Bundesstelle für Seeunfalluntersuchung
Federal Bureau of Maritime Casualty Investigation
Federal Higher Authority subordinated to the Ministry of Transport, Building and Urban Affairs

Investigation Report 305/06

Serious Marine Casualty

Collision between M/V LASS URANUS and M/V XIN FU ZHOU on 12 July 2006 on the Elbe River

2 May 2008

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The investigation was conducted in conformity with the law to improve safety of shipping by investigating marine casualties and other incidents (Maritime Safety Investigation Law - SUG) of 16 June 2002.

According to this the sole objective of the investigation is to prevent future accidents and malfunctions. The investigation does not serve to ascertain fault, liability or claims.

The present report should not be used in court proceedings or proceedings of the Maritime Board. Reference is made to art. 19 para. 4 SUG.

The German text shall prevail in the interpretation of the Investigation Report.

Issued by:
Bundesstelle für Seeunfalluntersuchung - BSU
(Federal Bureau of Maritime Casualty Investigation)
Bernhard-Nocht-Str. 78
20359 Hamburg
Germany

Head: Jörg Kaufmann
Fon: +49 40 31908300   Fax: +49 40 31908340
posteingang-bsu@bsh.de   http://www.bsu-bund.de

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1 Summary of the Marine Casualty

On 12 July 2006 towards 1426[1] the dry bulk cargo vessel LASS URANUS, proceeding down the Elbe River under German flag, collided with the Chinese flagged large container vessel XIN FU ZHOU, also proceeding down the Elbe, between buoys 132 and 130 off Finkenwerder.

Under good weather and visibility conditions the XIN FU ZHOU sailed behind the LASS URANUS, when suddenly the only Schottel propulsion system operated on board the LASS URANUS failed. After losing her forward propulsion and manoeuvrability, the LASS URANUS, which had kept to the right of the fairway, was unable to undertake effective measures to counter the hydrodynamic forces (suction and displacement streaming) generated during the XIN FU ZHOU's subsequent overtaking. In addition, during the overtaking both downstream vessels came upon the large container ship MSC MELISSA, sailing under Panama flag with destination Hamburg. The passage of the two large container ships, both of which were sailing under pilot's advice, took place at a distance of only approx. 38 m at the same time as the overtaking on a fairway section providing a width of 220 m.

The LASS URANUS turned with its bow to port towards the overtaking vessel, ultimately colliding with it at an angle of almost 80°. The bow of the LASS URANUS was significantly dented when it tore the starboard side hull plating of the XIN FU ZHOU over a length of eight meters above the waterline. Both vessels retained buoyancy and were able to proceed without assistance.

There were no personal injuries and no environmentally harmful substances were released as a result of the casualty.

[1] All times mentioned in the report refer to Central European Summer Time (CEST) = Universal Time (UTC) + 2 hours.

2 Scene of the Accident

Type of event:	Serious Marine Casualty, Collision
Date/Time:	12 July 2006
Location:	Hamburg
Latitude/Longitude:	φ 53° 32,8' λ 009° 50,9'

Section from the Chart 48, INT 1455, Federal Maritime and Hydrographic Agency (BSH)

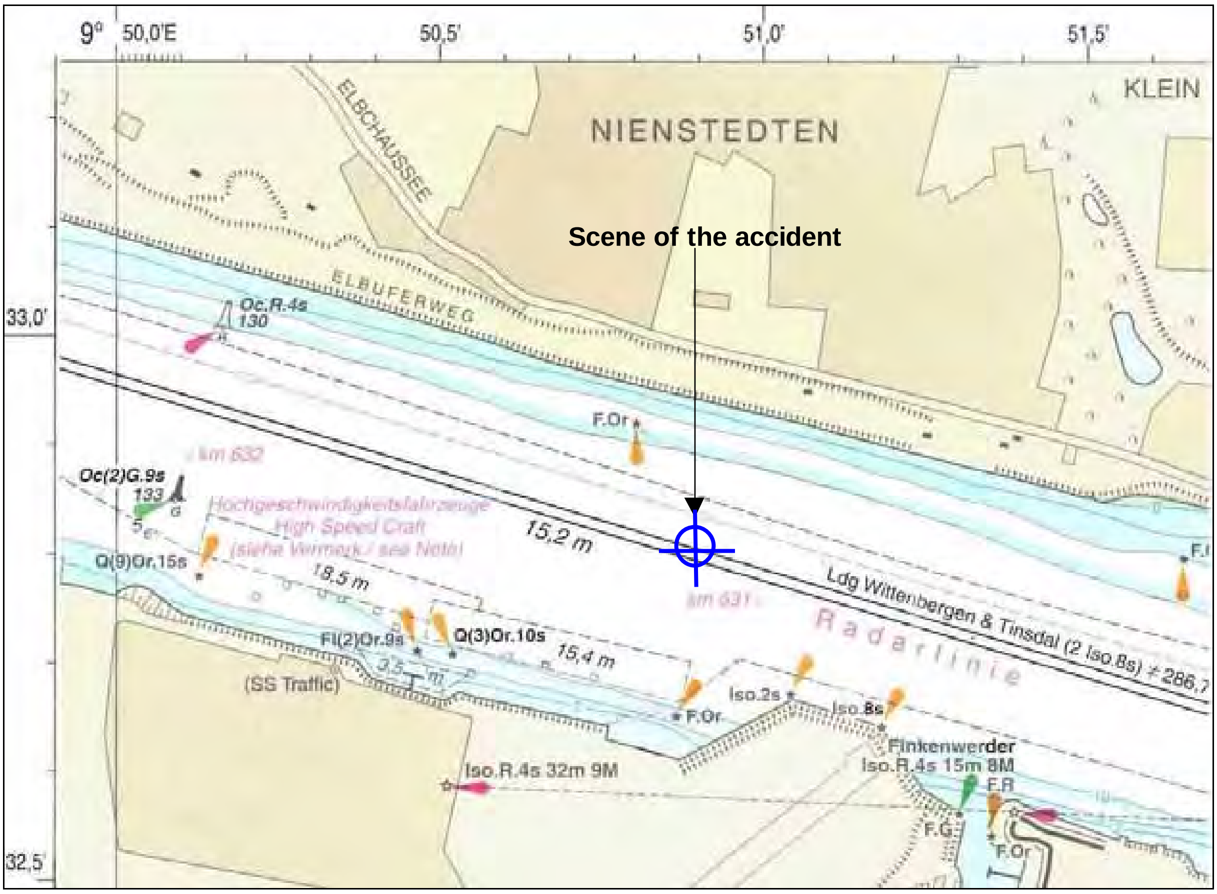

Figure 1: Nautical Chart

3 Vessel Particulars

3.1 LASS URANUS

3.1.1 Vessel photograph

Figure 2: Vessel photograph LASS URANUS

3.1.2 Vessel particulars

Name of the vessel:	LASS URANUS
Type of vessel:	Dry cargo vessel
Nationality/flag:	Germany[2]
Port of registry:	Rostock
IMO number:	9030498
Call sign:	DQFL
Shipping company:	S.K.R. Reederei GmbH, Hamburg
Year built:	1992
Shipyard/yard number:	Rosslauer Schiffswerft GmbH / 234
Classification society:	Germanischer Lloyd AG
Length overall:	74.94 m
Breadth overall:	11.39 m
Gross tonnage:	1,512
Deadweight:	2,377 t
Draft at time of accident:	4.45 m
Engine rating:	600 kW
Main engine:	2 Cummins 12 cylinder diesel, KT 38 M
Service Speed:	10 kn, 6.5 - 7 kn with one engine
Crew:	5

[2] Meanwhile the LASS URANUS changed registry (Portugal/Madeira).

3.1.3 Vessel's propulsion and manoeuvring parameters

The LASS URANUS’ propulsion system consists of two independent Cummins 12 cylinder four stroke diesel engines. Originally the total nominal output for both engines together was 1,194 kW at a nominal 1,800 rpm. However, in 2000 the nominal engine output was reduced to a total of 600 kW. Therefore, for each engine an output of 300 kW remained (cf. para 6.3.2.1).

In addition, the engine plant comprises two auxiliary diesel engines and an emergency and harbour diesel engine, all equally manufactured by Cummins, as well as a bow thruster. The 6 BT 5.9 G auxiliary diesel engines each provide 107 kW at a nominal 1,800 rpm. The emergency and harbour diesel set consists of a Cummins 4 B 3.9 G (44 kW nominal output at 1,800 rpm) and a LSA 42 L8L Leroy Somer generator. The shaft generators originally fitted on board had been removed in 2000.

Each of the main Cummins engines acts on a Schottel SRP 330 rudder propeller. Rudder propellers are combined propulsion and steering systems. The stepless 360° azimuthal rotation of these propellers enables their propulsion output to be used also for manoeuvring and positioning the freighter. The revolution speed of the two right-handed rudder propellers is continuously adjustable. According to measurements taken, the diameter of the propellers is 1,500 mm each.

The bridge of the LASS URANUS is equipped among other things with GPS, AIS and two daylight radar systems.

3.2 XIN FU ZHOU

3.2.1 Vessel photograph

Figure 3: Vessel photograph XIN FU ZHOU (after the collision)

3.2.2 Vessel particulars

Name of the vessel:	XIN FU ZHOU
Type of vessel:	Container vessel
Nationality/flag:	People's Republic of China
Port of registry:	Shanghai
IMO number:	9304796
Call sign:	BPBE
Shipping company:	China Shipping Container Lines Co., Ltd.
Year built:	2004
Shipyard/yard number:	Hudong-Zhonghua Shipbuilding Co., Ltd., Shanghai / H1353A
Classification society:	China Classification Society
Length overall:	279.9 m
Breadth overall:	40.3 m
Gross tonnage:	66,452
Deadweight capacity/tonnage (DWT):	69,235 t
Draft at time of accident:	12 m
Engine rating:	60,192 kW
Main engine:	MAN B&W 12K90MC-C 12 cylinder diesel
Service Speed:	26 kn
Crew:	22 + 1 pilot

3.2.3 Vessel's propulsion and manoeuvring parameters

The XIN FU ZHOU is powered by a MAN B&W 12 cylinder diesel engine with a nominal performance of 60,192 kW at 107.4 rpm. Vessel propulsion is by means of a fixed right-handed propeller. The vessel also has a bow thruster of 2,200 kW rating.

The rudder system comprises a semi-spade type rudder with a maximum rudder angle of 35°. The time needed to change from the "hard-a-port" to "hard-a-starboard" rudder position and vice-versa (hard over to hard over) is 26 seconds.

The bridge of the XIN FU ZHOU is equipped, among other things, with GPS, AIS, Voyage Data Recorder (VDR), Electronic Chart Display and Information System (ECDIS) and two radar systems.

3.3 MSC MELISSA

3.3.1 Vessel photograph

Figure 4: Vessel photograph MSC MELISSA

3.3.2 Vessel particulars

Name of the vessel:	MSC MELISSA
Type of vessel:	Container vessel
Nationality/flag:	Republic of Panama
Port of registry:	Panama
IMO No.:	9226918
Call sign:	H9VY
Shipping company:	MSC Mediterranean Shipping Co. S.r.l.
Year built:	2002
Shipyard/yard number:	Hyundai Heavy Industries Co. Ltd., Ulsan/ H1352
Classification society:	Germanischer Lloyd AG
Length overall:	303.89 m
Breadth overall:	40 m
Gross tonnage:	73,819
Deadweight:	85,786 t
Draft at time of accident:	10 m
Engine rating:	57,100 kW
Main engine:	Hyundai 10 K 98 MC-C
Service speed:	24 kn

4 Course of the Accident

4.1 External conditions at the time of the accident

At the time of the accident, in addition to the vessels involved in the collision – the LASS URANUS and the XIN FU ZHOU – and the oncoming vessel MSC MELISSA there were two other vessels in the relevant section of the Elbe River. Shortly before the passage of the MSC MELISSA and the XIN FU ZHOU the tug TUMAK had made fast at the stern of the MSC MELISSA. Equally travelling upstream was the pilot launch LOTSE 1, which - only a few seconds before the collision - had proceeded through between the LASS URANUS, which was already turning to port, and the XIN FU ZHOU (cf. fig. 5).

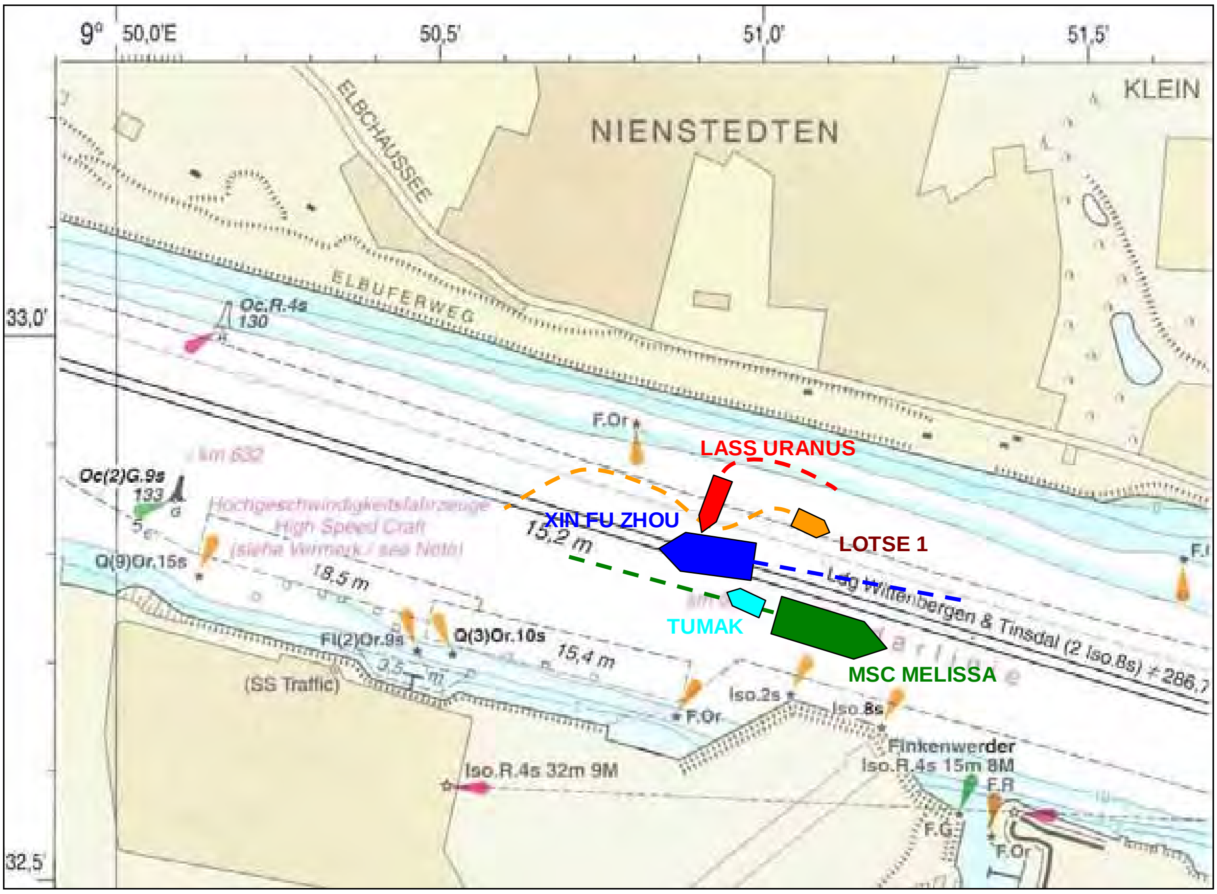

Figure 5: Illustration of the courses followed by the vessels at the scene of the accident

Weather conditions were good. Visibility was clear with a light breeze of 2 Bft. The collision took place one hour and 15 minutes after low water at the Seemannshöft tide gauge. There was therefore a flood current of increasing strength.

On behalf of the BSU, the Federal Waterways Engineering and Research Institute (BAW) retraced the current speed prevailing in the relevant section of the Elbe River on the day of the accident. Tide curves corresponding to the Seemannshöft tide gauge on the day of the accident, obtained from previously carried out simulations of Elbe River hydrodynamics, were used for this purpose (cf. fig. 6).

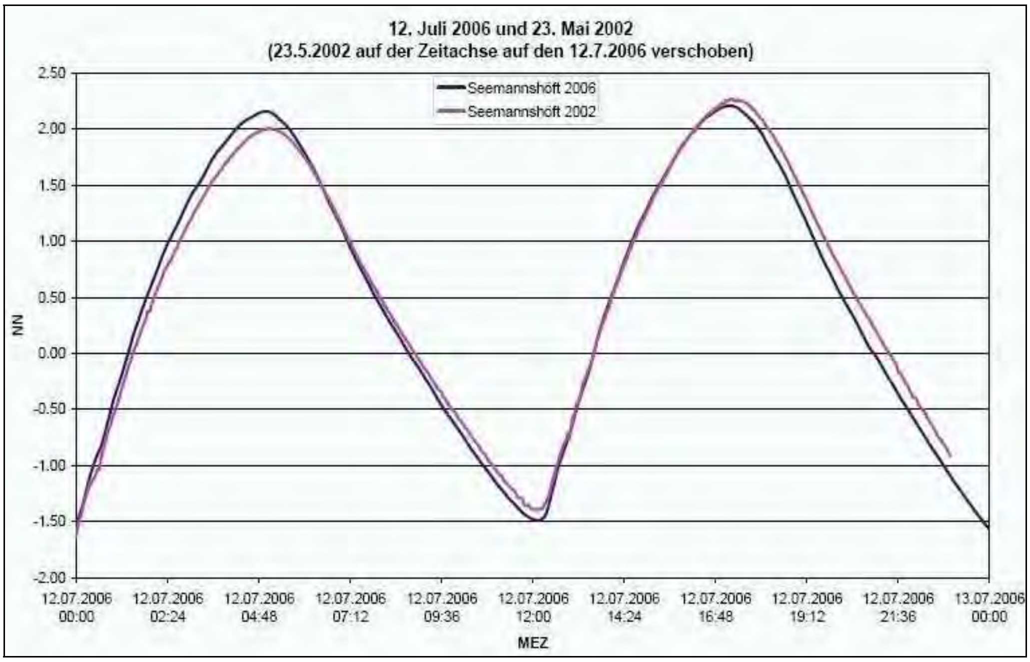

Figure 6: Seemannshöft tide gauge

The tide water levels of the curves for the day of the accident and the comparable day differed by only 0.05 m at 1426, the time when the accident took place. The illustration clearly shows that both tidal curves are also very similar in their remaining course. This leads to the conclusion that the current speed of the two tides was also that similar, that the values of the comparable tide can be used to estimate the current on the day of the accident. The increase in strength of the flood current found at the scene where the collision took place can be determined from the following illustrations of the current speed (figs. 7 and 8).

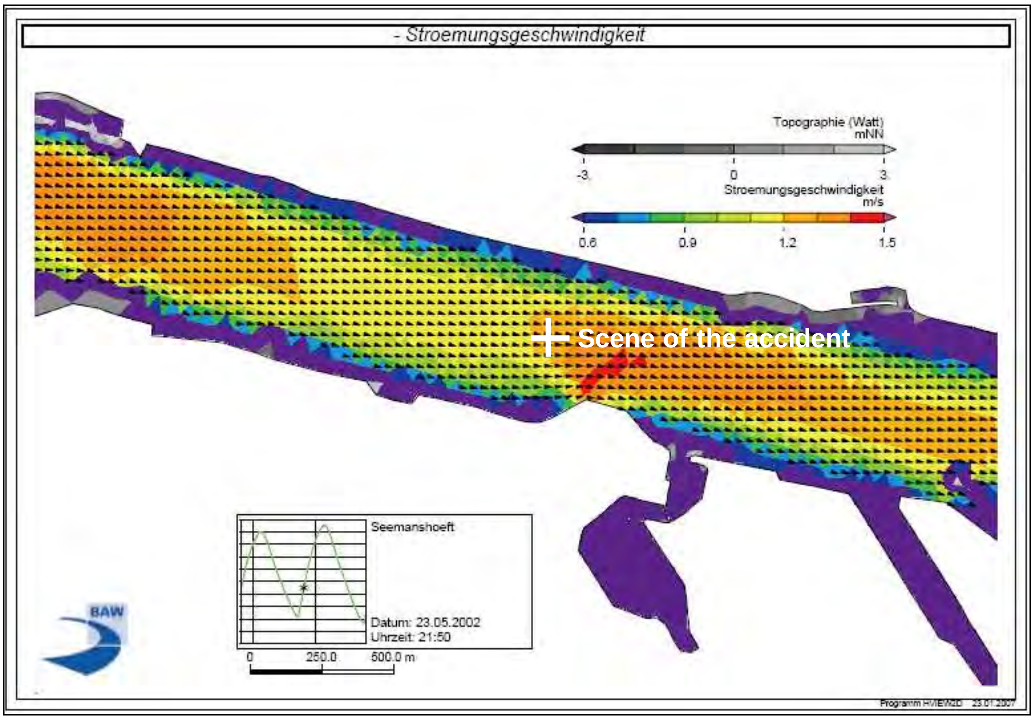

Figure 7: Current speed corresponding to 12 July 2006 - 1420

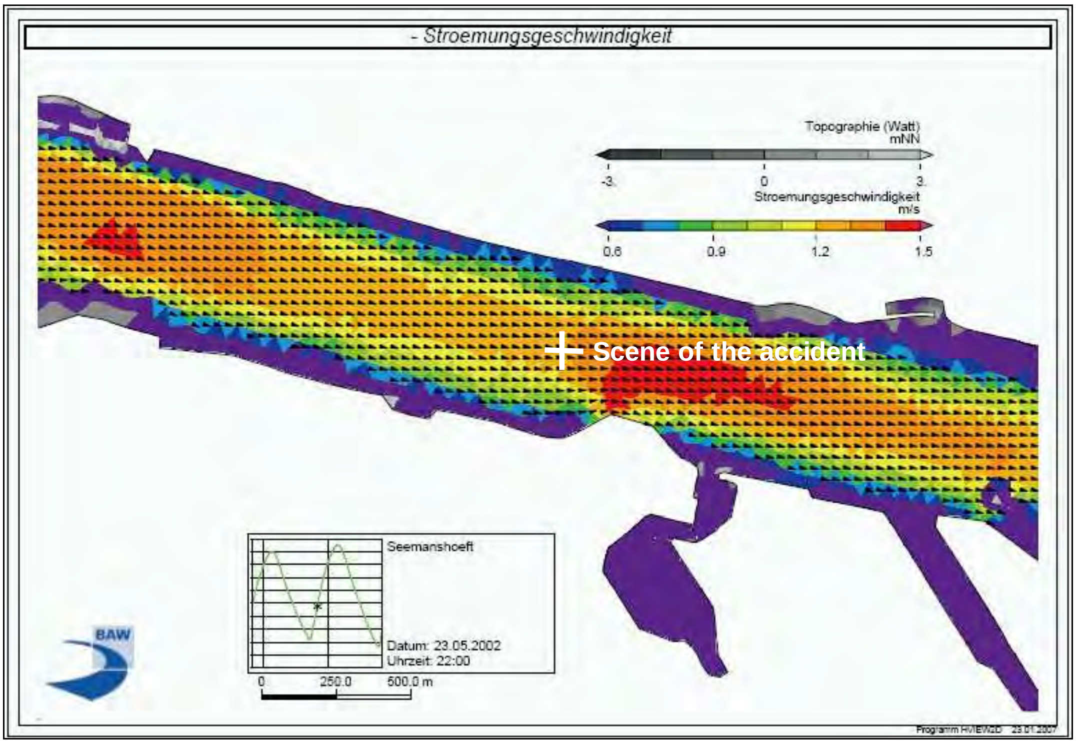

Figure 8: Current speed corresponding to 12 July 2006 - 1430

According to these determinations, at the time when the LASS URANUS, the XIN FU ZHOU and the MSC MELISSA met at the place of the accident the speed of the flood current was 1.0 m/s near the bank area and up to 1.4 m/s at the centre of the river.

The determination of the depth at the place and time of the accident based on measurements of the Hamburg Port Authority (HPA) Waterways Engineering Department, which had been carried out and evaluated one month prior to the accident. The values obtained from these measurements for the relevant section of the Lower Elbe were supplemented with information from the BSH Water Level Forecast Service. For the fairway area of the relevant section between buoys 132 and 130 this resulted in a nearly constant depth of 17.11 m.

4.1.1 Course of the LASS URANUS

On the day of the accident, the LASS URANUS had cast off from Luis Hagel at 1310 with 2,145 t fertiliser in bulk with destination Tees/Great Britain. The vessel was loaded almost to the load line (summer/FW).

The bridge was manned by an experienced master (Certificate of Competency without limitations, General Operator's Certificate), particularly familiar with local conditions as a former harbour pilot, and a helmsman who himself holds a master's licence (limited up to 6,000 GT "Mittlere Fahrt") and an Engineer's Certificate for engines up to 750 kW. Both are of German nationality.

The starboard propulsion of the LASS URANUS was not in operation right from the start of the voyage, in preparation of overhauls to be performed on the underwater section of the starboard rudder propeller (cf. para 5.1).

On the day of the accident there had been relatively high traffic, mostly by smaller craft (tug and tows, ferries, tugs). According to the GPS, the LASS URANUS was travelling at approx. 4.5 kn over ground. When passing the Parkhafen harbour basin, the XIN FU ZHOU was in the process of turning from the Parkhafen into the main Elbe fairway.

There had been a brief VHF exchange with the harbour pilot on board the XIN FU ZHOU and thereupon the LASS URANUS had kept to the far right hand side of the fairway. According to statements, buoy 132 had been passed at a distance of 3 to 5 m. Thereafter, the northern buoy line (course 286° true) was followed.

Shortly before passing Teufelsbrück, the MSC MELISSA, sailing upstream was said to have come into sight. Because of the imminent overtaking manoeuvre by the XIN FU ZHOU it was reportedly feared that all three ships would meet at the same point of the narrow fairway section lying ahead of the LASS URANUS. This also appeared hazardous due to the low water level. For this reason, the XIN FU ZHOU had been called to coordinate the overtaking process. There had been no answer.

The XIN FU ZHOU was said to have then started to overtake at significantly higher speed than the LASS URANUS'. Lateral distance was estimated small at approx. 60 to 70 m according to estimations. Reportedly, when the bow of the XIN FU ZHOU was at the level of the wheelhouse of the LASS URANUS, the latter had begun to navigate unsteady with a tendency to drift to port. Reportedly, this could at first be kept under control by means of rudder manoeuvres.

When the XIN FU ZHOU had approximately half overtaken the LASS URANUS, the oncoming MSC MELISSA passed on the other side. Approximately at the moment when all three vessels were at the same level, the LASS URANUS was said to have been sucked to port almost abruptly and with increasing acceleration. The immediate reaction had reportedly been steering "hard to starboard" at unchanged engine power (Full Ahead = 1,700 rpm). At the same time the bow thruster was reportedly added with full thrust to starboard. However, the drift to port of the LASS URANUS was said to have continued relentlessly.

Once the LASS URANUS had already drifted off the course by approx. 45°, it was reported that an abrupt drop in engine rating speed was noticed. Thereupon the helmsman immediately hurried into the engine room. The collision reportedly took place while he was still on his way.

In the engine room it was ascertained that the port main engine had stopped. The auxiliary diesel propulsion with both auxiliary engines reportedly operated properly. The port engine reportedly could be re-started immediately and without problems. No other technical faults were said to have been ascertained.

The failure of the main engine was said to have been a consequence of the unusually strong suction effects caused by the XIN FU ZHOU, resulting in an overload situation that was thought to have possibly led to the engine being shut down by the overload protection switch.

The LASS URANUS was then ordered back to the Holthusen quay by the Vessel Traffic Center (VTC). The voyage provided no technical problems. The port main engine is said to have been started and run without problems during tests at the Holthusen Quay. During the same night, the vessel called at the Peters Shipyard in Wewelsfleth without assistance or problems.

In addition to the repairs to the collision damage, the port engine was thoroughly inspected by Cummins service engineers. Reportedly no deficiencies were found and therefore also no technical work was carried out on the port engine.

4.1.2 Course of the XIN FU ZHOU

On the day of the accident, the XIN FU ZHOU was en route from Hamburg to Antwerp/Belgium. It had cast off from the container terminal at 1335, turned within the Parkhafen and then proceeded down the Elbe under Elbe pilot’s advice. The autopilot had reportedly not been activated.

The Teufelsbrück ferry pier had reportedly been passed at a “dead slow ahead” rate of speed. “Slow ahead” had been ordered in order to improve the ship’s steerability, as the encounter with MSC MELISSA was imminent. At that time, the LASS URANUS was reportedly proceeding downstream on the northern buoy line at a similar rate of speed. The vessel was said to have been approx. half a nautical mile ahead of the XIN FU ZHOU, and wake was visible.

It was planned reportedly onboard the XIN FU ZHOU to pass MSC MELISSA at first and to overtake LASS URANUS afterwards by means of raising the rate of turn. According to that the pilot initially proceeded to the portside bridge wing to keep an eye on the passing distance to MSC MELISSA. Reportedly he was on his way back to the wheelhouse when LASS URANUS called the XIN FU ZHOU on VHF because of a failure[3]. Thereupon the pilot reportedly hurried to the bridge wing on starboard, where he saw the LASS URANUS at point-blank range, stem to stem abeam. Reportedly wake was not visible anymore and LASS URANUS had significantly “run out of the rudder” to port.

A “hard starboard”-manoeuvre had been initiated onboard the XIN FU ZHOU. It was meant to give LASS URANUS some more space while she was turning towards port. “Hard -a-port” had been ordered half a minute later, whereby the collision could not be prevented.

After the collision, the XIN FU ZHOU at first continued her voyage to Brunsbüttel, where she turned and returned to the Predöhl Quay in the Port of Hamburg.

[3] The German word originally used was „Ausfaller“. During the accident investigation, a discussion arose on the meaning of „Ausfaller“ in this particular case. For further information about interpretations refer to para. 6.3.2.

4.1.3 Course of the MSC MELISSA

VHF radio records and the statements made to the Hamburg Water Police as well as radar records were used in order to retrace the vessel's course.

The MSC MELISSA was sailing under assistance of two Hamburg harbour pilots on her voyage from Antwerp/Belgium to the Predöhl Quay in Hamburg.

The XIN FU ZHOU was said to have been passed on the portside at a distance of approx. 20 to 30 m. The LASS URANUS was reportedly not noticed during the encounter, as she was on the starboard side of the XIN FU ZHOU.

There were reportedly no witnesses to the collision. There had merely been surprise and conjecture on the bridge concerning the small distance during the passage with the XIN FU ZHOU. After the passage and therefore after the collision had already taken place, one of the pilots reportedly called the Master over to the port wing to show him "a small vessel with black-out". Upon exiting into the wing a small green or blue vessel could reportedly be seen whose engine was reportedly running "ahead" and whose stem had turned to starboard. At the same time the XIN FU ZHOU reportedly continued her downstream voyage. Thereafter reportedly the Master and the pilot returned to the other pilot because of the imminent docking manoeuvre.

In the course of questioning by the Water Police, two sketches were made, representing on the one hand the turning of the LASS URANUS by an angle of almost 90° and on the other a lateral passing distance between the MSC MELISSA and the XIN FU ZHOU, supplemented by a written annotation "20 - 30 m".

4.1.4 Course of the LOTSE1

The pilot launch LOTSE 1 was travelling up the Elbe River in the direction of Teufelsbrück. When she sailed between the two seabound vessels, the LOTSE1 had been called by the LASS URANUS on VHF channel 74 and told to get out of there quick as the LASS URANUS had a "black-out". Thereupon it had reportedly been observed that the LASS URANUS was unable to maintain her course and that she had turned to port and into the XIN FU ZHOU.

In addition, a sketch was made indicating the positions of the MSC MELISSA, the XIN FU ZHOU, the LASS URANUS and the LOTSE 1 in regard to each other before the collision. On this sketch, the distance between the two large container vessels is estimated at approx. 40 m and the distance between the XIN FU ZHOU and the LASS URANUS as being approx. 120 m. The position of the pilot launch at the time of the collision is indicated as being approximately at the level of the stern of the XIN FU ZHOU.

Due to the small distance between the large container vessels, the LOTSE 1 reportedly therefore did not after all proceed upstream between them but between the XIN FU ZHOU and the LASS URANUS.

4.1.5 Photographic documentation of the course of the collision

The imminent triple encounter as well as the collision between the LASS URANUS and the XIN FU ZHOU was photographed by an experienced amateur photographer who happened to be on the northern bank of the Elbe River, using a digital camera with a zoom lens. The photographic documentation thus produced was provided to the BSU for the purpose of accident investigation.

The time data recorded by the camera for the relevant photographic evidence was compared with the radio timings shortly after the accident at a Hamburg Water Police station. Discrepancies were ascertained. Insofar as time references are made to the witness photographs (cf. below under para. 5.5.1), these refer to corrected time.

The following image (fig. 9) shows all vessels within the relevant section of the river.

© Adolf Wölke

Figure 9: Photo of triple encounter (detail)

In the foreground left the blue bow of the LASS URANUS can be seen, which is just being overtaken by the XIN FU ZHOU on portside. The oncoming vessels, the MSC MELISSA and the pilot launch LOTSE 1 are also shown, as is the tug TUMAK, which at this point had already tied to the stern of the MSC MELISSA.

Two more photographs show the position of the LASS URANUS immediately before the collision with the starboard side of the XIN FU ZHOU (figs. 10 and 11).

Figure 10: Photo of the vessels involved in the accident immediately before the collision

Figure 11: Close-up immediately before the collision

4.2 Consequences of the accident

The collision caused an approx. 4.8 m deep dent in the LASS URANUS' stem above the waterline (figs. 12 and 13).

Figure 12: Damage to the LASS URANUS' stem

Figure 13: Damage to the forecastle of the LASS URANUS

Damage in the vessel's interior ranged from the lower bosun store below the first deck all the way up to the forecastle (fig. 14).

Figure 14: Damage to the interior of the LASS URANUS

The LASS URANUS' shipping company did not provide information on the amount of the damage.

The hull of the XIN FU ZHOU sustained a tear above the waterline of approx. 0.5 m over a length of 8 m (figs. 15, 16 and 17).

Figure 15: Damage to the starboard side of the XIN FU ZHOU

Figure 16: Close-up of the tear on the starboard side of the XIN FU ZHOU

Figure 17: Location of the tear showed on the fire control plan of the XIN FU ZHOU

Due to the collision two frames were dented. The XIN FU ZHOU's shipping company did not provide any information concerning the amount of the damage.

5 Investigation of the Marine Casualty

After the collision had taken place, the LASS URANUS was ordered by the VTC to proceed to the Holthusen Quay. Once there, BSU and Water Police Hamburg officials independently began their respective accident investigations. The XIN FU ZHOU was unable to turn on the Lower Elbe due to her size. She proceeded to Brunsbüttel at first, turned and then returned to the Predöhl Quay in Hamburg at approx. 2100.

5.1 Survey of the LASS URANUS

The LASS URANUS was first surveyed on 12 July 2006 in the presence of representatives of the shipping company, of the classification society Germanischer Lloyd (GL) and of independent marine surveyors. Substantial photographic documentation was produced. After submission of the relevant ships' certificates and documents, the following could be ascertained:

Engine manoeuvres are not recorded on the LASS URANUS. The accident itself was recorded in the engine log as having occurred at 1420.

There was no entry to record the accident in the bridge log. There was no bridge bell book. The ship's position from time to time was documented on the nautical chart by means of check marks and the entry of time data. On the day of the accident the vessel's command was using BSH-Chart INT 1455 (Plan A: The Elbe from Schulau to Teufelsbrück), corrected to current issue and revision status.

The ship had left Dagenham/GB in ballast on 9 July 2006. One day later the starboard engine had reportedly been placed out of operation due to gear noise. There was no entry documenting this in the engine log. A defect of the underwater portion of the starboard rudder propeller was suspected, which according to the original plan was supposed to be inspected and if appropriate remedied on 12 July 2006. For this reason the starboard main engine was not operational on the day of the accident.

A visual inspection of the two main engines of the LASS URANUS revealed that security wires had been sealed on the respective injection pumps (cf. figs. 18 and 19). These seals were attached to the removable screw caps behind which are located the respective throttle shafts. They provide an option to set the fuel supply. If it is restricted, the obtainable engine power is reduced.

The seals on both the port and the starboard engines were intact.

Figure 18: Port main engine of LASS URANUS

Figure 19: Leaded injection pump of the port main engine of LASS URANUS

On the inspection date of 12 July 2006 the port main engine had been in operation for a total of 15,304 hours, while the starboard engine, which had been exchanged three weeks before the accident, had a total of 295 engine hours.

BSU officials inspected the ship again on 22 August 2007. On the inspection date of 21 August 2007 the port side main engine registered a total of 20,593 hours, and the starboard engine 5,515 operating hours.

In addition, the alarm panel at the control position on the bridge of the LASS URANUS was also more closely inspected (cf. fig. 20). It indicates potential faults and overload situations in the two main engines.

Figure 20: Alarm panel on the LASS URANUS' conning position

5.2 Inspection of the XIN FU ZHOU

The XIN FU ZHOU was inspected by the Hamburg Water Police on 13 July 2006, in Hamburg. All investigation results and photographic documentation was made available to the BSU.

BSU officials inspected the vessel on 14 July 2006. The records of the voyage data recorder were stored in order to reconstruct the course of the accident. The data that were stored contained, in particular, radar images and recordings of the microphones installed on the conning position, in the bridge wings and at the chart table.

On the day of the accident, the XIN FU ZHOU's command navigated on the basis of BSH Chart INT 1455 including all current corrections.

5.3 Inspection of the MSC MELISSA

In the morning of 13 July 2006 the Water Police Hamburg conducted investigations on board the MSC MELISSA in the Port of Hamburg. The investigation was, among other things, aimed at storing the voyage data recorder records for the previous day. For this purpose, Water Police officers were assisted by an employee of a German maintenance company.

For unknown reasons and in spite of the technical support it was not possible to replay the records of the voyage data recorder on site. The entire data set was therefore secured by the service technician on external storage media in order to be restored in the laboratory.

Subsequently the secured records could also not be read at the laboratory. The later attempt to secure data from the voyage data recorder of a further, uninvolved vessel that had been present in the relevant section of the Lower Elbe at the time of the accident proved equally unsuccessful. That other vessel was fitted with a voyage data recorder that was not working on the day of the accident; the device has been manufactured by the company whose technician had accompanied the Water Police onboard MSC MELISSA.

The results of the Hamburg Water Police's investigations were made available to the BSU.

5.4 Records of courses, speeds and positions

The VTC Hamburg made available the records of the traffic monitoring relevant for the accident investigation. These records particularly include position, course and speed data only for the XIN FU ZHOU and the LASS URANUS (cf. figs. 22 to 30). This is due to the fact that the MSC MELISSA, proceeding upstream, had not yet crossed the Finkenwerder reporting line.

The following table compares headings and course over ground as well as speed over ground of the LASS URANUS and the XIN FU ZHOU (cf. table 1). The data was selected from the shore based radar records.

	LASS URANUS			XIN FU ZHOU		
Time[4]	Heading	Course OG	Speed OG	Heading	Course OG	Speed OG
14:20:06	278°	278°	3.5 kn	286°	285,9°	6.6 kn
14:20:33	294°	293,6°	3.1 kn	286°	286,4°	7.0 kn
14:21:02	286°	286,4°	4.5 kn	284°	283,8°	6.9 kn
14:21:32	262°	261,6°	3.4 kn	290°	289,6°	6.6 kn
14:22:02	265°	264,6°	5.5 kn	278°	278,1°	9.2 kn
14:22:32	275°	274,8°	5.7 kn	284°	284,2°	7.0 kn
14:23:08	285°	285,4°	5.9 kn	282°	282,4°	7.0 kn
14:23:39	273°	272,6°	4.2 kn	284°	283,7°	7.4 kn
14:24:06	293°	293,3°	4.4 kn	278°	277,9°	5.4 kn
14:24:39	319°	318,9°	2.6 kn	284°	283,7°	7.4 kn
14:25:08	304°	303,6°	3.4 kn	283°	282,9°	7.9 kn
14:25:38	156°	155,7°	0.5 kn	283°	283,1°	7.3 kn
14:26:15	87°	86,8°	5.5 kn	283°	283,3°	7.0 kn
14:26:25	87°	86,8°	5.5 kn	283°	283,3°	7.0 kn
14:26:39	67°	66,8°	2.4 kn	292°	291,6°	6.1 kn

Table 1: Course and speed data for LASS URANUS and XIN FU ZHOU

The information for the XIN FU ZHOU has been compared to the VDR-records; only minor variations were shown. In addition to the data listed in the above table, the VTC Hamburg also recorded the vessels' positions as determined, which are displayed as courses steered on the chart in figure 21 below.

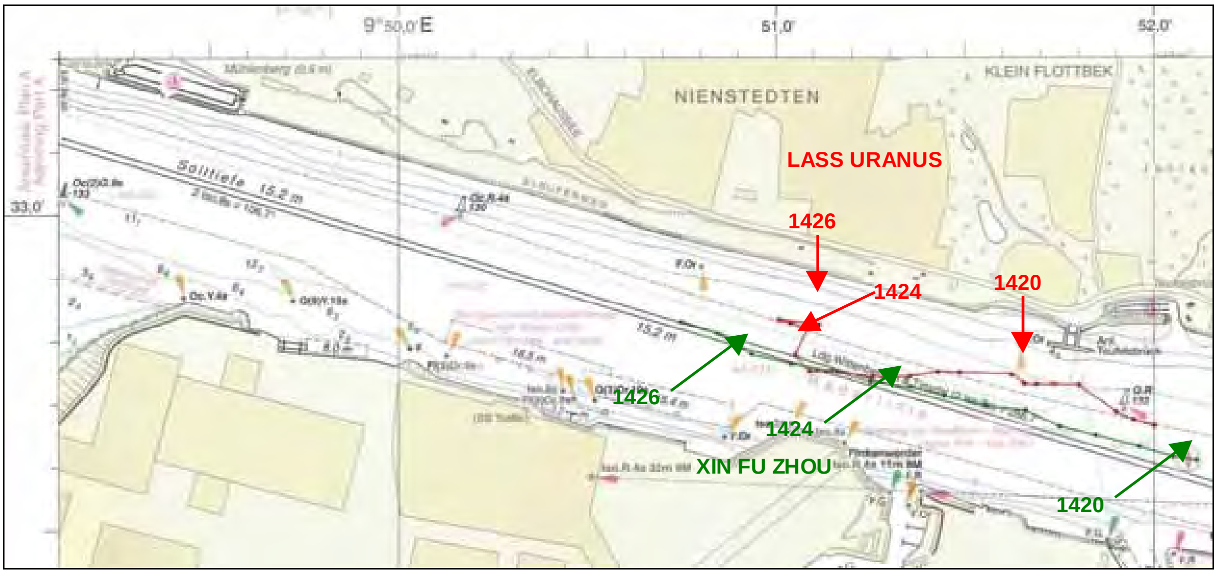

Figure 21: Courses steered

4 The time indicated is that of the time stamps on the VTC's records (cf. para. 5.5.2).

5.5 Radar and ECDIS records

For the reconstruction of the course of the accident, in addition to the radar records of the voyage data recorder on board the XIN FU ZHOU, the BSU also had access to records of the shore based radar station Seemannshöft of the VTC. The evaluation was also based on the course steered by the XIN FU ZHOU, which could be retrieved via the records of the vessel's ECDIS.

5.5.1 Preliminary remark

In the following interpretation of radar images it must be taken into account, as is the case with every evaluation of such records, that the technical possibilities of this system are limited. A realistic assessment of the triple encounter depends both on the quality of target discrimination and also on the location of the shore based station in regard to the target. This results among other things in shadowing effects. The Seemannshöft station is beyond the display detail of the following shore based radar images (cf. fig. 22).

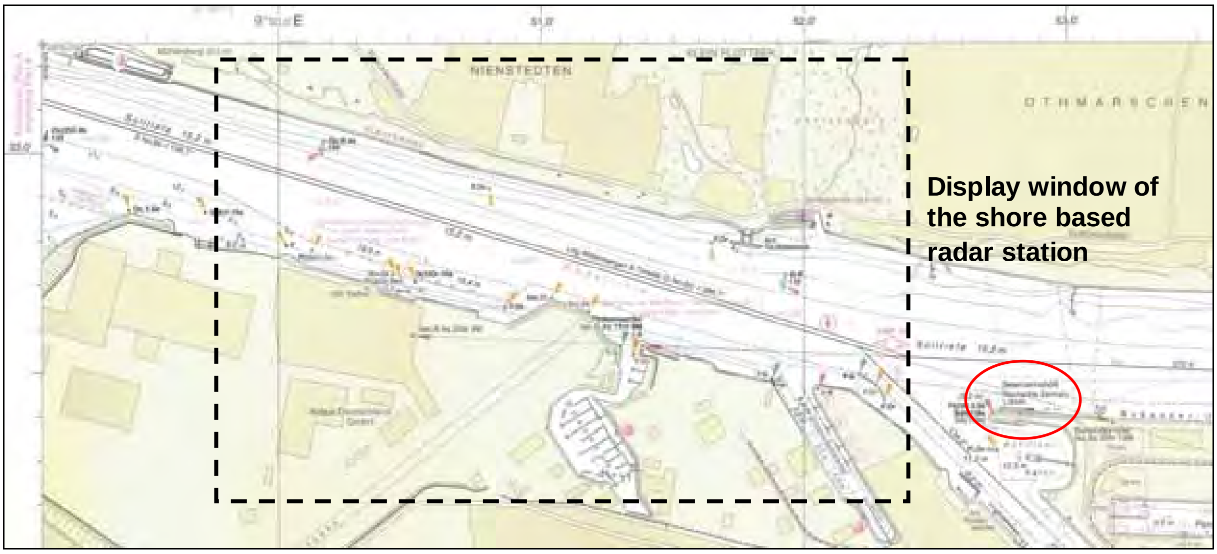

Figure 22: Location of the Seemannshöft shore based radar station

Every untreated radar record is analysed and processed using digital processors. In this process, clutter parameters are evaluated and signals received within the radar coverage area are calculated. A target acquisition threshold is set to help differentiate between useful signal and clutter, so that only radar data above the defined threshold value provide a target plot. Plots verified via several radar scans and further filtered and processed by means of the software are finally represented on the radar image and referred to as a "track". Each track contains the following parameters: position, course, speed and speed over ground.

Especially in river estuaries target tracking is, among other things, technically complex due to the shore cultivation and confined, tide depending fairways. In particular drawn out overtaking manoeuvres with reduced passing distances often cause a merging of radar targets depending on the type of vessel, the echo intensity and the spatial position in regard to the radar transmitter. As a result of the complex calculation and evaluation process based on the following radar images, it is necessary to take into account in their interpretation that the vessel positions represented thereon do not compellingly coincide with the vessels' actual positions at the time.

5.5.2 Records of the Seemannshöft shore based radar station

Records of the "Seemannshöft" shore based radar station are available for the period between 14:16:21 and 14:31:27 on 12 July 2006, the day of the incident. Images were recorded at average intervals of 30 seconds, with the shortest interval being 24 seconds, and the longest, 37 seconds. The times indicated were generated every six seconds in reconciliation with radio transmitted time signals.

The tracking signs for the craft shown on the radar plots significantly differed from the actual vessel positions, as can be seen on figure 23 below. According to information received from HPA, this problem has in the meantime been substantially remedied by means of an optimisation of the software used in the VTC.

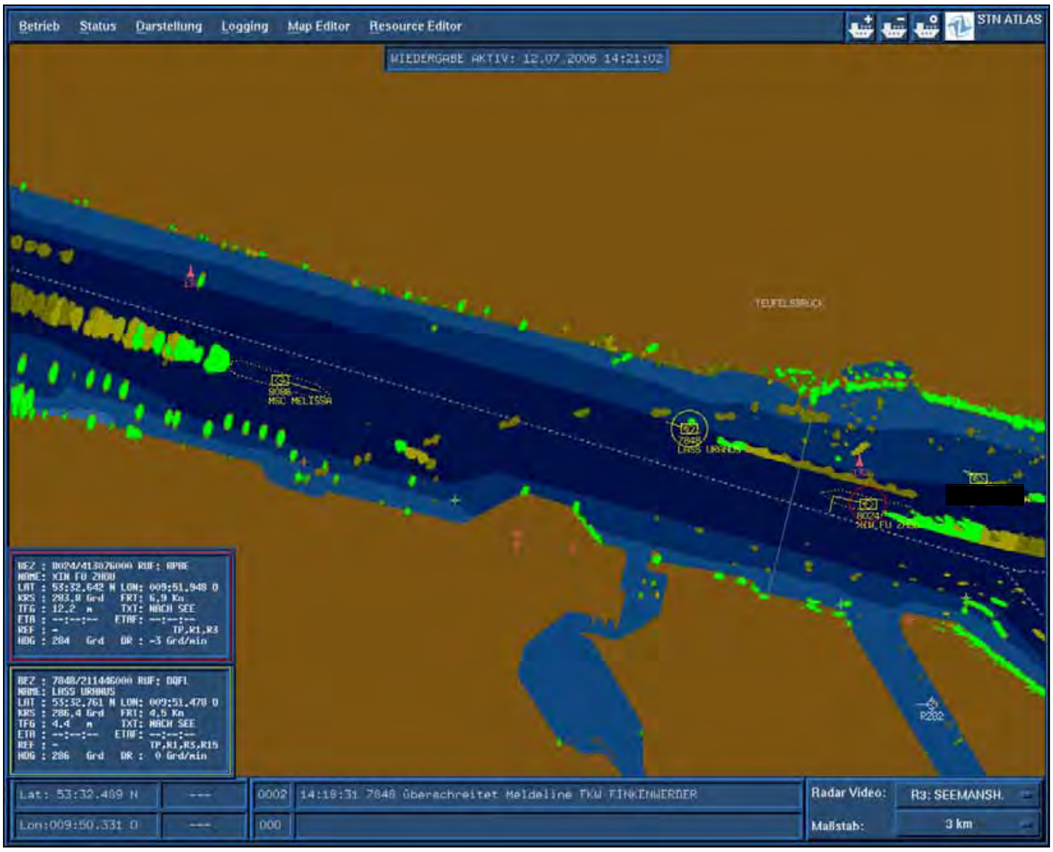

Figure 23: Shore based radar image at 14:21:02

According to shore based radar records, the course of the accident was as follows: In preparation for the overtaking by the XIN FU ZHOU, the LASS URANUS navigated on the northern buoy line (cf. fig. 23). On the radar plots the radar echo of the LASS URANUS is lost in the radar shadow of the XIN FU ZHOU until immediately prior to the triple encounter.

The tracking sign of the LASS URANUS continues to be shown, but does not represent the vessel's actual position (cf. fig. 24, 25).

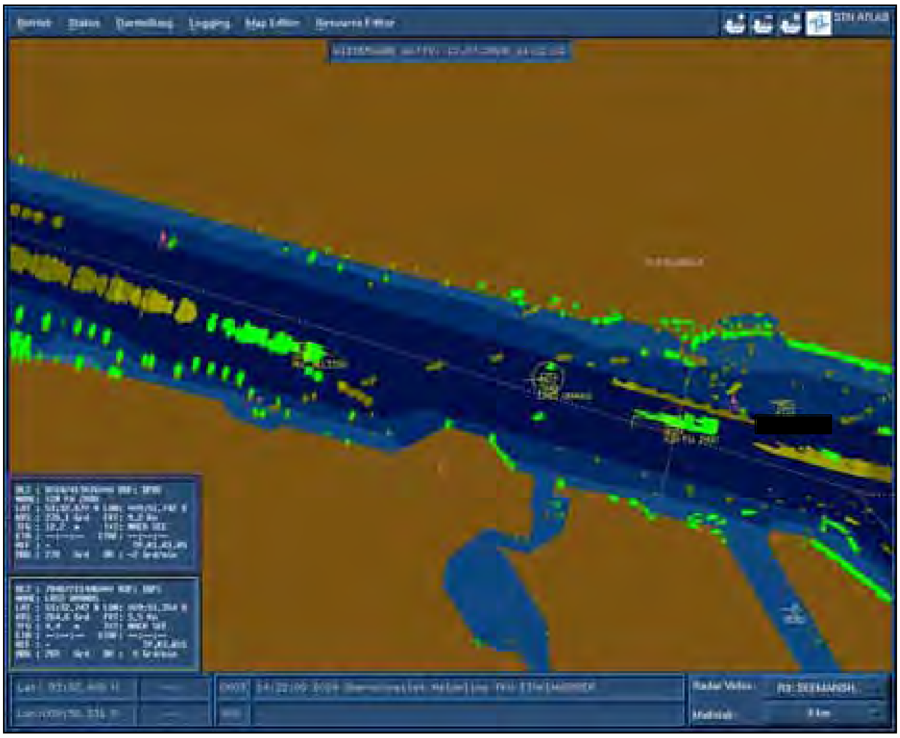

Figure 24: Shore based radar image at 14:22:02

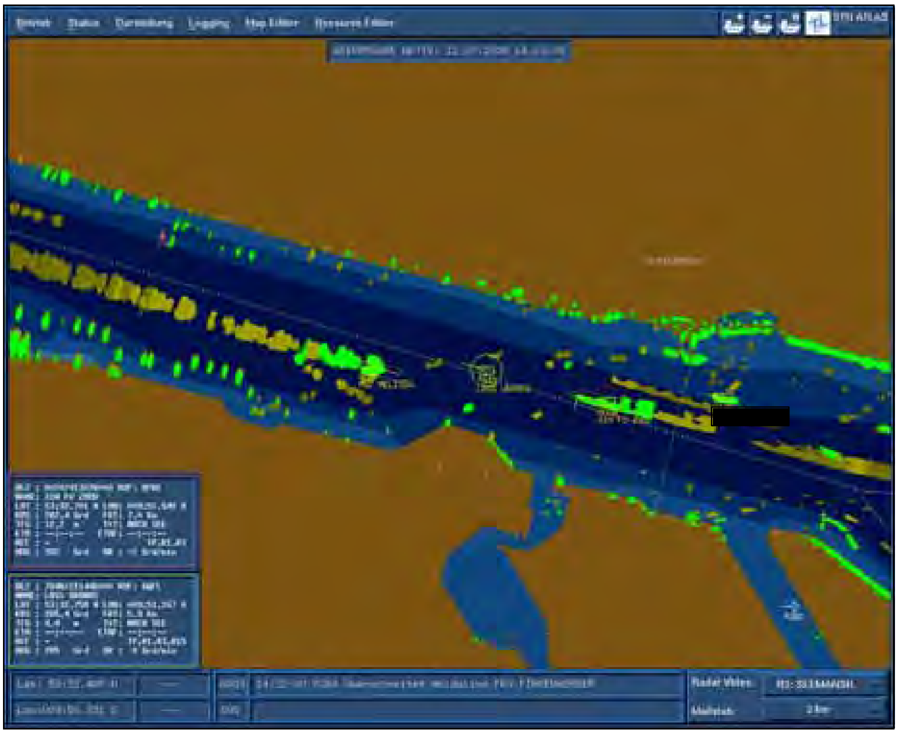

Figure 25: Shore based radar image at 14:23:08

Immediately before the collision the radar echo of the LASS URANUS again becomes visible. At that point the tracking sign jumps from the radar reference line to the calculated position of the vessel (cf. figs. 26 and 27).

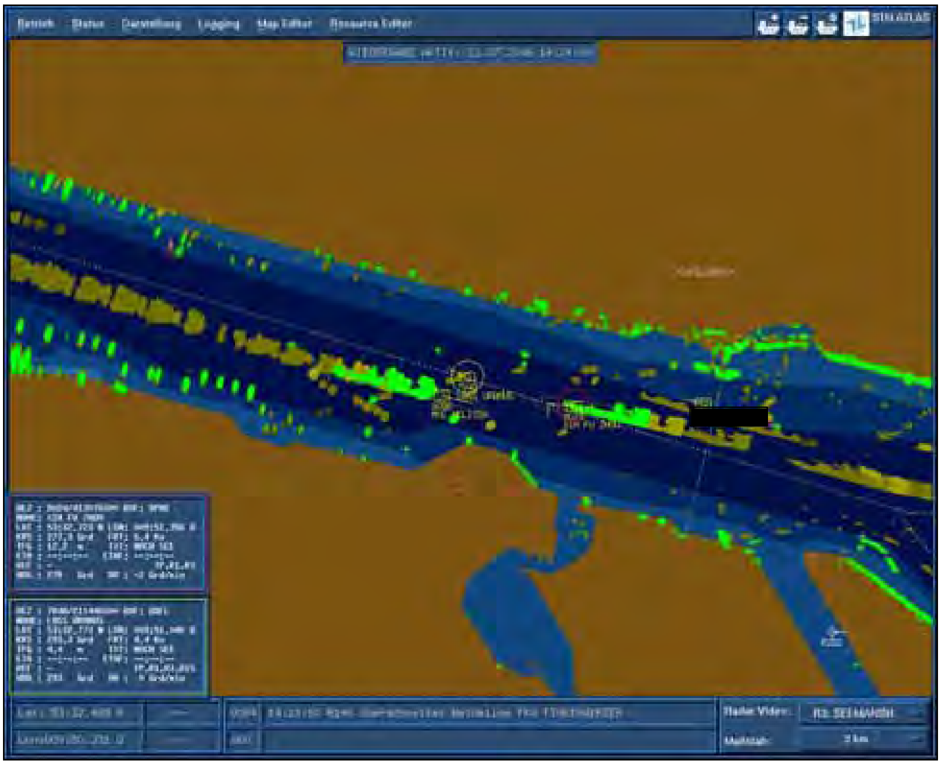

Figure 26: Shore based radar image at 14:24:08

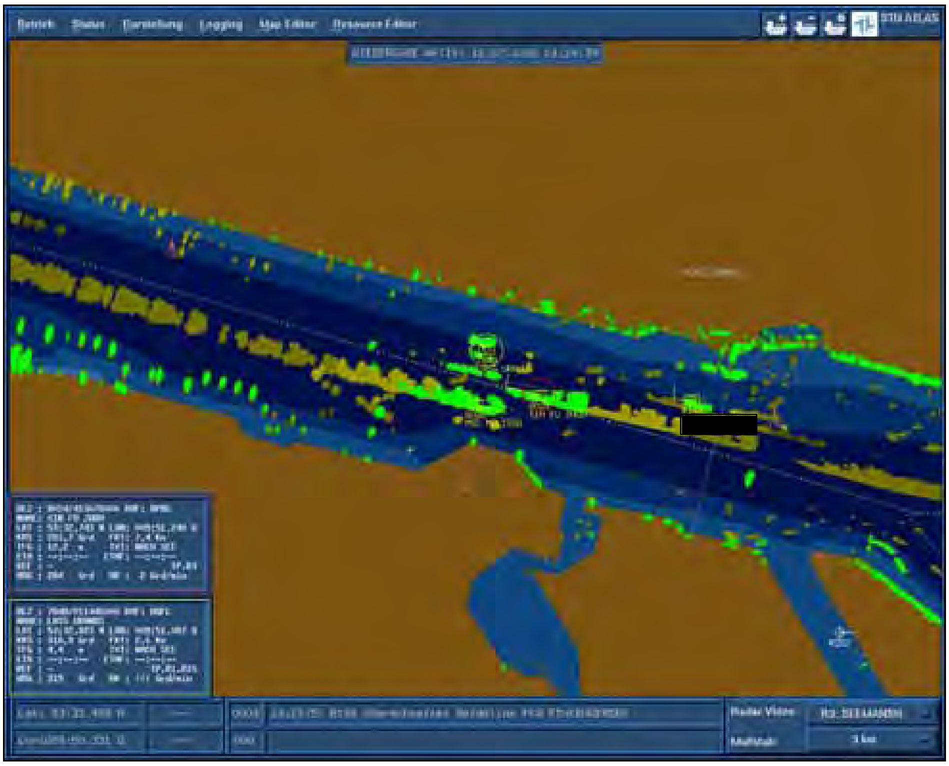

Figure 27: Shore based radar image at 14:24:39

Figure 27 shows the situation as a result of which the LASS URANUS is proceeding on the line of buoys and is at almost the same level as the oncoming MSC MELISSA. The LASS URANUS appears to proceed constantly ahead, but the speed over ground transmitted is now distinctly lower (2.6 instead of 4.2 kn).

According to the radar image, the bow of the XIN FU ZHOU is not yet at the level of the stern of the LASS URANUS at this point. The course steered by the XIN FU ZHOU as pictured enables the conclusion of an initiation of takeover, as a change of course to port towards the radar reference line becomes visible. The MSC MELISSA on the other hand keeps her course in the middle of the southern fairway.

The following radar plot, 29 seconds later, shows the radar echo of the LASS URANUS turning to port (cf. fig. 28).

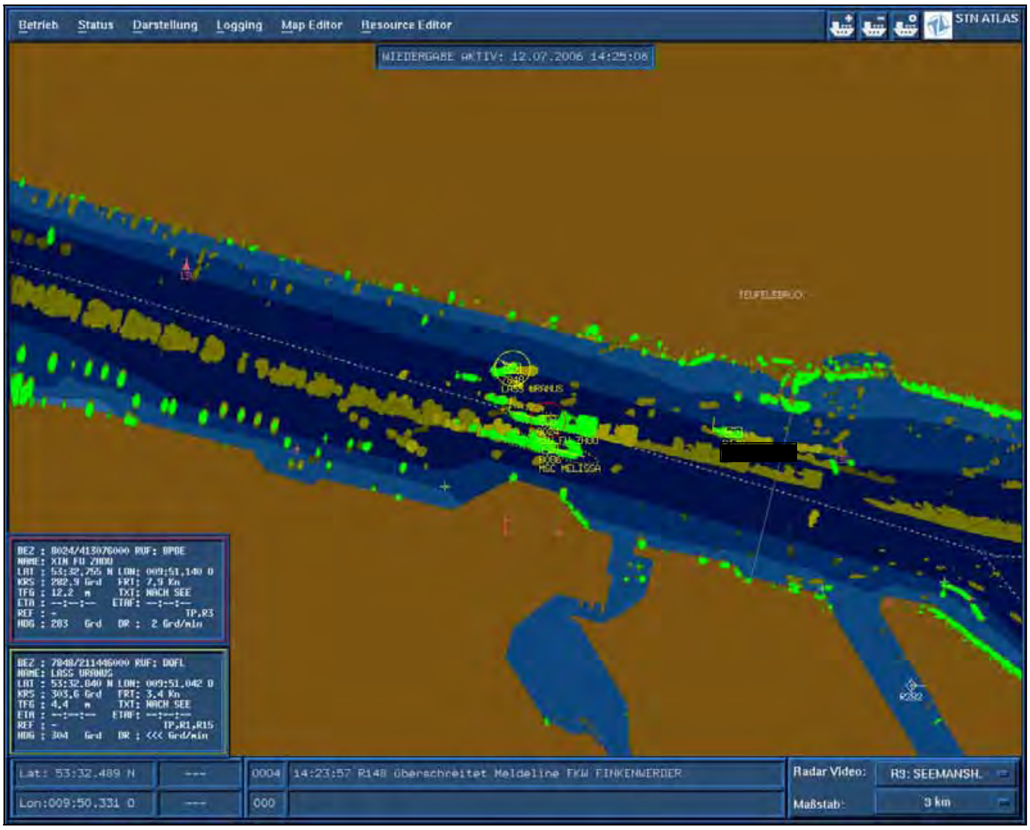

Figure 28: Shore based radar image at 14:25:08

The XIN FU ZHOU and the MSC MELISSA are almost at the same level, with the radar signal of the XIN FU ZHOU already on the radar reference line.

Another 30 seconds later, the radar plot shows the LASS URANUS distinctly turning to port at the time when the radar echo of the XIN FU ZHOU is approximately at the same level as that of the LASS URANUS (cf. fig. 29).

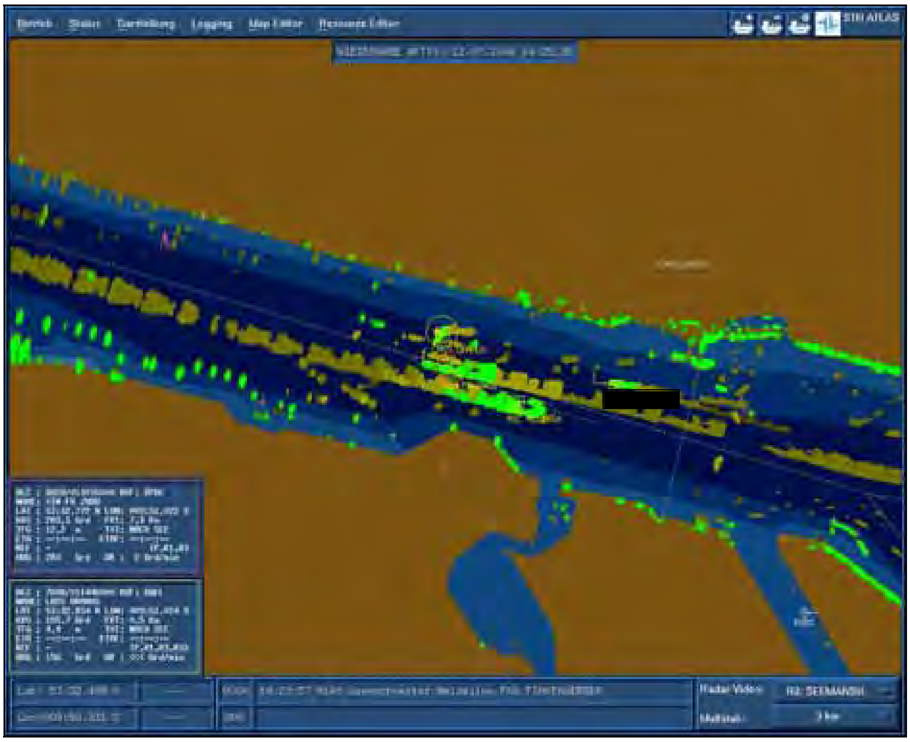

Figure 29: Shore based radar image at 14:25:38

The radar plot of 14:26:15 finally shows the collision between the LASS URANUS and the XIN FU ZHOU at an almost right angle (cf. fig. 30) The vessels' tracking signs again show a more significant deviation in regard to their actual positions.

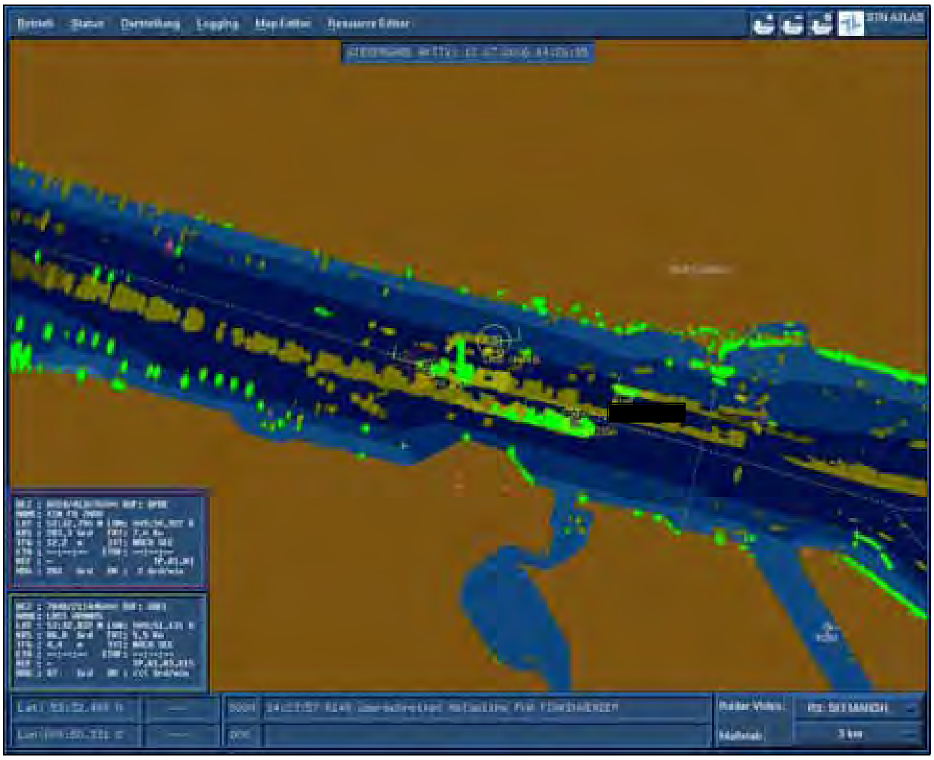

Figure 30: Shore based radar image at 14:26:15

After the collision the XIN FU ZHOU pursued her voyage, while the LASS URANUS once again turned her bow in the direction of heading (cf. fig. 31).

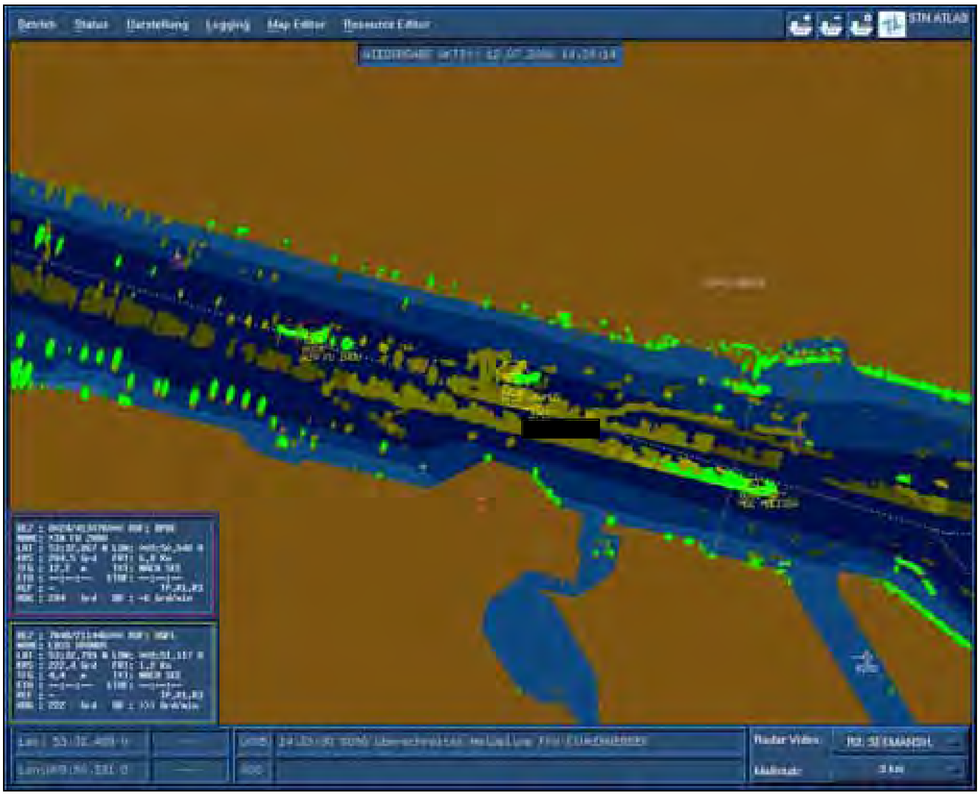

Figure 31: Shore based radar image at 14:28:14

Finally it can be ascertained that the radar echos of the relevant vessels involved are reproducibly represented by the shore based radar station in the 96 seconds immediately preceding the collision.

The display of the tracking signs cannot be considered to be reliable and therefore not be used in the reconstruction of the course of the accident.

The shore based radar images partially include false echos which, except for the above mentioned exception period, face clearly definable radar echos of the relevant vessels involved. Altogether therefore the radar plots enable a reliable assessment of the courses steered by the vessels involved in the accident at least within the one and a half minutes immediately prior to the collision.

5.5.3 Ship's radar records from the XIN FU ZHOU

The VDR memory stored on board the XIN FU ZHOU made it possible to evaluate the radar records for the day of the accident. The evaluation was limited to the relevant period between 14:21:58 and 14:27:28. The individual radar images were recorded at intervals of 13 to 14 seconds. For the sake of greater clarity, the names of the relevant vessels have been added to the first of the following series of images (fig. 32).

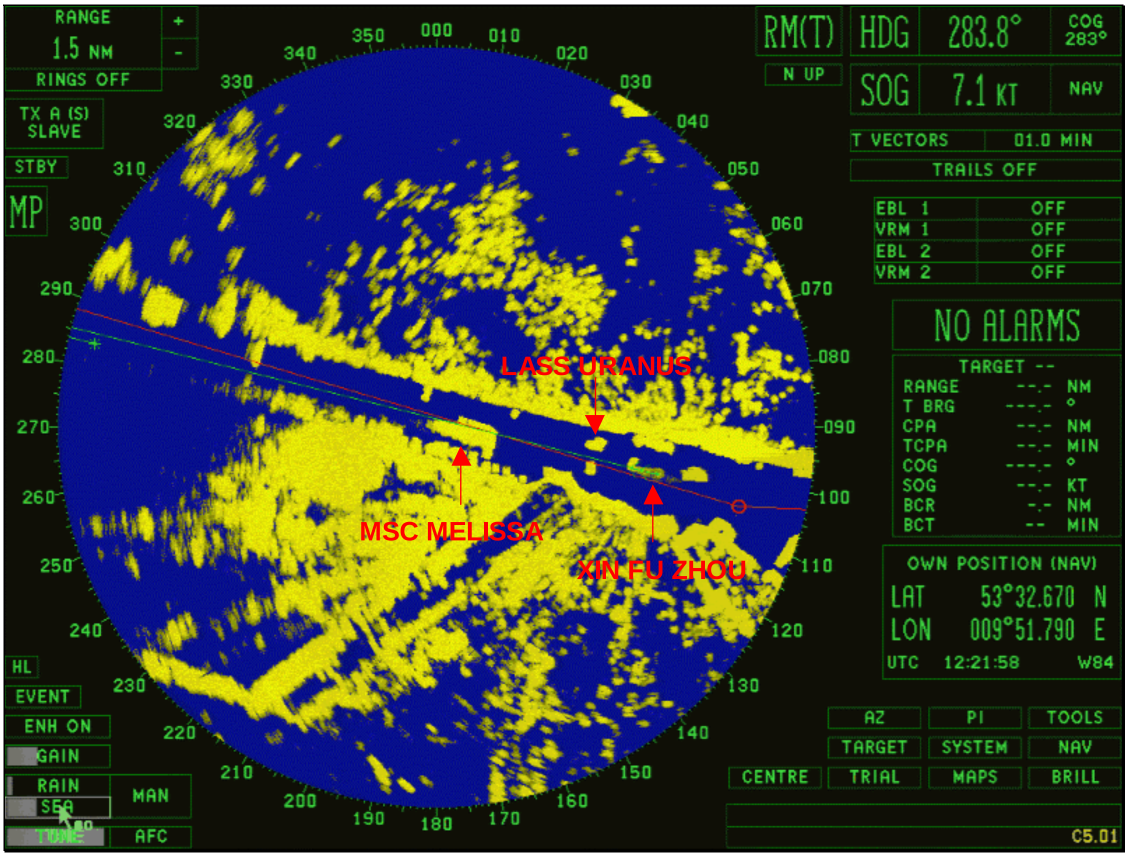

Figure 32: Ship radar image at 14:21:58

The following radar plot does not yet show a course change of the LASS URANUS, according to the radar XIN FU ZHOU is still approximately one ship's length astern the LASS URANUS (cf. fig. 33).

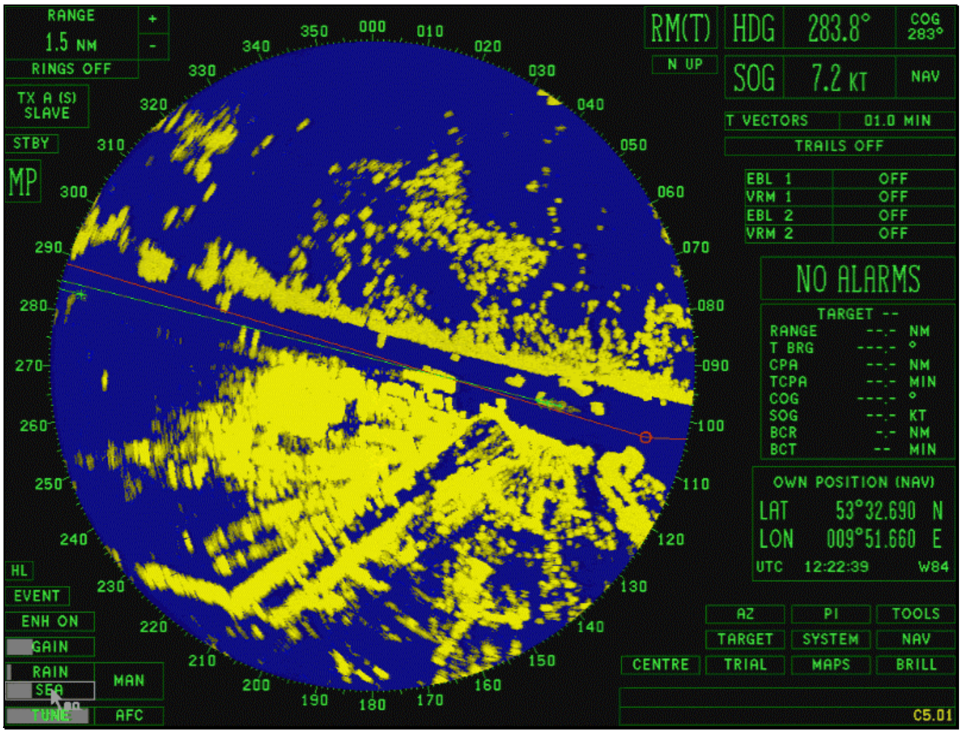

Figure 33: Ship radar image at 14:22:39

At 14:24:00 the three relevant vessels have approached one another, with the LASS URANUS still proceeding straight ahead according to the radar (cf. fig. 34).

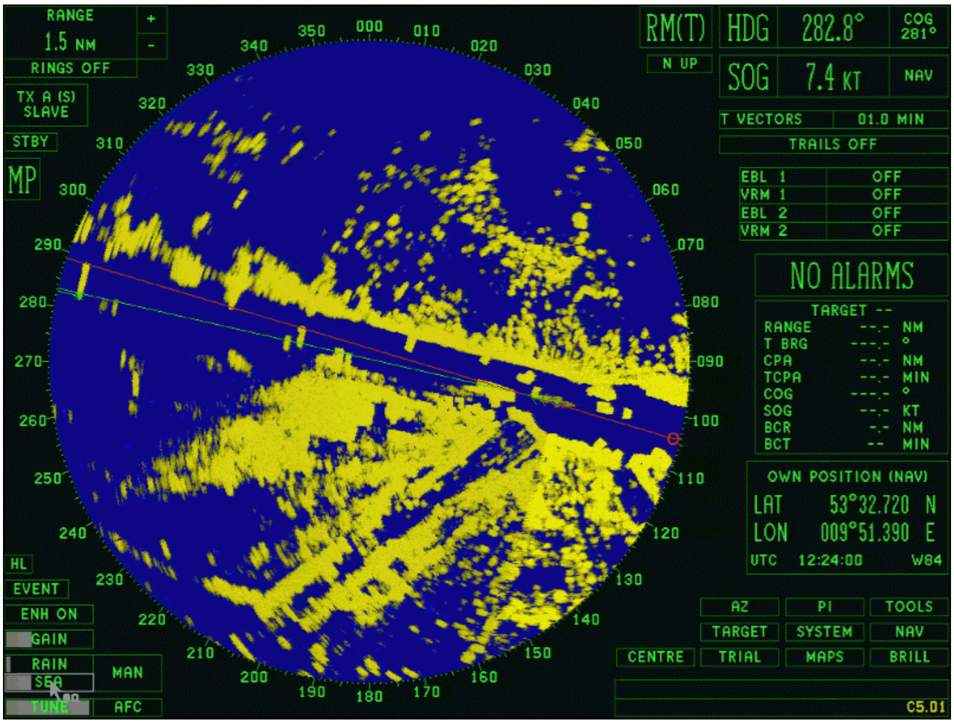

Figure 34: Ship radar image at 14:24:00

The ship radar on board the XIN FU ZHOU captures the radar signal of the LOTSE1 straight ahead for the first time at 14:24:27 (cf. fig. 35).

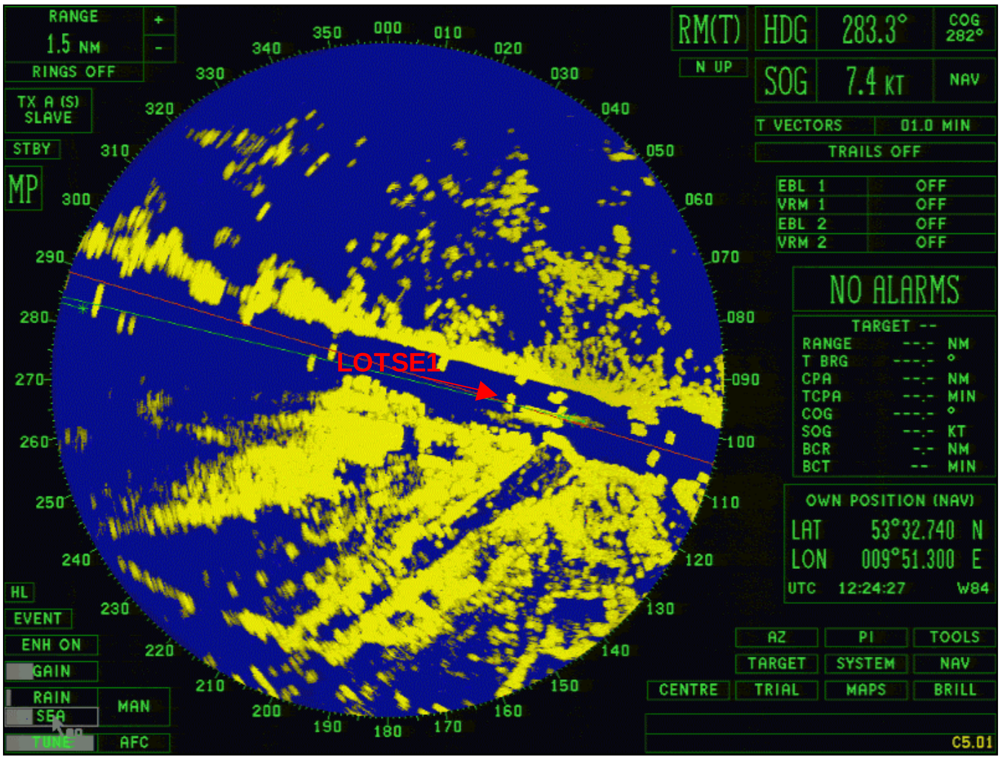

Figure 35: Ship radar image at 14:24:27

Fourteen seconds later the radar shows the LASS URANUS turning to port (cf. fig. 36).

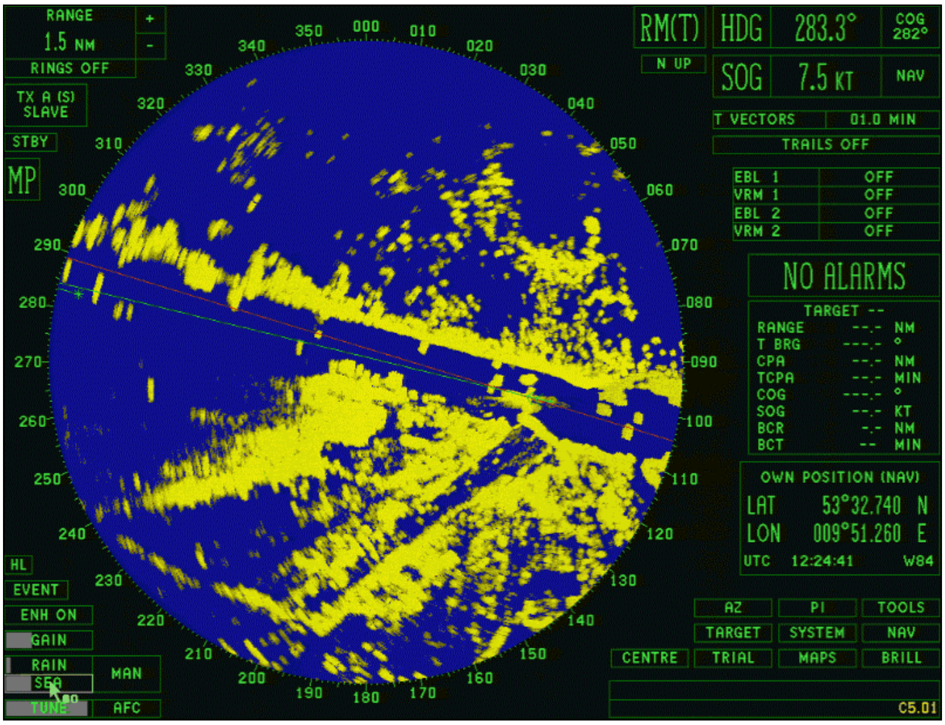

Figure 36: Ship radar image at 14:24:41

Another 14 seconds later the MSC MELISSA and the XIN FU ZHOU are almost alongside, LASS URANUS has turned further to port, and LOTSE1 is just about to proceed between the LASS URANUS and the XIN FU ZHOU (cf. fig. 37).

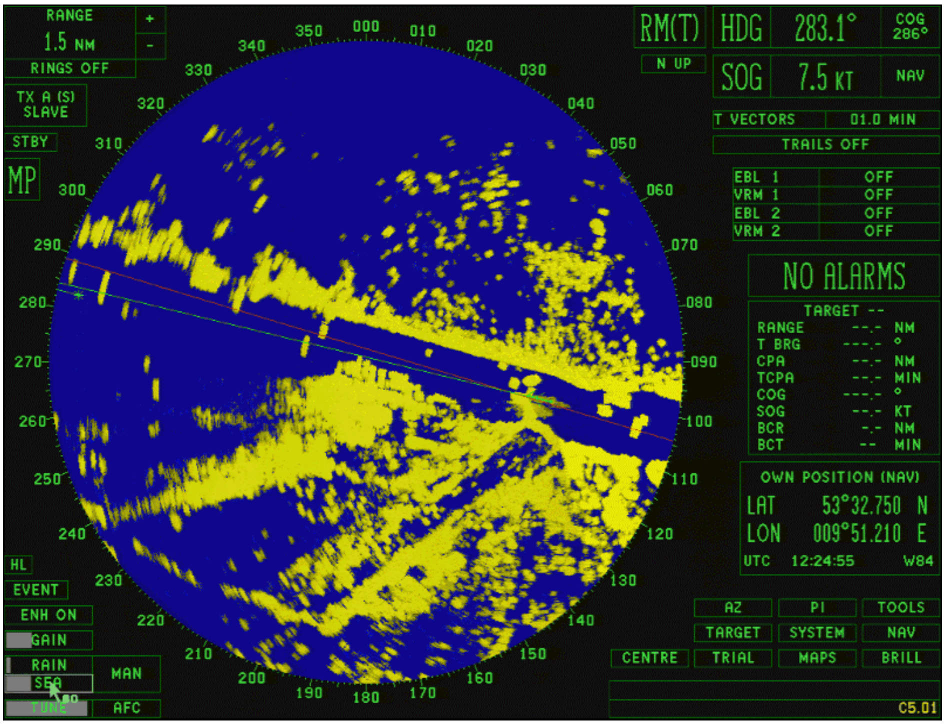

Figure 37: Ship radar image at 14:24:55

On the following radar images the echos of the individual vessels can barely be distinguished at a 1.5 nm radar range (cf. figs. 38 to 40). According to the interpretation, the collision took place at approximately 14:25:36 (cf. fig. 40).

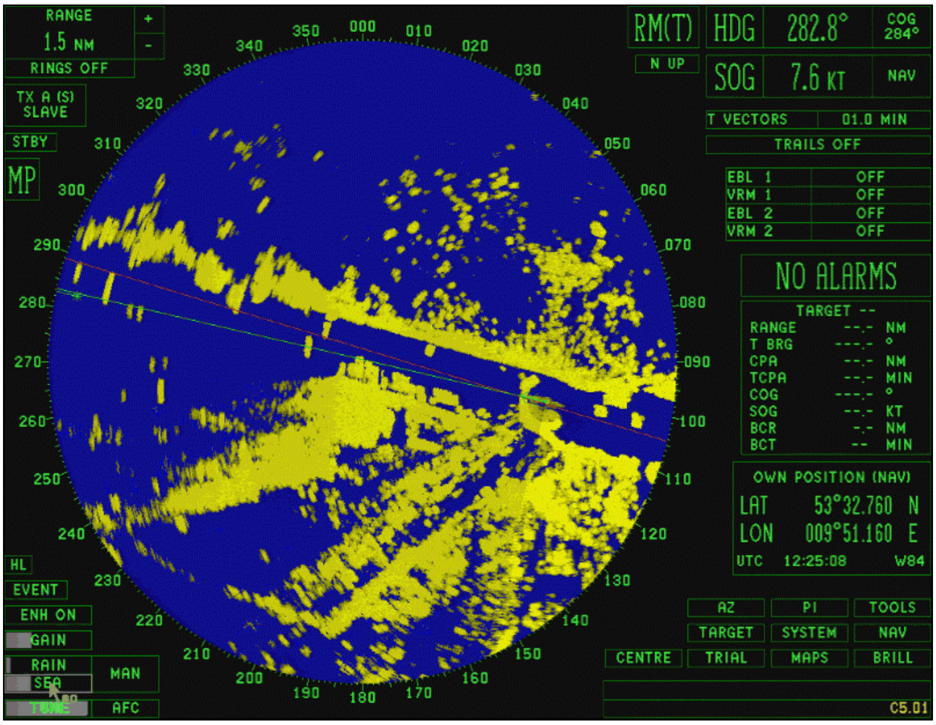

Figure 38: Ship radar image at 14:25:08

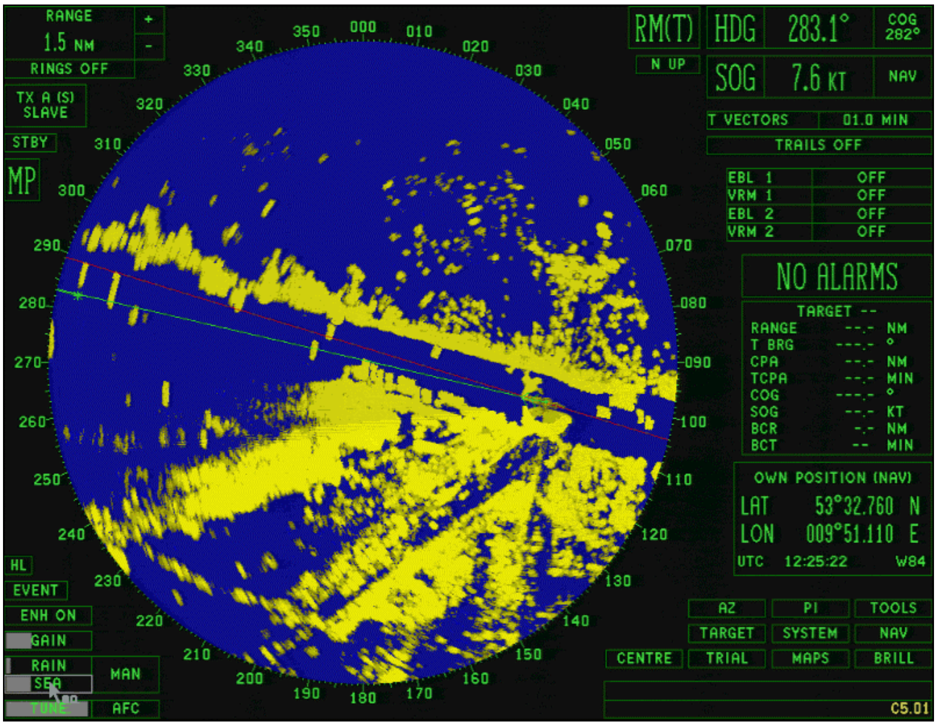

Figure 39: Ship radar image at 14:25:22

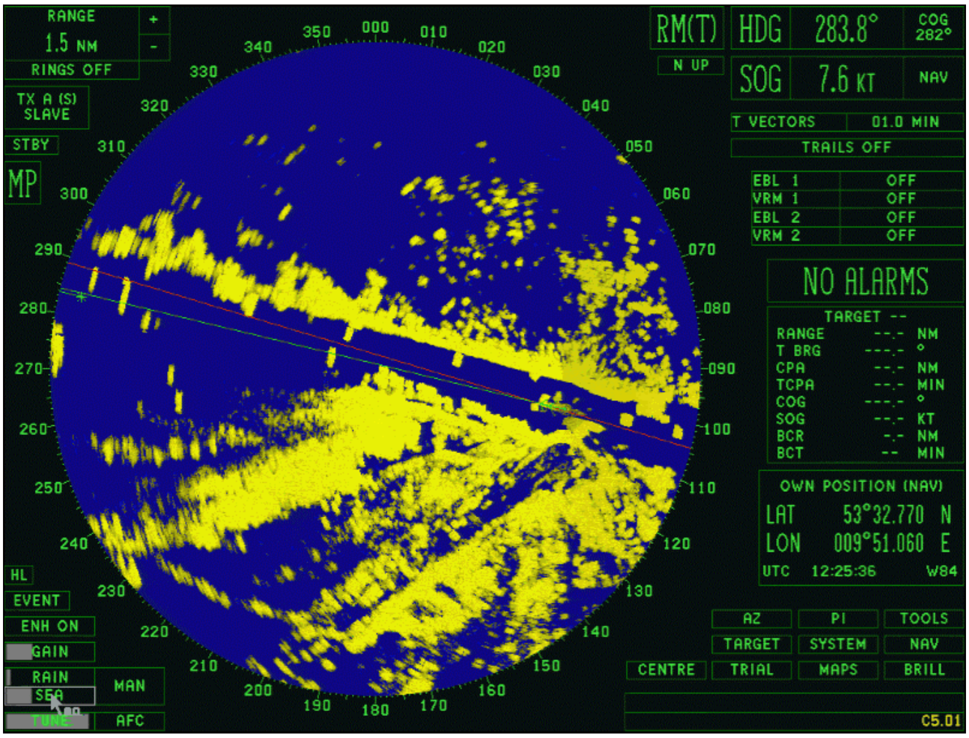

Figure 40: Ship radar image at 14:25:36

As concerns the XIN FU ZHOU's ship radar records it can be summarised that the courses steered by the relevant vessels can properly be reconstructed within the relevant period of time. In this respect both the shorter recording interval and the lesser radar shadows and false signals as compared to the shore based radar station represent an advantage.

5.5.4 Records of the XIN FU ZHOU's ECDIS

The ECDIS chart section secured on board the XIN FU ZHOU was used in addition to the radar records to reconstruct the course steered by the XIN FU ZHOU.

The waypoints of the XIN FU ZHOU for the day of the accident are reproduced on the chart section linked with the relevant timestamps (in UTC; cf. fig. 41). The figure clearly shows the overtaking with change of course to port, with occasional crossing of the northern radar reference line.

Figure 41: ECDIS plot obtained on board the XIN FU ZHOU

5.6 VHF radio traffic

The records of the VHF channels 14 and 74 for the day of the accident were evaluated as part of the accident investigation. The radio communications of relevance for the accident are reproduced below translated from the German verbatim without hesitation sounds. The times indicated refer to the radio timestamps of the VTC that are linked to each individual sound document.

5.6.1 VHF channel 74

Approximately half an hour before the collision the LASS URANUS was on the main Elbe fairway and passing the Parkhafen basin, where the XIN FU ZHOU had just turned. The Master of the LASS URANUS and the German Elbe pilot on board the XIN FU ZHOU made the following arrangement by VHF at 13:58:58:

XIN FU ZHOU (pilot):	LASS URANUS for XIN FU ZHOU.
LASS URANUS:	*Yes, I read you?*
XIN FU ZHOU (pilot):	Yes, we're about to leave the Parkhafen here with a big unit, can you go further into the north?
LASS URANUS:	*No, right now I can't, but come out, I'll take care here. I have a ferry on starboard and tug and tow in front of it. Just come out.*
XIN FU ZHOU (pilot):	Well OK.

Thereupon (14:02:20) the pilot of the XIN FU ZHOU made the following report to the VTC:

XIN FU ZHOU (pilot):	XIN FU ZHOU now leaving the Parkhafen.
VTC:	*All still clear.*
XIN FU ZHOU (pilot):	Thanks.

One of the two German pilots on board the MSC MELISSA transmitted, among others, the following position reports via VHF:

14:20:48	MSC MELISSA, Finkenwerder Pfähle, coming up Parkhafen Predöhl
14:22:31	MSC MELISSA, airstrip, coming up Predöhl.

Two minutes later the LASS URANUS several times unsuccessfully called the XIN FU ZHOU, at first in a calm tone of voice:

14:24:34	XIN FU please, we have a little failure[5] here.
14:24:41	XIN FU, please can you go northerly straight away please?

According to the radar plot of the shore based radar station of 14:24:39 the LASS URANUS was at this point in time still constantly proceeding on the nothern buoy line (cf. fig. 26). MSC MELISSA was approximately on the same level with LASS URANUS and XIN FU ZHOU sailed along the radar reference line, still approximately half a ship's length astern the LASS URANUS. The radar record was made five seconds after the first call and two seconds before the second call. The traffic situation can be considered to correspond approximately to the situation photographically recorded by the witness and shown in figure 9. The time linked to the witness' photograph is 14:24:44.

The next call of the LASS URANUS was emphatic and in a hectic tone of voice, eleven seconds after the last call:

14:24:52	XIN FU! LASS URANUS. The pilot boat.
LOTSE1:	*Pilot boat – we read you, URANUS.*

According to the digital time links, half a minute later two photographs were taken in which the LASS URANUS and the XIN FU ZHOU can be seen immediately before the collision (cf. fig. 10 of 14:25:26 and the following fig. 42 of 14:25:34).

5 The German word originally used was „Ausfaller". During the accident investigation, a discussion arose on the meaning of „Ausfaller" in this particular case. For further information about interpretations refer to para. 6.3.2.

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Figure 42: Additional photo of the vessels involved in the accident immediately before the collision

After the collision (14:26:14) the LASS URANUS called the XIN FU ZHOU on VHF channel 74, without receiving a reply. A little later (14:26:36) the following communication took place with an unknown radio user:

Unknown:	Do you read me, [first name of the Master of the LASS URANUS].
LASS URANUS:	*Yes, I read you.*
Unknown:	Yes, I'm pulling her away backwards.
LASS URANUS:	*Yes, OK, I have a failure, total failure here.*

5.6.2 VHF channel 14

After the accident, the radio communication between the vessels involved in the accident and the VTC took place on VHF channel 14.

Two minutes after the accident (14:27:56) the pilot on board the XIN FU ZHOU gave a first description of the accident to the VTC:

XIN FU ZHOU (pilot):	Hamburg Port, XIN FU ZHOU.
VTC:	*Hamburg Port, we read you.*
XIN FU ZHOU (pilot):	Yes. A moment ago there was the LASS URANUS alongside us. She had overtaken us and ran out of rudder and somehow ran into our side.
VTC:	*Aha. I'll try it.*
(another staff member)	*She ran into your side.*
XIN FU ZHOU (pilot):	She had turned over port. We had just passed the oncoming vessel and she was probably so drawn in by the suction of the two ships that she ran into us with the port side. Whether

	we have damage from that now I can't say yet. In any event she dented her nose.
VTC:	*On your port? On your starboard side.*
XIN FU ZHOU (pilot):	That is correct, yes.
VTC:	*Yep, thanks.*

Thereupon the VTC contacted the LASS URANUS. After the latter had shifted to the Holthusen Quay, the following radio communication between the parties involved in the accident was recorded at 14:46:33:

XIN FU ZHOU (pilot):	LASS URANUS from the Chinese.
LASS URANUS:	*Yes, we read you.*
XIN FU ZHOU (pilot):	Did you have a pilot on board?
LASS URANUS:	*No, there wasn't. We had a failure, a blackout, and then she got sucked in and then she flopped over there.*
XIN FU ZHOU (pilot):	Oh gosh, I'm sorry. Well we were also running quite slow, there was no more we could do either. Now that was, of course it is also caused by the fact that we had just met with the MSC, right?
LASS URANUS:	*We were all three of us together there, right? But there was nothing you could do, nothing one could do, then she just turns away like that and then ... although we were running at only 4 kn, but there's no point.. It's OK, we have to settle that somehow, right? Great, then have a good trip..*
XIN FU ZHOU (pilot):	Yes. I'm sorry, as I said, there's nothing much I can do about it, but if you had an engine failure then that goes without saying anyway.

5.7 VDR records on board the XIN FU ZHOU

The bridge of the XIN FU ZHOU is equipped with microphones over which the voyage data recorder records – among other things – conversations taking place on the bridge. These records enabled the BSU to reconstruct the relevant processes taking place there before, during and after the collision.

Conversations among the bridge crew conducted in English and Chinese, helm orders as well as the audible VHF radio communications were recorded via three microphones in the wheelhouse. The unanswered calls of the LASS URANUS on channel 74 before the collision can clearly be heard on the record. At 14:25:08 the helm is ordered "hard starbord". Another ten seconds later, after interjections in Chinese, an excited exclamation from the chart table "Hello! Mr. Pilot!" This is answered from the port side of the bridge house with "Yes, I see. We can't do anything." A few seconds later the command "hard -a-port" is ordered. After the accident, among other things the communication with the VTC was also recorded, whose literal content was reproduced under paragraph 5.6.2.

5.8 Expert opinion concerning photogrammetry

The accident reports and sketches provided by the witnesses as well as the radar, ECDIS and VHF records reveal that the distances between the two large container vessels and to the dry cargo ship at the time of the triple passage were of particular interest.

The BSU commissioned the Institute of Photogrammetry and GeoInformation (IPI) of the Leibnitz University in Hanover to define the distances between the vessels involved in the accident, the LASS URANUS and the XIN FU ZHOU, as well as between the XIN FU ZHOU and the MSC MELISSA. The expert opinion was based on the photograph made available by the witness, which showed the three vessels at the time of the triple passage (fig. 9). Excerpts from the opinion are reproduced below.

5.8.1 Background

Location positions in digital images are determined by means of measuring image co-ordinates (columns and rows) of the objects represented. To determine the distance of the vessels involved in the accident at the time when the image was taken, points are measured on the ship's side at waterline level. The column co-ordinates of the measurements enable the course angle to the object points to be determined.

In addition, the distances between the photographer's position and the measured object points on the ship's side are also required for unequivocal determination of its position on the water's surface. These distances are derived from the measurement of the length of vertical lines on the ship and on the picture taking into account known dimensions within the object, e.g. the height of the containers.

From the position co-ordinates of the ships' walls in a local co-ordinate system the distances can be calculated as a perpendicular distance.

5.8.2 Data

For the evaluation the situation image before the collision was used (fig. 9). Co-ordinates of the geographic reference system WGS 84 and Gauß Krüger co-ordinates were used respectively to determine the position and direction of the dimensional drawing and the camera position. The measurements of the ISO standard containers on the container vessels were used as comparative dimensions. From the vessel particulars the breadth of 40.3 m of the XIN FU ZHOU was used to calculate the distance.

The technical data of the camera/lens combination used were provided so as to account for the internal orientation of the camera. In addition, the focal length used was obtained from the supplementary image description information (EXIF data).

5.8.3 Calculation method

The column co-ordinates (easting) of the object points in the picture were measured in order to determine a position on the water's surface (cf. fig. 43).

Figure 43: Image co-ordinates measurement for distance determination

For the orientation of the scene in the superordinate co-ordinates system, the image co-ordinates of the pile in the foreground (point 127) and of the high rise building in the background (point 161) were also additionally measured. Certain dimensions (including freeboards) were derived from the given dimensions as reference lengths on the object. By comparative measurement of these distances in the image it was possible to calculate the distances of the object points from the camera's position point. Together with the calculated directions the position of the object points were outlined (cf. fig. 44).

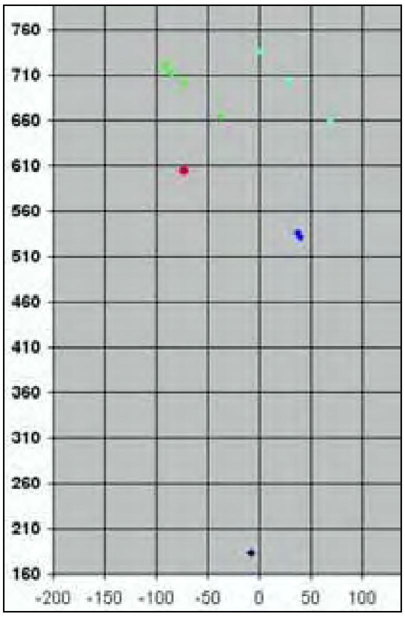


Figure 44: Relative positions of the selected object points

The measurement points on the sides of the container vessels were extended as a straight line and in each case the shortest distance from the neighbouring vessel was calculated to determine the distance between them.

5.8.4 Calculation results

The IPI calculation result evidences a distance of approx. 65.5 m between the LASS URANUS and the XIN FU ZHOU at the time recorded in figure 9. As the measurement points were at a great distance from the camera location (approx. 650 to 700 m) and the distance between the upper edge of the ship's side and the waterline could only be determined with a margin of error of +/- 30 cm, this results in a tolerance in the calculated distances of +/- 9.7 m.

The expert opinion indicates the average distance between the XIN FU ZHOU and the MSC MELISSA as being 37.7 m.

5.9 Expert opinion concerning hydrodynamics

The fact of the encounter among three seagoing vessels in confined waters with a subsequent collision, as well as the accident reports submitted, suggested the conclusion that hydrodynamic suction effects could have taken place when the LASS URANUS was being overtaken.

The BSU had already commissioned extensive expert opinions in the course of the investigation into the momentous collision on the lower Elbe between the container vessels COSCO HAMBURG and P&O NEDLLOYD FINLAND in 2004[6]. The results of the hydrodynamic studies undertaken at that time can however only be transferred to the present accident in their most fundamental aspects. On the one hand the LASS URANUS and the XIN FU ZHOU were not proceeding with the same speed, which means that – as opposed to the 2004 accident – the stream could not be considered to be quasi stationary. On the other hand the overtaking became a triple encounter by the arrival of an additional oncoming large container vessel, the MSC MELISSA. This brought about in particular the question to be examined in the expert's opinion as to whether and to what extent cumulative reciprocal hydrodynamic effects could have taken place.

The BSU therefore commissioned the Germanischer Lloyd (GL) to draw up a new hydrodynamic expert opinion on the basis of a numerical approach taking into account the complexity of the accident situation. Below, both the GL opinion and its results and also the general considerations of the previous experts that can be applied to the present casualty will be represented mostly verbatim as concerns their overview and otherwise paraphrased while preserving their general meaning.[7]

[6] The investigation report (File No. 45/04) and the expert reports drawn up at the time can be found on www.bsu-bund.de.

[7] The full GL opinion complete with Appendices is available on www.bsu-bund.de.

5.9.1 Background

The Potsdam Model Basin (SVA) made the following statements in its introduction to its 2004 expert opinion:

When vessels move at a short distance from each other, they mutually influence the relevant flow fields. In this situation, considerable hydrodynamic forces and moments can develop that impair the steerability of the vessels and can lead to collisions. This represents a major danger, especially in shallow water with a low water depth to draft (h/T) ratio. The most important reasons for collisions during an overtaking manoeuvre are insufficient distance between the vessels involved and excessive vessel speed, as this causes the forces and moments mentioned to increase.

The most important cause of the component force is the suction that develops because of the acceleration of the flow and reduction of the pressure between the two vessels. A further cause of the component force is the hydrofoil effect that leads to the fact that more particularly the vessel in the forward position experiences a force that is oriented towards the other vessel.

5.9.2 Initial parameters

The hulls of the LASS URANUS, the XIN FU ZHOU and the MSC MELISSA were modelled for the GL expert opinion, i.e. the lines of the vessels were transferred into an electronically readable description for the purposes of calculation. No significant hydrodynamic effects were expected from the additional vessels present on the scene of the accident (LOTSE1 and TUMAK), so that they were not included in the GL's modelling project.

A 4 km river section was modelled for purposes of the calculation of the relevant section of the Elbe (cf. fig. 45). For this purpose the sounding plans of HPA, the currents opinion of BAW and the water level data of the BSH Water Level Forecasting Service were made available to GL (cf. para. 4.1).The modelled river section has a constant depth of 17.11 m. The current speeds assumed are 1.375 m/s constant in the centre of the river and 1.0 m/s constant in the bank areas. Two strips at 1.17 m/s were defined as the transition areas.

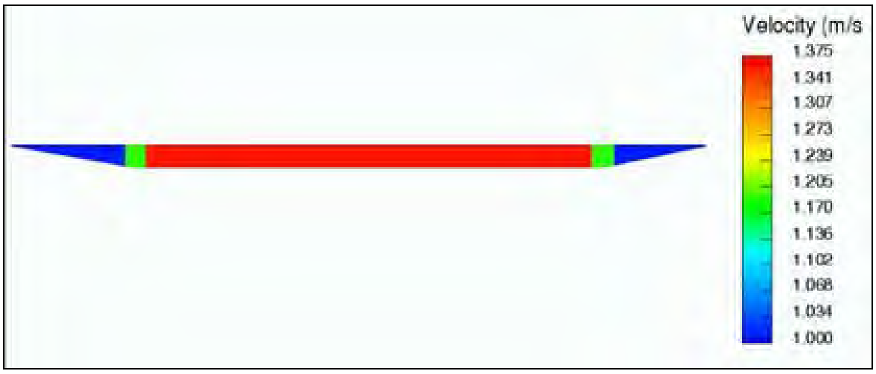


Figure 45: River cross-section including the assumed current dispersion profile

The GL's calculations are based on the simplifying assumptions that the vessels move in a straight line on parallel tracks and at constant speeds. The records of the Seemannshöft shore based radar station and of the XIN FU ZHOU's shipboard radar were made available to help determine the initial parameters. Taking into account the current conditions, therefore, in the model the LASS URANUS proceeded at an absolute speed of 1.6 kn, the XIN FU ZHOU at 7.6 kn and the MSC MELISSA at 5.6 kn.

The results of the photogrammetric analysis were used to determine the lateral distances between the vessels involved. The draughts were obtained from the respective shipping companies and by evaluation of the load lines photographed on the day of the accident.

A comparison between the witness reports of the accident and the radar as well as VHF records caused certain doubts to form during the accident investigation in regard to the exact point in time when the engine failure occurred on board the LASS URANUS. For the initial parameters it was of determining importance whether there was still any propeller thrust during the overtaking.

The GL expert opinion was based on the assumption, in accordance with the description of the accident provided by the crew of the LASS URANUS, that the LASS URANUS had not experienced engine failure before the hydrodynamic interactions with the XIN FU ZHOU could take place. This assumption was made with the objective to obtain more complex and therefore more significant results by means of assuming the presence of propeller propulsion.

5.9.3 Calculation method

The forces and moments occurred during overtaking and encounter were determined by means of calculations of the flows around the three vessels. For this purpose the GL used the simulation software COMET (Continuum Mechanics Engineering Tool) for the determination of hydromechanical flow parameters. According to the opinion, the calculated currents very closely follow the law of water as a so-called *Newtonian* fluid. The behaviour of the fluid is described by means of the fundamental equations of fluid mechanics (Navier-Stokes equations), time averaged according to *Reynolds* (RANSE[8]) and discretised. For details of this and the remaining equations and methods used (such as e.g. of the transport equation and the calculation grids for the current simulation) reference is made to the full text of the GL's expert opinion.

5.9.4 Calculation results

The GL carried out calculation series with and without inclusion of the free water surface. The first series was carried out without taking into account the free water surface as taking into consideration the relatively low speed of the ships in regard to

[8] Reynolds-Averaged Navier-Stokes Equations

the formation of waves the influence on the suction effect was considered to be of secondary importance (highest Froude number for the XIN FU ZHOU $F_r = 0.1$).

The pressure distribution on the underwater hull plating of the LASS URANUS calculated in the simulation constituted the foundation for the determination of the transverse forces and yaw-moments. The following figures show the pressure distribution from the underwater perspective. While just two minutes before the collision the pressure distribution is still even (cf. fig. 46), in the temporal approximation to the collision (approx. "Time: 120 s") the formation of a low-pressure area (marked in blue) at first at the stern (Time: 110 s) and later at the bow (Time: 130 s) can be clearly recognised (cf. fig. 47).

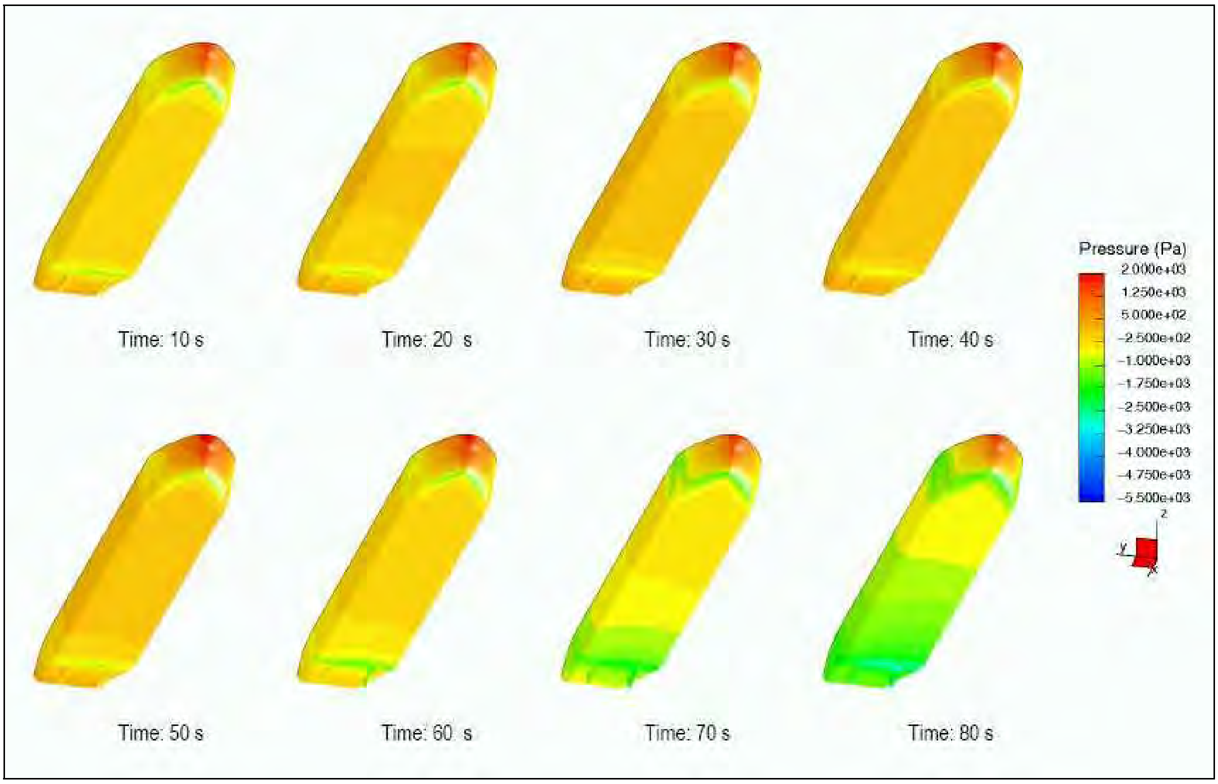


Figure 46: Pressure distribution on the hull plating of the LASS URANUS

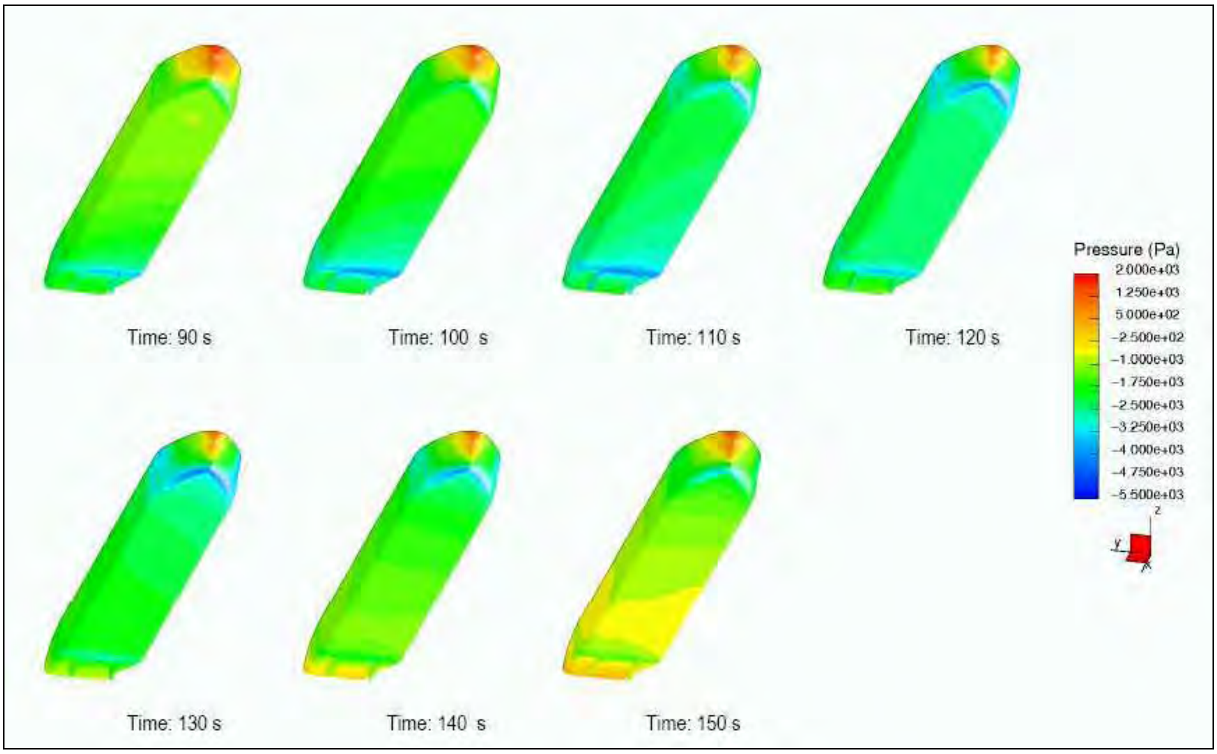


Figure 47: Pressure distribution on the shell plating of the LASS URANUS immediately before, during and after the collision

The integral parameters of the forces and moments occurred are contrasted in figures 48 to 50. The green curve corresponds to the respective integral parameter assuming the above defined constant vessel speed for the LASS URANUS. On the basis of the calculated dimension of the longitudinal forces however the GL assumed that the vessel's speed would change under the effect of these forces. For this reason, for a further simulation series a speed profile was estimated assuming constant propeller thrust. The red curve corresponds to the respective integral parameter under the assumption of a change in speed.

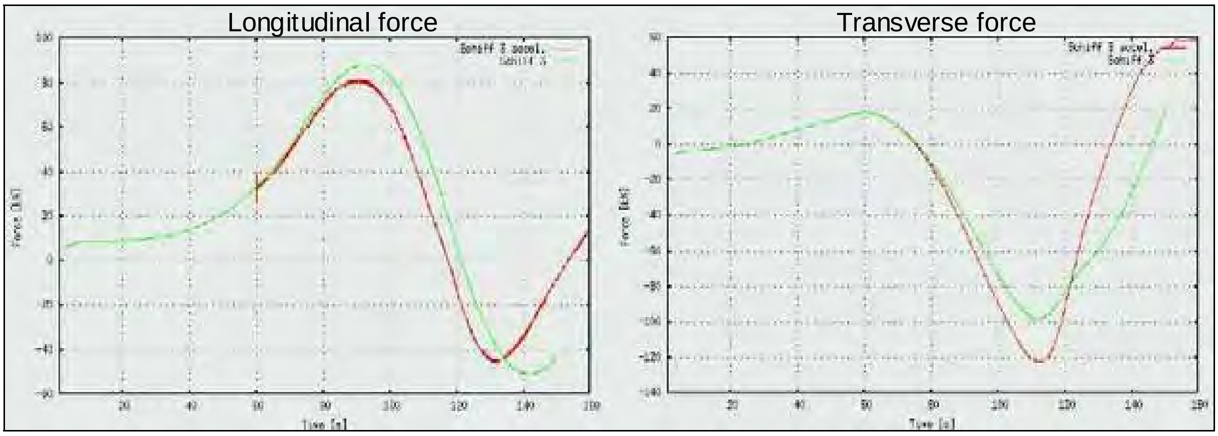


Figure 48: Longitudinal and transverse forces acting on the LASS URANUS

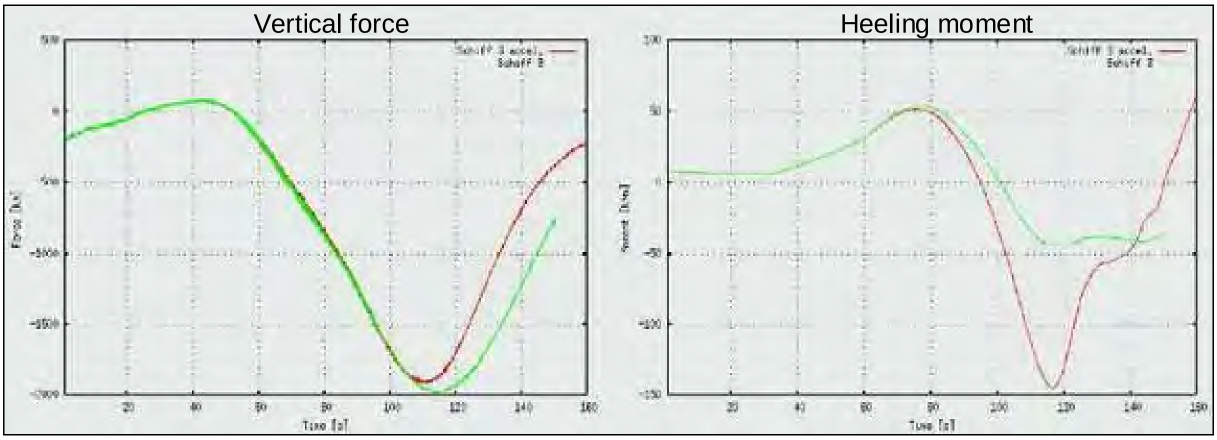


Figure 49: Vertical force acting on the LASS URANUS and heeling moment

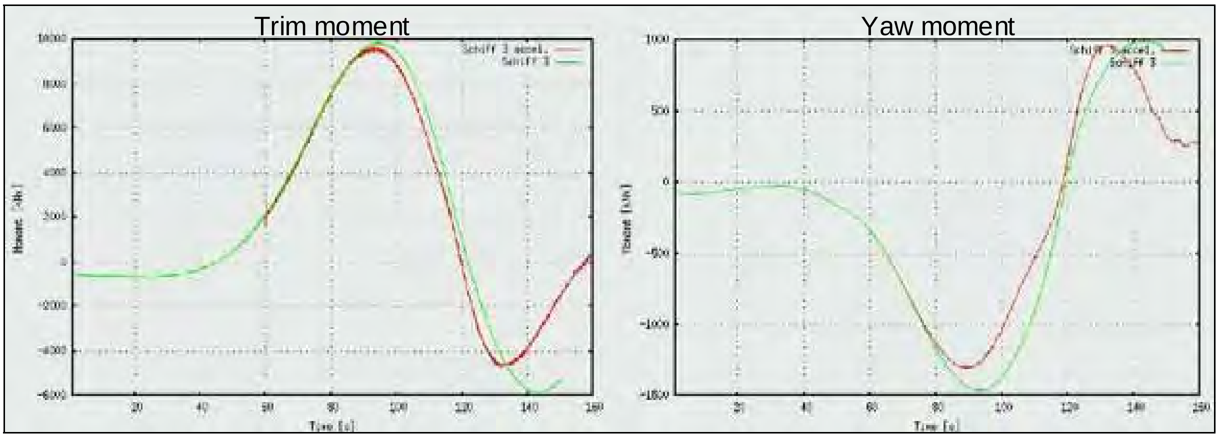


Figure 50: Trim and yaw moment acting on the LASS URANUS

5.9.5 Interpretation of results

The GL produced both graphic and text interpretations for the simulation results. The following figure 51 shows the pressure in the modelled section of the Lower Elbe during the triple encounter.

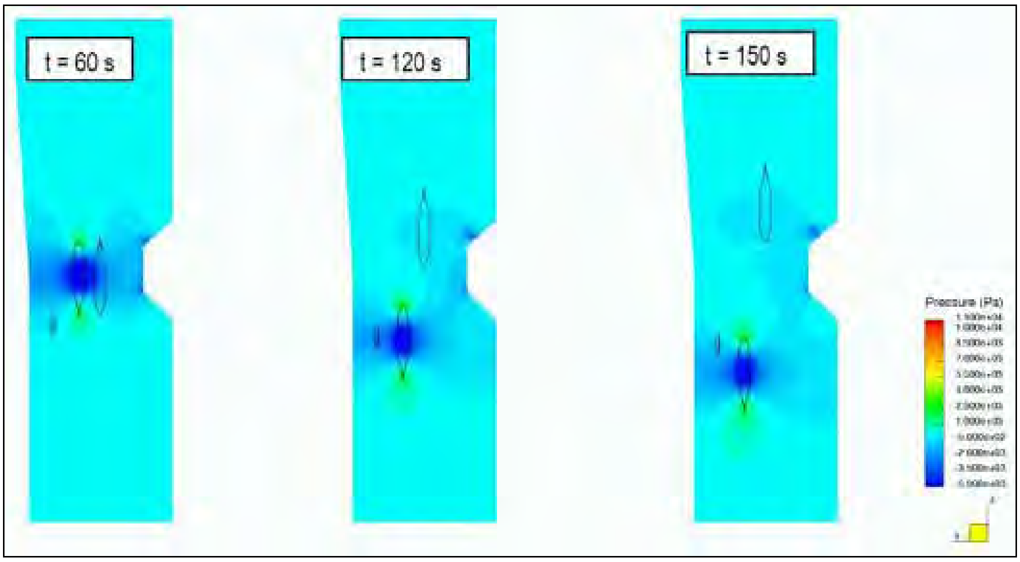


Figure 51: Pressure outline at the static water level

The low-pressure area generated by the XIN FU ZHOU due to its displacement effect can be clearly distinguished. In the simulation the LASS URANUS and the MSC MELISSA proceed at distinctly lower speeds through the water, so that their effect is present, but comparatively much smaller. In the overtaking model represented here with a constant overtaking distance, at approximately t = 60 s the LASS URANUS enters into the XIN FU ZHOU's low-pressure area, at approximately t = 120 s both vessels are at the same level and at t = 150 s the effect decreases again.

The effect on the LASS URANUS can be read off the following table by means of the timing of the integral parameters (cf. table 2).

	t = 60 s	**t = 120 s**	**t = 150 s**
Longitudinal force [kN]	Additional longitudinal force (increase of resistance)	Longitudinal force neutral	Longitudinal force in heading direction (decrease of resistance)
Lateral force [kN]	Lateral repellence force	Lateral suction force	Lateral repellence force
Buoyant force [kN]	Buoyancy starting to decrease	Decrease of buoyancy	Gradual buoyancy increase
Heeling moment [kNm]	Starting heeling moment to port	Heeling moment to starboard	Neutral heeling moment achieved
Trim moment [kNm]	Starting aft trim moment	Neutral trim moment	Forward trim moment
Yaw moment [kNm]	Starting outward turning yaw moment	Neutral yaw moment	Inward turning yaw moment

Table 2: Reaction forces/moments of the LASS URANUS

The shifting of the low pressure area acting on the LASS URANUS from the aft section of the ship (port, t = 110 s) to the forward section (port, t = 130 s) generate a transient yaw moment and the presence of a starboard/port asymmetry causes a lateral suction force.

Consideration of the adapted velocity trend of the LASS URANUS (cf. figs. 48 to 50, red curves) results in a slightly increased lateral force with an almost unchanged trend in the yaw moment.

The pressure distribution on the underwater shell plating of the XIN FU ZHOU and the MSC MELISSA, calculated in the simulations, resulted in almost constant calculation results during and after the collision.

5.9.6 Estimation of the manoeuvring moment

The mathematical demonstration of the lateral suction force acting on the LASS URANUS during the overtaking process raised the question as to what extent the LASS URANUS could effectively have countered the suction effect by means of manoeuvres. As the countermeasures taken in the moments immediately before the collision cannot be exactly determined ex post, the GL decided after consultation with

Schottel to form an estimate. For the LASS URANUS this estimation results in a manoeuvring moment of approximately 1,750 kNm.

5.9.7 Conclusions of GL

As a result of its numerical simulation GL drew the following conclusions:

As the overtaking vessel proceeding against the current the XIN FU ZHOU accordingly generates a low pressure field due to its own displacement flow. As soon as the LASS URANUS as the overtaken vessel enters this low pressure area, a suction force towards the overtaking vessel is generated in significant stages of the overtaking process. The pressure distribution developing however is of a non-stationary nature, resulting in an additional yaw moment with a changing algebraic sign.

At the start of the overtaking an outward turning yaw moment takes place (the stern is sucked in) and in the further course of the manoeuvre the LASS URANUS experiences an inward turning yaw moment (the bow is sucked in). This effect must be counteracted. According to the estimate, the steering moment of the LASS URANUS is of similar magnitude as that of the externally influencing yaw moment due to the suction effect, so that the possibility of outmanoeuvring it must be called into question.

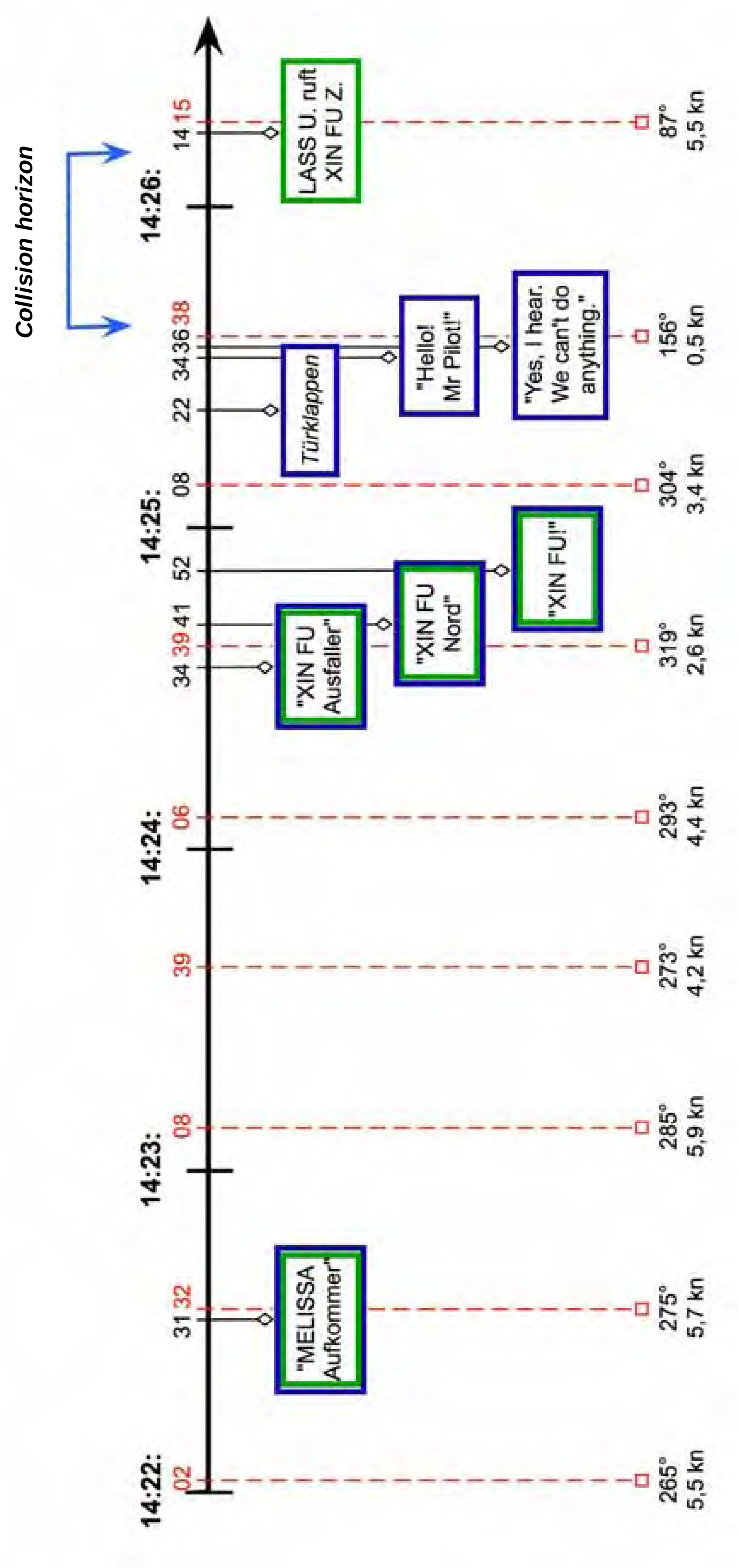
However, the practical navigational situation leads to navigational performances different from the conditions assumed in the model, which could influence the externally acting yaw moments and forces.

In addition, the simulation shows that the MSC MELISSA, proceeding with the current, had a subordinate influence on hydrodynamic forces and moments.

5.10 Summary

Through its evaluation of numerous records from various different sources, the accident investigation produced a complex general view of the course of the accident. For the sake of greater clarity, the time stamped records that document individually relatable aspects of the events of the accident are synchronised on a timeline in figure 52 below. The basis for the timing is the radio timed VHF recording of the VTC in Hamburg. The time on board the XIN FU ZHOU and therefore also the times shown on the VDR records differed from the timing reported by the VTC in Hamburg, but could be accurately synchronised via the radio traffic documented in both sources.

The distances between ships were not included in the graph, as the radar records provide indications of the positions of the relevant vessels, but the actual positions can vary as to individual details. The record synchronisation limits the collision period to the time between 14:25:36 and 14:26:14.



Caption:
- VHF channel 74 recordings of the VTC
- VDR recordings of the bridge microphones on board the XIN FU ZHOU
- Recordings of the VTC (course and speed of the LASS URANUS)

Figure 52: Time line graph of the events of the accident

In conclusion, it should be remembered that the LASS URANUS first reported a failure via VHF channel 74 one to one and a half minutes before the collision with the XIN FU ZHOU. If the above graph is additionally synchronised with the witness' photograph taken immediately before the collision (cf. fig. 42, time linked 14:25:34), then the collision took place one minute after the radio contact. This assumption is confirmed by the XIN FU ZHOU's ship radar records (cf. fig. 40).

It was possible to demonstrate mathematically that as a result of the overtaking by the XIN FU ZHOU the LASS URANUS was subject to strong hydrodynamic forces. The records of the Hamburg VTC show that shortly before the first radio call reporting the engine failure the LASS URANUS had lost speed and also drifted off the course line first to starboard and then in the opposite direction (over 150° to port), with its bow heading for the XIN FU ZHOU.

This characteristics match GL's calculation results, according to which the hydrodynamic interactions first caused the stern of the LASS SATURN being sucked in and immediately thereafter the bow being sucked in with a simultaneous increase in speed.

Because of the estimated manoeuvring moment of the LASS URANUS, as a result of GL's expert opinion it must be called into question that the freighter would have been able effectively to counter the resulting hydrodynamic forces even if her main engine had not failed.

6 Analysis

6.1 Encounter situation

The section of the Lower Elbe on which the triple encounter and the collision took place provided very little scope for potential evasion manoeuvres, especially for the container vessels XIN FU ZHOU and MSC MELISSA.

The VTC of HPA is responsible for traffic monitoring in this area. Contrary to other sections of the Lower Elbe, there are no overtaking or passing restrictions between buoys 132 and 130.

6.2 Overtaking

The hydrodynamics opinion of the GL concluded that by reason of her relative speed and the corresponding displacement effect the XIN FU ZHOU generated a low-pressure area that exposed the LASS URANUS to strong and changing suction effects. The BSU assumes that it had been planned on the part of the XIN FU ZHOU to overtake LASS URANUS not until the MSC MELISSA had been passed. This is supported by the fact that the rate of turn had been maintained at constant speed. Thus the pilot's attention paid to the MSC MELISSA in proceeding to the port bridge wing becomes explicable. However, according to the LASS URANUS' crew shortly before the passing of Teufelsbrück (about 1419) an overtaking manoeuvre had been suspected to take place during the triple encounter. Therefore it had reportedly been tried to coordinate the overtaking action by means of VHF. But the records of VHF channel 74 prove the calling of the XIN FU ZHOU has taken place not until one to one and a half minutes before the collision (about 14:24:30), when the LASS URANUS had already lost speed significantly and obviously suffered difficulties with the manoeuvrability.

Due to the unpredicted slackening of the LASS URANUS' speed, the bridge team of the XIN FU ZHOU was surprisingly caught in the position as an overtaking vessel. The sudden slackening of speed of the LASS URANUS sailing ahead had not been discovered as problematic until the LASS URANUS lay stem to stem abeam. Nevertheless had there been only a marginal possibility for the ship's command to ease the situation in case it had been detected at an earlier stage. Stopping the vessel would have had a negative impact on the steerability, whereby passing the MSC MELISSA would have posed additional threats. As an evasion manoeuvre was out of the question as well, only overtaking with the greatest possible passing distance remained for the XIN FU ZHOU.

According to the IPI's calculations, the passing distance to the LASS URANUS finally was at most of 75 m and there was a flood current increasing in intensity. The length ratio of the XIN FU ZHOU to the LASS URANUS is of almost 4:1. The BSU had already pointed out with regard to the accident investigation concerning the collision between the CMS COSCO HAMBURG and the CMS P&O NEDLLOYD FINLAND (cf. footnote 6) that on overtaking of a smaller vessel by a larger vessel an inadequate passing distance and the larger vessel's speed through the water are factors that can lead to the development of dangerous suction effects, which might possibly cause the smaller vessel to get out of hand. Thus the unintentionally occurred situation of overtaking the LASS URANUS while encountering the MSC MELISSA at the same time was fraught with risk.

The evaluation of the VHF channel 74 recordings revealed that the XIN FU ZHOU had at first made the LASS URANUS aware of its presence before leaving the Parkhafen basin (cf. para 5.5.1). At the first radio contact the LASS URANUS' command had also made it clear that she did not intend to adjust her course to starboard ("go further into the north") at that time. Rather, the arrangement was that the two vessels would watch out for each other. However, this does not represent an agreement in regard to overtaking within the meaning of section 23 para. 4 sentence 1 SeeSchStrO (German Traffic Regulations for Navigable Waterways).

Just under 25 minutes later the LASS URANUS reported problems ("failure") on VHF channel 74. The Elbe pilot on board the XIN FU ZHOU stayed at the port bridge wing. While on his way back to the wheelhouse he did hear LASS URANUS' failure call but did not answer it immediately, because he was initially heading to the starboard bridge wing. When he arrived there, he recommended a "hard starboard" manoeuvre. The intention was to try to move the XIN FU ZHOU's stern to port in order to provide enough space for the LASS URANUS' full turn to port. "Hard -a-port" had been ordered when this did not prove successful. Less the time necessary for the rudder angles, approx. one minute remained for the XIN FU ZHOU's crew from identifying the situation up to the collision.

The overtaking by the XIN FU ZHOU was caused by the slackening of speed of the LASS URANUS. In the end, the LASS URANUS was put at risk by the suction effect occurring during the triple encounter. This danger substantiated with the occurrence of the collision damage.

If the main engine of the LASS URANUS had indeed - as was asserted in the reports - been fully functional until shortly before the collision, then it should have been taken into consideration to at least temporarily give way to starboard across the 10 m line. This would have increased the distance to the overtaking vessel. The depth available on the day of the accident would have made that possible. However, it should be taken into account that halfway between buoys 132 and 130 the Nienstedten wave measuring pile is located still southerly of the 5 m line.

6.3 Main engine failure

After completion of the investigation it was not possible to determine without doubt whether the port main engine of the LASS URANUS failed only due to the hydrodynamic interaction with the XIN FU ZHOU as a result of an overcharge situation, or whether it had already failed beforehand for unknown reasons.

6.3.1 Alternative 1: Failure due to the overtaking

The accident analysis based on the assumption that the engine did not fail prematurely relies essentially on the information obtained on the main engines of the LASS URANUS and from the expert opinion commissioned in that regard.

6.3.1.1 Reduced engine rating

Both main engines of the LASS URANUS had been reduced in rating at the engine's manufacturer. For this purpose, the fuel flow was manually restricted at the injection pump (cf. figs. 18 and 19) of the dismounted engines. These are open pumping systems, in which the combustion pressure is only generated in the injection component. Rating reduction modifications are carried out on the controller side; the stop positions for the idle and the final rotation speed are inside the controller and can therefore only be reached by using tools. The fuel flow is reduced. Afterwards, each engine is sealed on the controller side.

The pump settings of the LASS URANUS altered in such way have been verified by the engine's manufacturer by means of defined test data. According to the manufacturer, that adjustment is sufficiently exact.

Determination of the LASS URANUS' engine rating at the time of the accident proved to be difficult. The shipping company, which had itself and not under the supervision of the Classification Society carried out ongoing maintenance on the system, repeatedly reported until August 2007 that the total nominal output was 750 kW. The vessel's command of the day of the accident as well as the vessel's command on board at the time of the second survey by the BSU both assumed an engine rating of 750 kW. The BSU informed the latter Master about the propulsion power reduction and its extent. The indication of 750 kW was inconsistent with the recent GL Certificates of Class, whose Annex first list 596 kW (Certificate of 14 March 2000) and later 600 kW (Certificate of 31 March 2003) as the total nominal output. In August 2007 the shipping company, too, indicated the output as being 600 kW.

The engines on board on the day of the accident were installed in 1995 and throttled in 2000. The reduction in output was approved by the GL. The reduced engine rating is decisive for the evaluation of the question as to whether the freighter would have been able, had the engine not failed, to counteract the suction forces developing during the overtaking process. As the Master of the LASS URANUS had many years' navigational experience, it would in principle have been possible with a functional, powerful main engine to avoid the collision by means of countermeasures according to experience with changing suction forces.

In the conclusions to the hydrodynamics expert opinion, GL did question the possibility of outmanoeuvring, as according to the calculations concerning the component suction force would have been approximately equal to the steering moment. Upon request GL reported that according to estimates not even operation of both engines would have sufficed in order to counter the yaw moment effectively.

This was ascribed to the fact that, according to the manufacturer's specifications, with twice the engine output the propeller thrust increases only by approx. 20 %. As a result of the quality of the data and the complexity of the calculations performed, the BSU considers the results obtained to be substantive.

6.3.1.2 Failure due to overload

According to the crew of the LASS URANUS, at the moment when the vessel was sucked almost abruptly and with increasing speed to port, course was immediately altered "hard starboard" at 1,700 rpm. At the same time the bow thruster was reportedly added with full thrust to starboard. Thereupon the engine revolutions reportedly fell abruptly when the LASS URANUS had already run out of its course line by approx. 45°.

When too much torque is applied to an engine, its revolution speed decreases, leading to a temperature rise. When the tolerance values are exceeded, the overload protection is activated, which automatically deactivates the engine and ultimately shuts it down. An overcharge situation can come about either due to external factors such as e.g. strong suction, or also due to unusual load during standard operation.

As on the day of the accident the LASS URANUS was only operating the port main engine, it can be assumed that it was being operated at its torque limit. An indication for this assumption is the report of 1,700 rpm as full load revolution speed, although the nominal factory revolution speed should be 1,800. Adding the bow thruster demanded further load of the engine. This is supplemented by an increased load on the propeller due to massive countersteering.

It was no longer possible to determine ex post whether this load due to normal operation would already have been enough to deactivate the engine, or whether the suction effect would ultimately have been decisive. On the part of the LASS URANUS, the BSU was informed the comment on VHF channel 14 at 14:46:33 (LASS URANUS: "... nothing one could do, then she just turns away like that and then ... although we were running at only 4 kn.") would implicate that the port main engine had been still in operation before the suction effect applied. In BSU's opinion, this comment could also express the surprise as it was possible at all for LASS URANUS' main engine to get into an overcharge situation despite the relatively slow speed.

The capacity of the single port main engine of the LASS URANUS, operated at full load, had driven the engine at least to its upper limit if not beyond by the necessary countersteering following the triple encounter situation. A failure due to overcharge cannot be entirely ruled out in this respect.

6.3.2 Alternative 2: Failure independent of the overtaking

Numerous indications however argue for the view that the main engine failed when the LASS URANUS was still outside of the area of influence of the low-pressure field generated by the XIN FU ZHOU. One minute before the collision, the LASS URANUS reported a failure. The distance between the positions of the two vessels half a minute earlier (1424) was approx. 150 m (cf. fig. 27 of 14:24:39). The calculated positions can however contain a margin of error. A comparison with the ship and shore based radar records does also not provide the required accuracy for an exact position determination.

The BSU therefore considers the documented radio traffic before and after the accident to be significant. Before and after the accident the LASS URANUS spoke of a "failure" and a "total blackout" (cf. para. 5.6). The channel 14 radio traffic after the collision clearly describes the course of the accident: "We had a failure, (…) and then she got sucked in and then she flopped over there."

Upon enquiry from the BSU it was stated that in the radio communications preceding the collision the expression "little failure"[9] before the accident had only referred to the steering characteristics and the vessel's swerve movements. At that point the engine reportedly was still fully available. The later engine failure during the triple passage on the other hand had been described as a "total failure". This statement is not convincing. It is standard usage in shipping circles to describe a failure of the main engine as a "blackout". A graded differentiation between "failure/blackout" and "total failure/total blackout", where the first expression were supposed to refer not to the engine but to the heading therefore seems unrealistic. In addition, after the accident, and as is customary in general usage, both expressions were used synonymously over channel 74: "(...) I have a failure, total failure here". (cf. para 5.6.1). The pilot on board the XIN FU ZHOU had as well interpreted the information about a "failure" as a failure of the engine, according to which he hurried to the starboard bridge wing in order to assess the situation. The request to the XIN FU ZHOU on VHF channel 74 approx. one minute before the collision to "go northerly straight away" is another indication for an engine failure independent of any suction effect. This suggests the conclusion that both vessels were still at such distance from each other that would have allowed for a respective manoeuvre to be carried out.

It should be considered according to the documented radio traffic and the witnesses statements to be probable that the port main engine of the LASS URANUS had failed for unknown reasons before the low-pressure area created by the XIN FU ZHOU reached the LASS URANUS.

Sudden propulsion failures have also occurred in the past on sister ships of the LASS URANUS.

9 Cf. the VHF transcript of channel 74, 14:24:34: "XIN FU please, we have a little failure here".

6.4 Functionality of the Voyage Data Recorder (VDR)

The reconstruction of the course of an accident is rendered significantly more difficult if the VDR is either not at all or only partially functional. Neither the data of the VDR on board the MSC MELISSA nor that installed on board the other vessel not involved could be used for the accident investigation.

The VDR is a salvageable data storage device for use on seagoing vessels. The gradual implementation of VDR carriage requirements for ships in international traffic according to Chapter V / rule 20 of the International Convention for the Safety of Life at Sea (SOLAS) began on 1 July 2002. Since 2006 existing cargo vessels must gradually be retrofitted with VDR or S-VDR (Simplified VDR). This carriage requirement also results from European Community Law (cf. Directive 2002/59/EC[10]).

Fast access to VDR stored data is essential for accident investigations. After an accident, the data can be used not only to determine causes, but also for prevention, as they provide the necessary information concerning such events. Accordingly, in a circular to the Member States (SN/Circ/246[11]) on 17 June 2005 the Safety of Navigation Subcommittee of the IMO[12] Maritime Safety Committee recommended that on board vessels equipped with VDR or S-VDR software and connections should be made available to enable on-site backup and playback of the stored data. The possibility to adequately backup accident data has been an integral part of the Resolution MSC.163(78)[13] of the IMO Maritime Safety Committee as a recommendation since 14 May 2004, containing performance standards for S-VDR on board seagoing vessels. The possibility of prompt access to stored accident information for investigation authorities has lately been strengthened by the Resolution MSC.214(81)[14] adopted on 12 May 2006, by which the performance standards for voyage data recorders were expanded by means of a mandatory provision of software and interfaces.

A manufacturer of a VDRs that did not meet the above mentioned performance standards has already been advised by the BSU of problems occurring in connection with data backup and evaluation (cf. accident report concerning the collision between the MV RITHI BHUM and the MV EASTERN CHALLENGER, ref. no. 343/04[15]). In an

[10] Directive 2002/59/EC of the European Parliament and Council of 27 June 2002 establishing a Community vessel traffic monitoring and information system, repealing Council Directive 93/75/EEC (ABl. L 208/10 of 5/8/2002 p. 10)

[11] Recommended means for extracting stored data from Voyage Data Recorders (VDRs) and Simplified Voyage Data Recorders (S-VDRs) for investigation authorities

[12] International Maritime Organisation of the United Nations

[13] Performance Standards for Shipborne Simplified Voyage Data Recorders (S-VDRs), Verkehrsblatt (Gazette of the Ministry of Transport, Building and Urban Affairs) 2005, p. 466

[14] Adoption of Amendments to the Performance Standards for Shipborne Voyage Data Recorders (VDRs) (Resolution A.861(20)) and Performance Standards for Shipborne Simplified Voyage Data Recorders (S-VDRs) (Resolution MSC.163(78)), Verkehrsblatt 2008, p. 149

[15] The investigation report can be found on the BSU's website, www.bsu-bund.de.

investigation still pending, no usable data could be secured at all, and in yet another investigation only data of inadequate quality could be obtained.

At the BSH's instance, the IMO Maritime Safety Committee has been provided with an amendment proposal for IMO performance standards for voyage data recorders, submitted by the Federal Republic of Germany. The deficiencies of VDR stored data made obvious during the investigation of the collision between the MV RITHI BHUM and the MV EASTERN CHALLENGER, which caused BSU to issue a safety recommendation to the VDR manufacturer and the BSH, gave reason for this proposal. The proposal submitted by the Federal Republic of Germany has been referred to the work programme of the Safety of Navigation Subcommittee. It stipulates technical improvement as well as the recording of AIS target data from other vessels.

The proposal of precise technical improvement regulations for IMO performance standards for voyage data recorders has been an important step to utilize stored ship's data for the incident investigation as well as for preventive training courses more efficiently in the future.

7 Safety Recommendations

The following safety recommendations shall not create a presumption of blame or liability, neither by form, number nor order.

7.1 Vessel traffic participants and pilots

The Federal Bureau of Maritime Casualty Investigation recommends that **vessel traffic participants and pilots** take into account the risk potential of encounter situations on-site the Airbus airstrip area, in particular if the specific situation involves more than two seagoing vessels. Overtaking at this section of the Lower Elbe with another large vessel oncoming simultaneously should be avoided.

7.2 Operators of seagoing vessels

The Federal Bureau of Maritime Casualty Investigation recommends that **operators of seagoing vessels** provide their vessel commands with reliable information concerning the impact of reduced engine ratings on the manoeuvrability of the respective vessel.

7.3 Manufacturers of Voyage Data Recorders

The Federal Bureau of Maritime Casualty Investigation recommends that **manufacturers of voyage data recorders** improve the hardware and software to ensure that recorded data are available in sufficient quality and can be analysed after a marine incident.

An excerpt from a recommendation of Investigation Report 343/04 is reprinted below as a reminder:

The Federal Bureau of Maritime Casualty Investigation recommends the manufacturer of the voyage data recorder to evaluate the technical inadequacies of the device that occurred in close co-operation with the Federal Maritime and Hydrographic Agency responsible to type approvals for vessels sailing under German flag and to secure the complete functionality of the system and the required quality of the data to be recorded in accordance with the performance standard of the IMO and the European standard. Furthermore the possibility of a suitable notification to the vessel's command of inadequacies within the device should be reviewed, and if appropriate implemented into practice. This applies especially with regard to the lack of sensor data mandatory for recording.

8 Sources

- Statements of witnesses:
  - Master and helmsman of LASS URANUS
  - Master of XIN FU ZHOU
  - Master of MSC MELISSA
  - Master of LOTSE1
  - Pilot on board XIN FU ZHOU
- Extract of bridge log of LASS URANUS
- Minimum Safe Manning Certificate of LASS URANUS
- Certificate of Class of LASS URANUS
- Pilot Card of XIN FU ZHOU
- ECDIS Records of XIN FU ZHOU
- Ship's radar records of XIN FU ZHOU
- Framing and Lines Plan of LASS URANUS
- General Arrangement Plan of LASS URANUS
- Time sheet of the Master of LASS URANUS
- Survey reports of the classification society GL for LASS URANUS
- Survey report of the See-Berufsgenossenschaft for LASS URANUS
- Engine particulars of the manufacturer Cummins
- GL inspection document for series motors without reduction of engine rating
- Sounding plans for the river Elbe (scene of the accident)
- Extract of the bridge log of MSC MELISSA
- Radar- and VHF records of the VTC Hamburg
- Section of nautical chart No. 48, INT 1455, BSH