Bundesstelle für Seeunfalluntersuchung
Federal Bureau of Maritime Casualty Investigation
Federal Higher Authority subordinated to the Ministry of Transport
and Digital Infrastructure

Investigation Report 330/13

Serious Marine Casualty

Collision between the MT CORAL IVORY and MV SIDERFLY on 28 October 2013 in the Kiel Canal

15 March 2016

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The investigation was conducted in conformity with the Law to improve safety of shipping by investigating marine casualties and other incidents (Maritime Safety Investigation Law – SUG) of 16 June 2002, amended most recently by Article 16(22) of 19 October 2013, BGBl. (Federal Law Gazette) I p. 3836.
According to said Law, the sole objective of this investigation is to prevent future accidents and malfunctions. This investigation does not serve to ascertain fault, liability or claims (Article 9(2) SUG).
This report should not be used in court proceedings or proceedings of the Maritime Board. Reference is made to Article 34(4) SUG.
The German text shall prevail in the interpretation of this report.

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1 Summary

At about 0256[1] on 28 October 2013, the Dutch-registered LPG[2] tanker CORAL IVORY and the cargo ship SIDERFLY, flying the flag of Saint Vincent and the Grenadines, collided in the Kiel Canal west of the viaduct at Brunsbüttel. The ammonia-laden CORAL IVORY had left her berth in Landeshafen Ostermoor (inland port of Ostermoor), located to the south of the canal route, a few minutes beforehand and started to turn into the Kiel Canal towards Kiel. Despite the use of her bow thruster, the ship moved too far into the northern part of the canal during this manoeuvre and collided with the oncoming SIDERFLY, which was sailing towards Brunsbüttel.

An astern manoeuvre enabled the CORAL IVORY to part from the other vessel shortly after the collision happened. The CORAL IVORY only sustained minor damage during the accident and was able to return to the inland port of Brunsbüttel under her own steam afterwards.

The shell plating of the SIDERFLY, fully laden with nitrogenous fertiliser, was torn open below the waterline during the collision. The inflowing sea water caused a steadily increasing list, which exposed the ship to an acute risk of foundering.

External assistance for the heavily damaged SIDERFLY was requested from the bridges of the CORAL IVORY and the SIDERFLY immediately after the accident on VHF radio. It was possible to take four crew members ashore a few minutes after the collision with the help of a work boat belonging to a nearby ship. The remaining five crew members and the pilot were taken safely on board a pilot tender that had rushed to the distressed vessel shortly afterwards.

Two tugs that had arrived at the scene of the accident shortly after the collision managed to push the SIDERFLY, which had drifted some 0.3 nm eastwards in the meantime, temporarily against the northern canal embankment and prevent the ship, which was listing at more than 20 degrees to the port side, from foundering.

A huge technical effort in the hours and days that followed made it possible to first stabilise the distressed vessel on the northern canal embankment and then make her temporarily buoyant.

The Kiel Canal had to be closed completely and later partly for the very complex process involved in securing the SIDERFLY for a total of three days. The SIDERFLY was shifted to the port of Brunsbüttel on 6 November 2013. After unsuccessful attempts to sell the ship, which was greatly in need of repair, she began her last voyage on 5 February 2014 when she was towed to the ship breaking yard.

[1] All times shown in this report are local = CET = UTC + 1 hour.
[2] LPG: **L**iquid **p**etroleum **g**as.

2 FACTUAL INFORMATION

2.1 Photo of the MT CORAL IVORY

Figure 1: Photo of the CORAL IVORY

2.2 Ship particulars: MT CORAL IVORY

Name of ship:	CORAL IVORY
Type of ship:	LPG tanker
Nationality/Flag:	Netherlands
Port of registry:	Rotterdam
IMO number:	9207039
Call sign:	PHPE
Owner:	Anthony Veder Rederijzaken B.V. Rotterdam
Year built:	2000
Shipyard/Yard number:	DAEWOO SHIPBUILDING & MARINE ENGINEERING, GEOJE, SOUTH KOREA/7602
Classification society:	Bureau Veritas
Length overall:	115.89 m
Breadth overall:	15.96 m
Gross tonnage:	5,831
Deadweight:	6,875 t
Draught (max.):	7.75 m
Engine rating:	4,900 kW
Main engine:	SsangYong-MAN B&W – 7S35MC
(Service) speed (max.):	14 kts
Hull material:	Steel
Manning:	19

2.3 Voyage particulars: MT CORAL IVORY

Port of departure:	Brunsbüttel/Ostermoor, Germany
Port of call:	Uusikaupunki, Finland
Type of voyage:	Merchant shipping, international
Cargo information:	Ammonia
Draught at time of accident:	6.8 m
Manning:	19
Pilot on board:	Yes
Number of passengers:	None

2.4 Photo of the MV SIDERFLY

Figure 2: Photo of the SIDERFLY

2.5 Ship particulars: MV SIDERFLY

Name of ship:	SIDERFLY
Type of ship:	General purpose/dry bulk cargo ship
Nationality/Flag:	St. Vincent and the Grenadines
Port of registry:	Kingstown
IMO number:	8412405
Call sign:	J8B2805
Owner:	Eestinova OU Tallin, Estonia
Year built:	1985
Shipyard/Yard number:	Elsflether Werft AG/408
Classification society:	Lloyd's Register
Length overall:	99.80 m
Breadth overall:	14.64 m
Gross tonnage:	2,882
Deadweight:	4,380 t
Draught (max.):	5.42 m
Engine rating:	1,228 kW

Main engine:	Deutz KHD SBV 8 M 628
(Service) speed (max.):	11 kts
Hull material:	Steel
Manning:	9

2.6 Voyage particulars: MV SIDERFLY

Port of departure:	Klaipėda, Lithuania
Port of call:	Antwerp, Belgium
Type of voyage:	Merchant shipping, international
Cargo information:	Urea (nitrogenous fertiliser in bulk)
Draught at time of accident:	5.20 m
Manning:	9
Pilot on board:	Yes
Number of passengers:	None

2.7 Marine casualty information

Type of accident:	Serious marine casualty, collision
Date, time:	28 October 2013, 0256
Location:	Kiel Canal west of the viaduct at Brunsbüttel
Latitude/Longitude:	φ 53°55.2'N λ 009°11.6'E
Ship operation and voyage segment:	Close-quarters situation on the canal
Consequences:	Temporary closure of the Kiel Canal; minor material damage to the MT CORAL IVORY; heavy damage to the MV SIDERFLY; no physical injuries or damage to the environment

Excerpt from Nautical Chart INT 1453 (RIVER ELBE FROM THE OSTE TO BRUNSBÜTTEL AND KRAUTSAND), BSH[3]

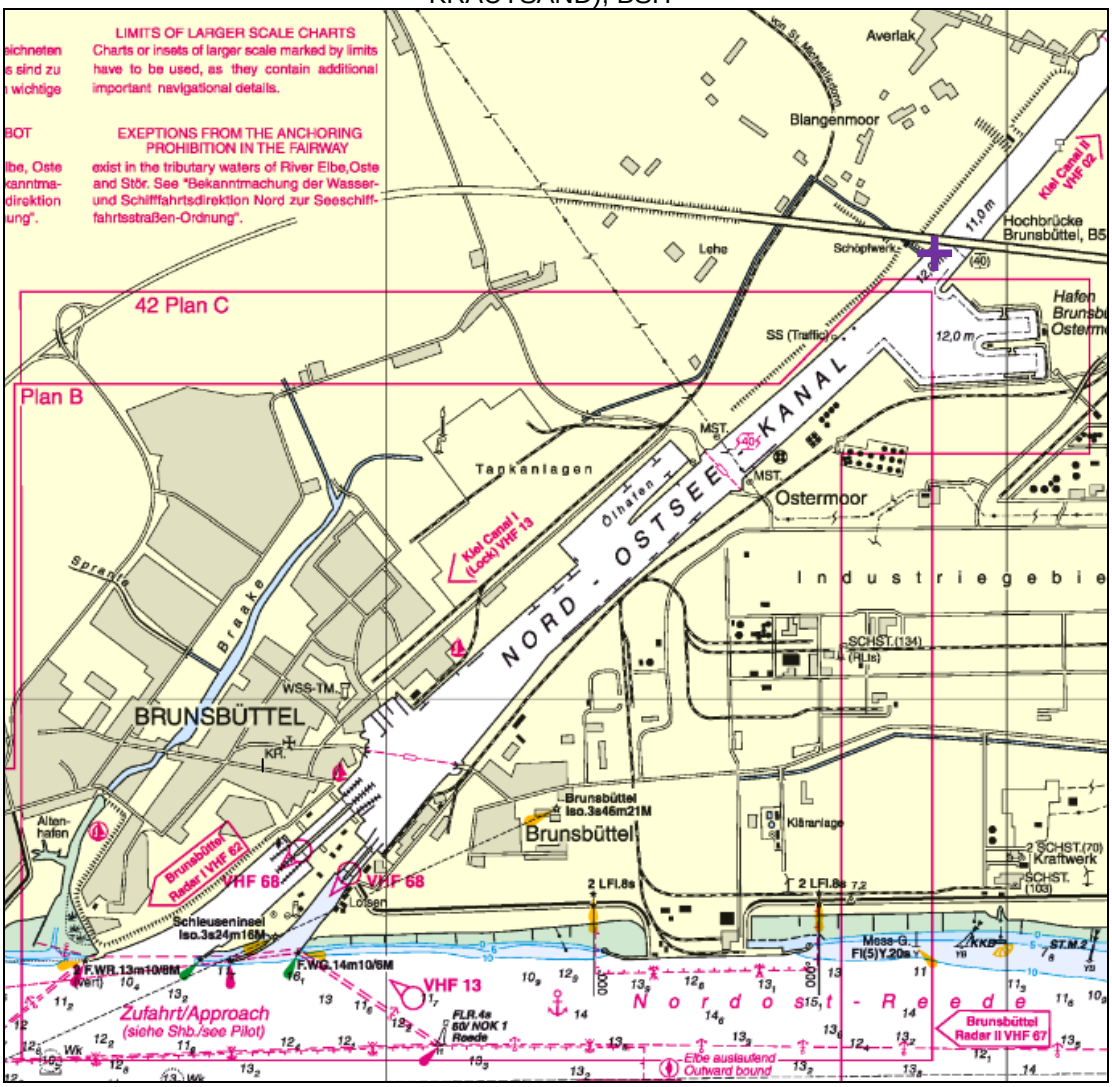

Figure 3: Scene of the accident

[3] BSH: Federal Maritime and Hydrographic Agency.

2.8 Shore authority involvement and emergency response

Agencies involved:	Vessel Traffic Service Kiel Canal, German Central Command for Maritime Emergencies[4], Waterway Police (WSP) Brunsbüttel, Brunsbüttel fire service
Resources used:	Kiel Canal ferry DANZIG, pilot tender KIEBITZ, tugs WOLF, LUCHS, PARAT, HANS, HELMUT, various fire service response vehicles, WSP boat SCHWANSEN, pollution control plane DO228, oil pollution control ship KNECHTSAND, other WSV[5] ships, and various shore-based salvage equipment
Actions taken:	Evacuation of the crew members and pilot from the SIDERFLY; temporarily full and later partial closure of the Kiel Canal; SIDERFLY temporarily secured on the northern canal embankment by two tugs; SIDERFLY stabilised and made fast on the northern canal embankment with the help of shore-based chain and line connections; oil booms deployed around the SIDERFLY; partial discharge of the distressed vessel and sealing of leaks in the hull to restore the SIDERFLY's buoyancy; pumping work
Results achieved:	MT CORAL IVORY remains fully seaworthy after the collision; efforts to stabilise MV SIDERFLY on the canal embankment and prevent her from foundering successful; SIDERFLY's buoyancy restored; SIDERFLY manoeuvred to a place of refuge on 6 November 2013 with tug assistance

[4] German Central Command for Maritime Emergencies (CCME): Joint institution of the Federal Government and the coastal States. Its purpose is to ensure joint management of accidents on the German coast. The CCME is responsible for planning, preparing, exercising, and implementing measures relating to the medical response, marine pollution response, firefighting, assistance, and security-related salvage in complex emergencies at sea.

[5] WSV: Waterways and Shipping Administration is a generic term for the federal agencies responsible for the administration of waterways and shipping in Germany's coastal and inland areas. Inter alia, the WSV operates its own vessels, e.g. for the deployment/maintenance of sea marks and the prevention of water pollution, for this purpose.

3 COURSE OF THE ACCIDENT AND INVESTIGATION

3.1 Course of the accident

3.1.1 Events before the collision

3.1.1.1 Course of the CORAL IVORY's voyage

The liquid petroleum gas tanker CORAL IVORY made fast at her berth in Landeshafen Ostermoor (part of the town of Brunsbüttel), located to the south of the canal route, at about 1200 on 27 October 2013. The ship was loaded with about 4,048 tonnes of ammonia in the hours that followed. The ship was ready to depart when the pilot and the canal helmsman boarded her at about 0230 on 28 October 2013. The master then briefed the pilot on the manoeuvrability and associated technical characteristics requiring observation of the ship, which is equipped with a left-handed controllable pitch propeller. The pilot was entrusted with navigational responsibility for the forthcoming casting off manoeuvre by mutual agreement.

At 0232, the pilot notified Vessel Traffic Service Kiel Canal (hereinafter 'VTS') on VHF channel 2[6] that he intended to start the canal passage. In this context, the nautical administrator responsible for controlling the traffic in the western part of the Kiel Canal at the VTS (hereinafter 'traffic controller')[7] gave the pilot detailed information about a convoy approaching from the east, which was soon to pass the area of the entrance to Landeshafen Ostermoor and consisted of five vessels at the time of the call. The CORAL IVORY was to wait for the convoy to pass and in addition to that liaise with the eastbound SUSANNE, which was in a waiting position on the western port boundary.

At 0245, the traffic controller advised the shipping of the general traffic situation in the western part of the Kiel Canal in his regular broadcast to all stations, which is also transmitted on VHF channel 2. Inter alia, he stated that the CORAL IVORY is currently located in Landeshafen, waiting for the BARMBEK, FINNSUN, SIDERFLY, and MITTELPLATE to pass, and liaising with the SUSANNE on who will start the canal passage first.

[6] Note: VHF channel 2 (Kiel Canal II) is used for communication between the vessels in the western section of the Kiel Canal on one hand and of the VTS on the other. It is a so-called duplex channel, meaning shore and ship stations send or receive on different (opposing) frequencies. As a consequence, a radio message transmitted to the VTS from one ship cannot be listened in on by another ship. By contrast, radio messages of the VTS transmitted on this channel can be heard on all ships.

[7] Note: The staff of VTS Kiel Canal comprise the nautical supervisor, who has overall responsibility, two subordinate nautical assistants, who control traffic in the area of the eastern and western stretch of the canal, and two lockmasters, who manage traffic flows associated with the lockage operations in Brunsbüttel. From time to time, one of the two traffic controllers performs the function of the nautical supervisor in an amalgamation of functions due to staff shortages. At the time of the accident, the traffic controller responsible for the eastern stretch was simultaneously acting as nautical supervisor.

The casting off manoeuvre was started at about 0250 and the ship had cleared the berth two minutes later. Apart from the pilot and the helmsman, who was executing the helm instructions of the pilot, the master and the chief officer were present on the bridge at this point. The second officer and two able-bodied seamen manned the forward manoeuvring station; the bosun and two able-bodied seamen the aft. Visibility was good and a force 4-5 Bft south-westerly wind prevailed.

At about 025230, i.e. during the casting off manoeuvre, the pilots of the SUSANNE, which also had the eastbound free-runner[8] JANA astern, and the CORAL IVORY agreed on VHF channel 13[9] that the CORAL IVORY would start the canal passage first.

Immediately after, the CORAL IVORY's pilot first called the SIDERFLY and announced that he would sail out of Landeshafen after the 'Group 6 vessel'[10]. The SIDERFLY was essentially requested to move slightly northwards. The SIDERFLY confirmed she would remain to the north. The CORAL IVORY's pilot then sent a similar request to the MITTELPLATE. The pilot of this vessel also replied that he would remain to the north.

Using the bow thruster and various helm manoeuvres, the CORAL IVORY was traversed away from the berth while the above communication was taking place. Her rate of speed was 'dead slow ahead'. The ship was then steered through Landeshafen at rates of speed alternating between 'dead slow ahead' and 'slow ahead' (averaging 4 kts).

The westbound BARMBEK referred to above had already passed the mouth of the port at the start of the casting off manoeuvre. The FINNSUN had also essentially passed before the CORAL IVORY started to steer for the mouth area of the port exit into the Kiel Canal.

Turning into the canal was initiated with starboard course alterations between 20 to starboard and hard to starboard. An order to set the bow thruster full to port was first issued to keep the ship clear of the port exit's northern boundary with a traversing manoeuvre. The ship was on a north-westerly course after the position necessary for that was attained. The bow had not yet reached the canal's fairway but was close to the mouth of the port exit into the Kiel Canal.

The SIDERFLY was still east of the viaduct at this point. The CORAL IVORY's pilot then had the bow thruster set to full to starboard to facilitate turning further to starboard.

[8] Free-runner is a term for a vessel exempted from the obligation of pilotage (point 15 of § 2 Para 1 SeeSchStrO).
[9] Note: VHF channel 13 (Kiel Canal I) is used for both ship/ship and ship/shore communication in the vicinity of the locks at Brunsbüttel. It is a so-called simplex channel, meaning all radio stations using this channel send and receive on the same frequency. As a consequence, a (third) radio station not involved in a two-way radio call can listen in on the radio messages of the two stations.
[10] Note: The Traffic Group 6 vessel FINNSUN is referred to.

At the same time, the hard to starboard rudder angle was maintained and the rate of speed repeatedly switched between 'dead slow ahead' and 'slow ahead' or 'half ahead'. The ship's speed over ground remained unchanged at between 4-4.5 kts in the process.

3.1.1.2 Course of the SIDERFLY's voyage

The SIDERFLY, loaded with fertiliser (nitrogen in the form of crystalline), sailed out of the Alte Schleuse lock at Holtenau at 2035 on 27 October 2013 and since then had been transiting the Kiel Canal in a westerly direction under pilotage. The scheduled pilot change was carried out in the vicinity of Rüsterbergen at 2340. The master, the officer on watch (who was controlling the helm), and the pilot manned the bridge of the ship subsequently. Due to the prevailing weather conditions, the rate of speed had to be set to 'full ahead' to arrive at canal speed (15 km/h). The SIDERFLY initially proceeded along the Kiel Canal in a convoy of two with the MV MITTELPLATE, which was following her. In the siding at Dückerswisch, which was reached at about 0155, the two vessels caught up with a westbound convoy of three, which was waiting there for the oncoming traffic and comprised the vessels NORDLAND, BARMBEK, and FINNSUN. The above five ships then continued their voyage in convoy without incident.

The SIDERFLY's pilot heard on VHF channel 13 that his two colleagues on the SUSANNE and the CORAL IVORY had agreed that the CORAL IVORY should sail out of Landeshafen into the canal before the SUSANNE. As already discussed above in the section 'Course of the CORAL IVORY's voyage', the SIDERFLY then received a direct call from the CORAL IVORY's pilot, announcing she was sailing into the canal and requesting that the SIDERFLY move northwards. The SIDERFLY's pilot acknowledged this information and had the ship take up a course roughly in the middle of the northern half of the canal. The CORAL IVORY was still not in sight of the bridge of the SIDERFLY at this point.

3.1.2 Ultimate development of the collision

The CORAL IVORY came in sight on the port side of the SIDERFLY about 300 m east of the viaduct. From the perspective of the SIDERFLY, it was evident that the CORAL IVORY would encounter problems when turning into the canal. The CORAL IVORY, carrying out the course alteration to starboard, was still at a relatively obtuse angle to the course of the canal.

It was noticed on the bridge of the CORAL IVORY that the rate of turn[11] was abnormally low. Moreover, a severe gust of wind had reportedly set in, the pressure of which on the aft section reportedly reduced the CORAL IVORY's turning motion further. Although the SIDERFLY was proceeding as far as possible to the northern side of the Kiel Canal, as agreed, the risk of collision with the SIDERFLY started to become increasingly apparent on the bridge of the CORAL IVORY due to the deceleration of her turning manoeuvre.

[11] Note: Rate of turn (ROT) is a nautical term that indicates the turning speed of a ship in degrees per minute (°/min.).

To prevent a collision, the CORAL IVORY's pilot opted for a 'full astern' manoeuvre. The corresponding change of pitch on the controllable pitch propeller reportedly set in immediately. By all accounts, the bow thruster was left at full to starboard. The hard to starboard rudder angle was reportedly also left unchanged.

In spite of these measures, the bow of the CORAL IVORY collided heavily at an angle of about 30 degrees with the port side of the SIDERFLY's forward section west of the viaduct at 0256.

3.1.3 Events after the collision

As a result of the collision, the CORAL IVORY's speed ahead was halted after reaching 3.5 kts over ground. The SIDERFLY also came to a halt close to the canal's northern embankment and rapidly started to list heavily to port because of water ingress resulting from the collision. The CORAL IVORY's pilot immediately sent an accident report on channels 2 and 13, and requested tug assistance for the SIDERFLY, which was clearly in distress. Assistance was also requested on VHF from the bridge of the SIDERFLY.

The SUSANNE, still west of the scene of the accident, deployed a boat immediately after the collision. This evacuated four crew members of the SIDERFLY, which was at an acute risk of foundering. The remaining five crew members and the pilot were also taken safely on board and then ashore by a pilot tender that had rushed to the distressed vessel shortly afterwards.

After the collision, a discussion as to whether it would in the meantime be better to continue pushing the SIDERFLY against the embankment or separate the two ships through an astern manoeuvre by the CORAL IVORY was held on the bridge of the CORAL IVORY. They opted for the latter. After the slow astern manoeuvre, the CORAL IVORY came into contact with the SIDERFLY a second time when her bow brushed against the port side level with the forward edge of the SIDERFLY's bridge during the subsequent efforts to position the CORAL IVORY lengthways on the canal. This did not cause further appreciable damage to either ship, however. The CORAL IVORY, which had sustained only minor damage, then navigated back towards Brunsbüttel under her own steam and made fast at the inland port there.

The SIDERFLY, fully laden with crystalline non-toxic nitrogenous fertilisers, was struck by the CORAL IVORY's ice-strengthened bulbous bow on the port side of her forward section during the first collision discussed above. This resulted in a hole of some 6 x 4.5 m in size in the shell plating of the ship. Three ballast tanks and a void space filled with about 380 tonnes of water rapidly. Moreover, movement in the SIDERFLY's structure caused by the collision resulted in four penetrations in the bulkhead of cargo hold 1. About 70 more tonnes of water was able to flow into the ship through these relatively small openings. Consequently, she listed rapidly and was at risk of foundering.

Due to the strong south-westerly wind, the non-manoeuvrable SIDERFLY initially drifted back in an easterly direction close to the embankment after the collision. With the help of the deployed starboard anchor it was possible to finally bring the ship to a halt about 300 m east of the viaduct.

Two tugs that had arrived at the scene of the accident shortly after the collision managed to push the SIDERFLY temporarily against the northern canal embankment and prevent the ship, which was listing at more than 20 degrees to the port side, from foundering.

A huge technical water-based and especially shore-based effort in the hours and days that followed made it possible to first stabilise the distressed vessel on the northern canal embankment and then make her temporarily buoyant (see **Figures 4 f.**).

Figure 4: Stabilising the SIDERFLY on the canal embankment

Figure 5: Lightering the SIDERFLY

The Kiel Canal had to be closed for the highly complex process of securing the SIDERFLY, which was additionally obstructed hugely in the course of the day of the accident by a storm rising to a hurricane. It was only possible to fully release the canal for use by traffic again three days after the accident at 1700 on 31 October 2013 in consultation with all the administrative bodies involved. The SIDERFLY was shifted to the port of Brunsbüttel on 6 November 2013. Attempts to sell the heavily damaged ship failed. The SIDERFLY finally left Brunsbüttel on 5 February 2014 for a ship breaking yard.

3.2 Consequences of the accident

3.2.1 Damage to the MT CORAL IVORY

The CORAL IVORY sustained minor damage above the waterline in the area of the port side of the stem (**Figures 6 f.**) during the collision with the SIDERFLY. Apart from that, only the ship's ice-strengthened bulbous bow was deformed – also only slightly (**Figure 8**).

Figure 6: Damage to the CORAL IVORY's stem

Figure 7: Damage to CORAL IVORY's stem (view inside)

Figure 8: Damage to the CORAL IVORY's bulbous bow

3.2.2 Damage to the MV SIDERFLY

The heavy impact with the CORAL IVORY's ice-strengthened bulbous bow resulted in a huge gash in the vicinity of frames 100-105 on the port side of the SIDERFLY's

forward section. This resulted in a hole of some 6 m in length and some 4.5 m (**Figure 9**) in height in the hull.

Figure 9: Hole in the SIDERFLY's hull (port side)

There was inevitably water ingress in several ballast tanks, in a void space, as well as in cargo hold 1 of the ship, which has only two cargo holds. The SIDERFLY started to list to port rapidly and it was due only to the tug deployment that she did not founder.

Figure 10: MV SIDERFLY listing to port

The contact with sea water rendered the cargo (fertilisers in crystalline form) in the hold unusable.

3.2.3 Physical injury and damage to the environment

The marine casualty did not result in any injuries. Moreover, there was no significant impact on the environment, as no fuel or lubricant tanks were damaged during the collision. Since the fertiliser carried by the SIDERFLY does not possess any lasting environmentally hazardous properties, the collision-induced contamination of the sea water with components of the cargo did not pose a risk to the environment, either.

3.3 Investigation

3.3.1 Course, sources, and material particulars

The BSU received notice of the accident from WSP Brunsbüttel immediately after the collision. A team of investigators travelled to Brunsbüttel immediately and began the investigation on board the CORAL IVORY, where interviews were held, documents inspected, and the recordings of the VDR[12] secured. It was not possible to survey the SIDERFLY, which was at an acute risk of foundering. Moreover, an attempt to interview her crew members failed. Although they were visited in their shore-based emergency accommodation on the same day as the accident, they asserted their right to refuse to disclose information.[13]

VTS Brunsbüttel's audio recordings of the radio traffic between the vessels involved and between the VTS and the CORAL IVORY made ahead of the collision were a key source of information for determining the causes of the accident. Important conclusions on the course of the accident could also be drawn from the recordings of the CORAL IVORY's VDR and the AIS data[14] of the two vessels involved in the collision. Since the SIDERFLY's gross tonnage is less than the applicable limit for the internationally binding VDR carriage requirement of 3,000, corresponding data were not available from this ship.
For the purpose of a comprehensive review of all the available sources of information, the extensive findings of WSP Brunsbüttel's accident investigation were also analysed.

During the first survey of the SIDERFLY by representatives of the CCME and the police after she was made fully buoyant and shifted to a berth in Brunsbüttel, suspicions that structural defects could have been one or even the main cause of the rapid water ingress after the collision arose. The BSU commissioned a shipbuilding expert with the clarification of this only secondary but nonetheless, in terms of

[12] VDR: **V**oyage **d**ata **r**ecorder. Mandatory system for storing various data (including voice, AIS, and radar recordings) on passenger ships and cargo ships of 3,000 GT and above adopted for international shipping in 2002.
[13] Note: In the course of the investigation, a German law firm provided the BSU with a report prepared in writing by the master of the SIDERFLY.
[14] AIS: **A**utomatic **i**dentification **s**ystem. All ships equipped with this system transmit GPS-based data, including position, course, speed, as well as possibly other information, at a standardised interval on VHF. These data can be displayed on a monitor or in an electronic chart system, for example. Moreover, an increasing number of sea marks and coastal radio stations are being equipped with AIS transponders and/or receivers.

clarifying the course of the accident, important aspect of the marine casualty investigation.

3.3.2 Audio recordings of the VTS

VTS Brunsbüttel's recordings of the VHF radio traffic (all in GERMAN language) were the most important source when it came to identifying and understanding the primary cause of the marine casualty.

The starting point for all further developments here was the radio call between the CORAL IVORY's pilot and the VTS at 0232 on the channel for general calls, 2 (Kiel Canal II). During this call, the pilot announced his intention to leave Landeshafen and begin the voyage towards Kiel. The traffic controller then asked about the draught, type of cargo, as well as the port of destination and received corresponding answers from the pilot.

Immediately afterwards, the traffic controller conveyed the following radio message, which is reproduced below verbatim because of its particular importance to the ensuing events:

"One Traffic Group 4[15], the NORDLAND, will come past you any minute now and Traffic Group 5 BARMBEK, a low-speed vessel[16], and 6 FINNSUN followed by two 3s are going through now; you have to wait for them. Then the SUSANNE is now coming from the Alte Schleuse lock, waiting at the port boundary. Please liaise with her. And then you can get started."

The pilot acknowledged reception of the radio message very succinctly, i.e. without repeating the preceding content. That concluded the direct communication between the VTS and CORAL IVORY before the collision.

At 0245, the traffic controller transmitted the periodic general call to all stations on channel 2 (Kiel Canal 2) and a notification for the shipping in the western part of the Kiel Canal (the Brunsbüttel to Breiholz section). In accordance with its purpose, the call included comprehensive information about the traffic movements in the aforementioned area of the Kiel Canal divided into eastbound and westbound vessels and stating the respective traffic group.

[15] Note: In accordance with point 5 of the Notice of the Directorate-General for Waterways and Shipping, Outstation North, concerning the German Traffic Regulations for Navigable Waterways (Seeschifffahrtsstraßen-Ordnung - SeeSchStrO), all vessels transiting the Kiel Canal are classified to one of the traffic groups 1-6 based on the specific characteristics and/or dimensions (length, breadth, draught) stated in the Notice. The respective classification is of fundamental importance to answering the question as to whether vessels on the Kiel Canal may overtake or encounter outside siding areas (see points 9 and 11 of the Notice), amongst other things.

[16] Note: The reference 'low-speed vessel' made in connection with the BARMBEK was required in the call to all stations because in the Kiel Canal the maximum speed limit of 12 km/h (6.5 kts) generally only applies to Traffic Group 6 vessels (as compared to the otherwise applicable maximum speed of 15 km/h (8.1 kts)). However, the reduced maximum authorised speed also applies to vessels with a draught of more than 8.50 m, meaning the Traffic Group 5 BARMBEK was also required to observe it (see points 12.13.1 f. of the Notice quoted in the preceding footnote).

Finally, the traffic controller used the call to all stations to inform eastbound traffic about the forthcoming start of the Kiel Canal passage by the CORAL IVORY. His wording follows verbatim:

"Traffic Group 4 CORAL IVORY, currently in Landeshafen, wait for the BARMBEK, FINNSUN, SIDERFLY, and MITTELPLATE to pass, then liaise with SUSANNE as to who is first, whether she will continue from the port boundary first; CORAL IVORY then later in Kudensee[17] clear to proceed."

The SUSANNE's pilot called the CORAL IVORY on VHF channel 13 (Kiel Canal I) at 025220. The CORAL IVORY's pilot responded to this call by merely stating in his microphone the first name of the pilot of the SUSANNE, who he clearly knew, in an inquiring tone a few seconds later. The call then progressed as follows:

SUSANNE's pilot:
"Hello X. I am going to proceed. I still have a JANA behind me."

CORAL IVORY's pilot:
"You have a signal again, I do not!"[18]

SUSANNE's pilot: ***"Yes, if you are fast, come. Otherwise I will get underway now."***

Immediately after announcing this request, the CORAL IVORY's pilot called the SIDERFLY (on channel 13), conveying the following information/request after acknowledgement of this call by the pilot of the SIDERFLY:

CORAL IVORY's pilot:
Yes, we are sailing out of Landeshafen right after the Traffic Group 6[19] vessel. Can you move slightly northward please?

The SIDERFLY's pilot replied:
"Yes, we will keep northward, okay."

Immediately afterwards, the CORAL IVORY's pilot conveyed the following without making a separate call: ***"MITTELPLATE too?"*** To which the MITTELPLATE's pilot replied: ***"Yes, X. We will keep northward, MITTELPLATE has understood."***

[17] Note: Kudensee: the siding area. The notification 'clear to proceed' informs the CORAL IVORY that she does not have to wait in the siding in question for the passage of oncoming traffic.
[18] Note: The notification of the CORAL IVORY's pilot relates to the signalling system's red stop signal due to the still outstanding passage of the westbound FINNSUN, which is located to the west of the entrance to Landeshafen Ostermoor. As with the corresponding systems in the siding areas, this signalling system forms part of the computerised traffic flow control system on the Kiel Canal, which is managed by the traffic flow control.
[19] Note: The reference to the Traffic Group 6 vessel relates to the FINNSUN's (which belongs to Traffic Group 6) westbound passage of the entrance to the port of Ostermoor.

There was no further ship/ship communication involving either the CORAL IVORY or the other vessels mentioned above prior to the collision between the CORAL IVORY and SIDERFLY. Moreover, up until the collision there was no further radio traffic between the VTS on the one hand and the CORAL IVORY or other vessels mentioned above on the other hand.

3.3.3 Course of the voyage taken by the vessels and shore-based AIS recordings

The shore-based AIS recordings confirmed the course of the voyage taken by the ships, as described by witnesses.

Figure 11 shows the traffic situation immediately before the start of the CORAL IVORY's casting off manoeuvre.[20] The BARMBEK has already passed the area of the port entrance. The FINNSUN's passage is also imminent. The SUSANNE is visible in a waiting position as a yellow icon at the bottom left of the figure.

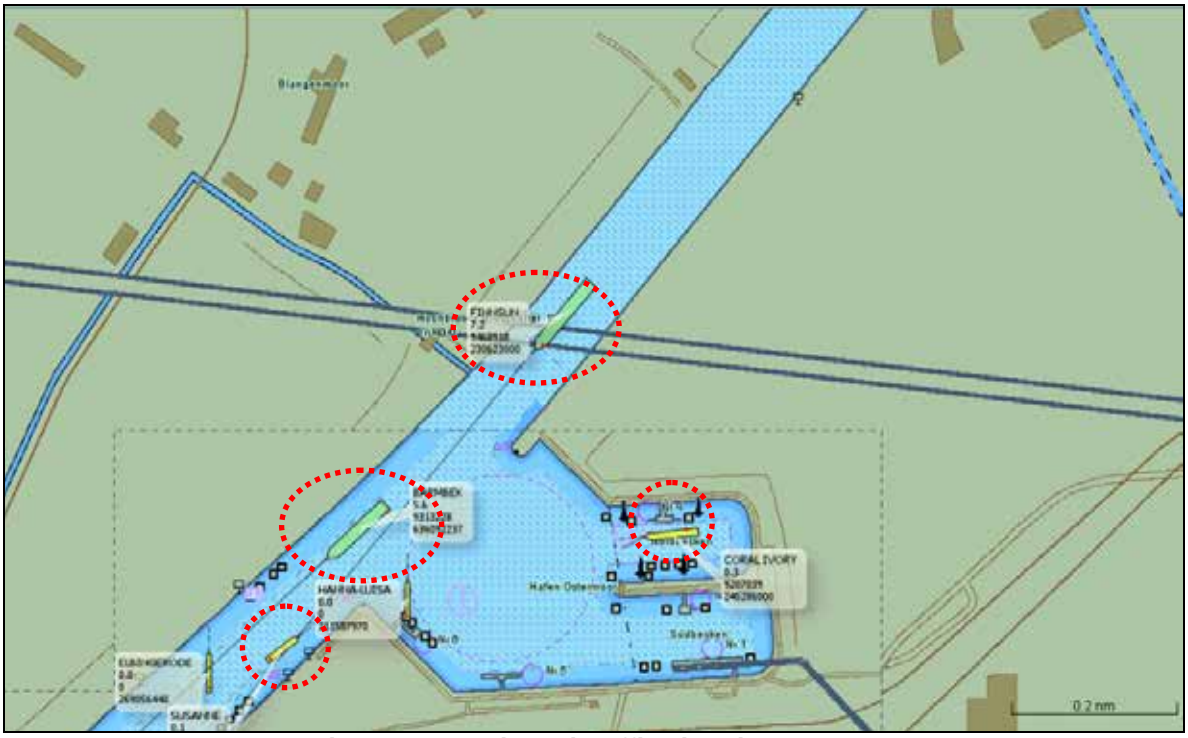

Figure 11: AIS-based traffic situation at 0250

The following AIS screenshot (**Figure 12**) shows the situation about one minute later. The CORAL IVORY has apparently started the casting off manoeuvre. The SIDERFLY is now visible in the top right of the figure.

[20] Note: With regard to this and all the following AIS screenshots, it should be noted that the ship positions, the respective lubber lines, and the position of the ship icons in relation to each other are possibly **only an approximation of the facts** because rendering errors and/or small time lags may occur during transmission of the AIS data due to interference and/or other technical factors. Moreover, AIS positions are always subject to proper configuration of the AIS transponder on board the particular vessel.

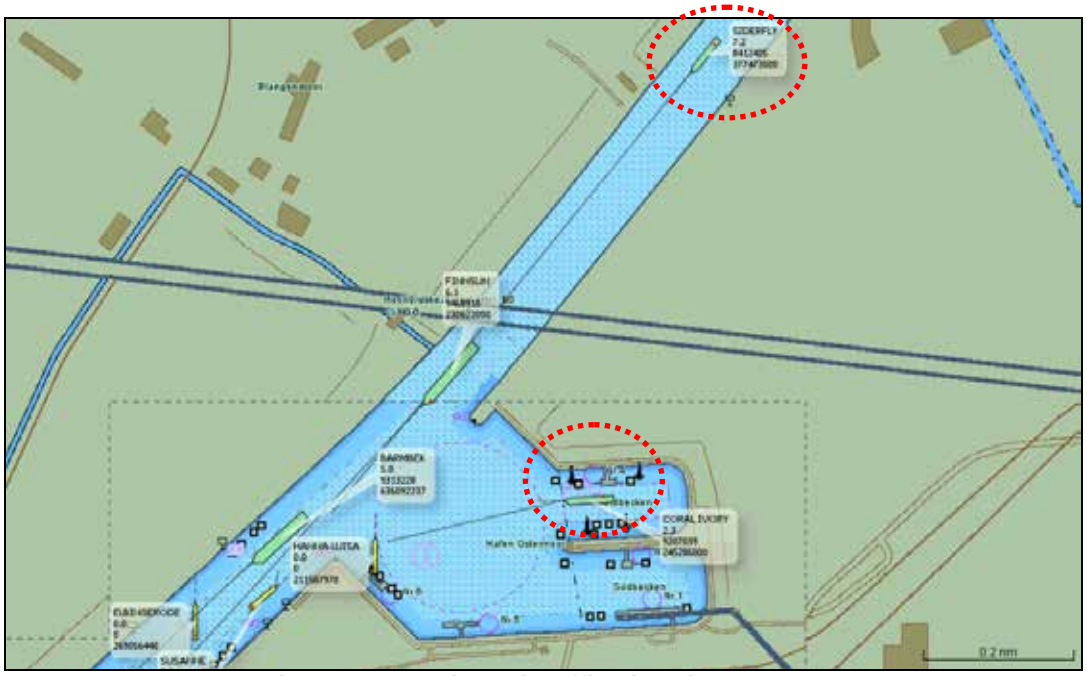

Figure 12: AIS-based traffic situation at 0251

The AIS situation about 3.5 minutes after the start of the casting off manoeuvre (**Figure 13**) indicates that the CORAL IVORY clearly plans to turn into the Kiel Canal at a relatively narrow distance to the pier head situated to the east of the port exit. The FINSUNN is just passing the port exit. At this point, the distance to the SIDERFLY is about 0.5 nm.

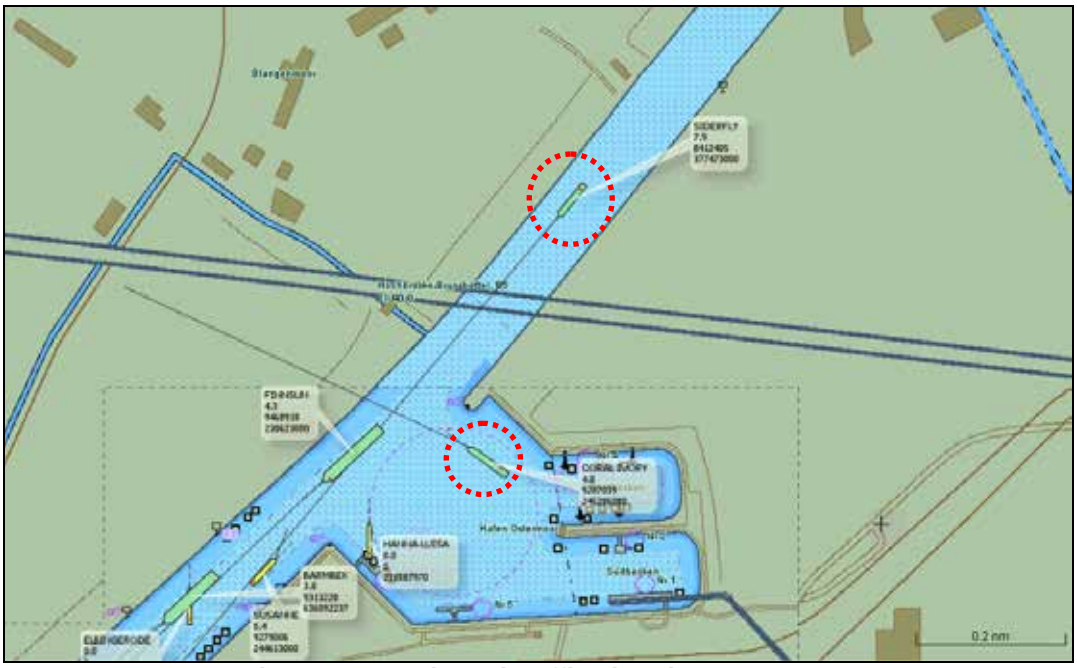

Figure 13: AIS-based traffic situation at 025430

The selected limitation of the CORAL IVORY to the northern part of the outer port during the turn into the canal becomes even clearer about 30 seconds later in **Figure 14** below. It is already evident that it will be virtually impossible for the CORAL IVORY, whose bow has reached the boundary of the mouth of the port exit to the Kiel Canal, to restrict herself to its southern half when filtering into the canal.

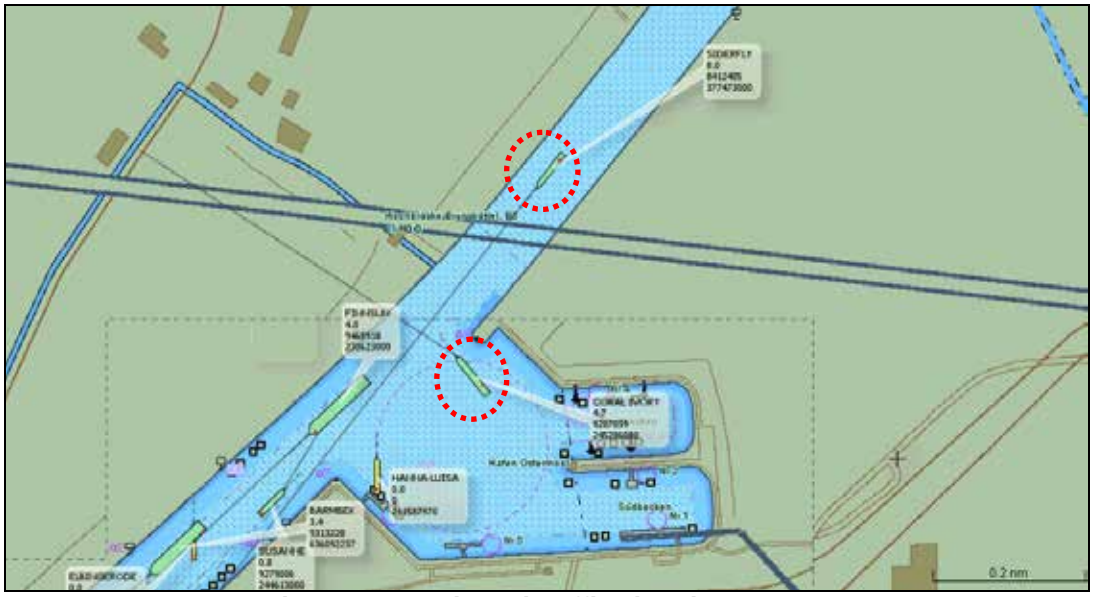

Figure 14: AIS-based traffic situation at 0255

The CORAL IVORY's bow has reached the middle of the canal in the AIS figure (**Figure 15**), which shows the traffic situation about 30 seconds later. The ship is still at a relatively obtuse angle to the course of the canal. The distance to the SIDERFLY, whose bow has now reached the viaduct, is about 0.2 nm. The immediate risk of collision is clearly visible.

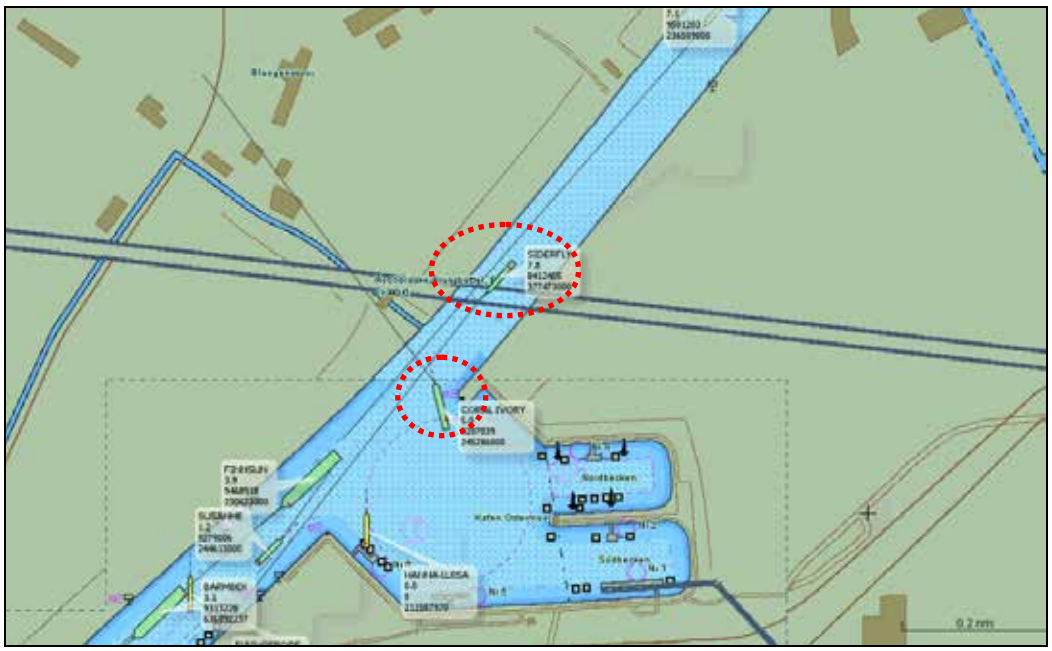

Figure 15: AIS-based traffic situation at 025530

The screenshot at about 0256 (**Figure 16**) suggests that the CORAL IVORY is still fully committed to attaining a heading lengthways to the canal before the passage of the SIDERFLY. However, it is also clear that the now available distance to the oncoming vessel of only 0.1 nm is barely sufficient for that. This is all the more true because the local conditions make it impossible for the SIDERFLY to evade to the north.

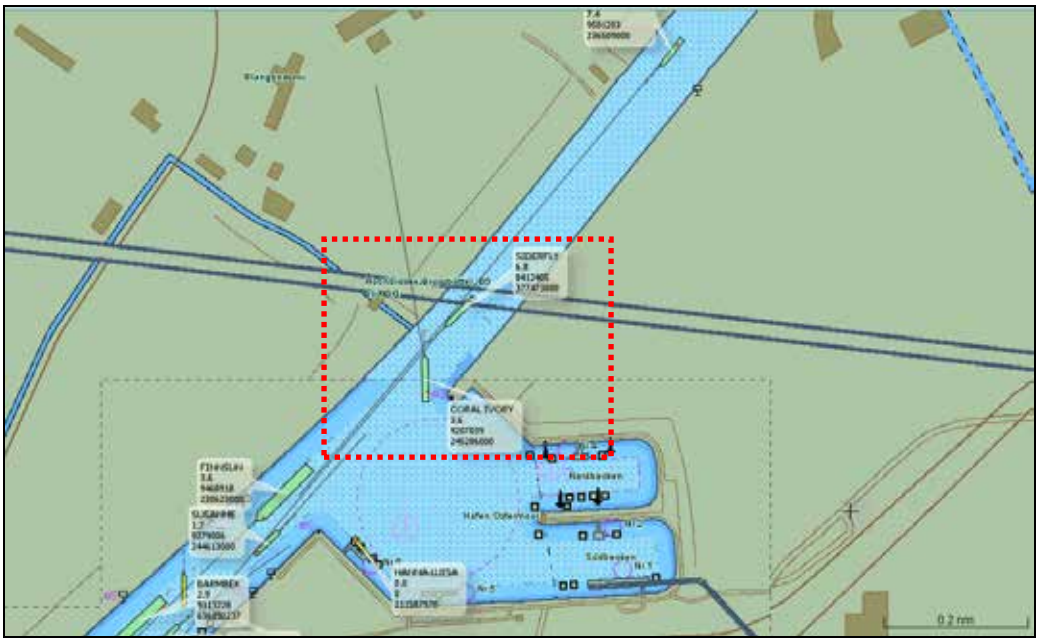

Figure 16: AIS-based traffic situation at 0256

The inevitable collision between the CORAL IVORY's bow and SIDERFLY's port side shown in **Figure 17** occurred at about 025630.

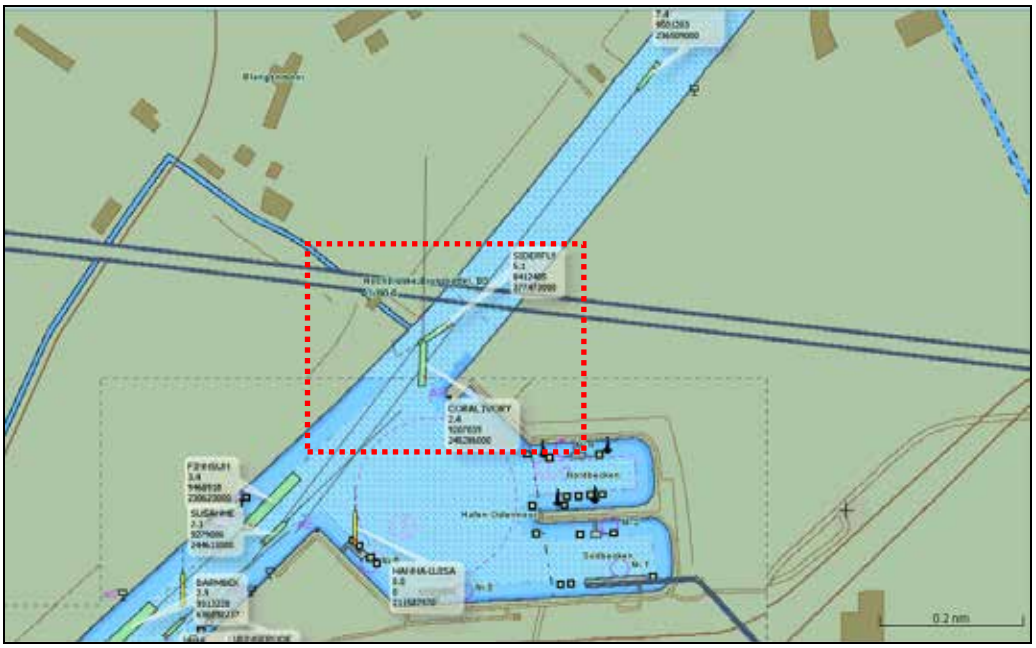

Figure 17: AIS-based traffic situation at 025630

Figures 18, 19, and 20 help to illustrate the various stages of the subsequent course of the voyage of each vessel involved in the collision. Here, **Figures 19 and 20** show that after the collision the SIDERFLY drifted about 0.3 nm to the east until it was possible to finally bring her to a halt and make her fast parallel to the northern canal embankment thanks to the anchor manoeuvre executed in the meantime and tug assistance.

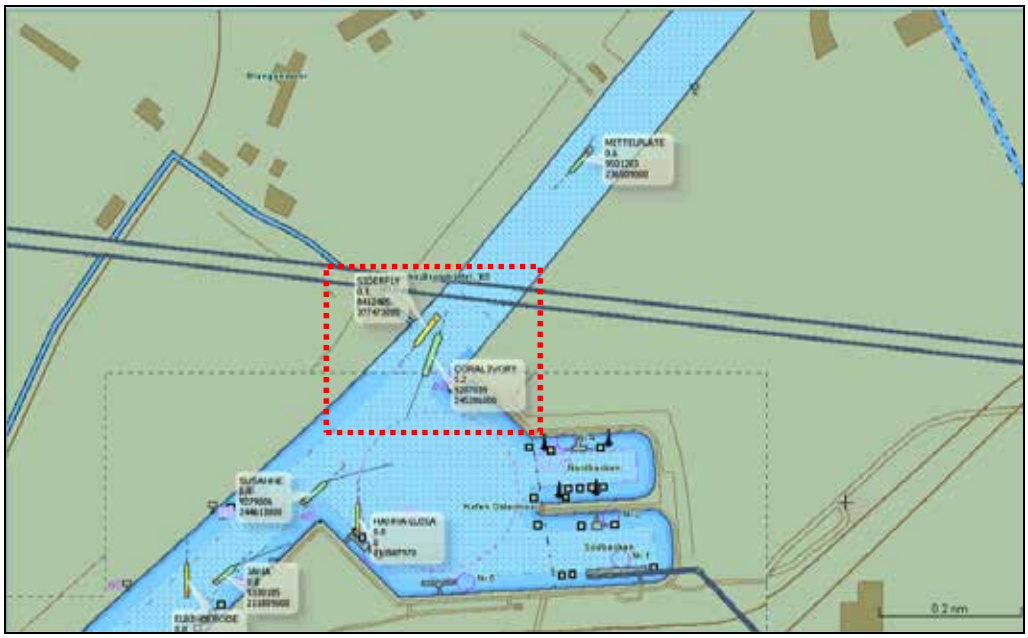

Figure 18: AIS-based traffic situation at about 0304
(the CORAL IVORY has parted from the SIDERFLY)

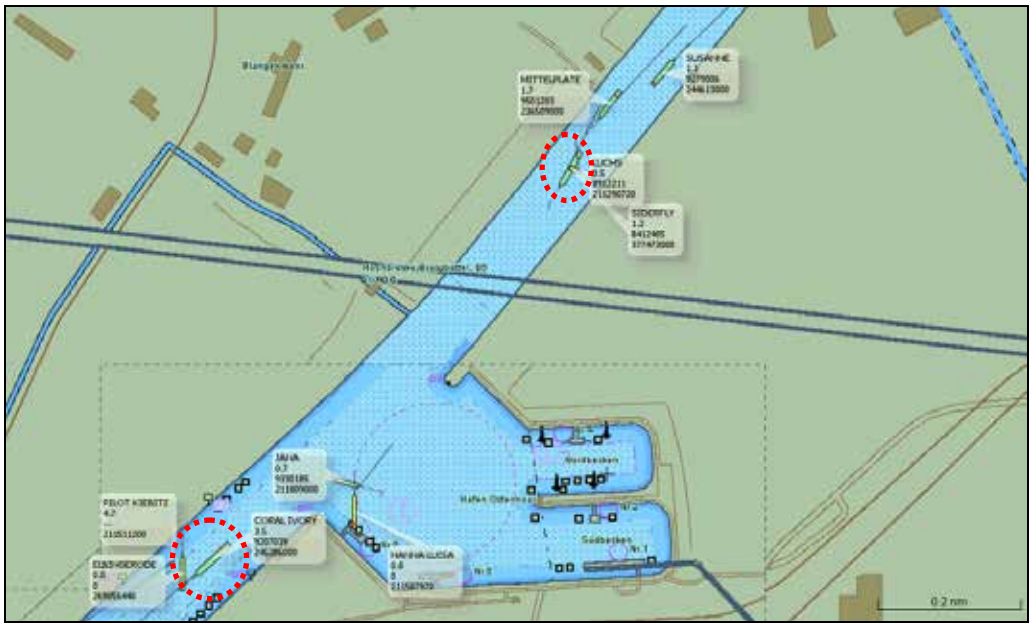

Figure 19: AIS-based traffic situation at about 0330
(the CORAL IVORY shortly before reaching the place of refuge)

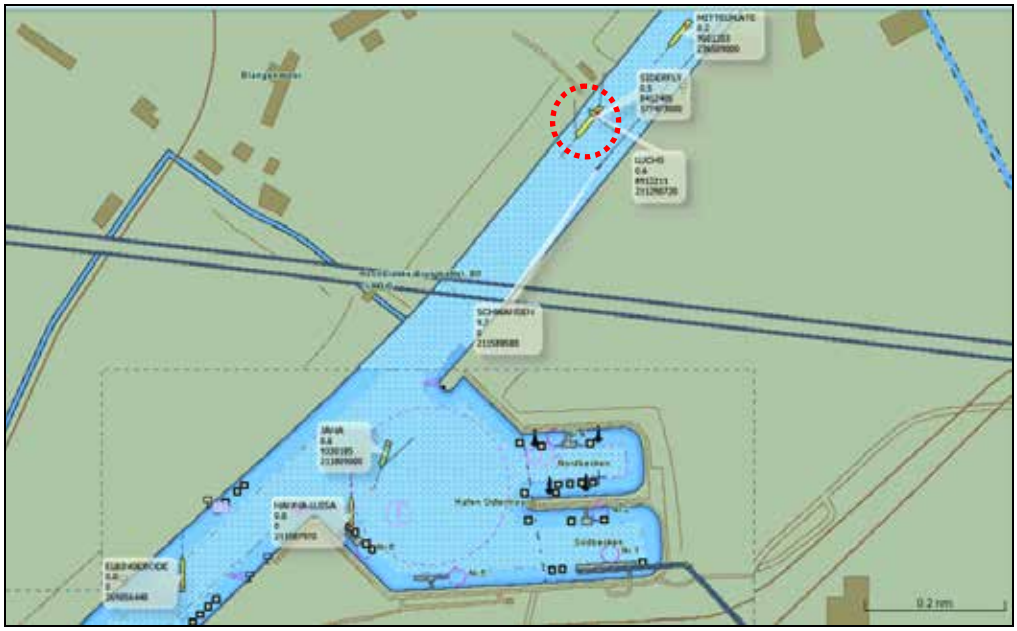

Figure 20: AIS-based traffic situation at about 0340 (the SIDERFLY's drift is definitively stopped)

3.3.4 CORAL IVORY's S-VDR

3.3.4.1 Preliminary notes

A DANELEC DM 300 S-VDR[21] was installed on board the ship. A data backup was initiated after the accident. Using the manufacturer's replay software, it was possible to download and reproduce the data in video or audio form without any technical complications. As is regularly the case when analysing VDR/S-VDR data after a marine casualty, the cross-manufacturer issue of only very poor audio data quality was evident during the analysis, however. Although not entirely incomprehensible, the data are very difficult to analyse at times due to variations in level and background noise. Since the internal discussions on the bridge of the ship were not relevant to gaining an understanding of and analysing the course of events leading up to and during the accident, but rather – as already discussed – the VHF radio communication recorded by the VTS between the CORAL IVORY on the one hand and the VTS, the SUSANNE, and the SIDERFLY on the other hand, an in-depth consideration of the audio recordings of the CORAL IVORY's S-VDR has been dispensed with in this investigation report. However, the radar, ROT, and AIS recordings made by the CORAL IVORY's S-VDR do deliver important information about the development of the collision and its possible causes. Therefore, these sources of information are looked at in detail in the following subsections.

[21] Note: The 'S' stands for simplified and means that the VDR installed on board is a simplified version. The feature set on S-VDR systems may be limited. SOLAS grants this derogation to all ships on which a VDR had to be installed in the course of implementing the retrofit requirement.

3.3.4.2 Audio recordings

The recording of discussions on the bridge between the pilot and ship's command is barely comprehensible. It is possible to reconcile the discussions held by the CORAL IVORY's pilot with the VTS or the pilots of the SUSANNE, the SIDERFLY, and the MITTELPLATE in terms of time and content, however. The quality of the relevant recordings of the VTS were much better, meaning section 3.3.2 is referenced to that extent.

Nevertheless, in spite of the quality issues, listening to the audio recordings on the VDR does deliver one important finding relating to the assessment of the objective development of the risk of collision by those present on the bridge of the CORAL IVORY. All of them, the pilot and the ship's command in particular, evidently believed until immediately before the collision that the entire length of the ship would reach the right (southern) half of the Kiel Canal in time and thus sail past the SIDERFLY without any complications. This conclusion arises from the fact that it is very quiet on the bridge up until the time of the clearly audible collision noises at 025620. The cries or other noises arising from stress or panic that are typically heard at the latest just before any collision are simply not audible.

3.3.4.3 Radar recordings

The S-VDR saved the radar images of the CORAL IVORY's port side X-band radar unit at 15-second intervals as per functionality. Accordingly, the unit was set to the 0.5-nm range with the ship's own position centred, operated in head-up mode[22], and delivered a very clear image. The radar unit's ARPA function[23] was not used throughout the relevant course of the voyage. No other changes to the image were made, either. Since the S-VDR was connected with only one radar unit (in compliance with the relevant performance standards), the analysis of the recorded data does not permit reliable statements as to whether the starboard S-band radar unit was used on the bridge additionally. According to witness testimony given, this device was also switched on during the casting off manoeuvre, however. The following image settings were found during the accident investigation and it was claimed they were not changed after the accident: head-up display mode at a range of 0.5 nm.

Figure 21 shows the radar image immediately before the start of the CORAL IVORY's casting off manoeuvre. The BARMBEK is now passing the area of the port exit and the FINNSUN is about to pass the viaduct. The CORAL IVORY's track data are visible on the top right of each of the following radar image screenshots.

[22] Note: In the head-up display mode, the lubber line on the radar image always points upwards, i.e. the display corresponds with the view out of the window.

[23] Note: The ARPA (automatic radar plotting aid) function makes it possible to display on the radar unit such information as the time and value of the next approach of a radar echo selected previously by the user.

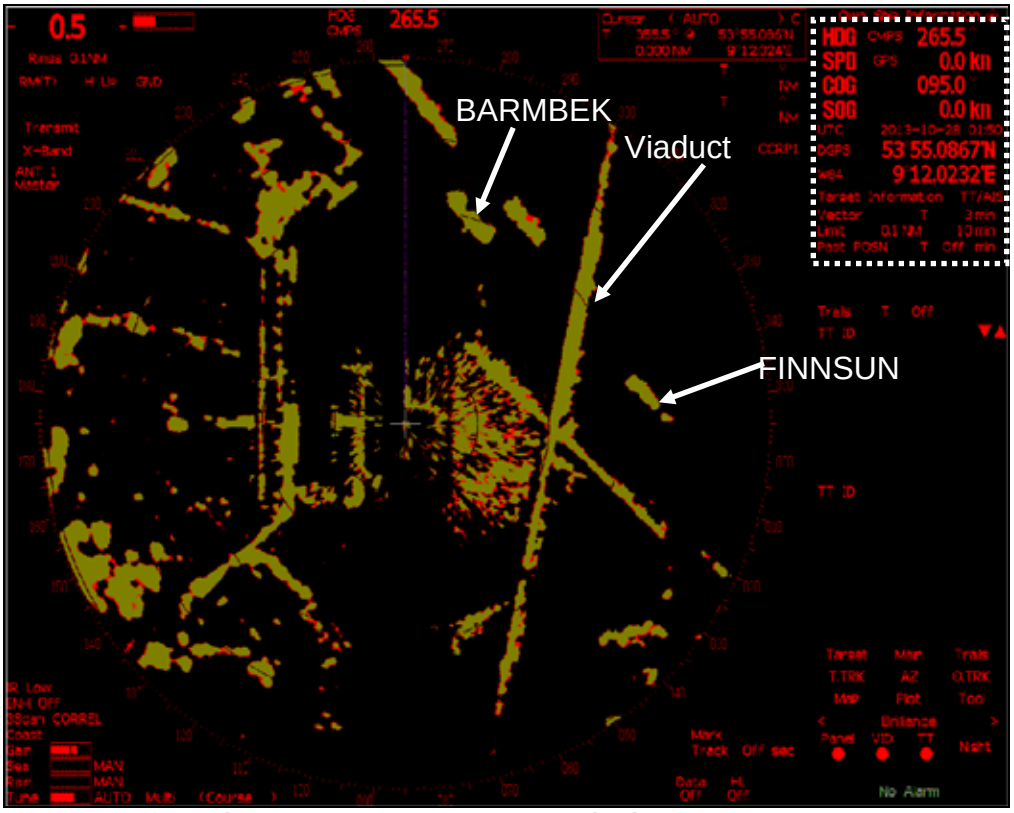

Figure 21: CORAL IVORY – radar image at 0250

Figure 22 shows that the FINNSUN is now passing the area of the port exit. The SIDERFLY is still not visible in the radar image.

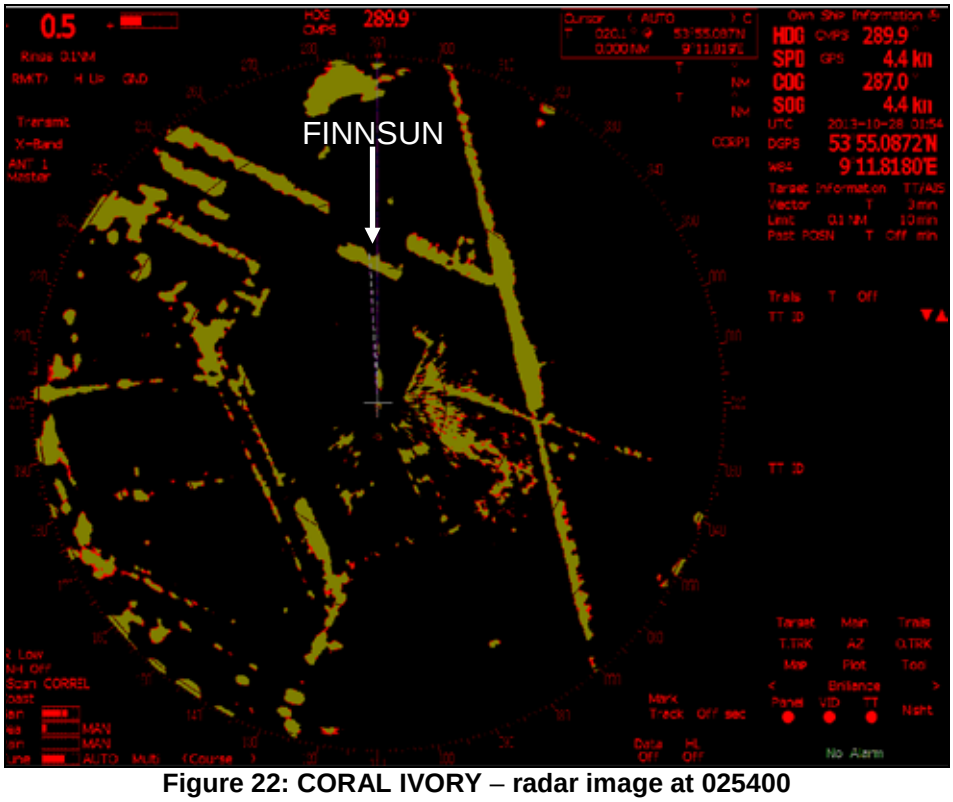

Figure 22: CORAL IVORY – radar image at 025400

The below radar image (**Figure 23**) relates to the time 025454. The AIS data reveal that the distance between the CORAL IVORY and the SIDERFLY is now only about 0.3 nm. In spite of that, the echo of the ship is still not visible on the radar image (which still covers the 0.5-nm range). Since the radar image continuously displays the land contours, the viaduct, and vessel echoes forward of the bow very clearly, the absence of the SIDERFLY's echo can only be explained by shadowing effects.

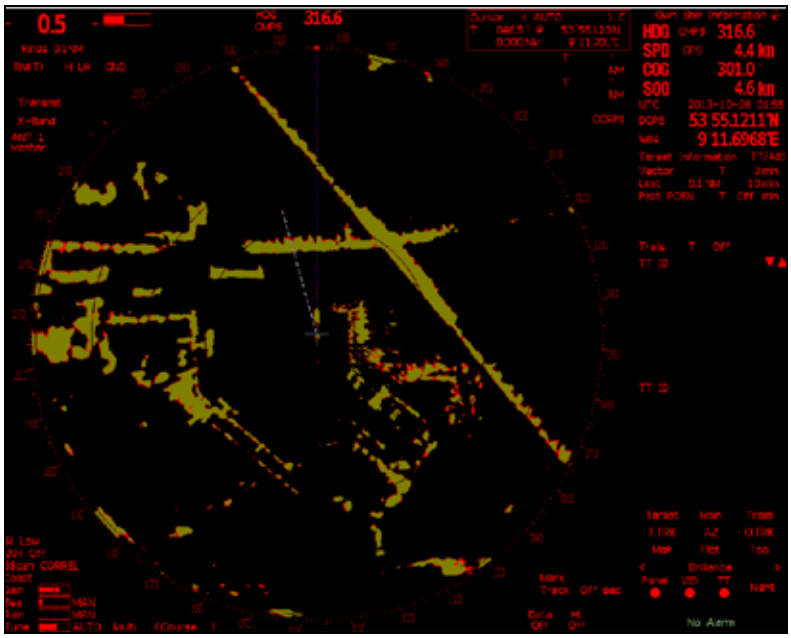

Figure 23: CORAL IVORY – radar image at 025454

In the next radar image (see **Figure 24**) stored 15 seconds later as per functionality, the SIDERFLY is suddenly clearly identifiable east of the viaduct.

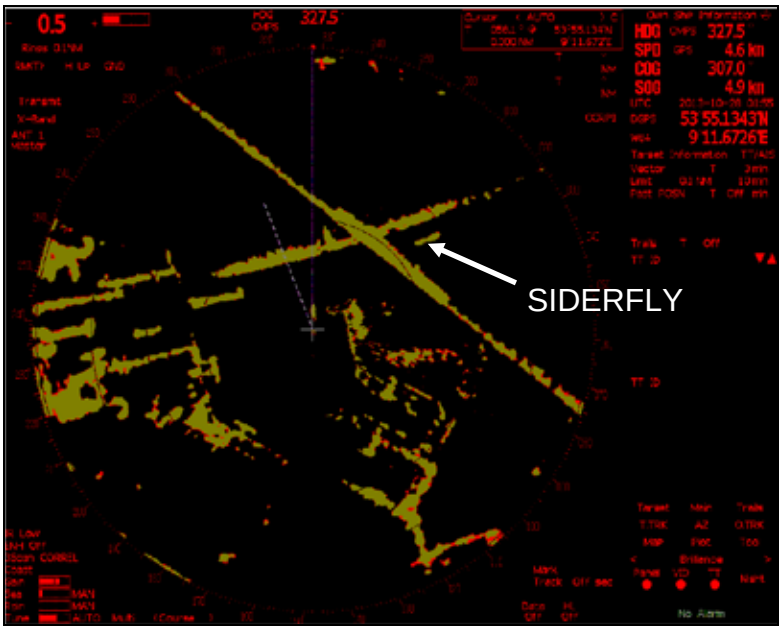

Figure 24: CORAL IVORY – radar image at 025509

It is clear in the following radar image, which illustrates the immediate approach of the vessels at 025609 (**Figure 25**), that the heading (course steered – blue dashed line) of the CORAL IVORY is still some distance from a course that matches the course of the canal.

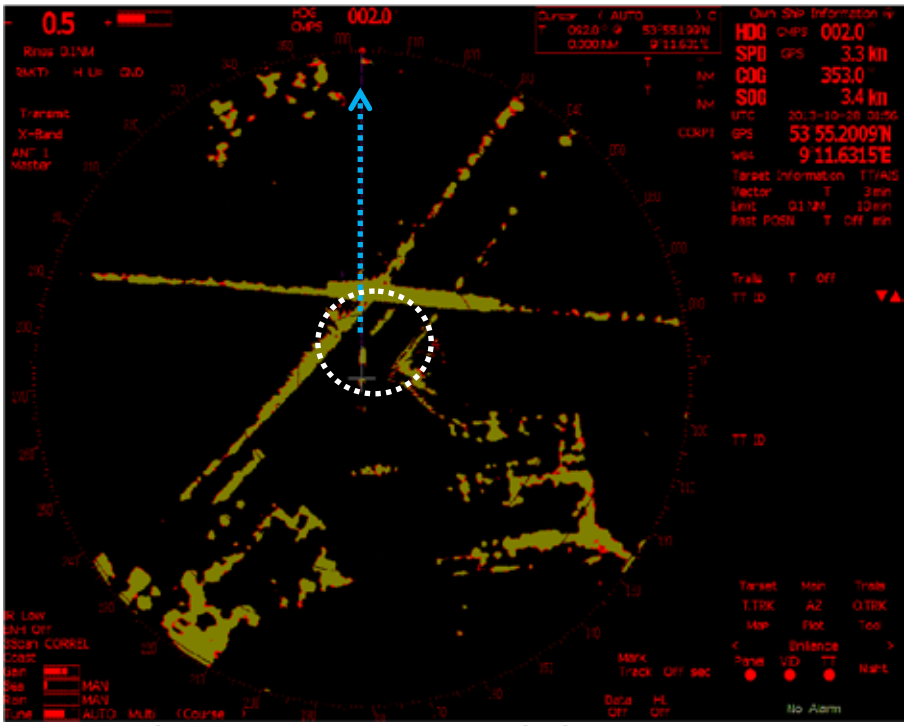

Figure 25: CORAL IVORY – radar image at 025609

Quite logically, the next radar image (**Figure 26**) shows the collision between the CORAL IVORY and SIDERFLY.

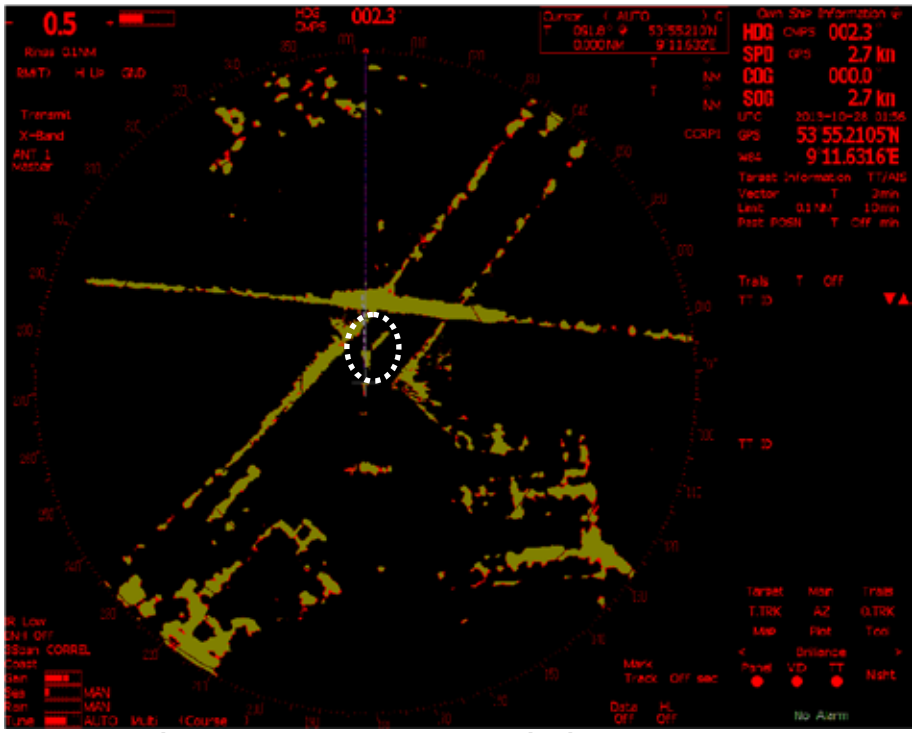

Figure 26: CORAL IVORY – radar image at 025624

3.3.4.4 Rate of turn

The recordings of the CORAL IVORY's S-VDR provide information about the ship's ROT, inter alia. The steady decline of the ROT in the final stage of the approach described by witnesses, which facilitated the collision and – as far can be heard – cannot be explained by helm commands on the bridge, is confirmed by the relevant continuous technical recordings. **Figures 27 ff.** (selected screenshots from the VDR's replay software) illustrate this.

They indicate that the CORAL IVORY turned to starboard (see **Figure 27**) at a rate of some 35°/min. at 025410. Starting at a starboard position, at this point an order was issued to set the helm to amidships temporarily, presumably to keep the ship sufficiently clear of the pier head. The ROT decreased very slowly in the ensuing 20 seconds. According to the recordings of the S-VDR, the SOG[24] was now 4.7 kts.

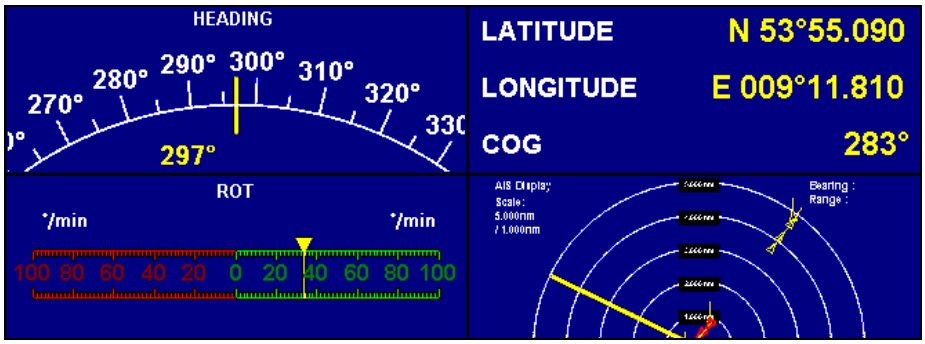

Figure 27: CORAL IVORY – ROT at 025410

When the ROT reached a value of 20°/min. at 025430, an order – clearly audible in the S-VDR's audio recordings – was issued to set the helm to hard to starboard.

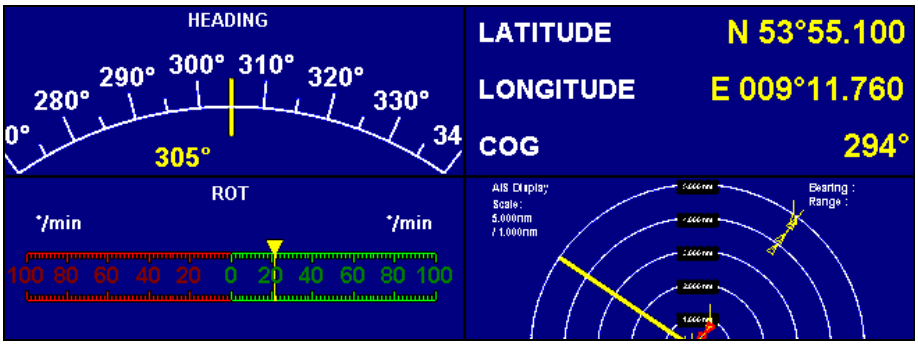

Figure 28: CORAL IVORY – ROT at 025430

The ROT increased accordingly to values of about 60°/min. in the ensuing 45 seconds (see **Figure 29**).

[24] SOG: Speed over ground

Figure 29: CORAL IVORY – ROT at 025515

The ROT then steadily dropped again from about 025515 onwards without a simultaneous discontinuation of the hard to starboard helm manoeuvre, however.

Figure 30: CORAL IVORY – ROT at 025545

Shortly before the collision (see **Figure 31**), the ROT had finally dropped to values of less than 20°/min. in spite of the hard to starboard rudder angle and use of the bow thruster. At this point, the SOG was still just over 3 kts.

Figure 31: CORAL IVORY – ROT at 025615

3.3.4.5 AIS

The AIS recordings of the CORAL IVORY's S-VDR permit a good overall view of the development of the collision. The self-explanatory screenshots (**Figures 32 ff.**) chosen for this report, which were taken from the replay software, illustrate the CORAL IVORY's course in the final three minutes leading up to the collision with the SIDERFLY, and also provide information on other GPS-based track data of the ship. With regard to the SIDERFLY, only the heading line is initially visible. The S-VDR only delivers other track data relating to the SIDERFLY from about 025500 onwards (see **Figures 35 ff.**).[25]

[25] Note: The accuracy of the AIS data may be impaired due to interference and/or improperly configured AIS transponders.

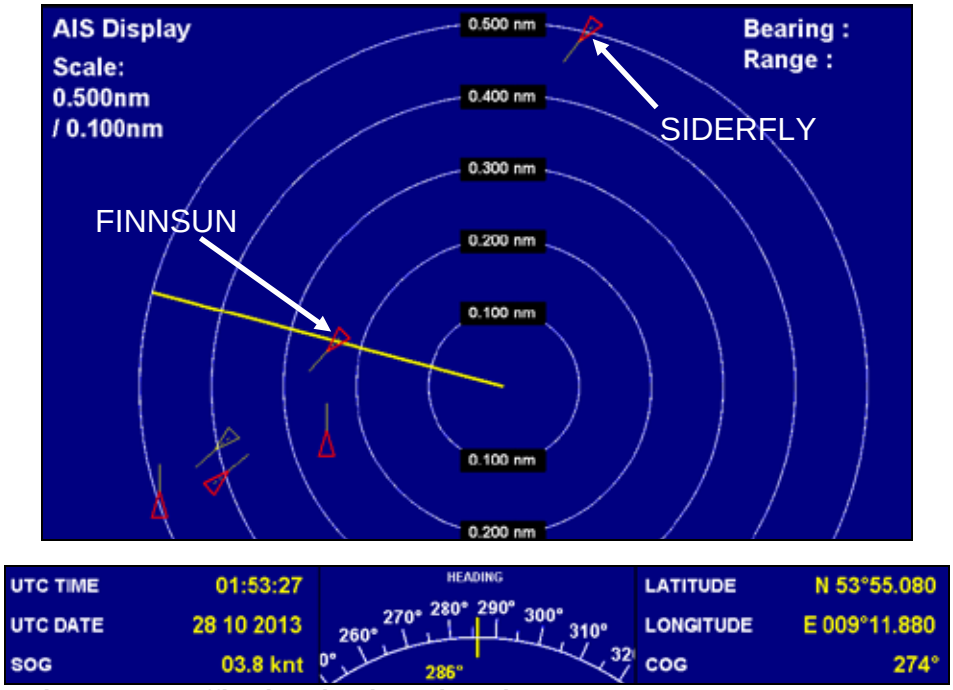

Figure 32: Traffic situation based on the CORAL IVORY's AIS at 025327

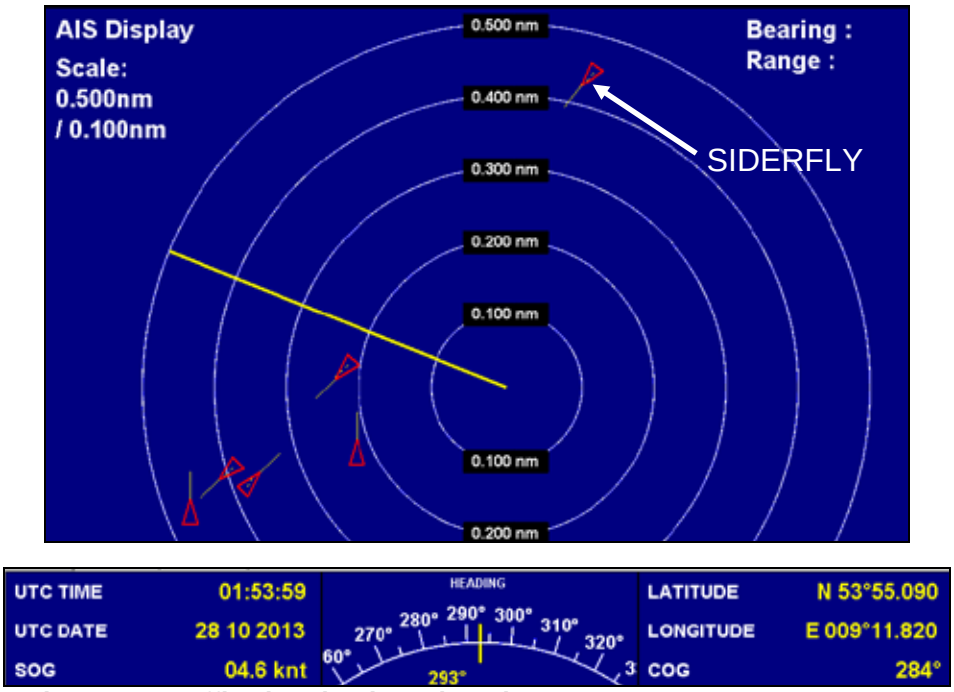

Figure 33: Traffic situation based on the CORAL IVORY's AIS at 025359

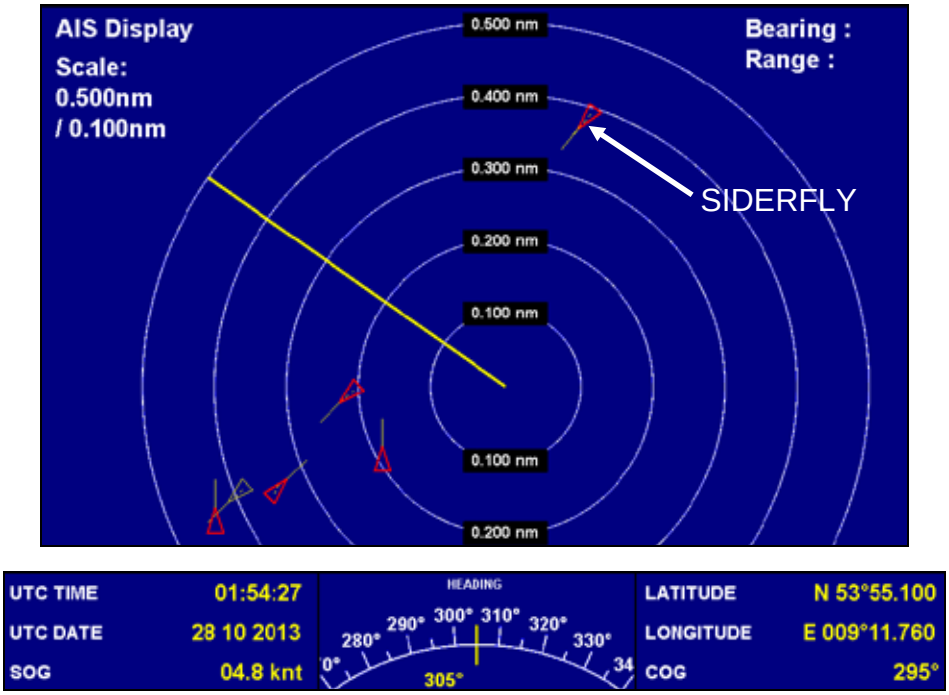

Figure 34: Traffic situation based on the CORAL IVORY's AIS at 025427

The AIS target details available from about 0255 (see upper right box in **Figures 35 ff.**) indicate that starting from 218° and exploiting the limited constraints of the canal to the absolute full, the SIDERFLY continuously changed her heading in the final 1.5 minutes leading up to the collision, reaching 223° by 20 seconds before the collision.[26] Presumably due to last-minute avoiding action, the SIDERFLY's heading was as much as 230° (see **Figure 39**) immediately before the collision.

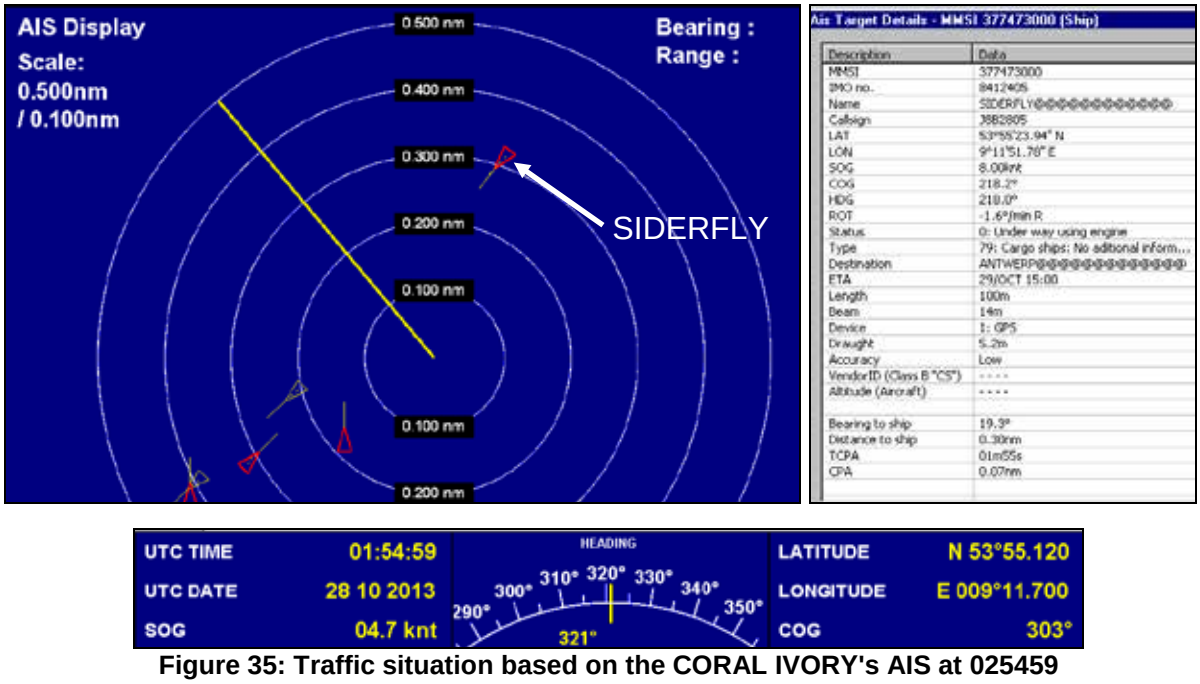

Figure 35: Traffic situation based on the CORAL IVORY's AIS at 025459

[26] Note: According to the nautical chart, the optimum heading line is 219° in the section of the Kiel Canal in question.

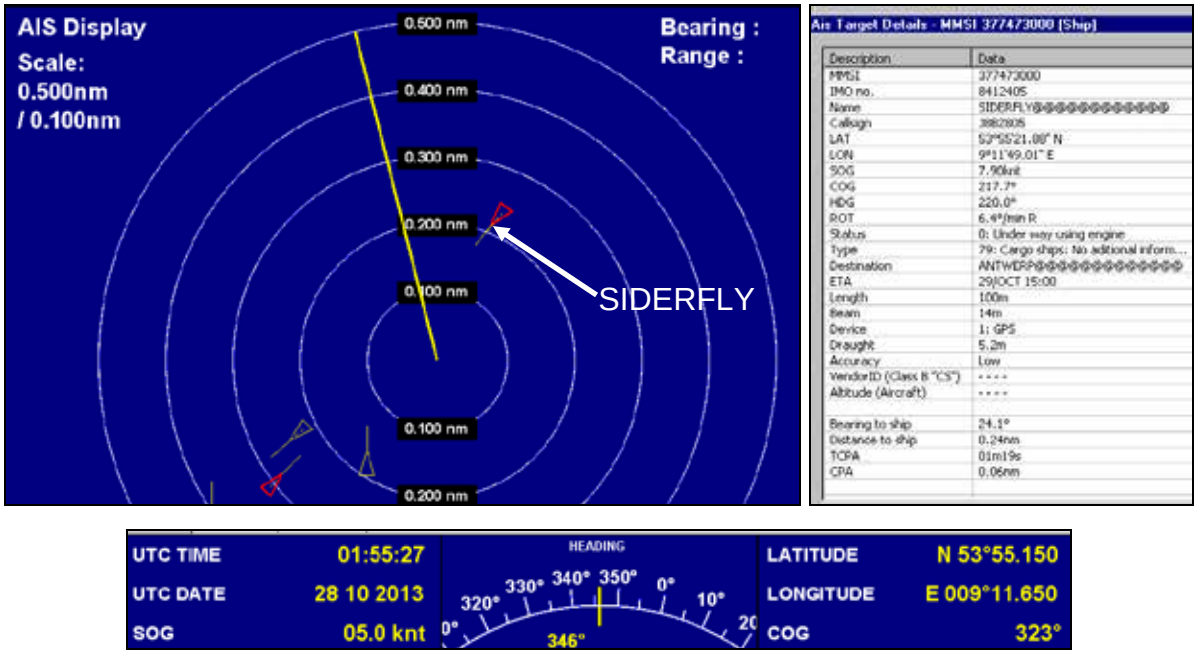

Figure 36: Traffic situation based on the CORAL IVORY's AIS at 025527

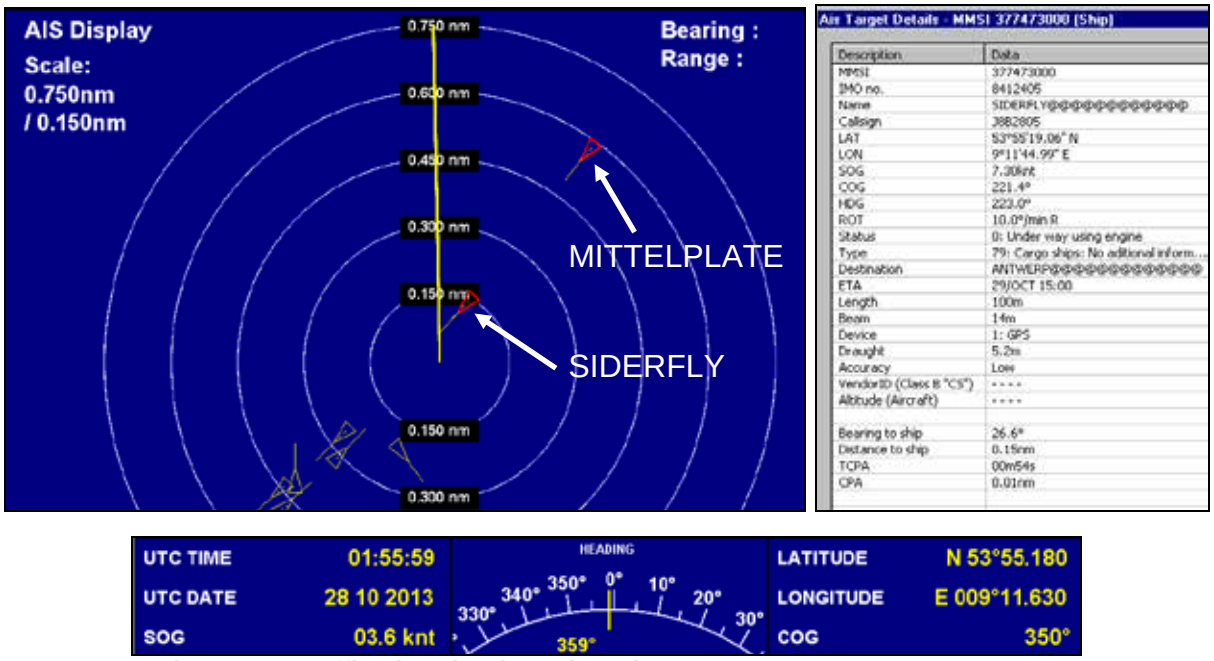

Figure 37: Traffic situation based on the CORAL IVORY's AIS at 025559

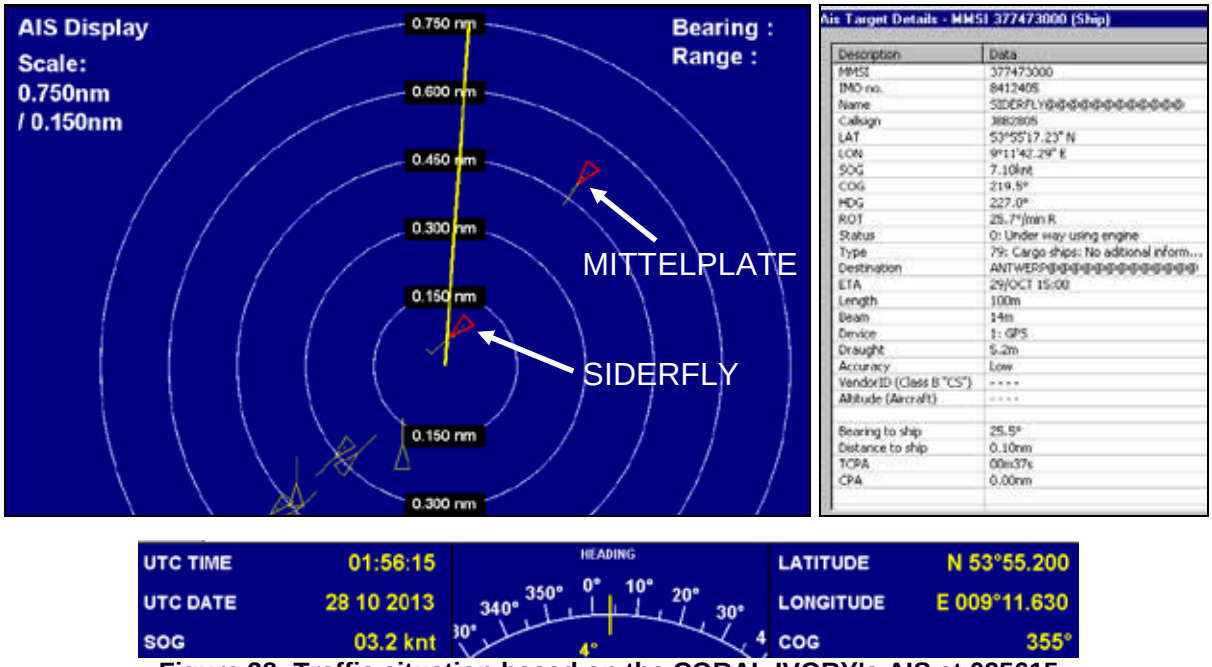

Figure 38: Traffic situation based on the CORAL IVORY's AIS at 025615

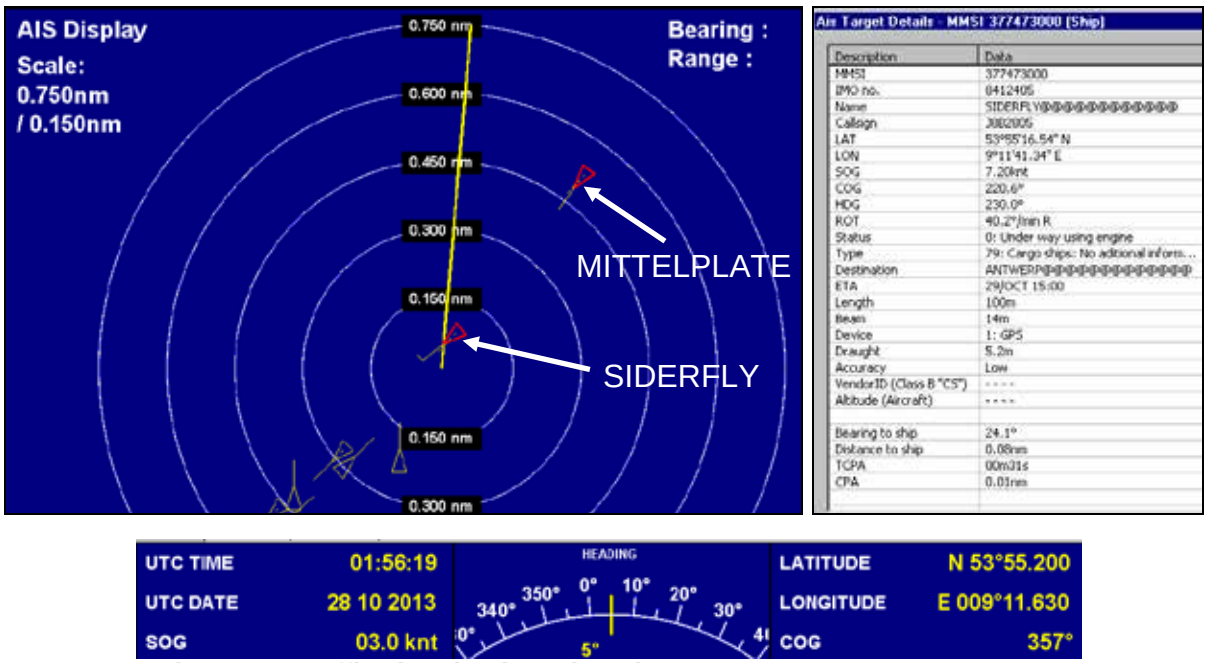

Figure 39: Traffic situation based on the CORAL IVORY's AIS at 025619 (immediately before the collision)

3.3.5 Weather conditions and visibility

3.3.5.1 Preliminary notes

Information from witnesses regarding the wind differed greatly at times. Apart from different personal observations marked by subjective elements, this is probably due to the fact that at the time the events leading up to, during, and following the accident

occurred, the powerful hurricane force depression 'CHRISTIAN' swept across west Europe, including northern Germany, generating very strong gusts in places.

With regard to the weather conditions prevailing at the time of the accident, the BSU has dispensed with the preparation of a report because it was possible to refer to a corresponding official report prepared by Germany's National Meteorological Service (DWD) on behalf of WSP Brunsbüttel. The BSU also had at its disposal wind measurement data from the Kiel Canal's official weather data recordings.

3.3.5.2 DWD report[27]

The DWD's official report describes the weather conditions in the vicinity of Landeshafen at the time of the accident as follows:

"Wind: The south-west wind reached mean values of about 20 kts (5-6 Bft) in the area of Brunsbüttel at the time of the accident; values standing at 32 kts (7 Bft) were detected in the North Sea area. At the same time, gusts with a force of 45 kts (9 Bft) were seen in the North Sea area and with a force of 33-35 kts (7-8 Bft) in the area of the accident. The wind only increased noticeably at around 1200 UTC with more than 50 kts (10 Bft) measured at times in the estuary area of the Elbe and even well above 70 kts on the open North Sea, i.e. more than hurricane force. [...]

Weather and visibility: It was generally overcast with a few drops of rain. The heavy rain had yet to occur but had arrived in Lower Saxony, however.

Temperature: Air and water temperatures stood at 13-14 degrees."

3.3.5.3 Kiel Canal's weather data recordings

The measuring instrument data indicate that in the area of Brunsbüttel (see **Figure 40**) an almost consistent south-westerly wind prevailed in the final ten minutes leading up to the collision at average – also almost consistent – speed values of 9 m/sec. (wind force 5 Bft). However, significant wind speed fluctuations occurred regularly within each minute period, which can only be explained by sporadic strong gusts and in some instances led to temporary shifts between wind force 4 and wind force 6.

[27] Source: The DWD's official report of 26 November 2013 on the weather conditions in the vicinity of the Kiel Canal/Landeshafen Ostermoor at 0257 CET on 28 October 2013.

Wetterdatenerfassung am NOK

Zeitpunkt	Windrichtung	Windgeschwindigkeit	WS Max.	WS Min.	WS-Mittel 10 Min.	WS-Mittel 60 Min.	WS-Mitt 24 H.
Synmet BRB	°	m/s	m/s	m/s	m/s	m/s	m/s
28 10 2013 2:45	214	8.5	12.6	7.9	10.5	11.9	10.8
28 10 2013 2:46	213	9.3	12.3	7.0	10.4	11.8	10.8
28 10 2013							
.0	12.4	7.0	10.4	11.8	10.8	2:47	219
2	12.4	7.0	10.4	11.8	10.8	28 10 2013 2:48	215
2	12.4	7.0	10.4	11.7	10.8	28 10 2013 2:49	215
6	12.4	7.0	10.3	11.7	10.8	28 10 2013 2:50	216
3	12.4	7.0	10.3	11.6	10.8	28 10 2013 2:51	216
2	12.4	7.0	10.2	11.6	10.8	28 10 2013	219
11.5	10.8	28 10 2013 2:53	215	9.8	12.4	7.0	10.1
11.4	10.8	28 10 2013 2:54	215	9.3	12.4	7.0	10.1
11.4	10.8	28 10 2013 2:55	219	8.7	12.4	7.0	10.1
11.3	10.8	28 10 2013 2:56	214	9.0	12.4	8.3	10.1
11.3	10.8	28 10 2013 2:57	215	9.6	12.4	8.3	10.1
221	9.4	12.4	8.3	10.1	11.2	10.9	28 10 2013 2:58
220	9.9	12.4	8.5	10.2	11.2	10.9	28 10 2013 2:59
218	9.6	13.4	8.5	10.2	11.2	10.9	28 10 2013 3:00
219	9.3	13.4	8.6	10.3	11.2	10.9	28 10 2013 3:01
217	10.6	13.4	8.6	10.4	11.1	10.9	28 10 2013 3:02
13.4	8.6	10.4	11.1	10.9	28 10 2013 3:03	220	9.7
13.4	8.6	10.4	11.1	10.9	28 10 2013 3:04	219	9.3

Figure 40: Wind data recordings on the Kiel Canal

3.3.6 Expert opinion on the structural seaworthiness of the SIDERFLY

3.3.6.1 Preliminary notes and object of investigation

After the SIDERFLY was made buoyant and she was shifted to a berth at the inland port of Brunsbüttel on 6 November 2013, the first survey produced evidence that structural defects could have been one or even the main cause of the rapid water ingress after the collision. Specifically, there were suspicions that the manholes between the void space and cargo holds of the ship were not closed properly before the accident. It was stated that this could have been a major cause of the water ingress in cargo hold 1. That the engine room flooded with water so soon after the collision was also questionable.

The BSU commissioned the Hamburg-based Ingenieurbüro Weselmann GmbH, which among other things specialises in damage and condition surveys on seagoing ships, with clarification of the aforementioned issues affecting the SIDERFLY's structural seaworthiness.

3.3.6.2 Content and findings of the expert opinion

The expert, Dipl.-Ing. Carsten Holst, surveyed the SIDERFLY on 12 November 2013 and submitted his report, which was drawn up in English and given the title 'Survey Report B 133/13 – Collision in Kiel Canal – MV SIDERFLY', to the BSU on 25 November. Extensive photographic documentation was attached as an Annex to the report.

Extracts of the material content and outcome of the survey are shown below in partly edited form.[28]

The following was found during the survey:

*A hole in the shell plating was located on the port side of the ship's forward section between frames 100 and 105. The length of this hole was about 6 m and the height about 4.5 m. The shell plating and reinforcement in this area were damaged by the CORAL IVORY's bulbous bow (see **Figure 41**).*

Figure 41: Hole in the SIDERFLY's shell plating (port side)

[28] Note: The following comments are shown in italics to make clear that they are based on the opinion of the expert.

The CORAL IVORY is classified with the classification society Bureau Veritas' highest ice class (1A).
The high degree of strength possessed by the CORAL IVORY's bulbous bow on the basis of this ice class contributed to the extensive damage to the shell plating on the SIDERFLY's port side.
The port side shell plating, the side stringers, the side longitudinals on the shell plating, and the bulkhead longitudinals were dented or destroyed through to the area of the port side bulkhead of cargo hold 1.
The following tanks were affected by the heavy damage to the shell plating and internal steel structure:

- *ballast water side tank 4 on the port side (volume 49.3 m³);*
- *ballast water side tank 8 on the port side (volume 76.4 m³);*
- *ballast water double bottom tank 12 on the port side (volume 54.1 m³), and*
- *void space on the port side between frames 72 and 105 (volume approx. 200 m³).*

The bulkhead on the port side of cargo hold 1 was torn open between the aforementioned ballast tanks and void space by the shell plating's structural steel beams intruding from the port side.
All the steel plates and beams in the area of damage exhibited acceptable scantlings. Age-related material shrinkage of the shell plating, the stringers, the longitudinals on the shell plating, and the bulkhead longitudinals was within the limits permissible. There were no signs of excessive corrosion.[29]

*As far as was visible during the survey, the topside shell plating on the port side was intact (see **Figure 42**).*

Figure 42: SIDERFLY's shell plating (port side)

[29] Note: This finding was also underlined in the original text of the expert opinion to highlight it.

*Four repaired holes were found in the port side longitudinal bulkhead of cargo hold 1. At the time of the survey, they had already been welded closed using steel plates (see **Figure 43** by way of example).*

Figure 43: Holes in the cargo hold bulkhead (cargo hold 1 on port side)[30]

According to information given by the staff member responsible for salvaging the SIDERFLY from the salvage company (the salvage master), who was present at the survey, all four holes were caused by displaced steel beams or stiffeners on the ballast tanks and void space. In the course of the collision, certain parts of the aforementioned components of the ship's structure had penetrated the cargo hold bulkhead due to the heavy impact of the CORAL IVORY's bulbous bow.

According to information given by the salvage master, the four holes had the following dimensions:

- *opening 1: approx. 100 x 100 mm*
- *opening 2: approx. 600 x 150 mm*
- *opening 3: approx. 100 x 100 mm*
- *opening 4: approx. 100 x 100 mm*

*The manhole covers in the bulkhead between cargo hold 1 and the void space had also been welded closed using steel plates (see **Figure 44** by way of example). According to information given by the salvage master, the watertight integrity of the manhole covers on the port side was slightly deficient. Due to slight leakage resulting from that, the manhole covers were reportedly welded as a precaution.*

[30] The scaffolding located in front of the cargo hold bulkhead conceals the two other holes in the figure.

By comparison to the holes in the cargo hold bulkhead caused by the collision, the leakage at the manhole covers was reportedly negligible, however.

Figure 44: Manhole cover welded closed using a steel plate

In the opinion of the expert appointed by the BSU, there is no evidence to suggest that the manhole cover seals between the cargo hold bulkhead and the void space below ballast tank 8 were defective before the accident. The heavy forces acting on the cargo hold bulkhead and manhole covers during the collision could have caused the slight leakage.[31]

An inspection of the fan cowls on the main deck of the SIDERFLY revealed no deficiencies.

*No technical defects were found during the inspection of the engine room, either. Residues of an oil/water mixture on the engine room bulkheads revealed that only the port side of the engine room had been flooded to the ceiling of the main deck in the course of the accident or during the salvage operation (see **Figure 45**).*
The steering gear compartment's fan cowl was found to be in a closed state.

[31] Note: This finding was also underlined in the original text of the expert opinion to highlight it.

Figure 45: Evidence of the increasing flooding towards the port side of the engine room

*Clear indications of the maximum water ingress during the accident or in the course of the salvage operation were found in the aft section of the superstructure (see **Figure 46**). The residues of water contaminated with oil permit the conclusion that the ship's maximum list stood at 22°.*
During the salvage operation, the water level on the port side of the ship reached a height that in all likelihood allowed water from the canal to enter the engine room via the exterior doors of the main deck and through the accommodation area.

Figure 46: Limit of maximum immersion on the port side of the SIDERFLY

Summary

*The maximum draught of the SIDERFLY, which has two holds, stands at 5.42 m. Her freeboard is 1.54 m at maximum draught. The draught of the ship stood at about 5.20 m when the collision occurred. According to the submitted cargo plan, the SIDERFLY was almost fully laden (see **Figure 47**). Ballast tanks 4, 8, and 12 were empty. The void space beneath ballast tank 8 was also empty.*

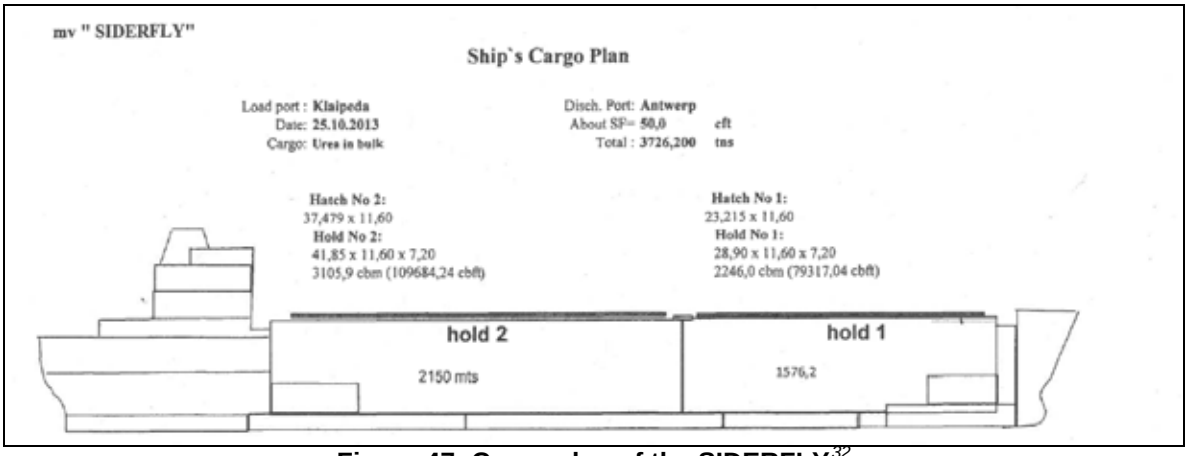

Figure 47: Cargo plan of the SIDERFLY[32]

The collision resulted in a 6 m x 4.5 m hole being torn in the forward section of the shell plating on the port side. This large hole led to the rapid flooding of ballast tanks 4, 8, and 12, as well as the aforementioned void space. Some 380 tonnes of water flooded the ballast tanks and the void space on the port side within a short period of time.
Cargo hold 1, loaded with artificial fertiliser, suffered water ingress through four collision-induced holes in the port side of the bulkhead. In sum, the holes covered an area of 0.22 m².

It is reasonable to assume that some 450 tonnes of water in total rapidly entered the aforementioned sections of the SIDERFLY's hull. In an almost fully laden ship of the dimension of the SIDERFLY, this water ingress quickly resulted in a corresponding list.

After the collision, the ship was grounded on the canal embankment. The SIDERFLY was made fast on the bank of the canal with the help of tugs and steel cables fixed ashore to prevent her from slipping off of the embankment.
According to information given by the salvage master, the list increased slightly during the salvage operation.

[32] Source: Ship's papers.

*Since the tugs inevitably pushed against the ship level with the hatch cover when the SIDERFLY was made fast on the port side, the hatch covers were lifted slightly (see **Figure 48**). This neutralised the watertight integrity of the hatches.*

Figure 48: Tug-induced load on the hatch cover

The water gradually entered the ship's two cargo holds via the hatch coaming and hatch covers, which were not properly watertight. This effect was exacerbated by the fact that hatch covers are basically designed only to prevent water ingress in the cargo hold resulting from weather and swell. This does not cover continued watertight integrity over an extended period, however.

The expert essentially summarised the results of his assessment as follows:

1. *The age-related material wear on those parts of the ship's structure considered and of relevance to the course of events leading up to and during the accident was within the limits permissible. There were no signs of excessive corrosion.*
2. *There was no indication of extraordinary leakage in the area of the manhole cover leading to the void space damaged by the collision. The void spaces in question are not normally filled with water. This means that any possible leakage there is not noticed during normal ship operation. It is possible that the manhole cover seals shifted slightly due to the impact of the collision. The vibration caused by the collision possibly led to the slight leakage.*
3. *Deficiencies were not found at the fan cowls on the main deck. All the fan cowls were in a fully operable condition.*
4. *In all likelihood, the engine room was flooded with water from the Kiel Canal that entered the ship through open access points to the superstructure level with the main deck.*
5. *The partial flooding of cargo hold 1 was caused by the collision-induced penetrations in the bulkhead. Moreover, the sea water entered the cargo hold via hatch covers that were not properly watertight.*
6. *The partial flooding of cargo hold 2 was only via the hatch cover, which was not properly watertight.*

3.3.7 Competence of the ship's commands, fatigue, and influence of alcohol

The BSU is not in possession of any evidence to suggest that inadequate competence of the ship's commands and pilots involved, fatigue or influence of alcohol can be seriously considered as having caused or facilitated the accident.

4 Analysis

4.1 Communication before the collision

The analysis of the audio recordings of the VTS and the CORAL IVORY's S-VDR revealed that the communication between the CORAL IVORY's pilot and the VTS and with the pilots of the vessels SUSANNE, SIDERFLY, and MITTELPLATE was of fundamental importance to the course of events leading up to and during the accident.

4.1.1 Assessment of the radio traffic between the VTS and CORAL IVORY

It is unequivocally clear from the audio recordings of VTS Brunsbüttel that a radio call concerning the modalities for filtering the CORAL IVORY into the Kiel Canal was held between the CORAL IVORY's pilot and the traffic controller some 20 minutes before the casting off manoeuvre began, and that both parties could hear and understand its content clearly.
The traffic controller told the CORAL IVORY's pilot that he would have to wait for the passage of the westbound vessels BARMBEK, FINNSUN and "two 3s" and that he must (also) liaise with the (eastbound) SUSANNE, which was waiting at the port boundary.[33]

In the aforementioned radio message, the SIDERFLY was not mentioned by name as a vessel whose passage had to be given way to. This fact is of no relevance to the course of events leading up to and during the accident, however. From the context of the VTS's message and based on the sources of information available to the pilot, it is reasonable to assume that he was fully aware of the composition of the convoy, which at this point still consisted of four ships approaching the viaduct at Brunsbüttel, from the outset.

As regards both the name of the ship and the '*obligation* to give way'[34] to the SIDERFLY, the traffic controller once again clearly informed the shipping that the CORAL IVORY is waiting at Landeshafen until the BARMBEK, FINNSUN, SIDERFLY, and MITTELPLATE have passed in the general call to all stations, and hence to the CORAL IVORY, too (also transmitted before the CORAL IVORY's casting off manoeuvre began).

If it was not already obvious, the direct VHF calls by the CORAL IVORY's pilot to the SIDERFLY and to the MITTELPLATE immediately after the casting off manoeuvre began, in which the two vessels were essentially requested to keep as far as

[33] Note: With regard to the legal nature of this message, see the comments in section 4.3.2. below.
[34] Note: See also the comments in section 4.3.3.

possible to the north, demonstrate that the CORAL IVORY's pilot was aware of their identity and that they were part of the convoy that was about to pass.

The BSU is unable to explain why the CORAL IVORY's pilot did not wait for the passage of the MITTELPLATE and SIDERFLY, but instead started the casting off manoeuvre beforehand contrary to the instructions of the VTS.

4.1.2 Assessment of the radio traffic between the SUSANNE and CORAL IVORY

The radio call with the CORAL IVORY's pilot, which was initiated by the pilot of the SUSANNE shortly after the CORAL IVORY casted off, indicates that the SUSANNE was keen to start her eastbound passage of the Kiel Canal as quickly as possible. This can be derived from the announcement of the SUSANNE's pilot to the CORAL IVORY: *"Yes, if you are fast, come. Otherwise I will get underway now."*

That the SUSANNE's pilot urged the CORAL IVORY to be quick, even though he must have known from the VTS's recently transmitted situation report that the CORAL IVORY first had to wait for the passage of the westbound convoy consisting of four vessels in any case, is something the BSU finds hard to comprehend.
On the other hand, viewed objectively the BSU finds it equally hard to comprehend why the CORAL IVORY's pilot did not want to give the SUSANNE 'priority' in respect of the forthcoming Kiel Canal passage by the two vessels.

4.1.3 Assessment of the radio traffic between the CORAL IVORY, SIDERFLY, and MITTELPLATE

Immediately after the SUSANNE's announcement that she intended to start the canal passage, the CORAL IVORY's pilot first called the SIDERFLY and then the MITTELPLATE, announced he was leaving Landeshafen, and essentially requested that both vessels move northwards. From the acknowledgements of the SIDERFLY's pilot and of the MITTELPLATE's pilot, in each case very brief, it can only be interpreted that neither objected to the CORAL IVORY filtering into the Kiel Canal early contrary to the announcement of the VTS.

With regard to these radio calls, viewed objectively it remains unclear why neither the pilot of the SIDERFLY nor of the MITTELPLATE reminded the CORAL IVORY of her obligation to give way, as notified by the VTS.

4.1.4 Flow of information and responsibilities[35] on the bridge of the CORAL IVORY

The BSU was not able to analyse the discussions between the ship's command and the pilot on the bridge of the CORAL IVORY reliably due to the poor quality of the corresponding recordings of the S-VDR. However, the statements of the witnesses interviewed indicate that the CORAL IVORY's pilot and her master liaised on the manoeuvring characteristics of the ship and modalities for the forthcoming start of the Kiel Canal passage after the pilot boarded. By his own admission, the Dutch master did not understand the discussions between the pilot, VTS, and vessels involved in

[35] Note: This does not concern a possible responsibility under civil or criminal law, but merely the navigational responsibility for executing the casting off manoeuvre and filtering into the Kiel Canal.

the course of events leading up to and during the accident in every detail due to insufficient knowledge of German, however. Although the pilot reportedly informed the master that it was necessary to wait for *"some traffic"* prior to the start of the voyage, he was reportedly not advised that the VTS had instructed the CORAL IVORY to first wait for the passage of all the vessels in the four-vessel convoy (i.e. also the SIDERFLY and the MITTELPLATE).

The master, who by his own account had already been in Landeshafen some nine times, stressed that the transfer of navigational responsibility to a competent and qualified pilot who is approved by the relevant authority and knows the area is reportedly quite normal on the Kiel Canal, in particular. Due to the extremely limited options for navigating in the canal, the master reportedly has hardly any opportunity to intervene in the activities of the pilot. The master also stressed in a written statement that he reportedly had no reason to doubt the information and decisions of the pilot.

4.1.5 Consideration of the ship/ship communication by the VTS

Analysis of the radio communication originating from VTS Brunsbüttel revealed that the traffic controller did not send any radio messages prior to the marine casualty other than the direct radio contact with the CORAL IVORY about 20 minutes before she cast off and the transmission of the general situation report at 0245 (both on channel 2). In particular, he did not intervene when the CORAL IVORY's pilot arranged the close-quarters situation with the MITTELPLATE and the SIDERFLY on channel 13 contrary to the instructions of the VTS.

The traffic controller explained this 'omission' by stating that he would only listen in on VHF channel 2 (Kiel Canal II). By his own admission, the traffic controller only listens in (indirectly) on channel 13 (Kiel Canal I), which the lockmaster (inter alia) uses in relation to the locks, but – as shown in the present case – is also used in the context of ship/ship communication, if this is set to a particularly loud volume at the lockmaster's workstation, which is several metres away. This was reportedly not the case prior to the accident.

4.2 Development of the collision

The analysis of the AIS and radar recordings, or the tracks of the CORAL IVORY and the SIDERFLY gained from that, shows that in the end the collision between the two vessels was objectively hardly avoidable with the selected turning circle, which was relatively tight and limited to the northern part of the outer port, and the resulting entry onto the Kiel Canal at an obtuse angle. The SIDERFLY navigated as far as possible to the northern limits of the canal and was not in a position to reduce her speed significantly without relinquishing manoeuvrability, especially in the prevailing weather conditions.

The manoeuvring behaviour of the CORAL IVORY may have facilitated the accident. At any event, the ROT recordings of the S-VDR confirm the deteriorating ability to steer the ship in the course of the turning manoeuvre described by witnesses, which on the merits of the case was not caused by technical deficiencies, however. Having said that, this does not alter the fact that the CORAL IVORY's early turn into the Kiel Canal (in spite of being aware of the simultaneously expected close-quarters situation with the SIDERFLY and especially in the manner selected) was the primary cause of the accident. A more extensive analysis by the BSU as to whether, for example, hydrographic characteristics or (concealed/latent) basic deficiencies in the manoeuvring behaviour of the CORAL IVORY contributed to or caused the accident is therefore unnecessary.

4.3 Legal categorisation of the course of events leading up to and during the accident

In the course of the legal assessment[36] of the development of the collision, it is important to distinguish between rules that are universally applicable when transiting the Kiel Canal and any special requirements that may derogate from them.

4.3.1 Relevant rules for encounters on the Kiel Canal – basic principle

The Notice concerning the German Traffic Regulations for Navigable Maritime Waterways (Seeschifffahrtsstraßen-Ordnung – SeeSchStrO) of the Directorate-General for Waterways and Shipping, Outstation North, issued by virtue of section 60 of the foregoing Regulations, lays down mandatory rules applicable to all traffic transiting the Kiel Canal, to the extent that they do not already arise directly from the foregoing Regulations. The classification of all vessels transiting the Kiel Canal into one of six traffic groups has a critical role in this regard. Classification is made in accordance with the specific risks posed by the particular vessel and/or her dimensions (see point 5 of the aforementioned Notice).
Due to her length of 99.80 m, the SIDERFLY belongs to Traffic Group 3 according to point 5.5.1. By contrast, the CORAL IVORY, at 115.89 m in length, is classified to Traffic Group 4 in accordance with point 5.6.1 of the Notice.

As regards the two vessels, the basic admissibility of an encounter outside a siding area is derived from section 24(4) SeeSchStrO in conjunction with the requirements of point 11 of the aforementioned Notice. Accordingly, an encounter in the section of relevance between canal kilometre (ckm) 5.2 and ckm 8.9 is, inter alia, admissible if the sum total of the traffic group numbers amounts to seven.
Consequently, the CORAL IVORY and the SIDERFLY were permitted to sail past each other based on the sum total of their traffic group numbers (7). However, this ascertainment applies only on the assumption that no other legal obstacle opposes the encounter.

[36] Note: In accordance with the essence and purpose of the BSU's maritime safety investigations, 'legal' here is not meant in the sense of civil or criminal law. Instead, in accordance with its legal mandate, the BSU assesses the course of events leading up to and during the accident, taking only the universally applicable traffic regulations on the Kiel Canal and any related specific broader obligations notified into consideration. Here, the BSU aims merely to gain insight into the causes of the accident so as to draw any necessary conclusions, which are detached from the people actually involved, for improving maritime safety in the future.

4.3.2 Responsibilities and powers of the VTS – basic principle

In accordance with the specific requirements for maritime traffic control[37] on the Kiel Canal, VTS Brunsbüttel is responsible for traffic flow control on the canal (see point 4 of section 55a SeeSchStrO). The purpose and objectives of traffic flow control according to the definition in point 26 of § 2 section 1 SeeSchStrO is to manage the traffic for the purpose of averting dangers or controlling the traffic flow.

Section 56(1) SeeSchStrO provides the powers of shipping police authorities, which as part of the Federal Waterways and Shipping Administration include VTS Brunsbüttel, to issue orders containing a requirement or prohibition to specified persons or to a specified group of persons ('Shipping police orders') when discharging their duties[38] under section 3 of the Maritime Navigation (Federal Competences) Act[39]. Section 56(2) SeeSchStrO states that shipping police orders shall have precedence both over the (universally applicable) provisions of the Regulations and over the requirements embodied in signs and signals.
Finally, regulations tailored to the requirements of the Kiel Canal and powers of the VTS/traffic flow control are also laid down in the 'Supplementary provisions relating to the Kiel Canal' at part 7 SeeSchStrO.
To that extent, the requirements of section 43 SeeSchStrO, extracts of which are quoted below, are of particular importance to the legal assessment of the causes of the collision between the CORAL IVORY and SIDERFLY.

§ 43 Reporting in for, and out from, passage through the Kiel Canal
(1) […]
(2) When a vessel stops for mooring anywhere on the Kiel Canal without having received an order to do so (stop call), she shall report out from passage to the competent VTS centre. Canal passage may not be commenced or resumed, as the case may be, until consent to do so has been received from the appropriate VTS centre. Upon receiving such consent, the vessel shall commence, respectively resume, passage without delay. The person in command shall, in complying with the requirements for conduct in traffic, take immediate account of traffic information provided by VTS centres in accordance with the circumstances of the traffic situation prevailing and shall comply with any measures of traffic flow control that may have been imposed.[40]
(3) […]

[37] See legal definition of maritime traffic control in point 22 of § 2 Para 1 SeeSchStrO: *"The term 'maritime traffic control' comprises the whole complex of traffic information and traffic assistance provided, and any restraints for the control and regulation of traffic issued or imposed, by a VTS centre for preventing collisions and groundings, for controlling the traffic flow, or for preventing hazards to the marine environment as may arise from shipping."*
[38] See the legal definition of the term shipping police in point 2 of § 1 of the Maritime Navigation (Federal Competences) Act: *"Prevention of threats to the safety and efficiency of traffic, as well as prevention of hazards and harmful effects on the environment on navigable waterways (shipping police) originating from maritime shipping [...]."*
[39] See § 3 Para 1 phrase 1 of the Maritime Navigation (Federal Competences) Act: *"Under point 2 of section 1, the authorities of the Federal Waterways and Shipping Administration may, after proper exercise of discretion, take any necessary action to prevent hazards and harmful effects on the environment, including eliminating disruptions to the safety and efficiency of the traffic on navigable waterways [...]."*
[40] Note: Emphasis added by the author of the report.

4.3.3 Assessment of the CORAL IVORY's casting off manoeuvre based on traffic legislation

In the light of the regulations shown in section 4.3.2, the CORAL IVORY's casting off manoeuvre gives rise to the following conclusions:

(1) under the legally enshrined duties and powers of the shipping police and based on the statutory definition of the competences of traffic flow control, the traffic controller did not abuse his discretionary powers when he essentially (and unequivocally) instructed the CORAL IVORY's pilot to wait for the passage of the vessels BARMBEK, FINNSUN, SIDERFLY, and MITTELPLATE before beginning the canal passage in consultation with the SUSANNE;
(2) in a formal sense, the corresponding instruction repeated by the traffic controller to all shipping in the western part of the Kiel Canal (i.e. also to the CORAL IVORY) in the general traffic situation report made shortly after direct radio contact with the CORAL IVORY was a 'shipping police order'. That the instruction was essentially an order/a prohibition that must be observed could be clearly inferred from the respective radio messages of the traffic controller;
(3) the pilot and/or ship's command of the CORAL IVORY cannot rely on the basic admissibility of encounters between Traffic Group 3 and 4 vessels without permission in the relevant section of the canal because according to section 56(2), shipping police orders take precedence over the (universal) provisions of the SeeSchStrO, and
(4) with regard to the special powers of traffic flow control on the Kiel Canal, section 43(2) SeeSchStrO quoted above gives additional clarification that the person in command shall comply with any measures of traffic flow control that may have been imposed (in this instance, the stipulation that the CORAL IVORY must wait for all oncoming traffic).

Moreover, regardless of the corresponding order of the VTS, the CORAL IVORY's obligation to wait for the passage of all four vessels in the convoy arises in this specific case from the 'Basic rules for conduct in traffic' laid down in section 3 SeeSchStrO alone, in particular from paragraph 1 of the aforementioned rule, extracts of which follow.

"The conduct of every person taking part in shipping traffic shall be such as to ensure the safety and easy flow of shipping traffic and to avoid any other person to be exposed to any damage or detriment, to be put at risk, or to be impeded or molested any more than is inevitable in the circumstances prevailing. Every person taking part in shipping traffic shall, in particular, take any precaution as may be required by the practice of good seamanship or by the special circumstances of the case. Any person in command of a vessel that is fitted with a VHF radiotelephone installation, while complying with applicable rules and regulations governing the conduct of vessels taking part in shipping traffic, shall maintain a listening watch for traffic information and assistance provided by a VTS centre – such information and assistance being, routinely, given in German and, upon request, in English – and shall take immediate account thereof in accordance with the circumstances of the traffic situation prevailing."

Applied to the actual traffic situation, a de facto necessity and legal obligation arises from that for the pilot and the ship's command of the CORAL IVORY to wait and not filter into the Kiel Canal until all four vessels in the convoy had passed the area of the mouth of the outer port in the Kiel Canal. That would have been the only way to

ensure that none of these vessels are: "to be exposed to any damage or detriment, to be put at risk, or to be impeded or molested any more than is inevitable in the circumstances prevailing."

4.4 Determinants

4.4.1 Weather conditions

There was neither fog nor was (night-time) visibility affected due to rainfall at the time of the accident.
The DWD report and even more so the wind values measured as part of the Kiel Canal's weather data recordings indicate that an almost consistent south-westerly wind prevailed at the time of the accident. Strong gusts due to the storm front that started to break as the day progressed ensured the wind speed fluctuated between wind force 4 and wind force 6 at the time of the accident. It cannot be ruled out that the CORAL IVORY's turn into the Kiel Canal was slowed down by the wind patterns discussed and/or the irregular effects of the resulting forces on her inhomogeneous port side wall. Both the related witness testimony and the ROT values stored by the S-VDR support this assumption. They indicate a drop in the ship's ROT, which – apart from effects of the wind – could not be attributed to other factors.

Categorisation of the difficult wind conditions, which also prevailed before the start of the casting off manoeuvre, i.e. were already known, as a factor that facilitated the accident does not alter the fact that the main cause of the collision between the CORAL IVORY and SIDERFLY was a failure to comply with the ordered obligation to give way and the self-imposed restriction to the northern part of the outer port when dimensioning the turning circle.

4.4.2 Seaworthiness of the MV SIDERFLY

Based on the requested expert opinion, it is beyond doubt that the SIDERFLY was in a seaworthy condition before the accident. The rapid development of a heavy list and resulting acute risk of foundering were caused only by the forces acting on the hull of the SIDERFLY due to the impact of the collision.

4.5 Emergency management after the accident

After the accident, the action necessary to get the crew and the pilot of the SIDERFLY, which was at an acute risk of foundering, safely ashore was initiated immediately by the pilot and ship's command of each of the vessels involved in the collision, the VTS, and the other vessels operating in the area of the collision. The rapid operational readiness and assistance of the SUSANNE's work boat merits special mention here. Coordination of the necessary and complex safeguarding action for the benefit of the SIDERFLY by the CCME and other agencies involved, as well as its successful technical implementation by the fire service, the deployed tugs, the appointed salvage company, and other shore-based operational units is also worthy of recognition.

5 Conclusions

5.1 Primary cause of the accident

The starting point of the causal chain, which culminated in the collision between the CORAL IVORY and SIDERFLY, was a failure to comply with the instruction to the CORAL IVORY to start filtering into the Kiel Canal only after the passage of the SIDERFLY (and MITTELPLATE) issued by VTS Brunsbüttel in the course of the traffic flow control entrusted to it, which legally was undeniably a shipping police order and must therefore be observed.

The CORAL IVORY pilot's reason for starting to turn into the Kiel Canal early can only be speculated on. However, it is clear that the CORAL IVORY's pilot and (secondarily) the pilots of the SUSANNE, the SIDERFLY, and the MITTELPLATE did not register the binding effect of the CORAL IVORY's obligation to give way, which was ordered by the VTS and announced in the general situation report. Otherwise,

(1) the CORAL IVORY's pilot would not have started to cast off early;
(2) the SUSANNE's pilot would not have urged the CORAL IVORY's pilot to be quick, and
(3) the pilots of the SIDERFLY and the MITTELPLATE would not have expressed their willingness to support a close-quarters situation with the CORAL IVORY without the slightest reservation.

Inasmuch, the traffic controller is not open to reproach. Even without explicitly emphasising that his statements represented a shipping police order, the binding nature of the ordered obligation to give way could be clearly inferred from the respective radio messages. Added to this is the fact that the additional duty of 'traffic flow control' means that under applicable law VTS Brunsbüttel's maritime traffic control on the Kiel Canal explicitly exceeds the standard scope of duties of Germany's other vessel traffic services (traffic information, traffic assistance, and traffic instructions), which focus on prevention, owing to the characteristics and necessities there.[41] This makes it all the more important that pilots and ship's commands operating on the Kiel Canal be aware that statements made by the VTS in relation to the actual flow of traffic there are not merely recommendations or advice, but binding instructions.

5.2 Communication and navigational responsibilities on the bridge of the CORAL IVORY

The navigational activities on the bridge of the CORAL IVORY were marked by the fact that prior to the start of the casting off manoeuvre the pilot and the master of the ship agreed that the pilot would assume responsibility for navigation. Accordingly, the pilot did not consult the master further when deciding on the course and speed of the ship.

[41] See section 55a SeeSchStrO.

Section 23(2) of Germany's Law on sea pilots (Seelotsgesetz) covers explicitly the admissibility of such action, which is common practice on the Kiel Canal, in particular. However, it also follows from the same rule that in keeping with the principles of international law and in spite of the existing obligation of pilotage, the master remains responsible for the ship in such a case in every respect under maritime law.

Section 23(2) Seelotsgesetz
[…]
(2) The master remains responsible for navigating the ship even if he permits the sea pilot to independently issue orders relating to navigation of the ship.
[…]

Chapter VIII, section A, part 4-1, point 49 STCW Code
Despite the duties and obligations of pilots, their presence on board does not relieve the master or the officer in charge of the navigational watch from their duties and obligations for the safety of the ship. The master and the pilot shall exchange information regarding navigation procedures, local conditions and the ship's characteristics. The master and/or the officer in charge of the navigational watch shall co-operate closely with the pilot and maintain an accurate check on the ship's position and movement.

Although easy to grasp on a human and practical level, the CORAL IVORY master's reasoning – that he reportedly relied on the officially documented competence and qualifications of the pilot who knows the area (and may) – is opposed by both the legal requirements discussed above and the actual circumstances surrounding the emergence of the hazardous situation.
Firstly, as he himself acknowledged, previous calls at Landeshafen Ostermoor had familiarised the master with the navigational difficulties that had to be overcome when filtering into the Kiel Canal. Secondly, the AIS data of the four vessels approaching the port exit from the east, which were available to him, indicated that at least an unfavourable culmination of turning-in manoeuvre and close-quarters situation(s) was highly likely.

Witness testimony and the corresponding S-VDR audio recordings of the bridge communication underpin the assumption that the CORAL IVORY's pilot did not fully inform the Dutch master of the ship about the CORAL IVORY's obligation to give way ordered by the VTS in German. It is not possible for the BSU to judge retrospectively whether the master would have actually intervened against the (early) start of the casting off manoeuvre in this case. However, it is clear that it is reasonable to assess this lack of information as a risk-increasing factor at the very least.

In this context, the BSU refers to IMO Resolution A.960(23) concerning the recommendations on training and certification and on operational procedures for maritime pilots, which the 23rd Assembly of the IMO adopted at its session of 24 November to 5 December 2003. In addition to various other important aspects of the work of a pilot, the Resolution also covers various aspects of co-operation between a pilot and the ship's command, which are stated in Annex 2 (Recommendation on operational procedures for maritime pilots) to the Resolution, at points 2, 5, and – with regard to the importance of verbal communication – 6, in particular.

Excerpt of IMO Resolution A.960(23), Annex 2:

2 DUTIES OF MASTER, BRIDGE OFFICERS AND PILOT

2.1 Despite the duties and obligations of a pilot, the pilot's presence on board does not relieve the master or officer in charge of the navigational watch from their duties and obligations for the safety of the ship. It is important that, upon the pilot boarding the ship and before the pilotage commences, the pilot, the master and the bridge personnel are aware of their respective roles in the safe passage of the ship.

2.2 The master, bridge officers and pilot share a responsibility for good communications and understanding of each other's role for the safe conduct of the vessel in pilotage waters.

2.3 Masters and bridge officers have a duty to support the pilot and to ensure that his/her actions are monitored at all times.

5 MASTER – PILOT INFORMATION EXCHANGE

5.1 The master and the pilot should exchange information regarding navigational procedures, local conditions and rules and the ship's characteristics. This information exchange should be a continuous process that generally continues for the duration of the pilotage.

5.2 Each pilotage assignment should begin with an information exchange between the pilot and the master. The amount and subject matter of the information to be exchanged should be determined by the specific navigation demands of the pilotage operation. Additional information can be exchanged as the operation proceeds.

[…]

6 COMMUNICATIONS LANGUAGE

6.1 Pilots should be familiar with the IMO Standard Marine Communication Phrases and use them in appropriate situations during radiocommunications as well as during verbal exchanges on the bridge. This will enable the master and officer in charge of the navigational watch to better understand the communications and their intent.

6.2 Communications on board between the pilot and bridge watchkeeping personnel should be conducted in the English language or in a language other than English that is common to all those involved in the operation.

6.3 When a pilot is communicating to parties external to the ship, such as vessel traffic services, tugs or linesmen and the pilot is unable to communicate in the English language or a language that can be understood on the bridge, the pilot should, as soon as practicable, explain what was said to enable the bridge personnel to monitor any subsequent actions taken by those external parties.

Although the preceding Recommendation 6.3 does not explicitly address cases where a vessel traffic service sends messages to the pilot in a language not spoken by the master, it is beyond doubt that its purpose and objectives also cover such scenarios. The ship's command can only satisfy its duty and ultimate responsibility for the safety of the ship, her crew, and the environment if it is fully informed about any information and orders addressed to and/or concerning the ship at all times.

5.3 Opportunities for the VTS to intervene

A marine casualty occurring in an area monitored by a VTS always gives rise to the question as to whether the VTS had the opportunity to prevent the marine casualty by giving verbal recommendations to the ship's crew(s) and pilots on VHF. Here, it should generally be noted that ship's commands and pilots 'on the ground' normally have a better overall view of the traffic situation than the traffic controller acting remotely at the VTS. Furthermore, when monitoring the various vessels operating in his area of responsibility, the latter is unable to and/or ought not focus his attention on individual traffic movements for an extended period in most cases. What is more, the party responsible at the VTS can normally rely on the fact that the pilots, highly qualified and subject to ongoing in-service training, exercise their profession in accordance with the universal legal requirements and the specific instructions issued. These considerations apply to the traffic on the Kiel Canal to the fullest extent. They are confirmed by the fact that based on the high number of traffic movements on the Kiel Canal, dangerous rule violations by pilots occur only rarely.

Based on the actual accident scenario, the BSU's marine casualty investigation has revealed that it is highly unlikely that the traffic controller listened in on the radio communication between the CORAL IVORY and both the SIDERFLY and MITTELPLATE on VHF channel 13, which contradicted the ordered obligation to give way, for lack of a corresponding obligation. Consequently, intervention of the traffic controller in response to the radio calls in question was ruled out.

In this connection, the Directorate-General for Waterways and Shipping – outpost North – pointed out vis-à-vis the BSU that the workplaces of the lock-keeper (Brunsbüttel lock, “Kiel Canal I”, and the traffic controller in the VTS Kiel Canal are located in a distance of about 6 m from each other. This means that the nautical supervisor on duty is able to overhear all VHF conversations.[42]

However, with regard to the day of the accident, it has to be noted that the position of the nautical supervisor on duty was not – as in principle provided for – manned with a subordinate, additional nautical supervisor, but instead with the traffic controller of the eastern stretch assuming both positions.[43]

At best, an opportunity for the VTS at the day of the accident to intervene therefore might have arisen from possibly noticing the CORAL IVORY cast off (early) on the radar and AIS. As already broadly explained above, the traffic controller cannot be expected to permanently monitor and analyse every ship movement that he is basically able to observe by technical means, however. This is especially true when he has only just made a clear statement on the flow of traffic and there is no evidence to suggest that – for whatever reason – problems may arise.

[42] Note: The working channel for the area of the Kiel-Holtenau locks („Kiel Canal IV”, VHF-channel 12) is currently only perceivable in the lock control station Kiel-Holtenau. However, it is planned to make available the radio communication in the Kiel-Holtenau lock to the VTS Kiel-Canal in Brunsbüttel at the end of 2016.
[43] Cf. the notes in fn. 7 on page 13 of the report.

Not least also of significance to the traffic controller's opportunities to intervene vis-à-vis the actual scene of the accident from the perspective of the BSU is the fact that the Landeshafen Ostermoor/Kiel Canal 'bottleneck' approach is not integrated with the Kiel Canal's computerised traffic flow control system. Inter alia, this computerised system puts the traffic flow planning of the traffic controller into effect from an IT point of view. Obligations of traffic to give way at the various siding areas due to size or other characteristics, as ordered by the VTS, are visually identifiable on the signalling systems installed there. Vessels that do not comply with their obligation to give way are registered automatically within the traffic flow control system by means of AIS. The traffic controller is alerted and can act accordingly.
By contrast, orders to vessels waiting in Landeshafen to enter the Kiel Canal are issued only on VHF radio. Any violation of such an order is not registered automatically.

The Directorate-General for Waterways and Shipping (GDWS) – outpost North – stated that the traffic on the Kiel Canal has so far been regulated by means of the siding signals of the adjacent sidings “Binnenhafen” (eastbound) and “Kudensee” (westbound) as the need arose (that means for the purpose of a safe entry into the port and a safe departure from the port Ostermoor). Nevertheless, the GDWS acknowledges that the collision involving CORAL IVORY and SIDERFLY gives rise to the examination of further measures with regard to safe shipping at the interface Binnenhafen Ostermoor/Kiel Canal and poses the question whether there is need for optimisation.

5.4 VHF-Communication on the Kiel Canal

With regard to the VHF-communication on the Kiel Canal it has to be noted that, in principle, the BSU does not deem it appropriate that two of the four radio channels relevant there, “Kiel Canal II” and “Kiel Canal III”, operate as duplex-channels.[44] These VHF channels serve the purpose of exchanging information between the VTS on the one hand and the ships in the western and eastern section of the canal on the other side so that it seems justified at first glance or even perhaps expedient to deprive a ship of the possibility to overhear the radio messages transmitted to the VTS by another ship. However, it is problematic that this causes a lack of information between the ships not able to hear each other when using a duplex-channel. This would not be the case when using the simplex-cannel, where all participants can communicate with each other and follow traffic agreements unrestricted and passive.

[44] Cf. the notes in fn 6 on page 13 and fn 9 on page 14, respectively, with regard to the terms simplex and duplex.

6 Joint MAIIF/IMPA initiative

Over the past few years, various members of the Marine Accident Investigators' International Forum (MAIIF)[45] have conducted studies and investigations that focused on co-operation between pilots and masters and/or officers on watch and thus identified deficits. The International Maritime Pilots' Association (IMPA) has also considered the issues in question at length. The two organisations have co-operated and developed a poster containing information, which is scheduled for circulation in printed form in the near future for use on the bridge of ships around the world. This poster will be presented to the IMO in February 2016. It is designed to raise awareness among ship's commands and pilots of just how important their co-operation is to navigational safety and is printed on the following two pages with the kind permission of the MAIIF.

[45] Note: The MAIIF is an association that facilitates information sharing and co-operation among marine casualty investigation agencies from all parts of the world. The BSU has been a member of this organisation since its inception.

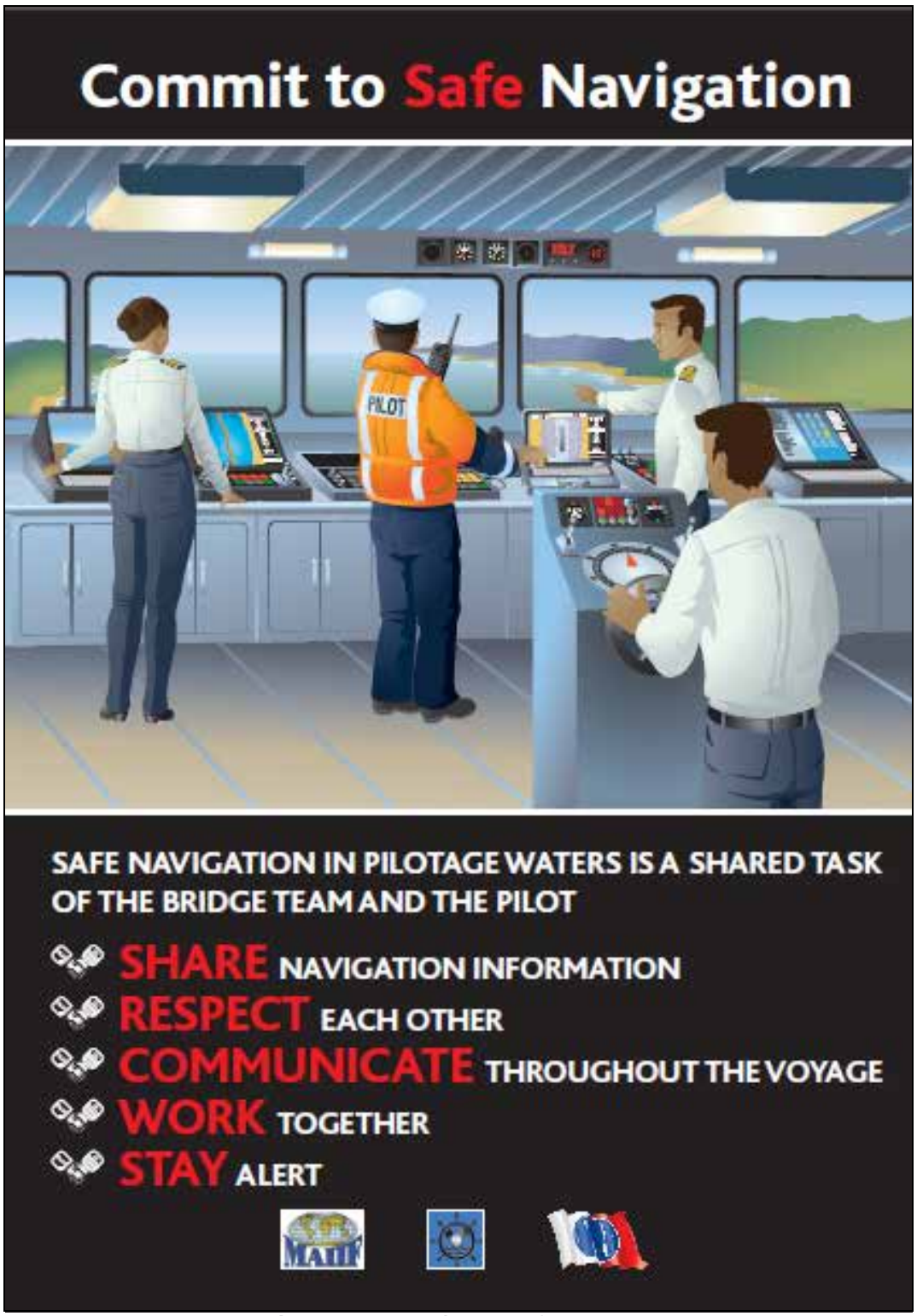

Figure 49: MAIIF/IMPA safety poster

MAIIF/IMPA Joint Education Project

Members of the Marine Accident Investigators International Forum (MAIIF) have completed numerous studies and investigations on the operational relationship between marine pilots and ship masters/watchkeeping officers. For its part, the International Maritime Pilots' Association (IMPA) has completed a number of surveys regarding operational practices on the bridge of vessels under pilotage including matters such as the initial master/pilot exchange and the nature and extent of support received from bridge teams throughout pilotage assignments. Safety deficiencies associated with teamwork on the bridge, including communication between marine pilots and masters/officers of the watch, is a shared concern for our two organizations.

It is well established that the pilot and the bridge team should develop a shared mental model of how a voyage will unfold. The initial master-pilot exchange is an important part of the process by which the master and the pilot can develop such a model and resolve uncertainties about how intended maneuvers are to be carried out. It is also important that adequate communication between the pilot and the bridge team continues throughout the voyage. When the pilot and bridge officers share a similar mental model of the voyage, they are able to individually monitor the progress of maneuvers from their different vantage points on the vessel, thereby reducing the possibility of single point failure.

While the IMO and Member States have demonstrated due diligence and have implemented mandatory training for ships' crews and pilots, the number of accidents in which the cause or a finding as to risk is related to the pilot/bridge team relationship continues to be an object of concern. MAIIF and IMPA have found that, in the absence of effective monitoring , the pilot has little support in the navigation of the vessel.

In marine pilotage operations, effective situational awareness involves: 1) perceiving critical factors in the environment, 2) understanding what those factors mean with respect to controlling the vessel, and 3) projecting what will happen in the near future and taking appropriate action. Situational awareness is enhanced by good communication and, since the bridge team and the pilot work together towards a common goal, ongoing sharing of information is necessary for both parties to be fully effective.

The respective obligations of pilots and bridge teams are well established in various international instruments. The *Standards of Training, Certification, and Watchkeeping Code* emphasize the importance of an ongoing exchange of information between the master and the pilot and state that "*despite the duties and obligations of pilots, their presence on board does not relieve the master or officer in charge of the navigational watch from their duties and obligations for the safety of the ship.*" At the same time, IMO's Resolution A960 states that: "*Masters and bridge officers have a duty to support the pilot and to ensure that his/her actions are monitored at all times*" and "*The master, bridge officers and pilot share a responsibility for good communications and understanding of each other's role for the safe conduct of the vessel in pilotage waters.*" (A960, Annex 2, paragraphs 2.3 and 2.2).

Figure 50: MAIIF/IMPA safety poster (reverse)

7 Safety recommendations

The following safety recommendations do not constitute a presumption of blame or liability in respect of type, number or sequence.

7.1 The Kiel Canal I Pilots' Association

7.1.1 The importance of traffic flow control radio messages

The Federal Bureau of Maritime Casualty Investigation recommends that the Kiel Canal I Pilots' Association raise awareness among its pilots during in-service training and/or by written information of the importance of radio messages sent in the course of traffic flow control by VTS Kiel Canal. Insofar as they contain stipulations that involve starting, interrupting or continuing a canal passage, then they are 'shipping police orders', which the ship's commands and pilots of the vessels concerned must comply with.

7.1.2 Communication between pilot and ship's command

The Federal Bureau of Maritime Casualty Investigation recommends that the Kiel Canal I Pilots' Association urge its pilots during in-service training and/or by written information to make available any information of importance to the vessel under pilotage to the party on the bridge responsible for the ship's command. It is especially important to ensure that ship's commands which understand only a little German or none at all are always aware of the content and outcome of radio communications held in German.

7.2 Directorate-General for Waterways and Shipping

7.2.1 Monitoring of radio communications by the VTS

The Federal Bureau of Maritime Casualty Investigation recommends that the Directorate-General for Waterways and Shipping review and where necessary optimise the operational procedures for monitoring traffic at VTS Kiel Canal. In particular, there should be an assessment as to whether with reasonable effort it is possible technically and from an organisational perspective for the nautical supervisor or assistant in charge of traffic flow control, as the case may be, to monitor VHF channels 12 (Kiel Canal IV) and 13 (Kiel Canal I). In terms of traffic flow control, this would make it possible to respond more rapidly if the content of any ship/ship communication is not consistent with their instructions.

7.2.2 Changing the VHF communication from duplex to simplex

The Federal Bureau of Maritime Casualty Investigation recommends that the Directorate-General for Waterways and Shipping (GDWS) examines the possibility of changing over the duplex-VHF channels VTS–ship and ship–VTS, serving the communication, to the simplex-channel.

7.2.3 Signalling system at the exit of the Landeshafen Ostermoor

The Federal Bureau of Maritime Casualty Investigation recommends that the Directorate-General for Waterways and Shipping examines the the possibility of installing a signalling system at the exit of Landeshafen Ostermoor, which is integrated with the traffic flow planning of the Kiel Canal's traffic flow control system with regard to an enhancement of safety of the traffic connection of the Landeshafen Osermoor to the Kiel Canal.

8 Sources

- Written accounts, statements, documents, and logs
- Ship's command of the MT CORAL IVORY
- Ship's command of the MV SIDERFLY
- S-VDR data of the MT CORAL IVORY
- Interviews/investigations on board the MT CORAL IVORY
- 'Survey Report B 133/13 – Collision in Kiel Canal – MV SIDERFLY' of 25 November 2013, Ingenieurbüro Weselmann GmbH, Hamburg
- Reports of the pilots involved
- Nautical charts and ship particulars, BSH
- Photos of the MT CORAL IVORY and MV SIDERFLY, Dietmar Hasenpusch Photo-Productions, Hamburg
- Findings and photos of WSP Brunsbüttel
- AIS recordings
- Audio recordings of VTS Kiel Canal
- Situational summaries and other information, CCME, Cuxhaven
- Official report of 26 November 2013 on the weather conditions in the vicinity of the Kiel Canal/Landeshafen Ostermoor at 0257 CET on 28 October 2013
- Wind values measured as part of the Kiel Canal's weather data recordings
- Statements on the draft of the investigation report