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

Investigation Report 41/09

Less Serious Marine Casualty

Collision on the Kiel Canal between MT VASI and MT BIRTHE THERESA on 12 February 2009 at 0300 h

1 December 2010

www.bsu-bund.de

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

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

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

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

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1 Summary of the marine casualty

MT BIRTHE THERESA was sailing from Klaipėda to Eemshaven fully laden. At 0250[1] on 12 February 2009, she cast off from the inland port of Holtenau to proceed on her passage through the NOK towards the west. The bridge was manned by the pilot, the master at the helm and the second officer.

MT VASI was sailing from Klaipėda to Rouen. At 0247 on 12 February 2009, she began to leave the lock as a low-speed, Traffic Group (VG) 4 vessel. In addition to the pilot, the master, second officer and a canal helmsman were situated on the bridge. There was practically no wind and visibility was good.
A collective call made at 0250 while they were sailing out of the lock informed the ship's command about oncoming vessels.
Agreements were made to clarify who should move where and when in the ensuing VHF radio traffic between the two pilots. The pilot of the VASI was reportedly aware that he had right-of-way because his vessel was already underway. In spite of that, he reportedly intended to grant the BIRTHE THERESA right-of-way as his vessel had to pass through the canal at low speed.
Therefore, the BIRTHE THERESA was to initially remain to the south of the canal axis and increase speed. However, rather than doing that she proceeded to the northern side of the NOK and in doing so crossed the bow of the VASI, which continuously increased her own speed and prepared to overtake. She overtook at 14 km/h while the speed of BIRTHE THERESA remained at approx. 10 km/h. As the overtaking manoeuvre was almost completed at 0259, the vessels began to sucking in one another. BIRTHE THERESA picked up speed and turned unexpectedly to port. At 0300, the two hulls came into contact and remained so until 0306. The vessels continued 'in a packet'; although they reduced their speed they did not separate from one another. At 0305, they even passed a upcoming vessel. At 0307, the bow of the BIRTHE THERESA turned away to starboard and she sailed into the northern embankment. The Vessel Traffic Service (VTS) was informed about the accident and the damage to the two vessels assessed. The VASI was then able to continue her voyage to Brunsbüttel. The BIRTHE THERESA freed herself from the embankment under her own steam and then returned to Kiel.

[1] Unless stated otherwise, all times shown in this report are local = CET = UTC + 1.

2 SHIP PARTICULARS

2.1 Photo of the MT VASI

Hasenpusch Photo-Productions

Figure 1: MT VASI

2.2 Vessel particulars, MT VASI

Name of vessel:	VASI
Type of vessel:	Tanker
Nationality/flag:	Cyprus
Port of registry:	Limassol
IMO number:	9435806
Call sign:	5BMV2
Owner:	Vasi Maritime Co. Ltd.
Year built:	2008
Shipyard/yard number:	STX Shipbuilding Co. Ltd.-Busan/5028
Classification society:	American Bureau of Shipping
Length overall:	120.00 m
Breadth overall:	20.40 m
Gross tonnage:	8,247
Deadweight:	12,923 t
Draught (max.):	8.71 m
Draught at time of accident:	F: 8.60 m, M: 8.65 m, A: 8.70 m
Engine rating:	4,516 kW
Main engine:	MAN B & W
(Service) speed (max.):	11.7 kts
Hull material:	Steel

2.3 Voyage particulars

Port of departure:	Klaipėda
Port of call:	Rouen
Type of voyage:	Merchant shipping International
Cargo information:	12,279 t urea/ammonium nitrate
Manning:	18
Pilot on board:	Yes
Number of passengers:	0

2.4 Photo of the MT BIRTHE THERESA

Hasenpusch Photo-Productions

Figure 2: MT BIRTHE THERESA

2.5 Vessel particulars, MT BIRTHE THERESA

Name of vessel:	BIRTHE THERESA
Type of vessel:	Tanker
Nationality/flag:	Singapore
Port of registry:	Singapore
IMO number:	9083184
Call sign:	9VFJ3
Owner:	Herning Shipping AS
Year built:	1995
Shipyard:	Societatea Comerciala Severnav S.A.
Classification society:	Lloyds Register
Length overall:	87.80 m
Breadth overall:	12.37 m
Gross tonnage:	2,094
Deadweight:	4,979 t
Draught (max.):	5.50 m
Draught at time of accident:	F: 3.60 m, A: 5.20 m
Engine rating:	1,853 kW
Main engine:	Caterpillar 3606
(Service) Speed:	n/a
Hull material:	Steel
Hull design:	Double side, double bottom

2.6 Voyage particulars

Port of departure:	Klaipėda
Port of call:	Eemshaven
Type of voyage:	Merchant shipping International
Cargo information:	1,501 t glycerine
Manning:	10
Pilot on board:	Yes
Number of passengers:	0

2.7 Marine casualty or incident information

Type of marine casualty/Incident:	Less serious marine casualty/collision
Date/time:	12/02/2009 0300 h
Location:	Kiel Canal, km 95.0
Ship operation and voyage segment:	Departure/harbour mode
Place on board:	Port side of the BIRTHE THERESA, starboard side of the VASI
Consequences:	No injuries, paint abrasions and dents above the water line on both vessels, no damage to the cargo or environment

Excerpts from the Kiel Canal chart, WSD-North 1995

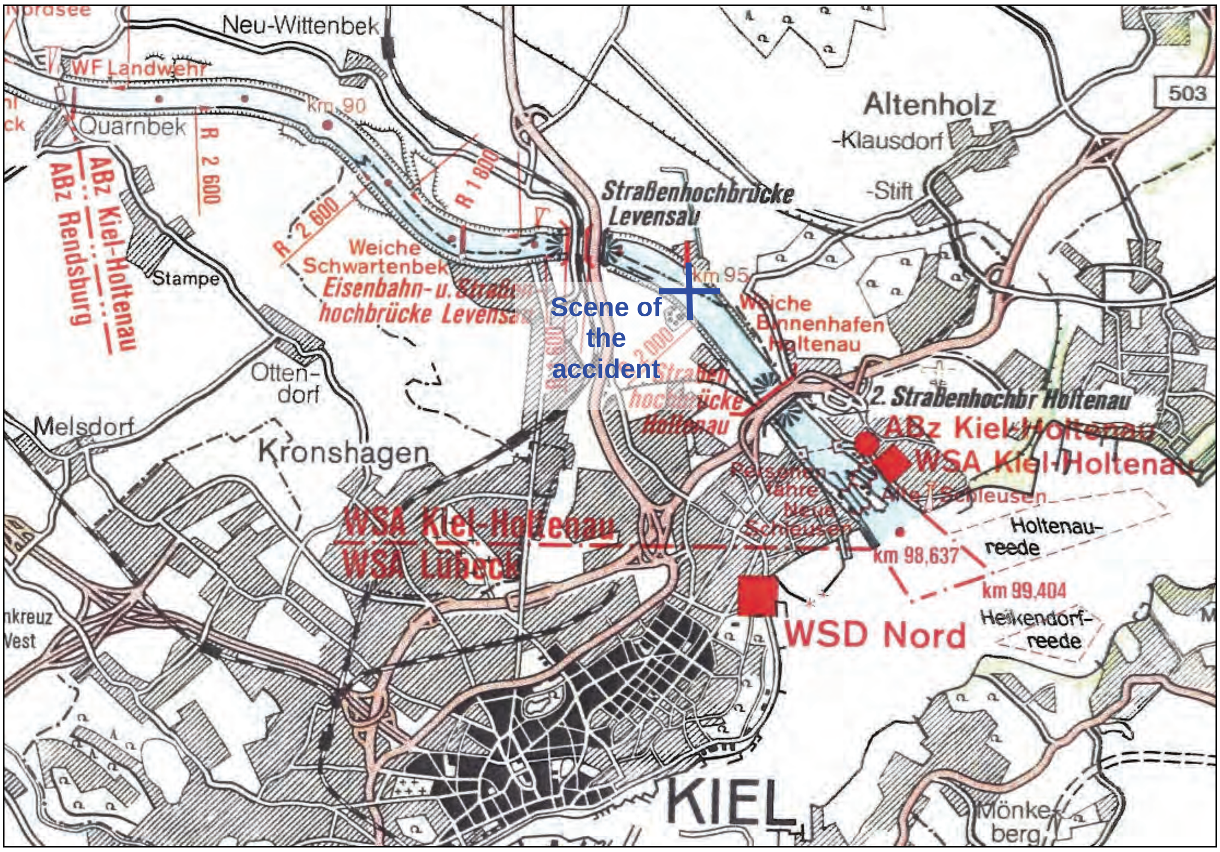

Figure 3: Scene of the accident – Overview

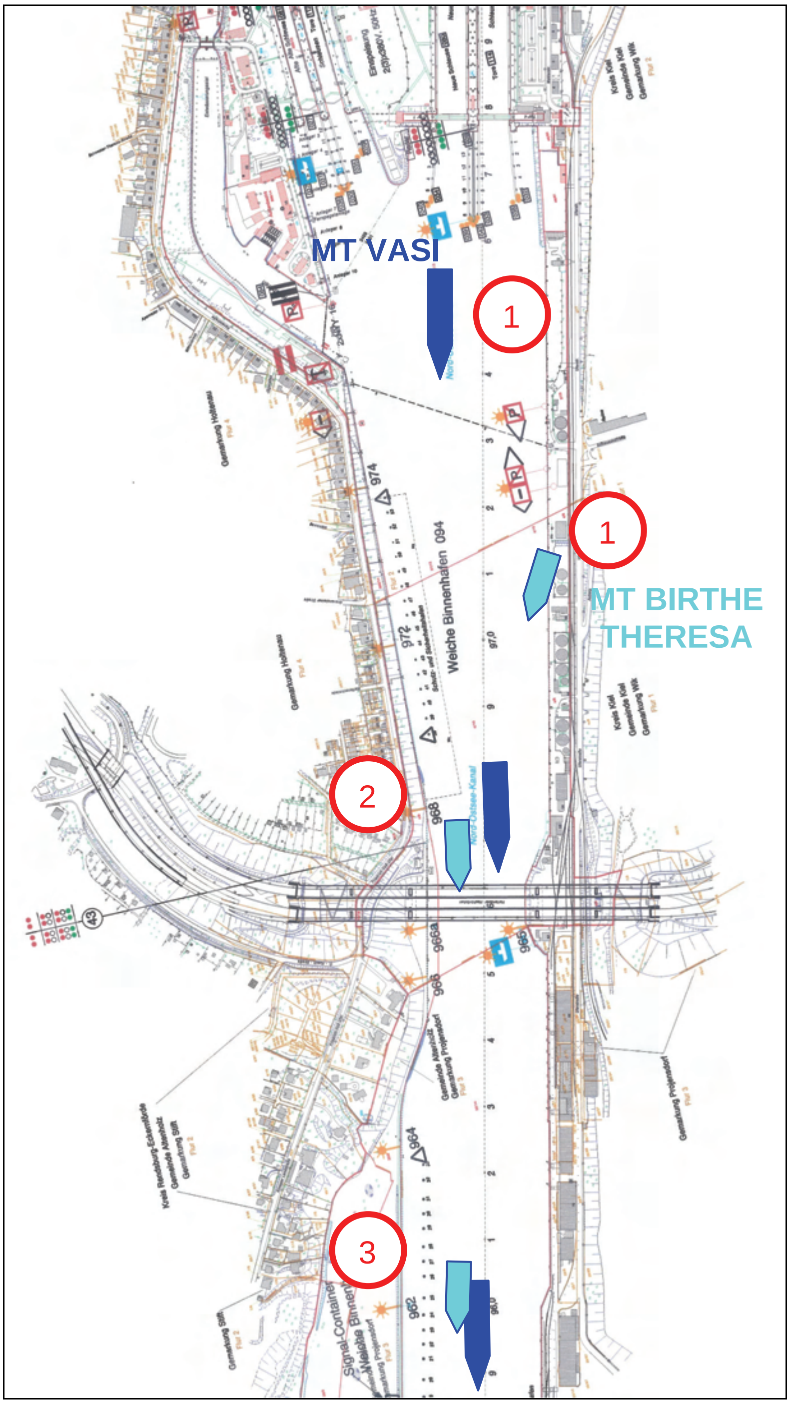

Figure 4: Scene of the accident in detail

2.8 Shore authority involvement and emergency response

Who was involved:	Vessel Traffic Service NOK
Resources used:	VHF radio
Actions taken:	Temporary closure of the NOK
Results achieved:	No further damage following the collision

3 COURSE OF THE ACCIDENT AND INVESTIGATION

3.1 Course of the accident

The BIRTHE THERESA was sailing from Klaipėda to Eemshaven and had 1,501 t glycerine on board. She moored at the inland port of Holtenau on 11 February 2009 at 0900 to have repairs carried out, after which she began her onward journey immediately. To that end, a canal pilot boarded the vessel on 12 February 2009 at 0240. In addition to the canal pilot, the bridge was manned by the master at the helm and the second officer. BIRTHE THERESA cast off at 0250.

The VASI was en route from Klaipėda to Rouen. She reached the lock at Kiel-Holtenau to proceed on the NOK on 12 February 2009 at 0225. She was carrying 12,278 t urea/ammonium and was fully laden. Due to the thus induced draught of 8.70 m (aft), she was categorised as a so-called low-speed, VG4[2] vessel for the canal passage.
The vessel began to leave the lock at 0247. The master, second officer and a canal helmsman were situated on the bridge. There was practically no wind and visibility was good.
A collective call[3] made at 0250 while they were sailing out of the lock informed the ship's command[4] about oncoming vessels.
As the VASI passed the lock's staging, she was called over VHF by the pilot of the BIRTHE THERESA, who advised that this vessel had just cast off from the Bominflot bunker station on the southern side of the inland port. The pilot of the VASI was reportedly aware that he had right-of-way because his vessel was already underway. In spite of that, he reportedly intended to grant the BIRTHE THERESA right-of-way as his vessel had to pass through the canal at low speed. This was discussed over VHF.[5]
The BIRTHE THERESA was to initially remain to the south of the canal axis and rapidly increase speed. However, rather than doing that she pulled to the northern side of the NOK and while doing so crossed the bow of the VASI. Following that, the speed of the VASI was increased further and set to overtake. On reaching the bridge at Holtenau, the VASI was positioned to the south of the canal axis; the BIRTHE THERESA was very close to the northern embankment. Upcoming vessels were out of sighting distance. The VASI overtook at an average speed of 14 km/h and the speed of BIRTHE THERESA remained at approx. 10 km/h. At 0259, the overtaking manoeuvre could be regarded as finished. However, immediately afterwards the vessels began to gravitate towards one another.

[2] Vessels are categorised into one of six traffic groups for the passage through the NOK, the smallest belonging to Traffic Group 1 and the largest to Traffic Group 6. This categorisation is based on the length, breadth, draught of the vessel and the dangerous nature of her cargo. Art. 26 para. 3 German Traffic Regulations for Navigable Waterways (SeeSchStrO) stipulates that vessels with a draught of more than 8.50 m may not exceed 12 km/h and are then referred to as 'low-speed vessels'.
[3] A 'collective call' is transmitted by the Vessel Traffic Service (VTS) every half hour; this provides information on the movement of shipping on the NOK via VHF. This information should be forwarded to the ship's command by the pilot.
[4] Unless stated otherwise, the term 'ship’s command' also includes the assigned pilot.
[5] See sub-para. 3.3.4

BIRTHE THERESA picked up speed and turned unexpectedly to port. At 0300, the two hulls came into contact and remained so until 0306. The vessels continued 'in a packet' and although they reduced their speed they did not separate from one another. At 0305, they passed a upcoming vessel in this manner. At 0307, the bow of the BIRTHE THERESA turned away to starboard and she sailed into the northern embankment. The VTS was informed about the accident and the damage to the two vessels assessed. The VASI was then able to continue her voyage to Brunsbüttel. The BIRTHE THERESA freed herself from the embankment under her own steam and then returned to Kiel.

3.2 Consequences of the accident

There were neither injuries nor environmental pollution.
The VASI sustained numerous scratches on the starboard side. On the BIRTHE THERESA the railing on the port bridge wing was damaged and paint was scratched along the entire length of the vessel, especially on the rubbing strake on the port side. The survey of the vessel's bottom revealed no negative findings. Leakage was not found on either vessel.

3.3 Investigation

3.3.1 Investigations by the waterway police

After the accident, the BIRTHE THERESA returned to Kiel and the VASI continued to Brunsbüttel. After the two vessels moored, the waterway police (WSP) began its on-site investigations, the findings of which were made available to the BSU. However, in contrast with the norm the BSU was not informed about the accident immediately. Numerous photos were taken, documents inspected, witness accounts obtained and the AIS data[6] of Vessel Traffic Service Brunsbüttel secured. In contrast, the securing of data from the VDR was not arranged[7].
The results of the WSP investigation show that:
"Both pilots heard the VTS message and thus understood that a VG5 vessel was approaching the Schwartenbek siding area from the west. Following that, both wanted to enter this siding area so as not to have to wait at the inland port. Coincidentally, the MT BIRTHE THERESA cast off from her berth just as the MT VASI left the lock and got underway. Indeed, the two pilots attempted to coordinate over VHF; however, neither sufficiently nor early enough to prevent an ambiguous situation. They did not make use of technical resources in a manner that customary seamanship or the particular circumstances of the case demanded.
The MT BIRTHE THERESA left her berth and ignored the right-of-way of the MT VASI, which was already proceeding on the fairway.
Although, with her draught of 8.70 m, the MT VASI was not permitted to exceed a speed of 12 km/h, the pilot allowed her to accelerate to 14.4 km/h during the overtaking manoeuvre.

[6] **A**utomatic **I**dentification **S**ystem – Introduced to improve maritime safety. All vessels equipped with this system transmit their current data, such as position, course and speed as well as possibly other information, which can be made visible on a monitor, via VHF. See sub-para. 3.3.3
[7] The further course of the BSU investigation revealed the fact that only the VASI had a VDR on board. MT BIRTHE THERESE was not yet obliged to carry one.

In summary, both pilots, who were actually responsible for the safety of the vessels, infringed the aforementioned legislation on the safety of maritime traffic.
The masters of the two vessels do not have command of the German language and were entitled to rely on receiving sound advice from their pilots.
However, the master of the MT VASI should have recognised the developing risk of collision and aborted the overtaking manoeuvre when he realized that the other vessel had begun to cross the fairway and move in front of his stem.
In contrast, as the master of the MT BIRTHE THERESA recognized the risk of collision, he was compelled to continue the manoeuvre to avoid damage that was potentially even greater."

3.3.2 Environmental conditions

There was no cloud cover and consequently no precipitation at the time of the accident. The air temperature was -1.5°C. There was very little wind and visibility was good.

3.3.3 AIS recordings of the VTS

The NOK vessel traffic system saves, inter alia, the AIS data of vessels on the canal. These data are primarily used by the Vessel Traffic Service on a real-time display for controlling vessels on the NOK.
However, the recordings are also used for the subsequent analysis of accidents.[8]

The following figures illustrate the sequence of events surrounding this collision.

[8] With regard to the ongoing debate on the accuracy of transmitted GPS data and their graphic reproduction on screens as well as in print, it should be noted that the findings below only indicate the tendencies of the respective course of the voyage.

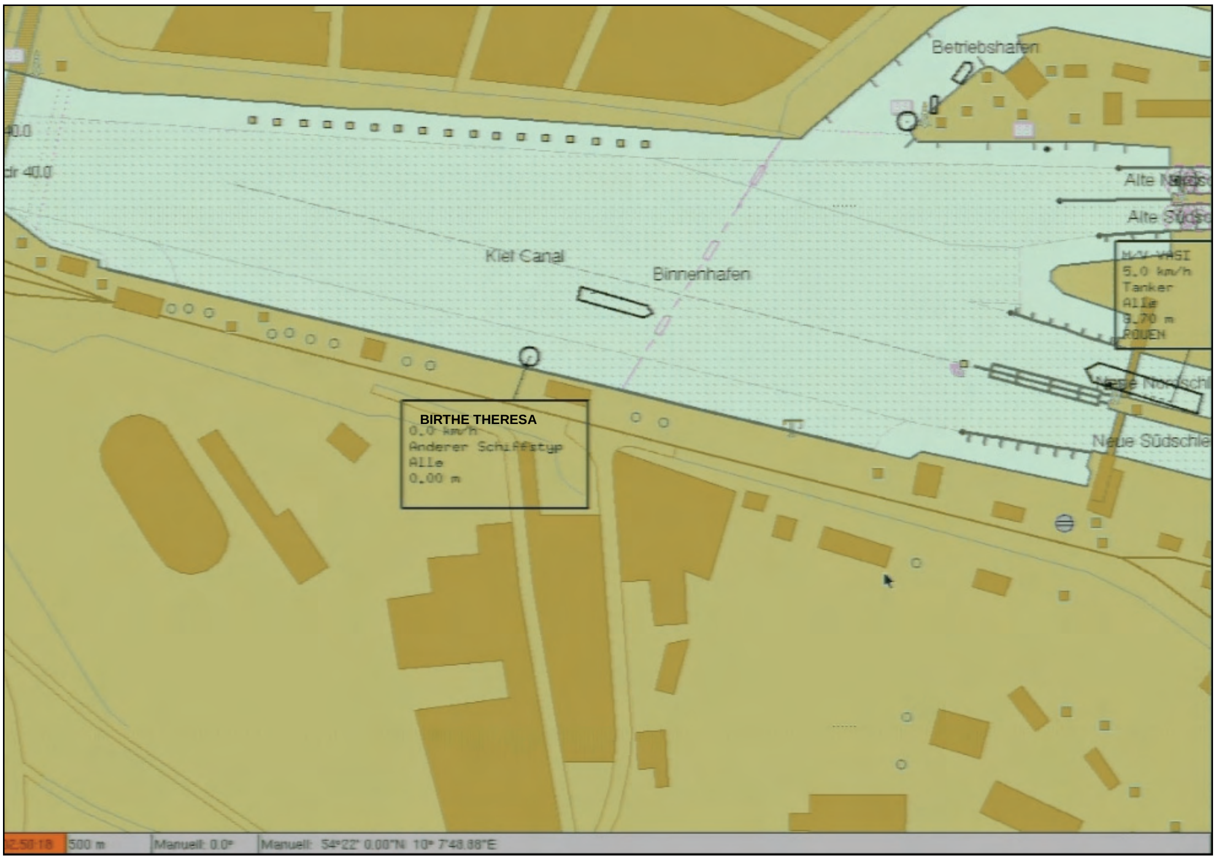

Figure 5: AIS display of the VTS at 025018

Figure 5 shows the initial situation: MT VASI leaves the Kiel lock (right) as a low-speed vessel. MT BIRTHE THERESA is still at the pier, but intends to cast off now.

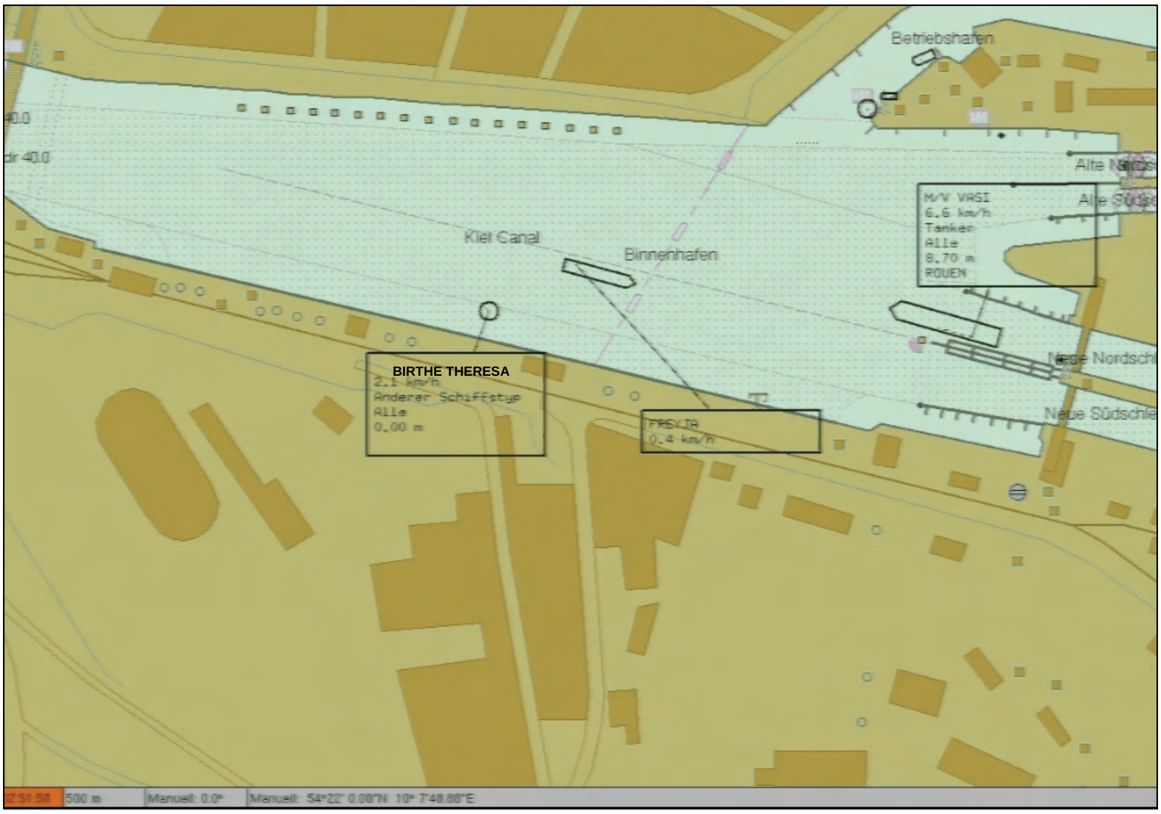

Figure 6: AIS display of the VTS at 025150

Figure 6 shows how MT VASI passes the lock's staging; MT BIRTHE THERESA has now cast off and is heading for the northern side of the NOK. Three minutes later, Figure 7 shows that MT BIRTHE THERESA has reached the northern side, but that MT VASI is still catching up.

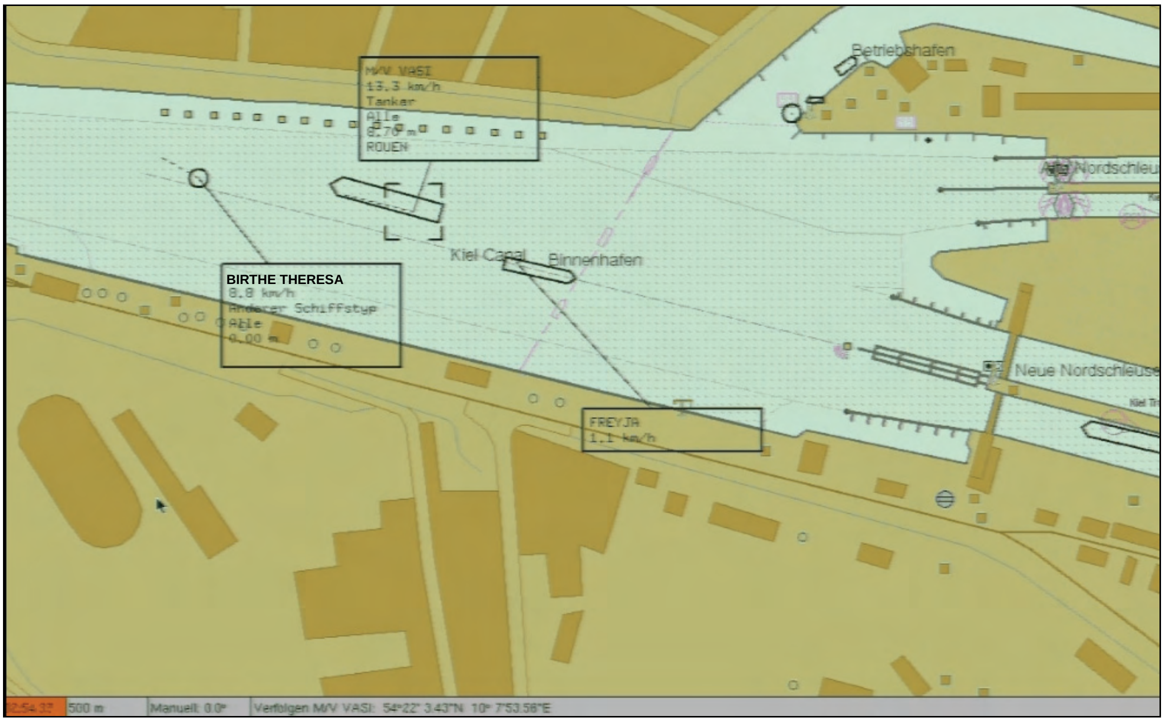

Figure 7: AIS display of the VTS at 025433

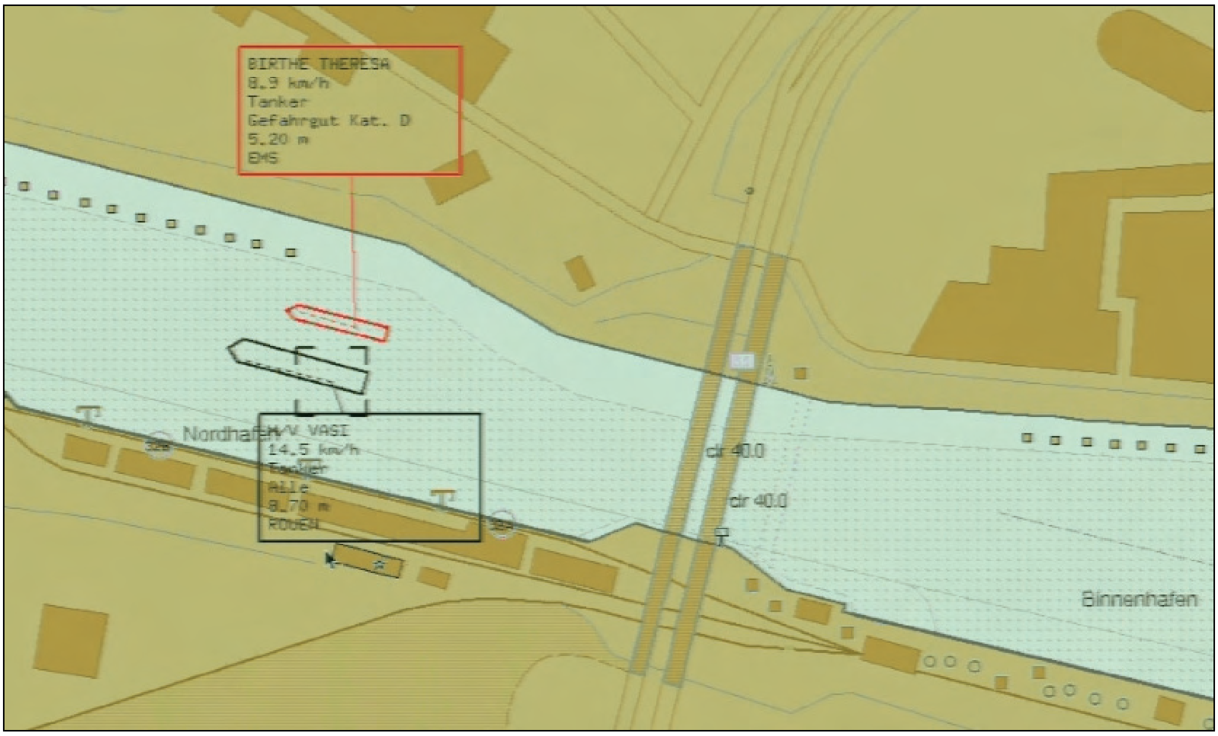

Figure 8: AIS display of the VTS at 025815

Figure 8 shows clearly how the VASI, as a low-speed vessel with a permitted maximum speed of 12 km/h, now proceeds at more than 14 km/h in order to overtake MT BIRTHE THERESA. This overtaking manoeuvre results in a suction effect. The bow of the MT BIRTHE THERESA is drawn towards the stern of the MT VASI, as illustrated in Figure 9.

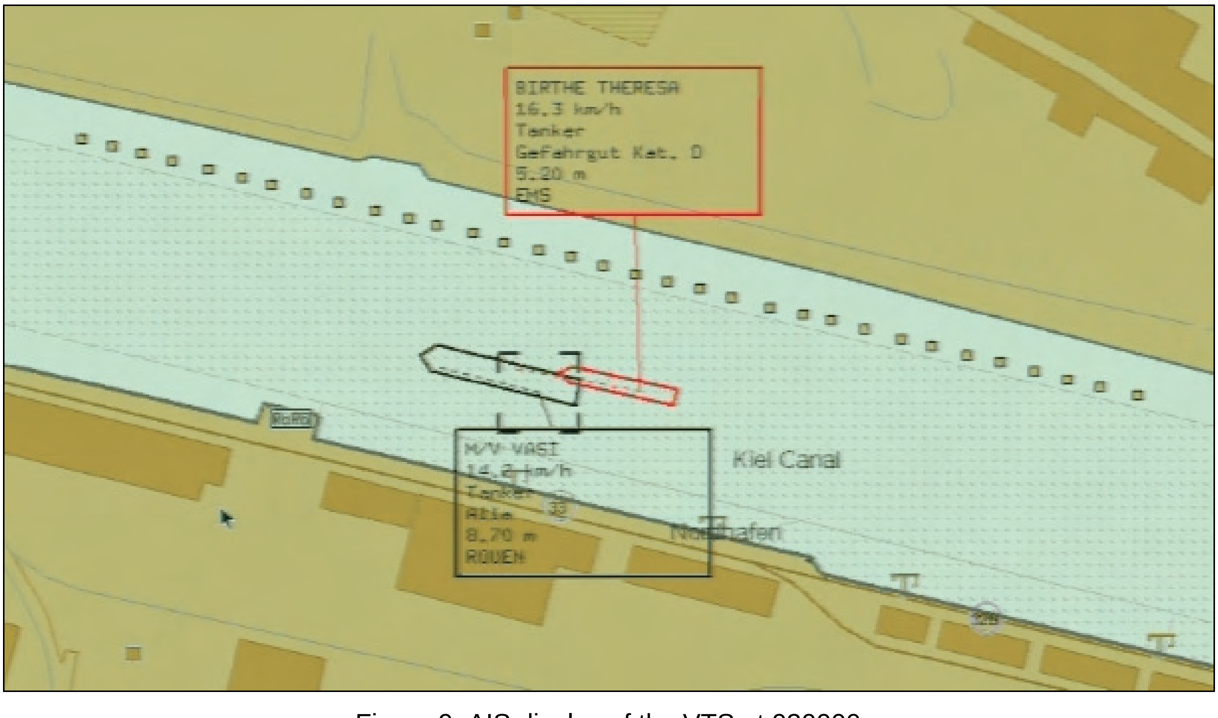

Figure 9: AIS display of the VTS at 030000

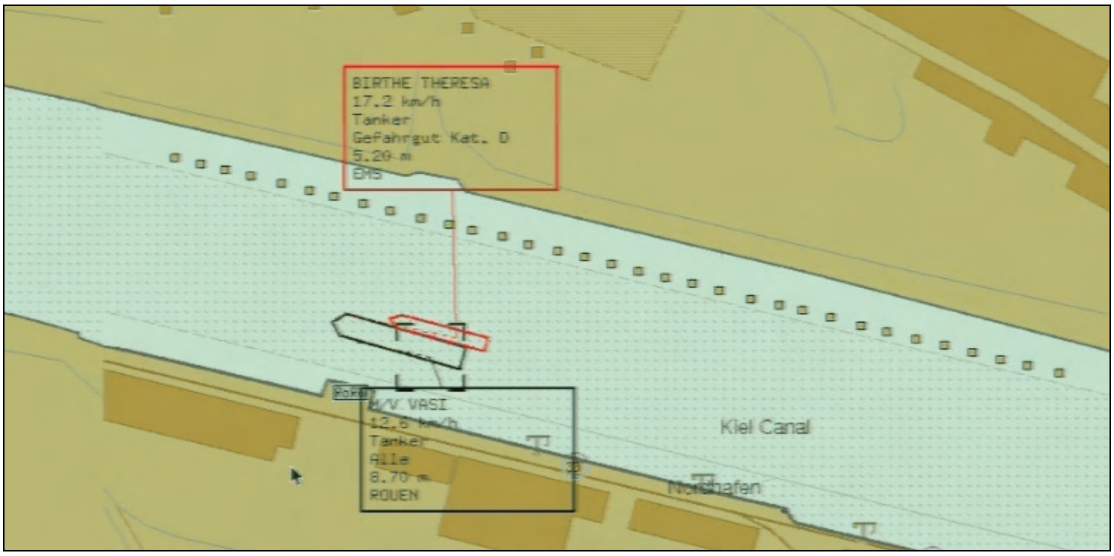

Figure 10: AIS display of the VTS at 030047

Figure 10 shows how the vessels no longer separate from one another. Instead, they continue for several minutes 'in a packet'. This highly charged situation is exacerbated as a upcoming vessel has to be passed. MV PERSEUS is shown in Figure 11.

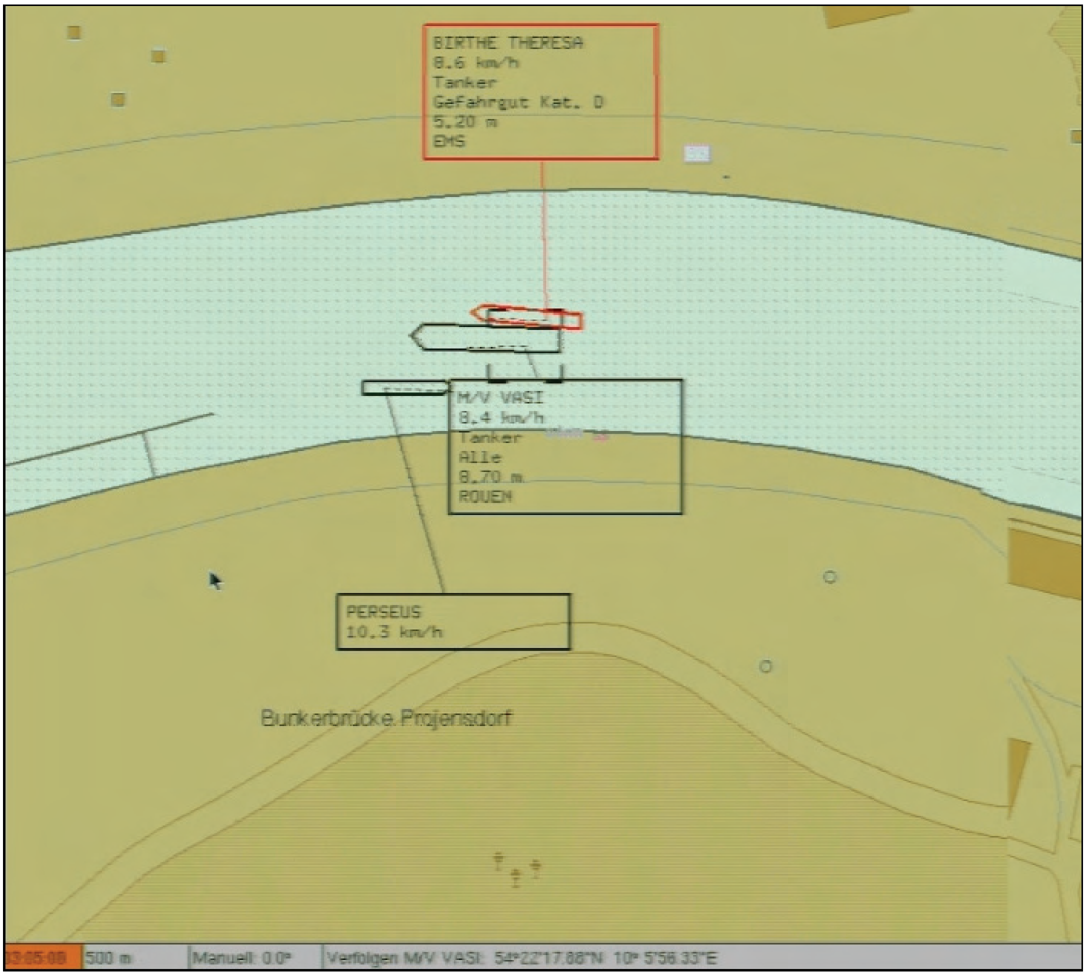

Figure 11: AIS display of the VTS at 030508

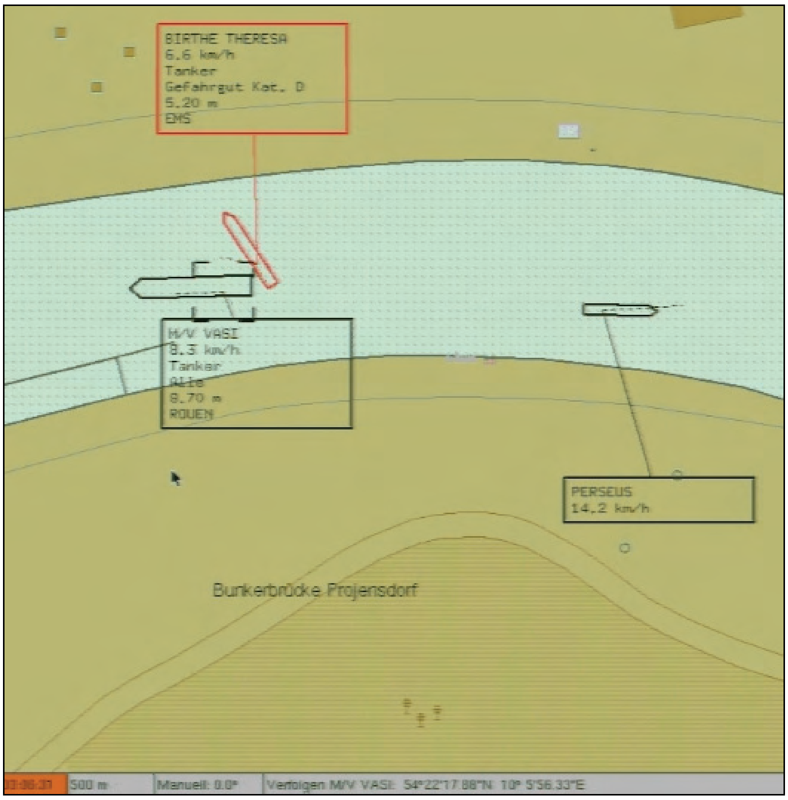

Figure 12: AIS display of the VTS at 030631

Meanwhile, the speed of both vessels was reduced so far that they separate from one another at about 7 km/h. Figure 12 shows how the MT BIRTHE THERESA turns away to starboard in the process. Figure 13 illustrates the outcome of this manoeuvre. While the MT VASI is able to keep course, MT BIRTHE THERESA sails on to the northern embankment of the NOK.

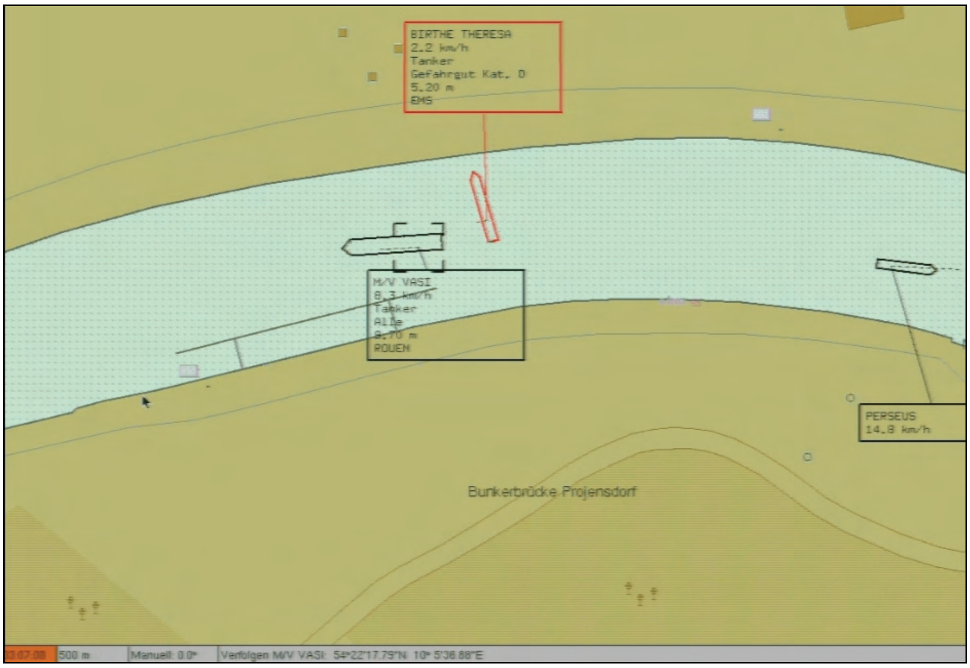

Figure 13: AIS display of the VTS at 030708

3.3.4 Audio recordings of the VTS

The VHF recordings start at 0220 with the collective call of the VTS for the eastern section[9], in which it is already stated that the VASI, as a VG4 vessel approaching from the Kiel lock, could still reach the Schwartenbek siding area in order to pass the expected oncoming traffic.
At 0231, the VASI asks the VTS how much time they still have in the lock to bunker water. The answer is none if the VASI does not want to wait in the inland port for an extended period. The lock master also urges the VASI to leave the lock as quickly as possible because he already has a vessel in the inland port which needs to pass through the lock.
At 0246, the MT BIRTHE THERESA calls the VTS and advises that she wishes to cast off now and proceed westwards. The VTS consents, but does not draw attention to the approaching VASI. Instead, it calls the MT VASI and confirms to her again that she must reportedly hurry in order to reach Schwartenbek and thus avoid waiting at the inland port of Kiel. No mention is given to the BIRTHE THERESA casting off.
The collective call follows at 0250 in which the sequence is clearly defined: MT VASI is to arrive at the Schwartenbek siding area before MT BIRTHE THERESA and pass the approaching VG5 vessel.
MT BIRTHE THERESA calls the VASI immediately after this collective call. A conversation follows between the two pilots, the outcome of which is that the MT BIRTHE THERESA should "step on the gas" now in order to begin the canal passage before the MT VASI. According to the instructions of the collective call at 0250, without such an agreement the VASI would have sailed past the MT BIRTHE THERESA and begun the canal passage to the Schwartenbek siding area before her.
At about 0255, the MT VASI makes a blunt, colloquial request to the BIRTHE THERESA to make room. It cannot be heard that BIRTHE THERESA gives her assent.
At 0300, the MT VASI reports the collision with the MT BIRTHE THERESA to the VTS. The VTS is not informed that the two vessels moved 'in a packet' for several minutes. The recordings do not indicate who reports to the VTS that the MT BIRTHE THERESA is now crossways to the canal at 0307. Following that, the nautical supervisor closes the section in both directions.
At 0311, the VTS asks the MT BIRTHE THERESA for an update, at which it is informed that she is stuck and requires a tug. The nautical supervisor intends to arrange one.
Shortly afterwards, the MT VASI reports in and asks if she can continue to proceed westwards. The nautical supervisor denies this request until all necessary information regarding the situation has been gathered. Over the next half hour, the damage to the two vessels is assessed and reported to the VTS. MT BIRTHE THERESA then frees herself under her own steam and commences her journey back to the previously vacated berth at the inland port of Kiel.

[9] Due to unexplained influences not only the required VHF channels were recorded in this case but also temporarily channel 73, used by the pilots. These recordings are very extensive. However, they cannot be considered complete.

3.3.5 Assessment of the accident by WSA Kiel-Holtenau

The Federal Waterways and Shipping Administration prepares its own accident report after every incident on the NOK. The competent Waterways and Shipping Authority (WSA) for this collision, Kiel-Holtenau, came to the following conclusions:
"The accident would never have happened if the parties had adhered to the applicable provisions in the SeeSchStrO, in which regulation of the right-of-way of vessels in the fairway is dealt with in art. 25 (2). This stipulates that vessels which follow the course of the fairway – i.e. are in motion – have a basic right-of-way over vessels leaving a berth or crossing the fairway.
The recorded dialogue of the pilots did not allow one to conclude that a clear, unambiguous agreement had been made. It was marked by vague innuendos and any objectivity, as would have been demanded by the situation described, was lacking. The masters of the two tankers were not involved in the development of the circumstances and were unable to monitor the situation since they do not have command of the German language. They had to rely on receiving sound advice from the pilots and that the manoeuvre was the result of a rational agreement.
The ensuing accident then developed from a typical sequence of hydrodynamic interactions between the two vessels (ship-to-ship interaction). As a result, the MT BIRTHE THERESA was first accelerated relentlessly by the powerful suction effect and then pressed into the side of the MT VASI.
After separating from one another, the dynamic pressure on the port fore ship of the MT BIRTHE THERESA in conjunction with the reciprocal suction forces in the aft section effected an abrupt change of course of 90° to starboard in a very confined space, the outcome of which was heading for the northern canal embankment at right angles therewith."

3.3.6 Manoeuvring behaviour of the vessels and hydrodynamics in the NOK

The BSU referred, inter alia, to the fact that in the future more attention should be given to the risk posed by suction during overtaking manoeuvres on the narrow fairway of the river Elbe in the report on the collision between the COSCO HAMBURG and the NEDLLOYD FINLAND[10]. This was especially relevant in view of the increasingly large container vessels which will call at Hamburg in the future.
The physical processes when vessels encounter and overtake at close-quarters in confined fairways are complex and very difficult to investigate. The non-linear relationship of forces and moments with the mutual effect of their individual flow fields cause vessels to move unpredictably. These interactions can lead to problems in handling the vessel.
'SIPAS', a joint project being carried out by three partners and coordinated by the Institute of Ship Theory, Simulation and Maritime Systems (ISSIMS) of the Department of Maritime Studies of the University of Wismar, is dedicated to this problem. The following research work and objectives are pursued in the 'SIPAS' project:

[10] See BSU report Ref.: 45-04

DST – Development Centre for Ship Technology and Transport Systems, Duisburg:
Experimental studies with ship models in a model tank for an improved, systematic recording of the interactive effects of hydrodynamics as well as a detailed analysis of motion behaviour during passing situations and the creation of a mathematical model.

Rheinmetall Defence Electronics, Bremen:
Implementation of the improved mathematical models to define the hydrodynamic interactions during passing situations in ship-handling simulators; enhancement of existing wind and flow models as well as a three-dimensional representation of the waves in the visualisation system of the simulators.

University of Wismar, Department of Maritime Studies, Warnemünde, ISSIMS:
Heighten the safety of sea-going vessels during passing situations in narrow fairways through the development of practical instruments for operational use on board and verification of the enhanced and modernised simulation technology in training scenarios for basic and ongoing training.

Objective: The overriding global objective of this project is to improve simulation of the critical overtaking and encounter phases for the purposes of basic and ongoing training as well as continuing research and development. The desired higher quality of mathematical models in ship-handling simulators aims to facilitate more realistic training in the conduct required to avoid the risks posed while overtaking and converging as well as the development of appropriate training modules. The findings of the project work are to flow into information which can be used to provide the ship's command (pilot, master, officer on watch) with in-depth advice in order to reduce the risk of collision during passing situations.[11]

To utilise the results achieved thus far, the BSU commissioned the University of Wismar, Department of Maritime Studies, Warnemünde, to prepare another expertise in which the following issues were to be examined:

1.) How could the accident have been avoided? That is, what rudder and engine manoeuvres should have been implemented? What distances should have been kept between the vessels? Can it be shown that the BIRTHE THERESA should not have been allowed to leave her berth?
2.) What would have been the most favourable manoeuvre to separate the vessels?

[11] Source: Website of the University of Wismar, Department of Maritime Studies, Warnemünde

The BSU provided the following documents for the study:
- A file containing the AIS recordings: 090212-vasi_birthe_theresa.xls
- Letter about the collision from WSD North dated 31/03/2010
- Article by C. Ballin: Die Verkehrslenkung im Nord-Ostsee-Kanal – Aufgaben, System und Hilfsmittel (traffic management on the Kiel Canal – tasks, systems and resources). HANSA 111 year 1974, No. 9

The analysis and preparation of the data provided by the client were the basis for the subsequent representation and evaluation of the data in the SimDat software application. The file provided by the client includes the recordings of individual AIS messages of the two vessels involved in the collision, MT VASI and MT BIRTHE THERESA.

The analysis of the type 1 AIS messages shows that the following relevant data were available for further utilisation:
- Timestamp (UNIX time of the recording device)
- Date
- Time
- SOG (Speed Over Ground – [1/10 kts])
- Longitude
- Latitude
- COG (Course Over Ground – [1/10 deg])
- True Heading ([deg])
- SOGcalc (internal speed calculation from AIS)
- DiffLastMessage (time difference to the previous data record – [s])

However, the supplied data contained absolutely no information about:
- engine data and engine commands (such as current and ordered rate of speed, number of revolutions, etc.);
- rudder data and helm commands.

During the work connected with preparing the data, the existing information was saved in separate text files, which were analysed further. In the first stage of analysing the data, the position information was correlated with the reference positions contained in the type 5 AIS messages (RefA RefB, RefC and RefD). Furthermore, the data of the two vessels were put on a uniform time base (start time 010000 on 12/02/2009) to facilitate direct temporal comparison. For the use of software tools for a situation analysis, the speed (SOG) was converted into the unit kts and the COG data into the unit deg.
As a result of the conversion process text files were created. These include the following data records:
- Start time
- Object file (with vessel particulars such as length, breadth, etc.)
- Area (sea area information to display the data in an ECDIS-like chart)
- Time (time difference to the start time)
- Lat (latitude)
- Lon (longitude)

- HDG (true heading in deg)
- COG (course over ground in deg)
- SOG (speed over ground in kts)
- SOGcalc (speed calculation from AIS data)

The first analysis of the plausibility and completeness of the files revealed that there is no or very few identical data recording times for the two vessels and constantly changing time differences occur between the individual data measuring points.

3.3.6.1 Representation of the collision with the aid of the SimDat software application

3.3.6.1.1 Modelling of the sea area

Reconstruction of the marine casualty was carried out using SimDat[12], analysis software which was developed in-house. Due to the varied interfaces and scope of the software, it is possible to import various data from other sources, such as AIS, and present this in the relevant environment.
The data supplied by the BSU were prepared accordingly and converted in the said environment for processing and visualisation. This facilitates a situation-based state and parameter analysis for any given recording time and thus better, much more detailed investigations on the course and possible causes of an accident.

Basis of the modelling of a selected sea area is the electronic chart system.
Preparation of charts for use in SimDat is carried out by digitizing (creation of an Electronic Navigational Chart – ENC) the paper nautical chart. Basically, any sea area can be digitized and prepared for the representation of objects in SimDat.

An overview of the result can be seen in the representation in Figure 14.

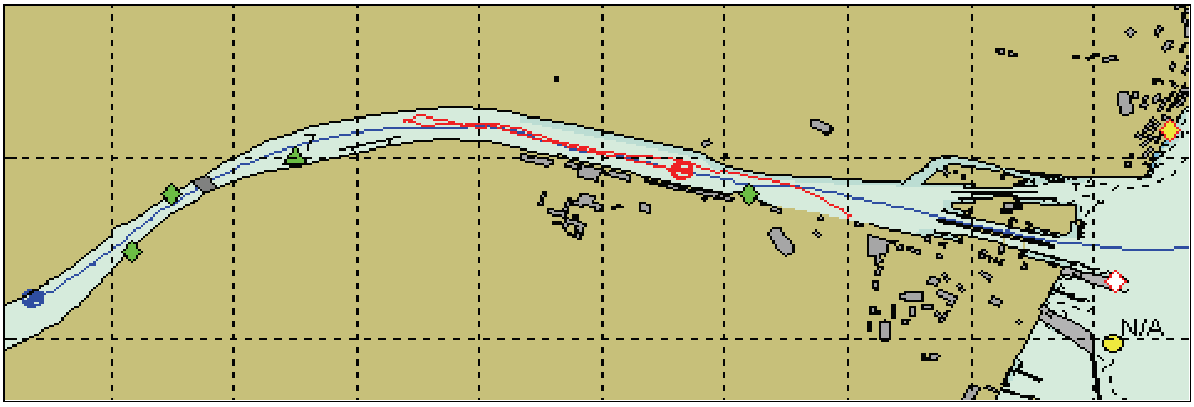

Figure 14: SimDat ENC representation with the tracks of the vessels
(Blue: VASI; Red: BIRTHE THERESA)

[12] SimDat: Simulation data analysis – Software for the graphical representation of manoeuvre values; see also [15] and [16] under Sources.

Representation in SimDat of the objects of the ENCs is limited to the following objects:

- Land area/Land contour
- Depth areas/Depth contours
- Buoys/Beacons
- Radar reference lines
- Built-up areas/Buildings/Bridges

3.3.6.1.2 Modelling of the vessels

Brief description of the vessels involved in the accident:

Parameter	Overtaking	Overtaken
	MT "VASI" Tanker, Cyprus, Year built 2006	**MT "BIRTHE THERESA"** Tanker, Singapore, Year built 1995
LOA	120.0 m	87.8 m
B	20.4 m	13.3 m
Df	8.6 m	3.6 m
Da	8.7 m	5.2 m

Modelling of the vessel particulars consists essentially of the parameterisation of the database records to be created for representation in SimDat. Inputs are reduced to the dimensions of the vessels and the positions of the sensors.
Using existing ship-shape definition files, the representation is created to scale according to the track data after the records in the database have been read-out.
Corrective actions include

– the production of a uniform time base for both vessels;
– correcting the position information by the reference positions of the antennas.

This results in a representation as in Figure 15.

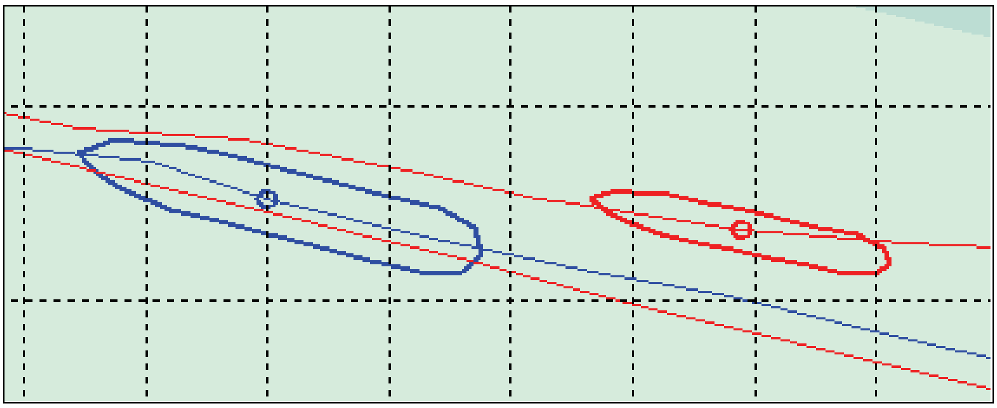

Figure 15: SimDat ship-shape representation (Blue: MT VASI; Red: MT BIRTHE THERESA)

3.3.6.1.3 Course of the manoeuvre and interpretation of the data

The following images show the chronological course of the overtaking manoeuvre for various times (note: opposite direction to the previous section). Colour scheme is as follows:

Blue: MT BIRTHE THERESA	Overtaken: LOA = 87.8 m
Red: MT VASI	Overtaking: LOA = 120.0 m

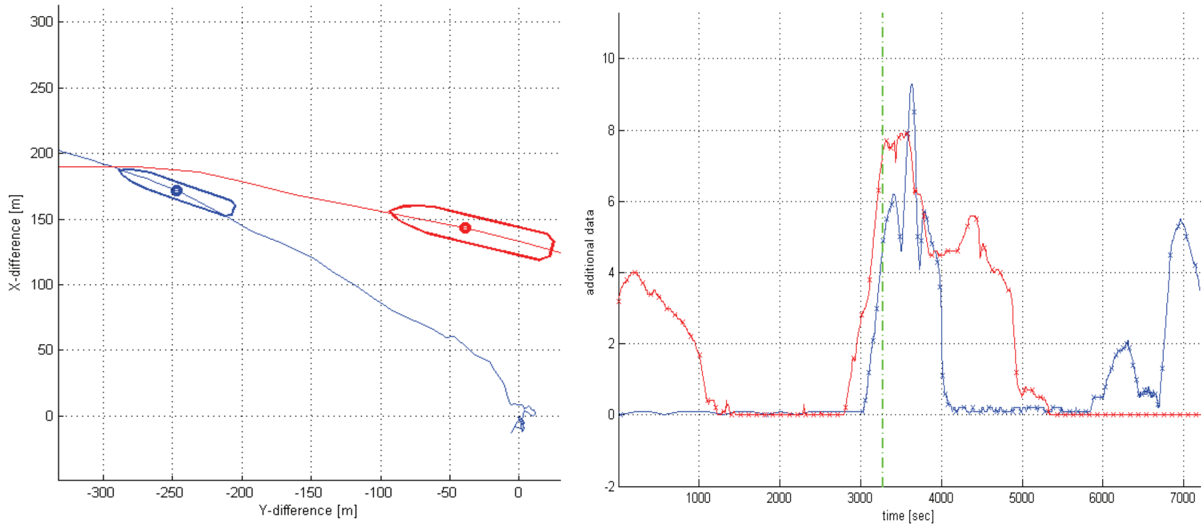

Figure 16: SimDat ship-shape representation (left) and courses of speed [kts] over time (right) at time 1 (Blue: MT BIRTHE THERESA, overtaken; Red: MT VASI, overtaking)

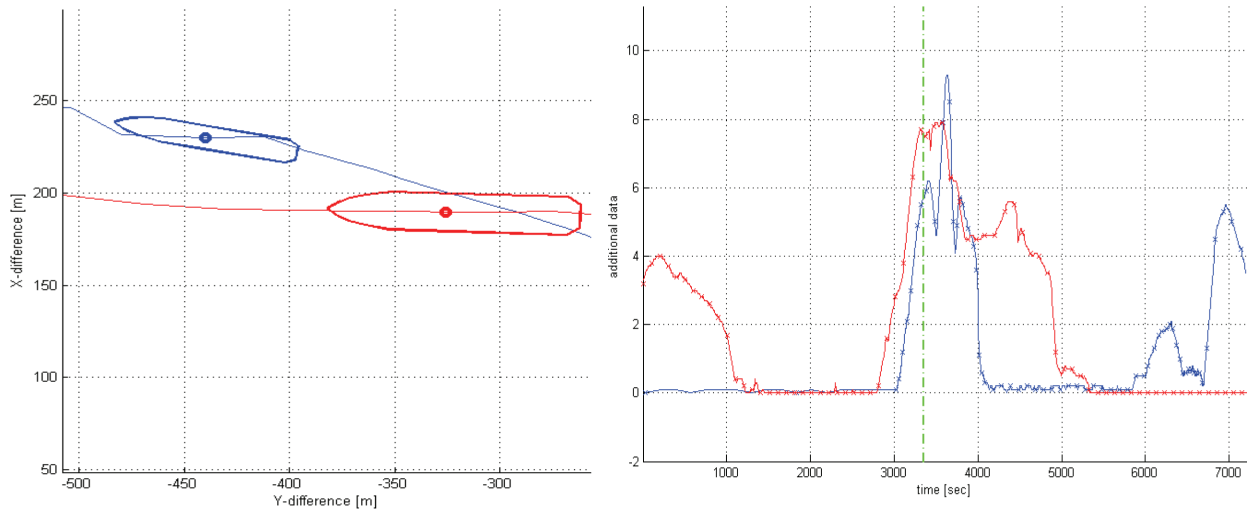

Figure 17: SimDat ship-shape representation and courses of speed at time 2

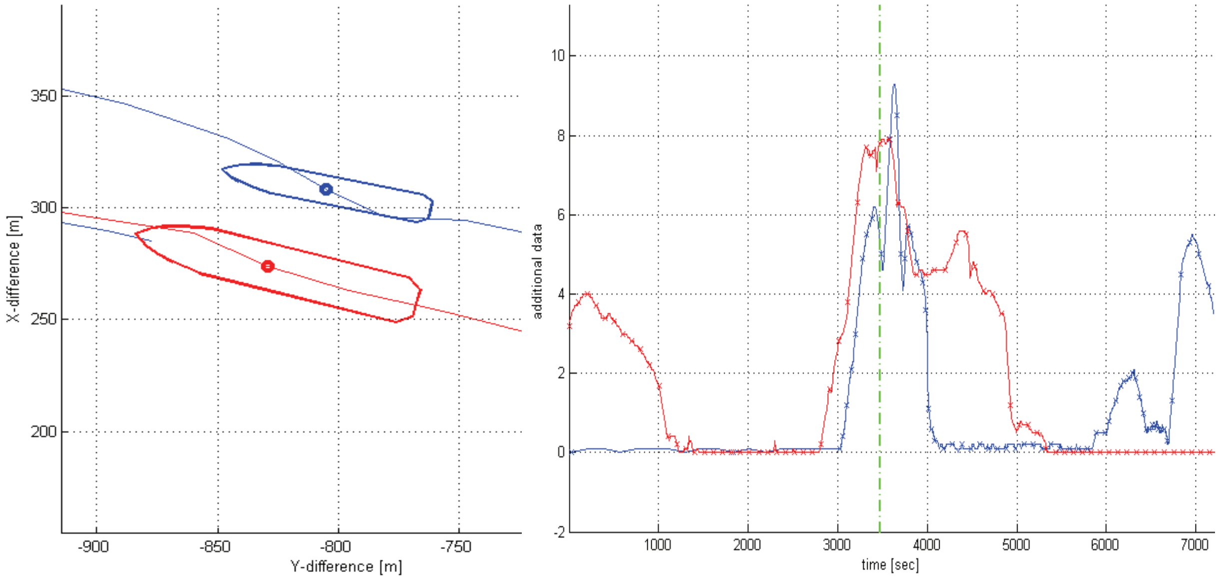

Figure 18: SimDat ship-shape representation and courses of speed at time 3

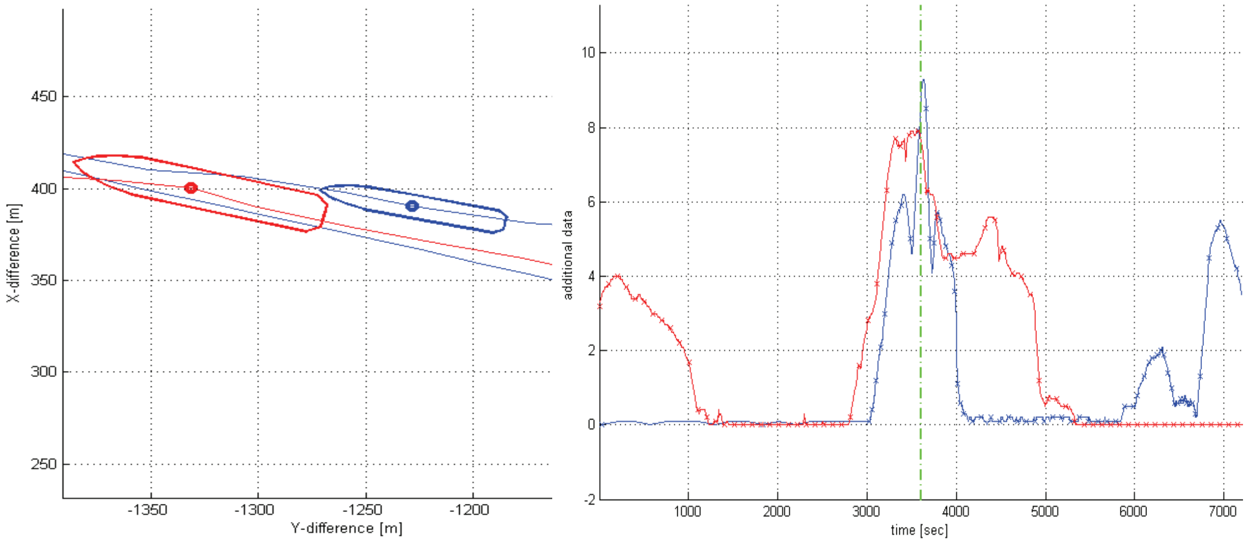

Figure 19: SimDat ship-shape representation and courses of speed at time 4

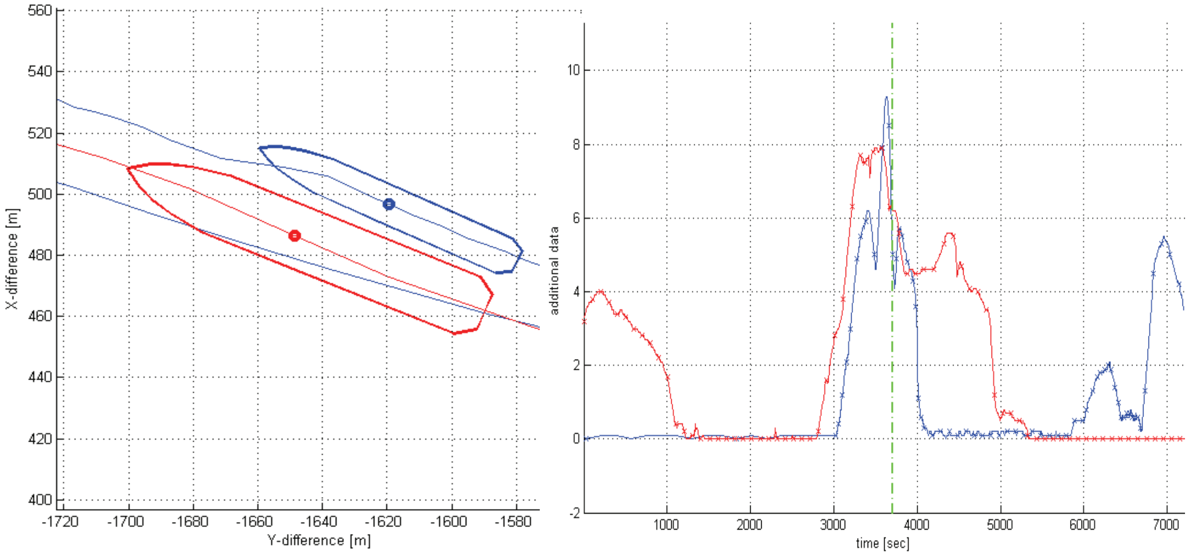

Figure 20: SimDat ship-shape representation and courses of speed at time 5

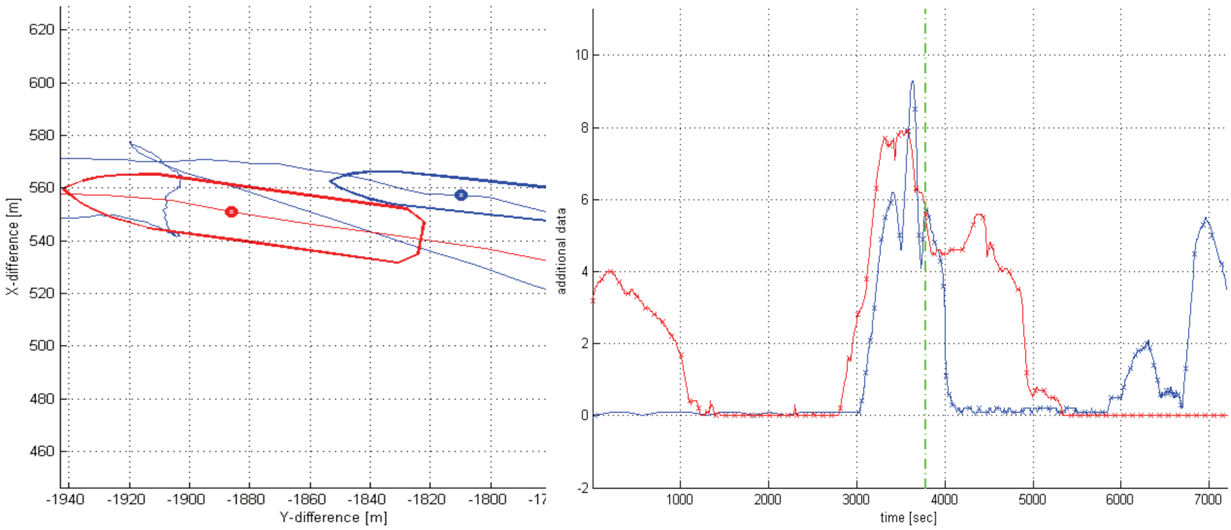

Figure 21: SimDat ship-shape representation and courses of speed at time 6

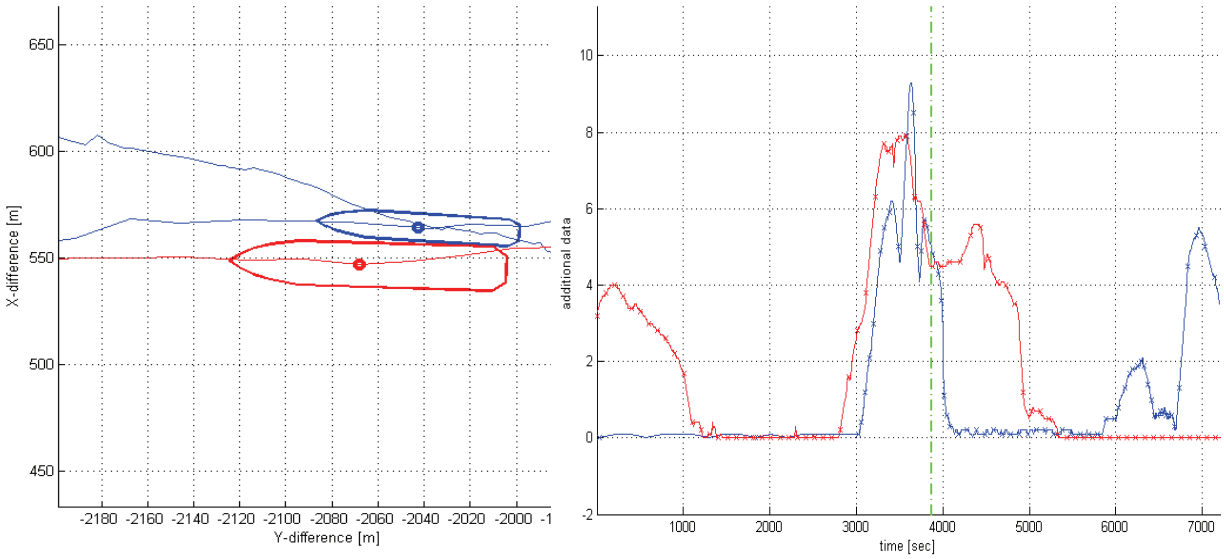

Figure 22: SimDat ship-shape representation and courses of speed at time 7

3.3.6.1.4 Discussion about the course of the manoeuvre

Passing situations in confined fairways require greater attention by the ship's commands involved and safe, well thought-out manoeuvring. In particular, when overtaking, adverse conditions (too high absolute speed, only low relative speed and thus relatively long passing time, low passing distance, flat, narrow fairway) can lead to complications when passing. This is due to hydrodynamic interactions between the vessels involved in the overtaking manoeuvre, which in extreme cases may lead to collisions or damage. Certain related facts are summarised in the Appendix[13], to which the following discussions refer.

In terms of hydrodynamics, the accident between the MT VASI and the MT BIRTHE THERESA must be assessed as follows:
The passing manoeuvre between the VASI (overtaking) and the BIRTHE THERESA (overtaken) is initiated at a lateral passing distance of about 40 m between the side of each vessel (analysis of the position data via AIS). The speeds at this time, also AIS data, are 7.6 kts (VASI) and 5.9 kts (BIRTHE THERESA).
This lateral distance can be estimated to be sufficient if one refers to the recommendations of the PIANC-IAPH Working Group 30[14], according to which the passing distance is represented as the sum total of a base distance (depending on the speed of the vessel) and an additional distance (depending on the traffic density).

[13] See para. 8.1: General description of a passing manoeuvre when overtaking vessels and determining the necessary distance
[14] Working Group No. 30 of the Permanent International Association of Navigation Congresses; see also [15] under Sources.

For the present case, that would result in a base distance of 1.0 B for the speed range 5kts–8kts and 0.4 B as the value for the maximum traffic density, which is applied here for the NOK. If we take the breadth of the VASI at 20.4 m as a reference value, 1.4 x 20.4 m would result in a required passing distance of 28.6 m.[15]
However, if one follows the recommendations of the Japanese Channel Designer (JCD), the specified passing distance for small tankers at a speed ratio of 1.2 is at least 2.24 B[16] [9]. This would result in a minimum distance of 45.7 m for the breadth of the VASI.

All these values should only be regarded as recommendations as there are no mandatory directives for determining safe passing distances when overtaking. In the initial phase, the passing manoeuvre is usually not critical due to the development of repelling transverse forces and an outward turning yaw-moment. If the vessels are in a midship-midship position, they are drawn strongly towards one another; this affects the smaller, lighter vessel being overtaken in particular. The lateral distance between the VASI and the BIRTHE THERESA reduced to about 30 m at this time. According to the PIANC assessment, the more favourable variant with 28.6 m, safe distance would have almost reached its limits at speeds of 7.8 kts (VASI) and 5.3 kts (BIRTHE THERESA). Since the VASI increased her speed further (7.9 kts) and the BIRTHE THERESA decreased her speed further (4.6 kts), a rapidly completed overtaking manoeuvre should have been expected. However, when the overtaking manoeuvre was almost complete, i.e. the VASI's stern was abreast with the bow of the BIRTHE THERESA, the overtaken vessel developed a strong, inward turning yaw-moment, which is typical in this phase. This led to the BIRTHE THERESA yawing to port and heading for the overtaking VASI. Lateral distance decreased rapidly and the so-called 'trapping phenomenon' occurred. In this phase, it is no longer possible for the overtaking vessel to increase her speed, even if the rate of speed is set so that higher speeds must be possible. There is an absolute loss in propulsion. In contrast, the speed of the overtaken vessel steadily increases even if the engine is set to STOP. In extreme cases, the speed of the overtaken vessel can exceed that of the overtaking vessel. As was the case here and in most other cases, the affect of the interactive forces and moments leads to parallel contact between the vessels, which then may continue 'in a packet'.
It is clear that these phenomena also occurred in the overtaking manoeuvre under investigation. After the BIRTHE THERESA was almost completely passed by the VASI, the lateral distance reduced to approximately 10 m due to her turn to port. In consequence of this encounter, the 'trapping phenomenon' came to the fore: while the speed of the VASI dropped, the BIRTHE THERESA was rapidly accelerated. Within about two minutes, her speed exceeded that of the overtaking vessel, the speed of which dropped further and further during this period. The hull of the BIRTHE THERESA slid forward along the VASI. As the two vessels were almost back to midships, they touched one another and their sides came into parallel contact due to the attracting transverse force.

[15] See Table 1 on page 32
[16] See also [15] under Sources

The assessment of the course of the overtaking manoeuvre is based on the position data and speed values output by the AIS of each vessel. All quantitative data on the lateral distance are subject to the inaccuracies of the satellite navigation system used. Unfortunately, no VDR recordings with manoeuvre parameters are available. Therefore, it is not possible to assess whether the overtaking manoeuvre was adversely affected by manoeuvres initiated by the ship's commands involved.

3.3.6.2 Response to the questions posed by the BSU and recommendations

3.3.6.2.1 How could the accident have been avoided? That is, what rudder and engine manoeuvres should have been implemented? What distances should have been kept between the vessels?

a) Basically, rudder and engine manoeuvres of the vessels should be applied so that they withstand the constantly changing attracting/repelling forces and torques caused by the passing manoeuvre. It is not possible to make an assessment of the manoeuvres carried out in this case because AIS recordings do not contain such data. Such data would have been available in the recordings of the VDR. However, these were not secured and are therefore not available for the evaluation.
b) In all likelihood, the accident could have been avoided if the selected distance between the vessels would have been greater while overtaking. However, the research community is not in a position to provide unambiguous values for a safe overtaking manoeuvre as things stand at present. Accordingly, an absolutely safe distance in the present situation and whether this would have been at all achievable within the spatial limits of the NOK cannot be determined conclusively.
c) Consequently, it is only possible to make an estimation of what passing distance would have been safe enough to avoid the collision.
   To estimate the safe passing distance for this overtaking manoeuvre, one may refer to the accident analysis at Figure 23 or the design guidelines for maritime canals under 8.1.2.

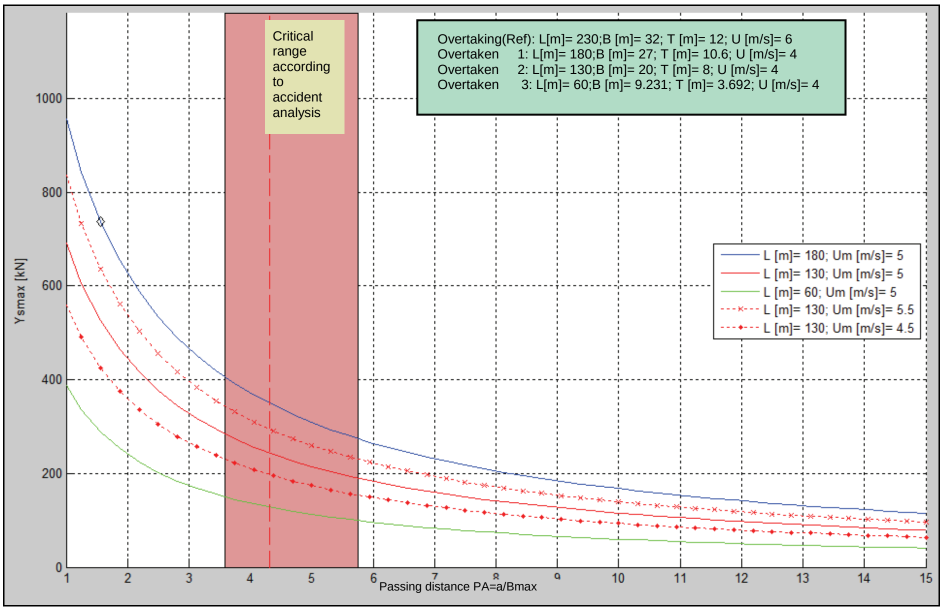

Figure 23: Maximum transverse forces that occur in relation to the passing distance between overtaking vessel (reference vessel) relative to the breadth of the vessel and overtaken vessels of different sizes as well as light red distance range in which collisions occurred

In this case, the accident analysis is only partially meaningful because the vessels investigated there were significantly larger and sailed at higher speeds. However, it is possible to make a qualitative statement about the potential risk.

Generally, the greatest gravitational forces occur between vessels involved in an overtaking manoeuvre when they are in the midship-midship position. In the overtaking manoeuvre between the VASI and the BIRTHE THERESA, this position is reached shortly before time No. 3 in Figure 18; the maximum lateral distance between the sides in this phase is 30 m. If this passing distance is set against the maximum breadth (in this case, B_{VASI} = 20.4 m), the resulting value is PA (passing distance) = 1.47. If this value is assigned on the abscissa at Figure 23, then according to this analysis the overtaking manoeuvre is already in the supercritical range.

If the overtaking manoeuvre is assigned to the speed category 5-8 kts according to the design guidelines for maritime canals as per the PIANC study (resp. also Table 1 below), we also see that a passing distance of no more than 30 m in the midship-midship position was borderline. A base distance of 1.0 x B and an additional distance of 0.4 x B (at a traffic density of more than 3 vessels per hour, which was adopted here as being applicable for the NOK) results in the above mentioned minimum passing distance of 1.4 x 20.4 m = 28.6 m. With the maximum speed reached of almost 8 kts, the transition to the next higher speed category 8-12 kts is achieved precisely here. If the values of this category are used as a basis, the resulting minimum required passing distance from 1.8 x 20.4 m is 36.7 m. Maintaining the additional distance of 0.4 x B and interpolation between the two categories for the base distance results in a critical distance value ([1.1 + 0.4] x B = 30.6 m) even from a base distance of 1.1 x B. Application of the Japanese design guidelines would require a much greater lateral passing distance (see above).

	Canals to open water	Inner, confined fairway
Speed of vessel	**Base distance**	
> 12 kts	2.0 B	1.8 B (new according to PIANC WG 49)
8 – 12 kts	1.6 B	1.4 B
5 – 8 kts	1.2 B	1.0 B
Traffic density of the encounter situation	**Additional distance**	
0 – 1 vessel/h	0.0 B	0.0 B
1 – 3 vessels/h	0.2 B	0.2 B
> 3 vessels/h	0.5 B	0.4 B

Table 1: Recommended passing distances for fairway design according to PIANC WG 30

In summary, the estimates for the safe passing distance indicate that the lateral distance between the sides was too low on reaching the maximum attracting transverse forces. In particular, this affects the smaller, lighter overtaken vessel (BIRTHE THERESA), which in the subsequent course of the overtaking manoeuvre came alongside the overtaking VASI due to the hydrodynamic interactions (trapping phenomenon).

Due to the absence of VDR recordings, it is not possible to assess whether, and if this was the case how, the overtaking manoeuvre was adversely affected by manoeuvres initiated by the ship's commands involved.

Studies on the safe passing distance when overtaking are being carried out in the SIPAS[17][14] research project; however, these are still ongoing.

3.3.6.2.2 Can it be shown that the BIRTHE THERESA should not have been allowed to leave her berth?

This cannot be shown, because if the parameters of the voyage were different, the encounter or overtake situation would not have occurred resp. elsewhere would possibly have occurred without damage.

In retrospect, it appears beyond doubt that a short period of waiting by the BIRTHE THERESA to enable the VASI to pass would have been the easiest and safest way to proactively avoid such a potentially dangerous overtaking situation.

On the other hand, a reduction in speed by the MT VASI would have been an equally possible solution in terms of safety.

[17] Safe passing distance of sea-going vessels when overtaking and converging; see also [15] under Sources

3.3.6.2.3 What would have been the most favourable manoeuvre to separate the vessels?

In principle, the manoeuvres should be applied so that they withstand the attracting/repelling forces and torques. However, rudder forces alone are not sufficient when vessels are in very close proximity.
Therefore, the only effective means of separating the vessels from one another after the contact are engine manoeuvres, for example, to slow down the overtaken vessel sharply. However, conversely it must be remembered that steerability is diminished by reducing the propeller speed; therefore, after separating, or possibly even before with advance manoeuvres, steerability must be restored and the corresponding manoeuvres initiated.

3.3.7 The vessel traffic system and its implementation

A subject of the ongoing investigation is the hydrodynamic handling properties of vessels involved in an overtaking manoeuvre. While carrying out research, the BSU came across an article in the HANSA from September 1974[18] in which Dr Carl Wilhelm Ballin describes traffic management on the Kiel Canal. However, since his remarks are a representation of the calculation hypotheses for defining traffic groups at that time, a letter was sent to Waterways and Shipping Directorate North in Kiel to discuss the current calculation hypotheses for traffic breadth in relation to canal breadth and the curve radii.
This also considered how the system of traffic groups and their management has been updated in the recent past. For example, an expertise was prepared by the Federal Waterways Engineering and Research Institute (BAW) in Hamburg/Rissen for the forthcoming enlargement of the eastern section of the NOK.
The technical paper of WSD-N is reproduced (editorially revised) here:

"The aforementioned article by Dr Ballin generally describes the principle of traffic management on the NOK and the system of vessel traffic groups developed for this purpose. In principle, this system as well as the mathematical and hydrodynamic hypotheses for this has continued to this day; the dimensions of the vessels in the respective traffic groups have only been slightly modified over the years in the light of experience gained.
The technical procedures were also modified (e.g. discontinuation of siding area staff, position detection using AIS equipment, traffic management and signalling with the aid of electronic distance-time graph) in the case of the introduction of the new vessel traffic system for the NOK (VSSNOK) in 2006; however, the methodology of the traffic management has remained unchanged. For example, intermediate ranges have been developed in traffic groups 1 to 3, within which interpolation between the ship length and beam takes place. In traffic groups 4 and 5, the possible beam has been raised (subject to the ship length) in addition to the intermediate ranges.
Hence, for example, Traffic Group 4 vessels at 140 m (or less) in length can now have a maximum beam of 23.5 m, at 160 m in length then accordingly a beam of 20.5 m.

[18] HANSA 111 year p.747 – 753, see para. 8.2

The current dimensions of the traffic groups have been published in section 5 of the Notices to the SeeSchStrO of WSD North.

Overtaking outside of the siding areas on the NOK has only been briefly addressed in the article; the conditions for this remain unchanged (see section 9 of the aforementioned Notices to the SeeSchStrO).

There are no specific local rules within the siding areas, in which overtaking must follow the rules of art. 23 SeeSchStrO in principle.

The accident under investigation by the BSU took place in the 'Binnenhafen/Nordhafen (inland port/north port) Kiel-Holtenau' siding area, which stretches for approximately 2,500 m from canal kilometre 95.2 to the Kiel-Holtenau lock group. The navigable breadths vary here due to the localities between 170 m in Nordhafen and 240 m in the area of the ferry. A limitation here is the area below the bridge at Holtenau, which has a navigable breadth of about 130 m. Furthermore, planning for the development of the NOK (enlargement of the eastern section, re-profiling of Levensau, adjustment of the total section with possible depth scenarios) will be implemented on the basis of the existing traffic management system.

This existing and proven system will be developed further in the coming years in the course of the individual development stages, in particular as a result of the related movement of larger than hitherto registered vessels. In that context, the question of either additional traffic groups or a modification of the entire system will be posed. As far as presently anticipated, this will be carried out with the help of external expertise (such as navigational parameters, hydrodynamics, erosion rates, stream bed stability).

The localities of the scene of the accident and the traffic situation are visible in the Vessel Traffic Service via radar coverage and the ECDIS viewer (with AIS data). However, interventions in the area of vessel manoeuvring are basically not feasible due to the technical limitations of these systems and other tasks of the Vessel Traffic Service according to VV-WSV 2408."

4 ANALYSIS

4.1 Background information on the passage planning

Shipping on the Kiel Canal is governed by the German Traffic Regulations for Navigable Waterways and its notices. The system is based, inter alia, on the fact that vessels of a certain size and larger may only encounter one another in the siding areas. To simplify this, vessels are categorised into traffic groups when entering the canal. Through making use of simple rules, these traffic group numbers (1 to 6) can be organised so that only correspondingly small vessels pass each other while en route on the NOK. All other vessels must wait for oncoming traffic in the siding areas.
A further simplification for protection of the canal and vessels is standardisation of the speed. Most of the vessels may only move at a maximum of 15 km/h. Furthermore, a few are categorised as so-called low-speed vessels, which means they may not exceed 12 km/h on the canal.
On the basis of these predefined speeds, Vessel Control and the pilots are always able to calculate the position at which vessels will pass.[19]
The problem of having to reach the Schwartenbek siding area by 0310 existed for the MT VASI and the MT BIRTHE THERESA. This was the time at which the BV HAVLIS, a VG5 vessel approaching from the west, would reach this siding area. If this passage was not feasible, MT VASI and MT BIRTHE THERESA would have to wait for BV HAVLIS until 0322 in the inland port. Furthermore, this would mean that MT VASI would be forced to wait again in Schwartenbek for the next approaching vessel. This would have led to a further delay until at least 0410. To that end, and especially since the VTS made this opportunity available to him, the pilot of the VASI planned to reach Schwartenbek by 0310 in the knowledge that as a low-speed vessel with a maximum permitted speed of 12 km/h the schedule for this plan could be tight.
A graphical representation of the traffic situation follows in Figure 24 with an excerpt from the electronic distance-time graph of VTS NOK.

[19] See also para. 6.6 of BSU Report 20/09 – Collision on the Kiel Canal (NOK) between HANSE VISION and BIRKA EXPRESS dated 1 March 2010.

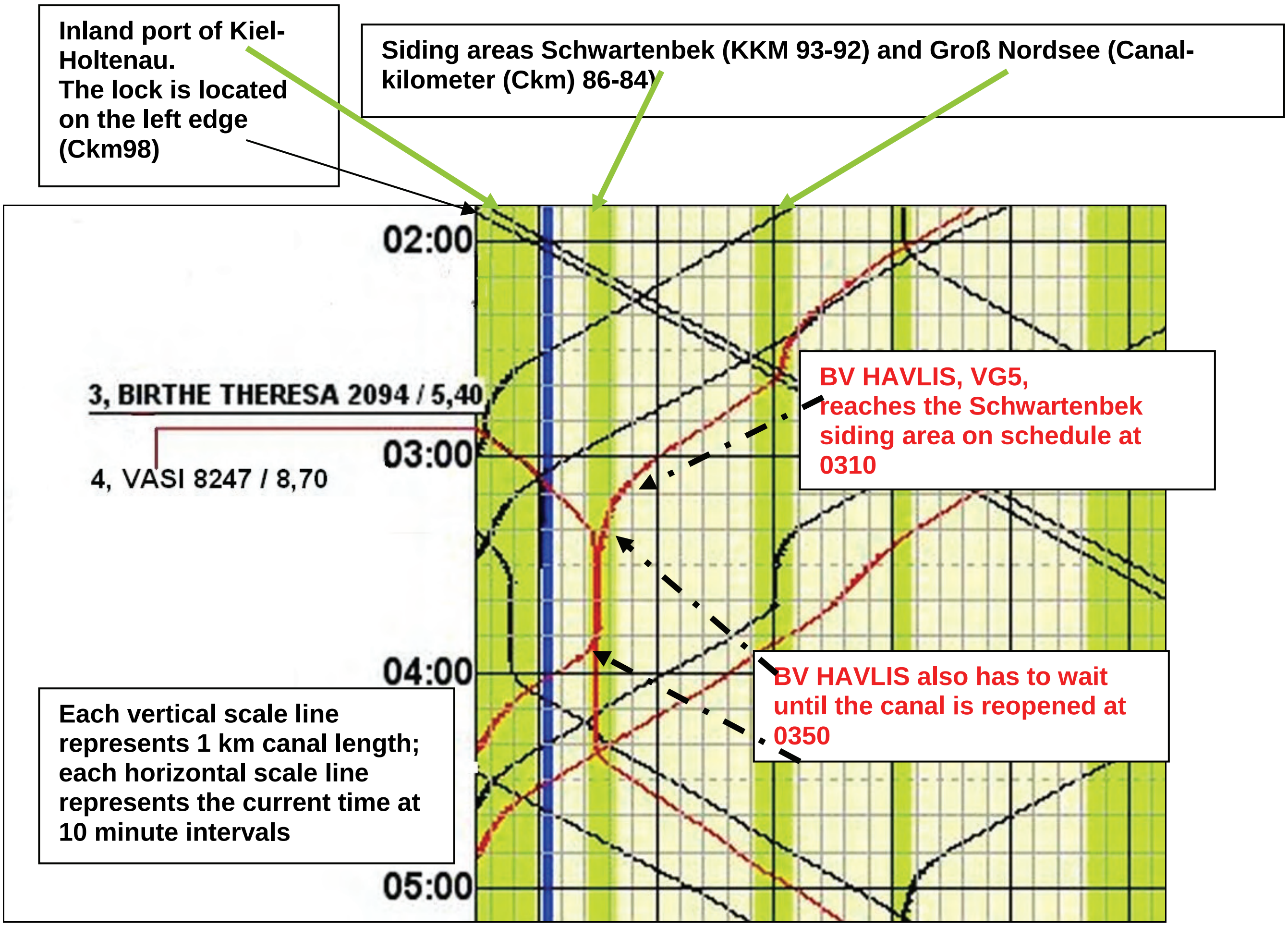

Figure 24: Excerpt from the electronic distance-time graph

With a canal speed of 15 km/h, BV HAVLIS would pass the Schwartenbek siding area at 0310. This is reported by the VTS through the passage time of the preceding Groß Nordsee siding area of 0242. For the remaining 3 km from the boundary of the Schwartenbek siding area to the boundary of the inland port, she would have needed another 12 minutes and would thus reach the inland port at 0322.

BIRTHE THERESA left her berth at 0250 and with a canal speed of 15 km/h would have needed 20 minutes for the 5 km from Bominflot to Schwartenbek. Therefore, she would have been in the siding area on time at 0310 to pass the BV HAVLIS there.

According to the AIS recording, VASI left the Kiel lock at 0251. As a low-speed vessel with a maximum speed of 12 km/h, she would have needed 25 minutes for the 5 km from there to Schwartenbek, meaning she would have arrived at 0316. From a practical perspective, the mathematical time overlap of 6 minutes is viewed by the pilots as acceptable; however, on the other hand no further delay was permitted.

4.2 Advice by the pilots

Neither master spoke German; therefore, they had to rely on the agreements and actions of the pilots.

Neither pilot met his obligation to advise his respective master in a manner that complies with the applicable regulations. Even without VHF radio, the situation could have been resolved by following the applicable regulations.

The pilot of the BIRTHE THERESA allowed the vessel to enter the canal traffic, even though he disturbed the right-of-way of the VASI in doing so. Conversely, the pilot of the VASI intended to allow the BIRTHE THERESA right-of-way so that the otherwise forthcoming overtaking manoeuvre could be avoided. On the other hand, he recognised that his vessel was to some extent pressed for time in terms of reaching the Schwartenbek siding area and therefore accepted that he may need to exceed the maximum permissible speed limit for so-called low-speed vessels. Allowing the BIRTHE THERESA right-of-way and yet also reaching the Schwartenbek siding area on time could, at any event, only be successful if the BIRTHE THERESA would have picked up speed swiftly. The pilot of the VASI ultimately felt compelled to overtake the BIRTHE THERESA when this did not happen. The pilot of MT VASI initially dispensed with his right of way and later on attempted to reclaim it for the purpose of overtaking. However, the audio recordings do not register the BIRTHE THERESE agreeing with that.

4.3 Communication

The audio recordings demonstrate the dangers associated with making arrangements, in this case between pilots, over VHF if they are not timely, and not objective.

An important role in this case is also played by the communication of the VTS. When both vessels contacted the VTS in short succession and reported their departure, the opportunity existed for the VTS to clarify exactly who should wait for who. At minimum, it should have informed each vessel about the other and their respective intentions. This could have contributed to the prevention of the accident.

4.4 Hydrodynamic aspects

According to the article by Dr Ballin and the technical paper of WSD-North (see sub-para. 3.3.7), the vessel traffic system on the NOK is based on calculations that were made at the time the canal was opened. Even though this system has since been proven in principle, accidents which are based on hydrodynamic effects have occurred repeatedly.

To account for the development of both growing vessel sizes and the number of vessels transiting, WSD-North has repeatedly commissioned the BAW in Rissen/Hamburg to prepare expertises to illustrate firstly the effects of widening the canal and secondly the increasing vessel sizes and their respective influence on traffic safety. The BAW would be in a position to simulate the NOK to scale in whole or in sections in a test tank and replicate the behaviour of different vessel sizes when approaching and overtaking. This would require extensive case studies with systematic parameter variations, in which all traffic groups and possible encounter and overtaking situations are to be included. The objective of such studies could be the development and adoption of an applicable criterion, as far as possible uniform, for an acceptable risk level for all encounter and overtaking scenarios in every NOK fairway section.

Such obtained values could ultimately help to increase safety on the NOK further.
In this context, reference may be made to the synthetic scenario-based studies of BALDAUF [3] and the studies of PETERS [10] and RAPP [11]. This work involved the formulation of principles for such traffic-related studies in areas used by line traffic and in particular on the NOK and possible approaches to further development of the NOK traffic management model were considered within the framework of preliminary studies. The work carried out so far could be used as a basis and starting point for necessary further simulation-based studies in a research and development project.

5 CONCLUSIONS

The handling of the two vessels following the agreements made between the pilots is regarded as the cause of the accident. However, the inadequate communication between the two pilots which preceded is rated an exception.

In law, the overtaking manoeuvre is clearly provided for in art. 25(2) point 4 SeeSchStrO. The vessel already underway in the fairway has right-of-way over the vessel leaving her berth. In the case investigated here, the low-speed vessel has right-of-way and correspondingly the vessel obliged to wait is faster during the canal passage. There are different approaches for the potential risk arising from that.

1. The two vessels observe the applicable regulations. The low-speed vessel would then begin her passage first and the faster vessel would have to overtake later.
2. After leaving the lock, the low-speed vessel remains in the inland port until the faster vessel has begun her passage and then follows. Since this is a “siding area”, waiting should be possible in the same way as in a siding.
3. The low-speed vessel remains in the lock until the faster vessel has picked up speed. This would, to the benefit of safety, have possibly influenced the entire course of the canal passage as well as the subsequent lock passages and to that extent intervention by the VTS was necessary.

VTS NOK has the task of managing traffic on the NOK. Every vessel movement should be approved by the VTS. Therefore, it would have been within its remit and powers to stop one of the two vessels and explicitly permit the other to proceed. In principle, the conduct of the VTS corresponded to the rules even without such explicit traffic management. However, in this case it would have been appropriate to at least notify each vessel that the other was also just getting underway when the respective vessel sent her departure message.

From the perspective of hydrodynamics, it remains to be noted that every encounter and overtaking situation on a narrow waterway such as the NOK carries an element of risk, which presently cannot be defined conclusively. The risk associated with two vessels that gravitate towards one another during a passing or overtaking manoeuvre is met by the traffic group scheme on the NOK. This scheme must continue to be updated constantly. In the process, further study hypotheses which involve theoretical approaches, computer simulations and model experiments should be reviewed with appropriate support.

6 Safety recommendations

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

6.1 Lotsenbrüderschaft NOK I + II (Brotherhood of NOK I + II Pilots)

The Federal Bureau of Maritime Casualty Investigation recommends that the pilots of the NOK moreover carry out canal passages in accordance with the traffic regulations for the canal and only make different arrangements by VHF in exceptional cases. If an arrangement is necessary, it must be comprehensive, explicit, objective and made with foresight. Ship's commands which do not have command of the German language should be involved in the arrangement.

6.2 Waterways and Shipping Directorate North

The Federal Bureau of Maritime Casualty Investigation recommends that in addition to the studies carried out hitherto, the WSD-North, Kiel, perform or commission a series of tests, which incorporate theoretical approaches, computer simulations and model experiments with present, scaled vessel models for its ongoing efforts to take current developments in relation to larger vessel dimensions into account.

7 SOURCES

- Investigations by the waterway police (WSP)
- Written statements
  - Ship’s command
  - Vessel operator
  - Classification society
- Witness accounts
- Technical paper of the Waterways and Shipping Directorate North, Kiel
- Vessel particulars, Federal Maritime and Hydrographic Agency (BSH)
- Excerpts from the NOK chart of WSD-North from 1995
- Vessel photos from Hasenpusch Photo-Productions
- HANSA 111 year p. 747-753: 'Die Verkehrslenkung am Nord-Ostsee-Kanal (Traffic Management on the Kiel Canal)' by Dr C. W. Ballin
- AIS and audio recordings of the Vessel Traffic Service Brunsbüttel NOK
- Expertise by Professor K. Benedict, University of Wismar, Department of Maritime Studies, Warnemünde, which in turn refers to the following sources:

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[7] Approach Channels – A Guide for Design. Final Report of the Joint PIANC-IAPH Working Group II-30 in co-operation with IMPA and IALA. Supplement to PIANC Bulletin No. 95, June 1997.

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[12] Baldauf, M.; Benedict, K.; Herberg, S.; Kirchhoff, M.: Binnenschiffe auf simulierter Fahrt (inland waterway vessels on a simulated voyage), in: Internationales Verkehrswesen (56), No. 5 / 2004; Hamburg, May 2004

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[16] Innovative Ship Simulation and Maritime Systems GmbH; info@issims-gmbh.de

8 APPENDICES

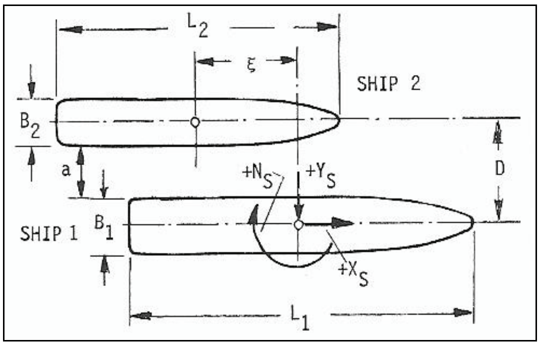
8.1 General description of a passing manoeuvre when overtaking vessels and determining the necessary distance

As part of his expertise, Professor Benedict explained the hydrodynamic findings that are now available following research in the recent past.

8.1.1 Forces and moments and their effect when passing

Flow fields and pressure fields, which influence one another when converging during a pass/encounter and when overtaking, form around the hull of moving vessels. This results in a change in pressure distribution and additional transient forces and moments occur, which affect the motion behaviour of vessels. The extent of this mutual effect depends largely on the following factors: speed and distance/position of the vessels in relation to each other, size, shape and load condition of the vessels involved as well as the nature and effects of possibly existing fairway boundaries. The effect rises: when the speed of the vessel increases, the distance reduces, with large displacement and increasing fairway boundaries. These tendencies apply equally when converging and when overtaking. However, the risk is greater when overtaking because the manoeuvre and thus also the action of the forces lasts for a longer period. In particular, the motion of the vessels involved is adversely affected at low speed differences. Therefore, explanation of the phenomenon is to be limited to the overtaking manoeuvre; rules of thumb for passing and overtaking are defined in section 3.9. below.
Particular difficulties arise from the fact that the resulting forces and moments change both in magnitude and in sign during the passing manoeuvre, therefore, it is necessary to respond continuously with respect to controlling the vessel. In Figure 26, the characteristic course of these forces is plotted (according to **[1]**) in relation to the position ξ during the overtaking manoeuvre, where vessel 2 is overtaking vessel 1 (see Figure 25): the longitudinal force Xs is negative in the first phase at the approach, the overtaken vessel is slowed down. However, after the overtaking vessel has passed somewhat a positive longitudinal force takes effect and the overtaken vessel is accelerated. This is especially pronounced if the overtaking vessel is larger than the overtaken vessel: a trough (water level drops next to the vessel) develops due to the flow of the overtaking vessel and in the process the overtaken vessel 'surfs' in the aft section as if through a downhill force.
The component force Ys initially leads to repulsion, then when the vessels are more or less abreast suction occurs and at the end of the manoeuvre repulsion follows. The yaw-moment Ns is positive at the beginning of the overtaking manoeuvre, which causes the overtaken vessel to be turned away from overtaking vessel. Following the level centre position with lesser moment effect, at the end of the overtaking manoeuvre the sign changes and the vessel is turned with the bow back towards the overtaking vessel.

The magnitude of these force and moment effects and especially the distance up to which vessels can encounter safely are important for the ship's command. A simple semi-empirical method developed by BRIX **[2]** for calculating the forces and moments is illustrated below. With the help of this method studies can be carried out on estimating safe passing distance.



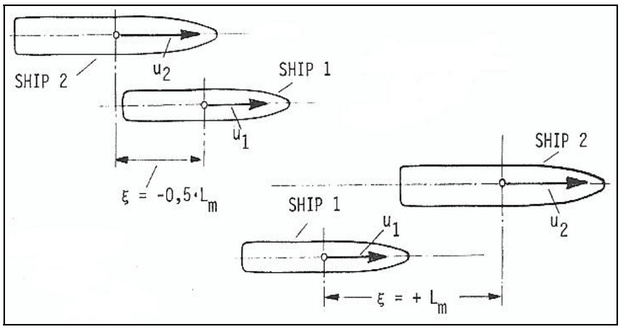


Figure 25: Designations in the overtaking situation of vessel 1 and vessel 2 at distance D of the vessel longitudinal axes from one another as well as the direction of the forces and moments (left) applied and selected overtaking manoeuvre situations, shown at the beginning of the overtaking manoeuvre and at the end of the manoeuvre (right); the parameter ξ represents the position of the vessels based on the average length $L_m = (L_1 + L_2)/2$ of the two vessels

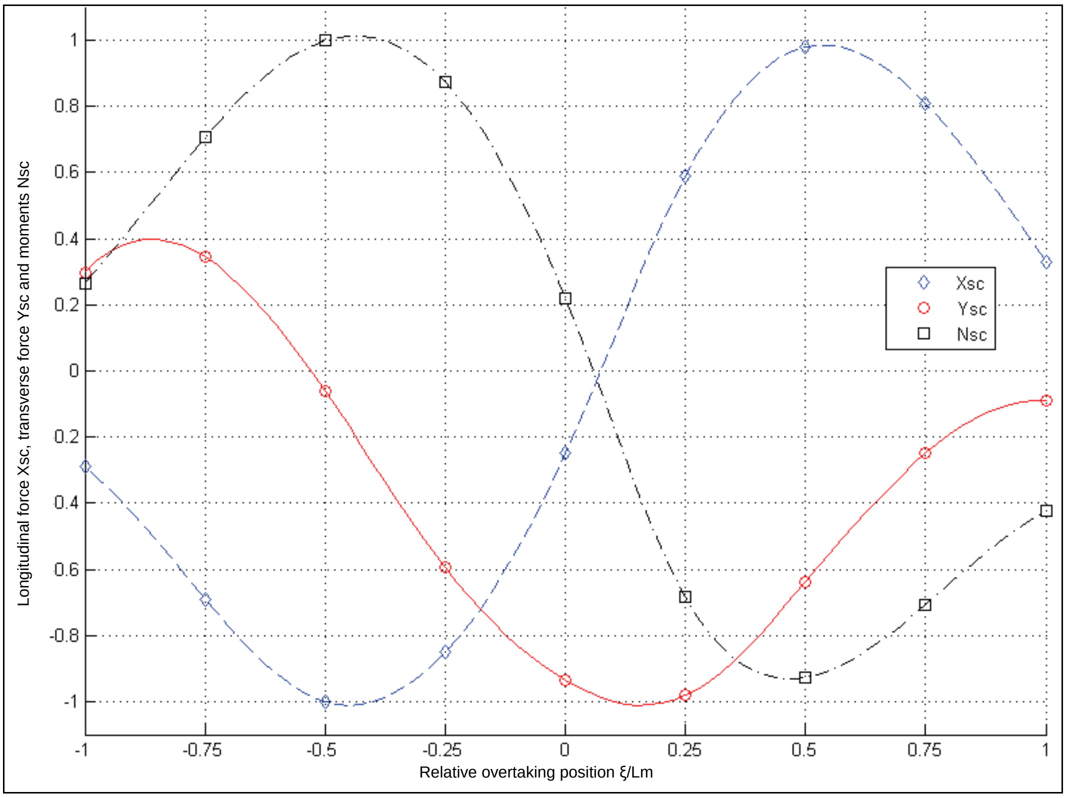


Figure 26: Characteristic reference curves for Xsc, Ysc and Nsc at selected overtaking positions ξ/Lm

According to BRIX, the respective maximum occurring values $X_S$max and $Y_S$max of the forces X_S and Y_S as well as the maximum value $N_S$max of the moment N_S can be calculated as:

$$X_S max = C_{XS} max \cdot \left(\frac{\rho}{2} V_m{}^2 \cdot L_m \cdot T_m\right) \cdot \left(\frac{D}{D_0}\right)^{-1}$$
$$Y_S max = C_{YS} max \cdot \left(\frac{\rho}{2} V_m{}^2 \cdot L_m \cdot T_m\right) \cdot \left(\frac{D}{D_0}\right)^{-1} \qquad (8.1\text{-}1)$$
$$N_S max = C_{NS} max \cdot \left(\frac{\rho}{2} V_m{}^2 \cdot L^2{}_m \cdot T_m\right) \cdot \left(\frac{D}{D_0}\right)^{-1}$$

at mean speed $V_m = (V_1 + V_2)/2$, mean vessel length $L_m = (L_1 + L_2)/2$ and mean draught $T_m = (T_1 + T_2)/2$. The time for the complete overtaking manoeuvre is $T = (L_2 + L_1)/(V_2 - V_1) = 2 \cdot L_m / \Delta u$. $Do=0.35 \cdot L_m$ is the reference distance at which the characteristic coefficients were determined, for which BRIX specified the following values:

$$C_{XS} max = 0{,}014 \ldots 0{,}017; \quad C_{YX} max = 0{,}025 \ldots 0{,}030; \quad C_{NS} max = 0{,}004 \ldots 0{,}005 \qquad (8.1\text{-}2)$$

These values are applicable to length ratios L2 / L1 up to about 2. If additional shallow water effects and lateral boundaries need to be accounted for, even larger values must be applied.
For the course of the forces actually acting, one only needs to multiply these maximum values with the respective reference values of the characteristic curves in Figure 26:

$$X_S(\varsigma) = X_{SC}(\varsigma) \cdot X_S max; \quad Y_S(\varsigma) = Y_{SC}(\varsigma) \cdot Y_S max; \quad N_S(\varsigma) = N_{SC}(\varsigma) \cdot N_S max; \qquad (8.1\text{-}3)$$

For the discussion on the vessel size's influence on the transverse forces, the calculated, maximum transverse forces as a function of the passing distance PA = a/Lmax in relation to the breadth of the respectively larger vessel in the respective comparative calculations are shown in Figure 27. Clearly visible is the exponential increase in transverse force with decreasing passing distance. To illustrate the influence of the speed, this has also been varied for the mid-sized vessel of L = 130m: we see that the transverse force drops significantly when the average speed is decreased by only 0.5 m/s to 4.5 m/s. High transverse forces are more hazardous for the smaller vessels, because with their lower masses they respond much faster than the sluggish, large vessels. The lower their speed, the greater the drift angle they must have in order to compensate for these transverse forces.

8.1.2 Determining the safe passing distance

To determine the hydrodynamic safe passing distance for risk detection and mitigation, a study had to be carried out on whether the respectively overtaken vessels were still in a position to compensate for the situation, for example, through a drift angle to compensate for occurring maximum transverse forces to prevent suction resp. rudder angles to compensate for the moment effects when passing vessels.

Such analyses using theoretical calculations or experimental studies are difficult. In particular, the precise limits are still not known, for example, for adequate countermeasures such as the yaw-angle resp. the rudder angle used above to maintain the track and a safe passing distance. Experimental studies are also difficult – the rudder moments necessary in the experiments quickly exceed the rudder angles at all possible, where, disadvantageously experiments with model vessels are difficult to reproduce because of the instability and considerable dynamics of the transient processes in the control **[4][5]**.

Therefore, in **[3]** an analysis was carried out of conducted model calculations and collisions, which occurred during overtaking manoeuvres. As a result, we see in Figure 27 that the observed distance before the onset of the no longer controllable more dominant suction effect was less than a value of $3.5 \times B_{max}$ (B_{max} = breadth of the larger vessel) in each case. Taking into account a safety margin of at least 20% (one tenth of the vessel's length), it was proposed that the hydrodynamic safe passing distance should be defined in the range of greater than $0.6 \times L_{max}$ and $3.5 \times B_{max}$ in order to avoid collisions during overtaking manoeuvres. This recommendation is very imprecise because it does not account for the influence of the speed of the vessels.

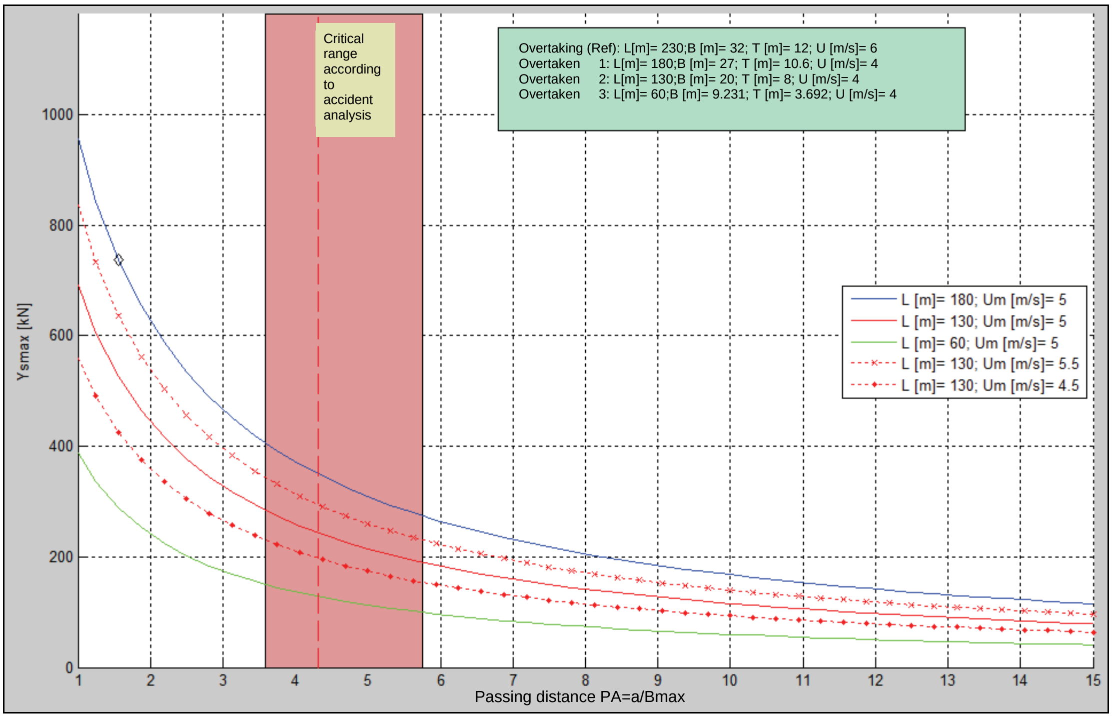


Figure 27: Maximum transverse forces that occur in relation to the passing distance between overtaking vessel (reference vessel) relative to the breadth of the vessel and overtaken vessels of different sizes as well as light red distance range in which collisions occurred

The lateral distance between converging vessels regarded as safe during the design of maritime canals should also permit conclusions for decision-making in the ship's command: among the most common guidelines are those of the PIANC-IAPH Working Group II_30 **[7]**. Here the lateral passing distance is made up of the base distance (subject to the speed of the vessel) and an additional distance (subject to traffic density) and is expressed as a multiple of the beam. Table 1 shows the recommended passing distances for encounter situations; these values should be increased by 50% for overtaking.

	Canals to open water	**Inner, confined fairway**
Speed of vessel	**Base distance**	
> 12 kts	2.0 B	1.8 B (new according to PIANC WG 49)
8 – 12 kts	1.6 B	1.4 B
5 – 8 kts	1.2 B	1.0 B
Traffic density of the encounter situation	**Additional distance**	
0 – 1 vessel/h	0.0 B	0.0 B
1 – 3 vessels/h	0.2 B	0.2 B
> 3 vessels/h	0.5 B	0.4 B

Table 1: Recommended passing distances for fairway design according to PIANC WG 30 **[7]**

In current Japanese design guidelines **[9]**, when determining the required lateral distance the interactive yaw-moment occurring during a passing manoeuvre must be compensated by a rudder angle of not greater than 15°. At 2.6 up to 5xB, the recommended values are then at times considerably higher than those of PIANC WG 30. Following simulations with different vessels (including modern, large container vessels up to 14,000 TEU) and evaluations of the practise in different areas, a comprehensive comparative study **[8]** on this issue revealed that 1.25 to 1.30 B is to be regarded as an adequate passing distance during convergences in shallow water and at medium speed (8 – 12 kts); for overtaking manoeuvres 1.25 to 1.5 B should be sufficient. Of course, here a sufficient distance to lateral boundaries must be possible because the influence of the bank effect may be even more disruptive. From a hydrodynamic, theoretical perspective, in the case of the values proposed on the basis of practise, it must be remembered that here compensatory manoeuvre strategies during converging and overtaking are applied, which include experience-based precautionary rudder angles to absorb anticipated turning motions.
As these studies and practise have shown, it is also possible to execute overtaking manoeuvres with smaller distances. However, decisive is always how well one can deal with rudder angles of more than 15° – if one then makes an error, accidents will happen – greater distances offer greater safety!

8.2 Article by Dr Carl Wilhelm Ballin

narrow channels/Shipping/Kiel Canal/

Die Verkehrslenkung am Nord-Ostsee-Kanal

Aufgabe, System und Hilfsmittel

Dr. Carl Wilhelm B a l l i n , Kiel-Holtenau

I. Einleitung

Schon mehrfach wurde über die Verkehrslenkung (häufig fälschlich Schiffslenkung genannt) am NOK geschrieben. Aus diesem Grunde scheint die Frage berechtigt, warum noch einmal ein Artikel über die Verkehrslenkung geschrieben wird.

Die Rechtfertigung für diesen Artikel soll nicht auf Kritik an den vorangegangenen Veröffentlichungen basieren. Das sei nur zur Vermeidung von Mißverständnissen gesagt. Hier soll die Verkehrslenkung am Nord-Ostsee-Kanal aus der Sicht des für diese Aufgabe zuständigen Kanalamtes Kiel-Holtenau dargestellt werden. Dabei sollen die sich aus den Abmessungen des Nord-Ostsee-Kanals einerseits und aus den Maßen und besonderen Eigenschaften der den Kanal passierenden Schiffe andererseits ergebenden Probleme des Verkehrs und seiner Abwicklung mit den Aufgaben ins Verhältnis gesetzt werden, die von den an der Verkehrslenkung Beteiligten mittels umfangreicher technischer und zum Teil komplizierter Hilfsmittel zu bewältigen sind. In diesem Rahmen lassen sich zur Darstellung und Lösung der Problematik leider Wiederholungen aus anderen Artikeln nicht vermeiden.

II. Problematik

Täglich passieren bis zu 250 Schiffe und mehr — Sportfahrzeuge nicht mitgezählt — den rund 100 km langen Nord-Ostsee-Kanal, an dessen Enden sich je ein neues Schleusenpaar (nutzbare Maße 310 m Länge und 40 m Breite) und ein altes Schleusenpaar (nutzbare Maße 125 m Länge und 22 m Breite) befnden. Die durchschnittliche Größe der Fahrzeuge beträgt dabei ca. 1200 BRT, die maximale Größe bis zu 36 000 BRT, was Ausmaßen von rund 245 m Länge und 32,50 m Breite entspricht. Größere Fahrzeuge können den Kanal nicht passieren, weil er diesen bei einer Wassertiefe von 11 m bei 44 m Breite in der Sohle und 102,5 m Breite im Wasserspiegel in den nicht ausgebauten Strecken Grenzen setzt.

Hinsichtlich der für die Passage zuzulassenden Schiffsgrößen ist naturgemäß von diesen Minimalmaßen des Kanals auszugehen. Die Maße der Ausbaustrecken von 90 m Breite in der Sohle und 162 m Breite im Wasserspiegel bei 11 m Wassertiefe müssen also bei der Zulassung außer acht gelassen werden. Diese Maße sind allerdings für die Verkehrslenkung von erheblicher Bedeutung, da sie eine Optimierung des Verkehrsflusses ermöglichen, worauf noch einzugehen sein wird.

An dieser Stelle sei der Hinweis gestattet, daß seit dem 15. Juni 1973 die metrischen Abmessungen der Schiffe (Länge, Breite, Tiefgang) für ihre Zulassung zur Kanalpassage und als Grundlage für die Verkehrslenkung maßgebend sind. Die alte Grundlage der BRT-Vermessung wurde aufgegeben, weil diese im Gegensatz zu früheren Zeiten kein wahres Bild mehr über die tatsächlichen Abmessungen der Schiffe vermittelt.

Es liegt auf der Hand, daß sich Schiffe oben genannter Maximalgrößen nicht auf der Kanalstrecke begegnen können, ja noch nicht einmal Schiffe mit Maßen erheblich darunter. Normalerweise führt dies zum Konvoi-Verkehr, wie wir ihn vom Suez-Kanal her kennen. Mit Hilfe von zwölf Ausweichstellen jedoch — den sogenannten Weichen — vermeidet die Verkehrslenkung den Konvoi-Verkehr, indem sie auf der Kanalstrecke wegen der Abmessungen der Schiffe und des Kanals nicht mögliche Begegnungen in die Weichen verlegt. Die zwölf Weichen sind zwischen 570 m und 5420 m lang und besitzen grundsätzlich auf beiden Seiten Dalben mit Pollern darauf, um den aus Verkehrsgründen wartenden Schiffen (Durchführung einer Kreuzung) das Liegen in gebotener Weise zu erleichtern.

Nicht nur die Abmessungen der zur Passage zugelassenen Fahrzeuge sind — wenn dies auch vielfach angenommen wird — von erheblicher Bedeutung für eine sichere Passage und damit für die Verkehrslenkung, die diese sichere Passage gewährleisten soll, sondern darüber hinaus auch die Besonderheiten der Fahrzeuge, die hier zu erwähnen sind, ohne daß schon auf die Verkehrslenkung im einzelnen eingegangen werden muß.

Grundsätzlich unproblematisch von Natur aus sind Trokkenfrachter. Anders dagegen ist die Situation bei Fahrzeugen mit gefährlichen Gütern. Zu nennen sind hier Tanker, welche brennbare Flüssigkeiten mit niedrigen Flammpunkten befördern oder befördert haben, ohne entgast worden zu sein, Gastanker und Chemikalientanker. Hält man sich vor Augen, daß beispielsweise ein Kubikmeter nicht entgaster Tankraum nach vorangegangener Beförderung von Rohöl die Sprengwirkung von einem Kilogramm Dynamit haben kann — bei einem 20 000-tdw-Tanker wären es also rund 20 t Dynamit — dann leuchtet es ein, daß diese gefährlichen Fahrzeuge einer besonderen Beachtung durch die Verkehrslenkung bedürfen.

Aber auch Fahrzeuge ohne gefährliche Güter können für den reibungslosen Verkehrsablauf eine Gefahr darstellen, deren Verwirklichung durch entsprechende Maßnahmen der

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Verkehrslenkung verhindert werden muß. So kann ein hoch in Ballast fahrendes Schiff vielfach nur unter entsprechender Berücksichtigung der Windverhältnisse in den Weichen aufgestoppt werden, weil der Gefahr des Treibens durch den Wind und der daraus resultierenden Kollisionsgefahr Rechnung getragen werden muß.

Auch außergewöhnliche Schwimmkörper, manövrierbehinderte Fahrzeuge und außergewöhnliche Schub- und Schleppverbände erfordern im Interesse eines gefahrlosen und zügigen Verkehrsablaufs besondere Lenkungsmaßnahmen. Diese Fahrzeuge können nämlich die übrige Schiffahrt außergewöhnlich behindern und bedürfen darüber hinaus häufig besonderer Rücksicht durch die Schiffahrt.

Neben den vorgenannten durch die Verkehrslenkung zu kompensierenden Gefahren muß auch den Gefahren durch bestimmte Wetterlagen Rechnung getragen werden. So gefährden Fahrzeuge im Nebel ohne oder mit nicht einwandfrei arbeitenden Navigationsmitteln wie z. B. Radar und Kompaß die übrige Schiffahrt in besonders starkem Maße. Auf das Wechselspiel zwischen Wind und Windanfälligkeit bestimmter Fahrzeuge, das besonders bei Ballastern akut ist, wurde bereits oben hingewiesen.

Wenn es auch zu weit führt, alle von der Verkehrslenkung zu berücksichtigenden Gefahrenquellen und Faktoren zu nennen, so darf doch nicht unerwähnt bleiben, daß der mögliche nachteilige Einfluß des sich in den Verkehrsfluß einreihenden Verkehrs aus den Häfen am Nord-Ostsee-Kanal sowie des sich auf der übrigen Kanalstrecke in den Verkehrsfluß einreihenden Verkehrs auf den stetig fließenden Längsverkehr im Interesse einer schnellen und sicheren Kanalpassage der durchgehenden Schiffe durch entsprechende Maßnahmen der Verkehrslenkung ausgeschaltet werden muß. In diesem Zusammenhang sei darauf hingewiesen, daß bis zu 50 Schiffe und mehr täglich in den Verkehrsfluß eingereiht werden müssen.

Die schwerste Einwirkung auf den Verkehr haben in der Regel Schiffsuntergänge im Fahrwasser, in die Böschung gelaufene Schiffe und Baumaßnahmen unter Benutzung erheblicher Teile des Fahrwassers. Durch diese Vorkommnisse wird nicht selten der Verkehr unterbrochen. Zur Beseitigung der sich für die Schiffahrt daraus ergebenden Gefahr — nämlich in die Unfallstelle oder Baustelle der genannten Art hineinzulaufen — sind den Gesamtverkehr betreffende, zum Teil sehr einschneidende und weitreichende Maßnahmen der Verkehrslenkung erforderlich, die bei Unfällen nicht im voraus geplant werden können.

III. Lösung der Problematik

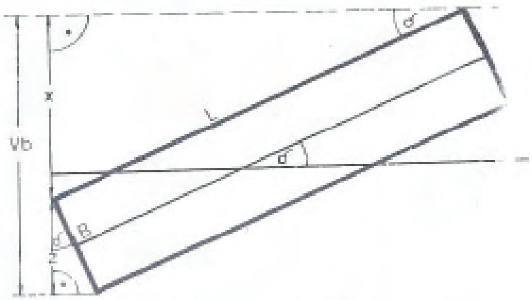
Alle vorstehend genannten Faktoren und zu kompensierenden Gefahren, die einzeln aber auch in allen nur denkbaren Kombinationen vorhanden sein können, sind bestimmend für den Verkehr, der nur durch eine alle Faktoren und Gefahren berücksichtigende Verkehrslenkung sowohl im Hinblick auf die Sicherheit des Verkehrs als auch hinsichtlich einer zügigen Passage der Schiffe optimal abgewickelt werden kann. Eine optimale Verkehrslenkung ist nur möglich, wenn drei Grundvoraussetzungen gegeben sind: Ein sinnvolles Lenkungssystem, ausreichende technische Hilfsmittel und qualifiziertes Personal zur Bewältigung der Lenkung. Diese Grundvoraussetzungen liegen vor.

Wenn im folgenden erst hinter dem System und den Hilfsmitteln auf die Aufgaben des Personals der Lenkung eingegangen wird, so geschieht das, weil das System und die Hilfsmittel Voraussetzung für die Tätigkeit des Personals sind.

1. Das System

Das System der Verkehrslenkung auf dem Nord-Ostsee-Kanal ist die Antwort auf die Frage, bis zu welcher Größe Fahrzeuge einander auf der Strecke begegnen können.

Unter Berücksichtigung der von den Schiffen einzuhaltenden ausreichenden Abstände von der Böschung und des einzuhaltenden Verhältnisses zwischen Kanalquerschnitt und eingetauchtem Schiffsquerschnitt steht der Schiffahrt sowohl im nicht ausgebauten Teil der Kanalstrecke al[s] im ausgebauten Teil der Kanalstrecke nur ein begr[enzter] Fahrstreifen zur Verfügung. Das bedeutet, daß die Verk[ehrs]breiten der Fahrzeuge zuzüglich einer sicheren Passi[er]standes die Breite dieses Fahrstreifens nicht überschr[eiten] dürfen. Um dieses zu gewährleisten, sind die Verkehr[sbrei]ten der verschieden großen den Nord-Ostsee-Kanal pa[ssie]renden Schiffe zu ermitteln. Dabei ist von der Tatsache [aus]zugehen, daß die Verkehrsbreite eines Fahrzeuges [nicht] immer seiner Breite entspricht. Insbesondere in den [Kur]ven vergrößert sich die Verkehrsbreite eines Schiffes, [da] der Vorsteven des Schiffes dem Mittelpunkt des Kr[eises,] dem das Schiff in der Kurve folgt, mehr zugewandt i[st, als] es dem Kurvenverlauf entspricht. Der Vorsteven des S[chif]fes ist also dem Mittelpunkt des Kreisbogens näher a[ls der] Achtersteven. Diese Eigenart der Schiffe ist dem [Über]steuern von Kraftfahrzeugen vergleichbar. Unter Be[rück]sichtigung des Vorstehenden errechnet sich die Verk[ehrs]breite eines Schiffes wie folgt (Bild 1):



L = Länge des Schiffes
B = Breite des Schiffes
δ = Derivationswinkel
Vb = Verkehrsbreite

$x + z = Vb$
$x = \sin\delta \cdot L$
$z = \cos\delta \cdot B$
$\sin\delta \cdot L + \cos\delta \cdot B = Vb$

Bild 1 Berechnung der Verkehrsbreite

Geht man unter Zugrundelegung eines Kurvenradius von 2500 m von einem Derivationswinkel von 5° aus, so lassen sich die Verkehrsbreiten der einzelnen Fahrzeuge leicht ermitteln und diesen zuordnen. Auf diesen den einzelnen Fahrzeugen zugeordneten Verkehrsbreiten beruht das Verkehrslenkungssystem. Auf der Basis der Verkehrsbreiten der erforderlichen Passierabstände und des einzuhaltenden Verhältnisses von Kanalquerschnitt zu eingetauchtem Schiffsquerschnitt werden alle für den Nord-Ostsee-Kanal-Verkehr in Betracht kommenden Fahrzeuge dergestalt in sechs Gruppen eingeteilt — die sogenannten Verkehrsgruppen —, daß nur diejenigen Fahrzeuge einander auf der Strecke unter Ausnutzung des zur Verfügung stehenden Fahrstreifens passieren können, deren Summe der Verkehrsgruppenzahlen sechs — dies gilt für die nicht ausgebauten Strecken — bzw. sieben — dies gilt versuchsweise für die ausgebauten Strecken — nicht übersteigt (Bild 2).

Unter Berücksichtigung der vorstehenden Verkehrsgruppeneinteilung sind aus hydrologischen Gründen zum Schutze des Kanalbettes Überholvorgänge nur zwischen solchen Fahrzeugen zulässig, deren Summe der Verkehrsgruppenzahlen 5 nicht übersteigt. Übersteigt die Summe der Verkehrsgruppenzahlen der sich begegnenden Fahrzeuge sechs bzw. sieben, so ist nur eine Begegnung in den Weichen möglich.

2. Die Hilfsmittel

Das vorstehend vereinfacht dargestellte Verkehrslenkungssystem ist die Grundlage für die Lenkung überhaupt. Für einen optimalen Verkehrsablauf jedoch ist das System allein nicht ausreichend. So stehen der Verkehrslenkung am Nord-Ostsee-Kanal eine Vielzahl technischer Hilfsmittel zur Abwicklung eines zügigen und sicheren Verkehrs zur Verfügung.

In diesem Zusammenhang ist darauf hinzuweisen, daß hier unter der Verkehrslenkung nicht nur der Aufga[ben]...

Ver-kehrs-gruppen	Fahrzeuge und Schubverbände ohne besonders gefährdende Ladung mit:		Schleppverbände ohne besonders gefährdende Ladung mit:		Fahrzeuge, Schub- und Schleppverbände mit besonders gefährdender Ladung, sowie nicht entgaste Tankfahrzeuge mit:
1	Längen Breiten Tiefgängen	bis 50 m bis 9 m bis 3,1 m	Längen Breiten Tiefgängen	bis 30 m bis 9 m bis 3,1 m	entfällt
2	Längen Breiten Tiefgängen	bis 75 m bis 12 m bis 3,7 m	Längen Breiten Tiefgängen	bis 75 m bis 12 m bis 3,7 m	entfällt
3	Längen Breiten Tiefgängen	bis 135 m bis 17,5 m bis 6,1 m	Längen Breiten Tiefgängen	bis 90 m bis 17,5 m bis 6,1 m	den in Sp. 2 bzw 3 aufgeführten Abmessungen der Verk.-Gruppen 1 u. 2
4	Längen und Breiten oder Längen und Breiten oder Längen und Breiten u. Tiefgängen	bis 140 m bis 22 m bis 155 m bis 20,5 m bis 160 m bis 19,5 m bis 9,5 m	Längen Breiten Tiefgängen	bis 135 m bis 19,5 m bis 6,1 m	den in Sp. 2 bzw. 3 aufgeführten Abmessungen der Verkehrsgruppe 3
5	Längen Breiten Tiefgängen	bis 210 m bis 27 m gemäß Tab.	Längen Breiten Tiefgängen	bis 160 m bis 27 m bis 9,5 m	den in Sp. 2 bzw. 3 aufgeführten Abmessungen der Verk.-Gruppen 4 u. 5
6	Längen Breiten Tiefgängen	über 210 m über 27 m gemäß Tab.	Außergewöhnliche Schleppverbände		den in Sp. 2 aufgeführten Abmessungen der Verk.-Gruppe 6 sowie Außergewöhnl. Schleppverbd.

Bild 2 Verkehrsgruppenzahlen

ereich der Verkehrslenkungsstellen in Brunsbüttel (zuständig von den Schleusen in Brunsbüttel bis zum Überlappungsbereich der Strecke Breiholz-Schülp) und in Kiel-Holtenau (zuständig vom Überlappungsbereich der Strecke Breiholz-Schülp bis zu den Schleusen in Kiel-Holtenau) zu verstehen ist, sondern darüber hinaus alle Aufgabenbereiche der mit der Disposition der Fahrzeuge im Hinblick auf ihre schnelle und sichere Passage Befaßten.

Ohne schon den Zweck und die Einordnung der Hilfsmittel in das Gesamtgefüge der Lenkung im einzelnen darzustellen — hierauf ist noch besonders einzugehen — sind folgende wesentliche Hilfsmittel zu nennen:

- Meldungen der auf den Nord-Ostsee-Kanal zulaufenden Schiffe;
- Verkehrssicherungsfunk mit den Küstenfunkstellen für den nicht öffentlichen UKW-Seefunksprechdienst
  - aa) Kiel-Kanal II Radio (Standort: Hafenkapitänsdienstgebäude Brunsbüttel; Sprechweg 2);
  - bb) Kiel-Kanal III Radio (Standort: Hafenkapitänsdienstgebäude Kiel-Holtenau; Sprechweg 3);
- Schleusenabfertigungsfunk mit den Küstenfunkstellen für den nicht öffentlichen UKW-Seefunksprechdienst
  - aa) Kiel-Kanal I Radio (Standort: Schleusenleitstand auf der Neuen Schleuse Brunsbüttel; Sprechwege 13 und 5);
  - bb) Kiel-Kanal IV Radio (Standort: Schleusenleitstand auf der Neuen Schleuse Kiel-Holtenau; Sprechwege 12 und 16);
- Signalanlagen für die Lenkung des Verkehrs in die Zufahrten und in die Schleusen;
- Lautsprecheranlagen im Schleusenbereich und in den Schleusen;
- Fernschreibverbindungen von den Leitständen der neuen Schleusen zu den Verkehrslenkungsstellen;
- Telefonverbindungen zwischen den Schleusenleitständen und den Verkehrslenkungsstellen;
- Signalanlagen für die Lenkung des Verkehrs auf der Kanalstrecke (Weichensignale);
- Telefonverbindungen zwischen den Verkehrslenkungsstellen und den Weichendienstgebäuden;
- Lautsprecheranlagen in den Weichen.

. Verkehrslenkungs-Personal

Das mit der Lenkung befaßte Personal besteht aus den Schleusenmeistern, den Bediensteten des Lenkungs- und Weichendienstes und den im Weichendienst Tätigen.

1. Schleusenmeister

In Brunsbüttel und Holtenau ist je ein Hauptschleusenmeister mit den ihm unterstellten Oberschleusenmeistern und Schleusenmeistern für die sichere und schnelle Durchschleusung der Schiffe verantwortlich. Die Dispositionen werden von den Hauptschleusenmeistern getroffen, die ihren Dienst im jeweiligen Schleusenleitstand der neuen Schleusen verrichten. Wegen des rund um die Uhr laufenden Verkehrs besteht Schichtdienst.

Die auf den Nord-Ostsee-Kanal zulaufenden Schiffe werden dem Schleusenmeister (hier und im folgenden ist mit dem Begriff „Schleusenmeister" der für die Disposition verantwortliche Hauptschleusenmeister gemeint) in Brunsbüttel durch den Schiffsmeldedienst gemeldet, wenn die Fahrzeuge Stadersand — elbeabwärts fahrend — oder Feuerschiff Elbe 1 — elbeaufwärts fahrend — passieren. In Kiel-Holtenau erfolgen die Meldungen durch die Lotsen vom Feuerturm Kiel aus. Diese Meldungen ermöglichen es dem jeweiligen Schleusenmeister, die Ankunftszeiten der Schiffe vor den Schleusenzufahrten unter Zugrundelegung der Schiffsgeschwindigkeiten, des Gezeitenstromes und der Wetterlage ziemlich genau abzuschätzen.

Hauptsächlich auf Grund dieser geschätzten Ankunftszeiten der Schiffe ist der Schleusenmeister ständig in der Lage, schon frühzeitig die erforderliche und dem ununterbrochen fließenden Verkehr angepaßte Belegung der Schleusen zu disponieren. Das bedeutet, daß für die gemeldeten Schiffe vom Schleusenmeister ausreichender Raum in den Schleusen vorzuhalten ist, wobei er besonders berücksichtigen muß, daß die aus dem Kanal kommenden und ihm von der jeweiligen Endweiche gemeldeten Fahrzeuge zügig aus dem Kanal hinausgeschleust werden müssen, um gefährliche Situationen in den Binnenhäfen vor den Schleusen zu vermeiden. Wenn diese ständigen Vorausdispositionen durch den Schleusenmeister bis zur tatsächlichen Ankunft der Schiffe wegen gewisser Zeitverschiebungen auch zum Teil noch geringfügig geändert werden müssen, so sind es doch diese Vorausplanungen, die dem Schleusenmeister eine optimale Belegung der Schleusen — er muß die Schleusenmaße mit den Abmessungen der Fahrzeuge unter Berücksichtigung der Manövrierfähigkeit der einzelnen Schiffe und der Wetterlage in Einklang bringen — und damit einen optimalen Schleusungsvorgang sowohl hinsichtlich der Sicherheit als auch im Hinblick auf die Schnelligkeit ermöglichen. Besondere Schwierigkeiten bereiten Fahrzeuge mit besonders gefährlichen Gütern. Diese dürfen aus Sicherheitsgründen nicht mit Fahrgastschiffen zusammen geschleust werden und bewirken so zusätzliche Belastungen.

Zur Realisierung der geplanten Schleusenbelegung stehen dem Schleusenmeister Signale zur Verfügung, mit denen er den zulaufenden Verkehr in die Zufahrten und in die Schleusen regelt (Bild 3).

Bild 3 Schleusensignale

Diese Signale reichen aber nicht aus. Häufig ist es erforderlich, daß der Schleusenmeister im Interesse der Sicherheit und Leichtigkeit des Verkehrs einzelnen Schiffen gezielte Anweisungen oder auf deren Fragen erforderliche Auskünfte gibt. Das geschieht dann mit Hilfe des Schleusenabfertigungsfunks oder — falls das Fahrzeug scho an den Schleusen steht — durch die Lautsprecheranla Schleusenbereich und in den Schleusen.

Während der Schleusenliegezeit müssen sich die unter Angabe bestimmter Daten wie z. B. Länge, Tiefgang, Art der Ladung für die Kanalfahrt anm Diese Anmeldung läuft beim Schleusenmeister auf un nach einer Überprüfung über Fernschreiber an di kehrslenkungsstelle gegeben. Bestehen über die geeignetheit eines Schiffes Zweifel, so wird das Schiff den Schleusenmeister selbst oder einen Beamten de kungs- und Außendienstes überprüft. Ein enger tel scher Kontakt zwischen dem Schleusenmeister und de kehrslenkungsstelle ist dabei unerläßlich. Bestehen die Kanalpassage eines Schiffes keine Bedenken und die Anmeldung in der Verkehrslenkungsstelle vor, so nimmt diese die aus der Schleuse in den Kanal auslauf Fahrzeuge in die Verkehrslenkung.

2. Lenkungs-, Außen- und Weichendienst

Wie bereits oben unter Abschnitt III/2 gesagt, gibt e Verkehrslenkungsstellen, von denen aus der gesamte kehr auf der Strecke entsprechend den bereits gena Zuständigkeitsbereichen durch die Bediensteten des kungs- und Außendienstes — Inhaber des Patentes Kapitäns auf Großer Fahrt — wegen des ununterbr fließenden Verkehrs im Schichtdienst gelenkt wird.

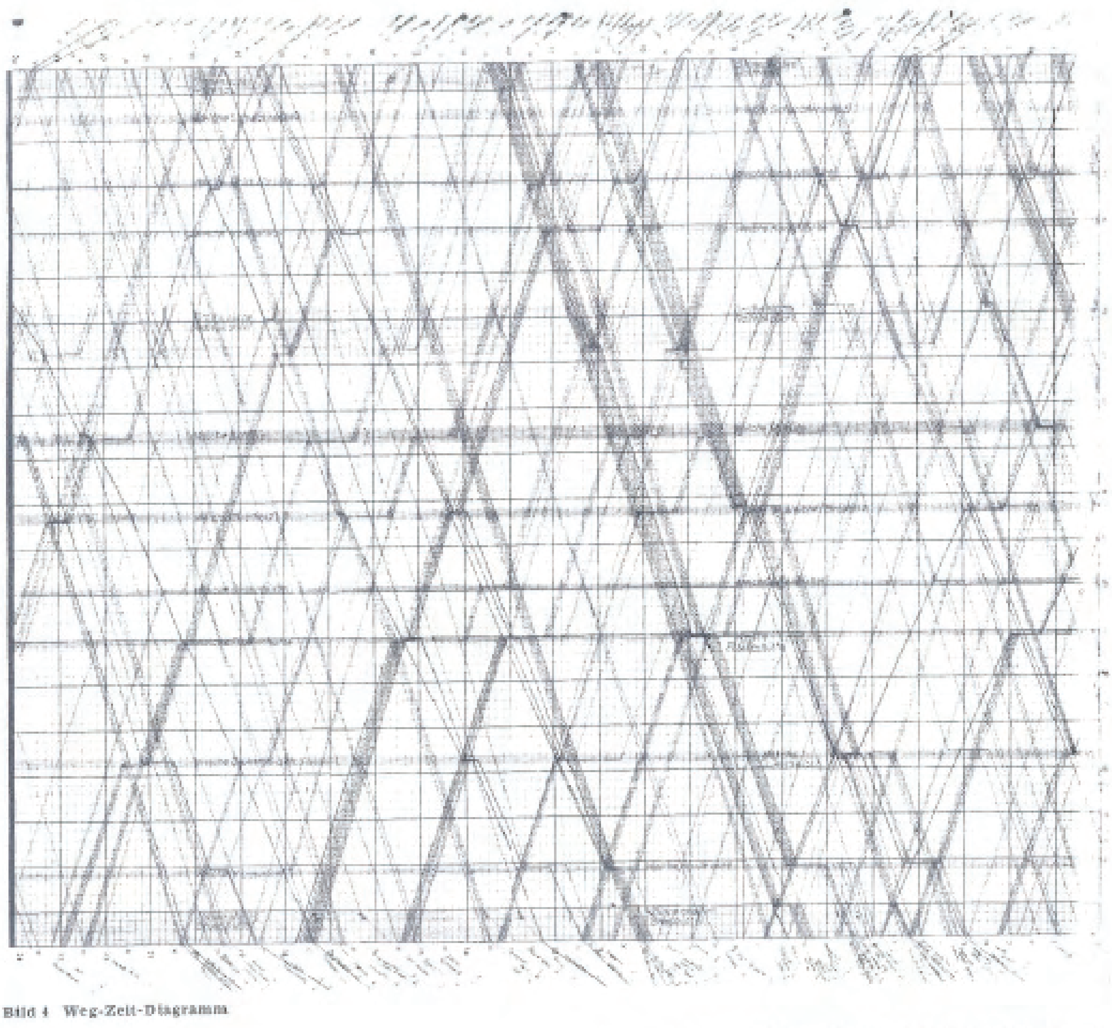


Bild 4 Weg-Zeit-Diagramm

Entsprechend der Zahl der den NOK benutzenden Fahrzeuge sind von den Verkehrslenkungsstellen bis zu 250 Fahrzeuge und mehr täglich durch den Kanal zu führen. Das bedeutet unter Zugrundelegung der Durchfahrtszeiten von ca. 6,5 bis 8 Stunden, daß jede Verkehrslenkungsstelle gleichzeitig den Verkehr von bis zu 40 Fahrzeugen und mehr nach dem unter Abschnitt III/1 dargestellten System unter Berücksichtigung der unter Abschnitt II beschriebenen Besonderheiten der Fahrzeuge, der jeweiligen Wetterlage und der außergewöhnlichen Verhältnisse auf der Strecke zu lenken hat.

Es liegt auf der Hand, daß diese Aufgabe von der Verkehrslenkung nur mit Hilfe eines Fahrplanes bewältigt werden kann. Dieser Fahrplan ist ein Weg-Zeit-Diagramm auf der Basis des Nord-Ostsee-Kanals, seiner Weichen und der Abstände der Weichen voneinander, wobei die Zeit auf der Ordinate und der Weg auf der Abszisse abgegriffen wird (Bild 4).

Sobald die Verkehrslenkung ein Fahrzeug vom Schleusenmeister übernommen hat, wird es unter Zuordnung der Zeit des Auslaufens und des Ortes in das Diagramm übernommen. Weil die im Nord-Ostsee-Kanal zulässigen Höchstgeschwindigkeiten (für Fahrzeuge, Schub- und Schleppverbände über 14 000 BRT Volldeckervermessung oder mit einem Tiefgang von mehr als 8,5 m 12 km/h = 6,5 kn; für alle anderen Fahrzeuge, Schub- und Schleppverbände 15 km/h = 8,1 kn) grundsätzlich von den Fahrzeugen ausgenutzt werden, kann der Verkehrslenkungsbeamte die Durchgangszeit des jeweiligen Fahrzeuges für die nächste Weiche vorausberechnen. Von dieser aus wird der Verkehrslenkung die tatsächliche Durchgangszeit gemeldet. Mit Hilfe dieser Meldung wird das Diagramm entsprechend der tatsächlichen Lage weitergezeichnet und die Durchgangszeit für die nächste Weiche auf der Basis der bisher vom Fahrzeug gelaufenen Geschwindigkeit vorausberechnet. Auf diese Weise wird das Schiff von Weiche zu Weiche bis zum anderen Ende des Kanals oder dem sonstigen Bestimmungsort weitergeführt.

Was hier für ein einzelnes Fahrzeug dargestellt wurde, muß der Verkehrslenker gleichzeitig für 40 Fahrzeuge und mehr (vgl. oben in diesem Abschnitt unter Nr. 2) bewerkstelligen. Weil diese vielen Fahrzeuge naturgemäß nicht alle in eine Richtung laufen, sondern nur zur Hälfte, kommt es zwangsläufig zu Begegnungen, die solange unproblematisch sind, wie die Summe der Verkehrsgruppenzahlen der sich begegnenden Fahrzeuge sechs nicht übersteigt (vgl. Abschnitt III/1). Übersteigt die Summe der Verkehrsgruppenzahlen der sich gegenüberstehenden Fahrzeuge sechs, so ist eine Begegnung nur noch in einer Weiche möglich.

Diese zwangsläufig nur in den Weichen zulässigen Begegnungen muß der Verkehrslenkungsbeamte vorausplanen, und zwar unter Berücksichtigung der Längen der in Betracht kommenden Weichen und der jeweils vorliegenden oben unter Abschnitt I aufgeführten Gegebenheiten. Das bedeutet, daß bei dem Erfordernis von nicht glatten Weichenbegegnungen — Begegnungen, bei denen Fahrzeuge warten müssen — diejenigen Fahrzeuge aufgestoppt werden, bei denen dies mit möglichst geringem Zeitverlust und dem geringsten Risiko unter Wahrung der Belange eines sicheren und leichten Verkehrs zu bewerkstelligen ist.

Bei Windstille und klarer Sicht ist dies relativ einfach. Bei Wind jedoch ist dessen Richtung und die ihm vom Schiff gebotene Angriffsfläche von erheblicher Bedeutung, und es ist daher häufig erforderlich, ein hoch in Ballast fahrendes Schiff mit seiner naturgemäß großen Angriffsfläche für den Wind zu Lasten abgeladener Schiffe fahren zu lassen. Dies kann jedoch dann zu risikoreich sein, wenn dem Ballaster mehrere Schiffe gegenüberstehen. In diesem Fall ist es vielfach sicherer, den Ballaster aufzustoppen, weil so nur bei einem einzigen Fahrzeug oder nur sehr wenigen Fahrzeugen durch das Aufstoppen bedingte auf einem engen Revier immer mit einer mehr oder weniger großen Gefahr verbundene Aufstoppmanöver gefahren werden müssen. Mag der Ballaster für sich auch schwieriger aufzustoppen sein als jedes der ihm gegenüberstehenden Fahrzeuge, so wird eine Vielzahl im einzelnen zwar weniger gefährlicher Aufstoppmanöver vermieden, die in ihrer Gesamtheit gegenüber dem einen Aufstoppmanöver des Ballasters jedoch gefährlicher sind. Auf diese Weise wird auch der durch die Anhäufung vieler Fahrzeuge in der Weiche hervorgerufenen Gefahr entgangen, die besonders in den kurzen Weichen sehr groß sein kann. Abgesehen von vorstehendem kann ein Aufstoppen eines Ballasters auch dann geboten sein, wenn dieser über besonders gute Manövriereigenschaften verfügt.

Fahrzeuge mit besonders gefährdenden Gütern erhalten nach Möglichkeit den Vorrang vor anderen Fahrzeugen, weil die von diesen Fahrzeugen mit besonders gefährdenden Gütern ausgehenden Auswirkungen bei einem Unfall — also der Realisierung der Gefahr — leicht den Charakter einer Katastrophe haben, was oben unter Abschnitt II bereits angedeutet wurde.

Bei schlechter Sicht wie z. B. Nebel bedeuten durch Kreuzungen bedingte Fahrzeugansammlungen in den Weichen eine besondere Gefahr, die über die ohnehin durch schlechte Sicht hervorgerufene Gefahr erheblich hinausgeht. Daß diese besondere Gefahr durch entsprechende Maßnahmen der Verkehrslenkung kompensiert werden muß, liegt auf der Hand. Fahrzeuge, die von den Häfen oder Liegeplätzen des Nord-Ostsee-Kanals aus ihre Fahrt antreten wollen, müssen sich bei der Verkehrslenkungsstelle melden und werden dann von dort so in den fließenden Verkehr eingereiht, daß dieser nicht gefährdet wird.

Außergewöhnliche Schwimmkörper, manövrierbehinderte Fahrzeuge und außergewöhnliche Schub- und Schleppverbände werden entsprechend ihren Eigenarten so durch den Kanal geführt, daß sie nicht gefährdet werden und selbst weder andere Fahrzeuge gefährden noch den Verkehrsfluß über Gebühr stören.

Bei Unfällen, wie z. B. Schiffsuntergängen, Aufsitzen von Fahrzeugen auf der Kanalböschung, Schiffsbränden oder

Böschungsrutschungen werden von den Bediensteten der Verkehrslenkung die ersten Maßnahmen zur Kompensation der dem fließenden Verkehr drohenden Gefahr ergriffen. Der Verkehr wird so gelenkt, daß keine Fahrzeuge dadurch gefährdet werden, daß sie in den Streckenabschnitt mit der Unfallstelle laufen. Erforderlichenfalls werden Fahrzeuge aufgestoppt. In diesem Zusammenhang sei erwähnt, daß auch die erste Benachrichtigung der für die Beseitigung der Gefahr zuständigen Stelle durch die Lenkungsbeamten erfolgt.

Wie bereits hervorgehoben, verfügt das Kanalamt Kiel-Holtenau über zwei Verkehrslenkungsstellen, eine in Brunsbüttel mit dem Zuständigkeitsbereich von den Schleusen in Brunsbüttel bis zum Überlappungsbereich der Strecke Breiholz-Schülp (Kanalkilometer 48—58) und eine in Holtenau mit dem Zuständigkeitsbereich vom Überlappungsbereich bis zu den Schleusen in Kiel-Holtenau. Der Überlappungsbereich ergibt sich daraus, daß der Verkehr auf dem Kanal von zwei Verkehrslenkungsstellen aus entsprechend dem naturgemäß unteilbaren Verkehr auf der gesamten Kanalstrecke nach einheitlichen Grundsätzen gelenkt werden muß. Diese nicht glückliche Konstellation der zwei Verkehrslenkungsstellen erfordert einen sehr intensiven Kontakt zwischen den beiden Verkehrslenkungsstellen mit einer ständigen wechselseitigen Anpassung der Verkehrslenkung an die Verkehrslage. Weil die Verkehrslenker der Weststrecke am besten wissen, wie der von Osten laufende Verkehr in die Weststrecke übernommen werden kann, wird von ihnen in der Weiche Schülp (km 58) das Setzen der Ostsignale (Weichensignale für die von Osten kommenden Schiffe) für Fahrzeuge der Verkehrsgruppe 4—6 veranlaßt. Umgekehrt veranlaßt der Verkehrslenker der Oststrecke in der Weiche Breiholz (km 48) das Setzen der Westsignale für Fahrzeuge der Verkehrsgruppen 4—6. Die Beschränkung dieser wechselseitigen Maßnahme erfolgt deshalb auf die Verkehrsgruppen 4—6, weil der Nord-Ostsee-Kanal für die Verkehrsgruppen 1—3 für sich gesehen voll zweischiffig ist. Durch dieses wechselseitige Setzen der Signale in Breiholz und Schülp wird dem Umstand der erforderlichen Übergabe der Schiffe im Überlappungsbereich von einer Lenkungsstelle auf die andere zwar Rechnung getragen, daß Erfordernis einer intensiven Abstimmung zwischen den Lenkungsstellen und die daraus resultierende zusätzliche Belastung der Verkehrslenker wird dadurch jedoch nicht beseitigt.

Das hauptsächliche Hilfsmittel für die Verkehrslenkung sind die Weichensignale, mit deren Hilfe die Schiffe erforderlichenfalls aufgestoppt werden können (Bild 5).

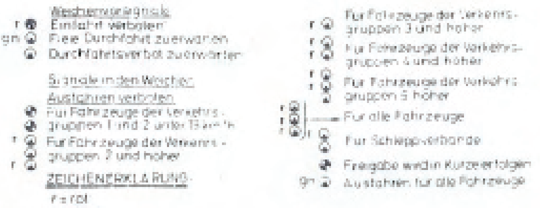


Bild 5 Weichensignale

Ferner können die Lenkungsbeamten fast alle Fahrzeuge mit Hilfe des Verkehrssicherungsfunks über UKW erreichen und ihnen erforderliche Anweisungen (Erlaß von Verfügungen) geben. Über UKW werden die im Kanal befindlichen Fahrzeuge von den Lenkungsstellen auch halbstündlich über die Verkehrslage unterrichtet und ihnen den Verkehr betreffende Fragen beantwortet.

Durch ein besonderes Telefonnetz ist die von den Weichen an die jeweilige Verkehrslenkung gerichtete Meldung der Passierzeiten der einzelnen Fahrzeuge gewährleistet. Mit Hilfe dieses Telefonnetzes kann der Verkehrslenkungsbeamte auch veranlassen, daß den eine Weiche passierenden Fahrzeugen über die Lautsprecheranlage in den Weichen Weisungen vom jeweiligen Weichenbediensteten übermittelt werden.

Man kann nicht von der Verkehrslenkung sprechen, ohne die Bediensteten des Weichendienstes zu nennen. Diese verrichten ihre Aufgaben — in erster Linie das Setzen der erforderlichen Signale auf Anweisung der Lenkungsbeamten — wie die Bediensteten der Verkehrslenkungsstellen im Schichtdienst in den Weichenstationen. Von dort aus melden die Weichenbediensteten die für die Lenkung durch wichtigen Passierzeiten der einzelnen Fahrzeuge an die jeweilige Verkehrslenkungsstelle für die Erstellung des Ist-fahrplanes als Grundlage für die Verkehrsablaufplanung. Darüber hinaus werden den Verkehrslenkungsstellen von den Weichenbediensteten Besonderheiten und die jeweilige Wetterlage gemeldet, da diese Daten — wie oben bereits gesagt — im Interesse eines sicheren und schnellen Verkehrsablaufs berücksichtigt werden müssen.

V. Im Lenkungsdienst tätige Bedienstete

Die Darstellung der Verkehrslenkung am Nord-Ostsee-Kanal wäre nur unvollkommen, wenn sie sich nur mit der Problematik, dem System und den Hilfsmitteln zu ihrer Lösung sowie mit dem Personal im Rahmen der Organisation auseinandersetzte und nicht auch mit der Verantwortung, die das mit der Lenkung befaßte Personal tragen muß, sowie dem Streß, dem das Personal ausgesetzt ist.

Wie schon gesagt, sind alle im Lenkungsdienst Tätigen Schichtgänger. Schichtwechsel ist jeweils um 13.00, 20.00 und 6.00 Uhr. Die Schichtreihenfolge der wegen der 42-Stunden-Woche erforderlichen vier Schichten ist ohne Berücksichtigung von Urlaub und Krankheit folgende:

Schicht 1 von 13.00 bis 20.00 Uhr
Schicht 2 von 20.00 bis 6.00 Uhr
Schicht 1 von 6.00 bis 13.00 Uhr
Schicht 3 von 13.00 bis 20.00 Uhr
Schicht 1 von 20.00 bis 6.00 Uhr
Schicht 3 von 6.00 bis 13.00 Uhr
Schicht 4 von 13.00 bis 20.00 Uhr
Schicht 3 von 20.00 bis 6.00 Uhr
Schicht 4 von 6.00 bis 13.00 Uhr
Schicht 2 von 13.00 bis 20.00 Uhr
Schicht 4 von 20.00 bis 6.00 Uhr
Schicht 2 von 6.00 bis 13.00 Uhr
usw.

Durch diese etwas kompliziert anmutende Schichtreihenfolge ist gewährleistet, daß der jeweils morgens um 6.00 Uhr von Wache Kommende erst am übernächsten Tag mittags wieder zum Dienst muß und so eine längere zusammenhängende Ruhezeit zur Erholung hat. Gleichwohl darf nicht verkannt werden, daß der Schichtdienst in jedem Falle — also auch in Anbetracht dieser Erleichterung — eine erhebliche physische Belastung darstellt, die am besten von denjenigen eingeschätzt werden kann, die einmal selbst Schichtdienst in irgendeiner Form kennengelernt haben.

Diese physische Belastung paart sich mit einer besonders starken psychischen. Diese hat ihren Ursprung nicht nur in der Art der Tätigkeit an sich, sondern insbesondere — und das kann nicht deutlich genug hervorgehoben werden — in der Tragweite der Entscheidungen. Es würde zu weit führen, hier ins einzelne zu gehen. Zur Verdeutlichung sei aber beispielsweise darauf hingewiesen, daß ein Schleusenmeister zwangsläufig die akute Gefahr einer Kollision heraufbeschwört, wenn er den erforderlichen Schleusenraum zu knapp disponiert oder gar versehentlich ein falsches Signal setzt. Ähnliches gilt für die Bediensteten der Verkehrslenkungsstellen. Haben diese zum Beispiel die Unmöglichkeit einer Begegnung nicht rechtzeitig bei der Verkehrsablaufplanung berücksichtigt, so wird diese Fehlentscheidung, die nicht rückgängig gemacht werden kann, in der Regel zu einer Kollision führen.

Zwischenfälle der vorgenannten Art bestehen zum Glück nur als Hypothese. Dies ist dem mit der Lenkung befaßten Personal zu danken, das seinen Dienst mit großer Gewissenhaftigkeit und Hingabe an den Nord-Ostsee-Kanal und seinen Verkehr versieht.