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

Summary
Investigation Report 250/11

Serious Marine Casualty

Collision between the CMV CCNI RIMAC and CMV CSAV PETORCA on 21 June 2011 in the area of the approach to the port of Yangshan

31 March 2014

www.bsu-bund.de

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 in the version applicable prior to 30 November 2011.

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.

This report should not be used in court proceedings or proceedings of the Maritime Board. Reference is made to the aforementioned version of Article 19(4) SUG.

The German text shall prevail in the interpretation of this investigation report.

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1 Summary

At 1153[1] on 21 June 2011, a collision occurred between the German-flagged container ship CCNI RIMAC and the Liberian-registered container ship CSAV PETORCA in Hangzhou Bay at the edge of the buoyed approach to Yangshan deep water port[2]. Calm seas and fog with varying visibility of about one to two nautical miles prevailed[3]. The RIMAC sailed out of the port of Yangshan at 1018 and proceeded along the Yangshan Gang Main Channel in an easterly direction at about 16 knots.[4] The PETORCA started to weigh anchor about 12.5 nm east of the subsequent scene of the accident at 1042. She then sailed into the channel and headed for Yangshan. In the ensuing period, the master of the PETORCA, which was proceeding at about 17.5 knots[5], was forced to leave the fairway plotted on the nautical chart temporarily because of the high number of fishing vessels and coasters.

At 1148, the traffic centre, VTS[6] Yangshan, gave the PETORCA to understand that she is outside the fairway and a vessel within the fairway is approaching with her.[7] The PETORCA acknowledged this and essentially informed the traffic centre that she reportedly intended to return to the northern part of the fairway immediately after the outbound ship was passed. She did not mention the ship by name but was undoubtedly referring to the RIMAC. VTS Yangshan repeated explicitly the information received from the PETORCA and acknowledged the stated course of action.

Regardless of the exchange of information between the PETORCA and VTS already discussed, the RIMAC called VTS Yangshan about 15 seconds later and asked about the oncoming vessel some 1.5 nm away. The PETORCA heard this query. Given the circumstances, she justifiably felt it concerned her and essentially requested the RIMAC to maintain her course at 1150. She reportedly intended to alter her course a little further to port.

[1] All times shown in this report are local: UTC + 8 hours.
[2] Note: Partially opened in 2005, Yangshan deep water port was built on and around the islands of Xiao Yang Shan and Da Yang Shan in the China Sea. It falls under the administration of the port of Shanghai, which is located some 50 nm to the north, and is connected to the Chinese mainland by a 32.5-km bridge.
[3] Note: To enhance the readability of this report, 'CCNI' and 'CSAV' have been dropped from the ship names regularly when quoting them below.
[4] Source of this and subsequent course/speed data of the CCNI RIMAC: S-VDR on the CCNI RIMAC.
[5] Source of this and subsequent speed parameters of the CSAV PETORCA: Ship's AIS data generated from the S-VDR on the CCNI RIMAC.
[6] VTS: **V**essel **t**raffic **s**ervice centre.
[7] Source of the radio and bridge communication here and below: audio recordings of the S-VDR on the CCNI RIMAC.

Consequently, without making an explicit statement, it was clearly the intention of the PETORCA that the two vessels should encounter green-green[8]. The RIMAC apparently understood the PETORCA's request incorrectly. Although "Okay" was her reply, this "Okay" was combined with the information that she would now move to starboard. However, this misunderstanding was not recognised by the PETORCA, for she merely replied with a brief thank you to the master. The RIMAC started to make the stated course alteration to starboard immediately after the radio contact was finished. The PETORCA altered her course slightly to port. The two vessels came within sight of each other shortly afterwards at a distance of about 0.8 nm (prior to that they had observed one another only on the radar). However, they could not prevent the collision at 1153, which was caused by the opposing evasion manoeuvres.

The PETORCA touched the RIMAC's superstructure on the port side at an angle of about 50 degrees with her bow and then scraped along several container stacks stowed in front of the superstructure. As a result of the collision, the RIMAC took on water due to a hole in the area of the port side of cargo hold 5; however, this did not compromise her buoyancy. 26 of the containers on the ship went overboard. The PETORCA was damaged only slightly in the area of the bow and bulbous bow. Consequently, she remained completely seaworthy.

After the water ingress in the cargo hold, a dangerous situation occurred in the roads of Yangshan on the following day. A chemical reaction followed by heat and smoke occurred inside at least one dangerous goods container stowed in cargo hold 5 because of water ingress. The crew of the RIMAC was temporarily evacuated from the vessel as a precaution. A special team discharged[9] the four dangerous goods containers affected as a priority, thus eliminating the ensuing hazardous situation.

The collision did not result in any injuries and there was no pollution of any significance.

[8] 'Green-green' is a nautical euphemism for vessels passing to their respective starboard side based on the green navigational lights to starboard. In contrast, 'red-red' stands for two vessels passing port side to port side.
[9] Note: Discharge is a nautical euphemism for unloading a ship.

2 FACTUAL INFORMATION

2.1 Photo of the CMV CCNI RIMAC

Figure 1: Photo of the CCNI RIMAC[10]

2.2 Ship particulars: CMV CCNI RIMAC

Name of vessel:	CCNI RIMAC (ex. WOTAN)
Type of vessel:	Container ship
Nationality/Flag:	Germany
Port of registry:	Hamburg
IMO number:	9226425
Call sign:	DPTS
Owner:	Transeste Schiffahrt GmbH, Jork
Year built:	2001
Shipyard/Yard number:	Kvaerner Warnow Werft GmbH, Rostock/23
Classification society:	Germanischer Lloyd
Length overall:	208.33 m
Breadth overall:	29.80 m
Gross tonnage:	25,703
Deadweight:	33,987 t
Draught (max.):	11.40 m
Engine rating:	19,810 kW
Main engine (type/manufacturer):	B&W two-stroke diesel 7 L 70 MC/Doosan Engine Co Ltd., South Korea
(Service) speed (max.):	22 kts
Hull material:	Steel
Manning (max.):	24

[10] Source: Owner of the CCNI RIMAC.

2.3 Voyage particulars: CMV CCNI RIMAC

Port of departure:	Yangshan deep water port (PRC)
Port of call:	Busan (Republic of Korea)
Type of voyage:	Merchant shipping/International
Cargo information:	1,159 containers
Draught at time of accident:	10.9 m
Manning:	19
Pilot on board:	No
Number of passengers:	None

2.4 Photo of the CMV CSAV PETORCA

Figure 2: Photo of the CSAV PETORCA[11]

2.5 Ship particulars: CMV CSAV PETORCA

Name of vessel:	CSAV PETORCA
Type of vessel:	Container ship
Nationality/Flag:	Liberia
Port of registry:	Monrovia
IMO number:	9215830
Call sign:	A8IL3
Owner:	DS Schiffahrt GmbH & Co KG, Hamburg
Year built:	2001
Shipyard/Yard number:	Hyundai Heavy Industries Co Ltd., Ulsan/1288
Classification society:	Germanischer Lloyd
Length overall:	304.00 m
Breadth overall:	40.00 m
Gross tonnage:	74,373
Deadweight:	80,596 t
Draught (max.):	14.00 m
Engine rating:	65,930 kW
Main engine (type/manufacturer):	B&W two-stroke diesel 12K98MC-C/Hyundai Heavy Industries Co Ltd., South Korea

[11] Source: Owner of the CSAV PETORCA.

(Service) speed (max.):	26.4 kts
Hull material:	Steel
Manning:	21

2.6 Voyage particulars: CMV CSAV PETORCA

Port of departure:	Ningbo (PRC)
Port of call:	Yangshan deep water port (PRC)
Type of voyage:	Merchant shipping/International
Cargo information:	Containers
Draught at time of accident:	9.5 m
Manning:	21
Pilot on board:	No
Number of passengers:	None

2.7 Marine casualty information

Type of accident:	Serious marine casualty, collision
Date, time:	21/06/2011, 1153
Location:	0.3 nm south of Yangshan Gang Main Channel (18.5 nm west of Yangshan)
Latitude/Longitude:	φ 30°31.4'N λ 122°23.6'E
Ship operation and voyage segment:	Approach to Yangshan (outbound and inbound)
Consequences:	Material damage to both ships Cargo damage on the CCNI RIMAC, including 26 containers overboard No injuries or environmental damage.

Excerpt of Nautical Chart 2703 (great circle chart of the Northern Pacific Ocean), BSH[12]

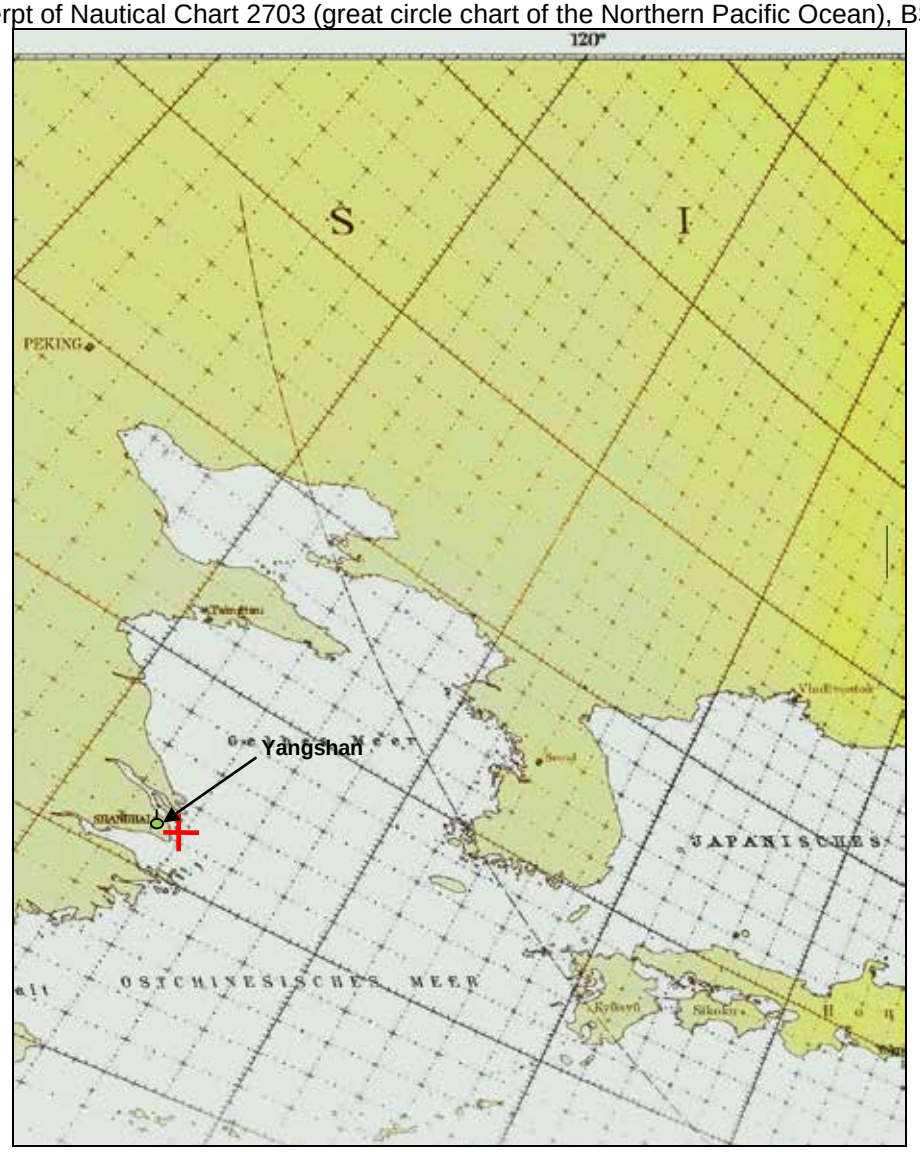

Figure 3: Scene of the accident

[12] BSH: Federal Maritime and Hydrographic Agency.

2.8 Shore authority involvement and emergency response

Agencies involved:	VTS Yangshan, Shanghai Maritime Search and Rescue Centre
Resources used:	Support tugs deployed to escort/assist the CCNI RIMAC en route to the roads of Yangshan
Action taken:	Special team deployed on board the CCNI RIMAC in the roads of Yangshan to survey and eliminate the hazards arising from a chemical reaction in a dangerous goods container due to the ingress of salt water. Temporary evacuation from the vessel of the crew of the CCNI RIMAC in the course of the action discussed above
Results achieved:	Relevant dangerous goods containers and the 26 containers floating in the sea salvaged successfully

3 COURSE OF THE ACCIDENT AND INVESTIGATION

3.1 Course of the accident

The 2,524-TEU[13] container ship CCNI RIMAC sailed out of the port of Yangshan, which is located about 18.5 nm west of the subsequent scene of the accident, under pilotage at **1018**. She then followed the course of the buoyed Yangshan Gang Main Channel fairway, which has an average width of only about 0.3 nm, on a south-easterly and later easterly heading. At **1118**, the pilot left the ship about 2.5 nautical miles east of where the fairway referred to and the Jinshan Hangdao fairway, which runs crossways, intersect (see **Fig. 4**).

Figure 4: CCNI RIMAC – radar image at 1118[14]

The RIMAC then increased her speed to about 16 knots and continued to proceed along the Yangshan Gang Main Channel on the general course of about 100° to be observed in this respect. The ship was navigated by the master supported by the third officer (OOW) and steered on autopilot from about **1142**. According to information given by the ship's command of the RIMAC, visibility was continuously under two nautical miles since leaving the port and dropped abruptly to levels of considerably less than one nautical mile in places at about **1130**. The PETORCA was reportedly located with the port radar[15] at a distance of 5.4 nm,

[13] TEU: **T**wenty-foot **e**quivalent **u**nit is the container stowage capacity based on the dimensions of a 20-foot ISO container.
[14] Source: S-VDR on the RIMAC; intersecting fairways marked and labelled by the author of the report.
[15] The analysis of the RIMAC's S-VDR revealed that no ARPA targets were acquired by the port radar recorded by the S-VDR at the time in question; however, the values referred to are largely consistent with those of the AIS target information that can be generated from the S-VDR. It must therefore be assumed that the data in question were determined using the ARPA function of the starboard radar – the S-VDR did not record this for system-related reasons – or originate from the RIMAC's ECS system. See also section 3.3.2 of the investigation report.

a TCPA[16] of 9.9 minutes, and a CPA[17] of 0.84 nm at **1142**.

For her part, the 6,479-TEU container ship CSAV PETORCA started to weigh anchor about 12.5 nm east of the subsequent scene of the accident and 2 nm south of the above-mentioned fairway at **1042**. She then sailed into the fairway and headed for Yangshan. In the ensuing period, the master of the PETORCA, which was proceeding at about 17.5 knots, was forced to leave the fairway plotted on the nautical chart temporarily because of the high number of fishing vessels and coasters.

Figure 5 below is indicative of the significant traffic density in the area of the accident at **1130**.[18]

Figure 5: Volume of traffic in the area of the accident (AIS signals at 112959)[19]

[16] TCPA: **T**ime to **c**losest **p**oint of **a**pproach.
[17] CPA: **C**losest **p**oint of **a**pproach.
[18] Note: The display is a screenshot from the replay software of the S-VDR on the RIMAC. In accordance with the functionality of the software, the author of the investigation report selected the display mode 'AIS Playback'. The author of the report also selected the PETORCA's AIS data. The selection made is recognisable from the white marking surrounding the AIS symbol of the ship, which was added by the replay software, and presentation of the corresponding AIS information in the text box to the left of the image highlighted red.
[19] Source: S-VDR on the RIMAC. Identification of the vessels involved in the accident and red marking to the left of the image added by the author of the report. The AIS targets are identified with a red cross by the system to make clear that their courses are not hazardous for the RIMAC. The yellow icons are sea marks equipped with AIS transmitters. **Note:** The heading (course steered) of the PETORCA, which was undoubtedly continuously steering westward, is displayed incorrectly both in terms of symbol and number (see the notes in section 3.3.2.2).

According to the AIS[20] target information (see area marked red in **Fig. 5**), the distance between the two vessels subsequently involved in the collision was 12.4 nm at this point. CPA and TCPA have the non-critical values 2.15 nm and 21.84 minutes.

At **1148,** the PETORCA was advised by VTS Yangshan that she is located outside the fairway and that a vessel within the fairway is approaching her. The PETORCA replied by stating that she would return to the fairway, the northern side in particular, after the oncoming vessel was passed. VTS Yangshan repeated and acknowledged the course of action.

It is likely that the ship's command of the RIMAC did not actively follow every detail of this arrangement. In any case, she called VTS Yangshan at about **1150**, directly after the radio contact referred to above, and asked about the intentions of the oncoming vessel, which was about 1.5 nm away, without mentioning the ship's name.

The PETORCA justifiably felt the question concerned her and for that reason contacted the RIMAC on her own initiative, without waiting for a reply from the VTS. As revealed by the ensuing course of events, the radio contact between the RIMAC and PETORCA that followed ended in a complete misunderstanding. While the master of the PETORCA worked on the assumption that both vessels had agreed to pass green-green, the master of the RIMAC was convinced that a port side to port side encounter with the oncoming PETORCA was reportedly intended.

Accordingly, the RIMAC altered her course to starboard immediately after the radio contact to increase the CPA. At the same time, the PETORCA, proceeding along the southern side of the fairway, altered her course slightly to port to put the supposedly agreed green-green pass into effect.

The two vessels came in sight of each other at a distance of 0.8 to 0.5 nautical miles between **115130** and **115230**. Each ship's command was confused by the course of the other vessel, which was inconsistent with the supposedly agreed manoeuvre. The master of the PETORCA responded to the starboard course alteration by the RIMAC and associated turn towards the PETORCA with an immediate hard to port course alteration. Furthermore, he reportedly stopped the engine and then set it to full astern. At the same time, the RIMAC, still turning to starboard, used the tyfon to issue a warning signal, sounded the general alarm, and called the PETORCA on VHF twice in 10 seconds without any success.

[20] 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 transmitters and/or receivers.

Immediately afterwards at **115259**, the PETORCA collided with the port side of the RIMAC in the area of the superstructure at an angle of about 50 degrees. The bow of the PETORCA then scraped along the port side of the RIMAC, brushed against several of the outer container stacks stowed on deck, and finally ploughed into the hull of the RIMAC amidships level with the waterline with her bulbous bow. This led to flooding in cargo hold 5.

The two ships subsequently broke away from each other. The RIMAC quickly started to list at about five degrees. The ship's command of the RIMAC promptly organised a preliminary damage analysis and after discovering the ingress of water immediately started to work on the ballast dimensions to eliminate the list. It took them about 30 minutes to offset the list.

Alongside the activities referred to above, the ship's command of the RIMAC attempted to make contact with VTS Yangshan immediately after the accident. This involved considerable difficulties. It took more than a minute for VTS Yangshan to respond to the RIMAC's accident report in the form of a request for confirmation of the collision addressed to the PETORCA. Orderly communication between VTS Yangshan and the two ships was slow to arrive at in the minutes that followed, too. In particular, communication attempts were marked by the fact that calls made by the three communicating parties were not always answered by the actual addressee, but instead by the other party not being spoken to. At times, the other party responded because or after the actual addressee had not answered promptly. In addition, there was repeated confusion between the three communicating parties with regard to the identity of the radio station sending a call or requested to answer.

After some toing and froing between the three communicating parties, the ship's command of the RIMAC finally succeeded in explaining the current situation to VTS Yangshan clearly, confirming the buoyancy of the RIMAC, and requesting tug assistance for the necessary return to the port of Yangshan in a series of radio messages between **1156** and **1158**. At **1201**, the PETORCA notified the VTS that they had anchored and were ascertaining the damage. At **1212**, the RIMAC anchored near the scene of the accident, too. At **1227**, the ship's command of the RIMAC informed VTS Yangshan that it had been possible to stabilise the situation on board and the list was eliminated.

The digital photo below (**Fig. 6**) was kindly provided by the ship's command of the RIMAC and bears a timestamp set by the camera of 0634 (presumably CEST = 1234 LT). Accordingly, it would have been taken about 40 minutes after the accident. The photo illustrates the restricted visibility at the time of the accident. According to the S-VDR analysis, the distance between the two vessels is 0.6 nm at the time stated.

Figure 6: CSAV PETORCA seen from the CCNI RIMAC after the collision[21]

3.2 Consequences of the accident

3.2.1 Damage to the CCNI RIMAC

Initially, the bow of the PETORCA scraped along the superstructure on the port side of the RIMAC's aft section. The consequences of the accident in this area of the RIMAC are essentially limited to damage to the provision crane on the port side and a relatively small hole in the forward edge of the deckhouse (see **Figs. 7** and **8**).

Figure 7: Damage to the superstructure (provision crane) of the CCNI RIMAC

[21] Source for Figures 6 to 17: ship's command of the CCNI RIMAC.

Figure 8: Damage to the superstructure of the CCNI RIMAC

Several containers stowed on the outside of the container stacks situated directly in front of the superstructure were torn open or heavily deformed when the PETORCA scraped past them subsequently (**Fig. 9 f.**). A number of stacks in this area started to tilt across the entire breadth of the ship (**Fig. 11**), which resulted in 26 containers, situated mainly on her starboard side, falling overboard.

Figure 9: Damage to the deck cargo on the CCNI RIMAC (general view)

Figure 10: Damage to the deck cargo on the CCNI RIMAC (side view from port)

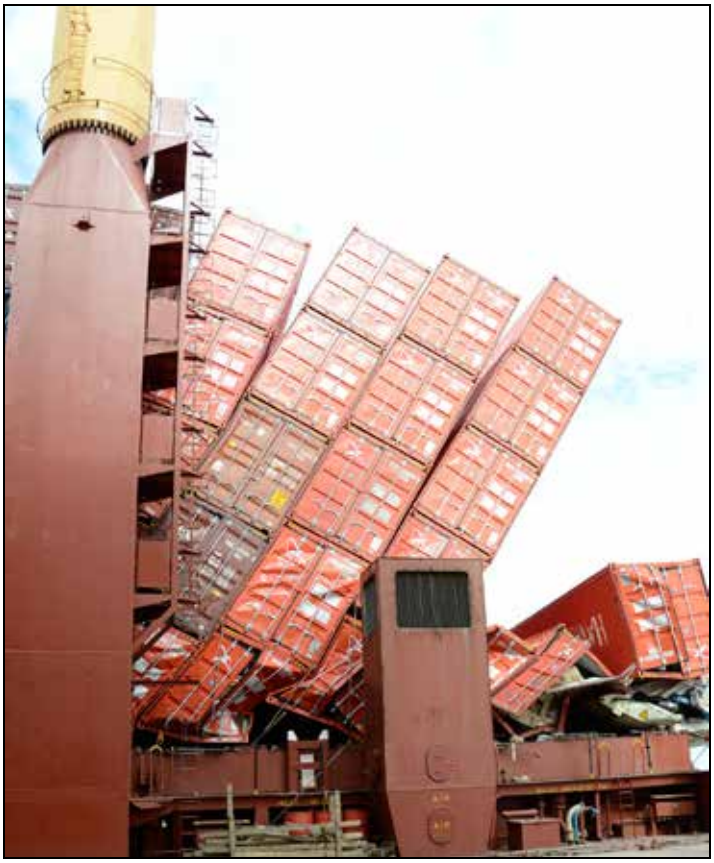

Figure 11: Tilted container stack (towards starboard) on the CCNI RIMAC[22]

[22] Note: Taken from level with the main deck at the forward edge of the superstructure towards the bow after the container bays directly in front of the superstructure were cleared.

The PETORCA finally ploughed into the hull of the RIMAC level with the waterline with her bulbous bow and created a hole in a ballast tank and the adjacent wall of cargo hold 5 in the process (see **Fig. 12 f.**). The cargo hold then flooded to the height of the waterline with salt water.

Figure 12: Damage to the shell plating on the CCNI RIMAC

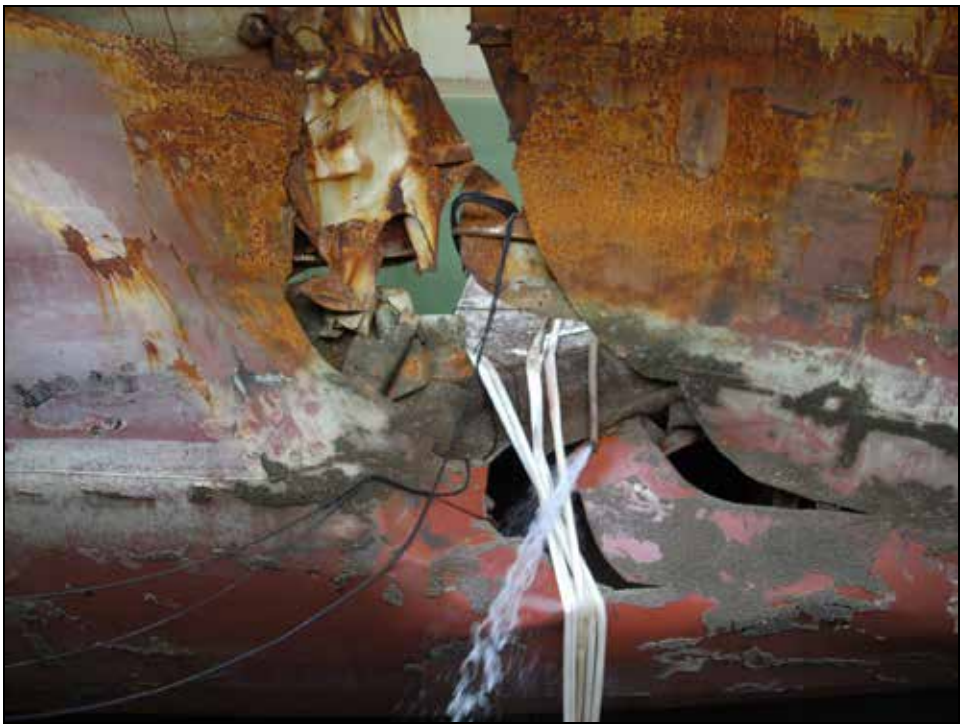

Figure 13: Damage to the shell plating on the CCNI RIMAC (close-up)

After the water ingress in the cargo hold, a chemical reaction followed by heat and smoke occurred during the next 24 hours in the roads of Yangshan.

This reaction was between the flammable contents of at least one dangerous goods container stowed below deck and the salt water that had entered.
The crew of the RIMAC was temporarily evacuated from the vessel as a precaution. Moreover, a special team eliminated the ensuing hazardous situation by discharging the deck cargo stowed above cargo hold 5 and the four affected dangerous goods containers as a priority (see **Fig. 14 f.**).

Figure 14: Deck cargo on the CCNI RIMAC being discharged in the roads of Yangshan

Figure 15: Elimination of the hazardous situation in cargo hold 5 of the CCNI RIMAC

Figure 16: Water ingress and evidence of heat development in cargo hold 5

3.2.2 Damage to the CSAV PETORCA

The damage to the PETORCA was limited to paint abrasions in the area of the bow (see **Fig. 17**) and a dent in the bulbous bow. Water ingress was not found in the course of sounding all the tanks and cavities open to consideration, which was carried out immediately.

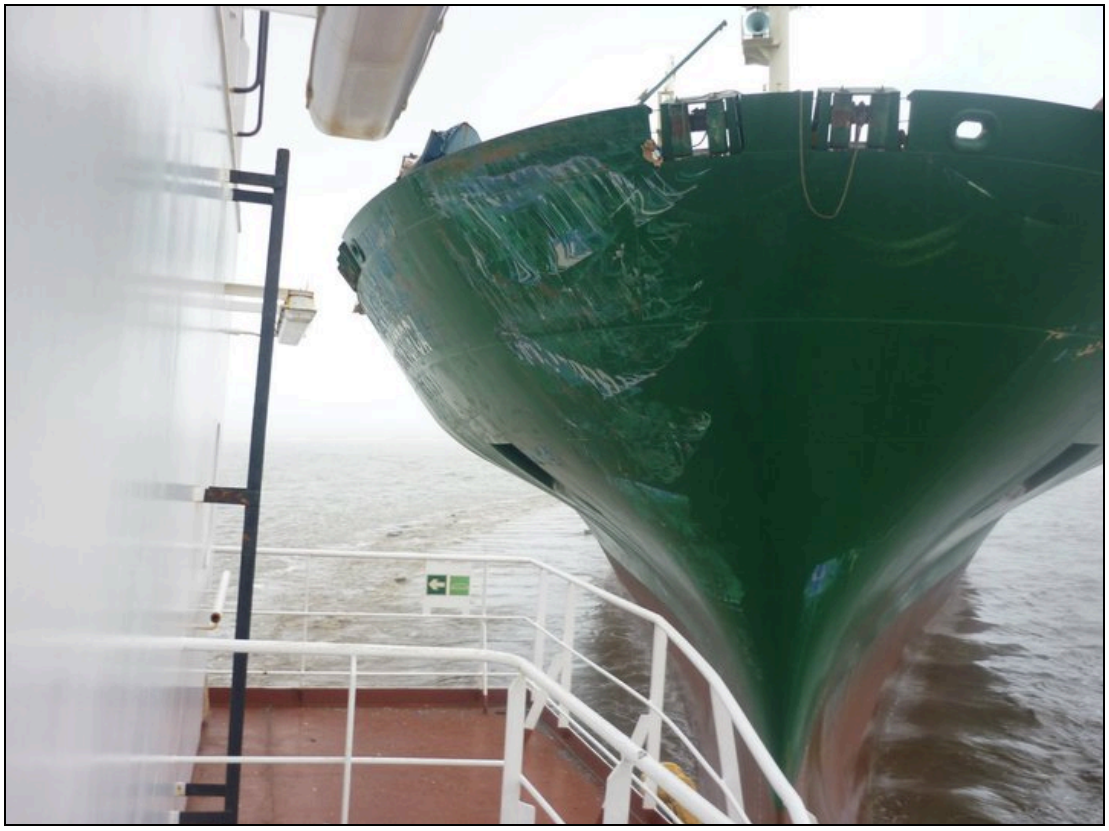

Figure 17: Paint abrasions on the bow of the CSAV PETORCA[23]

3.2.3 Injuries and environmental damage

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. The 26 containers on the RIMAC that fell overboard contained no environmentally hazardous substances.

[23] Note: The photo was provided by the ship's command of the RIMAC and shows the bow of the PETORCA seen from the RIMAC immediately after the two vessels parted from each other.

3.3 Investigation

3.3.1 Course, substantive particulars, sources

The accident was brought to the attention of the Federal Bureau of Maritime Casualty Investigation (BSU) by means of a copy of an accident report acknowledgement email from the Liberian flag State Administration (LISCR) on 23 June 2011. LISCR was informed about the collision by email from the China Maritime Safety Administration beforehand (22 June 2011). The owner of each vessel submitted information about the accident to the BSU afterwards following a corresponding request. The kind provision of various photos by the master of the RIMAC deserves special mention.

The analysis of the RIMAC's S-VDR data was of fundamental importance to reconstructing the accident[24]. The stored screenshots from the radar and, in particular, GPS-based speed parameters for both vessels made it possible to reconstruct the course of the voyage of each vessel subsequently involved in the collision with absolute certainty. However, the analysis of the communication on the bridge of the CCNI RIMAC and, in particular, radio traffic between each vessel, as well as between the two vessels and VTS Yangshan recorded by the S-VDR yielded definitive information as to the cause of the collision.

Further sources and starting points for the investigation were the statements of fact by the two masters, other documents provided by the vessel owners, an analysis of the navigational characteristics of the area of the accident based on the relevant British nautical charts, as well as an official weather report.

Unfortunately, the PETORCA's VDR recording was not provided, quoting ongoing disputes under civil law, to the BSU in spite of several requests. Therefore, communication on the bridge of this ship or radar images available to the ship's command at the time of the accident, for example, could not be assessed by the BSU.

3.3.2 VDR recordings on the CCNI RIMAC

A RUTTER VDR-100G2S S-VDR was installed on the RIMAC at the time of the accident. The master of the vessel complied with his obligation to make a backup after the collision. The data were submitted to the BSU without delay after the event.

[24] S-VDR: **S**implified **v**oyage **d**ata **r**ecorder; carriage requirement on vessels of 3,000 GT and above; system for gathering data to make it possible to determine and analyse the causes of an accident subsequently. In accordance with regulations, the VDR on board the RIMAC is a so-called simplified VDR, as it was installed only after the introduction of mandatory VDR systems for newly-built craft in the course of a retrofit. S-VDR systems may have a reduced feature set; however, they meet all the main performance guidelines for a 'normal' VDR.

3.3.2.1 Radar/ARPA[25]

The technical aids used by the ship's command of the RIMAC for navigating in the congested area included both radar units and a 'Transas Navi-Sailor 2400 ECS' electronic chart system. For system-related reasons, the S-VDR on the RIMAC only has one interface to the port radar unit and stores screenshots of the image displayed on the radar screen at 15-second intervals.
Therefore, using the analysis of the stored radar images the BSU was able to trace the development of the collision from the angle of one of the two radars on the RIMAC. Viewing the images clearly revealed that the ARPA function of the port radar was not used in the 15 minutes leading up to the accident. Otherwise, the acquisition[26] of radar targets would have been visible on the radar images in the form of the device's prescribed graphic accentuation of the ARPA targets. However, it is possible that the starboard radar unit, which also has ARPA functionality, was used for automated plotting.
According to a statement by the ship's command, the distance, TCPA and CPA of the PETORCA were calculated using the ECS at **1137**, inter alia. Since the accuracy of these data could be verified using the recorded AIS-based target information during the analysis of the S-VDR data, it must be assumed that (possibly in addition to using the immediate ARPA function of the starboard radar) ARPA data of the PETORCA were actually available via the ECS and used during the approach of the oncoming vessel.[27]

Figure 18 below is indicative of the traffic situation from the angle of the RIMAC's port radar unit at **1145**. At this point, the radar unit was operated at a range of 3 nm in the display mode north up, relative motion. The display was off-centre, meaning the actual sector that could be observed was about 5 nm ahead. Range markers ('RINGS') are displayed around the container ship's own position at intervals of 0.5 nm. Furthermore, a variable range marker surrounded the vessel's own position at a distance of 0.19 nm and a (manually variable) EBL[28] was set towards 118.8 degrees. The adjustments made by the ship's command to the monitor facilitated excellent observation of the traffic situation by radar.

[25] ARPA: **A**utomatic **r**adar **p**lotting **a**id.
[26] Acquisition means that a radar target has been added to the radar's automated plotting function by the user or automatically.
[27] Note: In addition to the interfaces to the ARPA radar units, the Transas ECS installed on board also has an interface to the shipboard AIS receiver (made by SAAB). This means that (ARPA) radar targets (and possibly also ARPA data), as well as AIS information (limited because of the system), which includes the ship's name, COG, SOG, and position, can be displayed on the ECS monitor. Consequently, there is no doubt that the oncoming vessel was actually identified as the PETORCA by the ship's command by no later than 1137 and then also plotted because of the imminent approach.
[28] Note: EBL: **E**lectronic **b**earing **l**ine; points to the (distorted) scale reading of 135 degrees on the radar image due to the off-centred position of the vessel on which it is displayed. The EBL setting was not changed at all. Therefore, it must be assumed that this EBL was not used during the approach of the PETORCA.

Accordingly, the PETORCA's echo on the starboard side of the RIMAC's lubber line (heading line) at a distance of about 4.5 nm is clearly identifiable (see the PETORCA's echo marked red in **Fig. 18**). With the exception of the range, the above settings were not changed later.

The main GPS-based speed parameters of the RIMAC and the course steered (heading), as determined by the gyrocompass, are displayed by the S-VDR replay next to the radar image in the data window at the top left. According to that, the heading was 101 degrees, the COG[29] 100 degrees, and the SOG[30] 15.8 knots at the time in question.[31]

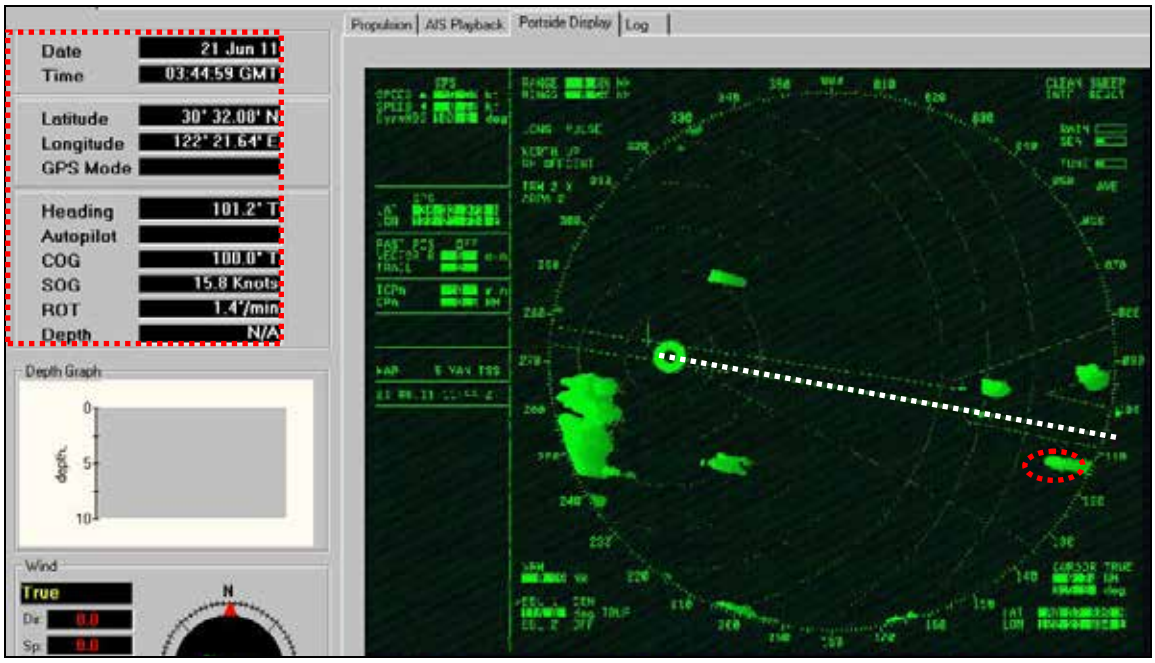

Figure 18: Starboard radar on the CCNI RIMAC at 114459 (S-VDR replay)[32]

The range of the radar unit was increased to 6 nm a few seconds before **Figure 19** below. The distance between the range markers changed accordingly by 0.5 nm to 1.0 nm. In the area ahead, echoes now appear up to a distance of about 9.5 nm because of the (still) off-centred setting.
The echo of the PETORCA is still easy to make out on the radar image. The distance between the two vessels involved in the subsequent collision is now about 3.2 nm. The course and speed of the RIMAC are essentially unchanged. The position and shape of the PETORCA's echo show – as far as can be derived from a radar image without ARPA support – that no significant course alteration has been made there, either.

[29] COG: **C**ourse **o**ver **g**round.
[30] SOG: **S**peed **o**ver **g**round.
[31] Note: The information in the S-VDR replay's data window is updated at 3-second intervals and the actual radar images at 15-second intervals. For this reason, there are differences between the speed parameters in the data window and those within each radar image displayed. However, these are negligible because they are so minor.
[32] Note: The red markings and heading line accentuated by white dashes in this and the following figures were added by the author of the report.

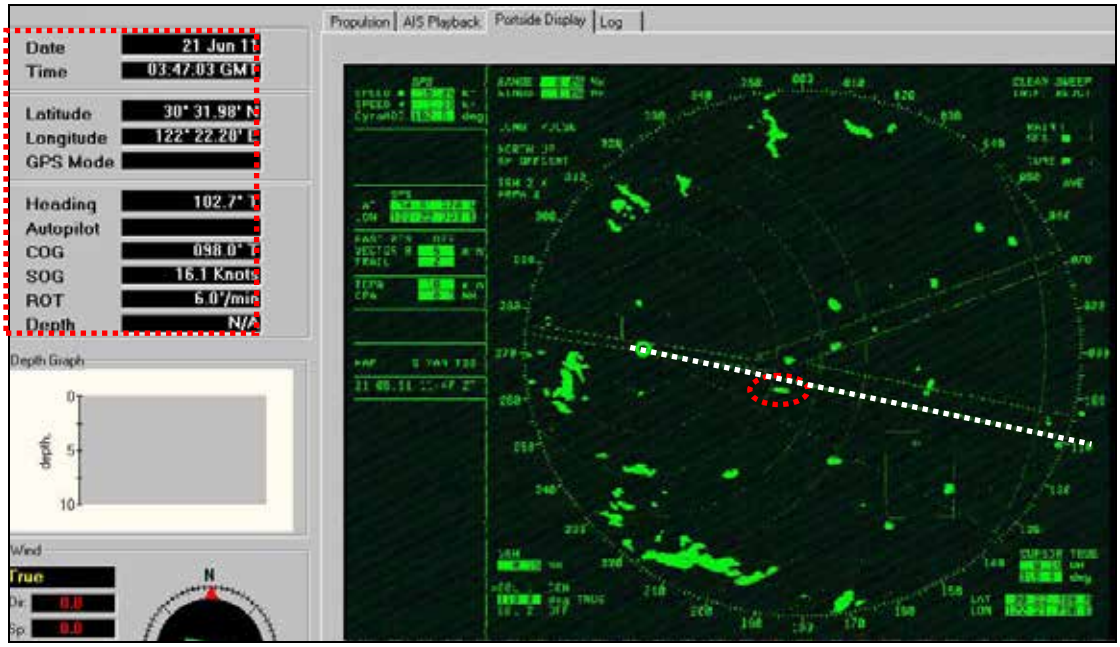

Figure 19: Starboard radar on the CCNI RIMAC at 114703 (S-VDR replay)

The RIMAC altered her course slightly to starboard during the next three minutes (see **Fig. 20** below). With regard to the PETORCA, alterations to the course of the voyage are still not visible – as far as possible on the radar image.

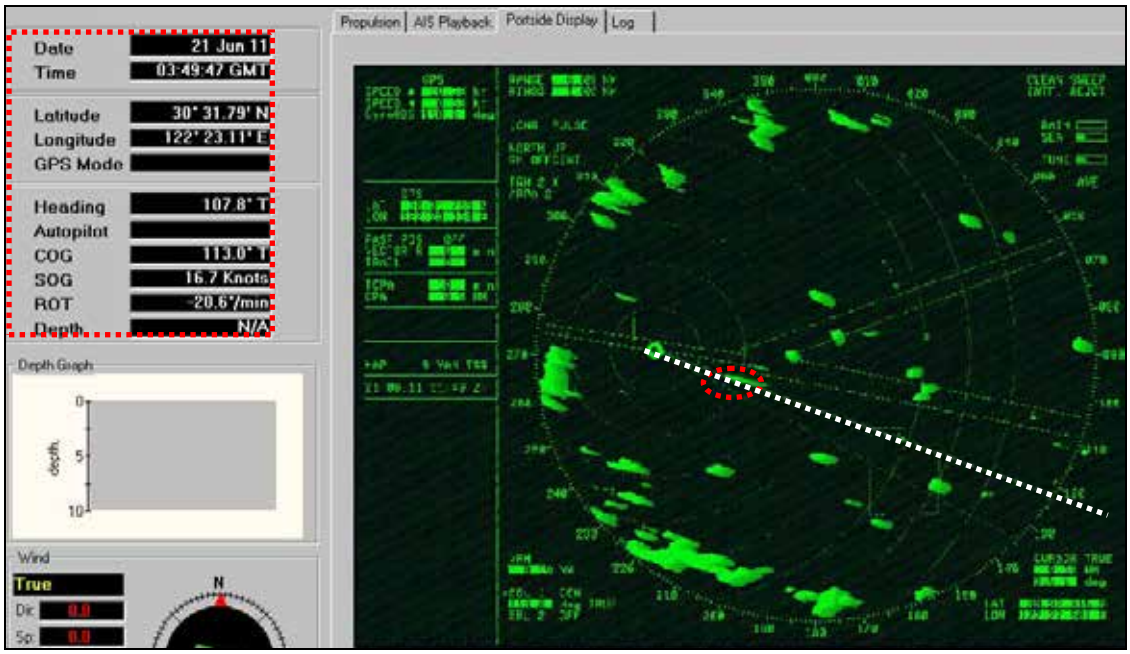

Figure 20: Starboard radar on the CCNI RIMAC at 114947 (S-VDR replay)

The VDR replay display at **115027** (see **Fig. 21** below) shows that the RIMAC has now turned back to port within the range of her original course. The distance to the PETORCA, whose speed parameters are – as far as visible – still the same, is 1.7 nm at this point.

Figure 21: Starboard radar on the CCNI RIMAC at 115027 (S-VDR replay)

As can be clearly seen from **Figures 22 ff**., the RIMAC started a continuous and rigorous course alteration to starboard at immediately after **115027**. The distance between the two vessels was about 1.3 nm.

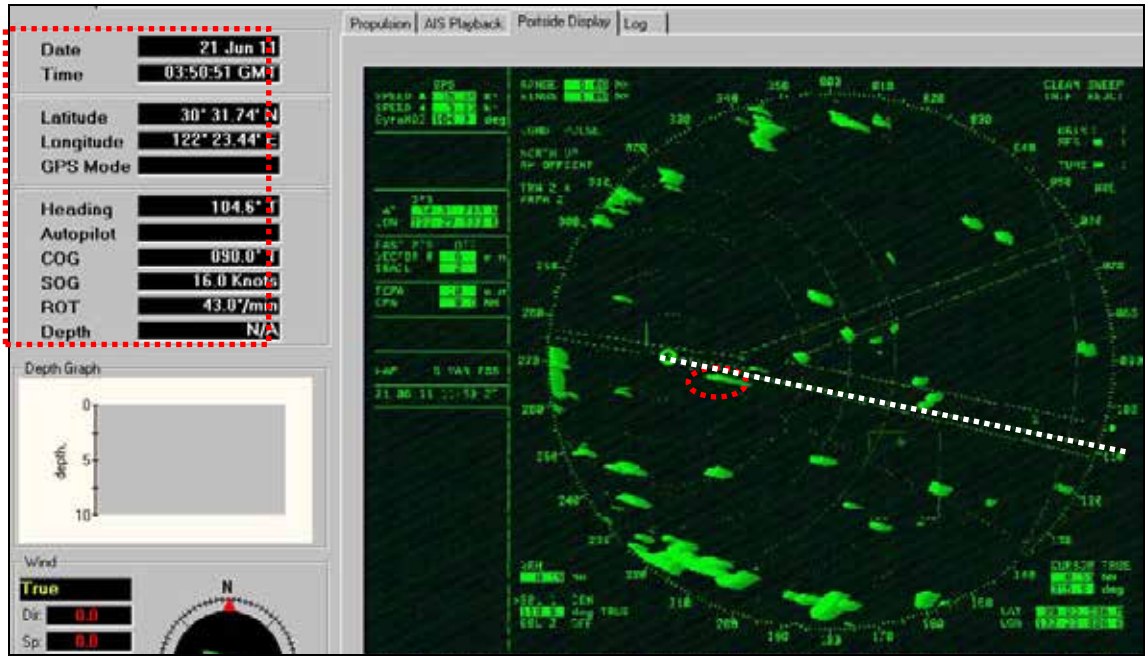

Figure 22: Starboard radar on the CCNI RIMAC at 115051 (S-VDR replay)

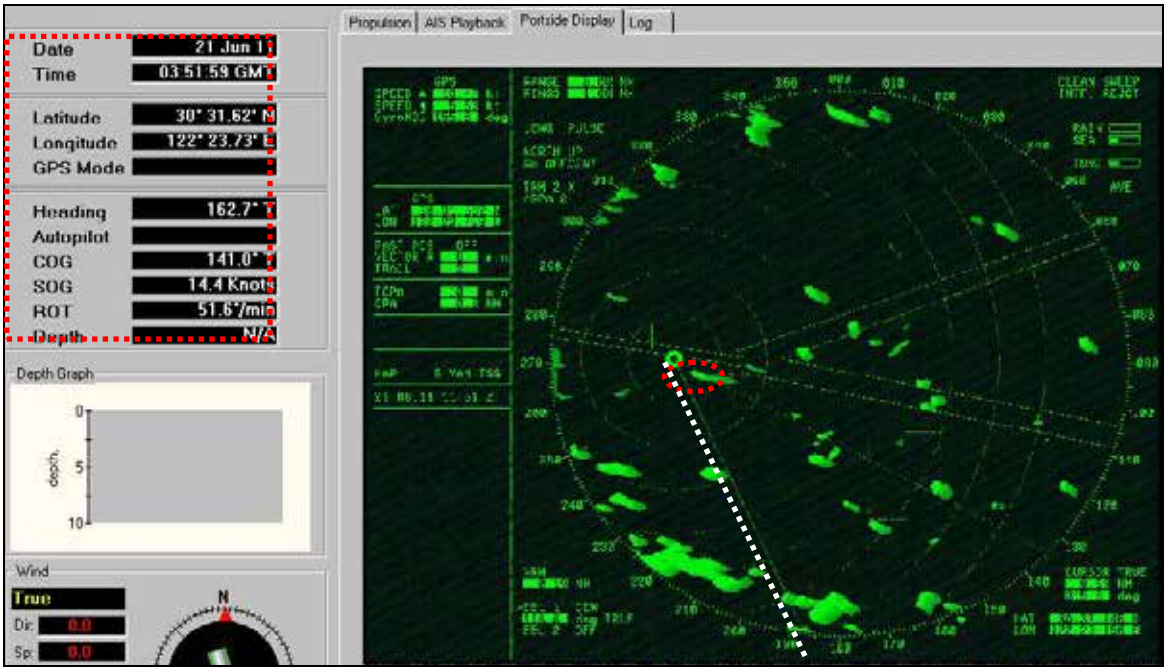

Figure 23: Starboard radar on the CCNI RIMAC at 115159 (S-VDR replay)

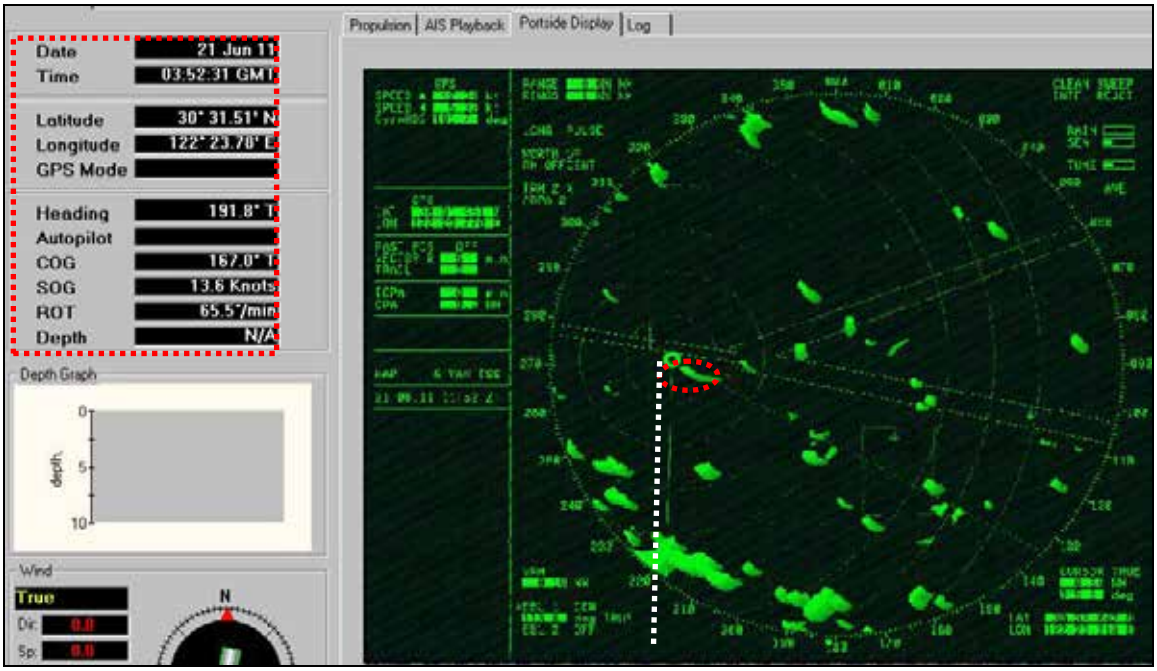

Figure 24: Starboard radar on the CCNI RIMAC at 115231 (S-VDR replay)

At about **115259** (see **Fig. 25** below), the PETORCA's echo merges with the centre of the radar image (RIMAC).[33] The two vessels collide. The repeated distinct continuation of the turn to starboard in the RIMAC's heading line, as compared to Figure 24, proves

[33] The aforementioned collision time could be verified during the analysis of the S-VDR's audio recording.

that the RIMAC tried to prevent the collision with the PETORCA until the very last minute by means of a hard to starboard manoeuvre.

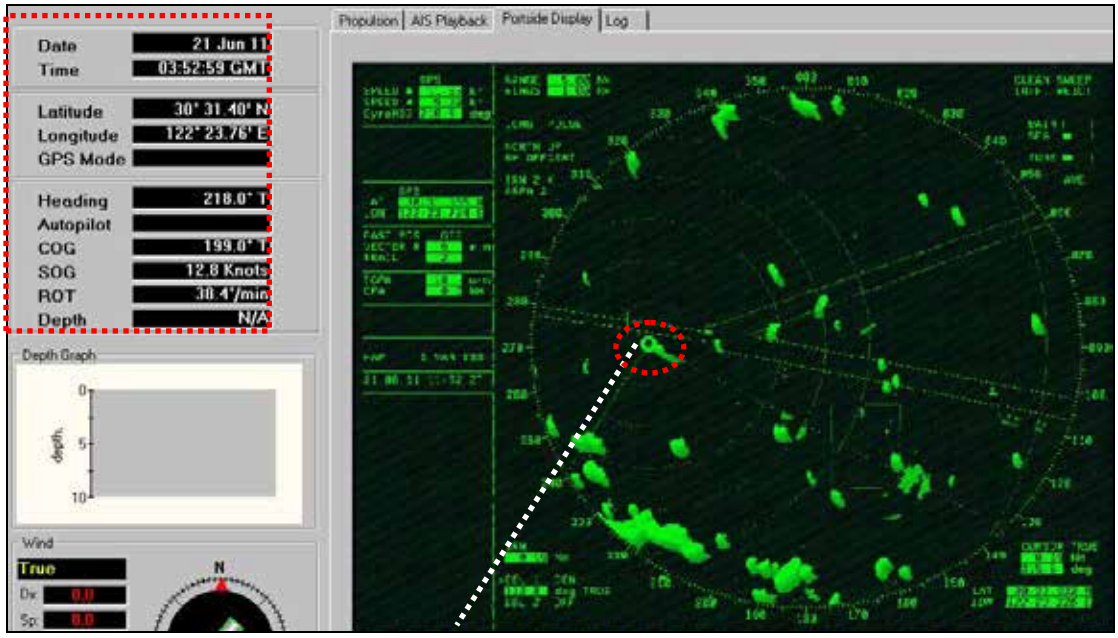

Figure 25: Starboard radar on the CCNI RIMAC at 115259 (S-VDR replay)

3.3.2.2 AIS analysis

As explained above, it was not possible to use the radar image recordings available from the RIMAC's S-VDR to determine the course of the voyage of the PETORCA in detail for lack of ARPA activation on the port radar. However, the replay software has the ability to select individual targets from the AIS data of the AIS targets within the reception area of the RIMAC, which are stored automatically by the S-VDR, and display them with various target information (including COG, SOG, CPA, and TCPA)[34] subsequently.[35]

The analysis of the first non-critical phase of the approach between the two vessels from the perspective of the PETORCA's AIS data (period from about **1130 to 1145**, see **Table 1** below) confirmed that the PETORCA proceeded on the proper (i.e. northern) side of the Yangshan Gang Main Channel to begin with. However, because of the need to respond to craft coming from starboard and at the same time follow the course of the fairway with moderate course alterations[36] to port, the ship's command moved into the southern part of the fairway and then beyond its southern limit at **about 1143**.

[34] The aforementioned parameters are not radar-based but the result of calculations within the system. The ships' speed parameters – which for their part are, inter alia, GPS-based – transmitted by the AIS targets form the starting point for this.

[35] Note: The functionality described and its graphic implementation shown below are available only via the S-VDR's replay software. Therefore, it could not be used on board as a source of information in this (edited) form before the accident.

[36] The lagged COG values had to be referred to for the investigation of the PETORCA's course because the heading values transmitted by AIS, which are actually more meaningful, were obviously incorrect.

With regard to the course of the fairway, it should be noted that the ideal passage from east to west involves a COG of 282 degrees initially, and then after a slight bend, which the PETORCA passed through at about 1145, a course of 279 degrees would have been appropriate according to the nautical chart.

Time	COG (°)	Time	COG (°)	Time	COG (°)	Time	COG (°)
113031	287	113431	266	113831	254	114231	264
113059	286	113459	264	113859	255	114259	265
113131	286	113531	264	113931	254	114331	265
113159	286	113559	264	113959	259	114359	266
113231	287	113631	257	114031	262	114431	267
113259	286	113659	254	114059	262	114459	271
113331	281	113731	254	114131	262	114511	274
113359	272	113759	255	114159	262	114523	277

Spreadsheet 1: Course of the CSAV PETORCA from 113031 to 114523

The merely estimated finding made while analysing the radar image, that the PETORCA made no substantial course alterations and followed the course of the fairway almost parallel to its southern side during the second phase of the approach of the RIMAC (period from about **114530 to 115030,** see **Table 2** below), was reconstructible. With regard to the PETORCA's slight course alteration to port, the same applies to the third and final phase of the approach from about **1151 to 1153** (highlighted in red in **Table 2**).

Time	COG (°)	Time	COG (°)	Time	COG (°)	Time	COG (°)
114531	278	114759	280	115031	281	115131	275
114559	279	114831	279	115051	278	115143	275
114631	282	114859	280	115059	278	115159	275
114659	283	114931	279	115111	276	115231	277
114731	281	114959	280	115123	275	115259	275

Spreadsheet 2: Course of the CSAV PETORCA from 114531 to 115259

The selected screenshots from the 'AIS Playback' display option of the RIMAC's S-VDR (**Fig. 26 ff.**) shown below correspond with the times of the radar images above in section 3.3.2.1, and give a 'bird's eye view' of the second and third phase of the approach of the vessels involved in the collision, in particular.

With regard to interpreting the figures, it should be noted that the heading of the PETORCA in the data window (area highlighted in red to the left of each image), as well as in the form of the graphic alignment of the ship symbol (including solid heading line) are displayed incorrectly. Nonetheless, the other values and their graphic representation, especially the COG of the two vessels (each identified as a dashed line by the system) and the heading of the RIMAC (solid lubber line), are perfectly feasible. It was not possible to establish the cause of the PETORCA's incorrect heading information.

However, it must be assumed that a technical problem in the area of the interface between the PETORCA's gyrocompass (source of the heading information) and the AIS transmitter of the ship is responsible for that.
The BSU dispensed with an extensive analysis and evaluation of the technical problem, as given the circumstances, the inaccurate rendering of the heading values had no influence on the decisions on board the RIMAC, and therefore were not responsible for the accident.

Figure 26: AIS display at 114459 (S-VDR replay)

Figure 27: AIS display at 114703 (S-VDR replay)

Figure 28: AIS display at 114947 (S-VDR replay)

Figure 29: AIS display at 115027 (S-VDR replay)

Figures 30 ff. below vividly demonstrate the consequences of the manoeuvre supposedly agreed on as a result of the radio contact between the two ships, which

finished at about **115027**. While the heading (solid heading line) and gradually[37] also the COG of the RIMAC continuously and rigorously change to starboard, only a slight course alteration to port can be seen in respect of the PETORCA's COG.

Figure 30: AIS display at 115051 (S-VDR replay)

Figure 31: AIS display at 115159 (S-VDR replay)

[37] The delayed change in the COG arises from the fact that the heading can be mapped through the interface to the gyrocompass of the RIMAC more or less in real time, while the COG display is inevitably only the lagged result of dead reckoning carried out by the system.

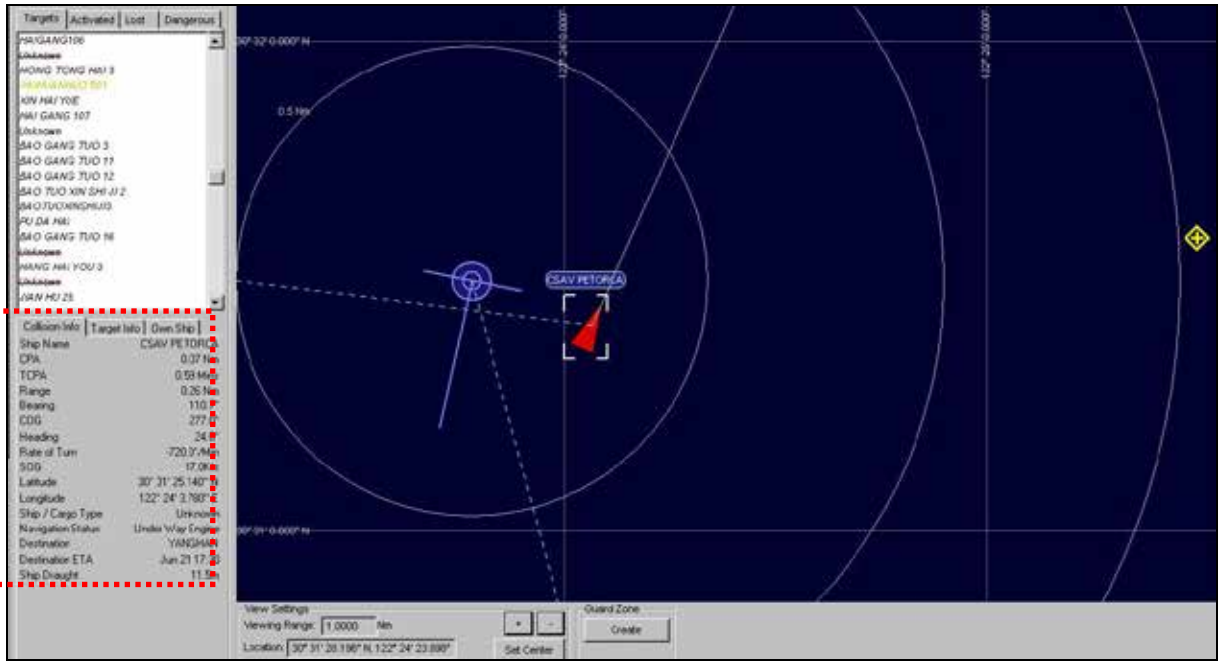

Figure 32: AIS display at 115231 (S-VDR replay)

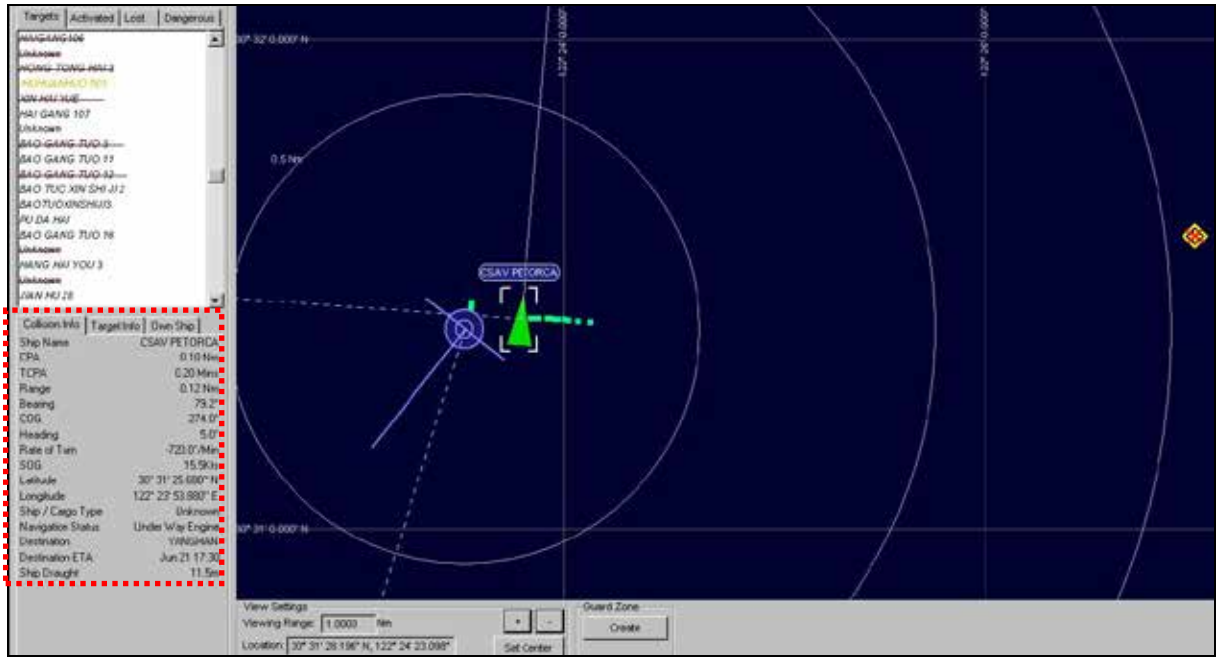

Figure 33: AIS display at 115259 (S-VDR replay)

3.3.2.3 Audio recording

As technically provided for, the RIMAC's S-VDR recorded internal communication on the bridge, as well as the VHF radio traffic continuously.

While the recordings of the bridge microphones were of poor quality in accordance with the previous experience of the BSU, the recording of the VHF radio traffic transmitted and received is largely clear and easy to understand. The analysis of the internal discussions – where this was possible given the significant problems with the

recording – demonstrates appropriately calm and well-organised crisis management by the ship's command of the RIMAC after the collision. The instruction to sound the general alarm shortly before the collision and attempts of the ship's command to make contact with VTS Yangshan immediately after the accident could be easily reconstructed by the BSU using the audio recording of the RIMAC's S-VDR, as well.

In contrast, internal and external communication on the bridge before the accident relevant to the investigation was essentially limited to the VHF messages between the ship's command of the RIMAC and PETORCA listed below. The radio contacts and various discussions after the accident are covered in the table below. The communication of particular relevance to the development of the accident is – as far as clearly understandable – listed in the form of bold information and verbatim quotations.

Spreadsheet 3: Internal and external communication on the CCNI RIMAC (S-VDR replay)

Time (approx.)	***Audible* activity of relevance to the accident and subsequent crisis management**[38]	**Note by the BSU**
114843	VTS Yangshan calls the PETORCA.	No response from the PETORCA.
114851	The VTS calls the PETORCA again.	
114854	The PETORCA acknowledges the call of the VTS.	
114855	**The VTS advises the 'navigator' of the PETORCA that the ship is outside the fairway and a vessel within the fairway is approaching.**	The name 'CCNI RIMAC' is not mentioned. The current distance to the oncoming vessel is not mentioned, either.
114912	**The PETORCA confirms that she is located to the south of the fairway and states that she will move to the northern part of the fairway as soon as the outbound vessel is passed.**	The name 'CCNI RIMAC' is not mentioned again. However, since the RIMAC is the only oncoming vessel open to consideration, there is no doubt that the VTS and PETORCA were discussing the same ship.
114924	**The VTS repeats the statement transmitted by the PETORCA almost verbatim, including the information regarding moving back to within the fairway after passing the oncoming vessel.**	The wording and content of the radio message from the VTS leave no doubt that the VTS explicitly acknowledged the PETORCA's plan and is in agreement with it.
114936	**The PETORCA confirms to the VTS that she will move back into the fairway.**	The context of the confirmation leaves no doubt that the PETORCA and VTS were agreeing on the PETORCA returning to the fairway after the encounter with the RIMAC. With that, the contact between the VTS and PETORCA before the accident is finished.

[38] The table shows only those activities that can be understood in the course of analysing the audio recording. There was undoubtedly more internal communication on the bridge of the RIMAC, especially after the accident; however, the corresponding recording could not be used for lack of quality.

114947	**The ship's command of the RIMAC identifies its ship by name and calls VTS Yangshan.**	No response from the VTS.
114955	The ship's command of the RIMAC identifies its ship by name and calls the VTS again.	
115003	The VTS acknowledges the call and switches to receive for the RIMAC.	
115004	**The ship's command of the RIMAC asks the VTS about the oncoming vessel some 1.5 nm away.**	The name 'CSAV PETORCA' is not mentioned. Given the context, there is no doubt that the question concerned the PETORCA.
115007	The PETORCA identifies herself by name and responds to the question of the RIMAC, stating (verbatim): ***"RIMAC, this is PETORCA. Please your course. I'm already now. I'm coming a little bit more to port. Please keep your course. I'm coming a little bit more to to port."***[39]	Given the circumstances, the PETORCA justifiably felt it concerned her; VTS Yangshan does not continue to participate in the radio contact.
115020	The ship's command of the RIMAC answers (verbatim): ***"Okay, okay, we coming to to starboard, okay, we coming to starboard."***	
115027	Essentially, the PETORCA replies: **"Thanks captain, have a good watch."**	The exact wording of this radio message may differ from the quotation because it was made very quickly and unclearly. However, there is no doubt that the PETORCA confirmed the RIMAC's statement regarding moving to starboard, without recognising or responding to the thus clearly expressed misunderstanding on the part of the RIMAC.
115051	Exclamation on the bridge of the RIMAC: ***"Oh, where he coming?"***	In all likelihood, this concerns the surprised exclamation of the rating or officer on watch after the PETORCA (and direction of her course) came into view at a distance of about 1 nm.
115055	Exclamation on the bridge of the RIMAC: *"Shit!"*	It is not possible to analyse the rest of the communication on the bridge. The internal discussions are drowned out by 'noise' from the VHF radio (irrelevant miscellaneous local traffic) also recorded by the bridge microphones. The recognisable scraps of conversation indicate confusion on the bridge of the RIMAC due to the actions of the PETORCA, which are not consistent with the supposedly agreed manoeuvre.
115203	Exclamation on the bridge of the RIMAC: *"What he is doing?"*	

[39] Note: In each case, the text in italics shown here and below, including any repeated words, are verbatim quotations that have not been edited.

115215	Instruction on the bridge of the RIMAC: *"General alarm! ... general alarm!"*	
115222 to 115258	Ship's command of the RIMAC calls: ***"CSAV PETORCA, CSAV PETORCA, this is RIMAC, what you are doing?"*** **Second call to the PETORCA.** Another instruction to sound a general alarm.	No answer from the PETORCA. Subsequent disquiet on the bridge in anticipation of the imminent collision.
115259	**Collision sounds are clearly audible.**	
115311	The ship's command of the RIMAC identifies its ship by name and calls the VTS to report the collision.	No response from the VTS.
115323	The RIMAC repeats the accident report to the VTS.	
115335	The VTS responds.	The content of the radio message cannot be heard. It probably concerns a call to the PETORCA. It is possible that the VTS erroneously attributed the previous accident report by the RIMAC to the PETORCA.
115347	Internal bridge communication in German: *"Ich bin nach Steuerbord ausgewichen, er ist nach Backbord gegangen." [I moved to starboard to make way, she went to port.]*	
115359	Internal bridge communication in German: *"Wir haben Wassereinbruch." - "Haben wir?" "Kuck mal!" - "Ich geh runter." [We have water ingress. – We have? Have a look! – I'll go down.]*	
115411	Radio message from the ship's command of the RIMAC: ***"CCNI RIMAC, we had a collision with the other ship." "Why you going to port?"***	In the state of agitation, the accident report is evidently linked with a question to the PETORCA.
115423	The VTS calls the PETORCA and asks for confirmation of the collision with the outbound vessel.	The PETORCA does not respond.
115427	The ship's command of the RIMAC responds: ***"We go to starboard, why you go to port? We had a collision. We have a list now."***	Presumably, the ship's command attributed the previous call from the VTS to the PETORCA incorrectly and understood it to be a call from the PETORCA to the RIMAC.
115435	The VTS responds with only one word: *"Otherwise?"*	The question goes unanswered.
115515	The ship's command of the RIMAC identifies its ship by name, calls the VTS again and reports the accident, as well as that the ship is listing to between three and four degrees.	The VTS does not respond.
115531	The VTS calls the PETORCA and switches to receive.	Presumably, the VTS thought the previous call by the RIMAC was made by the PETORCA.
115535	The ship's command of the RIMAC responds and briefly repeats the accident report.	
115539	The PETORCA intervenes in the communication and says – as far as can be heard – the following: ***"CCNI RIMAC on the outbound, we told them, we go to port and they come to starboard."***	

115547	The VTS inquires as to the damage to the vessel.	The question is presumably addressed to the PETORCA.
115548	The ship's command of the RIMAC transmits the following radio message: **"Why you coming to port? You must coming to starboard. There was crazy what you are doing!"**	
115555	The PETORCA replies: ***"No, I was telling that I'm coming to port. You should keep your course, you should keep your course. Okay?"***	
115623	The VTS calls the RIMAC.	
115631	The ship's command of the RIMAC responds and again advises on the list and also the intention to anchor.	
115635	The VTS asks whether the RIMAC wishes to anchor.	
115639	The ship's command of the RIMAC confirms the planned anchor manoeuvre and requests assistance.	
115643	The VTS questions the RIMAC as to the nature of the desired assistance.	
115647	The ship's command of the RIMAC requests the deployment of one or two standby tugs.	No response from the VTS.
115835	The ship's command of the RIMAC calls the VTS and advises that it will stabilise the ship but must return to port.	No response from the VTS.
115839	The VTS asks which vessel had made the call.	The wording of this request is difficult to understand because the RIMAC had previously identified its ship by name clearly, when it called the VTS.
115843	The ship's command of the RIMAC calls and repeats the Ø need to return to port; Ø existence of a list, and Ø request for tug assistance.	
115855	The VTS asks whether the RIMAC has collided with the PETORCA.	It seems as if the operator on duty at the VTS has been replaced and/or that the VTS is still having considerable difficulty attributing the sender (RIMAC or PETORCA) to individual radio messages (and understanding the terminology?).
115855	The ship's command of the RIMAC confirms this.	
115903	The VTS asks the RIMAC which part of the ship touched the PETORCA.	
115907	The ship's command of the RIMAC advises that the PETORCA touched the port side of the RIMAC.	
115911	The VTS asks the RIMAC if she is listing.	This had already been reported by the RIMAC several times.
115915	The ship's command of the RIMAC reports a list, damage to containers, and water ingress on the port side.	
115923	The VTS states that it will contact tugs and send	

	them to the RIMAC.	
120107	**The PETORCA calls the VTS and advises that they have anchored and started to ascertain the damage to their ship.**	The VTS did not respond to this message.
1202 to 1209	The VTS calls the RIMAC several times.	The calls are not responded to on board. The ship's command is – as indicated by the audible scraps of internal communication – apparently predominantly occupied with managing the crisis on the ship and the radio is not continuously manned.
120927	The RIMAC (OOW?) responds to a new attempt at calling by the VTS with the sentence: "Yes, go ahead!"	
120935	The VTS inquires as to the current situation on board the RIMAC.	
120936	The RIMAC (OOW?) briefly summarises the water ingress in cargo hold 5 and the ship's command is notified internally that they had been called by the VTS.	
121003	The RIMAC is called.	The sender of the call is not stated clearly. (Presumably, the VTS made the call.)
121011 to 121059	The ship's command of the RIMAC asks several times on VHF: *"Who is calling CCNI RIMAC?"*	No response.
121103	The ship's command of the RIMAC calls the VTS.	No response.
121219	The RIMAC (OOW?) calls the VTS.	
121227	The VTS responds with a question directed at the RIMAC: *"Do you have any danger, danger with you?"*	
121231	The RIMAC (OOW?) replies by asking: *"Dangerous Cargo?"*	
121239	The VTS operator responds: *"Negative, negative."* *He* apparently seeks the correct English wording and then asks the question: *"How about your condition now?"*	
121247	The RIMAC (OOW?) replies that there is water ingress in cargo hold 5 but no leakage.	The OOW apparently intends to state that no pollutants are escaping.
121251	The VTS acknowledges this information.	
121255	The RIMAC (OOW?) adds that they are in the process of anchoring.	No response from the VTS.
121343	The VTS calls the PETORCA.	
121347	The PETORCA acknowledges the call.	
121348	The VTS asks the PETORCA about the condition of the ship.	
121351	The PETORCA replies that they are in the process of checking the condition and requests 10 minutes to respond.	No response from the VTS.
121403	The PETORCA asks whether the VTS received the message.	
121407	The VTS asks if there is any leakage.	Given the context, the question seems to be directed at the PETORCA.
121410	The PETORCA once again states that they are still in the process of checking (this) and requests five to 10 minutes to respond.	

121423	The VTS confirms the PETORCA's request.	
121611	(VTS?) calls the RIMAC.	No response; the bridge crew is occupied with crisis management.
121839	The HANJIN CHICAGO calls the VTS.	
121847	The VTS switches to receive for the HANJIN CHICAGO.	
121855	The HANJIN CHICAGO reports 14 objects – presumably containers – close to the scene of the collision.	The distance between the HANJIN CHICAGO, approaching from the west, and the RIMAC is 2.6 nm at this point (source: AIS data from the RIMAC's S-VDR). Presumably, the containers in the water were not located physically but by means of radar.
121900	The VTS acknowledges the report of the HANJIN CHICAGO.	
122047	(VTS?) calls the CCNI RIMAC.	
122055	The RIMAC (OOW?) responds to the call.	
122105	The VTS asks the RIMAC if the ship has lost containers.	
122107	The RIMAC (OOW?) confirms that several containers are floating in the water.	
122119	The VTS asks how many.	
122131	The RIMAC (OOW?) considers and then replies that it is not possible to give this information at present.	
122643	The ship's command of the RIMAC calls the VTS.	
122651	The VTS switches to receive for the RIMAC.	
122652	**The ship's command of the RIMAC reports that the list is eliminated, the ship has anchored, and they are awaiting further decisions from the owner and the authorities.**	
122707	The VTS asks again whether RIMAC has anchored.	
122711	The ship's command of the RIMAC advises again that the RIMAC Ø has anchored; Ø was stabilised; Ø is no longer listing; Ø has water ingress in cargo hold 5, and Ø that everything is okay at present.	
122725	The VTS again requests – seeking the correct English wording – information about the condition of the RIMAC.	It is possible that the VTS operator had not understood the clear statements made previously by the RIMAC in every detail due to language difficulties. However, it is also conceivable that the VTS wanted to obtain more information on the situation of the ship and her cargo.
122727	The ship's command of the RIMAC replies that they have a hole in cargo hold 5 on the port side of the ship and two completely destroyed container bays.	
122739	The VTS acknowledges the report and anchor manoeuvre. The RIMAC is requested to switch to and remain on receive.	
122951	The recording of the VDR finishes.[40]	

[40] Note: The prescribed backup of VDR data was probably carried out at that moment, and thus the events of the 12 hours leading up to the activation of the backup stored.

3.3.3 Witness accounts

In the course of investigating the marine casualty, the BSU confined itself to an interview with the master of the RIMAC after his return to Germany, as well as an examination of the statements of fact prepared by the two ship's commands and other documents. Since the course of the accident and main causes of the collision could be reconstructed beyond doubt during the analysis of the RIMAC's S-VDR, it was unnecessary to obtain additional statements or hear other witnesses.

3.3.4 Chart coverage and navigational characteristics

The British paper chart BA 1199 (NINGBO GANG TO CHANGJIANG KOU) at a scale of 1:300000 followed by the (partially overlapping) chart BA 1124 (NORTHERN APPROACHES TO NINGBO GANG INCLUDING YANGSHAN DEEP WATER PORT) at a scale of 1:130000 are available for the eastern approach to the port of Yangshan (see excerpts at **Figs. 34 and 35** below).

Neither of these nautical charts have the scale recommended for an approach to a port (1:30000 to 1:75000).[41] The transition to the at least somewhat better resolution of Chart BA 1124 is located in the middle of the Yangshan Gang Main Channel (see red marking in **Fig. 34 f.**), meaning the scale of the only chart available for use on the eastern part of the fairway was 1:300000.[42]

[41] On the topic of scales in the area of approaches, see the comments in section 7.2.1 of the BSU's Investigation Report 455/05 of 15 January 2007 concerning the Grounding of CMV DORIA shortly after leaving Port Namibe on 20 October 2005.

[42] The ship's command of the RIMAC used an ECS for navigation. Technically, the ECS could only be used to supplement the paper chart because this was not an approved ECDIS system, however.

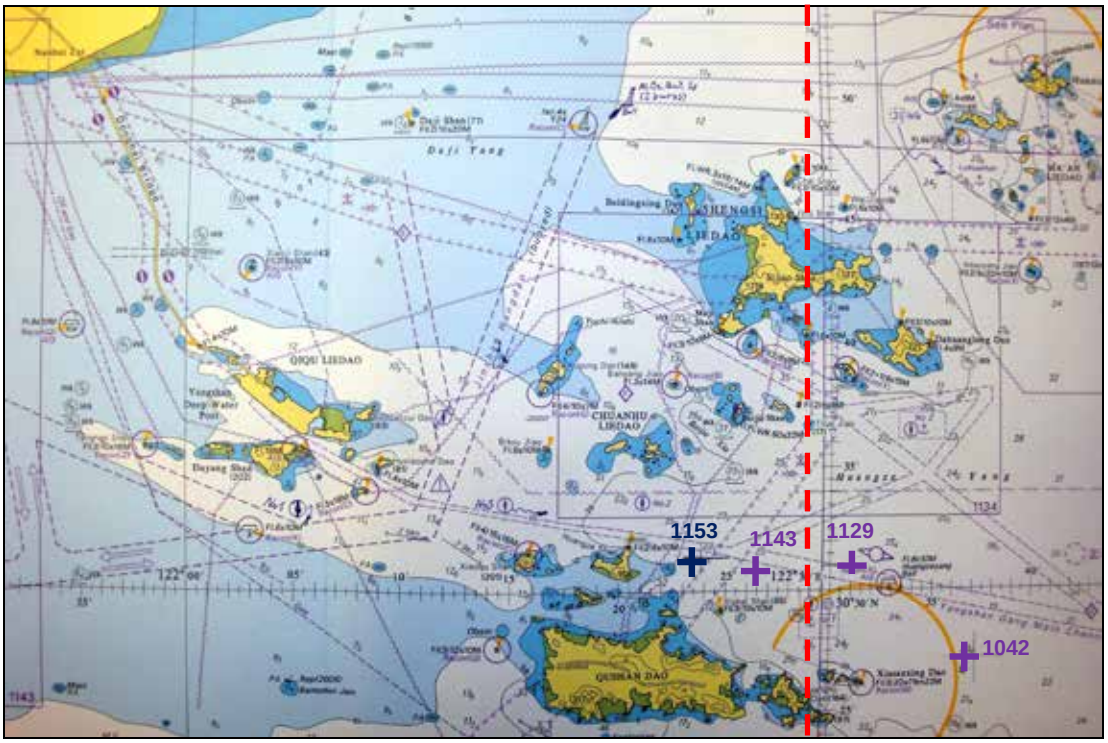

Figure 34: Excerpt of BA Chart 1199[43]

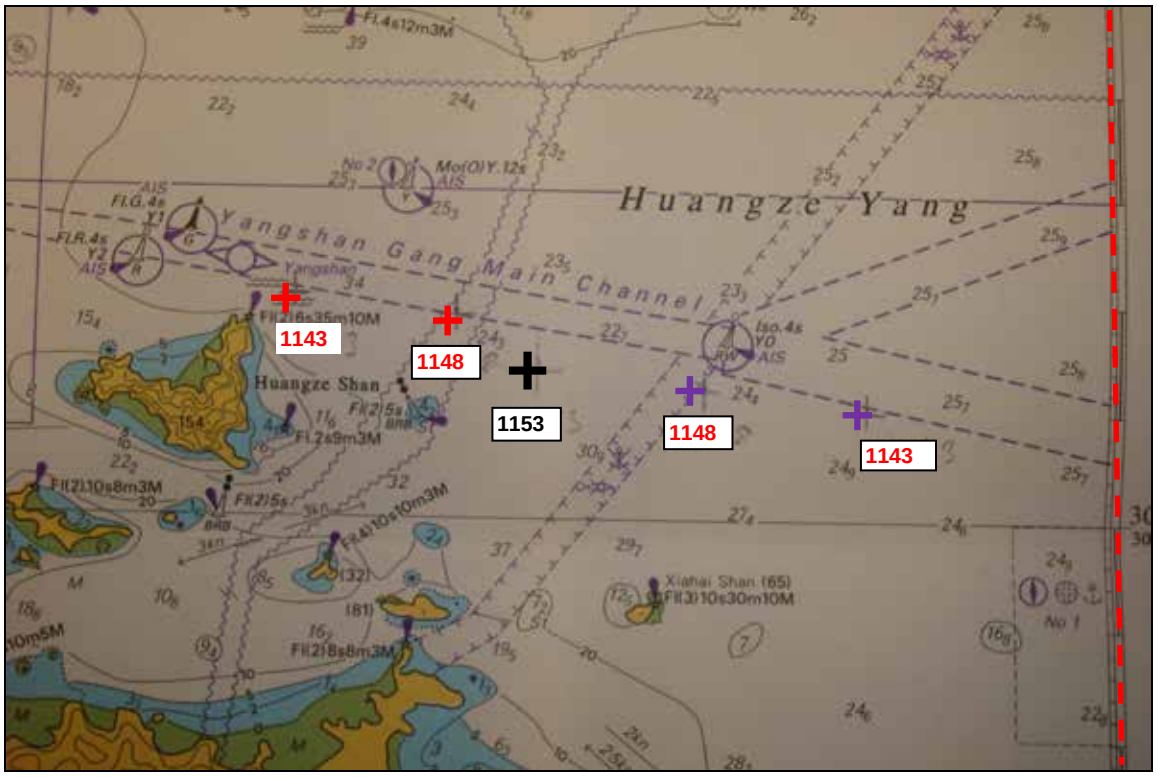

Figure 35: Excerpt of BA Chart 1124[44]

[43] The excerpt of the nautical chart serves only to illustrate the navigational characteristics. See also the copyright information at the end of the report. Red marking at the chart transition and selected positions of the PETORCA (purple) and scene of the accident (black) in the excerpt of the chart made by the author of the investigation report.

[44] See comment in the preceding footnote. Selected positions of the RIMAC highlighted in red.

The charts referred to indicate that Yangshan Gang Main Channel, of relevance to the eastern approach to the port of Yangshan, is only between 0.2 and 0.3 nm wide in places. Given the high density of traffic in this area and possible obligation to give way to crossing traffic, approaching the port of Yangshan from the east or leaving it to the west without possibly being at least temporarily forced to leave the boundaries of the fairway plotted in the chart seems practically impossible.

3.3.5 Weather and visibility conditions[45]

The Federal Bureau of Maritime Casualty Investigation requested an official report on the weather conditions and visibility in the area of the accident from the Maritime Consulting department of Germany's National Meteorological Service. The report confirms the very calm weather conditions and restricted visibility due to light precipitation and fog at the time of the accident. Although visibility of 3.5 km is presumed, it should be noted that this information is based solely on the observation data of individual weather stations in the greater Shanghai area. Moreover, the sudden formation of localised fog banks that may cause the acute deterioration in visibility from 2 nm to less than 1 nm described by the ship's command of the RIMAC is not unusual at sea, in particular.

3.3.6 Competence of the ship's commands, fatigue, influence of alcohol

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

[45] Source: Official report of 25 August 2011 on the weather conditions at about 0352 UTC on 21 June 2011 in the area of the Hangzhou Bay approach, Shanghai, China.

4 ANALYSIS

4.1 Action taken on board the two vessels before the collision

The course of the voyage of the two vessels could be reproduced beyond doubt using the radar images and AIS data stored in the RIMAC's S-VDR.

Time	CCNI RIMAC					CSAV PETORCA				CPA (nm)	TCPA (min)
	VDR on the CCNI RIMAC (GPS/gyrocompass on the ship)					VDR on the CCNI RIMAC (AIS data from the CSAV PETORCA)					
	Position		SOG (°)	COG (°)	HDG (°)	Position		SOG (°)	COG (°)		
	φ	λ				φ	λ				
114259	30°32.2'N	122°21.1'E	15.2	100.0	101.1	30°31.1'N	122°27.2'E	17.5	265	0.89	9.87
114331	30°32.2'N	122°21.2'E	15.3	101.0	100.6	30°31.1'N	122°27.0'E	17.5	265	0.85	9.34
114359	30°32.1'N	122°21.3'E	15.5	100.0	099.8	30°31.1'N	122°26.9'E	17.6	266	0.84	8.76
114431	30°32.1'N	122°21.5'E	15.6	099.0	100.0	30°31.1'N	122°26.7'E	17.6	267	0.83	8.20
114459	30°32.1'N	122°21.6'E	15.8	100.0	101.2	30°31.1'N	122°26.5'E	17.6	271	0.62	7.72
114531	30°32.1'N	122°21.8'E	15.9	101.0	101.8	30°31.1'N	122°26.4'E	17.6	278	0.31	7.23
114559	30°32.0'N	122°21.9'E	16.0	101.0	101.2	30°31.1'N	122°26.2'E	17.6	279	0.28	6.73
114631	30°32.0'N	122°22.1'E	16.1	099.0	100.3	30°31.1'N	122°26.0'E	17.5	282	0.20	6.22
114659	30°32.0'N	122°22.3'E	16.1	098.0	102.0	30°31.2'N	122°25.9'E	17.5	283	0.23	5.74
114731	30°32.0'N	122°22.4'E	16.2	102.0	104.7	30°31.2'N	122°25.7'E	17.4	281	0.18	5.23
114759	30°31.9'N	122°22.6'E	16.3	103.0	105.6	30°31.2'N	122°25.5'E	17.3	280	0.18	4.73
114831	30°31.9'N	122°22.7'E	16.4	104.0	107.2	30°31.3'N	122°25.4'E	17.3	279	0.18	4.22
114859	30°31.9'N	122°22.9'E	16.5	106.0	109.1	30°31.3'N	122°25.3'E	17.3	280	0.11	3.83
114931	30°31.8'N	122°23.1'E	16.6	109.0	111.4	30°31.3'N	122°25.0'E	17.3	279	0.09	3.21
114959	30°31.8'N	122°23.2'E	16.7	109.0	104.2	30°31.3'N	122°24.9'E	17.3	280	0.05	2.71
115031	30°31.7'N	122°23.3'E	16.2	098.0	096.3	30°31.4'N	122°24.7'E	17.3	281	0.18	2.27
115059	30°31.7'N	122°23.5'E	16.0	091.0	110.5	30°31.4'N	122°24.6'E	17.1	278	0.30	1.71
115131	30°31.7'N	122°23.6'E	15.2	117.0	138.7	30°31.4'N	122°24.4'E	17.0	275	0.14	1.40
115159	30°31.6'N	122°23.7'E	14.4	141.0	162.7	30°31.4'N	122°24.2'E	17.1	275	0.03	0.99
115231	30°31.5'N	122°23.8'E	13.6	167.0	191.8	30°31.4'N	122°24.1'E	17.0	277	0.07	0.59
115259	30°31.4'N	122°23.8'E	12.8	197.0	216.7	30°31.4'N	122°23.9'E	15.8	275	0.10	0.24
115331	30°31.3'N	122°23.7'E	12.8	225.0	207.8	30°31.4'N	122°23.8'E	12.7	260	0.11	-0.22
111159	30°30.9'N	122°24.0'E	0.0	359.0	057.7	30°31.2'N	122°23.3'E	0.0	214	./.	./.

Spreadsheet 4: Phases of the approach of the two vessels involved in the collision[46]

The speed parameters of the two ships in the 10 minutes leading up to the collision listed in **Table 4** above illustrate the three crucial stages of the approach (separated by red lines) based on the courses and changes in CPA/TCPA (fields outlined in green).

It is likely that the RIMAC initially tried to implement a port side to port side ('red-red') encounter with the PETORCA by making moderate course alterations to starboard. The RIMAC probably interpreted the PETORCA's initial continuous course alteration to starboard as her action in mirror image.

[46] Source: S-VDR on the RIMAC.

Viewed objectively, the approach gradually developed into a dangerous situation from about **1145** (phase 2), as the PETORCA made no further significant course alterations to starboard, which were essential for a 'red-red' encounter.

Two possible explanations for the RIMAC's temporary course alteration to port between **1149** and **1150** come into consideration. Either the ship's command of the RIMAC now prepared for a starboard side to starboard side pass ('green-green') because of the lack of further course alterations to starboard by the PETORCA or it was simply a question of the RIMAC not deviating too far to the south of the course of the fairway.

The master of the RIMAC gave the BSU to understand that he always aimed to act in strict accordance with the rules. He reportedly believes that to put into effect the obligations arising from Rule 19 (d) (i) COLREGs[47], it is perfectly logical to avoid a course alteration to port in respect of a vessel (detected only by radar) forward of the beam.
According to this standpoint, only the objective of not leaving the fairway could be applicable as a reason for the interim course alteration to port, and not making way for the PETORCA.

The misunderstanding between the ship's command of each vessel came into the thick of the objective uncertainty about the manner in which the forthcoming encounter would take place, as described above, which was the final cause of the collision. The starting point for this was the justified intervention of VTS Yangshan, which apparently recognised the emerging hazardous situation, and therefore addressed the PETORCA at **114855** with the advice (or warning) that she is located outside the fairway and a vessel is approaching her.
The ship's command of the PETORCA then consulted with the VTS between **1149 and 1150** and stated they would return to the fairway only after the oncoming vessel (RIMAC) had passed. However, for reasons that are almost impossible to comprehend, the two communicating parties failed to inform the RIMAC about the 'green-green' pass – occurring in less than three minutes – which stood in contrast to the 'red-red' encounter usually practised on fairways and, in particular, contravened Rule 19 COLREGs.

It is unclear whether the ship's command of the RIMAC had followed the aforementioned exchange of information in every detail. This is opposed by the fact that the name 'CCNI RIMAC' was not mentioned at any time during the communication in question. This may have precluded special attention to the contact between the PETORCA and the VTS. However, at least partial recognition is suggested by the fact that the PETORCA – whose name had been clearly stated several times during the VHF contact in question – was identified by the ship's command of the RIMAC a few minutes earlier via AIS by name as the vessel soon to be encountered.

[47] COLREGs: International Rules of 1972 for the Prevention of Collisions at Sea.

Also the fact that the RIMAC called the VTS at **114947** immediately after the contact pertaining to her between the VTS and PETORCA and asked about the intentions of the oncoming vessel is an indication that the personnel on the bridge of the RIMAC had at least partially registered that the VTS and PETORCA had discussed passing the RIMAC soon afterwards.

As shown by the further course of events, the radio contact between the RIMAC and PETORCA from about **1150** resulted in an agreement between the two ship's commands on the forthcoming encounter only on the face of it.

The entirely contradictory conversation

PETORCA: *"RIMAC, this is PETORCA. Please your course. I'm already now. I'm coming a little bit more to port. Please keep your course. I'm coming a little bit more to to port."*

RIMAC: *"Okay, okay, we coming to to starboard, okay, we coming to starboard."*

PETORCA: *"Thanks captain, have a good watch."*

is hard to explain.

In all likelihood, a discrepancy between the spoken word and respective actual and firmly established intentions was responsible for the ill-fated misunderstanding between the two parties.

As described above, the master of the RIMAC convinced the BSU that he believed observance of the COLREGs, in particular the 'iron rule' to avoid a course alteration to port as part of collision prevention in all circumstances, had absolute primacy. The reply *"Okay, okay, we coming to starboard, okay, we coming to starboard."* can be interpreted as evidence of this standpoint. It would seem that the thoughts of the master of the RIMAC were so focused on the alteration of course to starboard, for which he believed, pursuant to Rule 19, there was no alternative, that he 'confirmed' and then immediately and rigorously initiated one without registering that the PETORCA had not requested a course alteration to starboard from him.

In contrast, the PETORCA had apparently already believed for some time that because of her course next to the southern edge of the fairway and in the light of the oncoming RIMAC within the narrow fairway, a mutually agreed green-green pass with the RIMAC was perfectly logical. This belief that it was 'perfectly logical' is supported by the fact that the ship's command of the PETORCA saw no reason to inform the RIMAC about the imminent green-green pass.
Even the query of the VTS, for which the plan of the PETORCA – discussed exhaustively between the VTS and PETORCA at about **114945** – was apparently (similar to the RIMAC) not so logical, did not prompt the ship's command of the PETORCA to make contact with the RIMAC.

At this point, both vessels were only 1.7 nm away from each other, the TCPA and CPA were three minutes and 0.04 nm[48] respectively, and it should have been clear to the ship's command of the PETORCA that Rule 19 COLREGs actually obliged the oncoming RIMAC to start a course alteration to starboard in just a few moments. That the PETORCA saw no reason for it to call the RIMAC to affirm the green-green pass despite these facts can only be explained by the fact that they were absolutely confident on the bridge of the PETORCA that a tacit agreement on the manner in which the forthcoming encounter would take place had already been made with the RIMAC.

This subjective, mentally entrenched perspective of the ship's command of the PETORCA is probably the definitive explanation for them not or no longer registering the RIMAC's statement to move to starboard, which absolutely opposed a green-green pass, and passing on its thanks for the opposite of that previously discussed with the VTS and requested from the RIMAC shortly after, instead of intervening immediately with rigorous action.

Given the restricted visibility in the congested voyage segment, one must critically question whether the speed of the two vessels (RIMAC about 16 knots and PETORCA about 17.5 knots) is fully consistent with Rule 6 and Rule 19 (b) COLREGs. However, an allowance must be made for the fact that a reduction in speed would also entail a loss in manoeuvrability. Particularly relevant in the context of those made to prevent a potential collision is the fact that alterations in course are more time consuming at lower speeds; therefore, they need to be initiated earlier. However, in heavily congested voyage segments, this may lead to other dangerous approaches. Therefore, in retrospect it is – providing the speed chosen remains within a reasonable range – difficult to make a reliable statement on the speed at which the RIMAC and the PETORCA should have proceeded in order to comply with the essence and purpose of the aforementioned rules to the fullest possible extent.

4.2 Action taken on board the two vessels immediately before the collision

Immediately after the radio contact between the RIMAC and PETORCA, the RIMAC started the rigorous course alteration to starboard, which was objectively consistent with Rule 8 (b) and Rule 19 (d) COLREGs and even announced on VHF. About half a minute later and thus about two minutes before the subsequent collision, the PETORCA was visible on the bridge of the RIMAC. Since – as opposed to its verbal "Okay" – the ship's command of the RIMAC had not mentally absorbed the PETORCA's request to pass green-green, the confusion on the bridge of the RIMAC caused by the PETORCA's unexpected turn towards her is understandable. At this point, the RIMAC was already implementing a course alteration to starboard, which as collision prevention measure number 1 is preferable from an objective viewpoint.

[48] Source: AIS-based data from the RIMAC's S-VDR.

Therefore, apart from an emergency stopping manoeuvre, the ship's command of the RIMAC had no other options for an effective collision prevention measure. The absence of an immediate stopping manoeuvre is likely to have arisen from the hope that for her part the PETORCA would still alter her course to starboard in accordance with the presumed arrangement and in so doing remedy the hazardous situation at the very last moment.

While – at least from the subjective viewpoint of the RIMAC – it is explainable that the accident was more or less impossible to prevent on the RIMAC's bridge as a result of the supposedly taken manoeuvring arrangement, the remaining 2.5 minutes, and the adherence to Rule 19 (d) COLREGs, the inevitability of the collision is more difficult to understand from the perspective of the PETORCA. Indeed, the assumption on the bridge of the PETORCA was, more than ever, a forthcoming green-green pass with the RIMAC because of the supposed agreement. Of course, this does not absolve the ship's command of the PETORCA of its duties under Rule 5 and Rule 7 COLREGs to monitor the sea area properly, close range in particular, on the assumption of the need to avoid risk of collision, however. In the course of using the radar unit, the RIMAC's rigorous alteration of course to starboard initiated immediately after the end of the radio contact, which was diametrically opposed to the supposed arrangement, should have been noticed and led to an immediate response. Instead, the ship's command of the PETORCA seemed to stick to its planned green-green pass with the RIMAC until the very end purely on the basis of the supposed arrangement and without considering the actual and clearly disparate events.

4.3 Ship-based and shore-based crisis management immediately after the collision

As far as could be determined by the BSU based on the RIMAC's S-VDR recordings, crisis management on the two vessels was marked by a high degree of professionalism. Effective measures in relation to the water ingress in cargo hold 5 and associated list were taken on board the RIMAC quickly. The PETORCA conducted an analysis of the damage immediately, too.

The analysis of the VHF radio traffic after the accident using the S-VDR recordings revealed that VTS Yangshan, most likely due to language difficulties, experienced problems in coordinating properly the flow of information between the vessels involved in the collision on one hand, and the VTS on the other. Although both ships generally stated the sender and recipient clearly when transmitting their radio messages, errors in identifying the sender or intended recipient of messages repeatedly occurred between the communicating parties. Presumably, the name prefixes of the two vessels, 'CCNI' and 'CSAV', which sound dissimilar but still complicate communication, played a significant role in this regard.

5 CONCLUSIONS

Due to a lack of detailed information with respect to the PETORCA, the investigation of the marine casualty had to be limited to the analysis of data provided by the owner of the RIMAC, the S-VDR recordings in particular.
The analysis of these recordings made for extensive clarification of the reasons behind the marine casualty, however. Ultimately, the cause of the collision between the two vessels can be summarised in one sentence: Rather than hearing what was actually said when the manoeuvre was arranged, the ship's command of each ship heard what – based on the respective subjective opinion of the situation – was expected to be the only correct statement and already planned subjectively.

Once more, the finding that manoeuvring arrangements made to prevent collisions are very problematic and for various reasons involve the risk of ill-fated misunderstandings was confirmed.[49] It would appear that this is true even when there are no doubts as to the identity of the communicating parties and immediate verification of the implementation of (supposed) agreements is easily possible using modern technology (ARPA, AIS).

Once again, the collision between the RIMAC and PETORCA illustrates[50] that the risks inherent in any close-quarters situation – in restricted visibility, in particular – should never be underestimated. Within just a few minutes, a situation that appeared relatively uncomplicated only eight minutes before the subsequent accident developed into a collision, which could have claimed human lives had the course of events been less favourable.

Since the findings made were already the subject of investigations by the BSU, the publication of safety recommendations does not appear necessary, and the situation on the bridge of the PETORCA could not be clarified by the BSU in detail for lack of VDR recordings, the BSU is confining itself to the publication of this summary investigation report.

[49] On the same issue, see: Joint investigation report by the Marine Accident Investigation Branch (MAIB) and the BSU of 1 March 2006 concerning the collision between the MV WASHINGTON SENATOR and MV LYKES VOYAGER in the Taiwan Strait on 8 April 2005.
[50] See the BSU's Summary Investigation Report 304/10 of 15 October 2011 concerning the collision between the CMV JULA S and MV ZENITH WINNER on 24 July 2010 about 25 nm east of Tianjin.

6 SOURCES

- Written statements, documents and photos
  - Ship's command of the CMV CCNI RIMAC
  - Owner of the CMV CCNI RIMAC
  - Ship's command of the CSAV PETORCA
  - Owner of the CSAV PETORCA
- S-VDR recording of the CMV CCNI RIMAC
- Internet research (inter alia, analysis of Chinese newspaper articles about the marine casualty)
- Official report on the weather conditions at about 0352 UTC on 21 June 2011 in the area of the approach to Hangzhou Bay, Shanghai, China, by Germany's National Meteorological Service, Hamburg
- Nautical charts and ship particulars, Federal Maritime and Hydrographic Agency (BSH)
- BA chart numbers 1124 and 1199

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[51] Copyright Act of 9 September 1965 (BGBl. (Federal Law Gazette) I p. 1273), amended most recently by Article 1 of 1 October 2013 (BGBl. I p. 3728); The Copyright, Designs and Patents Act 1988, as amended by The Copyright and Related Rights Regulations 2003 (entry into force 31 October 2003).