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

Investigation Report 149/08

Serious marine casualty

Forward tug WILHELMINE broaching to in front of MV PAVEL KORCHAGIN on 4 April 2008 in the Port of Hamburg

15 April 2009

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/Seesicherheits-Untersuchungs-Gesetz, SUG) of 16 June 2002.

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

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

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

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1 Summary of the marine casualty

On 4 April 2008 at 2026[1], the forward tug WILHELMINE broached to in front of the bow of the Russian MV PAVEL KORCHAGIN bound for upcoming the Südwesthafen port. The accident occurred in the Port of Hamburg, off Tollerort, as the tripping line of the hawser was being hauled up. Endeavours had yet been made to move clear by applying "Full Ahead" and counter steering. The tug was, however, listing to starboard and the deck had been flooded. Then the tug came clear, righted itself and ended up on the port side of the seagoing vessel. On the bridge, two people were knocked to the floor. At the stern of the vessel, one person fell outboard but was able to hold on to a tire fender.
The wind came from SW at a force of 2 Bft and visibility was 4 km.

[1] The times stated in the report refer to Central European Summer (daylight-saving) Time = UTC + 2 h

2 Scene of the accident

Type of event:	Serious marine casualty, broaching to
Date/time:	4 April 2008, at 2026
Location:	Tollerort, Port of Hamburg
Latitude/longitude:	φ 53°32.5'N λ 009°56.7'E

Section from the chart 48, BSH (Federal Maritime and Hydrographic Agency)

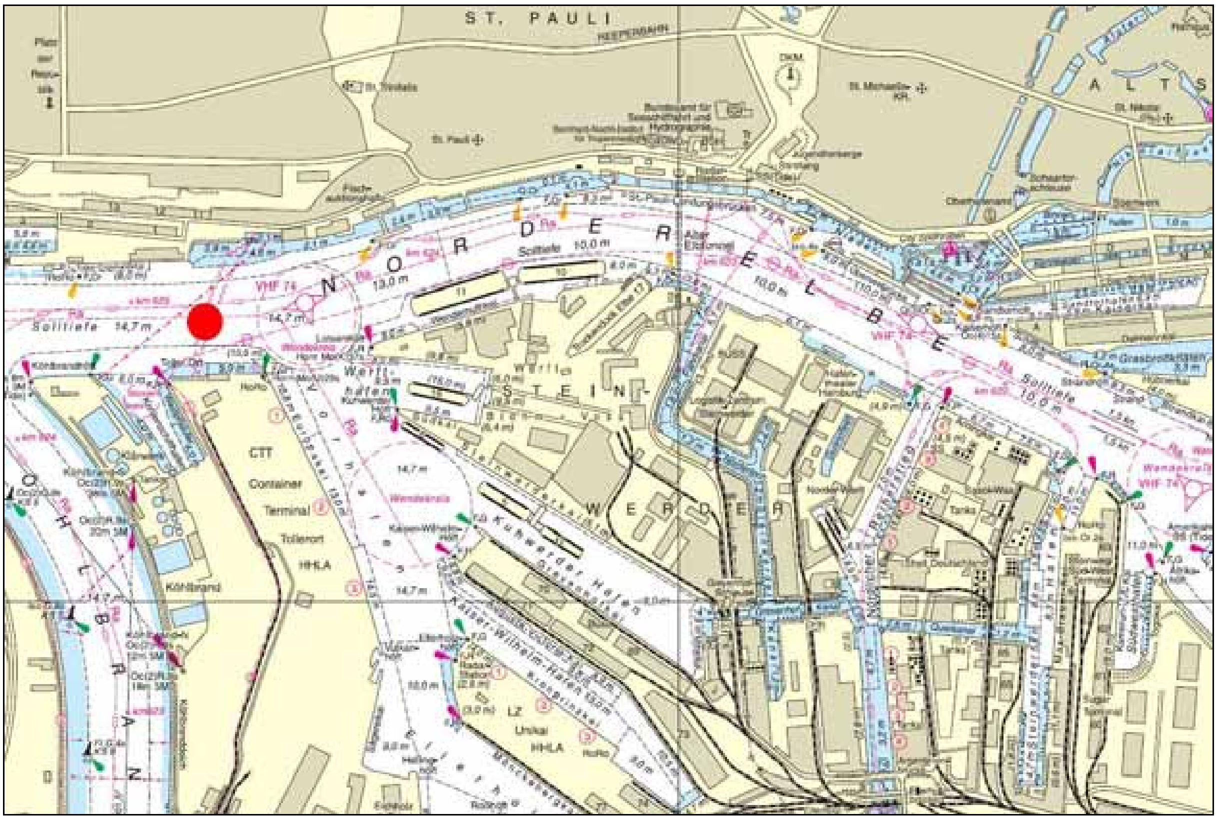

Figure1: Scene of the accident

3 Vessel particulars

3.1 Photo WILHELMINE

Figure 2: WILHELMINE

3.2 Particulars WILHELMINE

Name of the vessel:	WILHELMINE
Type of vessel:	Tug boat
Nationality/flag:	Germany
Port of registry:	Hamburg
IMO number:	8007133
Call sign:	DGKW
Vessel operator:	Petersen & Alpers
Year built:	1980
Shipyard/yard number:	Mützelfeldwerft GmbH Cuxhaven, 199
Classification society:	Germanischer Lloyd AG
Length overall:	26.39 m
Breadth overall:	8.80 m
Gross tonnage:	207
Draught at time of accident:	4.40 m
Engine rating:	2 x 640 kW
Main engine:	2 KHD Diesel, SBA 6M, 2 Schottel rudder propellers
Bollard pull	30.0 t
(Service) speed:	11.0 kn
Hull material:	Steel
Number of crew:	4

3.3 Photo PAVEL KORCHAGIN

Figure 3: PAVEL KORCHAGIN

3.4 Particulars PAVEL KORCHAGIN

Name of the vessel:	PAVEL KORCHAGIN
Type of vessel:	General cargo ship
Nationality/flag:	Russian Federation
Port of registry:	Arkhangelsk
IMO number:	7832775
Call sign:	UCPD
Vessel operator:	JSC Northern Shipping
Year built:	1980
Shipyard/yard number:	Vyborg Shipyard, 528
Classification society:	RMRS, Russian Maritime Register of Shipping
Length overall:	130.30 m
Breadth overall:	17.34 m
Gross tonnage:	5370
Draught at time of accident:	6.10 m
Engine rating:	4,490 kW
Main engine:	5DKRN 62/140-3
(Service) speed:	15.8 kn
Hull material:	Steel
Number of crew:	19

4 Course of the accident

On 4 April 2008, the WILHELMINE received the order, as a forward tug, to assist the PAVEL KORCHAGIN in the Port of Hamburg to its berth, shed 62 in Südwesthafen. The tug was awaited Tollerort/radar line. It was supposed to alongside the ship from the starboard side and tow it using the hawser come off.

At 2026, as the tripping line of the hawser was being hauled in, the WILHELMINE broached to in front of the PAVEL KORCHAGIN and was hit by her bow slightly aft of amidships on port side despite previous endeavours to come off by applying "Full Ahead" and counter steering. The tug was listing to starboard and the deck had been flooded. Then the tug came off, righted herself and ended up on the port side of the seagoing vessel. On the bridge, two people were knocked to the floor. At the stern of the vessel, one person fell outboard but was able to hold on to a tire fender.

According to the recordings and photos, the PAVEL KORCHAGIN is a conventional general cargo ship with a length of 130 m without a bulbous bow. The vessel's speed over ground directly prior to the collision at 2025:29 was, according to the radar recordings, 8.2 kn on a course of 079.9 degrees (see Fig. 4). The speed then fell suddenly to 4.6 kn (see Fig. 5). The draught of the vessel was 6.1 m. There are no detailed manoeuvre recordings available.

The wind came from SW at a force of 2 Bft. Visibility was 4 km with overcast skies and an ambient temperature of 8 °C. There was no rain.

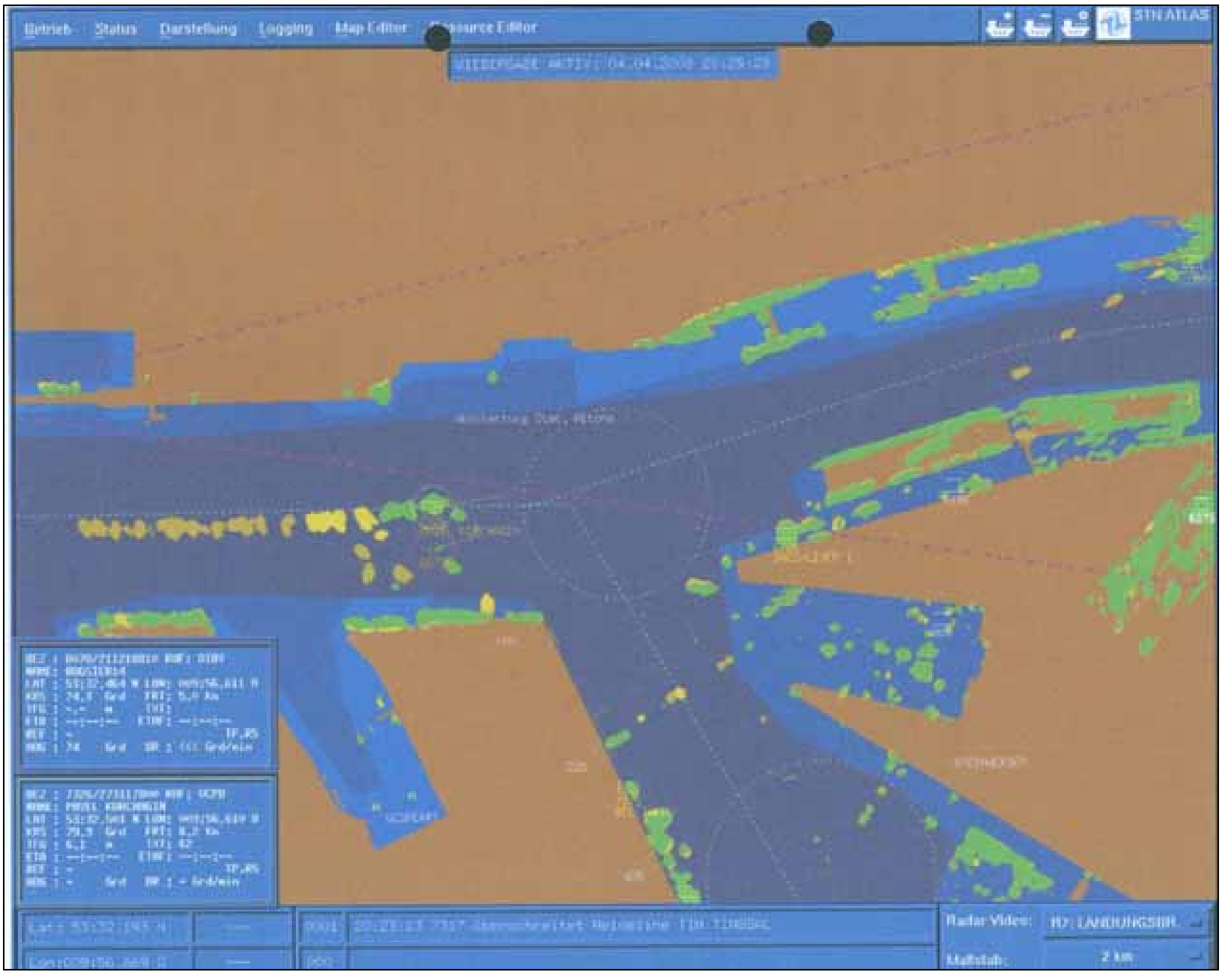

Figure 4: Vessel Traffic Service 2025:29

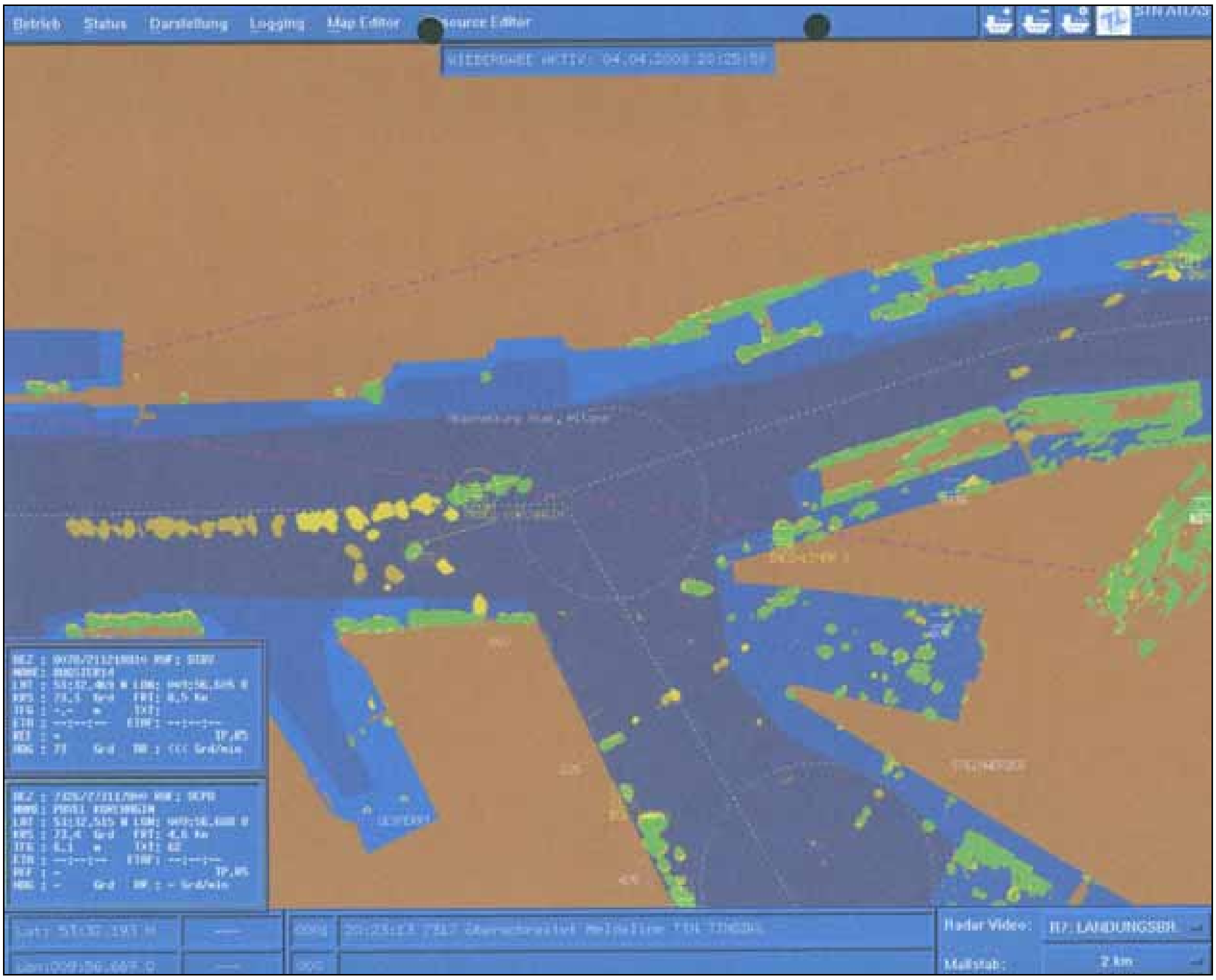

Figure 5: Vessel Traffic Service 2025:59

4.1 Statement of the tug's crew

On the bridge were the tug boat master, a helmsman, who was a trainee to become a vessel master and who was manoeuvring the tug, and a deckhand to operate the winches. The engineer was on the stern deck to establish the towing connection.

The trainee apparently sailed the tug at a speed through water of approx. 7 kn and approached, on the tug’s port side, parallel to the front of the ship at 700 rpm. The master observed the manoeuvre. The engineer caught hold of the hauling line at the bow of the seagoing ship in order to fasten the tripping line to it, by which the hawser line should be pulled on to the ship. That was the most difficult phase of the manoeuvre because it was essential to maintain the same distance from and speed as the ship.
For inexplicable reasons, the tug came extremely close to the ship and attempts were made with a "Full Ahead" manoeuvre and counter steering to maintain the distance. The tug moved ahead with its port side. The master took the helm when the tug was parallel with the ship, ahead by approx. two thirds of its length. Shortly after that, there was a loud noise and the bow of the ship collided with the port side of the tug slightly aft of amidships. The tug heeled considerably to starboard and the deck was covered with water. The listing may have been 50°. The impact caused two men of the bridge crew to be knocked to the floor.

Then the tug came clear and ended up on the port side of the seagoing vessel. The line connection to the ship had been released in the meantime by the crew on board. It was noted that, after the tug had righted itself, the engineer was no longer at the stern. The master remained at the helm and the trainee and the deckhand made their way to the stern. There, they found the engineer holding on to a fender outboard on the stern port side.

The master disengaged the engine and left the bridge to better assess the situation on deck. Using the lowered ladder, the engineer was able to climb back on to the deck with a little help. He was soaked through and went to take a shower. A short time later, the master continued the voyage and moored up in Neumühlen at the tug station. All systems were still working. However, water had found its way through the deck ventilators. Water had also made it into the engine room, alleyways and quarters, as well as the changing room.

The crew is unclear why the collision occurred: Either the sea-ship changed course to starboard or the tug moved into the ship's suction zone.
The engineer was taken by ambulance to Altona general hospital as a precaution.

4.2 Statement of the ship's crew

The port pilot embarked at 1958 and the voyage was continued at 7-8 kn. Communication with the requested tugs was carried out via VHF.

At 2022, the tug WILHELMINE approached the ship's bow on the starboard side at a distance of 5 m and caught the heaving line. At 2026, the heaving line was fastened to the tripping line. The PAVEL KORCHAGIN proceeded forward extremely slowly at 50 rpm. The rudder was midship. The tug then pulled ahead, came into contact with the stem and its port stern and moved from starboard to port side, swinging round for approx. 3-4 s in front of the stem. The engine was stopped immediately to avoid any major damage. At 2027, the WILHELMINE moved on to port side. Later, the tripping line was caught by the tug BUGSIER 14 and a towing connection was established.

There were no injuries on the PAVEL KORCHAGIN. Scratch marks were apparent on the port side of the ship's bow. The accident was apparently caused by the lack of due care and attention on the part of the tug boat master, who, in accordance with good seamanship, is required to keep a safe distance from the other vessel so that the tripping line can be taken up.

5 Investigation

The trainee, who was at the helm at the time of the accident under the supervision of the master, had been instructed for one month in order to later be able to sail independently as a tug master. With his previous employer, he had worked in the ferry service on the Elbe and in the Port of Hamburg for five years and was also familiar with twin-rudder propeller drives. This experience was very useful for manoeuvring with tug boats particularly during docking and undocking and manoeuvres. Up to the day of the accident, the trainee had undertaken 20 tug deployments under supervision. It was his second deployment of this nature on the forward tug of a vessel sailing upstream.

Following the accident, the tug was moored with starboard side to the outside jetty in Neumühlen. During the mooring manoeuvre, a lowered line was probably caught by the port Schottel drive during an astern manoeuvre. Several tire fenders lay on the starboard stern deck. The floor was wet in the superstructure. Hoses and pumps lay in the alleyways. There were no leakages in the engine room and underwater hull (see Fig. 6). The port bulwark on the main deck at the stern was dented (see Fig. 7). The bulkheads 2.5 m from the forward ballast water tank were dented and frames 18 and 21 were deformed. The tug had obtained permission from the GL surveyor to sail to Rendsburg for repairs. The engine systems were in full working order. A flange was loose on the heating valve station. The paint had come off the shell on the inside in some places. Water had penetrated through the port engine room ventilators.

Figure 6: Underwater hull

Figure 7: Main deck at the stern

5.1 Times sheets

The time sheets for the tug boat crew are in accordance with Directive 1999/95/EC of the European Parliament and the Council, as well as the Mariners' Law and the Regulation on Working Hours at Sea (See-Arbeitszeitnachweisverordnung). Accordingly, daily rest periods of 10 hours and maximum daily work times of 14 hours, as well as maximum weekly work times of 72 hours, must be observed. The core crew comprises the master, deckhand and engineer. Normally, the crew has eight days of work on the tug from Thursday to the following Thursday and then six days off. Work times are irregular around-the-clock, depending on orders received. An inspection of time sheets did not reveal any major irregularities or deviations from the permissible work and rest periods.

5.2 Current conditions and water levels

The current conditions are modelled by the Hamburg Port Authority's Department of Current Development and Hydrology. The results were verified against the real data of the measuring device at Teufelsbrück jetty. According to the results, the current at the scene of the accident was moving 0.5 m/s westwards with an outgoing tide, i.e. at the take-up of the hawser line, the PAVEL KORCHAGIN had a speed through water of 9.2 kn, if 8.2 kn is determined as the speed over ground (see Fig. 5 Vessel Traffic Service, and the Appendix).

5.3 Hydrodynamic interaction between a forward tug and ship

Interaction effects between the vessels occur[2] when they pass one another in an overtaking or encountering situation. The forces arising here and their effect on the prevailing steering dynamics of the vessels affected depend on many factors. Among others, the passing distance, the speed, the size and scale of the vessels affected and the width and depth of the fairway have a particularly large influence.

In the case of manoeuvring in restricted waterways and manoeuvring of seagoing vessels with tug assistance, such interaction effects between ship and tug may be particularly pronounced. This is due to the size difference of the vessels involved, the often extremely small gap between the vessels and - in particular in relation to the ship - the hydrodynamic limitation of the fairway. In contrast to usual overtaking and encountering situations on parallel courses, an assisting tug constantly changes its speed, direction and distances relative to the ship. In doing so the tug operates within the zone of influence of the potential field of the ship, which is particularly strong around the ship's bow. The resulting interaction effects cannot necessarily be foreseen by the tug's master when sailing but may be dangerous. The extent to which a specific position in relation to the ship may be dangerous for a tug depends in particular on its manoeuvrability[3]. Which factors in which constellation are especially critical for a tug that is manoeuvring in front of a moving vessel during its assistance would have to be investigated and measured in model trials and based on various scenarios.

The extent to which generally applicable qualitative statements and sailing recommendations relating to the problem of "hydrodynamic interaction between a forward tug and ship" can be derived would have to be evaluated as part of a research project with the involvement of experienced tug masters preferably in shipbuilding research institutes. The measurement results of the evaluated vessels could then be incorporated into navigation simulators. Due to the lack of a database and computer model ship handling simulators are currently not able to meet these requirements.

Technical literature only contains generalised statements about the interaction between a tug and ship. The bow-wave effect is often described. In order to avoid positions in the bow wave that pose a risk of capsizing, the book "Seemannschaft/Schiff und Manöver"[4] [Seamanship/Vessel and Manoeuvre] recommends maintaining a speed in the range of 3-5 kn; as of 6 kn, it is critical and a danger warning to the tug is necessary. Müller Krauss' "Schifffahrtsrecht und Manövrieren"[5] [Maritime Law and Manoeuvring] foresees a danger if a ship and a tug

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[2] Captain Olaf Kammertöns, Technical paper and tender with trials in a shallow water towing tank and navigation simulator, DST Entwicklungszentrum für Schiffstechnik und Transsportssysteme e.V. Duisburg (Development Centre for Ship Technology and Transport Systems)

[3] The BSU does not have any precise manoeuvre recordings for the time of the accident.

[4] Seemannschaft Bd. 3 [Seamanship Vol. 3]/Publ.: U. Scharnow, 3rd Edition 1987, Transpress-Verlag Berlin

[5] Handbuch für die Schiffsführung Bd. 2 [Ship's Command Manual Vol. 2]/Publ.: W. Helmers, F.v. Dieken, R. Amersdorffer, 9th Edition 1988, Springer-Verlag Berlin

are sailing almost the same speed, whereby even applying hard rudder manoeuvres cannot prevent the tug from turning towards the ship. In his article "Interaction at Sea"[6], E.C.B. Corlett describes situations that could arise on a forward tug which are illustrated in the following three diagrams:[7] In reality, it is important to note that the shallow water effect compared with deep water can increase the effective forces by up to four or fives times (as a rough estimate)[8]. The proportions of the vessel contours correspond more or less to the accident situation. In principle, the forward tug overtakes the ship (see Fig. 8). The other way, so-called "easing off" from ahead positions, would result in the same effect. The direction of force and moment suddenly switches. The pressure conditions are indicated with +/-.

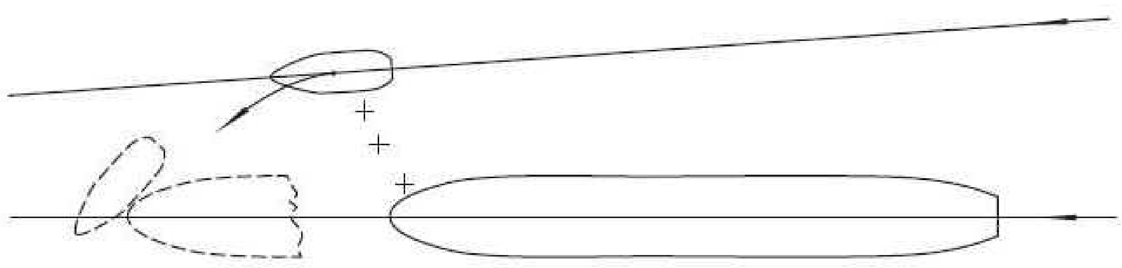

Figure 8: Overtaking situation

Fig. 9 indicates the angle of the current lines in relation to the tug and its skeg. The tug has to countersteer possibly 15° in order to remain parallel. On an ideal course, the WILHELMINE would have available the specified bollard pull of 30 t with an optimum position of the Schottel propeller for steering. The steering force of a rudder propeller tilted by the angle δ against the direction of travel gives the following

$$F_M = T \times \sin(\delta) + F_Q \cos(\delta) + F_{Strut}(\delta)$$

Here, T indicates the actual propeller thrust as a function of the revolutions and flow rate, and F_Q signifies the propeller transverse force that arises in the case of propeller cross-flow and that is against the direction of flow. F_{Strut} indicates the transverse force of the strut arm and can be compared with the rudder force of a common rudder. This means that the steering force of the rudder propeller can be calculated, but the force components must be determined and correctly superimposed, because in certain manoeuvring situations, some forces may have a countering effect and the steering force decreases considerably.[9]

[6] Journal of Navigation Vol. 32, No. 2 1979
[7] Diagrams revised and adapted to the accident situation BSH, Department of Graphic Technology
[8] In shallow water, the current can, for the most part, only flow around the side of the vessel and the displaced water cannot easily escape beneath the vessel.
[9] Refer to "Handbuch Schiffsbetriebstechnik" [Ship Operating Technology Manual] 1st Edition 2006, Seehafen Verlag

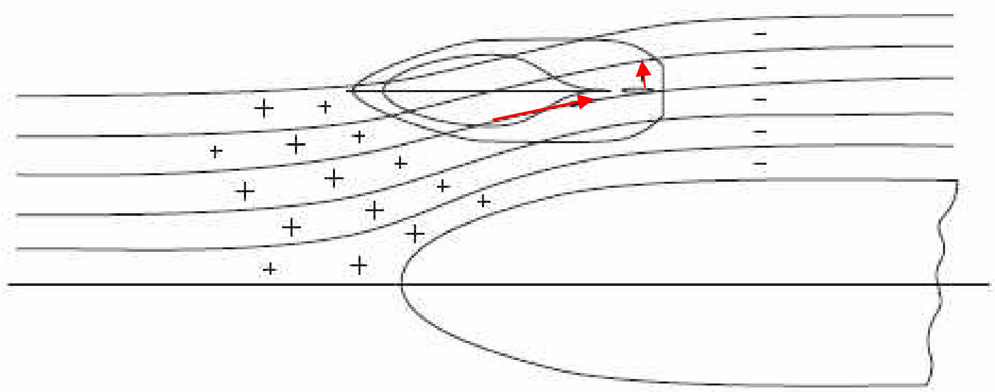

Figure 9: Bow wave

For the take-up of the tripping line on the starboard side of the PAVEL KORCHAGIN, the tug WILHELMINE had to sail close to the front of the ship and the bow. Shortly before broaching to, at 2025:29, the speed over ground was 8.2 kn. Travelling against a current of 1 kt, both vessels had a speed through water of 9.2 kn. This speed is decisive for the calculation of the hydrodynamic longitudinal and transverse forces, as well as the yaw moments. At a maximum speed of 11.0 kn, the WILHELMINE had only little force reserves left to maintain distance (see Fig. 10a-10c). During this manoeuvre, the stern of the tug can swing unexpectedly to starboard when abeam of the ship's bow water line (see Fig. 10d) if this is not counteracted by sufficient rudder moments. The result was that, following a "Full Ahead" manoeuvre, the WILHELMINE broached to across the bow of the PAVEL KORCHAGIN. If there was any doubt, such a manoeuvre should have been aborted, especially as the speed was relatively high at the time of line take-up and the local physical effect cannot be calculated. The effective forces and moments can only be decreased by reduced speed.

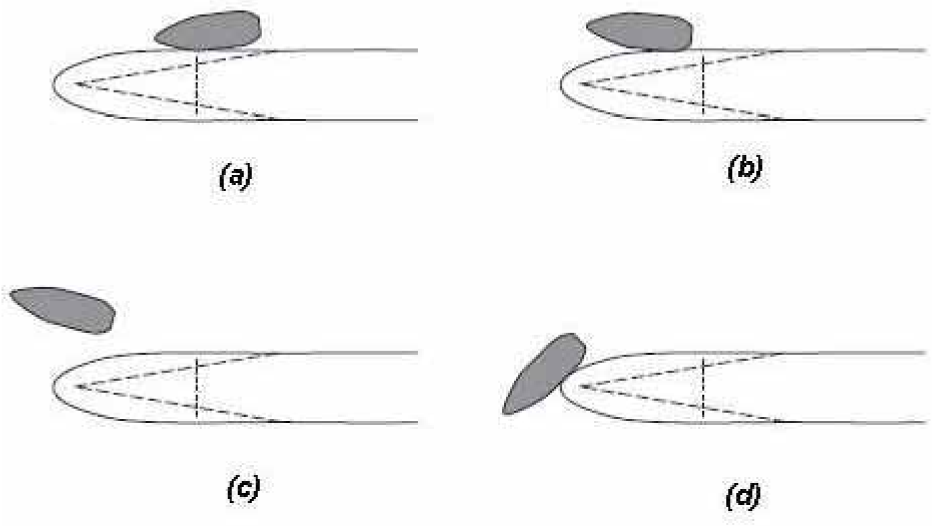

Figure 10: Course of the accident

5.4 Voyage on WILHELMINE

On 26 November 2008 at 1100, the WILHELMINE put cast off Neumühlen with three crew members and an incoming tide and sailed towards the bulk carrier EEC ATLANTIC. The deployment was coordinated via the ARGE Hamburg port tug. The order was written on a piece of paper and handed over to the tug master. The WILHELMINE was supposed to assist as a forward tug from Blankenese to the mooring place, Amsterdam Quay in the Dradenau port.

The master navigated by sight, crossed the fairway off Blankenese and turned in, approaching the front of the ship on her starboard side, coming from astern. When attempting to catch the ship's heaving line, the tug was inevitably forced to operate in the bow-wave zone. On the first attempt, the heaving line fell into the water (see Fig. 11). At a speed over ground of 8 kn, it was possible in the end to catch the heaving line in front of the bow and secure the tripping line. Once the tripping line had been made fast through the central hawse on the ship's forecastle, the hawser could be fastened. For this, the winch was operated by the engineer on the after edge of the bridge. While pulling the line in tightly, the deckhand determined that the shackle on the forerunner was loose. The hawser had to be slackened so that the bolt pin could be tightened with a shackle key. Then approx. 40 m of line were fed out. The procedure took approx. 5 min.

Figure 11: Take-up of heaving line

There were no problems during the voyage into Dradenau port. The tug master had to keep a constant eye on the hawser and position of the ship in the opposite direction to the direction of travel. He navigated solely by sight. The first pilot command to pull was given just before the curve to the mooring place on Amsterdam Quay (e.g. "4 points to port"). When the ship was parallel to the quay, the WILHELMINE pulled forward several times to reduce the distance to the pier. A ship's heaving line was then thrown ashore so that the people handling the mooring lines were able to catch the 1st head line. The position of the ship was corrected several times with pulling-in and letting-out manoeuvres so that the bow ended up in position in berth no. 10. The 2nd head line was then paid out and became entangled on the bollard. It was pulled ashore using a truck and a winch. Only once the 2nd head line had been cleared and tightened and the forespring was secured, the tug was dismissed by the pilot. The hawser on the ship was slowly lowered and finally heaved in using the tug winch, releasing the tow connection. The WILHELMINE then returned to its mooring place at Neumühlen, arriving there at 1315.

Communication and cooperation between a pilot and a tug master is regulated in a code of practice[10]. During this deployment, the pilot commands required were given. The most dangerous moment is the take-up of the hawser. Here, the tug inevitably moves into the other vessel's bow wave. As the speed through water is decisive for the hydrodynamic interaction between the tug and the other vessel, the tug master must intervene with the pilot if he believes the speed to be too high.

The tug master navigates largely by sight. In foggy conditions, work is problematic. The bridge equipment comprises an echo sounder, two radar screens, one posted ahead, one astern, connected to one antenna, a GPS receiver and a GPS transmitting heading device for stabilised radar operation, as well as a VHF radio system that has to be operated with a separate microphone and a foot switch. The speed through water cannot be measured and has to be calculated using the tide table and speed over ground or estimated by fixed-points. At the conning position the heading can be read off from the magnetic compass and the radar screens. If looking astern only the sensor data on the 2nd radar is available without having to turn around. The radar system shows, among other things, the sensor data from the GPS receiver and GPS heading device. The course has to be constantly corrected with the two hand wheels to control the Schottel drives. No autopilot system is installed and tandem operation is not possible. During tug assistance, the entire crew is on the bridge and all doors are locked.

Training for tug masters in Hamburg port is carried out in accordance with the vessel operator's stipulations and the local ship assistance ordinance (SeeSchAV). A certificate of competence to navigate a seagoing vessel is a prerequisite if the tug is registered as a seagoing vessel. The prospective tug master initially sails as a trainee alongside an experienced tug master on deployments on the bridge, deck

[10] Code of practice for port pilots and masters of the assistance tugs in Hamburg. Published by the Hamburg port pilots and representatives of the tug operators in August 1957 and last revised on 4 August 2005. The code of practice contains information and recommendations relating to operations between the ship and tug. It is intended to draw attention to dangerous situations but should not be seen as a binding regulation because operations on the tugs always differ.

and engine room and is familiarised with his duty. As soon as he feels confident and has experienced various situations, and after at least 3 month of experience and exam passed before an examination board of the competent authority, he is permitted to take sole responsibility for operating the tug. The SeeSchAV only valid in Hamburg, the biggest German seaport, takes into account the variety of special provisions of law, the maritime waterways and their designation as well as the water levels and passage heights of the bridges to be passed and the flood barrages. By demonstrating 3 month experience in practice the safety standard should be additionally enhanced. On the date of the accident, the helmsman was employed as a trainee on the bridge and has since been promoted to master. He has been employed with the vessel operator since March 2008 and operated the tug on this voyage.

According to the vessel operator inspector, there are no suitable simulators on which tug master can realistically be trained. Each tug order is unique. The diversity of seagoing vessels, natural conditions and interaction between the tug and the other vessel is extremely high. The factors of the various types of tugs are also different. The so called tractor tugs (WILHELMINE) are equipped with rudder propellers or Voith-Schneider drives. The hull design of the tug and seize of the skeg as well as the time the main engines need to respond to changes in power are different. Contrary to the tractor tugs predominantly in service in Hamburg frequently ASD (Azimuth Stern Drive) tugs and rotor tugs (tractor tugs with a third rudder propeller instead of the skeg) are in service. This tugs also have other manoeuvring characteristics . Irrespective of the numerous variations speed and proximity to the seagoing vessel have an impact. It applies as well to tugs with 30, 50 or 80 t bollard pull, this means stronger tugs are also subjected to hydrodynamic influences. The vessel operator does not expect results from science projects leading to useful application for tug masters in daily practice. Commands are given by the pilot while the execution is the responsibility of the tug master. Here, it is the cognitive abilities of the crews that are most important.

6 Analysis

During the course of the investigation and on the voyage with the tug WILHELMINE, the BSU determined that tug masters complain about the high speeds during the take-up of hawsers and their tugs thereby regularly running into critical situations[11]. At the time of this marine casualty, the speed through water was 9.2 kn[12]. This speed appears to be extremely high, as forces and moments in shallow water may increase by four to five times compared with deep water. The recommendations of the code of practice for port pilots and masters of the assistance tugs recommend on the one hand the lowest possible speed when establishing a line connection, and on the other hand, during the tug assistance, in this case after establishing the line connection, a maximum speed through water of 8 kn[13] but without differentiating further. It was not possible to clarify whether a manoeuvring error was made in this specific case, whether the speed was too high or whether the tug's bollard pull of 30 t, realised as steering force, was not sufficient to maintain an adequate distance from the front of the ship PAVEL KORCHAGIN during the take-up of the tripping line. No manoeuvre recordings were available to the BSU.

To clarify the cause of the accident, extensive hydrodynamic research is necessary preferably in tow tank institutes for shallow water environment. For this, the ships have to be modelled and realistic scenarios have to be developed with experienced tug masters. With draughts and water depths predetermined and the fairway modelled (Port of Hamburg), "towing" can be carried out in several trial runs at various speeds and with differing, relative tracks and distances in the test tank and the coefficients of the situation-related steering dynamics can be determined. The measurement data can then be programmed into a ship handling. The calculation of the interaction effects would then be carried out via the principle of interpolation. Critical situations could thus be simulated and thresholds in interactive operation between the tug and the other vessel could be defined.

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[11] No Complaints about excessive speeds on establishing towing connections have been submitted to Hamburg Port Authority.

[12] The precision of the caculated speeds is doubted by the port pilot association Hamburg, because the notices given about speeds have significantly increased. According to the newest performance requirements for logs in conjunction with the performance requirements of GPS-receivers 2% of the ships speed or 0,2 kn should not be exceeded. Previously 5%, 0,5 kn tolerance respectively, were permitted and the indicated GPS speed was not subject of the type approval test.

[13] Upon request of the Hamburg port pilots in the revision of the leaflet from 25 July 02 the speed through the water was increased from 6 to 8 kn in order to satisfy the minimum speeds of large container ships on „Dead Slow Ahead“ and the stronger new builded tugs after establishing the towing connection. An adequate speed should be kept in order to provide sufficient power reserves for the tug.

The combination of model trials and voyages carried out by tug masters in the simulator suggests that manoeuvres can be quantitatively and qualitatively assessed with regard to their "hydrodynamic interaction" danger potential. It may then be possible to derive from this recommendations for towing manoeuvres. These would apply initially to the modelled tug and the modelled ship in the constellations and scenarios tested. The extent to which recommendations for other combinations can be derived from this can only be described at the end of the above research. Before starting the practical training at the seagoing vessels scenarios could be trained at the ship handling simulator which assist in improving the training of tug masters and minimizing the risks of accidents.[14]
The Port of London Authority has recommended in their procedure instructions, sections 5.1 und 6.2 of the „Code of Practice for Ship Towage Operations on the Thames“ to reduce the speed to such a degree that a safe rendezvous manoeuvre and safe establishing of the towing connection can be ensured. The speed through the water amounts to approx. 4 kn[15] and should be agreed on in advance between seagoing vessel and tug. This speed allows for power reserves for the assisting tugs, if they have to suspend the manoeuvre.

An individual investigation by the BSU, as is the case for this incident, is, in this context, of little significance. It would be far better to arrange a widely applicable

[14] In the opinion of Hamburg Port Authority this statements are - contrary to the current practice - aimed at defining a minimum speed in establishing a towing connection. Such requirements are able to affect the safe manoeuvring ability of the ship assistance tugs significantly. For this reason they can endanger persons, environment and safety and ease of maritime shipping in Hamburg port and are therefore not leading to the defined goal. The factors to be taken into consideration in every individual case depend on type of vessel, dimensons, draft, trim, drive, affected port area, underwater morphology, tide and wind conditions and drive, construction and the strength of the tug. Compared with the current situation, that the towing connection should only be effected with mininum possible speed, an attempt to devolop generally admitted statements, would not enhance safety. On the contrary it is to be worried that designation of a speed averaged from tests would lead to the towing connection being established with an even higher determined rate of speed.
Corresponding tests according to the current technicals possibilities of simulation technics are in the limit range. Current simulators generally assume a parametric illustration of reality. This means that no complete numerical calculation of all forces are carried out. Instead the influence of defined parameters on dominant forces are covered and averaged in advance. Therefore it is possible to simplify in the real simulation and quickly enough access the parameters required for the simulation in real time.
As regards the usual simulation application cases such an approach does work sufficiently precise. This allows for the manoeuvre to be described realistic in order to train crew members or check if waters are navigable. The current simulator technic is only able to represent the following situation to a limited degree: interactions between ships navigating independent in distinct close quarter situations like a seagoing vessel and the ship assistant tug establishing the towing connection in a fairway completely constraint by its draft with sometimes little underkeel clearance in an air stream very whirled or focussed by construction and berth utilisation. In foreseeable time the use of simulators will be limited to parametrized standard situations. In the opinion of Hamburg Port Authority combining modell tests and voyages conducted by tug masters at the simulator cannot assess danger potentials of hydrodynamic interactions on establishing a towing connection quantative and qualitativ resilient and generally admitted.

[15] According to the statement made by Port of London Authority the speed is based on joint experiences of the pilots and tug masters gained over several years and special circumstances on the river Thames as well as different worldwide guidelines.

research project to evaluate the hydrodynamic interaction between the forward tug and the other vessel. Thereby the BSU is aware of the extent and expenditure as well as of the fact, that it will scarcely be possible to project such a plan alone. It might be possible to devise recommendations and improve simulation technologies for other areas on the basis of such scientific fundamentals. During the investigation the BSU was advised of MARTEC (Maritime Technologies):

In the maritime area European Ministries and research management institutions have affiliated in the network (ERANET) MARTEC. The Ministry of Economics and technology is the German project executing organisation and has commissioned the research centre Jülich with the coordination.

The project support in MARTEC is aimed at combining the advantages of a European partnership with the utilisation of national support modalities. The second call of this network is open for the period 01.04. – 29.05.2009. Project descriptions (MARTEC_Full_Proposal_Form_2009.doc) can be submitted during this period through www.martec.era.net/opencall. The consortiums should at least comprise two industrial partners based in different European countries. Less than 10 partners should be involved in the joint research project. 8 key topics, which are orientated at the national program “Shipping and Ocean engineering for the 21st century” are supported. This also includes the topics Ship and Port Operations”, which amongst others contain VTS and manoeuvring.

Further information is available on the MARTEC Pilot Call Page http://www.martec.era.net/opencall/.

7 Safety recommendation

The following safety recommendation does not constitute any presumption of guilt or liability.

7.1 Safety Partnership

The Federal Bureau of Maritime Casualty Investigation recommends the Hamburg port pilots and representatives of tug operators, as author of the procedural requirement “Leaflet for port pilots and masters of assistance tugs in Hamburg”, to jointly revise the Leaflet with Hamburg Port Authority and improve risk management. Furthermore the Federal Bureau recommends to evaluate speeds applied during tug assistance within the scope of a research project for the examination of hydrodynamic interactions between seagoing vessel and forward tug by appropriate science institutions. The Federal Bureau also recommends to devise adequate scenarios for training of tug masters at the ship handling simulator, in particular on establishing towing connections.

7.2 Tug Masters and Port Pilots

The Federal Bureau of Maritime Casualty Investigation recommends the masters of assistance tugs for seagoing vessels and port pilots to establish towing connections only on minimum possible speed and intensify communication as regards when, where and on which speed towing connections should be established.

Sources

- Findings of the Hamburg Waterway Police (WSPK2)

- Deployment of tug WILHELMINE accompanied by the BSU

- Written statements
  - Vessels' commands
  - Vessel operators
  - Classification society Germanischer Lloyd

- Witness accounts
  - Tug boat master
  - Trainee
  - Tug deckhand
  - Ship master
  - 3rd officer, forecastle

- Reports/expert opinions
  - Hamburg Port Authority Department of Current Development and Hydrology Michael Berendt
  - DST Entwicklungszentrum für Schiffstechnik und Transsportssysteme e.V. Duisburg, Captain Olaf Kammertöns
  - Seemannschaft Bd. 3 [Seamanship Vol. 3]/Publ.: U. Scharnow, 3rd Edition 1987, Transpress-Verlag Berlin
  - Handbuch für die Schiffsführung Bd. 2 [Ship's Command Manual Vol. 2]/Publ.: W. Helmers, F.v. Dieken, R. Amersdorffer, 9th Edition 1988, Springer-Verlag Berlin
  - "Handbuch Schiffsbetriebstechnik" [Ship Operating Technology Manual] 1st Edition 2006, Seehafen Verlag
  - E.C.B. Corlett, Journal of Navigation Vol. 32, No.2 1979
  - Code of Practice for Ship Towage Operations on the Thames 2005, Port of London Authority
  - Report on the investigation of the loss of the tug Flying Phantom while towing Red Jasmine on the River Clyde on 19 December 2007 resulting in 3 fatalities and 1 injury, Marine Accident Investigation Branch (MAIB Nr. 17/2008)
  - MARTEC (Maritime Technologies) – Call on submitting procect proposals, project executing organization science centre Jülich, Dr. Ralf Fiedler

- Nautical charts and vessel data of the Federal Maritime and Hydrographic Agency/Bundesamt für Seeschifffahrt und Hydrographie (BSH)

- Radar recordings
  - Nautische Zentrale Hamburg [Hamburg Vessel Traffic Centre]

- Photos
  - Vessel operator Petersen & Alpers, Hamburg
  - Vessel photos Hasenpusch, Schenefeld

8 Appendix

Flow rate of the Elbe on 04.04.08 20:25, level with Tollerort

To determine the flow rate on 04.04.08 at 20:25 level with Tollerort, the currents from the current atlas of the Bundesanstalt für Wasserbau [Federal Waterways Engineering and Research Institute] dated 2000 and the current measurement of the flow rates at Teufelsbrück were consulted. Initially, the model was compared with the natural measurements to obtain an estimate of current comparability. The following values on 04.04.08 were evaluated as hydrological framework conditions for the variant selection of the model calculation: the head water outflow 1172 m^3/s, with high tide at 2.06 m ODN (ordnance-datum) and low tide at -1.63 m ODN. The mean ratios for the head water are 700 m^3/s, the mean high tide is 2.26 m MSL and the mean low tide is -1.44 m ODN. Deviations between the hydrological framework conditions on 04.04.08 and the mean tide ratios indicate that there was higher head water (+500 m^3/s) and a tide reduced by approx. 0.2 m. These framework values were used as a basis for selecting the model variant with the mean head water and a mean tide.

Figure 1 shows the localised connection between Tollerort and Teufelsbrück and the flow rate from the model calculation for the area under consideration. The mapped current shows that, for the relevant tidal time (approx. two hours to low tide), the currents are fundamentally similar at the two locations.

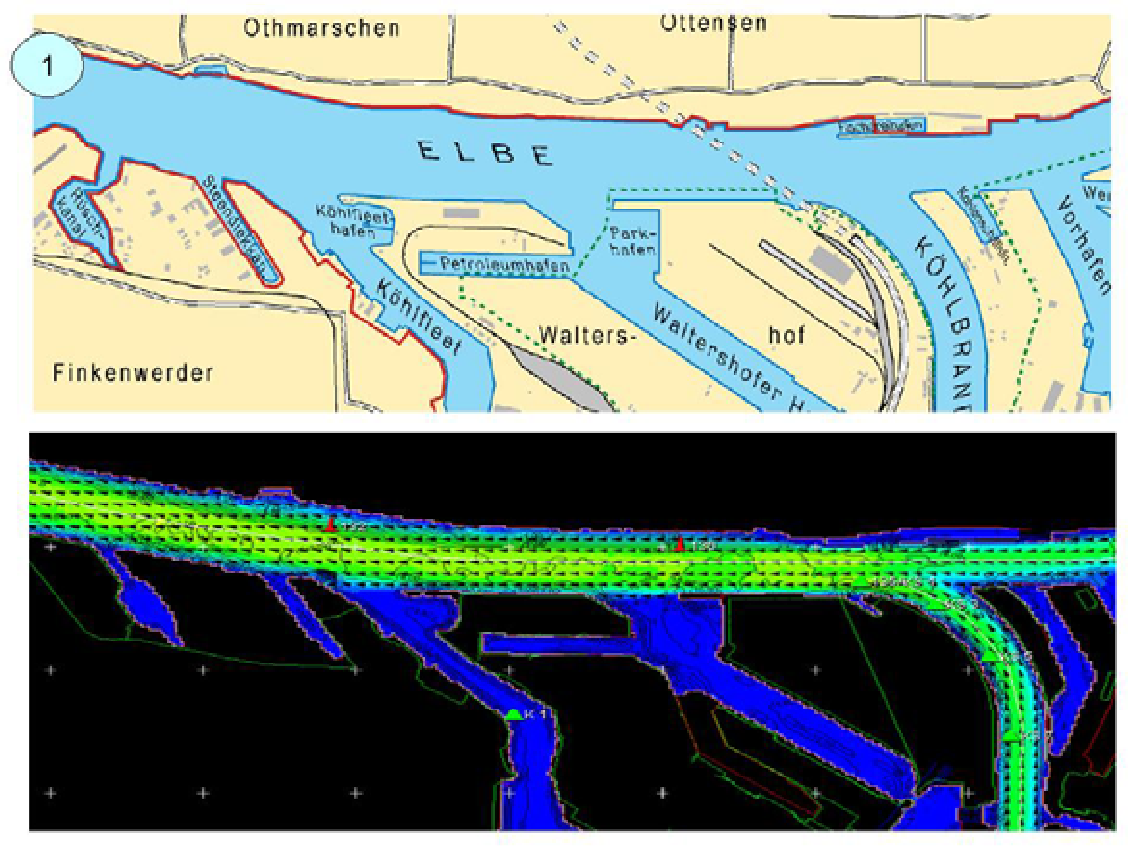
Figure 2 gives the water level and the flow rate of the current measurement system at Teufelsbrück for 04.04.08, and the time 20:25 is also specifically pinpointed. The prevailing flow rate was 0.76 m/s in a westerly direction (ebb current). Low tide occurred at 22:25, two hours after the time under consideration.

Figure 3 shows the transfer of tide times on 04.04.08 to the model based on the water level. Two hours before low tide corresponds to a model time of 07:25.

Figure 4 gives the flow rate and the water level for the measuring point Teufelsbrück for the time two hours before low tide. As a comparison of the measured currents and the model result shows, the ratios tally, meaning that the model results can be applied as a good approximation of the flow rate.

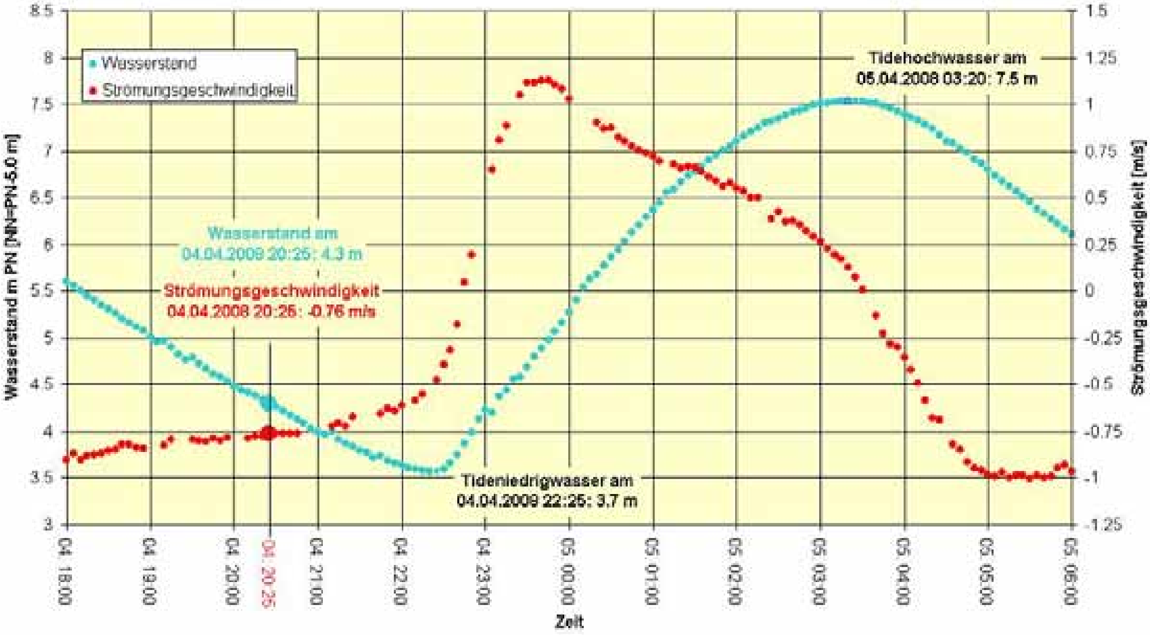
Figure 5 shows the current from the current atlas at Tollerort at the time two hours before low tide, which is 0.49 m/s at the time under consideration, flowing in a westerly direction. This is a flow rate calculated across a cross-section of the water. **Figure 6** shows this rate again in the relevant expanse, revealing that, from the centre of the water to the edge, the rate decreases.

HPA, current at Tollerort on 04.04.08



2

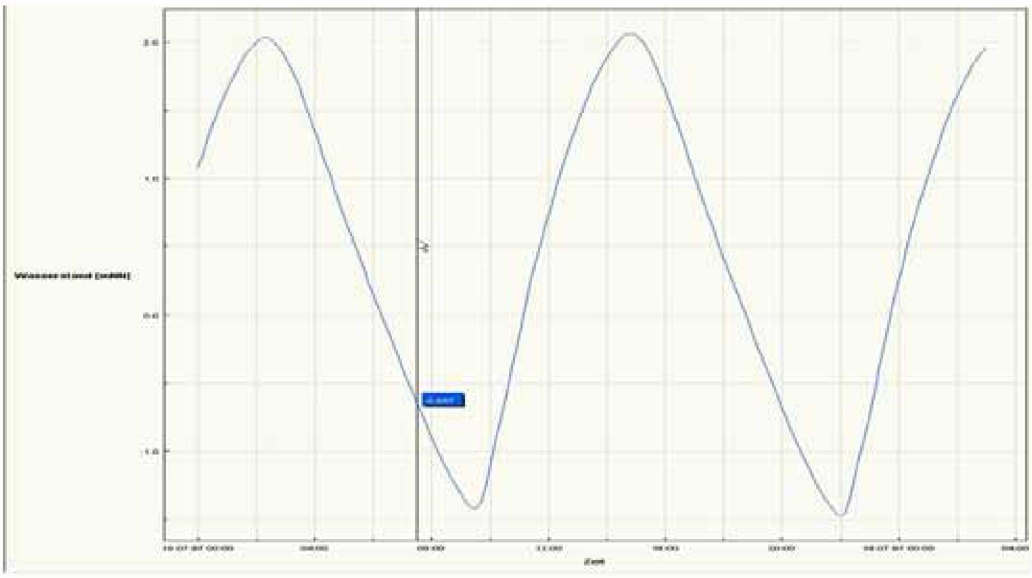
Flow rate at the Teufelsbrück measuring station from 04.04.08 to 05.04.08



HPA, current at Tollerort on 04.04.08

3

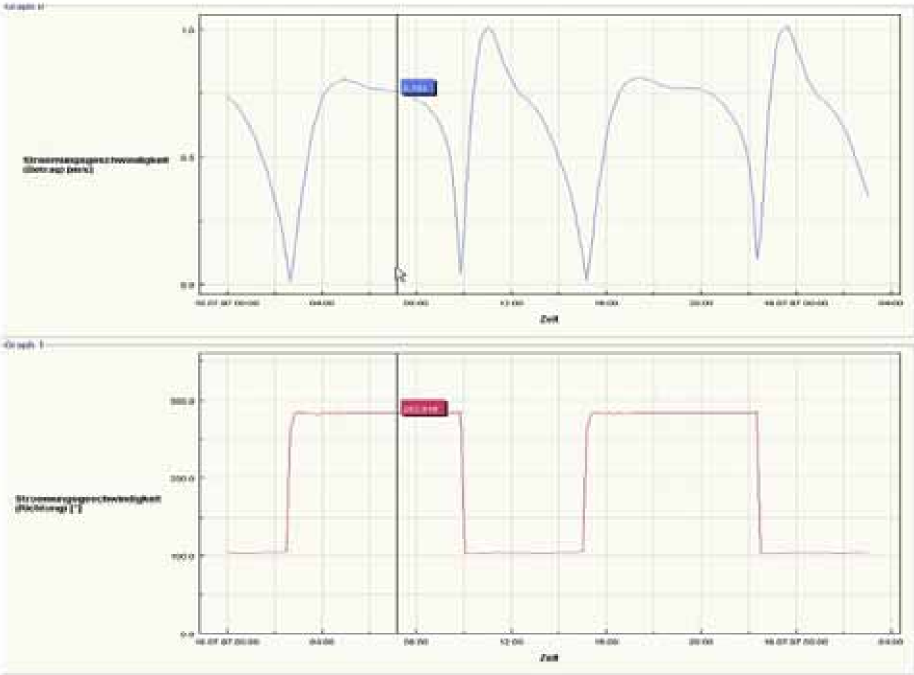
Water level at Teufelsbrück, two hours before low tide



HPA, current at Tollerort on 04.04.08

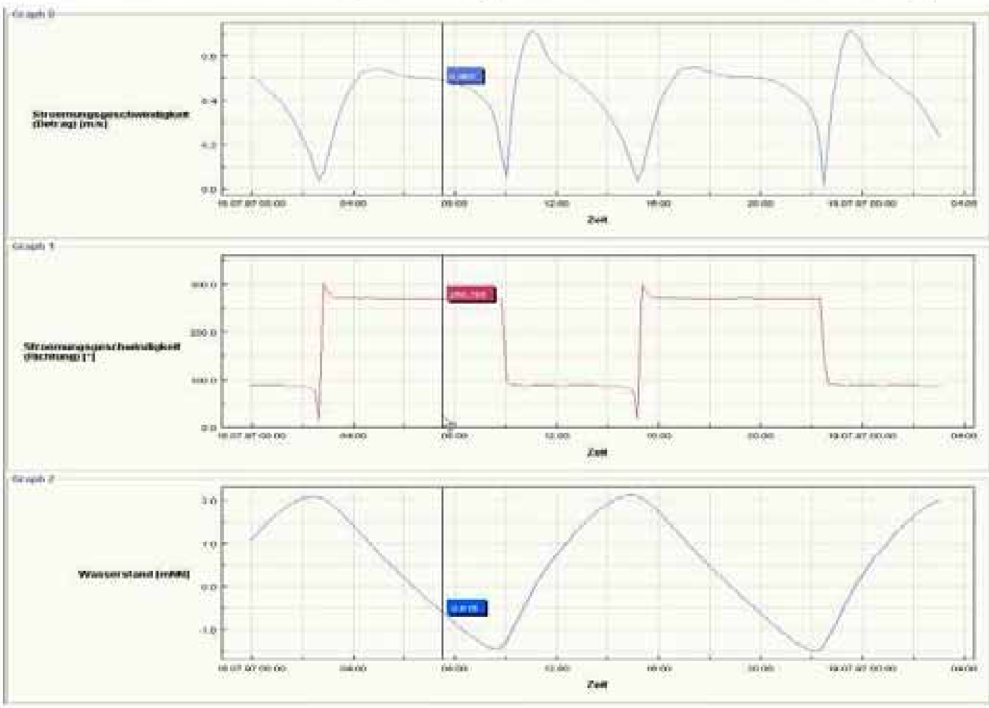
4

Model result: flow rate and direction of flow at Teufelsbrück two hours before low tide



5

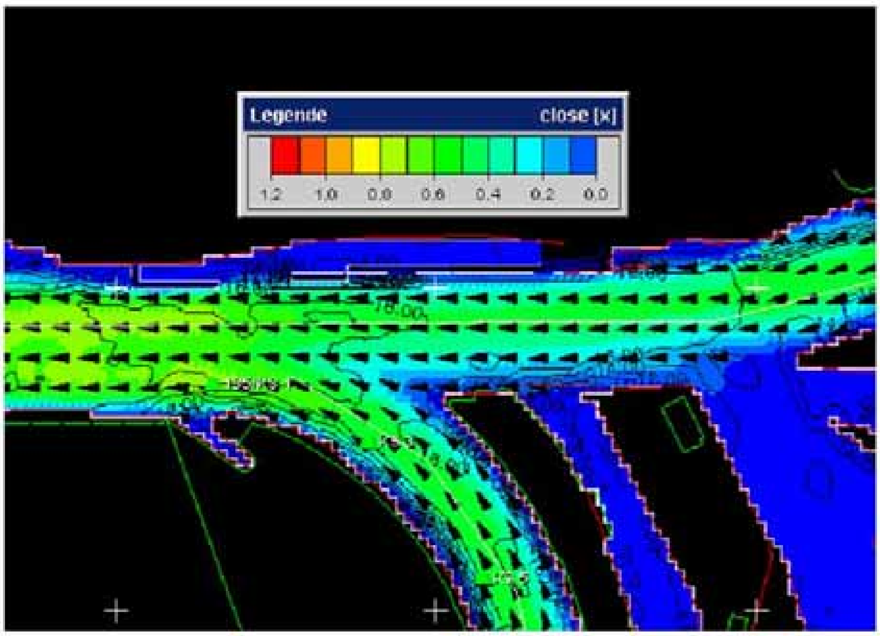
Model result: flow rate and direction of flow at Tollerort two hours before low tide (averaged across a cross-sectional area)



HPA, current at Tollerort on 04.04.08

6

Model result: flow rate end direction of flow at Tollernort two hours before low tide (averaged across depth)



HPA, current at Tollerort on 04.04.08