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

Summary
Investigation Report 373/13

Serious Marine Casualty

Collision while mooring between the MV MERWEBORG and the ro-ro MV CAROLINE RUSS at Steubenhöft in Cuxhaven on 12 December 2013

1 December 2014

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 1 of 22 November 2011, BGBl. (Federal Law Gazette) I p. 2279.

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 investigation report.

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1 Summary

At 1530[1] on 12 December 2013, the general cargo ship MERWEBORG, flying the flag of Curacao, collided in fog with the CAROLINE RUSS, which was laid up ahead of her at the ro-ro berth and flies the flag of Antigua & Barbuda, while mooring at Steubenhöft in Cuxhaven with the intention of collecting a technician to have the starboard radar system repaired. The MERWEBORG's starboard bow and rescue boat with davit were damaged. Moreover, the bridge wing buckled and the gantry crane was torn from its guideway. The CAROLINE RUSS had two tears on her bow above the waterline. The accident did not give rise to injuries and no pollutants escaped. The master, the chief officer, as well as the Elbe and port pilots manned the bridge of the MERWEBORG.

[1] All times shown in this report are Central European Time (CET) = Universal Time Coordinated (UTC) + 1

2 FACTUAL INFORMATION

2.1 Photo of the MERWEBORG

Figure 1: Photo of the MERWEBORG

2.2 Ship particulars

Name of ship:	MERWEBORG
Type of ship:	General cargo vessel
Nationality/Flag:	Curacao
Port of registry:	Willemstad
IMO number:	9142552
Call sign:	PJMY
Owner:	Esmeralda Schifffahrts-Verwaltungs-GmbH
Year built:	1997
Shipyard/Yard number:	Scheepswerf Bijlsma Lemmer BV/678
Classification society:	American Bureau of Shipping
Length overall:	134.5 m
Breadth overall:	16.5 m
Gross tonnage:	6,540
Deadweight:	9,200 t
Draught (max.):	7.1 m
Engine rating:	5,280 kW
Main engine:	Stork Wartsila
(Service) Speed:	12 kts
Hull material:	Steel
Hull design:	Double hull

2.3 Voyage particulars

Port of departure:	Saraylar, Turkey
Port of call:	Sundsvall, Sweden
Type of voyage:	Merchant shipping/International
Cargo information:	8,437 t of marble chippings
Draught at time of accident:	7.3 m
Manning:	11
Pilot on board:	Yes

2.4 Photo of the CAROLINE RUSS

Figure 2: Photo of the CAROLINE RUSS

2.5 Ship particulars

Name of ship:	CAROLINE RUSS
Type of ship:	Roll-on roll-off ship
Nationality/Flag:	Antigua & Barbuda
Port of registry:	St. Johns
IMO number:	9197533
Call sign:	V2OC
Owner:	Ernst Russ GmbH & Co. KG
Year built:	1999
Shipyard/Yard number:	J.J. Sietas KG Schiffswerft/1188
Classification society:	Germanischer Lloyd
Length overall:	153.5 m
Breadth overall:	23.6 m
Gross tonnage:	10,448
Deadweight:	12,736 t
Draught (max.):	6.9 m
Engine rating:	15,600 kW
Main engine:	Wartsila 16V46B
(Service) Speed:	21 kts
Hull material:	Steel
Hull design:	Double hull

2.6 Voyage particulars

Port of departure:	Unknown
Port of call:	Cuxhaven
Type of voyage:	Merchant shipping/International

2.7 Marine casualty or incident information

Type of marine casualty/incident:	Serious marine casualty, collision
Date, time:	12/12/2013, 1530
Location:	Steubenhöft, Cuxhaven
Latitude/Longitude:	φ 53°52.1'N λ 008°43.0'E
Ship operation and voyage segment:	Berthing
Place on board:	Forecastle and superstructure
Human factors:	Yes, error of judgement
Consequences (for people, ship, cargo, environment, other):	Call at shipyard

Excerpt from Nautical Chart 44, BSH map of Cuxhaven

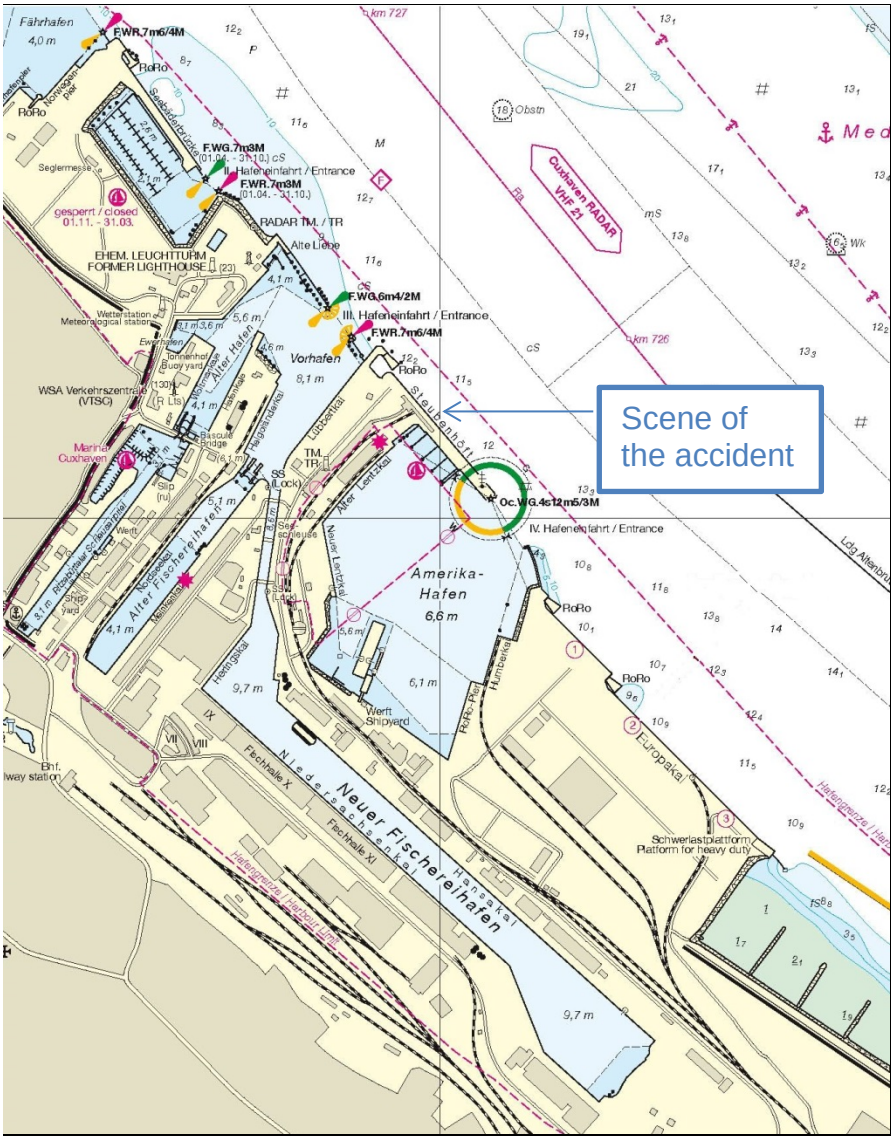


Figure 3: Nautical chart

3 COURSE OF THE ACCIDENT AND INVESTIGATION

3.1 Course of the accident

On 12 December 2013, the MERWEBORG, sailing from Saraylar in Turkey to Sundsvall in Sweden, was off Cuxhaven to collect a technician at the Steubenhöft berth for repairs to a radar system. Fog with visibility of less than 1,000 m and light south-westerly winds of force 3-4 Bft prevailed. The intention was for the MERWEBORG to make fast on her starboard side ahead of the CAROLINE RUSS, which was laid up at the ramp of the ro-ro berth. The master and chief officer manned the bridge. The Elbe pilot was picked up at the Elbe approach buoy at 1248, and participated in shore-based radar guidance. Shortly before reaching buoy 31, the government vessel GRIMMERSHÖRN overtook on the radar reference line at a distance of roughly 150 m on the port side. The port pilot's transfer boat approached about 0.5 nm short of buoy 31a in the middle of Grimmershörn Bay.

At 1514, the port pilot was picked up on the starboard side. On the bridge, the sea pilot advised him on the situation, manoeuvring characteristics of the right-handed controllable pitch propeller, and the controls. The bearing error on the gyrocompass reportedly stood at +2°, i.e. the heading was 149.2° for the specified course of the leading lights of 151.2°. The port radar system was reportedly set to a range of 1.5 nm, centred north-up, relative, with good resolution. The starboard radar system was faulty. The VHF systems were set to channel 21 for the radar guidance service and channel 71 for the local radio channel. Both anchors were ready to drop. After the transfer, the port pilot assumed responsibility for pilotage and steered using the heading control system (formerly autopilot). The Elbe pilot moved away and did his paperwork, while the port pilot advised the master on the berthing manoeuvre behind the CAROLINE RUSS. The plan was to pass the CAROLINE RUSS relatively closely in order to then traverse to the pier on starboard. While making fast, it is important to try to keep the head current (at up to 5 kts) precisely ahead, especially since high inflow velocity would cause the bow thruster to stop working effectively. Reportedly, the forecastle would veer away from the pier at the moment the ship deviates from the direction of the current by only a few degrees. It is then reportedly very difficult to counteract hydrodynamic interactions. The crew was advised on making fast and line guidance.

A gyrocompass heading of 154° and course over ground of 156° at 5-5.5 kts speed over ground was reportedly steered about 4 cbl short of buoy 31a in Grimmershörn Bay. The pitch was reportedly 60% (about half ahead). The radar guidance service at Cuxhaven Radar was informed; course and speed were initially maintained. The MERWEBORG was displaced slightly to the south of the fairway. The eastern jetty of Amerikahafen was reportedly straight ahead on the radar screen. The heading was reportedly altered to 148°, the speed over ground reportedly stood at 5.5 kts, and – setting north-west – there was an almost exact head current. This track would pass Steubenhöft at a distance of 1 cbl. The closest point of approach (PASSING DISTANCE) to the CAROLINE RUSS would have amounted to 130-140 m. At the ferry terminal, the MERWEBORG was just outside the edge of the dredged channel plotted on the nautical chart.

The entrance to the marina at Seebäderbrücke was passed at a distance of about 1.5 cbl and the pitch of the controllable pitch propeller was reportedly set to 20% (dead slow ahead). This was done with the aim of reducing the speed to a minimum to maintain the ability to steer. The CAROLINE RUSS was first sighted at a distance of roughly 2-3 cbl while passing the outer port. The distance to the outer port was reportedly 1 cbl and the speed over ground 4-4.5 kts. The MERWEBORG was logged off from the radar guidance service because it was no longer needed for berthing. Even though the speed was reduced, the MERWEBORG suddenly approached the CAROLINE RUSS. To get the forecastle through the current, this was reportedly immediately responded to with a hard to port rudder and an increase in pitch to 60%. However, even though the hydrodynamic effect of the CAROLINE RUSS should have intensified the turn (bank effect, bow pushes away), she only turned slowly to port. When the forecastle overlapped with the ramp, the transverse distance to the CAROLINE RUSS was about 50 m. The bow thruster was reportedly set at full power to port. However, there was still no effect. The heading was reportedly 143° and the speed over ground 4.7-4.8 kts, without the MERWEBORG separating from the CAROLINE RUSS. The pitch was reportedly set to half astern to reduce the force of the expected impact.

Shortly afterwards, the forecastle (starboard shoulder) touched the port superstructure of the CAROLINE RUSS at an acute angle. The CAROLINE RUSS pushed against and away from the pier in the process. A slight vibration was felt on the bridge and the collision caused the MERWEBORG's bow to turn to port. After that, the starboard wing of the MERWEBORG collided with the protruding forecastle of the CAROLINE RUSS and her bow struck the pier. She was initially held onto the pier through the deployment of the fore spring at 1540 and bouncing, until she was made fast at 1554 with three lines fore and two lines aft.

Figure 4: Bow damage on the CAROLINE RUSS

Figure 5: Bow damage on the MERWEBORG

Figure 6: Gantry crane, rescue boat Figure 7: Starboard bridge wing

During the collision, two deck officers manned the bridge of the CAROLINE RUSS. At 1530, the officers were alerted by a loud noise and vibration. It could be seen from the port wing how the ship's side of a vessel scraped along at an angle of 30-40° below the forecastle. The vessel was very slow and inclined due to the ebb current. Black smoke came out of the funnel and at 1531 the MERWEBORG's starboard wing collided with the CAROLINE RUSS below the forward superstructure and pushed her forward 3-4 metres. A fore spring and a stern line parted in the process. The MERWEBORG then turned to starboard and her bow struck the pier. She separated from the CAROLINE RUSS and then made fast further forward on the pier.

Figure 8: Damage to the pier

There were no injuries and no pollutants escaped during the accident. The MERWEBORG's starboard wing was torn and bent backwards. The deck beneath that was dented. The frame of the starboard side window was deformed. The starboard davit of the rescue boat was broken and the boat deck with boat damaged. The gantry crane was lifted out of its guideway and damaged. The forecastle with guard rail and cable tier was dented. The CAROLINE RUSS's forecastle sustained two tears of 4-5 m in length about 7 m above the waterline and her gangway was damaged.

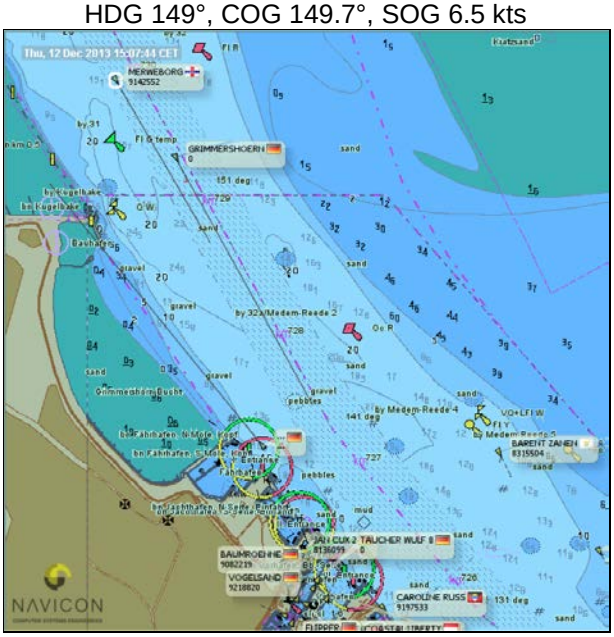
4 ANALYSIS

The BSU refers to data from the waterway police (WSP) in the form of analysed AIS recordings of the NAVICON system, analyses of the MERWEBORG's simplified voyage data recorder (S-VDR), an expert opinion by the Federal Waterways Engineering and Research Institute in Hamburg (BAW), sounding charts from the port authority in Cuxhaven, and several berthing manoeuvres conducted by the Brotherhood of Elbe Pilots on the MTC's ship-handling simulator in Hamburg in the following analysis. The BAW provided the tidal streams expected at Steubenhöft for the time of the accident and incorporated the course of the accident into an animation. Here, the MERWEBORG's voyage data, which are taken from the S-VDR data and pre-structured in a table, are referred to. These data had to be smoothed and reconciled with the audio recordings (collision noises), as well as the positioning inaccuracies of the global navigation satellite system (GNSS), to bring the inconsistent data pool in line with reality. In particular, the data shown in the table for a period of nine minutes indicate the speed over ground and the generated rates of turn (ROT) in conjunction with the animation, examples of which are shown by four images in the expert opinion.

AIS (automatic identification system) analysis from the Joint Control Centre of the Waterway Police of the Coastal States in Cuxhaven. A time lag exists compared to the VDR analysis at the BSU and the BAW in Hamburg. The times displayed must be corrected by +65 seconds to make them consistent with the VDR data. The VDR times are correct. The BSU notified the control centre in Cuxhaven of the issue on 10 September 2014.

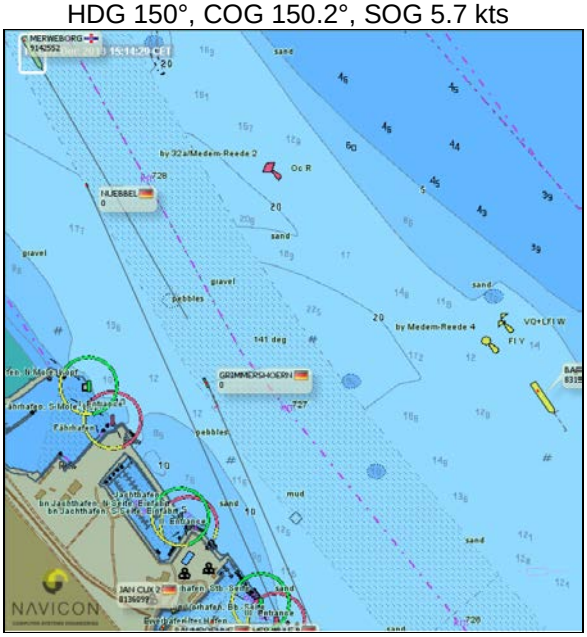
Heading (HDG), course over ground (COG), and speed over ground (SOG)

HDG 149°, COG 149.7°, SOG 6.5 kts



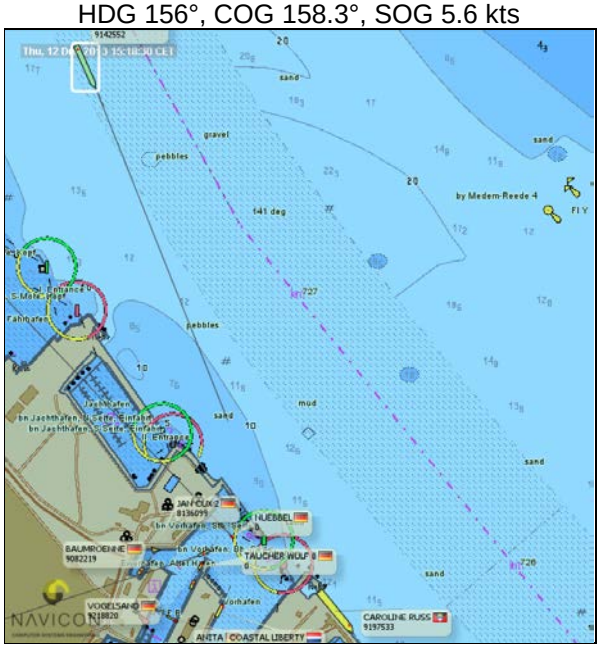
AIS 150740

HDG 150°, COG 150.2°, SOG 5.7 kts



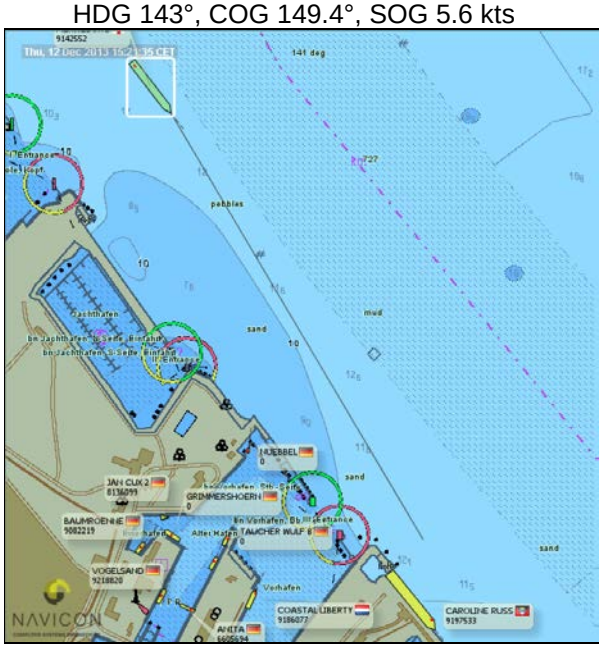
AIS 151429

HDG 156°, COG 158.3°, SOG 5.6 kts



AIS 151830

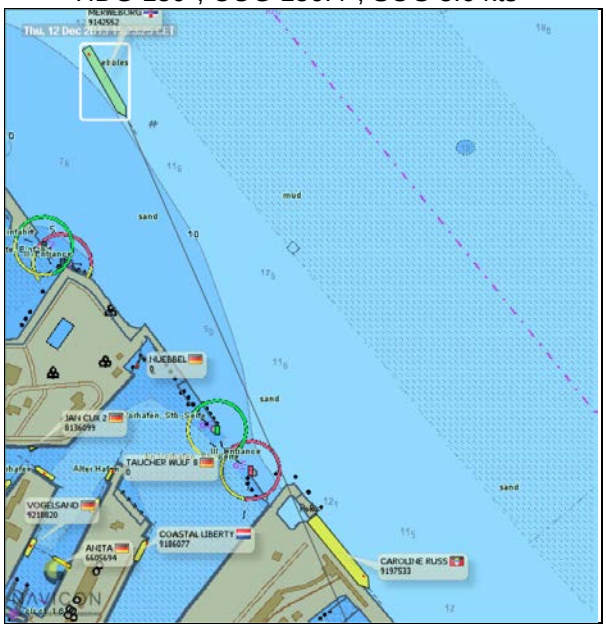
HDG 143°, COG 149.4°, SOG 5.6 kts



AIS 152131

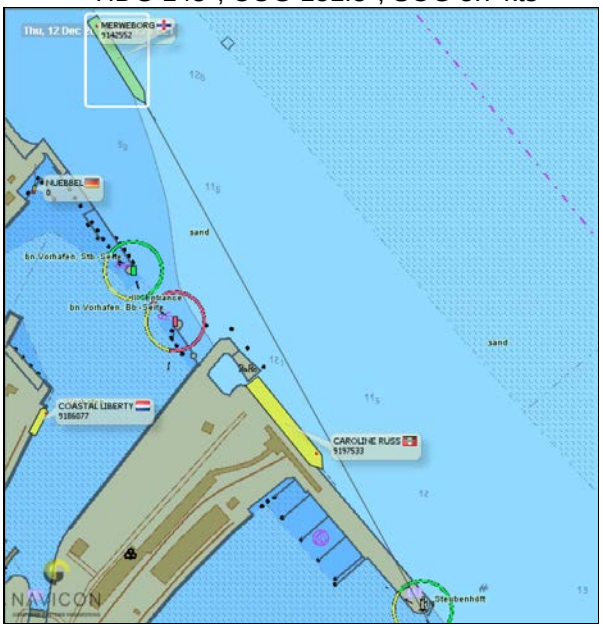
The MERWEBORG heads at an acute angle from the edge of the dredged channel directly for her berth at Steubenhöft. The COG is directed at the end of the pier.

HDG 150°, COG 156.4°, SOG 5.6 kts



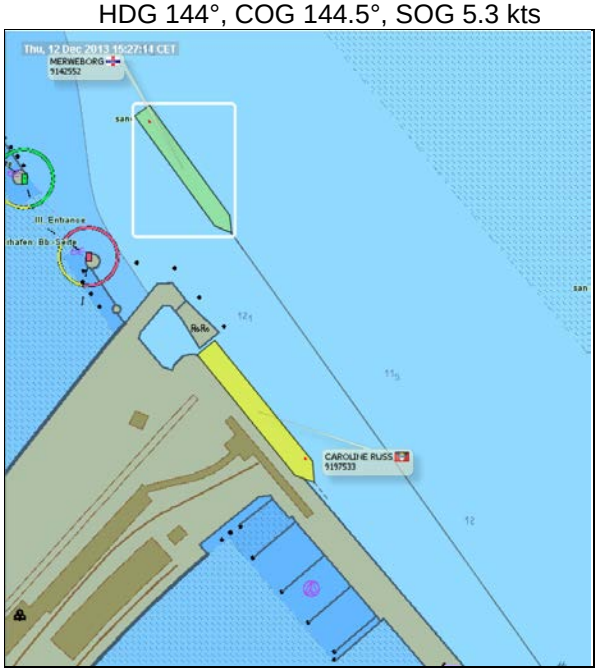
AIS 152320

HDG 148°, COG 151.3°, SOG 5.7 kts



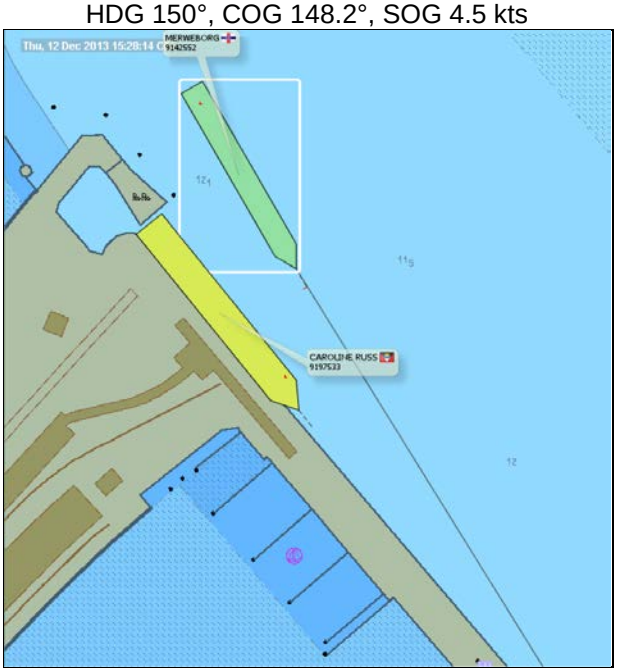
AIS 152520

HDG 144°, COG 144.5°, SOG 5.3 kts



AIS 152711

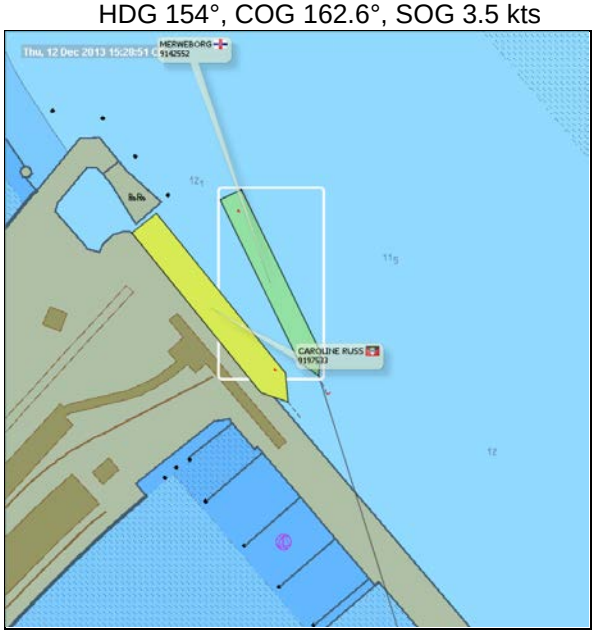
HDG 150°, COG 148.2°, SOG 4.5 kts



AIS 152811

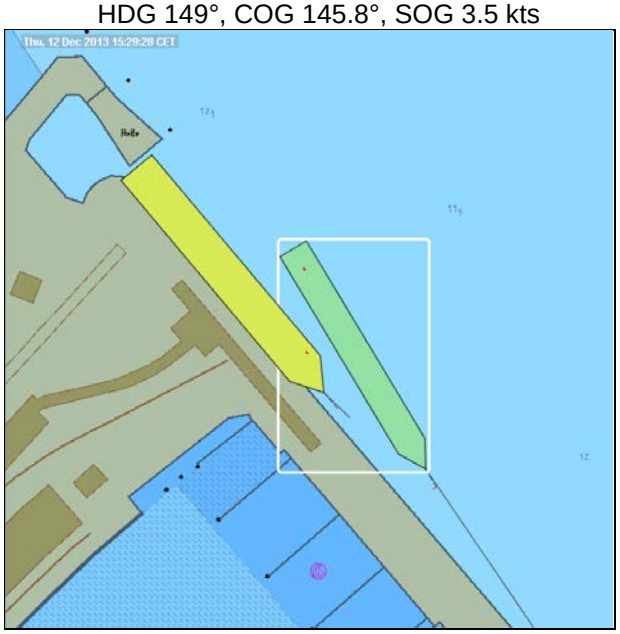
It is evident that the heading was briefly changed to about 5° to port between 1522 and 1526, while at 5.6 kts the SOG remained almost stable. The speed was not reduced until after that. At 1528, when the MERWEBORG reached the CAROLINE RUSS up to amidships, the transverse distance from the forecastle only stood at 40 m at a speed of 4.5 kts.

HDG 154°, COG 162.6°, SOG 3.5 kts



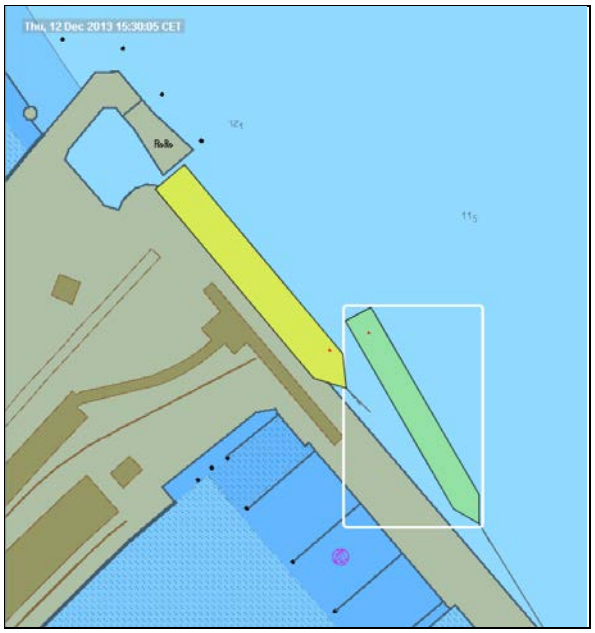
AIS 152850

HDG 149°, COG 145.8°, SOG 3.5 kts



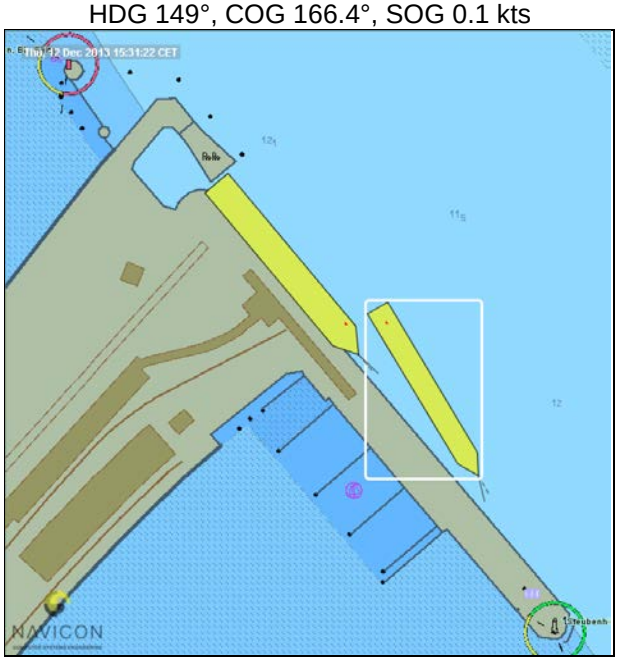
AIS 152927

HDG 150°, COG 148.4°, SOG 0.9 kts



AIS 153003

HDG 149°, COG 166.4°, SOG 0.1 kts



AIS 153120

The speed during the berthing manoeuvre was too high and the passing distance too low. That it would culminate in a collision was inevitable. Hydrodynamic interactions were to be expected in the area of the CAROLINE RUSS. With its reverse berths for recreational craft, Steubenhöft is on stilts at the pier, i.e. not separated by a wall from the Elbe current.

Figure 9: Steubenhöft berth

Voyage data recorder

The MERWEBORG was equipped with a simplified voyage data recorder (S-VDR). Therefore, less sensor data were recorded as compared to a full-spec. voyage data recorder (VDR). Inter alia, the rudder angles and ROTs/min were absent. Moreover, no radar images were recorded because the starboard system was faulty. Consequently, it was only possible to analyse the audio data and the HDG, COG, and SOG from the S-VDR. The data were smoothed to make it possible to map the collision according to the recorded data, i.e. the antenna position of the CAROLINE RUSS was corrected to A = 22 m, B = 132 m, C = 11 m (previously 4 m), and D = 10 m (previously 17 m), and that of the MERWEBORG to A = 123 m, B = 12 m, C = 1 m (previously 8 m), and D = 15 m (previously 8 m). The CAROLINE RUSS was thus located at the fenders on the quay wall and the MERWEBORG was set according to the collision noises. The courses and speeds were smoothed using a digital low-pass filter and a cut-off frequency of 0.01 Hz. The position data were used to calculate SOG and COG. They are consistent with the recorded VDR data. The ROT was computed based on the second difference of the smoothed HDG multiplied by 60. These measures made it possible to map the two collisions at 152953 and 153044 realistically.

Audio data

The Elbe pilot and port pilot met on the bridge at 1515 and did the handover. Everything was reportedly as it should be with the exception of the faulty starboard radar system and +2° bearing error on the gyrocompass. The pilotage assignment was continued using the heading control system (formerly autopilot). At 151842, the port pilot stated that he reportedly had to pilot two vessels after the MERWEBORG. Moreover, at 151910 he informed the master that the current here could run at up to 5 kts. Although the Elbe pilot moved away to do his paperwork, he made his colleague, the port pilot responsible, aware of critical situations. At 152200, he felt that the PASSING DISTANCE to the CAROLINE RUSS was very tight. The port pilot responded by explaining that he had experienced problems mooring during a rising tide while piloting the GRAN CANARIA when the distance from the pier was too great. Therefore, he prefers to proceed closer and can apply port rudder if necessary. At 152453, the port pilot remarked to his colleague that there was reportedly only half an hour between his next two pilotage assignments and that organisation was a regular cause for complaint among his colleagues. At 152610, the Elbe pilot noticed a drift of 3°. At 152656, the port pilot asked the master about the efficiency of the controllable pitch propeller. It is a right-handed propeller and its efficiency is directed to starboard at the stern. At 152921, the Elbe pilot intervened energetically with the command ahead and port rudder; the stem post is reportedly moving towards the CAROLINE RUSS. Collision noises (first collision with the starboard bow, scraping) and a persistent alarm can be heard from 152953 onwards. After that, the engine was set to full ahead, the rudder to hard to starboard, and the bow thruster to full to port on the recommendation of the Elbe pilot. They then stopped. A second collision (with the starboard wing) can be heard at 153044.

The bow then struck the pier and the accident is reported to the VTS centre.

Expert opinion by the BAW

Assessment of the underlying data

Based on a comparative analysis of the timestamp of the VDR data, the AIS data of the Waterways and Shipping Administration (WSV), and the AIS recordings of WSP Cuxhaven, the VDR data were used to map the course of the accident because the latter time recordings from the GPS signals were consistent with the WSV data.

The VDR data, recorded at one-second intervals, were used for uniform mapping of the voyage of the MERWEBORG. To facilitate mapping, the time-dependent position data of the two vessels were firstly aligned in respect of her berth with the submitted electronic navigational chart (ENC; re: CAROLINE RUSS); secondly, they were then synchronised with the audio recordings (MERWEBORG and CAROLINE RUSS collision noises; re: MERWEBORG). The external inaccuracies of the GNSS positions were thus corrected. No time-dependent rudder angles were included in the MERWEBORG's VDR data set. Extensive measurements of the local current patterns at the port of Cuxhaven were not available for the time of the accident. For comprehensive preparation of the VDR, AIS, and bathymetric data, as well as the current patterns at the time of the accident, the results of the computation of the 3D hydrodynamic numerical model of the tidal Elbe (as of 2010, UnTRIM) on hand were used and integrated with the ENC at the BAW. This involved selecting a tide from the BAW computation period of 2010, the tidal characteristics (HWL/LWL) of which roughly corresponded to those of the tide of 12 December 2013, thus making it possible to expect almost matching tidal current patterns. The current data from the computations are available as depth-averaged values, meaning higher values must be applied close to the surface. The 3D computation results were analysed separately (only spatially limited) for the analysis of the current patterns at the entrance to the outer port. Local meteorological effects at the time of the accident are not included in the current data.

UTC	HDG	COG	SOG	ROT
142300	144.3	147.3	5.6	6.1
142301	144.4	147.3	5.6	6.1
142302	144.5	147.4	5.6	6.1
142303	144.6	147.7	5.6	6.1
142304	144.7	147.9	5.6	6.4
142305	144.8	147.9	5.6	6.7
142306	144.9	148.0	5.6	7.0
142307	145.0	148.2	5.6	7.2
142308	145.2	148.4	5.6	7.3
142309	145.3	148.5	5.6	7.3
142310	145.4	148.7	5.6	7.3
142311	145.5	148.9	5.6	7.3
142312	145.6	149.0	5.6	7.2
142313	145.8	149.2	5.6	7.2
142314	145.9	149.3	5.6	7.3
142315	146.0	149.4	5.6	7.3
142316	146.1	149.6	5.6	7.3
142317	146.2	149.8	5.6	7.2
142318	146.4	150.0	5.6	7.1
142319	146.5	150.2	5.6	7.0
142320	146.6	150.3	5.6	7.0
142321	146.7	150.4	5.6	7.0
142322	146.8	150.7	5.6	7.1
142323	146.9	151.1	5.7	7.1
142324	147.1	151.4	5.7	7.0
142325	147.2	151.5	5.7	6.9
142326	147.3	151.5	5.7	6.6
142327	147.4	151.6	5.7	6.5
142328	147.5	151.9	5.7	6.3
142329	147.6	152.1	5.7	6.3
142330	147.7	152.2	5.7	6.4
142331	147.8	152.3	5.7	6.4
142332	147.9	152.4	5.7	6.4
142333	148.0	152.5	5.7	6.2
142334	148.1	152.7	5.7	5.9
142335	148.2	152.9	5.7	5.6

UTC	HDG	COG	SOG	ROT
142336	148.3	153.0	5.7	5.3
142337	148.4	153.2	5.7	5.1
142338	148.5	153.3	5.7	4.9
142339	148.5	153.3	5.7	4.7
142340	148.6	153.4	5.7	4.6
142341	148.7	153.5	5.7	4.5
142342	148.8	153.6	5.7	4.5
142343	148.8	153.9	5.7	4.5
142344	148.9	154.2	5.7	4.6
142345	149.0	154.3	5.7	4.7
142346	149.1	154.4	5.7	4.7
142347	149.2	154.5	5.7	4.5
142348	149.2	154.5	5.7	4.1
142349	149.3	154.7	5.7	3.7
142350	149.3	154.8	5.7	3.3
142351	149.4	154.9	5.7	2.8
142352	149.4	155.2	5.7	2.3
142353	149.5	155.3	5.7	1.9
142354	149.5	155.3	5.7	1.6
142355	149.5	155.4	5.7	1.4
142356	149.5	155.5	5.7	1.4
142357	149.5	155.5	5.7	1.4
142358	149.6	155.5	5.7	1.5
142359	149.6	155.6	5.7	1.4
142400	149.6	155.7	5.7	1.3
142401	149.6	155.7	5.7	1.1
142402	149.7	155.8	5.7	0.9
142403	149.7	155.8	5.7	0.7
142404	149.7	155.9	5.6	0.5
142405	149.7	155.9	5.6	0.3
142406	149.7	155.9	5.6	0.2
142407	149.7	156.1	5.6	0.1
142408	149.7	156.2	5.6	0.1
142409	149.7	156.3	5.6	0.1
142410	149.7	156.3	5.6	0.0
142411	149.7	156.3	5.6	0.0

UTC	HDG	COG	SOG	ROT
142412	149.7	156.3	5.6	-0.1
142413	149.7	156.3	5.6	-0.1
142414	149.7	156.3	5.6	-0.2
142415	149.7	156.2	5.6	-0.3
142416	149.7	156.2	5.6	-0.5
142417	149.6	156.1	5.6	-0.8
142418	149.6	156.0	5.6	-1.1
142419	149.6	156.0	5.6	-1.5
142420	149.6	156.0	5.6	-1.9
142421	149.5	156.0	5.6	-2.4
142422	149.5	156.0	5.6	-2.8
142423	149.4	155.8	5.6	-3.3
142424	149.4	155.6	5.6	-3.9
142425	149.3	155.5	5.6	-4.6
142426	149.2	155.5	5.6	-5.4
142427	149.1	155.4	5.6	-6.1
142428	149.0	155.4	5.6	-6.8
142429	148.9	155.3	5.6	-7.4
142430	148.7	155.1	5.6	-7.8
142431	148.6	154.8	5.6	-8.1
142432	148.5	154.3	5.6	-8.4
142433	148.3	153.9	5.6	-8.6
142434	148.2	153.7	5.6	-8.8
142435	148.0	153.5	5.6	-8.9
142436	147.9	153.3	5.6	-9.0
142437	147.7	153.2	5.6	-9.0
142438	147.6	153.1	5.6	-8.8
142439	147.5	153.2	5.6	-8.6
142440	147.3	153.2	5.6	-8.4
142441	147.2	153.1	5.6	-8.2
142442	147.1	153.1	5.6	-7.8
142443	146.9	153.0	5.6	-7.4
142444	146.8	152.8	5.6	-6.7
142445	146.7	152.5	5.6	-6.1
142446	146.6	152.2	5.6	-5.5
142447	146.6	152.2	5.6	-4.9

UTC	HDG	COG	SOG	ROT
142448	146.5	152.1	5.6	-4.4
142449	146.4	152.0	5.6	-3.8
142450	146.4	151.9	5.6	-3.2
142451	146.3	151.7	5.6	-2.6
142452	146.3	151.5	5.6	-2.0
142453	146.3	151.3	5.6	-1.4
142454	146.2	151.0	5.6	-1.0
142455	146.2	150.8	5.6	-0.7
142456	146.2	150.6	5.6	-0.4
142457	146.2	150.6	5.6	-0.2
142458	146.2	150.6	5.6	-0.1
142459	146.2	150.6	5.6	-0.1
142500	146.2	150.6	5.6	0.0
142501	146.2	150.6	5.6	0.0
142502	146.2	150.5	5.6	0.0
142503	146.2	150.6	5.6	-0.1
142504	146.2	150.6	5.6	-0.1
142505	146.2	150.6	5.6	-0.2
142506	146.2	150.5	5.6	-0.3
142507	146.2	150.5	5.6	-0.5
142508	146.2	150.5	5.6	-0.7
142509	146.1	150.5	5.6	-0.9
142510	146.1	150.5	5.6	-1.2
142511	146.1	150.5	5.6	-1.5
142512	146.1	150.4	5.6	-1.7
142513	146.0	150.3	5.6	-1.8
142514	146.0	150.3	5.6	-1.8
142515	146.0	150.3	5.6	-1.8
142516	146.0	150.2	5.6	-1.9
142517	145.9	150.2	5.6	-2.1
142518	145.9	150.2	5.6	-2.2
142519	145.9	150.1	5.6	-2.2
142520	145.8	150.0	5.6	-2.1
142521	145.8	149.9	5.6	-1.8
142522	145.8	149.8	5.6	-1.5
142523	145.7	149.7	5.6	-1.1

UTC	HDG	COG	SOG	ROT
142524	145.7	149.7	5.6	-0.8
142525	145.7	149.6	5.6	-0.5
142526	145.7	149.5	5.6	-0.2
142527	145.7	149.5	5.6	0.1
142528	145.7	149.6	5.6	0.3
142529	145.7	149.6	5.6	0.6
142530	145.8	149.6	5.6	0.9
142531	145.8	149.8	5.6	1.1
142532	145.8	150.0	5.6	1.4
142533	145.8	150.0	5.6	1.6
142534	145.9	150.0	5.6	1.8
142535	145.9	150.1	5.6	2.0
142536	145.9	150.1	5.6	2.0
142537	146.0	150.0	5.6	2.0
142538	146.0	150.1	5.7	2.0
142539	146.0	150.2	5.7	1.9
142540	146.0	150.2	5.7	1.9
142541	146.1	150.3	5.7	1.9
142542	146.1	150.3	5.7	1.8
142543	146.1	150.3	5.7	1.7
142544	146.2	150.2	5.7	1.6
142545	146.2	150.2	5.7	1.5
142546	146.2	150.2	5.7	1.4
142547	146.2	150.2	5.7	1.5
142548	146.3	150.3	5.7	1.6
142549	146.3	150.4	5.7	1.8
142550	146.3	150.4	5.7	2.0
142551	146.4	150.4	5.7	2.1
142552	146.4	150.5	5.7	2.1
142553	146.4	150.6	5.7	2.0
142554	146.5	150.7	5.7	1.8
142555	146.5	150.8	5.7	1.6
142556	146.5	150.9	5.7	1.5
142557	146.5	151.0	5.7	1.5
142558	146.6	151.1	5.7	1.5
142559	146.6	151.2	5.7	1.6

UTC	HDG	COG	SOG	ROT
142600	146.6	151.3	5.7	1.6
142601	146.6	151.3	5.7	1.6
142602	146.7	151.4	5.7	1.5
142603	146.7	151.5	5.7	1.5
142604	146.7	151.6	5.8	1.5
142605	146.7	151.6	5.8	1.7
142606	146.8	151.8	5.8	1.9
142607	146.8	152.1	5.8	2.3
142608	146.9	152.2	5.8	2.7
142609	146.9	152.2	5.8	3.0
142610	147.0	152.2	5.8	3.3
142611	147.0	152.2	5.8	3.4
142612	147.1	152.1	5.8	3.3
142613	147.1	152.1	5.8	3.1
142614	147.2	152.2	5.8	2.9
142615	147.2	152.2	5.8	2.7
142616	147.2	152.1	5.8	2.6
142617	147.3	152.2	5.8	2.6
142618	147.3	152.3	5.8	2.4
142619	147.4	152.3	5.8	2.2
142620	147.4	152.4	5.8	1.9
142621	147.4	152.3	5.8	1.6
142622	147.5	152.2	5.8	1.2
142623	147.5	152.1	5.8	0.9
142624	147.5	152.1	5.8	0.6
142625	147.5	152.1	5.8	0.4
142626	147.5	152.2	5.8	0.3
142627	147.5	152.3	5.8	0.2
142628	147.5	152.5	5.8	0.1
142629	147.5	152.6	5.8	0.1
142630	147.5	152.8	5.8	0.0
142631	147.5	152.9	5.8	0.0
142632	147.5	153.0	5.8	0.0
142633	147.5	153.1	5.8	0.0
142634	147.5	153.1	5.8	-0.1
142635	147.5	153.0	5.8	-0.2

UTC	HDG	COG	SOG	ROT
142636	147.5	153.0	5.8	-0.3
142637	147.5	153.0	5.8	-0.4
142638	147.5	152.9	5.8	-0.6
142639	147.4	152.8	5.8	-0.9
142640	147.4	152.6	5.8	-1.3
142641	147.4	152.5	5.8	-1.7
142642	147.4	152.4	5.8	-2.1
142643	147.3	152.3	5.8	-2.4
142644	147.3	152.2	5.8	-2.7
142645	147.2	152.1	5.8	-2.9
142646	147.2	152.1	5.8	-3.1
142647	147.1	152.1	5.8	-3.3
142648	147.1	152.0	5.8	-3.5
142649	147.0	152.0	5.8	-3.6
142650	147.0	151.9	5.8	-3.7
142651	146.9	151.8	5.8	-3.6
142652	146.8	151.8	5.8	-3.3
142653	146.8	151.7	5.8	-2.9
142654	146.7	151.8	5.8	-2.6
142655	146.7	151.8	5.8	-2.3
142656	146.7	151.8	5.8	-2.2
142657	146.6	151.7	5.8	-2.1
142658	146.6	151.7	5.8	-2.2
142659	146.6	151.7	5.8	-2.3
142700	146.5	151.6	5.8	-2.4
142701	146.5	151.6	5.8	-2.5
142702	146.4	151.5	5.8	-2.6
142703	146.4	151.4	5.8	-2.8
142704	146.3	151.3	5.8	-2.9
142705	146.3	151.1	5.8	-2.9
142706	146.2	151.0	5.8	-2.8
142707	146.2	150.9	5.8	-2.8
142708	146.2	150.9	5.8	-2.8
142709	146.1	150.9	5.8	-2.8
142710	146.1	150.9	5.8	-2.9
142711	146.0	151.0	5.8	-3.0
142712	146.0	151.0	5.8	-3.0
142713	145.9	151.0	5.8	-3.1
142714	145.9	150.9	5.8	-3.2
142715	145.8	150.8	5.8	-3.2
142716	145.7	150.7	5.8	-3.1
142717	145.7	150.6	5.8	-3.0
142718	145.6	150.4	5.8	-2.9
142719	145.6	150.3	5.8	-2.8
142720	145.6	150.2	5.7	-2.6
142721	145.5	150.2	5.7	-2.5
142722	145.5	150.1	5.7	-2.4
142723	145.4	150.1	5.7	-2.5
142724	145.4	150.1	5.7	-2.6
142725	145.3	149.9	5.7	-2.7
142726	145.3	149.7	5.7	-2.8
142727	145.2	149.6	5.7	-2.9
142728	145.2	149.5	5.7	-3.0
142729	145.1	149.5	5.7	-3.2
142730	145.1	149.3	5.7	-3.5
142731	145.0	149.2	5.7	-3.9
142732	145.0	149.1	5.7	-4.3
142733	144.9	148.9	5.7	-4.5
142734	144.8	148.9	5.7	-4.5
142735	144.7	148.9	5.7	-4.4
142736	144.7	148.8	5.7	-4.3
142737	144.6	148.7	5.7	-4.2
142738	144.5	148.5	5.6	-4.1
142739	144.5	148.3	5.6	-4.2
142740	144.4	148.1	5.6	-4.3
142741	144.3	147.9	5.6	-4.5
142742	144.2	147.8	5.6	-4.8
142743	144.1	147.7	5.6	-4.9
142744	144.1	147.7	5.6	-5.0
142745	144.0	147.5	5.6	-5.0
142746	143.9	147.4	5.6	-4.8
142747	143.8	147.4	5.6	-4.6
142748	143.7	147.4	5.6	-4.3
142749	143.7	147.4	5.6	-4.2
142750	143.6	147.2	5.5	-4.1
142751	143.6	147.2	5.5	-4.1
142752	143.5	147.1	5.5	-4.2
142753	143.4	147.0	5.5	-4.2
142754	143.3	146.9	5.5	-4.3
142755	143.3	146.8	5.5	-4.3
142756	143.2	146.7	5.5	-4.3
142757	143.1	146.6	5.5	-4.3
142758	143.1	146.6	5.5	-4.2
142759	143.0	146.5	5.5	-4.0
142800	142.9	146.3	5.4	-3.7
142801	142.9	146.2	5.4	-3.3
142802	142.8	146.1	5.4	-2.7
142803	142.8	146.1	5.4	-2.1
142804	142.8	146.0	5.4	-1.6
142805	142.8	145.8	5.4	-1.0
142806	142.8	145.7	5.4	-0.5
142807	142.8	145.7	5.4	0.0
142808	142.8	145.5	5.3	0.5
142809	142.8	145.4	5.3	1.0
142810	142.8	145.3	5.3	1.6
142811	142.8	145.3	5.3	2.2
142812	142.9	145.3	5.3	2.9
142813	142.9	145.3	5.3	3.4
142814	143.0	145.2	5.3	3.9
142815	143.1	145.2	5.3	4.3
142816	143.2	145.3	5.2	4.5
142817	143.2	145.3	5.2	4.6
142818	143.3	145.3	5.2	4.6
142819	143.4	145.4	5.2	4.5
142820	143.5	145.5	5.2	4.4
142821	143.5	145.5	5.2	4.3
142822	143.6	145.6	5.2	4.4
142823	143.7	145.7	5.1	4.5

UTC	HDG	COG	SOG	ROT
142824	143.7	145.9	5.1	4.7
142825	143.8	146.1	5.1	5.0
142826	143.9	146.2	5.1	5.4
142827	144.0	146.4	5.1	5.7
142828	144.1	146.6	5.1	5.8
142829	144.2	146.8	5.1	5.9
142830	144.3	147.0	5.1	5.9
142831	144.4	147.1	5.0	5.8
142832	144.5	147.1	5.0	5.7
142833	144.6	147.1	5.0	5.7
142834	144.7	147.2	5.0	5.7
142835	144.8	147.2	5.0	5.8
142836	144.9	147.2	5.0	5.8
142837	145.0	147.4	5.0	5.7
142838	145.1	147.5	4.9	5.6
142839	145.2	147.5	4.9	5.6
142840	145.3	147.4	4.9	5.6
142841	145.4	147.3	4.9	5.6
142842	145.4	147.3	4.9	5.6
142843	145.5	147.5	4.9	5.7
142844	145.6	147.7	4.9	5.9
142845	145.7	147.9	4.8	6.1
142846	145.8	148.1	4.8	6.3
142847	146.0	148.1	4.8	6.5
142848	146.1	148.2	4.8	6.6
142849	146.2	148.4	4.8	6.6
142850	146.3	148.6	4.8	6.6
142851	146.4	148.6	4.8	6.5
142852	146.5	148.8	4.7	6.4
142853	146.6	149.0	4.7	6.4
142854	146.7	149.1	4.7	6.5
142855	146.8	149.3	4.7	6.6
142856	146.9	149.4	4.7	6.7
142857	147.0	149.5	4.7	6.7
142858	147.2	149.9	4.6	6.7
142859	147.3	150.2	4.6	6.6

UTC	HDG	COG	SOG	ROT
142900	147.4	150.3	4.6	6.6
142901	147.5	150.5	4.6	6.5
142902	147.6	150.8	4.6	6.7
142903	147.7	151.1	4.6	7.0
142904	147.8	151.3	4.5	7.5
142905	148.0	151.3	4.5	7.9
142906	148.1	151.3	4.5	8.3
142907	148.3	151.3	4.5	8.6
142908	148.4	151.3	4.5	8.8
142909	148.6	151.6	4.4	8.9
142910	148.7	151.8	4.4	9.1
142911	148.9	152.0	4.4	9.4
142912	149.0	152.3	4.4	9.8
142913	149.2	152.6	4.4	10.2
142914	149.4	152.9	4.3	10.6
142915	149.6	153.2	4.3	10.9
142916	149.7	153.4	4.3	11.1
142917	149.9	153.6	4.3	11.4
142918	150.1	153.9	4.3	11.6
142919	150.3	154.1	4.2	11.8
142920	150.5	154.2	4.2	11.9
142921	150.7	154.4	4.2	12.0
142922	150.9	154.6	4.2	12.2
142923	151.1	154.8	4.2	12.2
142924	151.3	155.3	4.1	12.1
142925	151.5	155.8	4.1	11.9
142926	151.7	156.2	4.1	11.6
142927	151.9	156.4	4.1	11.2
142928	152.1	156.6	4.1	10.8
142929	152.2	157.0	4.0	10.3
142930	152.4	157.2	4.0	9.9
142931	152.5	157.5	4.0	9.5
142932	152.7	157.9	4.0	9.3
142933	152.8	158.7	4.0	9.1
142934	153.0	159.7	3.9	8.8
142935	153.1	160.4	3.9	8.5

UTC	HDG	COG	SOG	ROT
142936	153.3	160.7	3.9	8.2
142937	153.4	160.9	3.9	7.9
142938	153.5	161.0	3.9	7.6
142939	153.6	160.9	3.9	7.4
142940	153.8	160.9	3.8	7.1
142941	153.9	160.9	3.8	6.8
142942	154.0	161.0	3.8	6.5
142943	154.1	161.1	3.8	6.0
142944	154.1	161.1	3.8	5.3
142945	154.2	161.3	3.8	4.3
142946	154.3	161.4	3.8	3.1
142947	154.3	161.5	3.8	1.7
142948	154.3	161.8	3.7	0.1
142949	154.2	161.9	3.7	-1.6
142950	154.2	161.8	3.7	-3.5
142951	154.1	161.9	3.7	-5.7
142952	154.0	162.2	3.7	-8.1
142953	153.8	162.3	3.7	-10.5
142954	153.6	162.4	3.7	-12.9
142955	153.3	162.5	3.7	-15.1
142956	153.0	162.9	3.7	-17.2
142957	152.7	163.5	3.7	-19.1
142958	152.4	164.0	3.7	-20.9
142959	152.0	164.2	3.7	-22.4
143000	151.6	164.0	3.7	-23.8
143001	151.2	163.6	3.7	-24.9
143002	150.8	163.1	3.6	-25.9
143003	150.4	162.8	3.6	-26.5
143004	150.0	162.5	3.6	-26.9
143005	149.5	162.1	3.6	-26.8
143006	149.1	161.6	3.6	-26.4
143007	148.7	161.2	3.6	-25.7
143008	148.3	160.7	3.6	-24.5
143009	147.9	160.1	3.6	-22.8
143010	147.6	159.6	3.6	-20.9
143011	147.3	159.1	3.6	-18.8

UTC	HDG	COG	SOG	ROT
143012	147.0	158.3	3.6	-16.5
143013	146.8	157.4	3.6	-14.2
143014	146.6	156.8	3.5	-11.9
143015	146.4	156.2	3.5	-9.5
143016	146.3	155.6	3.5	-7.1
143017	146.2	155.0	3.5	-4.6
143018	146.2	154.3	3.5	-2.1
143019	146.2	153.5	3.5	0.4
143020	146.2	152.9	3.5	2.8
143021	146.3	152.4	3.5	5.1
143022	146.4	152.0	3.4	7.2
143023	146.6	151.6	3.4	9.2
143024	146.8	151.2	3.4	10.9
143025	147.0	150.7	3.4	12.5
143026	147.2	150.3	3.4	13.9
143027	147.4	149.9	3.3	15.2
143028	147.7	149.6	3.3	16.2
143029	148.0	149.5	3.3	17.2
143030	148.3	149.3	3.3	18.1
143031	148.6	149.2	3.2	18.8
143032	148.9	149.3	3.2	19.4
143033	149.2	149.5	3.2	19.7
143034	149.5	149.6	3.1	20.0
143035	149.8	149.8	3.1	20.0
143036	150.1	150.2	3.1	19.9
143037	150.4	150.6	3.0	19.6
143038	150.7	150.9	3.0	19.1
143039	151.0	151.0	3.0	18.4
143040	151.3	151.0	2.9	17.2
143041	151.6	150.9	2.9	15.6
143042	151.8	150.8	2.8	13.2
143043	152.0	150.3	2.8	10.0
143044	152.1	149.2	2.7	5.9
143045	152.2	148.1	2.7	1.1
143046	152.1	147.6	2.6	-3.8
143047	151.9	148.3	2.6	-7.9

UTC	HDG	COG	SOG	ROT
143048	151.7	150.4	2.5	-10.8
143049	151.5	153.2	2.5	-12.6
143050	151.3	155.5	2.4	-13.7
143051	151.1	156.1	2.3	-14.4
143052	150.9	153.9	2.3	-14.7
143053	150.7	149.8	2.2	-14.8
143054	150.4	146.0	2.2	-14.2
143055	150.2	143.5	2.1	-12.9
143056	150.0	142.3	2.0	-10.9
143057	149.9	142.2	2.0	-8.6
143058	149.8	141.8	1.9	-6.4
143059	149.8	140.0	1.9	-4.4
143100	149.7	137.2	1.8	-2.8
143101	149.7	134.1	1.7	-1.6
143102	149.7	131.8	1.7	-0.6
143103	149.7	130.3	1.6	0.2
143104	149.7	129.7	1.6	1.1
143105	149.7	132.1	1.5	2.1
143106	149.7	137.1	1.5	3.1
143107	149.8	142.4	1.4	4.0
143108	149.9	147.0	1.4	4.7
143109	150.0	149.3	1.3	5.2
143110	150.1	147.3	1.3	5.4
143111	150.2	143.6	1.3	5.5
143112	150.2	141.8	1.2	5.4
143113	150.3	143.4	1.2	5.2
143114	150.4	147.8	1.1	4.9
143115	150.5	150.4	1.1	4.6
143116	150.5	147.6	1.1	4.3
143117	150.6	141.6	1.0	4.0
143118	150.7	136.9	1.0	3.8
143119	150.7	135.5	1.0	3.8
143120	150.8	137.9	0.9	3.9
143121	150.8	144.4	0.9	4.3
143122	150.9	154.0	0.9	4.8
143123	151.0	163.7	0.9	5.2

UTC	HDG	COG	SOG	ROT
143124	151.1	171.3	0.9	5.4
143125	151.2	176.7	0.8	5.3
143126	151.3	178.8	0.8	5.0
143127	151.4	178.3	0.8	4.5
143128	151.4	176.8	0.8	4.0
143129	151.5	173.9	0.8	3.6
143130	151.5	169.9	0.7	3.4
143131	151.6	164.2	0.7	3.3
143132	151.6	155.8	0.7	3.3
143133	151.7	145.9	0.7	3.3
143134	151.8	137.1	0.7	3.2
143135	151.8	131.8	0.7	3.0
143136	151.9	130.2	0.7	2.7
143137	151.9	132.2	0.6	2.3
143138	151.9	137.7	0.6	2.1
143139	151.9	145.4	0.6	2.0
143140	152.0	151.0	0.6	1.8
143141	152.0	152.8	0.6	1.5
143142	152.0	155.2	0.6	0.9
143143	152.0	159.0	0.6	0.1
143144	152.0	162.3	0.6	-0.7
143145	152.0	167.0	0.6	-1.5
143146	151.9	172.0	0.6	-2.2
143147	151.9	174.7	0.6	-2.6
143148	151.9	176.4	0.5	-2.7
143149	151.8	178.9	0.5	-2.8
143150	151.8	182.3	0.5	-2.8
143151	151.7	185.9	0.5	-2.9
143152	151.7	188.7	0.5	-3.1
143153	151.6	189.7	0.5	-3.3
143154	151.6	188.6	0.5	-3.6
143155	151.5	186.3	0.5	-3.9
143156	151.4	185.2	0.5	-4.2

Description and evaluation of the course of the accident

To illustrate the course of the accident, the synchronised, computed data were prepared as time-dependent frames and animated in conjunction with the VDR audio recordings. Here, the ENC depth data are based on chart datum, and the displayed bathymetric data as from 142700 from the BAW's model on MASL. For the assessment of the current patterns at Steubenhöft at the time of the accident, individual voyage situations are assessed separately and evaluated with regard to seagoing ship/navigable maritime waterway interaction (Figs. A to D).

The MERWEBORG's running speed level with the entrance to the outer port stood at about vSOG » 5.4 kts at an ebb current velocity of around ve » 1.2 m/s (= 2.3 kts), meaning the speed through water calculated was about vSTW » 7.7 kts (Fig. A; time: 142805). The ship sailed virtually in the opposite direction to the depth-averaged current vectors, meaning an almost even flow around the hull was to be expected. According to the gauge at Steubenhöft, the tide level stood at -1.32 MASL, the actual depth of water at the ship was h » 11 m on average at a distance of L » 100 m from the entrance, decreasing to around h » 8 m in the middle of the port entrance. The turning motion to port of no more than ROT P = 5°/min (142744) was reduced to some ROT P = 1°/min within 21 s.

Evaluation: Effective interactions of the MERWEBORG, running at d = 7.3 m, with the bathymetry, the quay facilities, as well as the elevated ro-ro ramp could not be derived from the data prepared. Cross currents from the outer port exit as a result of the ebb current cannot be derived from the current computations of the BAW's 3D HN model.

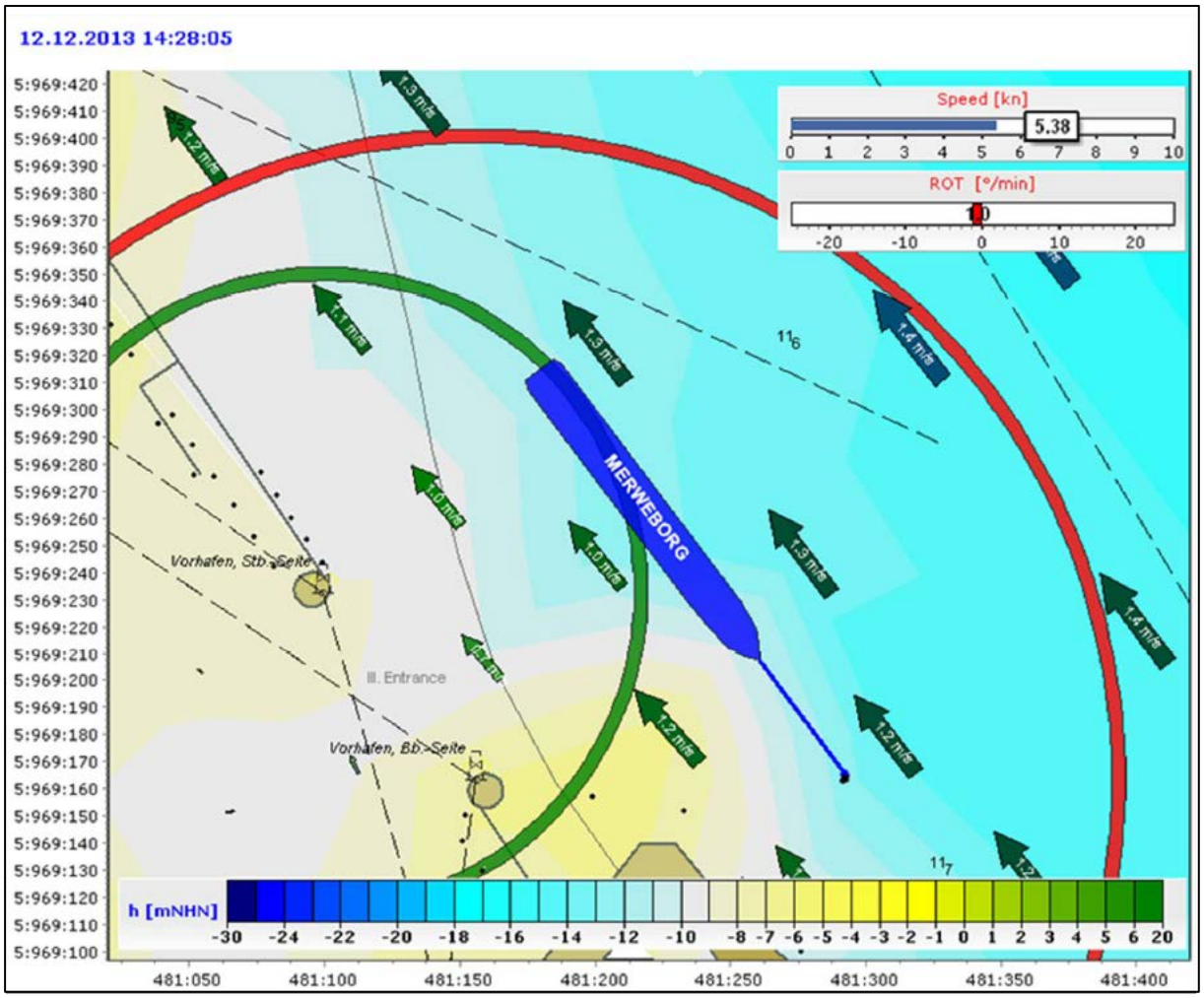


Figure A: ENC position of the MERWEBORG at a speed of roughly vSTW » 7.7 kts off the outer port with overlaid depth-averaged current and bathymetric data from the BAW's HN model (2010)

The MERWEBORG passed the entrance to the outer port one minute later (Fig. B; time: 142904); a course difference of about +5° to starboard was now determined. The speed through water calculated at a depth-averaged ebb current of ve » 1.1 m/s (= 2.1 kts) was about vSTW » 6.6 kts. The present PASSING DISTANCE of the bow to the moored CAROLINE RUSS (d = 5.9 m) stood at some 37 m, the stern to a theoretic line along the moored vessel roughly 52 m. During the passage of the outer port entrance, as well as the shoals located to the south-east of that with present water coverage of roughly h » 5-6 m, the vessel turned from port ROT P = 1°/min to starboard ROT S = 7.5°/min. At this point, based on the underlying depth-averaged current data from the HN model, the inflow to the MERWEBORG came from an angle of about 6°.

Evaluation: The reversal of the turning motion of the ship from port to starboard is not due to interaction between the vessel and shoals to the south-east of the outer port entrance, the latter would have intensified the turn to port. The tidal oblique inflow of about 6° did not cause the strong development of the turning motion from port to starboard, either.

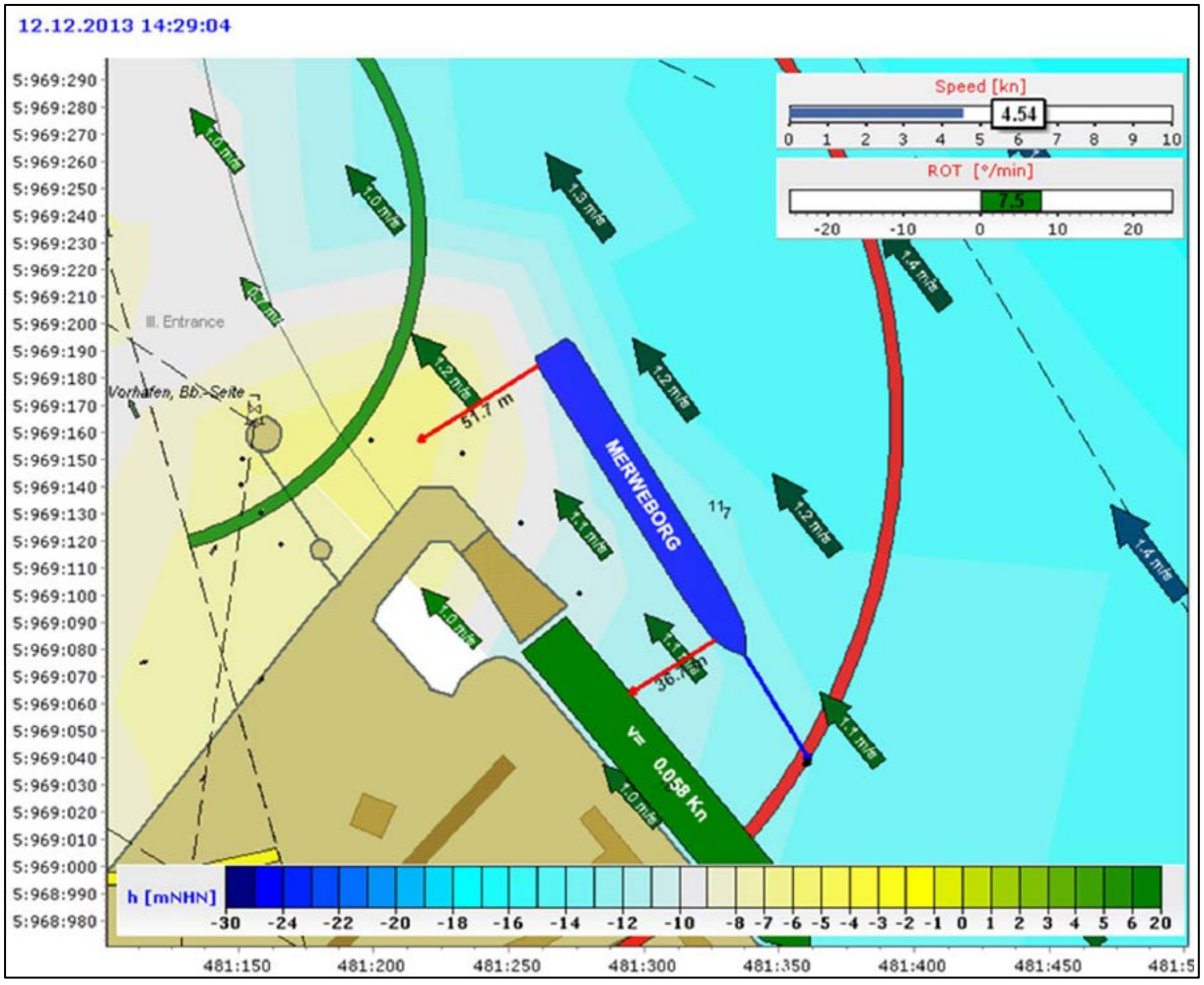


Figure B: ENC position of the MERWEBORG at a speed of roughly vSTW » 6.6 kts off the outer port with overlaid depth-averaged current and bathymetric data from the BAW's HN model (2010), as well as computed distances to the moored vessel

Within only about 20 s, the turning motion to starboard increased to the maximum of ROT S = 12.2°/min (Fig. C; time: 142922). The speed through water was marginally reduced to some vSTW » 6.3 kts, the depth-averaged tidal stream was roughly ve » 1.1 m/s (= 2.1 kts), still at an inflow angle of approximately 6°. The PASSING DISTANCEs to the CAROLINE RUSS (d = 5.9 m) or to a theoretic line along the moored vessel now stood at some 25 m (bow) and 47 m (stern).

Evaluation: The increased turning motion to starboard is caused neither by bank effects, a ship/ship interaction, nor by the tidal oblique flow.

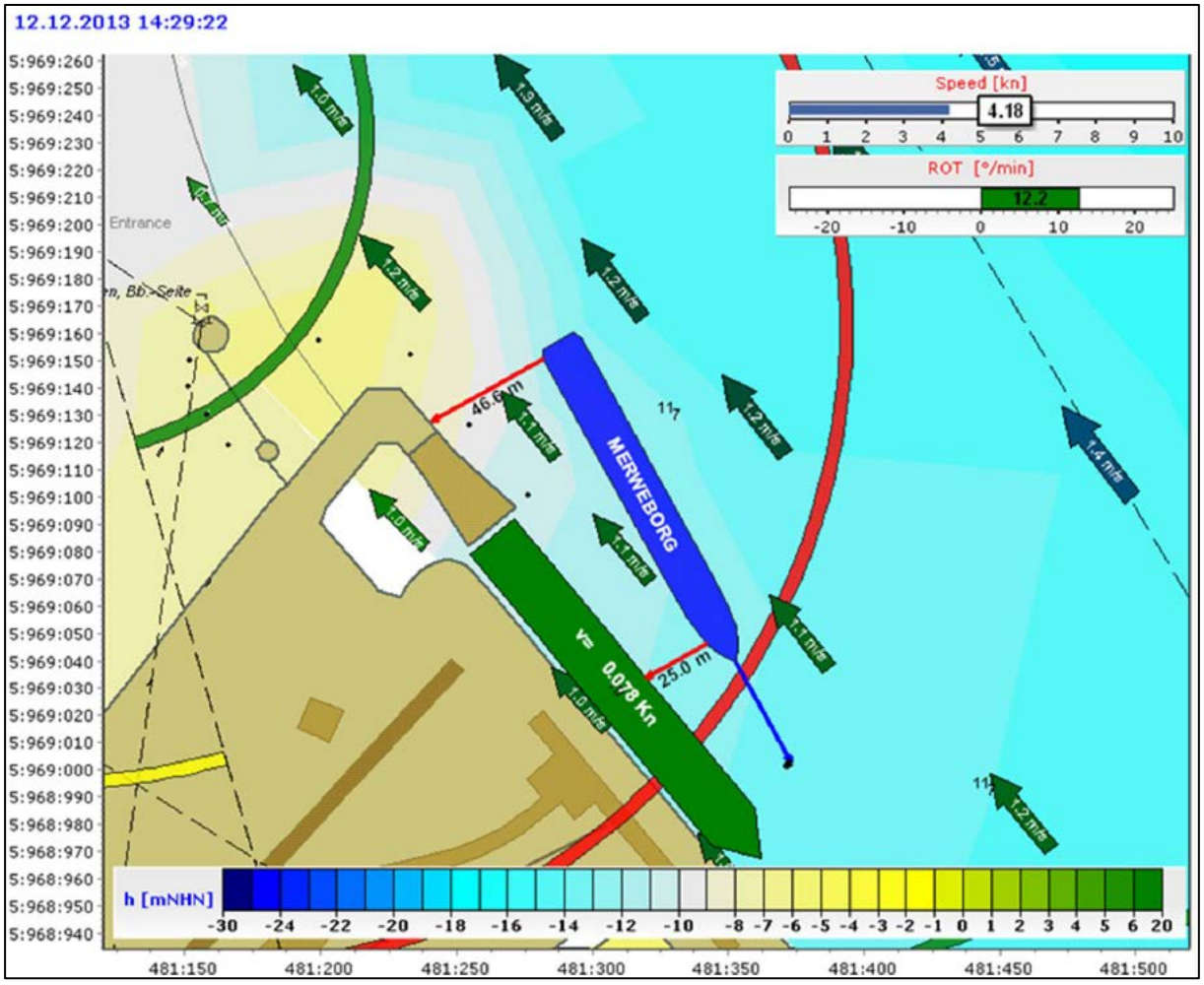


Figure C: ENC position of the MERWEBORG at a speed of about vSTW » 6.3 kts off the outer port at maximum ROT to starboard with overlaid depth-averaged current and bathymetric data from the BAW's HN model (2010), as well as computed distances to the moored vessel

After about another 20 seconds (Fig. D; time: 142941), the MERWEBORG was roughly level with the CAROLINE RUSS at a speed of about vSTW » 5.9 kts and shallow angle of about 15° towards the bow of the moored CAROLINE RUSS (d = 5.9 m). At this point, the inflow to the MERWEBORG (d = 7.3 m) came from an angle of about 14° on the port side with a depth-averaged tidal stream of roughly ve » 1.1 m/s (= 2.1 kts). The distance from the MERWEBORG to the CAROLINE RUSS was about 10 m at the bow. The stern was roughly 38 m to a theoretic line along the moored vessel. The turning motion to starboard was reduced from the maximum to ROT S = 6.8°/min at this point in spite of the tidal inflow of about 14°.

Evaluation: It is not possible to infer that hydrodynamic interaction between the MERWEBORG (d = 7.3 m) and the CAROLINE RUSS (d = 5.9 m) facilitated the collision in spite of the passing speed of about vSTW » 6 kts and low PASSING DISTANCE. Possible hydrodynamic interactions opposed the present behaviour of the MERWEBORG. The low distance of the bow may have facilitated the reduction in the ROT to starboard due to the speed-induced pressure distribution at the bow (bow wave).

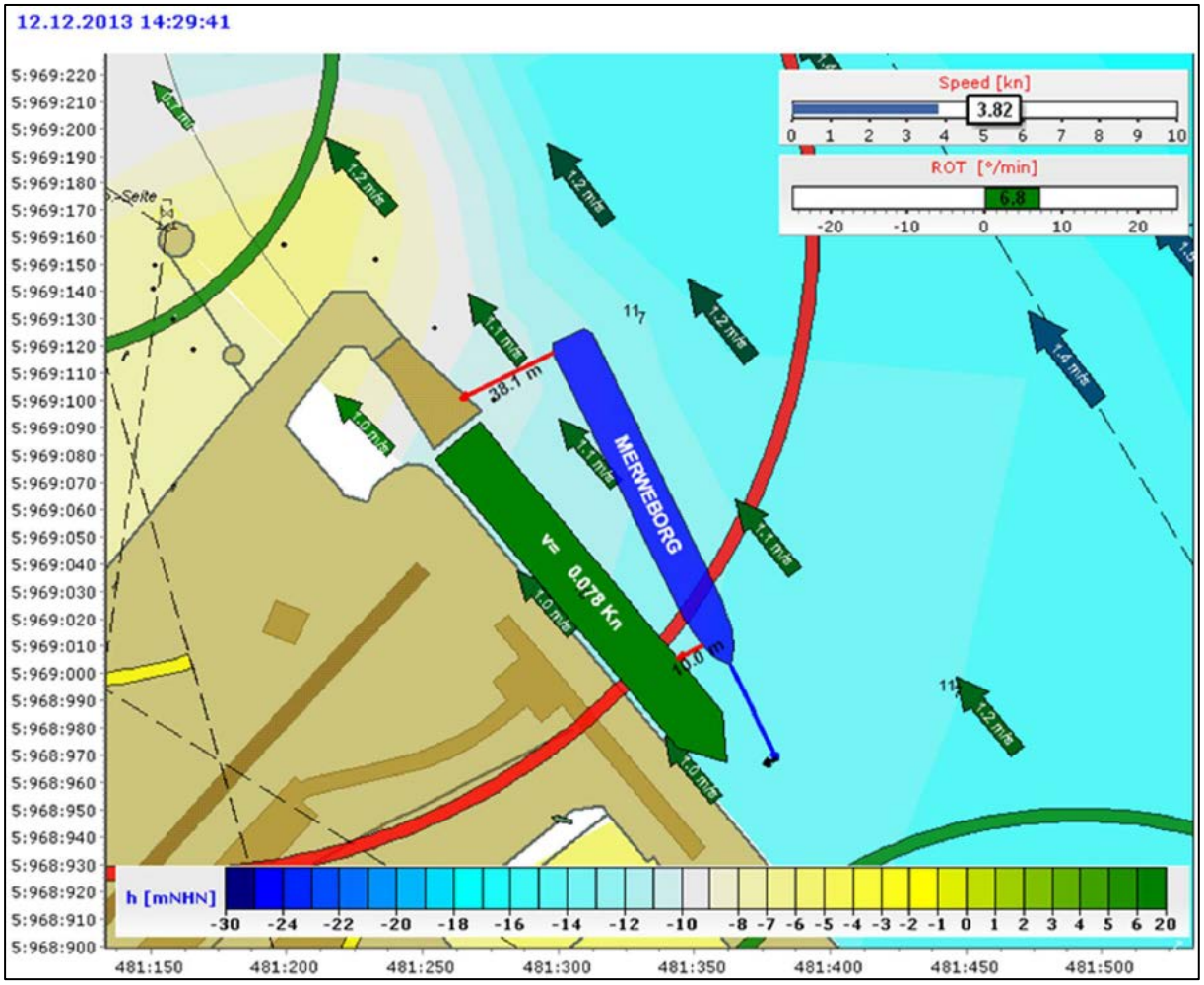


Figure D: ENC position of the MERWEBORG at a speed of about vSTW » 5.9 kts level with the CAROLINE RUSS with overlaid depth-averaged current and bathymetric data from the BAW's HN model (2010), as well as computed distances to the moored vessel

Conclusions on the course of the accident

Based on the prepared and interpolated voyage and position data of the MERWEBORG, as well as the depth-averaged current data from the hydrodynamic numerical model of the BAW off Cuxhaven at the time of the accident, it cannot be inferred that hydrodynamic interactions (bank effects, ship/ship interaction) affected the handling of the MERWEBORG. To assess potential cross flows from the outer port entrance in the form of a surge, the BAW recommends that possible lockage, sluice or discharge operations at about LWL -1.3 MASL be checked at the relevant operators of the various outer port sections.

MTC simulation

On 28 May 2014, several berthing manoeuvres involving Elbe pilots at Steubenhöft under similar conditions to those of the MERWEBORG were simulated at Maritime Training Center in Hamburg. The ebb current was set at 4 kts in accordance with the information then available. The BSH's sailing directions for the North Sea indicate that the tidal streams along the quay facilities set across and at times into the entrances at up to 5 kts. The manoeuvre is shown in the form of a time lapse in Fig. 10. For reasons of simulation, a current setting away from the pier had to be taken into account while berthing at Steubenhöft. It is striking that during this manoeuvre, at 1-2 kts SOG, the vessel sailed much slower, closer and more parallel to the pier than during the accident. The current model at the Steubenhöft berth was reportedly not true to reality. In particular, manoeuvres had to be continuously corrected when berthing. Hydrodynamic interactions were reportedly not sufficiently accounted for in the model. Nevertheless, a different approach of pilots is clear: they did not take the direct track from the fairway to the berth. The direct approach at smaller distances and a speed of 5.5 kts resulted in a collision in the simulator, too (see Fig. 11).

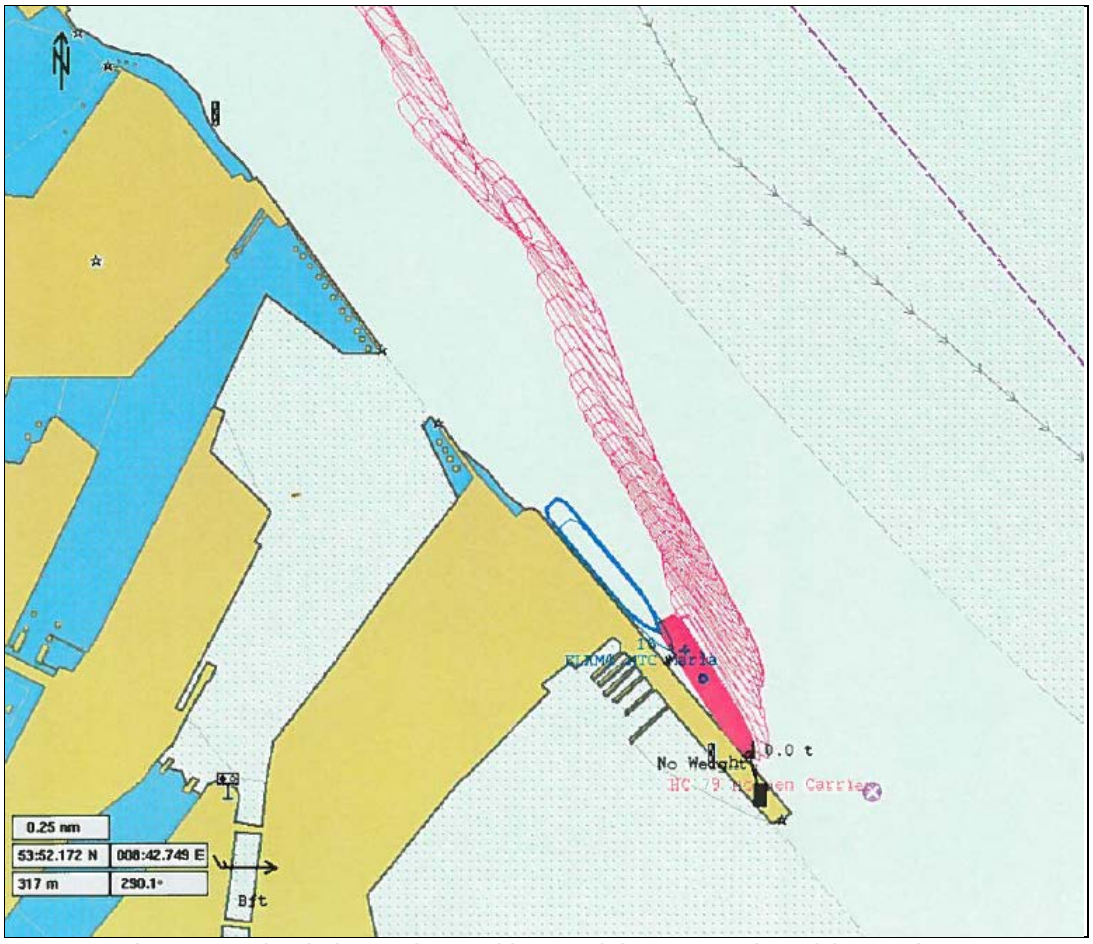


Figure 10: Simulation at the Maritime Training Center (MTC) in Hamburg

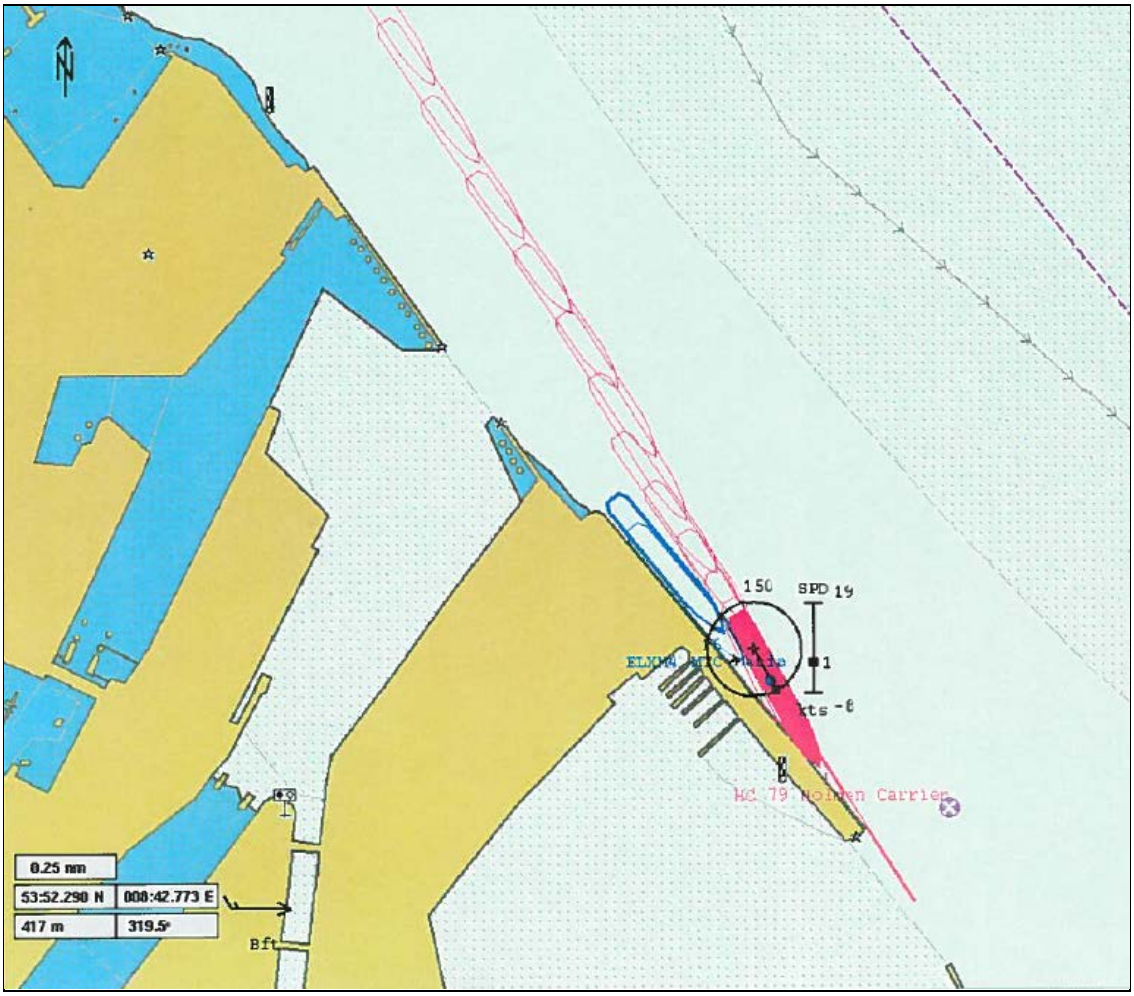


Figure 11: Simulation of the accident at the MTC

The actual course made good during the accident is compared with a simulation at the MTC in the following four figures (AA-DD) created by the BAW (see Fig. 10). While passing the outer port in Cuxhaven, the MERWEBORG (red icon) and the model ship, HOLMEN CARRIER (blue icon), are almost parallel to begin with.

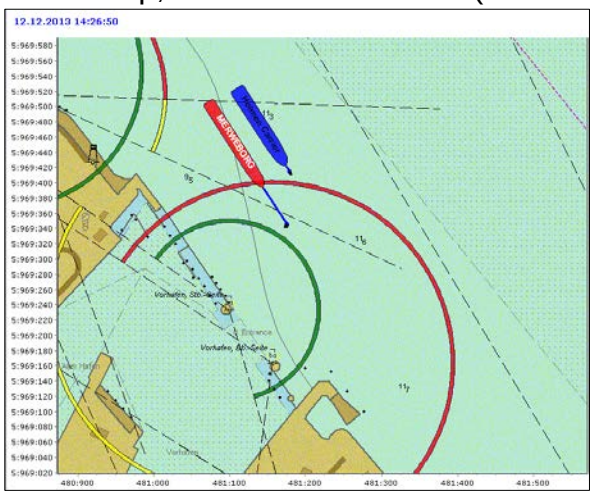


Figure AA: Comparison of track to the north-west of the outer port

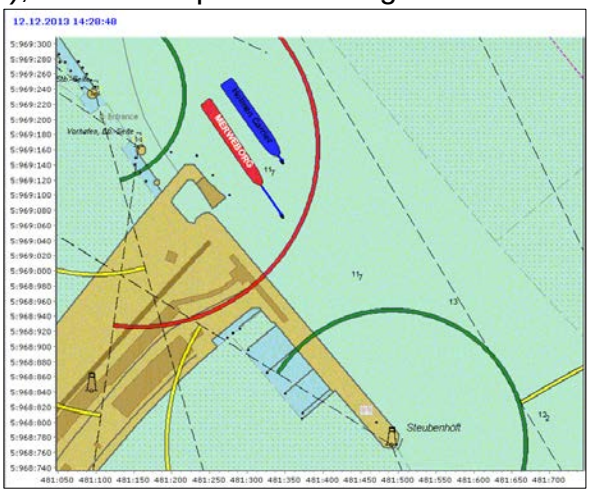


Figure BB: Comparison of track to the south-east of the outer port

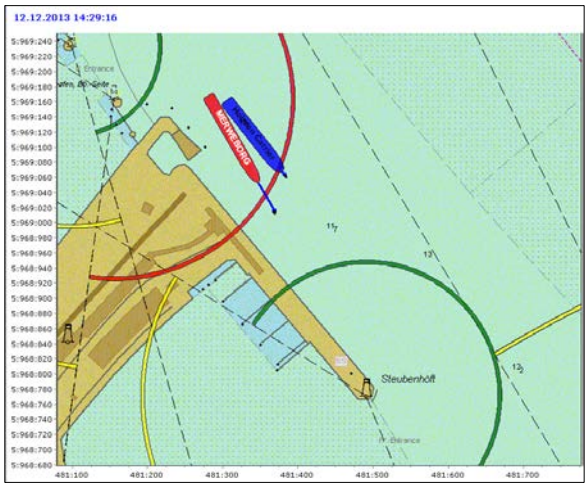


Figure CC: Comparison of track to the north-west of Steubenhöft

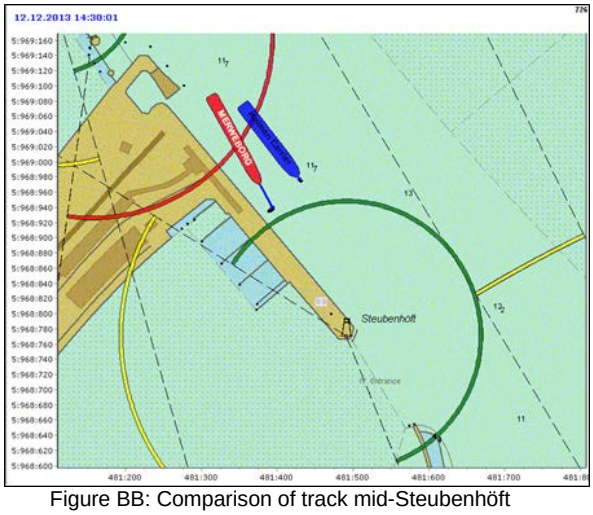


Figure BB: Comparison of track mid-Steubenhöft

Only behind the ro-ro berth at Steubenhöft does the MERWEBORG turn to starboard, while the HOLMEN CARRIER continues parallel to the pier. The BAW was not able to clarify this effect sufficiently. Due to the sand accumulation off the ro-ro berth, a hydrodynamic effect to port would have been more likely. Extensive measurements of the local current patterns in Cuxhaven are not known. The port authority is currently installing a gauge at Steubenhöft. The current force of 2.1 kts computed in the BAW model for the Steubenhöft berth deviates significantly from the data in the BSH's sailing directions and statements given by the pilots (4-5 kts). However, the stronger current would only be more significant in terms of the berthing manoeuvre in the event of an ebb current rather than an ebb and counter current. Discharge operations at the locks to the outer port are carried out monthly. Here, floating segments would be carried out with the natural flow of the Elbe. The force of the ebb current at low tide is less than 0.3 of a knot (see Fig. 12) and had no material impact on the MERWEBORG. The current inside the outer port spirals anticlockwise during an ebb current and clockwise during a rising tide. Larger ships may only enter or depart during slack water so that they are not caught amidships by the Elbe's current. According to the BAW, neither the scouring at the Steubenhöft berth (see Fig. 13) nor the stilt design at the pier had a material impact on their final hydrodynamic assessment. This scouring, which the port authority at Cuxhaven aims to counter by means of aggradation, could have explained the hydrodynamic effect and the turning motion of the MERWEBORG to starboard. Prepared one week before the accident, the sounding chart was almost up-to-date.

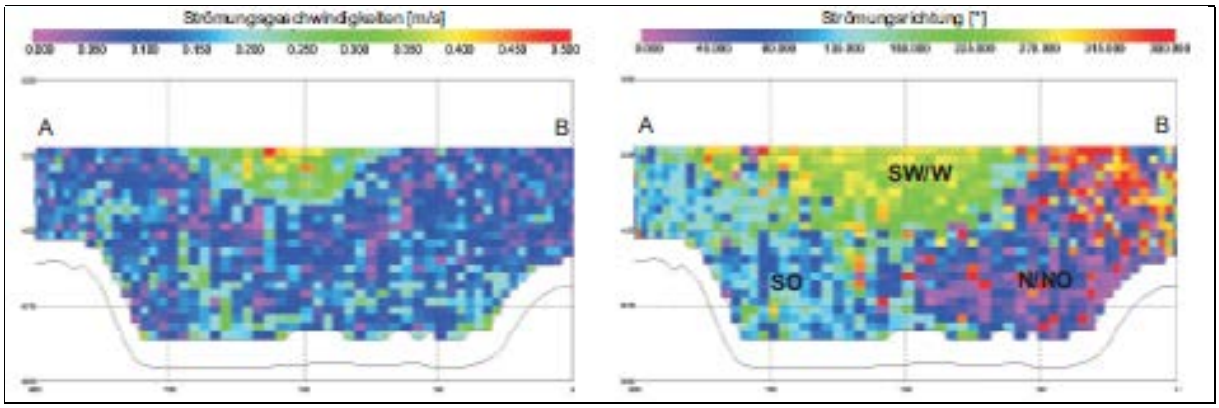


Figure 12: Port authority's current measurements at the entrance to the outer port of 25 February 2011

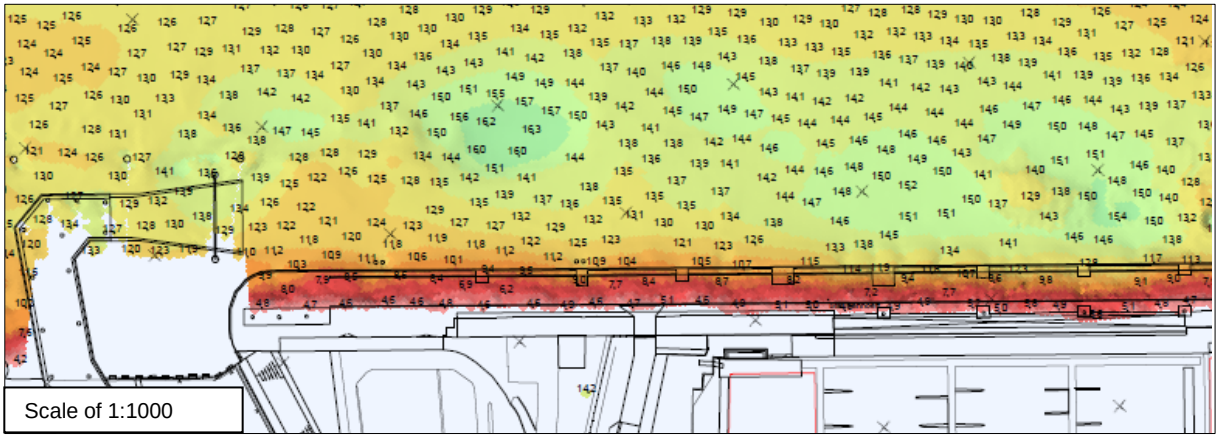


Figure 13: Port authority's sounding chart of 5 December 2012, Steubenhöft, scouring (green areas)

While the HOLMEN CARRIER continues to run parallel to the pier in the simulator, the MERWEBORG makes a starboard turning motion; it is unlikely that this was caused by natural hydrodynamic interactions. Rudder and bow thruster records of the MERWEBORG that could provide better insight into the manoeuvring were not available.

5 CONCLUSIONS

The analysis of the VDR data and the manoeuvring simulations at the MTC in Hamburg revealed that the MERWEBORG, advised by a port pilot, approached the Steubenhöft berth in Cuxhaven too quickly, too close, and at too much of an angle to the CAROLINE RUSS. Manoeuvring with the existing controls outweighed hydrodynamic interactions acting between the MERWEBORG, the CAROLINE RUSS and the berth.

The SOG during the first collision between the starboard forecastle of the MERWEBORG and overhanging port bow of the CAROLINE RUSS at 152954 still stood at 3.7 kts. This was too high for a berthing manoeuvre even if the ebb current was running in the opposite direction at about 2.1 kts according to the BAW model and about 4-5 kts according to the pilots in the final stage. The second collision involving the bridge wing happened at 153044 and the bow then struck the berth when stopping. The accident did not give rise to injuries and no pollutants escaped. The CAROLINE RUSS had two tears on her bow above the waterline. The MERWEBORG sustained severe damage to her bow, her starboard bridge wing, her gantry crane, as well as her rescue boat and davit.

The Elbe pilot, who was relieved at 1515 in Grimmershörn Bay, had already advised the port pilot that the distance was too low at 1522. The parallel PASSING DISTANCE to the CAROLINE RUSS would have been roughly 40 m. The port pilot justified the low distance with a previous berthing manoeuvre carried out by him on the GRAN CANARIA, which almost failed in a rising tide when the PASSING DISTANCE was too great. Therefore, he prefers to proceed closer and can apply port rudder if necessary. At 152453, the port pilot remarked to his colleague that there was reportedly only half an hour between his next two pilotage assignments. At 1526, the Elbe pilot made his colleague aware of a drift of 3 kts. At 1527, the port pilot inquired as to whether the MERWEBORG had a right-handed controllable pitch propeller with steering efficiency at the stern to starboard. At 1529, it was found that the MERWEBORG's bow was moving to starboard. An attempt to prevent a collision with the CAROLINE RUSS and moor the MERWEBORG was then made with the last manoeuvre. This manoeuvre was appropriate for a right-handed controllable pitch propeller and was done to contain the starboard turning motion towards the CAROLINE RUSS.
The port pilot had to complete two pilotage assignments immediately after. From an organisational perspective, the time frame he had until his next assignment on the car carrier GRAN CANARIA was relatively tight. According to the AIS recordings, she would have arrived at the pilot transfer point in Grimmershörn Bay at roughly 1630. Consequently, time was against him and he may have been less cautious than usual because of that.[2]

[2] Due to the increased volume of traffic in the ports of Cuxhaven, the Brotherhood of Elbe Pilots is providing four additional port pilots as from 1 December 2014. This should reduce the burden during peak traffic periods.

He was convinced passing the CAROLINE RUSS at a close distance was the right thing to do because passing at too great a distance would complicate berthing in the prevailing conditions, as had already reportedly happened to him once before. However, at the same time he had not assessed the fact sufficiently that on this occasion an ebb current was setting and the manoeuvre was a different, not comparable but rather easier berthing manoeuvre because of the counter current. That does not justify the high SOG of 5.6 kts and emergence of the unpredictable hydrodynamic interactions with the Steubenhöft berth and the CAROLINE RUSS associated with that just five minutes before the collision, however. In this case, the vessel would rather have been expected to push away to port, as continuously changing sand accumulation is situated off the ro-ro berth. The actual effect was brought about by the oblique inflow of 14°, possible scouring and as a result of that displacement towards the berth. The analysis of the VDR data (see above tables) provides no evidence for other hydrodynamic interactions. The ebb current of no more than 0.3 of a knot at the outer port had no material impact on the MERWEBORG's approach. As demonstrated in the ship-handling simulator, the oblique inflow could have been avoided if the vessel had proceeded parallel to the direction of the current instead of at an acute angle directly towards the pier.

The master left operating the controls to the pilot. Within qualified organisation on the bridge, temporary assumption of responsibility for navigating a vessel is consistent with current practice. The pilot's colleague advised him on the MERWEBORG's manoeuvring characteristics and navigational equipment and he had discussed the berthing manoeuvre with the master. Nevertheless, responsibility for the crew and ship remains with the master or officer on watch, respectively. He must always keep an overall view of dangerous situations. Here it is irrelevant whether the controls are operated via instructions and crew or the pilot directly. This requires clear communication of responsibilities and duties. The master or officer on watch should have intervened when the low PASSING DISTANCE to the CAROLINE RUSS was imminent. In this case, only one radar system was operational and there was fog, however. This complicated monitoring the track.

The Brotherhood of Elbe Pilots has now reviewed the accident on a ship-handling simulator. The pilots are trained there on a regular basis. Inasmuch, there is no further need to issue safety recommendations.

The latest sounding charts, hydrodynamic analyses, and the experience of the Elbe pilots make it possible to improve and adapt the Steubenhöft model for ship-handling simulators, meaning simulation of the hydrodynamic effects can be more in line with reality. It is not possible to demonstrate any hydrodynamic effect under the pier because of the stilt design. In the area of the entrances to the outer port and Amerikahafen, there are smaller outgoing and incoming currents in the different water layers. Larger vessels can be caught amidships by the Elbe's current in the entrances. It is necessary to observe the morphology of the seabed (sand accumulation, scouring) of the ro-ro berth, as well as at Steubenhöft berth.

6 SOURCES

- Enquiries by WSP Cuxhaven (WSPK4)

- Written statements
  - Ship's commands
  - Owner
  - The classification society American Bureau of Shipping (ABS)

- Witness accounts

- Expert opinion/technical paper
  Dr.-Ing. Klemens Uliczka, Dipl. Ing. Martin Wezel, Dr. rer.-nat. Frank Kösters
  Federal Waterways Engineering and Research Institute – Coastal Department –
  Bundesanstalt für Wasserbau – Dienststelle Hamburg

  MTC Marine Training Center Hamburg GmbH (ship-handling simulator),
  pilots from the Brotherhood of Elbe Pilots

  Deputy Harbour Master Kolter, Cuxhaven

- Nautical charts and ship particulars, BSH

- AIS recordings, Joint Control Centre of the Waterway Police of the Coastal States in Cuxhaven

- Photos by WSP Cuxhaven, Hasenpusch, and the port authority of Cuxhaven