTS operator gave them neither any clear information about TERNVIND's status nor confirmation that they could continue towards the pilot station. Nevertheless, the crew in the pilot boat concluded that STENA JUTLANDICA was on the way in under her own steam and therefore assumed that their help was not required, which is why they continued towards Gothenburg.

A further five minutes later, approx. ten minutes after the collision, the VTS asked for information about the condition on board each of the vessels and sent word that the vessels were to call the JRCC[12] themselves if assistance was needed. This conversation was conducted in Swedish with both vessels as it was now the Swedish-speaking apprentice deck officer who was handling VHF communications on TERNVIND.

In conjunction with the collision, the master of STENA JUTLANDICA had come up to the bridge, having already been on his way there as the vessel was about to enter the pilotage area. On the vessel, the rest of the operational crew was roused and instructed to undertake damage control. It was possible to establish that there had been an immediate submergence of the vessel in conjunction with the entry of water, but that the water had only entered limited areas. However, these areas included a space containing electronics for the operation of the engines. At the same time, the master ordered the chief officer, who had now come up to the bridge, and the officer of the watch to implement the procedural list for collisions, while navigation was taken over by the vessel's previously off-duty .

On the basis of his knowledge of the vessel's properties in terms of its ability to withstand leaks, the master was able to make the decision to continue towards Gothenburg. The initial plan was to get up to Böttö in order to find shelter there for a potential evacuation.

[12] Joint Rescue Coordination Centre that is part of the Swedish Maritime Administration.

During the course of events, the On Board Service Manager, who had the role of evacuation leader, was on the bridge and kept the crew members around the vessel, including the information desk, informed about how the situation developed. The crew were thus able to answer questions from passengers before any message was put out via the public address system. At 02:35, the master informed the passengers about the occurrence via the internal public address system. No audio alarm was activated on board. At the same time, a decision was made to contact the shipping company's emergency organisation. While this was going on, the master received information from the engine room that they still could and would have control over the engines, even if the electronics were to be damaged and knocked out of action. The voyage could therefore continue towards Skandiahamnen, which the master decided was an alternative place to evacuate the passengers directly onto a quay. As it later was assessed that it would be possible to manage the flooding of water into the space containing the electronics, the master decided to continue the voyage to the ordinary mooring site at Masthugget. Contact was made with the JRCC when the officer called at 02:54 in accordance with the procedural list.

In a similar way, damage control was conducted on board TERNVIND and it was possible to establish fairly soon that the damage was very limited. The vessel continued towards anchorage C, east of Trubaduren, where the vessel anchored ahead of a subsequent inspection of the hull. The JRCC called TERNVIND at 03:09.

1.2 Damage

In the collision, STENA JUTLANDICA suffered hull damage both above and below the waterline, the former being caused by the bow and the latter by the bulbous bow of TERNVIND.

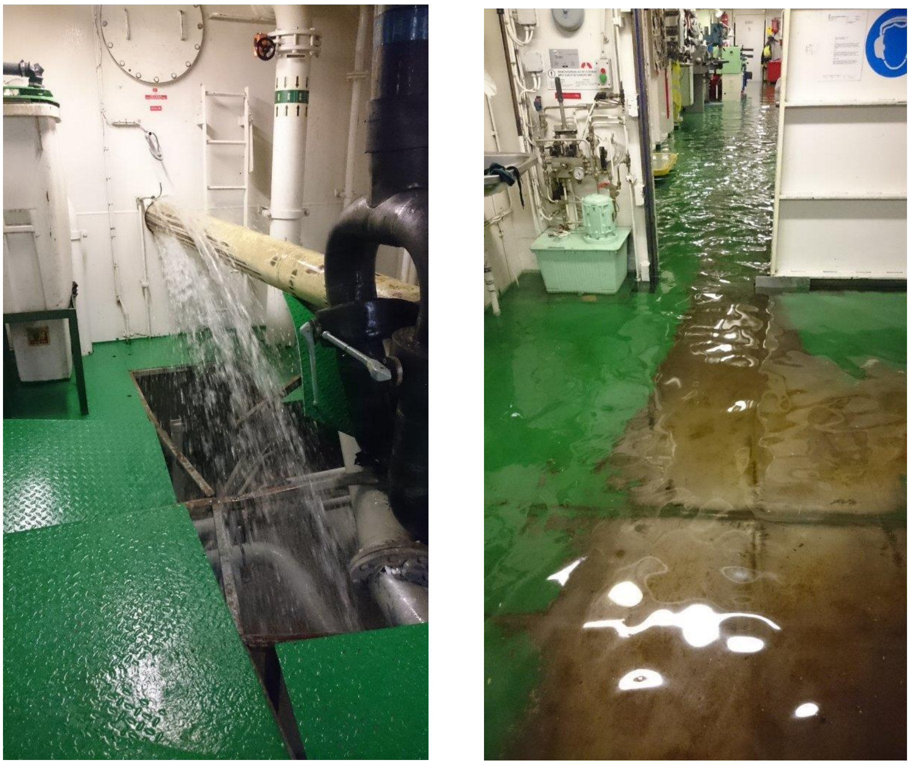


Fig. 4a and 4b. Water leak in the pump room on STENA JUTLANDICA. Image: Stena Line.

Above the waterline, damage occurred on the main deck between frames 100–106. No water entered there, but the supply hatch and supply lift were damaged. However, under the waterline, 1,220 m^3 of water entered immediately and filled watertight sections 9 and 10 as a result of damage between frames 101–118 (see Fig. 5). This resulted in a levelled submergence of the vessel. A total of 43 tonnes of steel had to be replaced.

STENA JUTLANDICA's DIP[13] indicates, for example, that the damage in this area, according to the plan's colour code, was to be regarded as "green and yellow", i.e. did not in itself constitute an imminent threat to the vessel.

[13] A DIP (damage information plan) is an aid to the crew for making decisions concerning action in the event of water intrusion in a vessel. It is also to provide the crew with a good understanding of the vessel's stability, both when intact and in the event of water intrusion. The DIP is commonly structured as a roll-down poster showing the vessel's silhouette and on which colour codes (green, yellow and red) indicate how serious the damage is. In addition to the colour codes, the plan also contains data presented in another way, e.g. in the form of diagrams.


Fig. 5. Damage to STENA JUTLANDICA. The photograph is taken in dry dock. Image: Terntank.

The port fin stabiliser, that was out during the collision, was damaged and in turn damaged some pipes, which also led to a pump room taking in water. It was not possible to pump out the pump room because of this damage. This space also contained electronic equipment for the vessel's engine control system. In order to protect this equipment and also make it possible to pump out, a manhole was opened into an empty tank under the pump room. The water thus ran into the tank and could be pumped out. STENA JUTLANDICA was able to proceed to the quay under her own steam.

TERNVIND suffered only minor damage to her forward bulwark[14] and bulbous bow (see Fig. 6).

Fig. 6. Damage to TERNVIND.

[14] A bulwark is the extension of the ship's side above the level of the weather deck.

1.3 Location of the event

The accident occurred in the outer reaches of Gothenburg's archipelago, just outside of the area in which pilotage is compulsory, a couple of hundred metres to the west of the buoy Sänkberget (see Fig. 3). This location is within the area of VTS Göteborg.

In accordance with specific regulations and to inform traffic in this area about other traffic and activities in the area, all vessels with a gross tonnage greater than 300 are to report to VTS Göteborg, which in turn responds to the call with current information (further information in Section 1.7).

On the way in, reporting is to take place when the vessel enters the VTS area, which is defined as 6 M from Vinga. For ferry traffic from Fredrikshavn, the course laid out is 072° and entry into the fairway normally takes place with the vessel passing between Trubaduren and the buoy to the north of this, Gamla Gumman (see Fig. 3). The line between the following buoy on the western side of the fairway, Ekeskärsbåden, and Sänkberget on the fairway's eastern side constitutes the pilotage line, i.e. compulsory pilotage applies to the area within these buoys. Subsequently, the course is 032° until Böttö, where there is a choice between either the southern or northern fairway. Before this, one further reporting point has been passed, just after the passage of Ekeskärsbåden.

On the way out of one of Gothenburg's ports, the equivalent reporting is to take place prior to sailing, followed by one further report when passing Nya Älvsborg. Following this, the voyage continues in either the northern or the southern fairway until these converge at Vinga Sand, i.e. by Böttö. The course is then approx. 212°. The pilotage line for outgoing traffic is the same as that for incoming traffic, i.e. between the buoys Ekeskärsbåden and Sänkberget. After that, the destination determines whether the vessel heads west, i.e. turns around Ekeskärsbåden or potentially Gamla Gumman, or south, proceeding to the east of Trubaduren down towards Vanguards Grund.

The deepest part of the fairway is bounded in the east by a line that stretches between Sänkberget and Uppgrund. Sänkberget, which is a west cardinal mark, marks a shoal immediately east of the buoy that is at a depth of 11.1 metres. About 0.7 M east-north-east of Sänkberget is a further west cardinal mark that marks Värngrund, which is an aggradation rising to a depth of 8 metres.

1.4 The vessels

1.4.1 STENA JUTLANDICA

General

STENA JUTLANDICA was built as a combined train, ro-ro and passenger vessel in the Netherlands in 1996 for the route between Gothenburg in Sweden and Fredrikshavn in Denmark. The railway tracks were however tarmacked over and the vessel has only been used as a ro-ro/passenger vessel. The vessel has twelve decks. Deck 3 (counted from the bottom) is the main deck, i.e. the car deck where loading takes place directly from the quay. The cargo space extends upwards and also consists of the majority of Deck 4. The engine room and stores for the vessel's catering department are under Deck 3. Deck 5 is above the car deck. This is another car deck that is partly open and is reached through openings in the side of the vessel via ramps on the quay. The cargo space extends up through the majority of Deck 6. The forward part of this deck is covered by the vessel's furnished section, which is on Deck 7 and above, this includes the crew cabins and the passenger accommodation.

As STENA JUTLANDICA was built to allow the transport of railway carriages, she is unusually strong and has also been built to have very good performance in terms of stability. Consequently, STENA JUTLANDICA copes with more water intrusion than required by the regulations. The vessel copes with water intrusion in more than two watertight compartments under the main deck, which is one of the minimum requirement. Under the waterline, there are a number of watertight doors, that are essentially to be kept closed while at sea in order for the watertight compartments to function. The doors can be closed both locally and remotely. For practical reasons, however, STENA JUTLANDICA has received a permission from the Swedish Transport Agency for door no. 2 to be open also while at sea.

STENA JUTLANDICA's evacuation system consists of what are known as slides, i.e. inflatable ramps on which to slide down to a raft on the surface of the water for onward transfer to other rafts. The vessel's carrying capacity amounts to 1,500 passengers and approx. 550 cars or around 105 lorries.

Point 1 on the collision instructions for STENA JUTLANDICA is the closing of watertight doors. The first instruction concerning contact with outside parties is point 14 on the check-list, which instructs to raise the alarm in accordance with alarm instructions. In turn, the first page of the alarm instructions contains an instruction to raise the alarm with the shipping company's own Security Centre (SSC). The following page has a flow chart with instruction to contact the JRCC and other vessels when in distress.

On this voyage, all but one of the ballast tanks were filled in order to improve the vessel's stability as a result of the relatively poor weather and a lack of heavy cargo. The tank that was empty was on the port side and happened to lie just under the pump room in which the electronics for the engine control system are located. The reason why this tank was not filled was a desire to compensate for the vessel's inherent mild list to port.

Bridge

The bridge is at the forward most part of Deck 11 and extends over the entire breadth of the vessel and a bit further out over her sides. The entire bridge is covered and the central part overhangs forward, with a specific space for the navigators, consisting of two chairs beside each other with a console in the middle and all the necessary equipment within reach. The necessary equipment for manoeuvring is also located on each of the bridge wings, where there is also manual steering. On the centreline, behind both the navigators' chairs, there is a small console from where manual steering is undertaken.

Fig. 7. The bridge on STENA JUTLANDICA. The desk where manual steering takes place is in the foreground, in the middle of the image. The rudder angle indicator is visible below deck (in the roof) between the chairs.

The equipment includes three radars of the model Sperry Vision Master with ARPA[15], two Sperry gyrocompasses, an AIS[16], a VDR from the brand Consilium, satellite navigation equipment and ECDIS (electronic nautical chart).

[15] ARPA (automatic radar plotting aid): automatic plotting of the radar echo (calculation of the echo's movements).
[16] AIS: Automatic Identification System.

There are several systems for steering: an older EMRI automatic steering system, a Sperry Track Pilot (which can be programmed with an entire voyage where every course change has to be accepted) and Sperry automatic steering (every course change is initiated manually with a new course and turn radius). The latter is a function of the Track Pilot system. The controls are in the left armrest of the navigational officer's chair and this is the automatic steering system that is normally used. There are also controls in the chair on the port side.

Sperry automatic steering, which was being used in this event, consists of a joystick that is used to change course by pressing on the left button and then moving the stick in the respective direction. The course is displayed on one of the screens, e.g. the radar screen or the ECDIS. The turn radius is regulated by moving the joystick towards the operator (astern), in order to reduce it, and away from the operator (ahead), in order to increase it. The range is from 0.1 M to 4.0 M. When a new course with a turn radius is assigned, this is shown as a line on the radar screen in the form of a "curved headline", i.e. the intended future course. The course change is initiated by pressing on the ACCEPT button (to the right on the armrest, see Fig. 9).

Fig. 8. The desk between the navigators' chairs on STENA JUTLANDICA. The knob that is used to override the steering can be seen marked with fluorescent tape on the right, between the binoculars and the VHF receiver (see also Fig. 10). The finger in the upper-right corner is resting on the joystick for the automatic steering system that was used on this occasion.

Fig. 9. The joystick for the automatic steering system that was used on STENA JUTLANDICA, located on the armrest of one of the navigator's chairs.

In addition, the vessel can be steered manually with contact steering[17] using a wheel at the steering station behind the navigators' chairs. Connection of the manual steering is done by the officer turning a control on the console between the navigators' chairs and the helmsman confirming with a push of a button on the steering desk. Accordingly, two active elements are required to activate the manual steering (see Fig. 10).

By the navigators' chairs there is also an override steering system in the form of a knob that is spring-loaded and takes priority over all the other systems mentioned. This can be set in two positions with switch-over using the same knob as the switch over between automatic steering and manual steering. In one position, the rudders are moved in either direction as long as the knob is activated. When the knob is released, the system returns to automatic. In the other position, the rudders are set at the angle to which the knob has been set and remains there until the knob moves again (see Fig. 10). This override function is not used regularly, but it is still the case that it is used, for example in the river in order to get the vessel to turn faster in tight curves.

According to information from the crew, switch-over between automatic steering and manual steering takes place frequently and it is therefore a procedure that the crew on the bridge are familiar with. According to the officer of the watch, the fact that the override function was not used in the event in question was because the lookout was already at the manual steering station and the switch-over to

[17] Contact steering means that as long as a wheel or joystick is moved in one direction or another, the rudder moves in this direction and remains there until the wheel or joystick is activated again.

manual steering thus took place there directly. Nevertheless, the officer does not consider himself to be unfamiliar with the override system. He had used this sufficiently frequently to feel comfortable with it.

Fig. 10. The desk between the navigators' chairs on STENA JUTLANDICA. The override knob is located close to the officer's chair, circled in green (top right of the image). The knob to switch between different methods of steering the vessel is on the aft part of the panel, circled in blue (bottom left of the image).

The rudders are powered hydraulically with four pumps, two to each rudder, two of which are normally used in the open sea, while all four are activated when manoeuvring and in, for example, fairways.

Crew members

The master, who is a Master Mariner with a Captain's ticket, had been employed by Stena Line for 24 years at the time of the occurrence. He was first employed as an able seaman, but advanced to officer after four years and for the last eight years has been the master of STENA JUTLANDICA. He has a pilotage exemption for the area in question.

The officer of the watch had been employed by the company for eleven years prior to the event and was promoted to in 2013. He is a Master Mariner and held an STCW II/1 certificate of competency. Aside from a short period on other vessels within the Stena group, he has only worked on STENA JUTLANDICA.

The able seaman, who acted as lookout on this occasion, had been at sea for 48 years when the collision occurred, the last 21 of which with Stena Line. He has been on STENA JUTLANDICA since she was delivered.

All the bridge personnel involved were Swedish speaking and Swedish is also the working language used on the vessel.

1.4.2 TERNVIND

General

The chemical tanker TERNVIND was built in Tuzla, Turkey in 2008 and was taken over by Terntank in 2013. The vessel is built with a bulbous bow and has a double bottom and double sides, with a total of 4,419 m^3 SBT[18]. TERNVIND has 12 cargo tanks divided up into six wing pairs with a loading capacity of 12,187 m^3 at a fill factor of 98 %. The vessel also has two deck tanks of a total of 260 m^3.

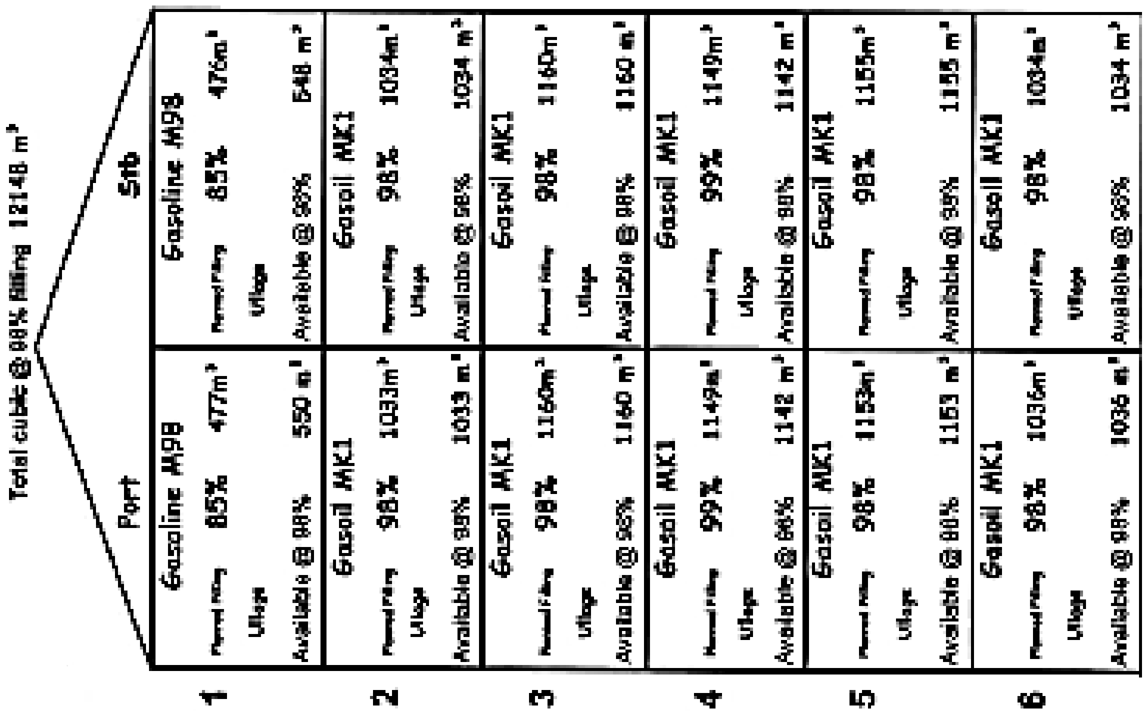


Fig. 11. Current loading plan for TERNVIND. Image: Terntank.

[18] SBT (segregated ballast tanks): tanks that are only used as ballast tanks.

On this occasion cargo tanks 1 starboard and port were loaded with petrol and the other cargo tanks were loaded with diesel (see Fig. 11). The bridge, engine room and living quarters are all located in the aft portion of the vessel. The living quarters contain a total of 16 single-bedded cabins for the crew.

The main engine is a nine-cylinder MAN with an output of 4,500 kW. The vessel is also equipped with three LIAG/MAN generators with an output of 592 kW. The vessel has a high-efficiency rudder that can be set at up to 70° to starboard or port at low speed, while at higher speeds can be set at up to 35°. The vessel is driven by a variable-pitch propeller.

Bridge

TERNVIND was built with built-in bridge wings. The bridge is arranged according to the pilot/copilot model, with two navigator chairs and a centre console equipped with autopilot, manual steering and engine-room telegraph. Behind them is a console for the helmsman with manual steering of the contact steering type. The navigation equipment includes two X-band and S-band[19] radar apparatuses with ARPA function from the brand JRC, GPS and DGPS[20], GMDSS[21] with several VHF stations and two electronic nautical charts (ECDIS) from the brand Transas. The vessel is also equipped with AIS and VDR. The image from the X-band radar is recorded on the VDR.

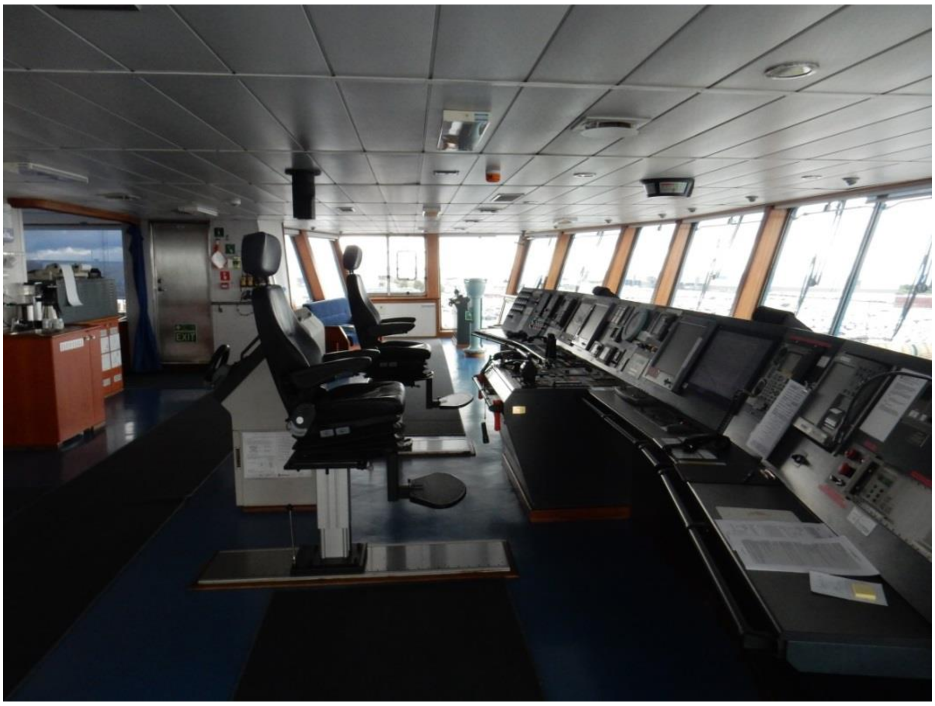


Fig. 12. The bridge on TERNVIND. The desk where manual steering takes place can be seen between and behind both the navigators' chairs, on the left of the image.

[19] Radar with 3 cm and 10 cm wavelength, respectively.
[20] GPS and DGPS: satellite navigation systems.
[21] GMDSS: system for external emergency communication.

The location of the instruments is such that the X-band radar is placed by the port-side navigator’s chair, while the S-band radar and the ECDIS screen are placed by the starboard side chair. At the time of the collosion, the master was at the starboard chair having supervised the disembarkation of the pilot.

Crew members

The master became a radio officer in 1990 and remained so for eight years, before changing over to become an ordinary sailor. Some years later, he studied to become a Master Mariner and was employed as an officer. In 2006, he became a second officer with Terntank, was promoted to chief officer two years later, before promotion to master in 2011. He held a Captain’s ticket. At the time of the occurrence in question, he had been on board for two and a half months and this was his first tour[22] on the vessel. As Gothenburg is a port the vessels from this shipping company visit frequently, he was well acquainted with the fairway.

The officer of the watch had gone to sea as an able seaman, but had now been an officer for eight years. With some interruptions, he had been working for Terntank since 2011. This was his first tour on TERNVIND, which he had been on board on for one and a half months. He held an STCW II/2 certificate of competency.

The able seaman of the watch had been at sea for 20 years, the last twelve of which with Terntank. He had been on TERNVIND for three months.

The apprentice deck officer, 41 years old, was conducting the third of the four internship periods included in the Master Mariner programme on board TERNVIND. He had been on board for just under two months. As an on-board apprentice, he was not part of the ordinary crew.

None of the crew members involved, aside from the apprentice deck officer, were Swedish speaking. The working language on the vessel is English.

1.5 Meteorological information

According to the Swedish Maritime Administration’s weather station at Vinga, the wind direction was approx. 230° (around south-west) and had been so since around 21:00. The average wind speed was 14 m/s, gusting at up to 17 m/s. The tide was +5 cm. At the time of the collision it was dark.

SMHI reports that the significant wave height[23] was 1.6–1.8 metres, direction 250° (estimated values), while the current was around nor-

[22] Tour – period of work at sea.
[23] Significant wave height is the average height of the highest one third of the waves over the course of the 30-minute period.

therly 0.1 knots. The visibility was 6–10 M and there was possibly light rain showers.

1.6 The rescue operation

Provisions concerning rescue services are found primarily in the Civil Protection Act (SFS 2003:778, Swedish abbrev. LSO) and the Civil Protection Ordinance (SFS 2003:789, Swedish abbrev. FSO).

According to Chapter 1, Section 2, first paragraph of LSO, the term "rescue services" denotes the rescue operations for which central government or municipalities shall be responsible in the event of accidents and imminent danger of accidents in order to prevent and limit injury to persons and damage to property and the environment.

Central government is responsible for mountain rescue services, air rescue services, sea rescue services, environmental rescue services at sea, rescue services in case of the emission of radioactive substances and for searching for missing persons in certain cases. In other cases, the municipality concerned is responsible for the rescue services (Chapter 3, Section 7, LSO). The accident in question concerns sea rescue services, environmental rescue services at sea and municipal rescue services.

The Swedish Maritime Administration is responsible, through the combined air-sea rescue centre, JRCC, for sea rescue services in Swedish state waters. In accordance with Chapter 4, Section 3 of LSO, sea rescue services encompass search and rescue for people who are or are feared to be in distress at sea and for medical transport from vessels.

Pursuant to Chapter 4, Section 5 of LSO, within Swedish territorial waters and within the Swedish economic zone, the authority determined by the Swedish Government is to be responsible for rescue services when oil or other harmful substances have entered the water or there is an imminent threat of this happening. This does not apply to watercourses, canals, ports and lakes other than Vänern, Vättern and Mälaren. The Swedish Coast Guard are responsible for environmental rescue services in state waters.

The in question occurred in a central government rescue services area, but STENA JUTLANDICA moved, on the route into the berth, into a municipal rescue services area; the boundary between central government and municipal rescue services passing in a line south-west of the outer part of Arendal and Älvsborgshamnen via Nya Älvsborg to the shore below Västerberget (at Långedrag).[24] At this boundary, formal responsibility was thus transferred to the municipal rescue services.

Both vessels were in contact with VTS Göteborg on VHF channel 13 immediately after the collision. The JRCC was subsequently informed by the pilot planning centre (Gothenburg Pilot), which assisted the

[24] The municipal rescue services area also includes Torshamnen, which is outside of the stated area.

VTS with this. The VTS informed both vessels that they were to contact the JRCC should they require assistance. Neither of the vessels did so and the JRCC therefore classified the case as NIL (see Section 1.6.1). Consequently, no action was taken on the part of the JRCC.

The Coast Guard was called by the VTS at 02:21 and set up a case concerning the accident at that time. It is noted in the command centre log book at 02:28 that two units, KBV 032 and KBV 312, were called out. At 02:55 it is noted that holes had been confirmed in the hull of STENA JUTLANDICA, that images from one of the units was sent over to the command centre and that diving had been arranged on TERNVIND.

The municipal rescue services met STENA JUTLANDICA upon her arrival at the berth in Masthugget and assisted with bilge pumps. However, the rescue services were able to leave after a couple of hours.

1.6.1 *Information about the JRCC*

The JRCC is an integrated air-sea rescue centre that is part of the Swedish Maritime Administration. The centre is manned around the clock and constantly monitors VHF channel 16 and VHF/MF DSC[25]. They also have access to the distress frequency on medium frequency 2182. In addition, they monitor the telephone to which those in distress are connected if they call 112 in the event of an occurrence that involves central government sea rescue. Radio and telephone calls are recorded (this also applies to VHF channel 13, which is however, not monitored by the JRCC). In accordance with the JRCC operational handbook, sea rescue cases are classified on a four-degree scale:

- Uncertainty: A situation in which the course of events needs to be monitored, more information needs to be gathered and in the present situation there is no need to call out rescue units or there is doubt about the safety of a vessel or people. Internal search of information can begin.
- Alert: When vessels or people have problems and need assistance, but are not in immediate danger. This is commonly associated with a fear that the situation is serious, but there is no known threat that requires immediate intervention.
- Distress: When a vessel or people are highly likely to be in distress and require immediate assistance.
- NIL: Used in other cases when the SAR Mission Coordinator (SMC) assesses that the alarm is not credible or that nothing that constitutes a threat to human life has or may have occurred.

[25] MF: medium frequency. DSC: digital selective calling.

In addition, the assessment instructions in the operational handbook state: "The SMC makes an assessment of the occurrence based on the facts collected . If there is insufficient facts, an internal search for more information begins. It is important that assumptions are differentiated from facts. An assessment made on the basis of assumptions is to be continually evaluated for a potential new assessment."

The centre is staffed around the clock by two coordinators for marine missions and two for aviation. At night, watch duty for both marine and aviation is performed by one further coordinator who thus reinforces the centre while the others are on call and can rest, but be woken up when necessary. Accordingly, a total of five coordinators can quickly be summoned to duty.

The coordinator who was awake and on duty monitoring distress calls on the night in question had worked as an SMC since 2001. Before that, he had been at sea for 15 years. He began as an able seaman and ended up as a chief officer.

There is no explicit obligation for shipping to report to the JRCC in the event of a marine casualty, as opposed to the obligation to report to the Coast Guard with reference to environmental emissions or to the Swedish Transport Agency with reference to damage to vessels.

1.6.2 *Reconstruction of the sequence of events with respect to the rescue operation*

The following information is taken from the Swedish Maritime Administration audio files. However, it has to be noted that the JRCC does not monitor VHF channel 13. The calls that took place on this channel were thus not overheard by the SMC at the JRCC. The description of the calls that took place on channel 13 has therefore been placed in italics below. The collision occurred at approx. 02:17:00.

02:18:10 *VHF13* *T[26] to VTS: Confirms collision.*

02:18:30 VHF[27] The JRCC in a radio call concerning a sea rescue mission in Kalmarsund. That mission took place in parallel with the collision in Gothenburg's archipelago.

02:18:47 *VHF13* *VTS to SJ[28]: SJ confirms collision.*

02:21:30 *VHF13* *The pilot boat to VTS: Asks if they are needed without really getting an answer. Announces that they are continuing towards the city.*

02:22:15 Tel Gothenburg Pilot to JRCC: Provide information about the collision, but state that it is not known if

[26] T: TERNVIND.
[27] VHF channels that the JRCC monitors, i.e. other than channel 13.
[28] SJ: STENA JUTLANDICA.

		there are any injuries. The JRCC responds that the occurrence is noted in the log, but nothing else is done.
02:26:36	*VHF13*	*VTS to SJ: SJ announces that they are taking in water in the engine room and that the leakage is being investigated.*
02:38:56	*VHF13*	*SJ to VTS: Announces that they are still taking in water and are not able to pump it out. Asks for help to order tugboats with pumps.*
02:45:32	*VHF13*	*KBV312 to SJ: Announces that they have been called out because of the collision and that they have documented the damage from the outside.*
02:45:57	*VHF13*	*VTS to SJ: Confirms the order of tugboats and bilge pumps.*
02:45:53	Tel	SOS to JRCC: Call from a member of the public about another case.
02:51:25	Tel	Gothenburg fire and rescue service to JRCC: Asks if the JRCC knows when SJ will berth. Conversation about how the work is to be arranged. The JRCC states that they do not have any information about the occurrence and that neither of the vessels called and that they are therefore assuming that there is no threat to life.
02:54:46	Tel	SJ to JRCC: Provide information about the collision and a situation report. At the same time, an incoming call from the Swedish Transport Agency's inspector on duty is received by the JRCC. The calls are combined into a three-way call.
03:09:24	VHF[29]	JRCC to TERNVIND: Asks for a situation report.
03:18:34	*VHF 13*	*SJ to VTS: SJ announces they are berthed.*

The responsible SMC at the JRCC has stated that as neither of the vessels reported the occurrence to the JRCC, the JRCC was not aware of whether the collision had resulted in any injuries or damage. The SMC therefore assumed that there was no risk to human life, which is the explanation for why the accident was classified as "NIL"; the lowest of the four classes. It is not before the conversation with STENA JUTLANDICA at 02:54:46 that it became clear to him that the vessel had taken in water. Had this been known earlier, the occurrence probably would have been classified as "Alert" and additional coordinators would have been woken up.

[29] VHF channels that the JRCC monitors, i.e. other than channel 13.

Over the course of the evening and night, a couple of other cases had been handled, but the SMC did not believe that the shift in question was particularly demanding.

1.7 Vessel traffic service (VTS)

In some areas, there is a VTS that has the task of providing traffic information and serving maritime traffic in heavily trafficked or environmentally sensitive areas. The VTS also has radar monitoring in some of these areas. The Swedish Transport Agency's regulations and general advice (TSFS 2009:56) concerning VTS and ship reporting system (SRS) specifies how reporting is to be conducted and where this is to be done. This document also sets out what the information to the vessel may contain, which, among other things, includes information about other vessels in the VTS area that may have an impact on navigation and other circumstances that may be of significance. Furthermore, Sections 18–19 of these regulations state that a vessel is to provide information to the VTS centre about "damage to machinery, plant or instruments […] that may substantially impair the vessel's safe navigation and performance" or if the VTS centre requests information because "vessel traffic shall be able to move safely and efficiently in the VTS area". The regulations, which apply to vessels with a gross tonnage of over 300 or a length of over 45 metres (including towing vessels with a barge that are together over 45 metres), also state that the information is to be provided in English, unless there are exceptional circumstances.

The Swedish Maritime Administration is responsible for the VTS in Sweden. The operational procedures of the VTS (Version 11.0, dated 11 June 2015) describe how this is done in purely practical terms. This document states that the principal aim is to "provide shipping with relevant information so that those on board can make correct decisions at the right time in order to prevent grounding, collisions and environmental impact". Furthermore, it states that, when necessary, a certain vessel may receive warnings and advice and that communication is to take place in English (exceptions are only granted in exceptional circumstances). Under the heading "Averting intervention", it also states that "the VTS operator must use all available means by which to prevent a suspected future grounding, collision or other hazard and, in the event of doubt, the VTS operator must regard the suspected situation as a certainty and act accordingly".

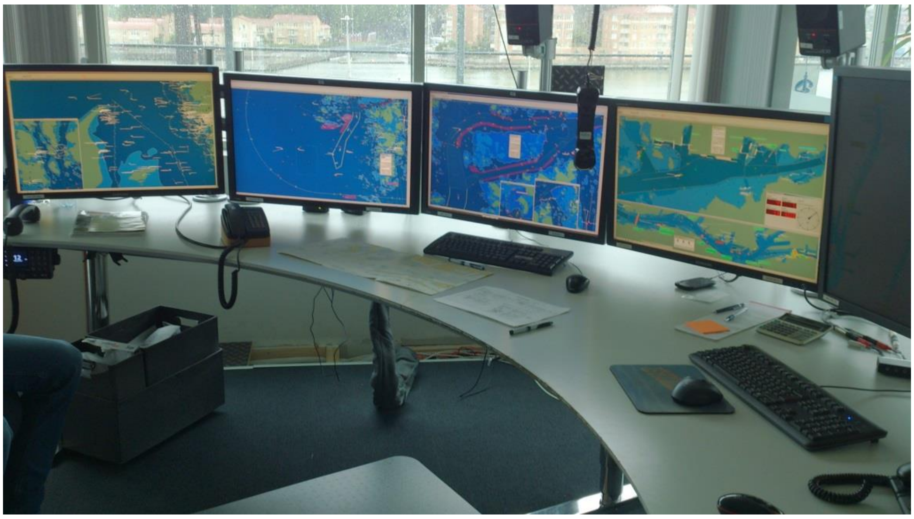


Fig. 13. The VTS centre.

When developing the VTS operation, there has been a discussion within the Swedish Maritime Administration about how an intervention is to be implemented without disrupting operations on board or stealing the attention of the vessel's crew unnecessarily. The instructions are that in such situations, use can be made of what is known as a "blind call", i.e. a vessel is called by name and with a message (e.g. "you are heading shallow waters") that does not require a response. Alternatively the operator can adapt their voice and tone to the situation (as an example, it states that a neutral tone is less likely to steal attention, while a more urgent or challenging tone can have the opposite effect).

VTS Göteborg, which is the VTS area in which the collision in question took place, has radar monitoring of the area and access to AIS. The AIS tracks are recorded, together with the radio traffic that takes place in the VTS area. VHF channel 13 is the designated channel for radio communication within the VTS area.

The VTS operator during the occurrence was a Master Mariner and had worked as an officer since graduating in 2006 up until his employment as a VTS operator in 2012. The operator had therefore been working as a VTS operator for just over three years. The VTS operator's mother tongue is Swedish.

1.8 Pilotage, the pilot boat and related activities

The pilot boat PILOT 746 SE, which collected the pilots from B GAS LYDIA and TERNVIND, was manned by two boatmen and at the time of the collision it was heading towards Gothenburg via the southern fairway (the Böttö fairway).

On PILOT 746 SE there is radar, electronic nautical charts and other equipment for the vessel's operation. This equipment is located in a way that makes it easily accessible to the master, who has a place in the middle of the three chairs that are located beside one another in the forward part of the cabin, and for the lookout, who has a place on the starboard side. However, there is no equipment specifically intended for the person sitting on the port side (which is usually where the pilot sits), nor does this boat have any equipment intended for pilotage or assisting other vessels. There was also no portable equipment available for this purpose.

The crew on the pilot boat had worked between 18:00 and 24:00 in the evening of 18 July, after which they had switched over to standby, in which they constituted “first drive”, i.e. it was them who would be first to be called out to conduct operations up until 02:00 on the morning of 19 July. Following this, they switched over to “second drive” until 08:00 the same day, after which the crew would go on leave. The operation in question thus constituted a “first drive”, that would conclude when they arrived at the pilot location when another crew took over the “first drive” standby shift.

The pilots were on a shift of respectively four and five days, and would both finish this period of work on 20 July. Both had been resting since the morning of 18 July and the pilotage of B GAS LYDIA and TERNVIND were the first pilotage operations following this rest. They were called up for their respective operations after midnight on 19 July. TERNVIND’s pilot had no other operations on the 19 July, while the pilot of B GAS LYDIA had three further pilotage operations on the same morning.

The investigation shows that the pilot, having left TERNVIND, monitored the vessel from the pilot boat in order to ensure that everything looked good and that she returned to course.

The pilot who piloted TERNVIND states that the location where he disembarked from TERNVIND was appropriate in order to reduce the effect of wind and waves. In better weather, the pilot would have departed later. The pilot on B GAS LYDIA, which is a smaller vessel than TERNVIND, also states that the weather justified an earlier disembarkation.

According to information from the crew of the pilot boat, the choice of location for collection or drop-off of the pilot is significant as there is a certain sensitivity to wind and waves when the wind is westerly. However, if the wind is southerly, it is less important where the pilot is collected or dropped off as there is nothing in the area that provides shelter. The pilot boat crew therefore do not believe that there is any specific location, better or worse, in the weather conditions that prevailed at the time, when the wind and waves were south-westerly. The location that the pilots departed on this night was, however, the location that is normally used. The location is inside the pilotage line.

The pilot who piloted TERNVIND was a Master Mariner and had worked at sea on and off since 1996, becoming an officer in 2001. The pilot was a master for one year until the employment as a pilot began in 2009. The pilot held a full pilot’s ticket for Gothenburg.

1.9 Voyage data recorders and technical information

1.9.1 VDR, AIS and audio files

The VTS recording that SHK has been given access to is a combined recording of radar tracks, AIS tracks and audio files from the VHF traffic. The tracks reveal information including the location where the pilot left TERNVIND and the location of the collision. As indicated in Fig. 14, the location where the pilot disembarked is around six cable lengths inside the pilotage line. In addition, audio recordings from the bridges from each vessel's VDR have contributed to a good understanding of the sequence of events.

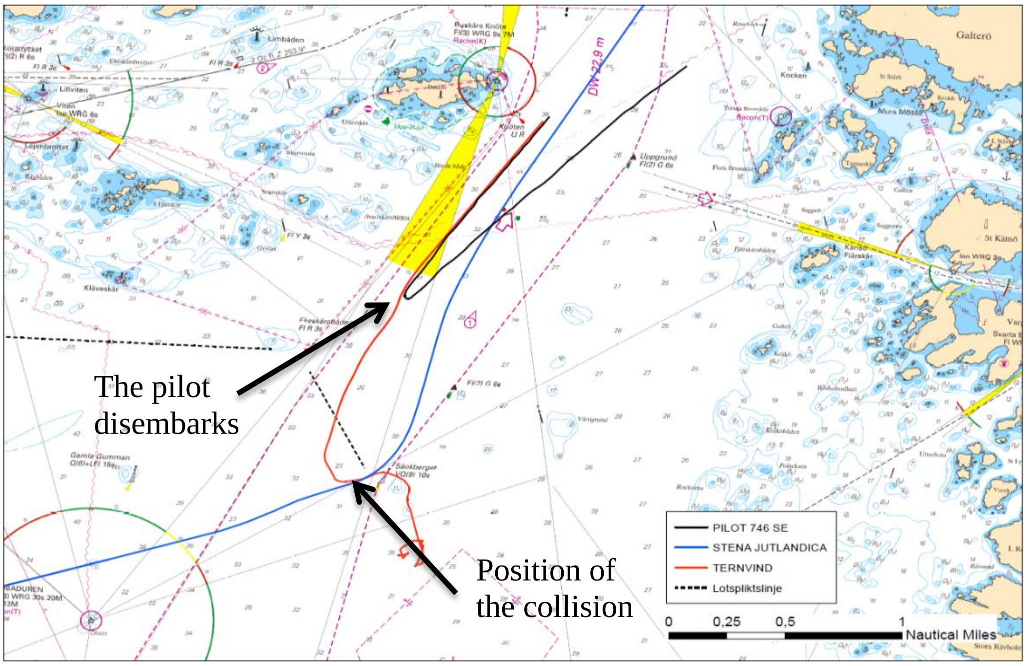


Fig. 14. Nautical chart of the area that contains the AIS tracks of the vessels in question. STENA JUTLANDICA's AIS track is blue, TERNVIND's is red and the pilot boat's is black. The pilotage line is marked with a dashed black line. Image: Swedish Maritime Administration no.: 10-01518.

With the help of data from STENA JUTLANDICA's VDR, it can be established that a turn to port with a radius of 1.4 M was initiated just before the VHF call from TERNVIND (see Fig. 15 and 18). Furthermore, it has been possible to create a reconstruction of the rudder movements. In addition, the VDR shows that all the watertight doors were closed at the moment of collision, apart from door no. 2, which was closed just after the collision.

From TERNVIND's VDR, it is primarily audio files and radar images that have contributed to the reconstruction of the sequence of events.

However, both VDRs show some deficiencies in terms of the recording of data. The sound on the recording from STENA JUTLANDICA stutters, at which point the file has to be restarted.[30] In addition, there is a complete absence of engine orders and engine manoeuvres and the

[30] Stena Line has subsequently announced that the problem only arises when the audio files are played together with other files.

rudder information comes and goes. Rudder information and engine manoeuvres are completely absent from the VDR data from TERNVIND.[31] In those parts where there is a lack of data, it has not been possible to verify the information provided by the crews.

The sound files obtained from the JRCC and the Swedish Maritime Administration reproduce both telephone and radio calls and contain radio traffic from VHF channels 13 and 16.

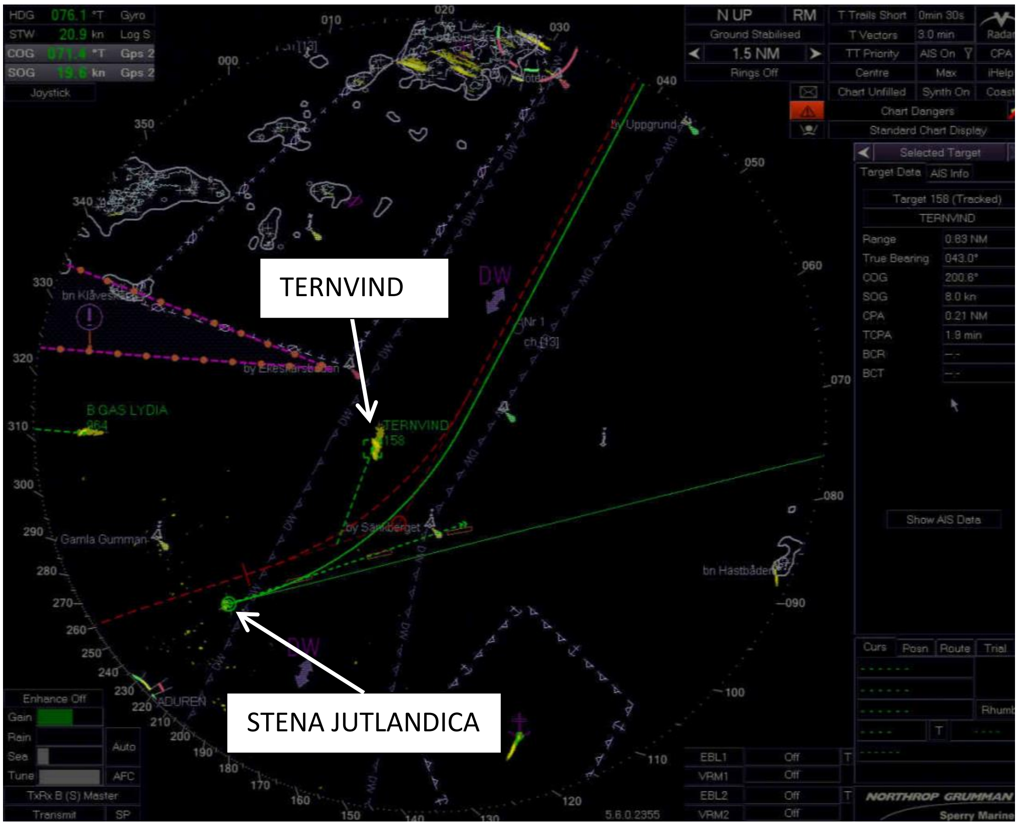


Fig. 15. Radar image (appears with north up) from STENA JUTLANDICA at the moment the turn to port with a radius of 1.4 M begins. The CPA to TERNVIND is seen on the right and, according to the ARPA, is 0.21 M. The green dashed lines in front of each vessel is that vessel's estimated route unless the conditions change. The unbroken, curved green line in front of STENA JUTLANDICA is the course that she will follow when the turn begins. The time at this point is 02:14:44.

[31] The requirement is specified in IMO Resolution A.861(20). Cf. Section 1.11.6.

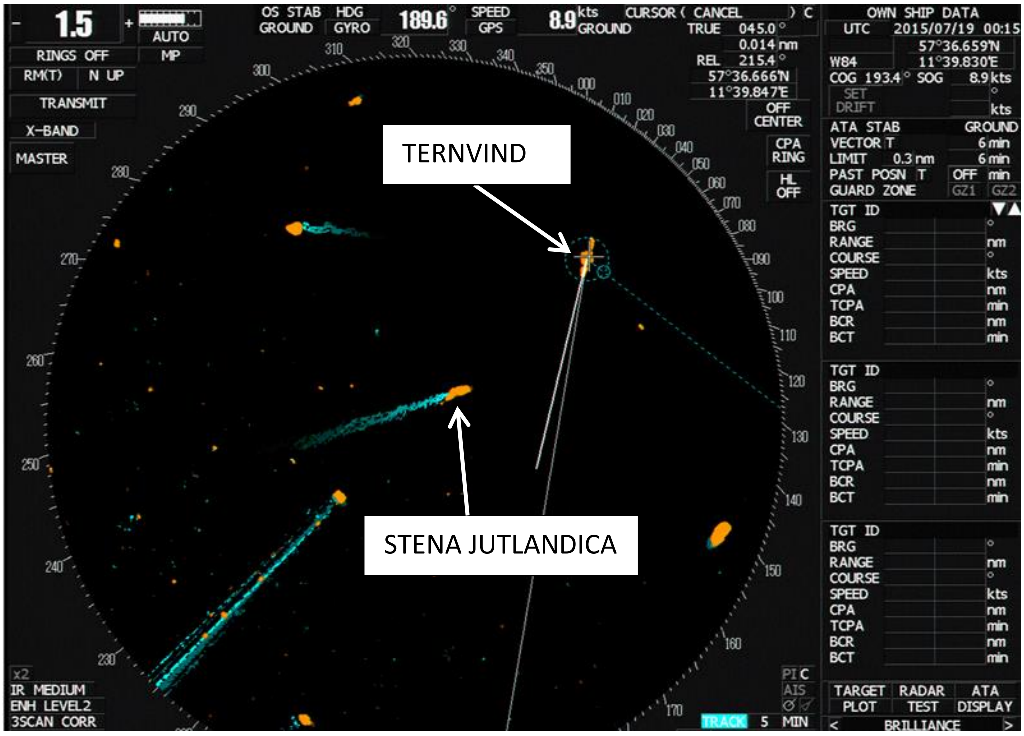


Fig. 16. Radar image (appears with north up) from TERNVIND's X-band radar when the master calls STENA JUTLANDICA at 02:15:12. TERNVIND is in the small circle at the top right, with white course indicator of approx. 190°. STENA JUTLANDICA is the yellow echo at the centre of the image. The distance between the vessels is now just over 0.7 M.

It can be established that there are some differences in the information concerning times between the data recordings that are included in the investigation. However, this only involves differences of a single second, which has not been assessed as having any vital significance to either the analysis or the understanding of the report. A summary of the sequence of events in graphical form can be found in Appendix 1.

1.9.2 Radar and ARPA

Both vessels has radar apparatuses with an ARPA function. The minimum requirement for this function is specified by the IMO[32] and varies depending on how old the radar is. However, in no case are the requirements for accuracy with respect to CPA less than 0.3 M.[33] A prerequisite for the value is that both the own vessel and the target vessel have maintained their course and speed for at least three minutes prior to the reading. The accuracy is also dependent on the precision of a number of input values, e.g. compass and log, but principally the performance of the radar. Changes in course increase the degree of uncertainty. There is also a delay in the system and it is therefore often easier to see a change in course optically than on the radar screen.

[32] IMO: International Maritime Organization.

[33] See, for example, IMO Resolutions A.823(19), MSC.64(67) and MSC.192(79). See also ARPA. Automatic Radar Plotting Aid, Per-Åke Kvick, Kalmar Maritime Academy, January 2005.

1.10 Reconstruction and simulations

In order to obtain a good understanding of the sequence of events, a reconstruction of the occurrence has been created on behalf of SHK in a Kongsberg Maritime Polaris bridge simulator. The vessels' movements and the weather, visibility and light conditions have been recreated in this facility. The reconstruction itself is then based directly on input data from both vessels' VDRs and thus may be considered to provide a very reliable picture of the sequence of events.

Following this, a number of simulations have been conducted in the same facility in order to study alternative sequences of events (refer to Appendix 2, for an account of these simulations). It should be noted that the aim of the simulations has not been to investigate and establish how the crew should have acted in the situation that arose. Instead, the aim has been to contribute to a better understanding of the collision. The simulations cannot be regarded as having the same degree of reliability as the reconstruction. Nevertheless, they may at any rate be considered to provide a good understanding to alternative sequences of events. Vessel models with similar characteristics to the vessels involved in the collision have been used in the simulations. The results are judged not to have been affected in any vital way by the small discrepancies there are between the simulator models and the actual vessels. However, it should be noted that, even though the simulations are assumed to provide a good picture of the sequence of events and the options available in terms of course of action in the situation that arose, they cannot be regarded as constituting an absolute truth.

1.11 Relevant regulations

1.11.1 Navigation rules

Applicable navigation rules can be found in the Swedish Transport Agency's regulations and general advice (TSFS 2009:44) on navigation rules. Those that are relevant to this occurrence include Rule 2, which states that nothing exempts the master or the crew from their responsibility for having neglected to take precautionary action that is considered to constitute good seamanship. In addition, Rule 7 (Risk of collision) states that if there is any doubt of risk of collision, such a risk shall be deemed to exist and all available means shall be used to determine whether there is a risk of collision at an early stage. Rule 8 (Action to avoid collision) states that action shall be made in ample time and be large enough to be readily apperent and that series of small changes should be avoided. Furthermore, it states that speed is to be reduced by stopping or reversering if necessary.

In addition, the following rules are of significance in this case.

Rule 5 – Look-out

Every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.

Rule 15 – Crossing situation

When two power-driven vessels are crossing so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way and shall, if the circumstances of the case admit, avoid crossing ahead of the other vessel.

Rule 16 – Action by give-way vessel

Every vessel which is directed to keep out of the way of another vessel shall, so far as possible, take early and substantial action to keep well clear.

Rule 17 – Action by stand-on vessel

***(a)** (i) Where one of two vessels is to keep out of the way the other shall keep her course and speed.*

(ii) The latter vessel may however take action to avoid collision by her manoeuvre alone, as soon as it becomes apparent to her that the vessel required to keep out of the way is not taking appropriate action in compliance with these Rules.

***(b)** When, from any cause, the vessel required to keep her course and speed finds herself so close that collision cannot be avoided by the action of the give-way vessel alone, she shall take such action as will best aid to avoid collision.*

***(c)** A power-driven vessel which takes action in a crossing situation in accordance with sub-paragraph (a)(ii) of this Rule to avoid collision with another power-driven vessel shall, if the circumstances of the case admit, not alter course to port for a vessel on her own port side.*

***(d)** This Rule does not relieve the give-way vessel of her obligation to keep out of the way.*

Rule 34 – Manoeuvring and warning signals

***(d)** When vessels in sight of one another are approaching each other and from any cause either vessel fails to understand the intentions or actions of the other, or is in doubt whether sufficient action is being taken by the other to avoid collision, the vessel in doubt shall immediately indicate such doubt by giving at least five short and rapid blasts on the whistle. Such signal may be supplemented by a light signal of at least five short and rapid flashes.*

The comments to the Swedish Maritime Administration’s Navigation Regulations etc. state that “keep course and speed” does not mean that the vessel in question must maintain the course and speed they were keeping when the give-way vessel was sighted. Instead, it means that the vessel is to manoeuvre the course and speed that, independently of the other vessel, would be required for proper navigation and correct performance in other respects, for example in order to follow the fair-way.

1.11.2 Watchkeeping, lookout and navigational information

According to Chapter 2, Section 1 of the Swedish Transport Agency's regulations (TSFS 2012:67) on watchkeeping, the master is to organise appropriate, effective and safe watchkeeping. Under the leadership of the master, the officer of the watch on the bridge is responsible for ensuring that the vessel is operated in a safe manner. The watchkeeping system is to be organised in such a way that the first watch at the beginning of a voyage and the subsequent watches are sufficiently rested and ready for their duties. The effectiveness of the personnel going on watch may not be impaired as a result of fatigue. According to Chapter 3, Section 3, the master or officer of the watch is also responsible for ensuring that the watch is reinforced if necessary to enable the vessel to be operated in a safe manner.

According to Chapter 4, Section 2, on a vessel where there is no automatic steering facility in operation, at least two crew members are to be on watch on the bridge, in addition to the officer of the watch. One of these crew members is to be helmsman. The other is to either keep lookout from the bridge or be in its immediate vicinity. According to Chapter 4, Section 10, the lookout is to devote themselves entirely to keeping careful lookout and may not be allocated or perform any duties that could interfere with this duty.

According to Chapter 4, Section 21, the officer of the watch is to know where the vessel's safety and navigation equipment is located and how this equipment is used. He or she is also to be familiar with and take into consideration the equipment's operational limitations. The officer of the watch is also to use all available navigation aids and is not to hesitate to, when necessary, make use of steering gear, machinery and sound signalling apparatus (Chapter 4, Sections 23 and 25).

When using automatic steering in heavily trafficked waters, in the event of reduced visibility and in all other dangerous situations, it is to be possible to immediately switch over to manual steering. On such occasions, the officer of the watch shall have access to a qualified helmsman, who shall be able to take over the steering immediately. A responsible officer shall execute or supervise the switch-over from automatic steering to manual steering and vice versa. The requirement to have a helmsman appointed and for the steering equipment to be switched to manual steering shall be taken into account in good time so that every possible dangerous situation can be dealt with in a safe manner (Chapter 4, Section 34).

1.11.3 Liability if someone is found in distress

Chapter 6, Section 6, second paragraph of the Swedish Maritime Code (1994:1009) contains provisions concerning the master's obligation to rescue those in distress. If the master finds someone in distress, he is obliged to provide all assistance possible and necessary in order to rescue the person in distress, provided this can take place without serious risks to the own vessel or to those on board. If the master otherwise learns that someone is in distress or of some danger that threatens maritime traffic, he is, under the conditions just given, obliged to take action in order to rescue the person in distress or avert the danger in accordance with the regulations that the government have issued.

In accordance with Section 6 of the ordinance (2007:33) concerning the master's obligation in the event of threats to maritime traffic and distress at sea, a master who learns that someone is in distress is obliged to proceed with the vessel as quickly as possible to the location of the accident and provide all assistance possible and necessary in order to save the person in distress. However, this does not apply if the master cannot provide assistance, if it is unreasonable for the vessel to proceed to the location of the accident or if assistance is not required.

1.11.4 Communication

According to Section 9 of the Swedish Transport Agency's regulations and general advice (TSFS 2011:2) concerning navigation safety and navigation equipment, the English language is to be used on all vessels on international voyages in safety communications between vessels and between vessels and the shore. The same applies to onboard communication between pilots and watch personnel, provided those directly involved do not have a common language other than English. With regard to language in radio traffic in VTS operations, please refer to Section 1.7.

According to the Swedish Transport Agency's general advice to the same paragraph, the phrases in IMO Resolution A.918(22) are to be used.[34] According to this resolution, yes and no question from the sender are to be responded to with a clear "yes" or "no", followed by a repetition of the phrase in question. Furthermore, ambiguous words, synonyms and abbreviations should be avoided.

1.11.5 Compulsory pilotage

Pilotage is conducted by the Swedish Maritime Administration, while some regulation and supervision is conducted by the Swedish Transport Agency, which regulates this activity in its regulations and general advice concerning pilotage (TSFS 2012:38). This sets the pilotage line and regulates which vessels are encompassed by compulsory pilotage. Both vessels involved in this occurrence were

[34] A.918(22), IMO Standard Marine Communication Phrases (SMCP).

encompassed by compulsory pilotage inside the pilotage line, which stretched between the buoys Ekeskärsbåden and Sänkberget. Instead of employing a pilot, those on board can themselves take responsibility for the vessel's operation if they have been granted a pilotage exemption, which was the case for STENA JUTLANDICA, the master of which had such an exemption.

The regulations do not differentiate between compulsory pilotage for incoming or outgoing vessels, i.e. compulsory pilotage applies inside the pilotage line for all vessels, regardless of the direction in which they are sailing. Nevertheless, the regulations do not say that the pilot must be on board the vessel being piloted, rather they allow for the vessel to be guided by the pilot from a pilot boat or in another appropriate manner (Chapter 4, Section 3). Section 4 of the same chapter gives the pilot the option of leaving the vessel before the pilotage line in bad weather. However, this may only take place in exceptional cases.

1.11.6 VDR

According to Sections 26–27 of the Swedish Transport Agency's regulations and general advice concerning navigation safety and navigation equipment (TSFS 2011:2), all passenger vessels on international voyages or with a gross tonnage of 300 or more, and other vessels with a gross tonnage of 3,000 or more are to be equipped with a VDR in order to make the investigation of accidents easier. The same applies to cargo vessels built after 1 July 2002. According to Section 28, the information collected is to be made available to the relevant authority within the EU in the event of an accident within its territorial waters.

At the annual inspection, the Swedish Transport Agency checks factors such as that all data listed in the installation specification is being recorded and adheres to the standard in IMO Resolution A.861(20) Performance Standards for Shipborne Voyage Data Recorder (VDR). According to the requirements in the resolution, a VDR is to record data including the vessel's position, heading, speed, radar data, rudder angles, engine order, VHF traffic and communications and mandatory alarms on the bridge.

1.11.7 Requirements, guidelines and advice for steering systems

The general advice to Chapter 4, Section 17 of the Swedish Transport Agency's regulations and general advice (TSFS 2011:2) concerning navigation safety and navigation equipment states that the bridge's equipment and layout should fulfil the criteria in MSC/Circ.982 and SN.1/Circ.265.

IMO circular MSC/Circ.982 from 1998 provides proposals for equipment that is to be available at different workstations. It is proposed that the navigator's workstation have a heading/track control system and controls for the main rudder (including an override).

IMO circular SN.1/Circ.265 contains guidelines for designers and system integrators to use in the design and integration of navigation and bridge systems. The guidelines consist of a number of general and specific principles that take into account the needs and prerequisites of people to perform in a safe manner in a bridge environment. The circular refers back to MSC/Circ.982. The following points are a selection from the circular that have a direct impact on the design of workstations on the bridge.

- "5.1 The system should have the capability of allowing the operator to decline or override the automated ship control functions at any time or intervene part way through a process by means of a simple operator action."
- "5.4 The system should support procedures and actions to address failure modes and default to manual controls on failure of automated ship control functions."

IACS[35] recommendation no. 95, concerning how the SOLAS convention and Chapter 5 in it is to be interpreted, addresses two alternative designs. One alternative is for the navigator's workstation to have manual controls for steering, while the other is for the helmsman at the helm to replace this control.

The applicable ISO standard (ISO 8468:2007) contains no guidelines that state there is to be manual controls for the rudder at the navigator's workstation. However, there are to be controls that can be used to change course. In the previous edition manual hand steering controls at the conning station were also addressed.

1.12 Fatigue and working hours

The Karolinska Sleepiness Scale (KSS) is a validated self-assessment scale for fatigue. The scale goes from 1 to 9, with 1 to 3 equivalent to a very alert state and 7 to 9 a state in which there is a great or very great risk of falling asleep. A person who assesses oneself to be at level 5 or above on this scale can be regarded as in a state in which they would describe themselves as tired. The closer to 9 on the scale a person gets, the harder it is for them to stay awake.

The first signs of fatigue can be slight cognitive changes which lead to simple mistakes. Fatigue at this level can lead, for example, to the need for a certain amount of effort or reflection in order to remember something. If something in the surroundings changes and requires the person's attention, they would however normally have no problem reorganising themselves to deal with these requirements.

However, when the level approaches or exceeds 7 on the KSS, a person has greater difficulty perceiving, understanding and predicting their surroundings. The ability to plan and make decisions that are

[35] IACS = International Association of Classification Societies.

further ahead is particularly affected. In this state, decision-making is impaired in a comprehensive manner, in terms of both which decisions are made and also because it takes longer to make these decisions. At the same time, it becomes difficult to perceive how close you actually are to falling asleep at a level of 7 and over on the KSS. In addition, under stressful conditions, a person may perceive themselves as less tired, even though they actually are exhausted.

Swedish and international researchers have been working to chart how the scheduling of crew members affects individuals and working teams. These studies have found that even if a work and rest schedule complies with all the formal requirements for rest, it is far from certain that the rest periods are distributed in the best possible way for the individual crew member.[36]

1.12.1 Night work

The normal circadian rhythm for a person involves sleeping at night and being awake during the day. This rhythm is supported by a variation in daylight. A normal night's sleep or other main continuous period of sleep for a person with a normal circadian rhythm is between seven and nine hours. The amount of sleep required differs from one person to the next, but is normally within this range. A main continuous period of sleep shorter than seven hours involves a varying degree of sleep deficit. Less than five hours' continuous sleep involves a critical deficit.

There are two principal physiological processes that affect how awake or tired someone is. One is the circadian rhythm, the body's natural rhythm that regulates physiological changes at different times of the day, the other is the relationship between how much and when we sleep or are awake.

The body is predisposed to adhere to the natural rhythm of sleeping at night and being awake during the day. At night, normally sometime between 02:00 and 05:00, people are most tired. If someone who normally sleeps at this time is awake, they will be in a very tired state.

However, people can adapt to being awake at night and have their main period of sleep during the day. This is regulated by the second of the two processes mentioned above, i.e. the relationship between when and how much we sleep and are awake. If someone changes when they have their main period of sleep, they can adjust their circadian rhythm by about one to two hours per day. The body is thus able to adapt to sleeping and being awake at times other than those that are normal. If given sufficient time to adapt, the body is therefore able to cope with, for example, shift work, without it having a decisive impact on how alert a person is. Provided that there are conditions for an

[36] E.g. Fatigue Management Toolkit, a project within a collaboration between several European higher education institutions, among them Chalmers University of Technology and Karolinska Institutet (www.project-horizon.eu/).

undisrupted sleep, the main period of sleep in combination with other rest can be sufficient to avoid exhaustion or sleep deficiency.

Night work, particularly shift work, is still associated with some risks. Even if a person is able to adapt to working at night, the circadian rhythm means, in spite of adaptation, that there are critical times at which they are more tired than normal, e.g. during the period between 02:00 and 05:00 at night, mentioned previously[37].

There is a direct correlation between the time of the day at which the main period of sleep begins and how long it lasts. In general, the period of sleep is reduced if it begins after midnight and before 18:00 in the evening. This is due to the fact that we wake up when it is light. Another factor that has an impact is how long a person has been awake. A continuous period awake longer than 18 hours carries a high risk of reduced alertness.

1.12.2 Investigation of work, rest and sleep hours for officers of the watch

An investigation has been conducted in order to analyse the risk of fatigue among the responsible officers of the watch on each of the vessels at the time of the occurrence. The investigation has taken into account working and rest hours, together with information from interviews, and the data have also been analysed with the help of a special software, Martha[38]. It cannot be claimed that this software takes into account individual differences, but it is designed on the basis of a validated method. The results are estimates according to the previously mentioned KSS, with a value over 5 meaning that work it taking place with a reduced level of alertness and a value over 8 meaning that there is a high risk of falling asleep. The latter is a very critical level with a high risk of cognitive impact in an individual.

The officer of the watch on board STENA JUTLANDICA was on a schedule of nine hours’ working time between 19:00 and 04:00 and then another shift between 13:30 and 16:30. The main period of sleep (equivalent to “night time rest”) was taken following the night shift, with an opportunity for additional recovery between the afternoon shift and the evening shift. An analysis of the schedule shows that a critical time period can be found after 24:00 and becomes worse after 02:00. The end of a long shift with a lot of time on the bridge has thus been placed at the most critical time of the day and just before the main period of sleep. The fact that this specific schedule, which is the summer schedule, is perceived as demanding has been confirmed by the information provided by the officer of the watch. The shift’s length and arrangement means that he often feels tired toward the end of the shift, especially towards the end of the working week. However, he did not feel that he was more fatigued than normal at the time of the occurrence in question.

[37] This period has an equivalent during the day, normally around 15:00–16:00.
[38] However, the software itself is still a prototype, which is why there may be shortcomings in the presentation of the data.

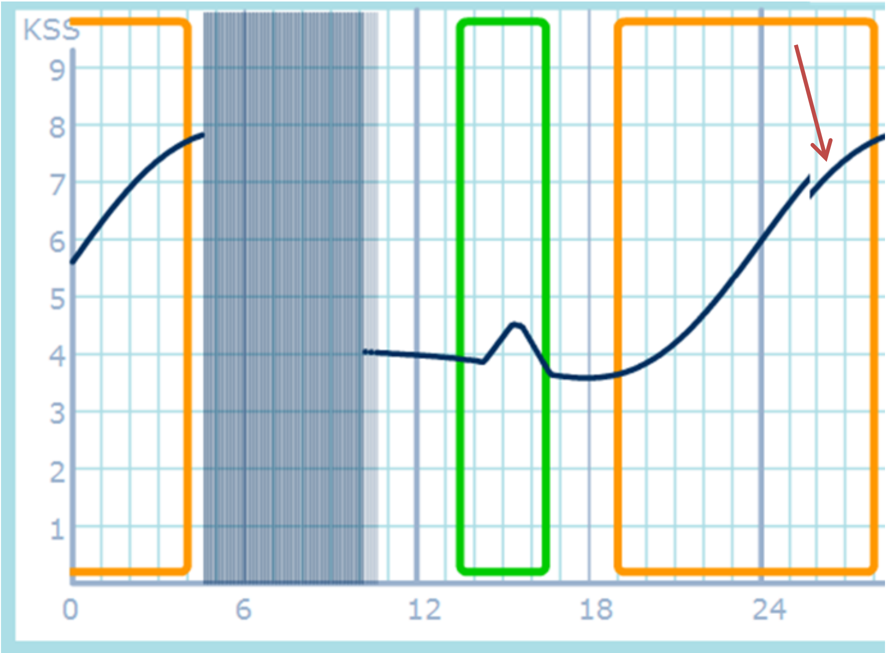


Fig. 17. An example of a wave pattern for level of tiredness/alertness according to the Karolinska Sleepiness Scale.[39] The Y-axis shows the KSS value, while the X-axis shows the time. The basis used is the work schedule for the officer on board STENA JUTLANDICA. The example shows a curve with a starting time at midnight between 17 and 18 July, approx. 26 hours before the collision. The collision took place at around 02:17, which is indicated by the red arrow.

The master of TERNVIND, who did not have scheduled working hours, had reasonable chances of achieving sufficiently good sleep and rest periods. The master normally had night-time rest of at least seven to eight hours, provided the work did not require operations at night. His working hours were thus primarily during the day. However, the occurrence in question was preceded by a couple of deviations from the routine. The night before the collision, the master's rest period was interrupted for three hours between 22:30 and 01:30 in conjunction with the vessel's arrival in Gothenburg. On the night of the collision itself, the master was also on duty at a time that is normally arranged as a rest period.

Deviations from normal working hours can be studied retrospectively in the work and rest log. According to this journal, the master had had two rest periods, 01:30–08:00 and 17:00–24:00, over the course of the previous 24-hour period. The master has stated that he got a total of just over 10 hours sleep in these two rest periods. Given the circadian rhythm, it is reasonable to assume that it may have been difficult for the master to actually sleep during the rest period that preceded the shift on the night of the accident, even though there was actually plenty of time for recovery. This follows from the rest period being partly during the day and with the last rest period before that having been completed as late as 08:00. The master himself states that fatigue was not a contributing factor to the collision.

[39] The figure is a combination of two images from the Martha software as detailed diagrams like this can only be displayed for one 24-hour period at a time. The two images were combined using an image manipulation program. The small difference that can be seen in the wave pattern just after 24:00 is only an effect of how the program shows the pattern on the two days.

No information has emerged that would support the statement that either of the officers of the watch did not fulfil the regulatory requirements in terms of work and rest hours.

1.13 Procedural drift

In all types of activity based on rules or standards, there is a risk of a gradual increase in the discrepancy between how the duties are intended to be undertaken and how they are actually executed. If this process continues without an attempt being made to understand and counteract it, a clear gap will emerge between the desired and actual outcome. This is known as procedural drift and it often takes place in very small steps, which are in themselves very difficult or even impossible to detect. In the long run, however, procedural drift can lead to accidents.

There can be several reasons why procedural drift arises. Rules or procedures may, for example, be “over or under-designed” so that they become difficult or impossible to comply with or various elements and goals in a working process may be incompatible. Over time, deviations from procedures that do not lead to any detrimental impact reinforce the belief that these non-conformities are safe and there is thus a risk of them becoming standardised.

In organisations and systems where there are targets that are at risk of conflicting with one another, for example, when efficiency must be balanced against safety, there is always a certain breeding ground for procedural drift. People tend to pursue more efficient working practices, at the same time as efficient work is usually rewarded, directly or indirectly, by managers. Only when something unwanted happens, such as someone hurting themselves, does this type of deviation from the applicable rules or procedures get noticed.

1.14 Other occurences of relevance

- PILOT 116 SE/RIB Delta – collision on 26 October 2014 (SHK RS 2015:09): When the pilot boat collected a pilot from a departing vessel, the pilot tracked the vessel’s onward journey using the pilot boat's electronic chart, which was thus used for something other than the pilot boat’s operation. In conjunction with this occurrence, the Swedish Maritime Administration has decided to equip pilot boats with a mobile navigation system that makes it possible to monitor other vessels via AIS independently of the pilot’s location and the pilot boat’s equipment.

- EK-RIVER – grounding on 25 November 2011 (SHK RS 2014:08): The vessel anchored and dragged in bad weather before running aground immediately thereafter. The investigation’s conclusions included that there was a certain doubt among the Swedish Maritime Administration’s personnel about where the boundaries for compulsory pilotage actually lie.

- SMART (IMO GISIS C0009375-R01), MELLUM (IMO GISIS C0006109-R01), KATIE (IMO GISIS C0005650-R01), CROWN BREEZE (IMO GISIS C0007373-R01): Common to these occurrences (two collisions and two groundings) is that they occurred immediately after a pilot having disembarked early or after the pilotage having lacked continuity in conjunction with the pilot being relieved.

- POMERANIA/RIO GRANDE – collision on 31 January 2005 (Swedish Maritime Administration 080202-05-15206/080201-05-15207): The vessels collided when the officer on the give-way vessel accepted a too small margin in CPA (significantly lower than the IMO standard stipulates) to the other vessel and when follow-up was not implemented.

- LANGELAND – sinking 31 July 2009 (AIBN Norway Maritime 2012/08): The vessel contacted the shipping company to inform them that they had developed a list of 10–15° and that they therefore intended to continue inside the skerries. The vessel capsized just after without having contacted the JRCC. All those on board died.

- ÄLVSNABBEN 5 (SHK RS 2014:09) – loss of engine control leading to a collision on 11 August 2013: As the navigator was not familiar with the details of the propulsion system, they lost control and the vessel ended up in a pre-installed drive setting that, combined with the automatically set course, led to a collision with a moored vessel.

- GOTLAND (SHK RS 2014:11) – grounding off Oskarshamn on 2 January 2014: One of the reasons why this vessel ran aground was the lack of opportunity for the navigator to quickly and simply switch over to manual steering and thus take control of the vessel themselves.

2. ACTIONS TAKEN

2.1 Stena Line

Stena Line has taken the following actions as a result of this occurrence:

On voyages towards Gothenburg, the master of the vessel is notified earlier in order to reinforce the bridge team prior to arrival in the area concerned. The steering system on STENA JUTLANDICA has also been upgraded with, amongst others, improved opportunities for easier switch-over between automatic steering and manual steering. There has been a general review of the signals to the VDR equipment in order to ensure that all signals are recorded in the system.

2.2 Terntank

Terntank has taken the following action as a result of this accident:

Organised discussions and safety meetings have been conducted within the shipping company’s vessels based on the accident and the internal investigation. More intense relevant training and education has also been implemented for the company’s officers. Furthermore, internal procedures have been updated with regard to navigation with a pilot on board and actions in the event of a collision. Finally, a review of risk assessment for navigation in congested waters and with a pilot on board has been implemented.

2.3 The Swedish Maritime Administration

A discussion has begun within the Swedish Maritime Administration concerning an additional reporting point when departing (at Buskärs Knöte). The intention is that this will update the information about the traffic present.

The applicable procedures state that when a pilot departs prior to the pilotage line, they are to inform the pilot ordering service. As a result of this occurrence, a discussion is now taking place concerning expanding this information exchange to also encompass the applicable VTS.

A new alarm list with a better allocation of duties between all functions has been drawn up within the VTS organisation, at the same time as discussions and exercises concerning becoming better at breaking into communications that are unclear or are going wrong are being conducted.

In terms of the pilotage organisation, procedures for hand-over to the master will be clarified in order to achieve consistency, procedures will be updated in order to ensure that the vessel’s name is always used in communications and that this takes place in English whenever possible, even on vessels involved in domestic traffic. In addition, a process to chart how common it is for the pilot to leave prior to the pilotage line will be implemented in all pilotage areas. Furthermore, there is a procurement process under way to acquire a new navigation system that makes it easier for the pilot to monitor vessels from the pilot boat.

At the JRCC, instructions and support templates have been clarified, with a focus on "seeking source data". In addition, the occurrence is being used as a specific case study for personnel.

3. ANALYSIS

The occurrence brings a number of questions to the fore, among them issues concerning navigation (with associated rules) and communication. In addition, there are grounds to address how the VTS, the pilotage and the pathways for raising the alarm have functioned. Some organisational aspects also need to be highlighted, among them the problems that can arise in conjunction with fatigue and night work. In this respect, the investigation has been restricted to only include the officers of the watch on the vessels. Issues relating to procedural drift have also been covered. One further question that has shown itself to be pertinent is how a damaged tanker containing 10,000 tonnes of oil products and a passenger vessel with just over 600 people on board could end up in a damaged condition in the waters of the archipelago without the JRCC taking any action. Finally, there are grounds to briefly address the damage the vessels sustained in the collision.

3.1 The pilotage

TERNVIND was sailing with a pilot on board as the vessel was within the compulsory pilotage area and none of the crew has a pilotage exemption. The pilotage should, in accordance with the applicable rules, have continued up to the pilotage line, which is drawn between the buoys Sänkberget and Ekeskärsbåden. However, following a handover concerning current traffic, including the incoming ferry, the pilot left TERNVIND as early as six cable lengths prior to this, according to the pilot because the wind and waves, which were coming from the south-west (230°), made it less safe to disembark further south. As the pilot had left TERNVIND, he regarded the pilotage to be complete after having tracked TERNVIND's route from the pilot boat in order to ensure that the vessel returned to course and everything looked good.

It may be said that, in each individual case, the pilot is best equipped to determine where the transfer between the piloted vessel and the pilot boat is to take place. In this respect, the pilot needs to take into account both their own personal safety and the piloted vessel's safe navigation. Pilotage such as this must, however, continue to at least the boundary that is set. It is still possible for the pilot to accomplish their task from the pilot boat, even if the conditions for this were not optimal as the pilot boat's equipment was only designed for the pilot boat itself.

It is possible with hindsight to conclude that it would have been preferable in this case had the pilot actually remained on TERNVIND, partly because the master would then not have been distracted by the pilot's departure and partly because the pilot would have constituted an additional resource on the bridge who would have been able to participate in planning the forthcoming meeting with STENA JUTLANDICA. In light of this, SHK is of the opinion that there is justification for the Swedish Maritime Administration to take action to ensure that applicable regulations are complied with and that the Administration review its internal procedures and instructions in this respect. According to information received, such actions are already being planned by the administration. As there are also indications that it has become a practice within the pilotage area that the pilots leave piloted vessels somewhat earlier than the regulations stipulate (see Section 1.8), regardless of the weather, SHK is of the opinion that it may be pertinent for the Swedish Maritime Administration, in this context, to take into account the risks of procedural drift (see Section 1.13).

SHK has no opinion on from where the pilotage is conducted, but if this takes place from a location other than the piloted vessel, the technical conditions for this need to be fulfilled. As mentioned before, the Swedish Maritime Administration is in the process of procuring a new navigation system that will improve the pilots' possibilities to monitor the ships from the pilot boat. SHK consider it to be important that the administration completes this work as soon as possible and provide pilots with the appropriate equipment for this purpose. (see Section 1.14: PILOT 116 SE/RIB Delta).

3.2 The communication

The communication within the VTS area that preceded the close quarters situation involving TERNVIND and STENA JUTLANDICA was, generally speaking, unclear. The language used alternated between English and Swedish and the information was sometimes incorrect. In addition, it happened that the wrong vessel responded to calls and calls were not being confirmed. Nevertheless, the sometimes confusing radio communications within the VTS area in the initial phase did not come to have any influence on the initial sequence of events.

The radio conversation that took place between TERNVIND and STENA JUTLANDICA was, however, crucial for the course of events. The call was made by the English-speaking master of TERNVIND, who received a response in Swedish. This can possibly be explained by the call having been made using the names of the vessels alone, since the names sounds similar in Swedish and English.

The subsequent question was also asked in English, but the reply was initially formulated in Swedish. SHK is of the opinion that it is understandable that an English-speaking person who hears the response from STENA JUTLANDICA obtain the perception that the two vessels would pass starboard to starboard. Even though the communication for an English-speaking person can be considered to adhere to the principle of confirmation through repetition in accordance with the IMO standard, there is no clear “yes” or “no” and repetition of the same phrase as in the question.

In the case in question, the misunderstanding meant that those in command of the vessels had definite but diametrically opposite understandings of how the meeting would take place. The turn to port that STENA JUTLANDICA mention in the response to TERNVIND’s proposal to pass starboard to starboard was not conducted so that the vessels would be able to pass starboard to starboard, but to follow the fairway.

Following the call, there were three people who still came to suspect that something was not right: the officer on STENA JUTLANDICA (who had reason to clarify his previous response in a further call), the Swedish-speaking helmsman on TERNVIND (who attempted to make the master aware that something was not right) and the VTS operator (who had reason to monitor the vessels on her screen and called both vessels immediately thereafter).

However, the master of TERNVIND did not hear the subsequent call from STENA JUTLANDICA. He had already turned his attention to the helmsman, with instructions to turn to port in order to head towards the destination and provide space for STENA JUTLANDICA, and had mentally concluded the call. The officer on STENA JUTLANDICA also took no action to ensure that his supplementary information had been understood by TERNVIND. The master of TERNVIND only responded to the worry expressed by the helmsman with a reassuring response. It was thus a complete surprise to him that STENA JUTLANDICA did not implement the port turn that would have been required to pass starboard to starboard.

In total, the communication that took place gives reason to emphasise how important it is that communication must be sufficiently early, clear and unambiguous, especially when it involves making a departure from the rules concerning right of way.

SHK is also able to conclude that, in accordance with the Swedish Transport Agency’s regulations and general advice concerning navigation safety and navigation equipment, communication between vessels on international voyages is to take place in English, as is the case for communication within the VTS area, provided there are no exceptional circumstances. Such circumstances cannot be regarded as having existed in this case. As the investigation clearly shows that the discipline in this respect can generally be regarded as deficient, SHK find that there is justification to recommend that the Swedish Maritime Administration, which has a supervisory role through the VTS in at least the VTS area, in addition to already initiated actions, take action to work for and monitor that communication in the area takes place in English to the greatest possible extent.

3.3 Navigation

3.3.1 TERNVIND

According to the applicable navigation rules, TERNVIND was the vessel that was obliged to give way, which they were well aware of.

The master has stated that the CPA to STENA JUTLANDICA after the pilot had left the vessel was 0.3 M. However, according to a simulation of the sequence of events, which in this phase is consistent with the reconstruction directly based on information from the vessels' VDRs, the CPA would have been 0.17 M if both vessels had maintained course and speed (see Appendix 2, Simulation 6). Normally, a situation such as this is managed by maintaining course, reducing speed and allowing the other vessel to pass ahead; turn to starboard and pass astern of the other vessel; or a combination of these actions. In this case, the master maintained course and choose to propose passing starboard to starboard. When this proposal was suggested, the distance between the vessels was just over 0.7 M (see Fig. 16).

TERNVIND's proposal to pass starboard to starboard came after the master on TERNVIND has supervised the departure of the pilot from the vessel and he had therefore been concentrating on that. He stated himself that this led to him being surprised by STENA JUTLANDICA's rapid approach. Another factor that contributed to the crew of TERNVIND not tracking STENA JUTLANDICA more carefully was that they were temporarily without a lookout on the bridge as both the able seaman and the officer of the watch were down on deck in order to deal with the pilot's disembarkation.

The proposal to pass starboard to starboard meant a deviation from the navigation rules. On the other hand, the fact that TERNVIND wanted to pass starboard to starboard may in itself be understandable as such as passage could have been a smooth way of passing given where both the vessels were and were headed. This is also confirmed by the fact that those on board STENA JUTLANDICA also had discussed this possibility. It is certainly possible to agree to a deviation from the navigation rules. In this case, however, the proposal to pass starboard to starboard came far too late and in a situation where such a passage would have forced STENA JUTLANDICA to turn hard to port immediately after the call. In spite of such a hard turn, STENA JUTLANDICA would, according to the simulations, anyway have passed relatively close.

The turn to port made by TERNVIND, which was initially made in order to come onto the correct heading for the onward voyage south and at the same time to give STENA JUTLANDICA space, appears, given how TERNVIND had understood the agreement, to be completely logical. Immediately after this, however, it was noticed that STENA JUTLANDICA was not making the turn the master on TERNVIND had expected and his own port turn instead changed into a manoeuvre to avoid a collision. In this situation, a turn to port was in fact the only possible means of avoiding a collision available for TERNVIND as they had expected STENA JUTLANDICA to turn to port. In the light of this, a turn to starboard would have resulted in a very dangerous situation. In actuality, however, TERNVIND's turn to port resulted in the collision taking place. If TERNVIND had not made any turn to port or evasive manoeuvre, STENA JUTLANDICA would have passed ahead of TERNVIND, although very close (Simulation 5).

According to the master, the turn to port was combined with the vessel being put into full astern. It has not been possible to verify this as the VDR did not register engine manoeuvres, but the sound heard on the audio files from the bridge could originate from the astern manoeuvre. Nevertheless, this action did not have an impact in practice on the situation in question. The small reduction in speed that can be noted could also be explained by the turn to port that was conducted.

3.3.2 STENA JUTLANDICA

As STENA JUTLANDICA closed on the beginning of the fairway, the crew on the bridge had a clear view of the traffic situation, in spite of the risks for misunderstanding that existed as a result of the uncertainty present in the VHF traffic. The vessel had turned and held a course somewhat further south than usual with consideration given to the outgoing traffic. There was a discussion on the bridge about the options available, including the opportunity to pass TERNVIND starboard to starboard. However, no active action to plan the meeting with TERNVIND was taken and nor was there any direct obligation to do so at this stage – STENA JUTLANDICA was not obliged to give way, but should instead keep her course and speed.

The officer on STENA JUTLANDICA planned to enter the fairway as close to the eastern side as possible, taking into account TERNVIND. According to the officer on STENA JUTLANDICA, the ARPA showed a CPA to TERNVIND of just over 0.3 M at this stage.

In spite of this relatively tight CPA, STENA JUTLANDICA began a turn to port in order to place the vessel correctly for the onward voyage in the fairway. The turn was begun with a radius of 1.4 M, but this was soon increased to 1.6 or 1.7 M in order to make the turn a little slower, which would result in the vessel ending up farther out on the eastern side of the fairway. This turn was initiated about two minutes prior to the collision and just under 30 seconds prior to the VHF call between the vessels. Due to this turn, the already limited margin to TERNVIND was reduced further. According to the radar image from STENA JUTLANDICA's VDR, the ARPA plot on the radar actually showed a CPA to TERNVIND of 0.21 M at this point (see Fig. 15).

As the situation developed and as a close quarters situation drew ever closer, the requirements for STENA JUTLANDICA to also take action to enable the vessels to pass safely should be regarded to have increased. According to the regulations, in the event of doubt about another vessel's intentions, it is the duty of the officer of the watch to try to gain its' attention. However, this was not done.

The phrase "keep course and speed" means that the vessel is to manoeuvre the course and speed that, independently of the other vessel, would be required for proper navigation and correct performance in other respects, for example in order to follow the fairway. However, a vessel may take action through its own manoeuvring when it is clear that the other vessel is not taking appropriate action. If a collision cannot be avoided, vessels that are to maintain course and speed are to take action in order to avoid the collision. In which case, a vessel is not to change course to port for a vessel that is on the port side (see Section 1.11.1, Rule 17).

It is true that the area in which the vessels were is a fairway, but it cannot be regarded as so limited that it is entirely necessary to follow it as there is sufficient water, for example, on the eastern side of Sänkberget or for a 360-degree turn to starboard. It is SHK's opinion that it is inappropriate in a situation such as this to begin a turn towards another vessel and thereby reduce an already small margin between the vessels, regardless of which vessel is obliged to give way.

Simulations have shown that even with TERNVIND's evasive manoeuvre to port, the collision could have been avoided had STENA JUTLANDICA refrained from her initial turn to port until she had passed the bow of TERNVIND. Simulations 7 and 8 show that STENA JUTLANDICA would actually have passed very close (0.12 or 0.17 M) and would have needed to have a smaller turn radius (0.50 or 0.75 M), but would have avoided the collision had she waited before turning to port. She would probably have ended up worryingly close to Sänkberget, but the option of going east of the buoy or simply making a 360-degree turn to starboard cannot be excluded as alternative course of action.

When those on STENA JUTLANDICA realised that something was about to go wrong, action was taken to avoid the collision. To begin with, the port turn was maintained with a course towards Sänkberget. As the automatic steering was turned on, the manoeuvre was conducted as a normal turn with a programmed turn speed, i.e. when the new turn speed or heading is achieved, the rudder was braced in order to maintain the turn speed or course. Subsequently, there was a switch over to manual steering. However, this only took place about 28 seconds after the automatic steering turn to starboard had been initiated (see Fig. 18). Consequently, the evasive manoeuvre was not as effective as it could have been if the manual steering had been turned on immediately or if the override joystick had been used.

The reason for the override steering not being used is stated to have been that it was better to switch over immediately to manual steering as the lookout was at the manual steering desk. It has however not been possible to establish with any certainty the reason why the switch-over was delayed. There are no indications that point to there being any technical fault with the switch-over system.

As previously indicated, it requires two manoeuvres to switch over to manual steering: firstly, a switch-over on the navigator’s panel and then a confirmation on the steering desk. From the information submitted and the audio recording from the bridge, it is possible to draw the conclusion that it appears to be the switch-over on the navigator’s desk rather than the confirmation on the steering desk that was delayed. Neither the helmsman nor the officer of the watch has been able to remember or explain why there was a delay before the switch-over was initiated. One explanation may of course have been that it was a stressful situation; another that the decision-making was affected by fatigue (further information below). SHK has also investigated whether the design of the steering system may have had an influence on the occurrence. However, the crew have stated that they are well familiar with and accustomed to the switch-over procedure. Regardless of what the reason for the switch-over being delayed was, the vessel ended up being operated using automatic steering at this point in time, with a limited course change to starboard.

With reference to evasive manoeuvres, the simulations have shown that in the situation in question, with the turn to port commenced previously, the absence of or too small an evasive manoeuvre to starboard would have resulted in STENA JUTLANDICA colliding with TERNVIND’s starboard side (Simulation 3), while a late and hard evasive manoeuvre would have led to STENA JUTLANDICA’s quarter colliding with TERNVIND’s starboard side (Simulation 2), unless a well-executed port manoeuvre possibly could have counteracted the skid effect towards TERNVIND. It can be concluded from this that the action, in the form of the evasive manoeuvre implemented by STENA JUTLANDICA, probably contributed to reducing the damage to TERNVIND and also to avoiding an oil spillage.

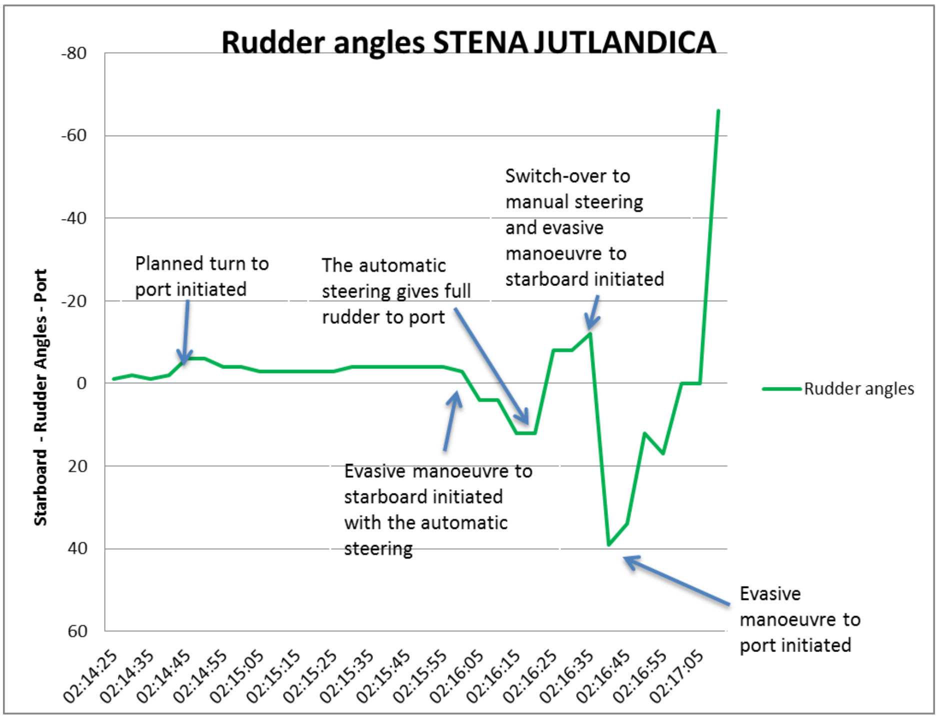


Fig. 18. STENA JUTLANDICA's rudder angles during the sequence of events. The arrow on the left shows the turn to port with a radius of 1.4 M, after which it is possible to divine from the curve that the radius increases as the rudder angle decreases. The second arrow shows the evasive manoeuvre to starboard that was made using the automatic steering and the third arrow points to when the rudder braced in order to hold the new course. The fourth arrow indicates when the manual steering was confirmed on the steering desk and the rudder was set hard to starboard. However, it is not possible to see when the switch-over took place on the desk by the navigators' chairs. The fifth arrow indicates when the rudder was set hart to port.

3.3.3 VDR, radar and ARPA

It can be noted that both STENA JUTLANDICA and TERNVIND were equipped with VDRs, but that there were shortcomings on both vessels in terms of the data that had been collected. However, Stena Line has stated that the company has conducted a general review of signals within the VDR system to ensure that all signals are saved, but it is not clear if this concerns only the STENA JUTLANDICA or all of the company vessels. Consequently, SHK sees a need for both shipping companies to review how VDR data collection functions in their respective vessels.

On both vessels, data from the radar apparatuses was used with the ARPA function in order to calculate the CPA to the other vessel. These data are stated to two decimal places, which can give the impression that the data are precise. In this context, one must be aware that there can be large variations in the accuracy of the radar equipment. The minimum requirement for accuracy in an ARPA is set to 0.3 M (see Section 1.9.2). Accordingly, using too small margins and blindly relying on data provided by the ARPA is associated with some risk. It has also been confirmed in this investigation that variations in the values arise when the vessel's speed or course changes, which is also calculated with some delay. An example of the impact this can have is the fact that both the responsible officers have stated that the CPA was at 0.3 M at a certain stage, while the CPA in the reconstruction was in practice shown to be under 0.2 without any changes in course and speed having been made.

Proceeding in open sea with such small margins can only be regarded as acceptable under certain conditions, e.g. when keeping out of the way of another vessel by going astern of it and clearly indicating this. Under all circumstances, this requires continual visual monitoring and an increased preparedness for supplementary actions, e.g. manual steering.

3.3.4 *Fatigue and working hours*

Given the sleep and rest hours of both vessels' officers of the watch as supported by the available interview data, it is possible to express an opinion concerning the probable degree of fatigue of the offices at the time of the occurrence in question. Factors that affected them both were the time of the day, i.e. that it was night time and that the occurrence also took place at a critical point in time between 02:00 and 05:00.

The officer on STENA JUTLANDICA was at the end of a long shift that included a great deal of time on the bridge and was to have his main rest period after this. Even though the duties over the course of the nine-hour shift were varied, it is possible to conclude that the schedule itself constitutes a major risk of fatigue that is expressed as impaired performance in terms of attentiveness, planning and decision-making.

Given what is known within the field of fatigue research, it is reasonable to suspect that, at the time of the occurrence in question, the master on TERNVIND was working in a state of reduced alertness. This is because he was working at a point in time that was normally assigned as a rest period and the work was also undertaken at the point in time during the night that is normally critical. This means that there was also a certain risk of impaired performance in terms of attentiveness, planning and decision-making with reference to the master of TERNVIND, even though he himself did not feel that he was affected by fatigue.

There are also examples in the sequence of events that support this assessment. Even though it is possible to hear on STENA JUTLANDICA's VDR that the officer of the watch discussed a starboard passage with the lookout about ten minutes prior to the collision, the planning of the meeting of the two vessels was not as well-thought out as was required in the situation, especially in the phase where the situation became increasingly sensitive. Similarly, it can be concluded that the meeting with the incoming ferry was not unknown to the master of TERNVIND, but that he was still surprised by the ferry's rapid appearance following the departure of the pilot. The master of TERNVIND has also stated himself that he misjudged the passenger ferry's speed.

The communication between the vessels prior to the meeting took place very late and in a way that was almost impossible not to misunderstand. The misjudgements made, the defective communication and the late and deficient planning of the meeting constitute signs that the officers may have been affected by fatigue. In this case, both vessels' officers of the watch have noticed the other vessel well before the close quarters situation arose, but both of them were almost passive when it came to understanding and preparing for the meeting. This may also be a sign of decision-making that was affected by fatigue. In summary, SHK is of the opinion that fatigue may have been a contributory factor to the accident in this case.

SHK realises that it can be difficult in a shipping company to reduce the risks of fatigue, but believe that a ferry company, especially one with sailings in accordance with a predetermined timetable and thus predictable conditions, could better optimise the schedule and take into account the known risk associated with, for example, long periods awake, far too rapid shifts in work and rest periods, long shifts at night or in the dark and particularly critical times of the day.

Where possible, attempts should be made to avoid schedules that involve the most critical elements being undertaken when an employee is the most fatigued. Experience from both Swedish and international research should be able to serve as guidance in a review of scheduling and contribute, for example, to finding better times for watch changes or to a better allocation of duties between officers at the critical times of the day. Having the master to be woken up earlier to enforce the bridge team in the area concerned has also to be considered to be an adequate and safety promoting measure for compensating potential fatigue within the crew.

3.4 The function of the VTS in conjunction with the collision

The VTS operator, who overheard the VHF communication between STENA JUTLANDICA and TERNVIND, had misgivings about the situation and therefore monitored both vessels on the radar screen, which also has AIS tracks. The operator was thus able to come to the conclusion that a close quarters situation was in the process of arising and chose to act in accordance with the instructions that are in place for such situations. Clearly this action did not prevent the collision, but in spite of the fact that the calls made to both vessels came at a very late stage, it is possible to conclude that they did not, in any case, exacerbate the situation by disturbing those on board. SHK makes the assessment that the action taken in this respect was consistent with the instructions that apply to this activity.

3.5 The damage

STENA JUTLANDICA suffered damage both above and below the waterline in the collision. The damage above was caused by TERNVIND's bow penetrating the side and the main deck, which caused damage to the supply hatch and supply lift. This led to a need for extensive repairs. There was no cargo unit or people in the damaged area and no damage or injuries aside from the damage to the ferry.

The damage under the waterline resulted in two dry tanks being damaged and two watertight compartments filling with water. This led to a pretty much immediate submergence of the vessel, but as the dry tanks stretch across the entire breadth of the vessel, there was no list. As the vessel has very good stability properties, the water intrusion did not result in any risk of capsizing or sinking.

Nevertheless, the stabiliser fin was damaged, which in turn damaged piping in another of the vessel's compartments that is used as a pump room. As a result, there was also water intrusion there, which risked damaging the electronic equipment in the compartment. This damage resulted in some risk to the vessel. If this equipment, which included the vessel's engine control system, had been damaged, it could have made the onward voyage into the city more difficult. While it is possible to control the engines without the control system, when all is said and done, this is not a normal form of operations, which means that complications are to be expected. However, the engine crew was able to keep down the water level by opening a man hole to the ballast tank under the pump room (the only empty ballast tank on this occasion), making it possible to get the water out of the way.

Fig. 19. By opening this man hole, in spite of the water level in the room rising, it was possible to lead the water away from the pump room. Image: Stena Line.

The damage to TERNVIND actually resulted in no safety risks, but the vessel still remained at the location for further examination by divers.

3.6 Pathways for raising the alarm

When the vessels collided, immediate damage control began on each of them. A rather good overview of the damage was obtained at an early stage and resulting action followed. At the same time, the VTS received the information required in accordance with the area regulations and was able to call around the relevant authorities, among them the Coast Guard, the Swedish Transport Agency and its inspector on duty. The VTS operator also ensured that information about the collision was forwarded to the JRCC via the pilot planning centre.

On the vessels, the crews followed their respective check-lists for this type of occurrence and then contacted their respective shipping companies, who in turn acted in accordance with their set of procedures. With regard to TERNVIND, the consequences of this were that the extent of the damage could be established as being so minor that reporting to the relevant authorities was not deemed necessary.

On STENA JUTLANDICA, the chief officer was tasked with acting in accordance with the check-list for collisions. This included closing watertight doors and contacting the shipping company's emergency organisation. It also includes contacting outside parties when needed in accordance with separate alarm instructions. However, this point does not come up until point 14 on the check-list. This led to the vessel not making contact with the JRCC until 37 minutes after the collision, i.e. just before arriving at the quay in Masthugget.

In reality, there is no explicit obligation to report every accident to the JRCC and it is entirely understandable that there is a number of other very important tasks that need to be accomplished as quickly as possible in a situation such as this. Nonetheless, SHK has some concerns that a large ferry with just over 600 people on board and with what can in any case be termed serious damage below the waterline, together with a damaged tanker with almost 10,000 tonnes of oil products, were able to operate in the waters of the archipelago without either the JRCC or the Coast Guard being contacted.

Even though the master of STENA JUTLANDICA was familiar with the vessel's good stability properties and was able at an early stage to conclude that there was no imminent danger to either the vessel or those on board, there were still some uncertain elements in the situation, not least when considering the risk of the engine control system being knocked out. This is also supported by the master's reflection concerning a potential evacuation at Böttö. The example LANGELAND in Section 1.14 shows on the one hand that it is not unheard of for those on board to first choose to report to the shipping company rather than the sea rescue service and, on the other, that this can impede or delay any rescue operation, with drastic results. It is also possible in this case to conclude that internal reporting to the shipping company has been prioritised ahead of reporting to the public rescue services. SHK questions such a prioritisation and is of the opinion that there are grounds for Stena Line to revise the vessel's procedures, and those of the shipping company, with regard to what priority contact with the JRCC is to have.

Evacuation of a passenger vessel the size of STENA JUTLANDICA, with around 600 people on board, cannot be done in an instant, instead it requires preparations to be made. It is therefore advantageous to inform the JRCC at an early stage, regardless of whether or not an evacuation subsequently becomes necessary. The fact that an effective and coordinated rescue operation in this type of occurrence requires good cooperation between public authorities further reinforces the requirement that the alarm be raised at an early stage. SHK believes it would have been advantageous for the ferry to inform the JRCC about what had happened at an early stage, partly to give the JRCC information as a basis for an accurate risk assessment and partly to provide the JRCC with the opportunity to switch to a state of alert.

In this context, it can be noted that the passengers on board were informed about the occurrence using the public address system relatively late, more specifically 18 minutes after the collision. Although it can be difficult to obtain certain information about what has happened and even though it is possible in this case to obtain information from the crew, it is still important that all passengers and crew members are informed. If there is no detailed or certain information to provide, it is still possible to make an announcement about what has happened, that the situation is being dealt with and that more information will be provided when it becomes available.

3.7 The rescue services

As expressed in Section 2.6, SHK has some concerns that two damaged vessels, one with a crew and oil products and the other with a crew and a large number of passengers on board, were able to be in the archipelago without any rescue operation being initiated or prepared, aside from the environmental protection that the Coast Guard increased its state of alert for. The JRCC learned about the collision at 02:22 (five minutes after the collision) when the pilot planning centre called on behalf of the VTS. The JRCC then chose to classify the occurrence as NIL and took no other action. The SMC has stated that he expected one of the vessels to contact the JRCC if assistance was required.

As far as can be understood from the internal instructions that apply to the JRCC, it appears to been more appropriate to classify the case as at least "uncertainty". According to the instructions, this would have meant that the JRCC would have gathered information itself about the occurrence, however without a requirement or expectation that any other units would be activated. It cannot be said to have been difficult for the JRCC to gather further information. It was possible, for example, to contact the VTS or one of the vessels, or to listen to VHF channel 13. In this case, it is not thought that there were any impediments, e.g. high workload, to this. The investigations indicates that if the SMC had been in possession of accurate information about the extent of the damage, they would have classified the occurrence differently. According to the SMC, if an alternative classification had been made, it would have been natural to wake one of the other coordinators who was on standby.

All in all, it can thus be concluded that the JRCC knew that the collision had occurred, but did not know the extent of the damage or if any form of assistance was required. No action to obtain an answer to this was taken. A factor that contributed to the JRCC not having relevant information about the occurrence was of course that neither of the vessels contacted the JRCC until a later stage.

The occurrence can be interpreted as there having been a non-conformity concerning internal procedures, which in turn constitutes a sign of possible procedural drift in the organisation. As the evidence in this investigation, which concerns a single deviation, is not sufficient in order to draw any conclusions concerning whether or not there has been a procedural drift within the organisation, SHK delegates the task of making this assessment to the Swedish Maritime Administration in conjunction with the actions the occurrence occasions.

In this context it should be noted that the investigation indicates that the pilot boat, which had understood from the VHF traffic that STENA JUTLANDICA and TERNVIND had collided, called the VTS and asked if they were needed or if the pilot boat could continue in towards Gothenburg. In spite of the lack of information about the vessels' status from the VTS operator and confirmation that they could leave the location, the boat continued in towards the city. It is the opinion of SHK that, given the obligations incumbent on a master in conjunction with a marine casualty, in the event of distress or when there is a danger to maritime traffic, it would be reasonable to await confirmation or otherwise establish that the vessels or the people on board were not in any danger and that their help was not needed before continuing.

4. CONCLUSIONS

4.1 Findings of the investigation

a) TERNVIND, with a pilot on board, was heading south and was obliged to give way to the incoming STENA JUTLANDICA.
b) The radio communication within the VTS area was inconsistent and sometimes confusing.
c) The pilotage of TERNVIND was concluded before the pilotage line.
d) When the pilot left TERNVIND, there was no lookout on the bridge.
e) TERNVIND increased her speed to not more than eight knots after the pilot has left as the meeting with STENA JUTLANDICA approached.
f) STENA JUTLANDICA set a course that was somewhat further south in order to give more space to TERNVIND.
g) STENA JUTLANDICA began a slight turn to port with a turn radius of 1.4 M before the vessel passed the bow of TERNVIND. The turn radius increased immediately thereafter.
h) TERNVIND proposed passing starboard to starboard when the distance between the vessels was 0.7 M.
i) Misunderstanding in this communication resulted in STENA JUTLANDICA intending to pass port to port, while TERNVIND intended to pass starboard to starboard.
j) The VTS overheard this communication, understood that there could have been a misunderstanding and called the vessels to try and intervene.
k) TERNVIND kept out of the way to port in order to increase the distance to STENA JUTLANDICA as TERNVIND presumed that STENA JUTLANDICA would pass starboard to starboard.
l) When TERNVIND realised that there was a risk of collision, evasive manoeuvres to port and astern were executed.
m) When STENA JUTLANDICA realised that there was a risk of collision, an evasive manoeuvre to starboard was immediately initiated, followed by a second evasive manoeuvre to port, but with actions that were not sufficiently effective.
n) Together, both vessels' respective turn to port constituted a prerequisite for the collision to take place.
o) STENA JUTLANDICA suffered damage that included a hole in the hull that resulted in the intrusion of water into two of the vessel's watertight compartments.
p) There was no leakage, injuries or other serious damage on TERNVIND.
q) The Coast Guard and the municipal rescue services took action in order to deal with the situation.
r) The JRCC received information about the occurrence and classified it as NIL.
s) The JRCC's actions did not comply with the applicable internal instructions.
t) The officers of the watch were probably affected by fatigue.

4.2 Causes

The accident was caused by improper planning of the vessels' meeting, combined with a misunderstanding in the communication concerning this meeting. Together, both vessels' respective turn to port also constituted a prerequisite for the collision to take place.

Inadequate lookout on TERNVIND and the pilotage ending too early probably constituted contributory causes of the accident. Another contributory cause may have been that officers of the watch on the vessels were probably affected by fatigue.

5. SAFETY RECOMMENDATIONS

It is recommended that the Swedish Maritime Administration:

- Fully implement the measures that have been initiated in order to ensure that pilotage is conducted within the areas that are defined in applicable regulations and monitor that this is taking place (see Section 3.1). (*RS 2016:05 R1*)

- Take action to ensure, monitor and continuously follow up that the communication within the VTS areas is conducted in accordance with applicable regulations (see 3.2). (*RS 2016:05 R2*)

- Implement measures in order to ensure that operations in the JRCC are undertaken in accordance with applicable instructions and monitor that the clarifications that have been made in these instructions have the intended effect (see 3.7). (*RS 2016:05 R3*)

It is recommended that Stena Line Scandinavia AB:

- Check that VDRs on the shipping company's vessels save the data required by the regulations (see Section 3.3.3). (*RS 2016:05 R4*)

- Review working schedules or in some other way compensate for the risks of fatigue that may arise in its operations (see 3.3.4). (*RS 2016:05 R5*)

- Consider revising on-board instructions with the intention of giving a higher priority to reporting to the JRCC (see 3.6). (*RS 2016:05 R6*)

It is recommended that Terntank Ship Management AB:

- Ensure that lookout is kept on board its vessels in accordance with the applicable regulations (see 3.3.1). (*RS 2016:05 R7*)
- Check that VDRs on the shipping company's vessels save the data required by the regulations (see 3.3.3). (*RS 2016:05 R8*)

The Swedish Accident Investigation Authority respectfully requests to receive, by **3 October 2016** at the latest, information regarding measures taken in response to the recommendations included in this report.

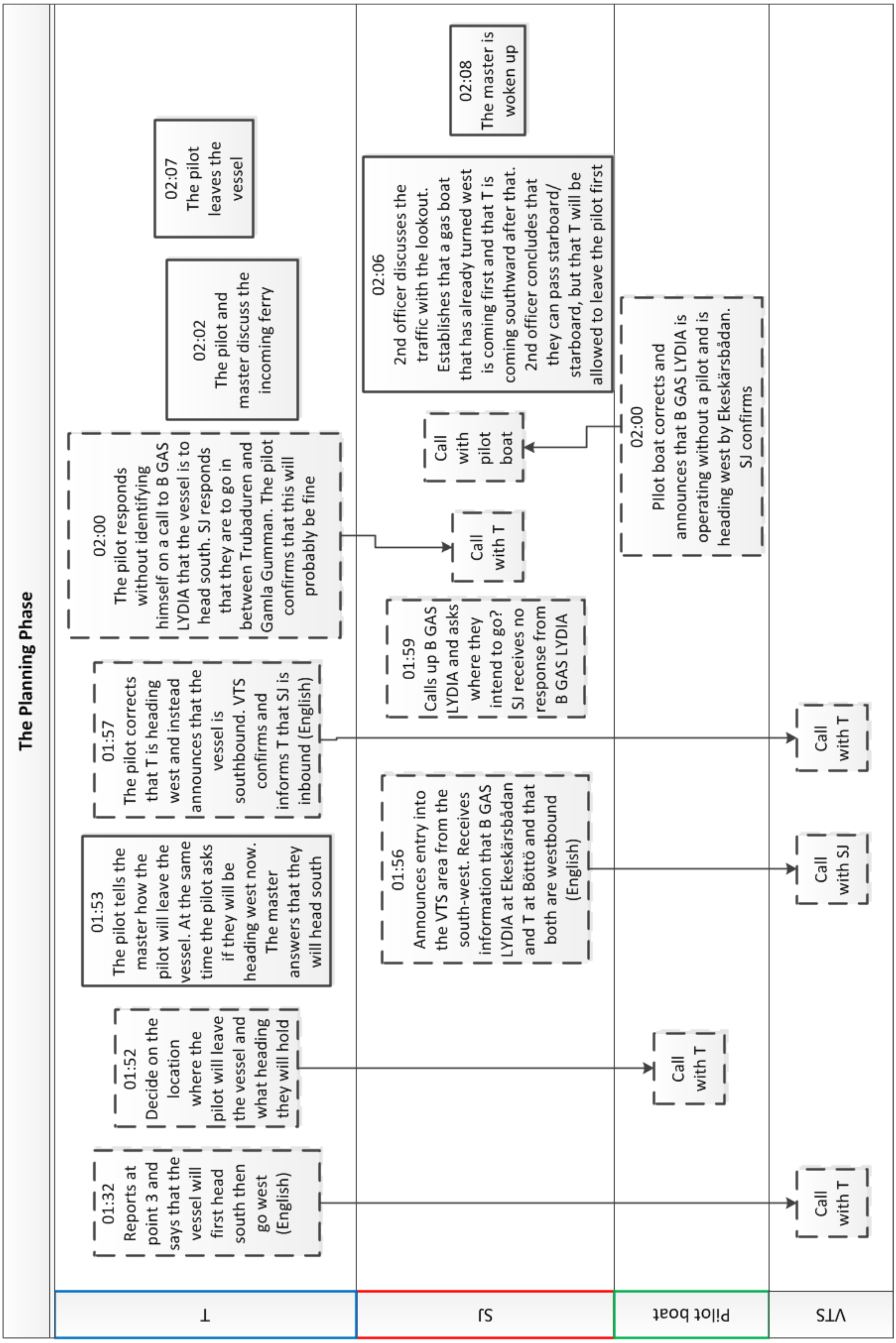
On behalf of the Swedish Accident Investigation Authority,

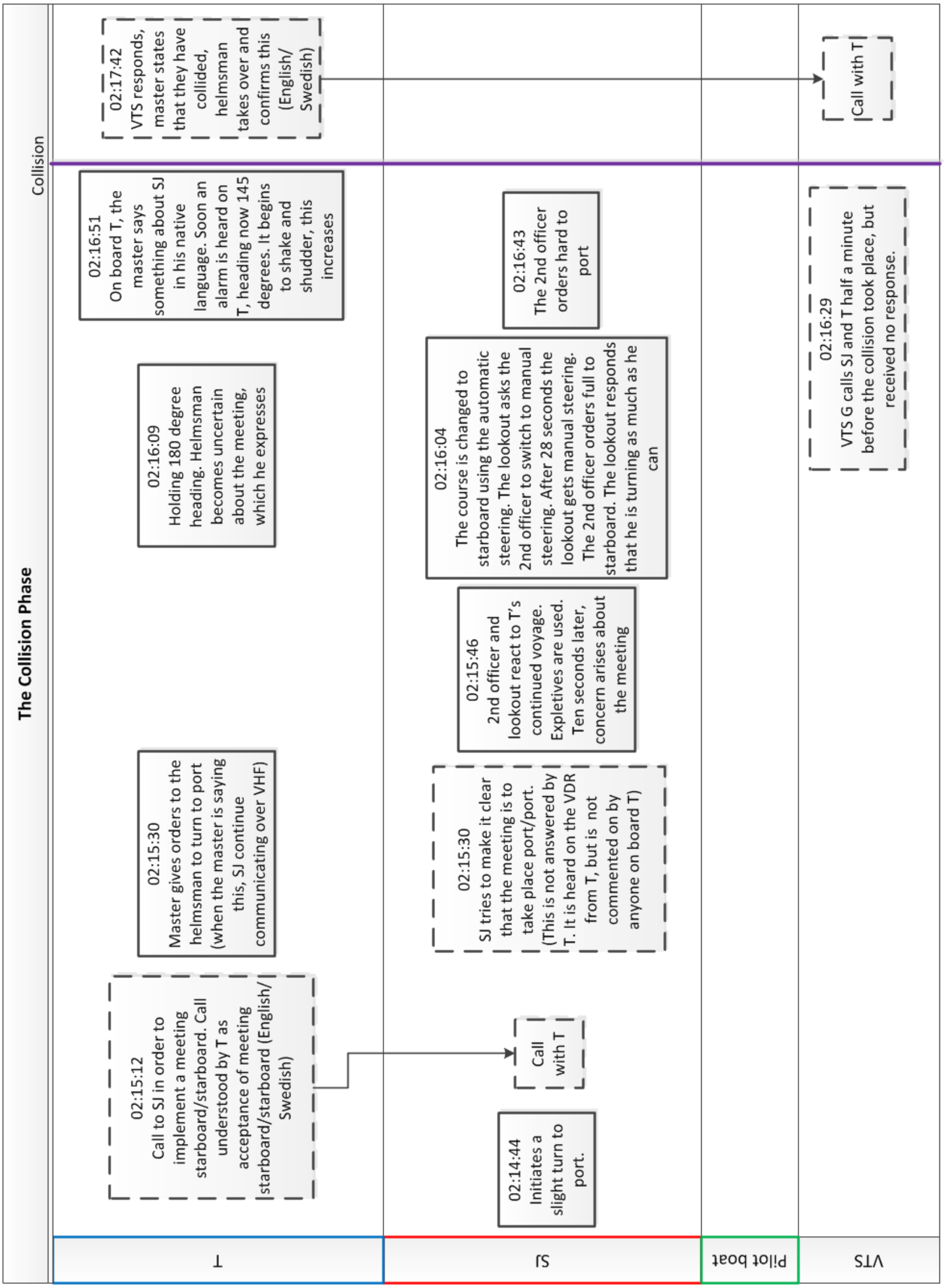
Helene Arango Magnusson Jörgen Zachau

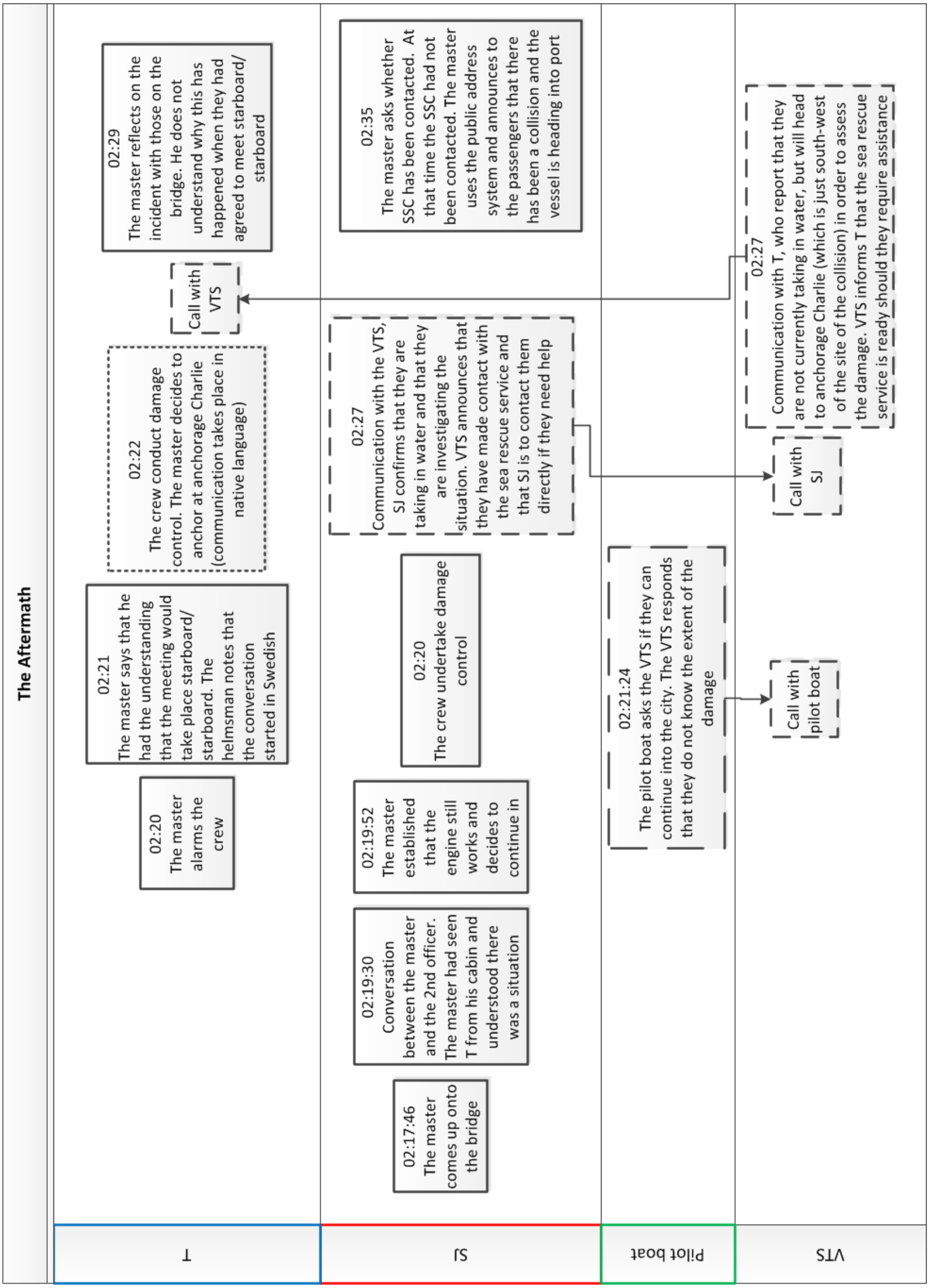
Appendix 1

Description of the sequence of events in diagrammatic form. Dashed framing indicates radio communication. This takes place in Swedish unless otherwise stated.

- Page 1: The planning phase
- Page 2: The collision phase
- Page 3: The aftermath


The Planning Phase
T
SJ
Pilot boat
VTS
01:32 Reports at point 3 and says that the vessel will first head south then go west (English)
Call with T
01:52 Decide on the location where the pilot will leave the vessel and what heading they will hold
Call with T
01:53 The pilot tells the master how the pilot will leave the vessel. At the same time the pilot asks if they will be heading west now. The master answers that they will head south
01:56 Announces entry into the VTS area from the south-west. Receives information that B GAS LYDIA at Ekeskärsbådan and T atBöttö and that both are westbound (English)
Call with SJ
01:57 The pilot corrects that T is heading west and instead announces that the vessel is southbound. VTS confirms and informs T that SJ is inbound (English)
Call with T
01:59 Calls up B GAS LYDIA and asks where they intend to go? SJ receives no response from B GAS LYDIA
02:00 The pilot responds without identifying himself on a call to B GAS LYDIA that the vessel is to head south. SJ responds that they are to go in between Trubaduren and Gamla Gumman. The pilot confirms that this will probably be fine
Call with T
02:00 Pilot boat corrects and announces that B GAS LYDIA is operating without a pilot and is heading west by Ekeskärsbådan. SJ confirms
Call with pilot boat
02:02 The pilot and master discuss the incoming ferry
02:06 2nd officer discusses the traffic with the lookout. Establishes that a gas boat that has already turned west is coming first and that T is coming southward after that. 2nd officer concludes that they can pass starboard/starboard, but that T will be allowed to leave the pilot first
02:07 The pilot leaves the vessel
02:08 The master is woken up


The Collision Phase
Collision
T
SJ
Pilot boat
VTS
02:15:12 Call to SJ in order to implement a meeting starboard/starboard. Call understood by T as acceptance of meeting starboard/starboard (English/ Swedish)
02:15:30 Master gives orders to the helmsman to turn to port (when the master is saying this, SJ continue communicating over VHF)
02:16:09 Holding 180 degree heading. Helmsman becomes uncertain about the meeting, which he expresses
02:16:51 On board T, the master says something about SJ in his native language. Soon an alarm is heard on T, heading now 145 degrees. It begins to shake and shudder, this increases
02:17:42 VTS responds, master states that they have collided, helmsman takes over and confirms this (English/ Swedish)
02:14:44 Initiates a slight turn to port.
Call with T
02:15:30 SJ tries to make it clear that the meeting is to take place port/port. (This is not answered by T. It is heard on the VDR from T, but is not commented on by anyone on board T)
02:15:46 2nd officer and lookout react to T's continued voyage. Expletives are used. Ten seconds later, concern arises about the meeting
02:16:04 The course is changed to starboard using the automatic steering. The lookout asks the 2nd officer to switch to manual steering. After 28 seconds the lookout gets manual steering. The 2nd officer orders full to starboard. The lookout responds that he is turning as much as he can
02:16:43 The 2nd officer orders hard to port
02:16:29 VTS G calls SJ and T half a minute before the collision took place, but received no response.
Call with T


The Aftermath
T
SJ
Pilot boat
VTS
02:20
The master alarms the crew
02:21
The master says that he had the understanding that the meeting would take place starboard/ starboard. The helmsman notes that the conversation started in Swedish
02:22
The crew conduct damage control. The master decides to anchor at anchorage Charlie (communication takes place in native language)
Call with VTS
02:29
The master reflects on the incident with those on the bridge. He does not understand why this has happened when they had agreed to meet starboard/ starboard
02:17:46
The master comes up onto the bridge
02:19:30
Conversation between the master and the 2nd officer. The master had seen T from his cabin and understood there was a situation
02:19:52
The master established that the engine still works and decides to continue in
02:20
The crew undertake damage control
02:27
Communication with the VTS, SJ confirms that they are taking in water and that they are investigating the situation. VTS announces that they have made contact with the sea rescue service and that SJ is to contact them directly if they need help
02:35
The master asks whether SSC has been contacted. At that time the SSC had not been contacted. The master uses the public address system and announces to the passengers that there has been a collision and the vessel is heading into port
02:21:24
The pilot boat asks the VTS if they can continue into the city. The VTS responds that they do not know the extent of the damage
Call with pilot boat
Call with SJ
02:27
Communication with T, who report that they are not currently taking in water, but will head to anchorage Charlie (which is just south-west of the site of the collision) in order to assess the damage. VTS informs T that the sea rescue service is ready should they require assistance

Appendix 2 – Simulations

Fig. 20. The image shows how the situation appears from the tanker's bridge in the simulator when the ropax ferry passed.

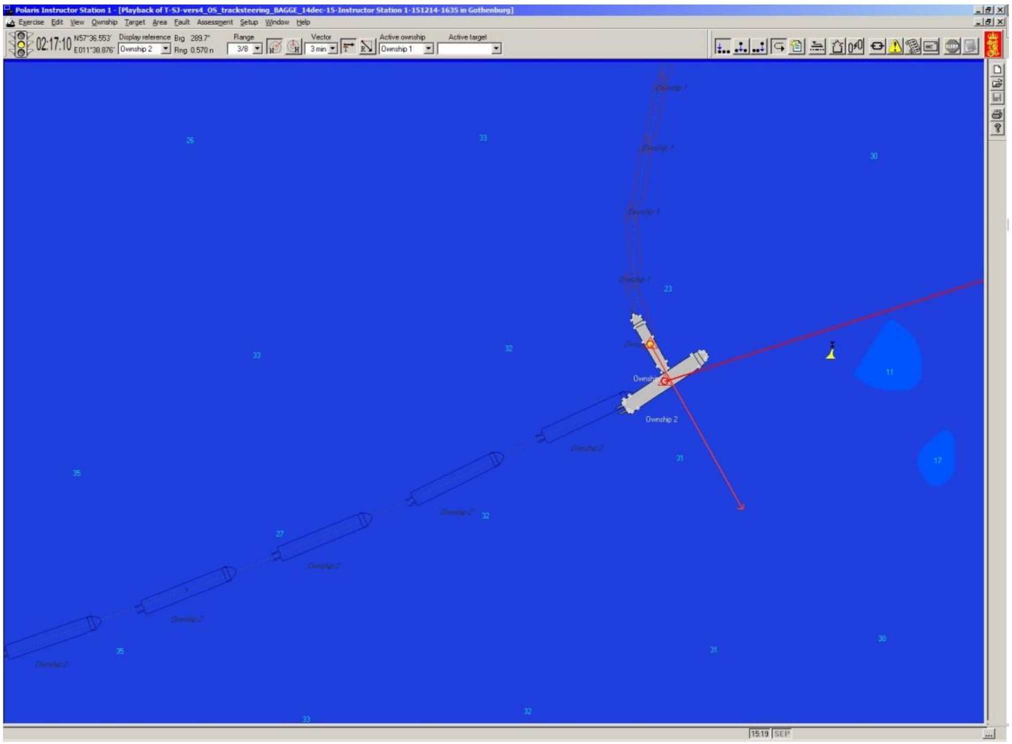
The models in the simulations are

- Loaded product tanker L: 141.5 m, B: 23.0 m, D: 9 m, trim: 0, engine 5,235 kW, max. speed 13.5 knots, 1 propeller right-handed variable-pitch blades, rudder 60°-60°.
- Ropax ferry, L: 209.0 m, B: 31.2 m, D: 6.4 m, trim: 0, engine 2x15, 597 kW, max. speed: 22 knots, 2 propellers variable-pitch blades "inward rotating", Becker rudder 65°-65°.

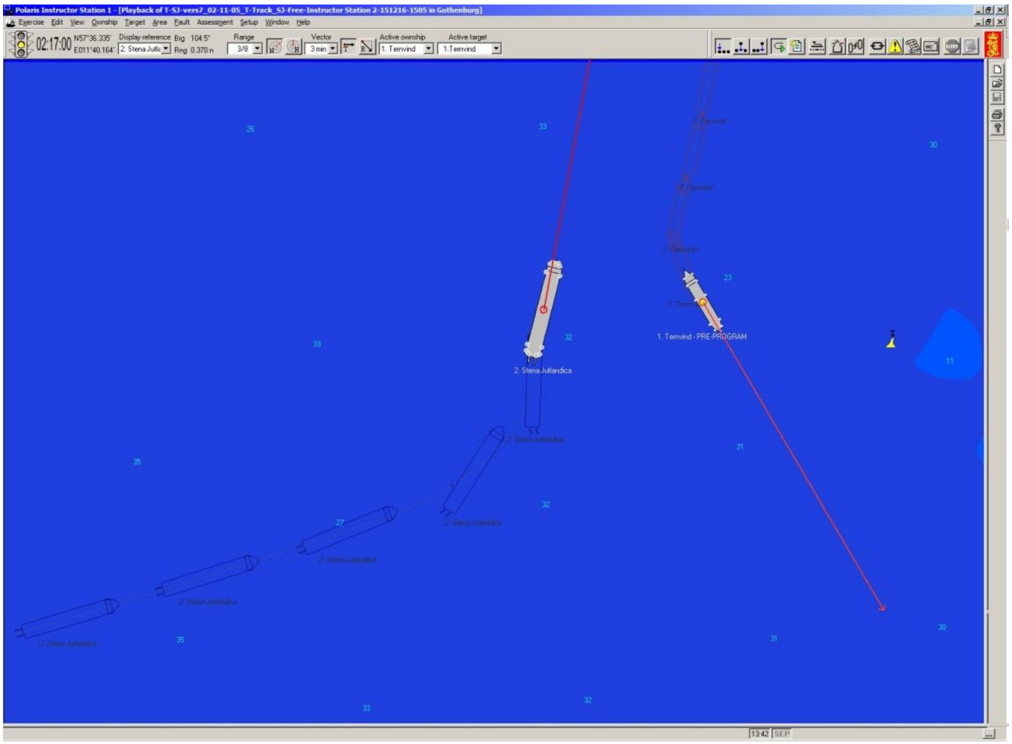
The results are judged not to have been affected by the small discrepancies between the simulator models and those of the actual vessels. However, it should be noted that, even though the simulations are assumed to provide a good picture of the sequence of events and the options available, they are still simulations and cannot be regarded as constituting an absolute truth. The distance between the vessels has been measured from TERNVIND's half length (L2) to the closest point on STENA JUTLANDICA.[40] A selection of the different scenarios is shown in the images below.

The simulations were preceded by a reconstruction of the sequence of events, based on input data from both vessels' VDRs. The reliability of the reconstruction may therefore be regarded as high.

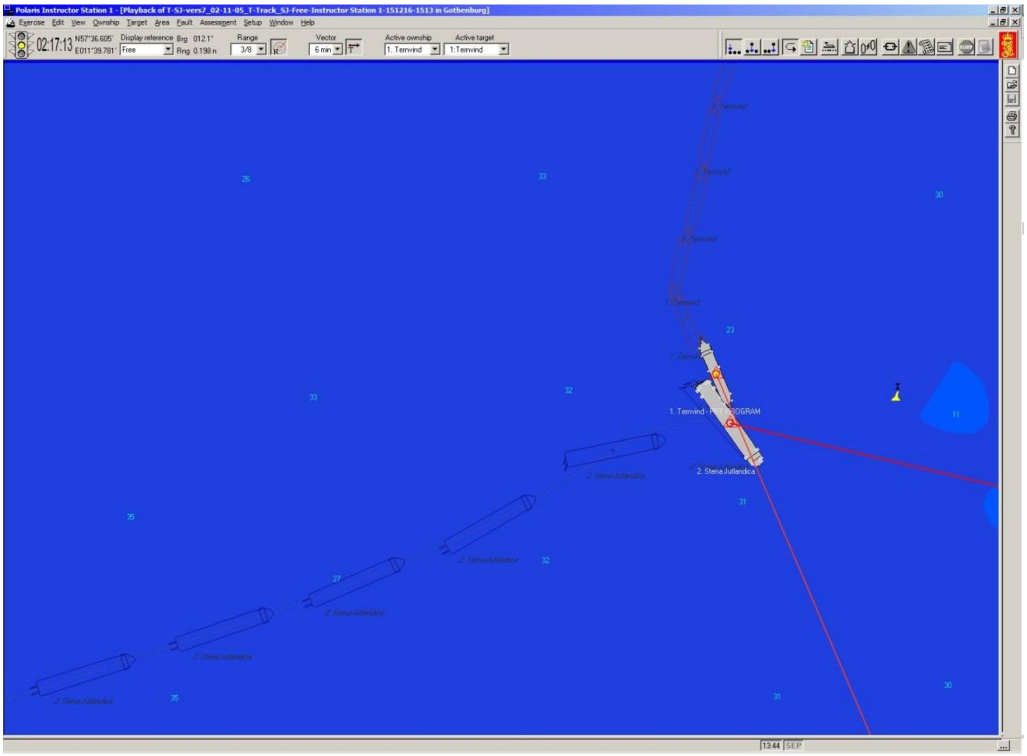
[40] This is so as to avoid any errors as a result of the placement of the radar.



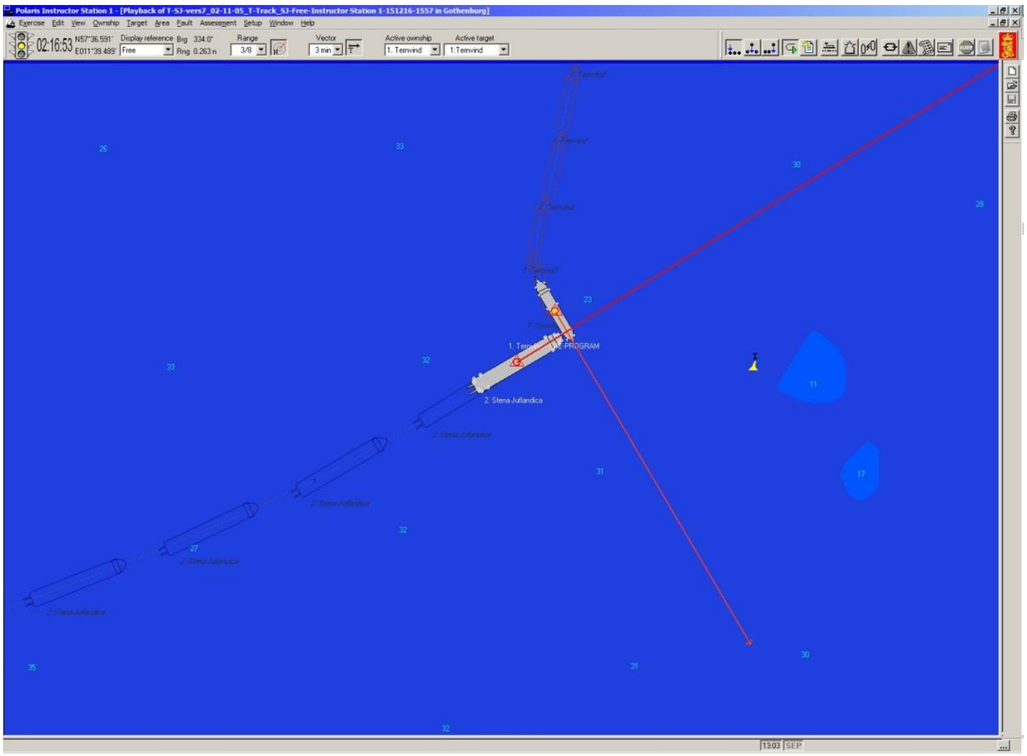
Reconstruction (Simulation 0). STENA JUTLANDICA turns to port with a turn radius of 2.0 M, followed by evasive manoeuvres to starboard and then port. TERNVIND turns to port. A simulation with STENA JUTLANDICA's turn radius set to 1.4 M resulted in the same point of impact. Only a marginal difference in time was present.



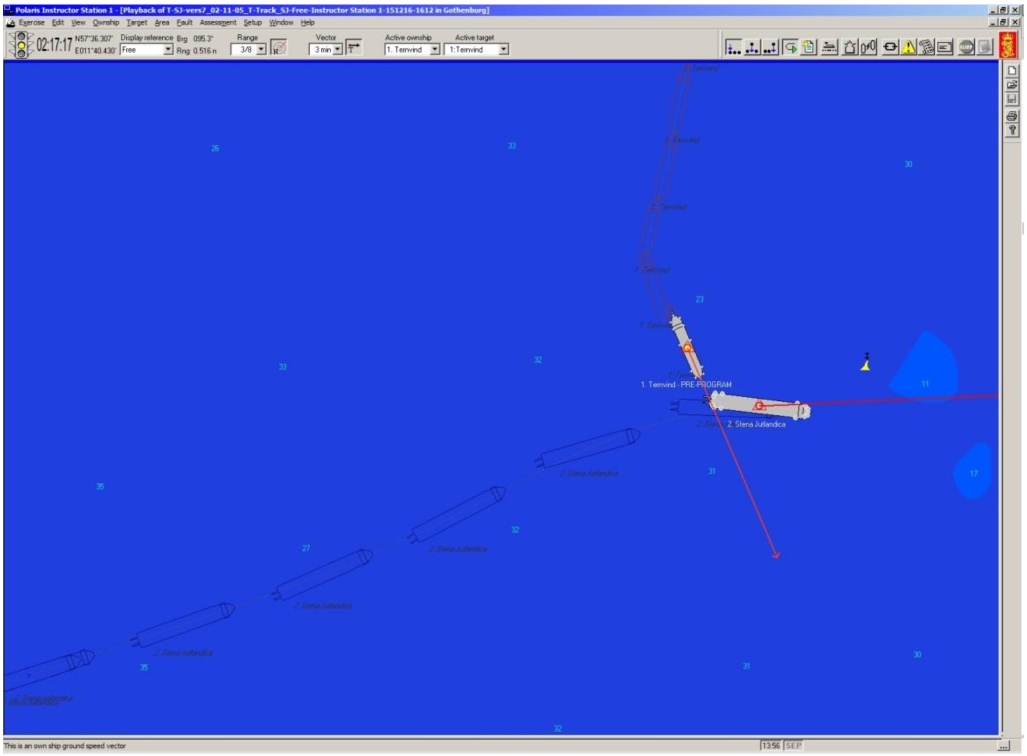
Simulation 1. STENA JUTLANDICA turns to port with manual rudder 20° after the VHF call and passes 0.18 M astern of TERNVIND, which implements the turn to port.



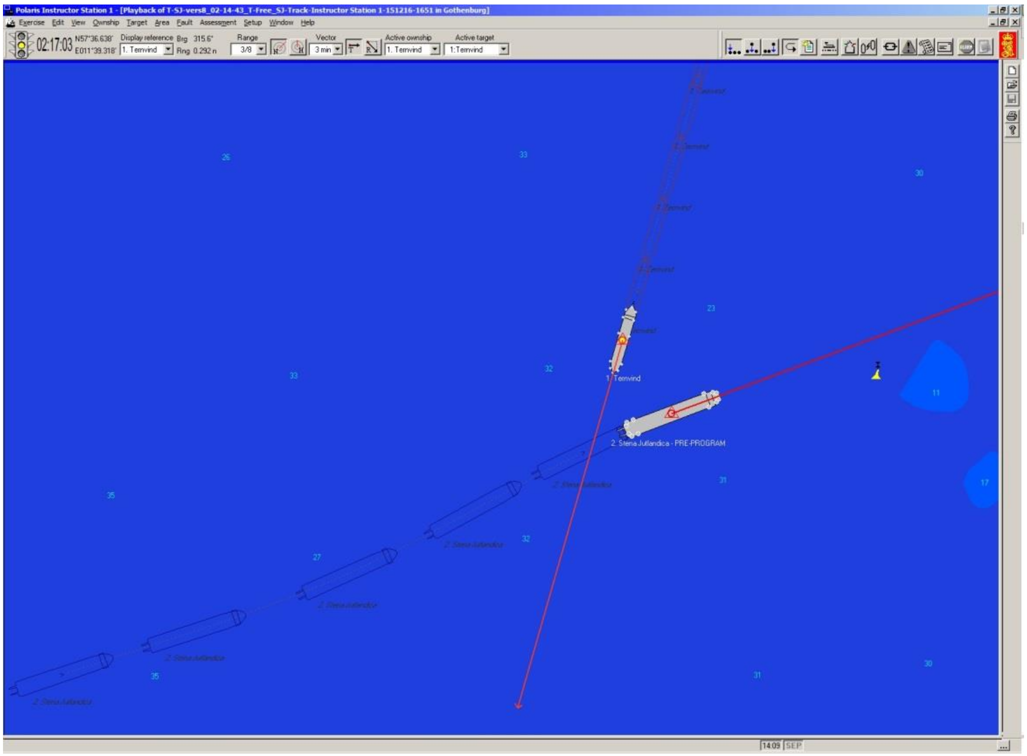
Simulation 2. STENA JUTLANDICA begins her turn to port before the meeting and makes a late evasive manoeuvre manually full starboard before correcting with a turn to port and colliding with her port quarter against the starboard bow of TERNVIND. TERNVIND has implemented the turn to port.



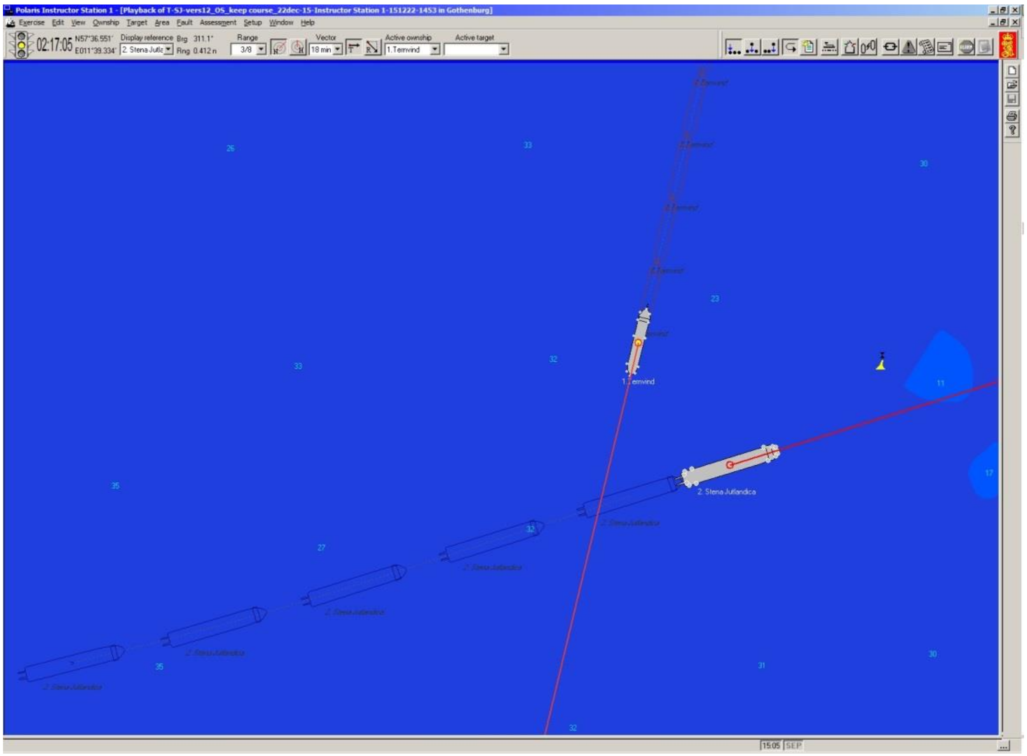
Simulation 3. STENA JUTLANDICA initiates the turn to port before the meeting, but turns to starboard with only automatic steering (radius 2.0 M) following the VHF call and colliding with TERNVIND's starboard side. TERNVIND has implemented the turn to port.



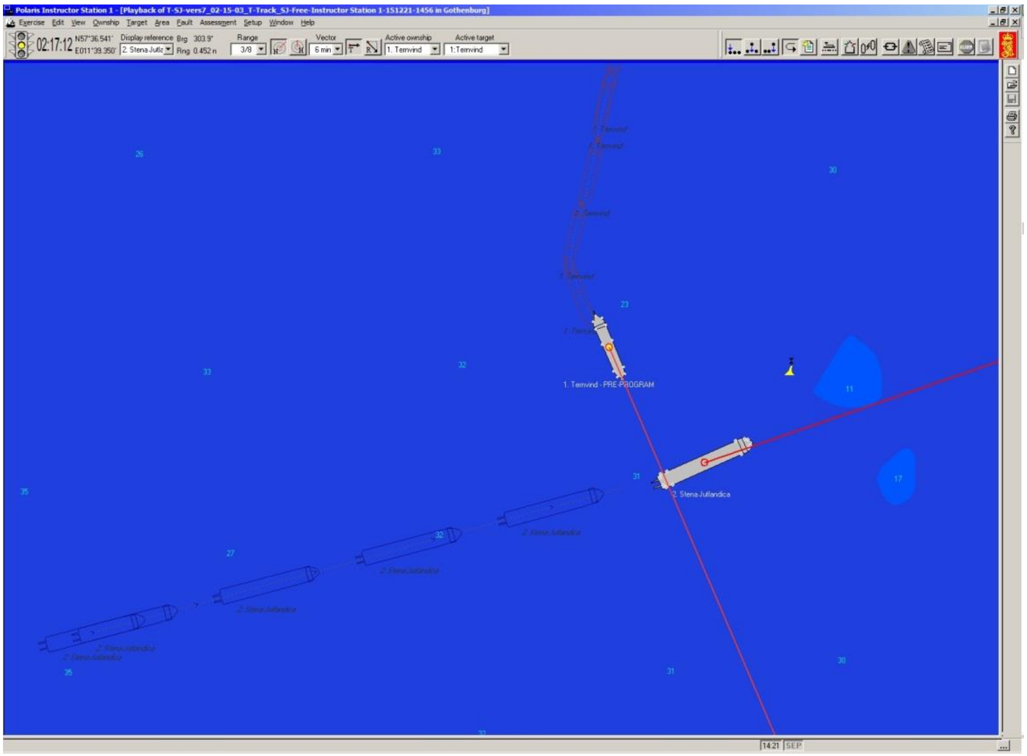
Simulation 4. STENA JUTLANDICA initiates her turn to port before the meeting and then turns to starboard with a turn radius of 0.50 M, without correcting with a turn to port. The vessel passes very close to TERNVIND. TERNVIND has implemented the turn to port.



Simulation 5. STENA JUTLANDICA initiates the turn to port before the meeting and passes approx. 0.1 M ahead of TERNVIND, which does not change course.

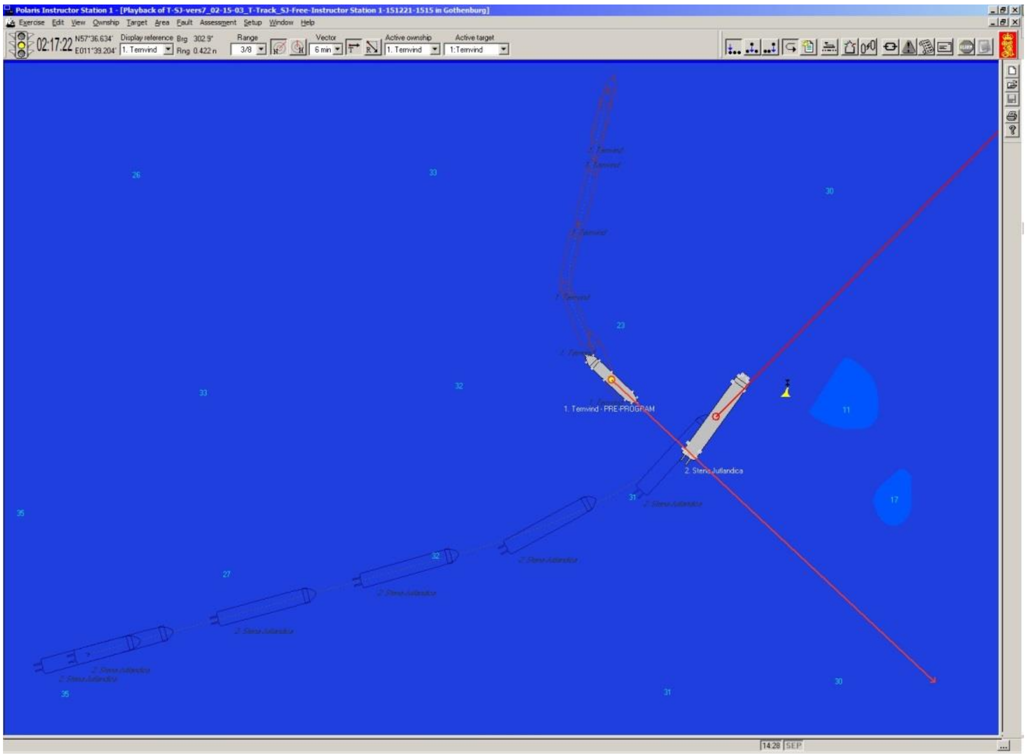


Simulation 6. Neither of the vessels change course. STENA JUTLANDICA passes 0.17 M ahead of TERNVIND.

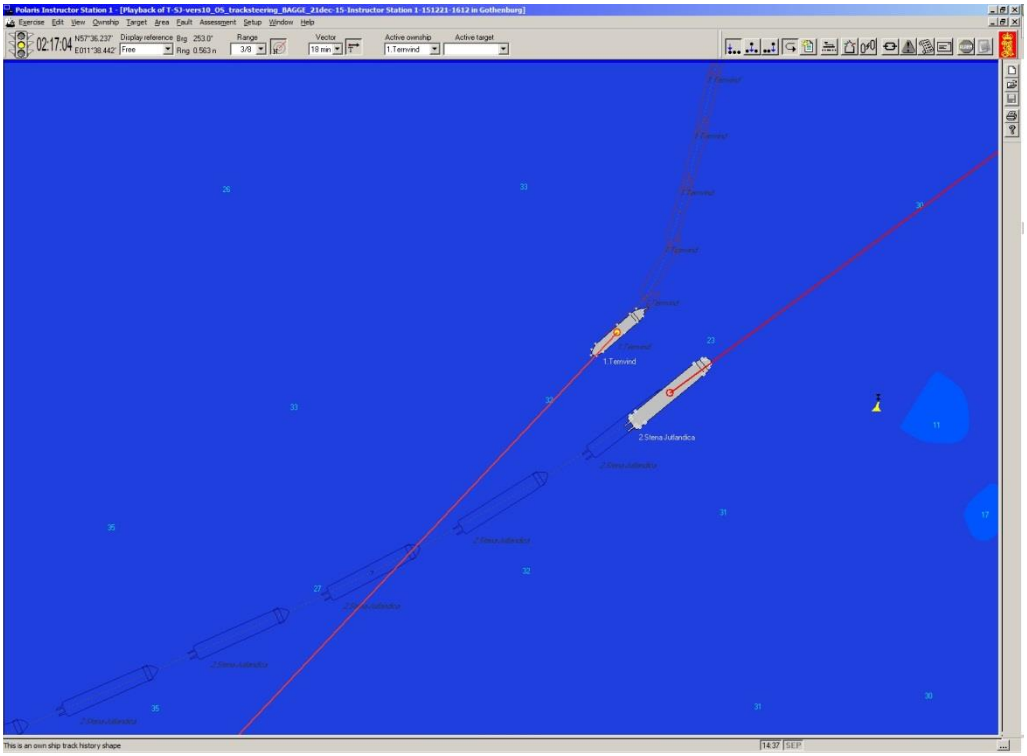


Simulation 7. STENA JUTLANDICA turns to port only when TERNVIND's mast-head lights are in a range line[41]. The turn radius is 0.75 M. STENA JUTLANDICA passes ahead of TERNVIND with a margin of 0.17 M. TERNVIND implements her turn to port. STENA JUTLANDICA comes very close to Sänkberget.

[41] The two masthead lights being in a range line means that they are at the same angle from the position of the observer, i.e. the observer is directly ahead of the bow of the vessel.



Simulation 8. STENA JUTLANDICA turns to port only when TERNVIND’s mast-head lights are in a range line (they are at the same angle from the position of the observer, i.e. directly ahead of the bow of the vessel). The turn radius is 0.50 M. STENA JUTLANDICA passes ahead of TERNVIND with a margin or 0.12 M. TERNVIND implements her turn to port. STENA JUTLANDICA comes very close to Sänkberget.



Simulation 9. TERNVIND turns to starboard with 20° rudder following the VHF call, STENA JUTLANDICA turns to port. The vessels pass port/port at a distance of 0.09 M.