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

Marine Accident Investigation Branch

Investigation Report 117/11

Very Serious Marine Casualty

Collision between the TYUMEN-2 and OOCL FINLAND on 14 April 2011 in the Kiel Canal

27 June 2014

The following is a **joint report by** the German Federal Bureau of Maritime Casualty Investigation as lead investigating authority and the United Kingdom's Marine Accident Investigation Branch. The two bodies have conducted this investigation jointly and in accordance with the IMO's Casualty Investigation Code (Resolution MSC.255(84)). The working language used for this joint investigation was English. The German text shall prevail in the interpretation of this report.

Moreover, the investigation was conducted in conformity with the law to improve safety of shipping by investigating marine casualties and other incidents (Maritime Safety Investigation Act – SUG) of June 2002 in the version applicable until 30 November 2001. According to the 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 Article 19 para. 4 SUG in the aforementioned version.

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

Director: Volker Schellhammer
Phone: +49 40 31908300 Fax: +49 40 31908340
posteingang-bsu@bsh.de www.bsu-bund.de

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List of Abbreviations

AIS	Automatic Identification System
BAW	Bundesanstalt für Wasserbau / Federal Waterways Engineering and Research Institute
BBE	Brandbekämpfungseinheit / Fire Fighting Unit
BrSchG-SH	Brandschutzgesetz Schleswig-Holstein / Law on fire protection
BSH	Bundesamt für Seeschifffahrt und Hydrographie / Federal Maritime and Hydrographic Agency
BSHL	Bundesverband der See- und Hafenlotsen / Federal Association of Maritime and Harbour Pilots
CEST	Central European Summer Time
CF-card	CompactFlash-memory card
COG	Course over Ground
COLREG	Conventions on the International Regulations for Preventing Collisions at Sea
DAT	Digital Audio Tape
DWD	Deutscher Wetterdienst./ Germany's National Meteorological Service
ECDIS	Electronic Chart Display and Information System
ENC	Electronic Navigational Chart
FRM	Final Recording Medium
HavkomAbkG	Havariekommando-Abkommen Gesetz / Law on establishing a central command for maritime emergencies
HDG	Heading
HK	Havariekommando / Central Command for Maritime Emergencies
IMO	International Maritime Organisation
IRLS	Integrierte Regionalleitstelle / Joint Regional Control Centre
ckm	Canal kilometre
KRLS	Kooperative Regionalleitstelle / Integrated Regional Control Centre Middle
LKN-SH	Landesbetrieb Küstenschutz, Nationalpark und Meeresschutz Schleswig-Holstein
MAIB	Marine Accident Investigation Branch
MERAC	Maritime Emergencies Reporting and Assessment Centre,
MSC	Maritime Safety Committee
NMEA	National Marine Electronics Association
NOK	Nord-Ostsee-Kanal / Kiel Canal
OSC	On Scene Coordinator

PNG	Portable Network Graphics
PPU	Portable Pilot Unit
RDG-SH	Rettungsdienstgesetz Schleswig-Holstein / Law on rescue services
ROT	Rate of Turn
SeeSchStrO	Seeschifffahrtsstraßenordnung / German Traffic Regulations for Navigable Maritime Waterways
SeeLG	Seelotsgesetz / Law on maritime pilots
SOLAS	International Convention for the Safety of Life at Sea
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
S-VDR	Simplified Voyage Data Recorder
TEL	Technische Einsatzleitung der Feuerwehr / Technical operational command
TG	Traffic group
VDR	Voyage Data Recorder
VO-KVR	Verordnung zu den Kollisionsverhütungsregeln / Ordinance on COLREGs
VRM	Variable Range Marker
VTS	Vessel Traffic Services
WSA	Wasser- und Schifffahrtsamt / Waterway and Shipping Office
WSD	Wasser- und Schifffahrtsdirektion / Waterway and Shipping Directorate
WSP	Wasserschutzpolizei / waterway police
ZSUK	Zentrale Schiffsuntersuchungskommission / Inspection body for inland waterway vessels

1 SUMMARY

The TYUMEN-2, which flies the flag of the Russian Federation, was proceeding westwards on the Kiel Canal (NOK) in a convoy on 14 April 2011. Sailing towards her from the opposite direction was the OOCL FINLAND, also in a convoy. This ship flies the flag of the United Kingdom. At the time of the encounter, visibility in the canal section between the viaduct at Grünental and the siding at Fischerhütte stood at about 100 metres. Each ship was being advised by a pilot and had a canal helmsman on board.

While approaching the TYUMEN-2, the OOCL FINLAND moved too close to the embankment on her starboard side. Due to the resulting bank effect, the ship started to push away. It was not possible to contain this effect with a hard-over rudder and increase in speed. The OOCL FINLAND turned out of control towards the TYUMEN-2 and collided with her in the area of the superstructures at 0700[1]. This caused the wheelhouse of the TYUMEN-2 to be torn off completely and subsequently sink in the canal. The collision resulted in the death of the pilot and the canal helmsman. Two members of the crew of the TYUMEN-2 were seriously injured and another slightly injured. After the collision, the TYUMEN-2 grounded on the embankment.

The OOCL FINLAND survived the collision virtually unscathed. To begin with, nobody on the OOCL FINLAND was aware of the serious consequences on the TYUMEN-2 because of the fog. The ship continued her voyage and later made fast in Rendsburg for the investigation on board.

After the collision, this section of the canal was initially closed.

Owing to the visibility, the secluded position of the accident and the poor communication conditions, the scale of the accident remained unknown for a prolonged period. The unknown extend of damage gave rise to a large-scale operation involving rescue workers and firefighters. Moreover, action was taken to prevent oil pollution. The German Central Command for Maritime Emergencies (CCME) assumed overall control of the operation.

After the rescue operation was finished, two tugs towed the TYUMEN-2 to the siding at Fischerhütte.

Traffic was permitted to proceed under certain conditions at 1223 on 14 April 2011 after the position of the wheelhouse in the canal had been found and marked. The wheelhouse of TYUMEN-2 was later salved.

[1] Unless stated otherwise, all times shown in this report are local = UTC + 2.

2 FACTUAL INFORMATION

2.1 TYUMEN-2

2.1.1 Ship Photo

Figure 1: Photo of the TYUMEN-2

2.1.2 Ship Particulars

Name of vessel:	TYUMEN-2
Type of vessel:	Cargo ship
Nationality/Flag:	Russian Federation
Port of registry:	Novorossiysk
IMO number:	8727848
Call sign:	UGSQ
Owner:	TGI-Leasing Ltd.
Operator:	Rescom Tyumen Ltd.
Year built:	1989
Shipyard:	Slovenske Lodenice
Classification society:	Russian Maritime Register of Shipping
Length overall:	116.05 m
Breadth overall:	13.40 m
Gross tonnage:	3,086
Deadweight:	3332 t[2]
Draught (max.):	4.18 m
Engine rating:	2 x 515 kW on two fixed pitch propellers
Main engine:	2 x Skoda 6-27.5 A2L
(Service) Speed:	8.0 kts
Hull material:	Steel
Rudder:	Three balanced rudder blades
Minimum safe manning:	11

[2] Acc. to Russian Maritime Register of Shipping

2.1.3 Voyage particulars

Port of departure:	Riga, Latvia
Port of call:	Hull, United Kingdom
Type of voyage:	Merchant shipping / International
Cargo information:	Lumber
Manning:	13
Draught at time of accident:	D_f= 3.90 m, D_a= 4.00 m
Pilot on board:	Yes
Canal helmsman:	Yes
Number of passengers:	None

2.2 OOCL FINLAND

2.2.1 Ship Photo

Figure 2: Photo of the OOCL FINLAND

2.2.2 Ship Particulars

Name of vessel:	OOCL FINLAND
Type of vessel:	Container ship
Nationality/Flag:	United Kingdom
Port of registry:	London
IMO number:	9354351
Call sign:	MMYD4
Owner:	Anina Shipping Ltd.
Operator:	Döhle IOM Ltd.
Charterer:	Orient Overseas Container LInie
Year built:	2006
Shipyard/Yard number:	J.J. Sietas KG Schiffswerft/1234
Classification society:	Germanischer Lloyd
Class:	100 A5 E3 Container Ship, Open-Top
Length overall:	149.14 m
Breadth overall:	22.50 m
Gross tonnage:	11,662
Deadweight:	13,720 t
Draught (max.):	11.30 m
Engine rating:	8,400 kW on a controllable pitch propeller
Main engine:	MaK 9M43
(Service) Speed:	18.5 kts
Hull material:	Steel
Hull design:	Double bottom, bulbous bow, ice class, bow and stern thrusters
Minimum safe manning:	12

2.2.3 Voyage particulars

Port of departure:	Hamburg, Germany
Port of call:	Gdynia, Poland
Type of voyage:	Merchant shipping / International
Cargo information:	Containers
Manning:	19
Draught at time of accident:	D_f= 7.70 m, D_a= 7.80 m
Pilot on board:	Yes
Canal helmsman:	Yes
Number of passengers:	None

2.3 Marine casualty or incident information

Type of marine casualty:	Very serious marine casualty, collision and grounding
Date, time:	14 April 2011, 0700
Location:	Kiel Canal (NOK), km 32.2
Latitude/Longitude:	φ 54°8.5'N, λ 009°20.65'E
Ship operation and voyage segment:	Pilotage waters
Place on board:	Superstructures of the TYUMEN-2, forecastle of the OOCL FINLAND
Consequences:	Two people killed and three injured, loss of the wheelhouse and other serious damage to the TYUMEN-2. Hydraulic oil escaped from the TYUMEN-2. Slight damage to the forecastle and cargo of the OOCL FINLAND.

2.3.1 Nautical chart

Excerpt from Nautical Chart ENC DE 421045 of the BSH

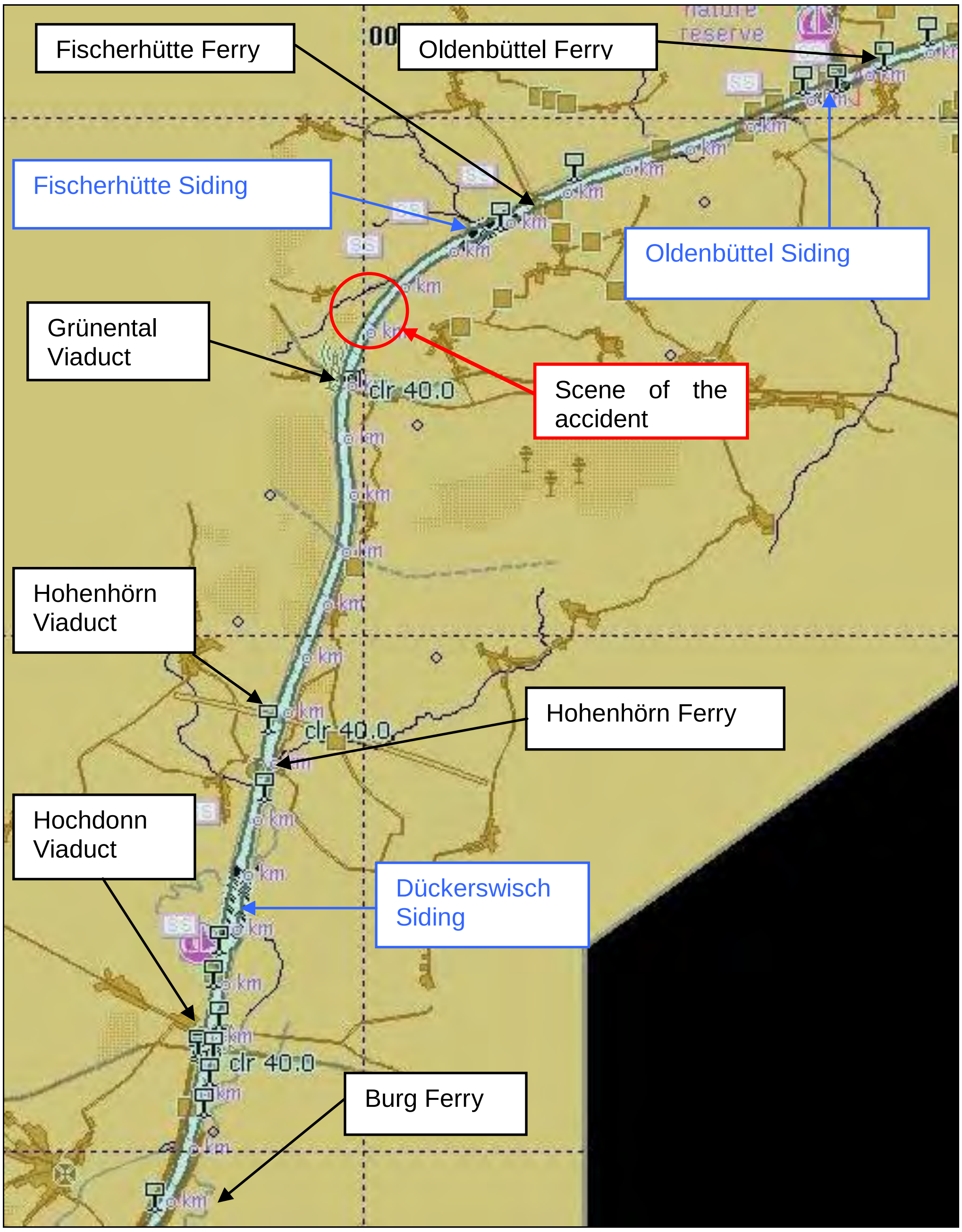

Figure 3: Nautical chart showing the scene of the accident

2.3.2 Shore authority involvement and emergency response

Agencies involved:	Waterways and Shipping Office (WSA) Brunsbüttel and its Vessel Traffic Service (VTS), rescue workers, firefighters, German Central Command for Maritime Emergencies (CCME), police and waterway police (WSP), Federal Agency for Technical Relief (THW)
Resources used:	Canal ferries, rescue vehicles, firefighters and boats from the fire brigade, two rescue helicopters, water pollution control ship NEUWERK, workboats and the sounding ship of WSA Brunsbüttel, two tugs, police boat SCHWANSEN
Action taken:	Investigate scene, transportation of operational units to TYUMEN-2, medical first aid and transportation of casualties, evacuation of deceased, preparation of oil booms, TYUMEN-2 towed to safe berth, scene of accident sounded and marked, crew of TYUMEN-2 supported by psychosocial emergency care unit, organisation of recovery of wheelhouse of TYUMEN-2
Results achieved:	Medical care for the casualties, TYUMEN-2 secured, full navigability of the NOK restored

3 COURSE OF THE ACCIDENT AND INVESTIGATION

3.1 Course of the accident

3.1.1 TYUMEN-2

The TYUMEN-2, which flies the flag of the Russian Federation, loaded 3,216 m³ of cut lumber in Riga. Her port of destination was Hull and she was scheduled to transit the Kiel Canal while en route there. To that end, the TYUMEN-2 left the lock at Kiel-Holtenau at 2351 on 13 April 2011 and sailed into the NOK. The ship was classified to Traffic Group 3 for the passage. The ship's command was assisted by a pilot and a canal helmsman. The BALTIC NEWS caught up with the TYUMEN-2 during the canal passage. While waiting in the siding at Schülp, they were joined by the NORDIC DIANA and CLIPPER SUND, which entered the canal later. The ships then left the siding in the following order: BALTIC NEWS, NORDIC DIANA, TYUMEN-2 and CLIPPER SUND.
The pilot and the canal helmsman on the TYUMEN-2 were replaced at 0530 at the pilot station in Rüsterbergen. After arriving on the bridge, the new pilot was briefed by the master. Upon taking up his advisory role, the pilot specified the required courses to the canal helmsman. The master, chief engineer and a cadet were on the bridge in addition to the pilot and helmsman in the period that ensued. Visibility in the area of Breiholz, which was ahead of the ship, was reported to be 300 m in the situation report of the Vessel Traffic Service at 0545.
Since the BALTIC NEWS had to wait for oncoming ships in the siding at Fischerhütte because of her size, the NORDIC DIANA, TYUMEN-2 and CLIPPER SUND passed there. The TYUMEN-2 left the siding at Fischerhütte at 0653. Prior to that, the situation report at 0645 stated visibility was 200 m to 300 m and less in places. After leaving the siding at Fischerhütte, the NORDIC DIANA[3] proceeded ahead at a distance of about 0.75 nm. The CLIPPER SUND[4] followed at a distance of about 0.9 nm.
At 0657, the TYUMEN-2 passed the oncoming TRANSANUND. The next ship to approach was the OOCL FINLAND. The collision with the OOCL FINLAND happened at 070014.

3.1.2 OOCL FINLAND

The OOCL FINLAND, flying the flag of the United Kingdom, had loaded containers in Hamburg and was en route to Gdynia. The pilot and two helmsmen boarded at the lock in Brunsbüttel for the NOK. The master briefed the pilot on the controls and the ship sailed out of the lock at 0454. The master left the bridge at 0500, after which the bridge was manned by the second nautical officer, pilot, and helmsman. The ship was classified to Traffic Group 5 because of her size.
The TRANSANUND (Traffic Group 5) was proceeding ahead of the OOCL FINLAND at a distance of about 0.75 nm. The ESHIPS BAINUNAH (Traffic Group 3) followed

[3] Gross tonnage: 2774, Length: 92 m, Breadth: 14 m, Draught: 5.8 m.
[4] Gross tonnage: 2613, Length: 89 m, Breadth: 13 m, Draught: 4.9 m.

the OOCL FINLAND at a distance of about 0.5 nm. The change of the nautical officers took place at 0600 and the third officer took command of the navigational watch. At about 0645, the BRANDGANS, a service ship belonging to WSA Brunsbüttel, was overtaken.
At 0648, by which time the sun had already risen, the pilot asked the VTS to the reactivate the canal lighting because of a deterioration in visibility. At 0655, the OOCL FINLAND passed the viaduct at Grünental. Up to this point the small convoy had passed through the NOK without any delays.
A course alteration to 30° was initiated on the OOCL FINLAND at 065809. This subsequently brought the ship closer to the right embankment in her direction of travel, the so-called southern side. This led to the stern being sucked in and to the so-called 'push away' effect in the period that followed. Despite a hard-over starboard rudder combined with an increase in speed, the OOCL FINLAND turned to port towards the oncoming TYUMEN-2 and collided with her at canal kilometre[5] (ckm) 32.2. The wheelhouse of the TYUMEN-2 was torn off completely during the collision. The course of the OOCL FINLAND was subsequently stabilised and to begin with the ship continued her voyage.

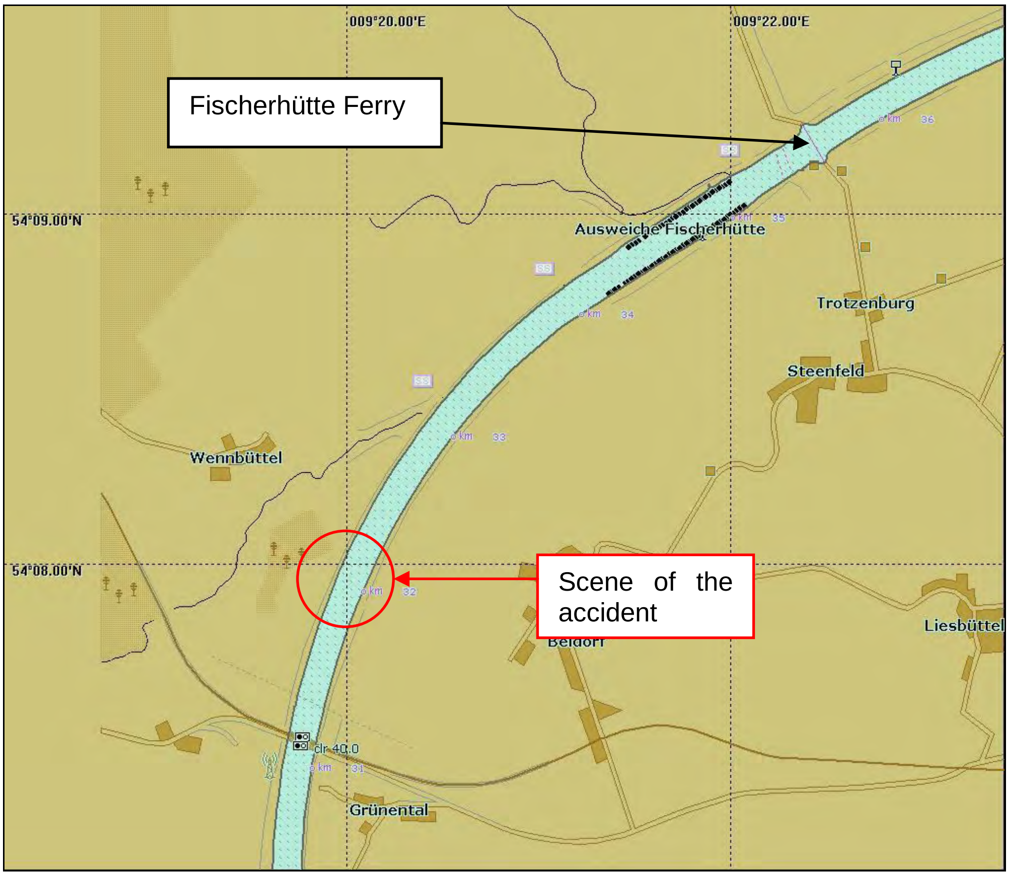

Figure 4: Scene of the accident

[5] The kilometre posts begin in Brunsbüttel.

3.1.3 Consequences of the accident

3.1.3.1 TYUMEN-2

Separated from the rest of the superstructures because of the collision, the wheelhouse of the TYUMEN-2 plunged into the canal. Prior to that, parts of the wheelhouse must also have been situated on the deck of the OOCL FINLAND for a short period as the TYUMEN-2's canal helmsman as well as furnishing and equipment from the bridge were found there later behind the forecastle. The helmsman died there. The TYUMEN-2's pilot was found dead on her deck after the collision. The master and the cadet suffered serious injuries and the chief engineer a minor injury and broke a foot. Following the lack of control, the ship ran into the embankment on the southern side at an angle of approximately 45°. External communication was impossible due to the total destruction of the bridge.
The collision also caused damage to the lifeboat on the port side, its launching device and other parts of the superstructures. A small quantity of hydraulic oil escaped.

Figure 5: TYUMEN-2, damage to the superstructures and lifeboat

3.1.3.2 OOCL FINLAND

The collision damage on board the OOCL FINLAND was only minor. No members of the crew were injured. There were only small indentations and cracks on the port side of the forecastle and on the upright breakwater. One container was also damaged. There was no damage to the environment.

Figure 6: OOCL FINLAND, damage to the bow and one container

3.1.3.3 Other vessels

After becoming aware of the collision due to information from the OOCL FINLAND's pilot to the Vessel Traffic Service (VTS), the ship's command of the ESHIPS BAINUNAH, which was following the OOCL FINLAND, reduced speed. An attempt to communicate with the TYUMEN-2 failed (see also section 3.2.5.6 on page 61). Although it was just possible to prevent a collision with the TYUMEN-2 (see Figures 7 and 8), at 0705 the vessel grounded on the northern embankment near the TYUMEN-2 while performing an evasion manoeuvre.
The ESHIP BAINUNAH was able to free herself from the embankment shortly after and continued her voyage to Kiel at about 0711, where she made fast at the Total bunkering bridge for the enquiries of the waterway police and class approval. The voyage data recorder of the ESHIPS BAINUNAH was read by a service technician at Kiel by order of the waterway police.

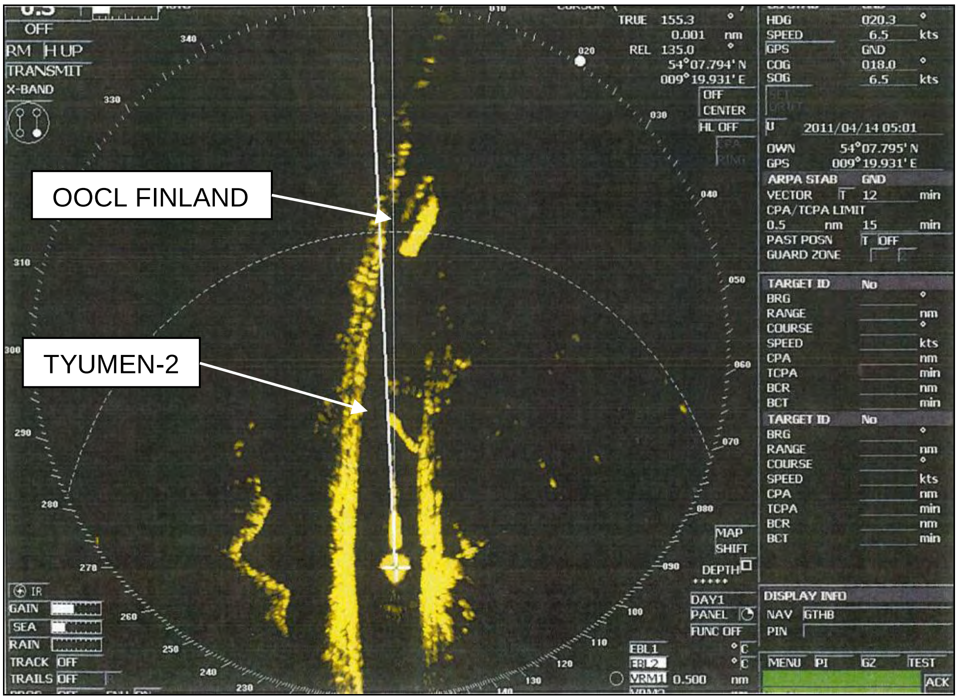

Figure 7: Radar image of the ESHIPS BAINUNAH at 0701

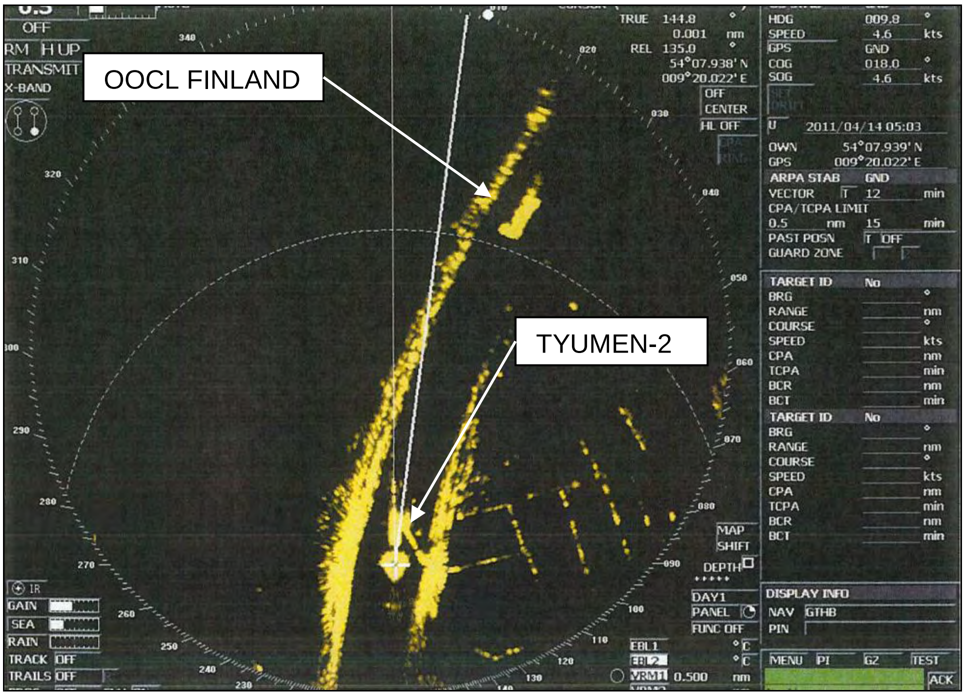

Figure 8: Radar image of the ESHIPS BAINUNAH at 0703

Proceeding westward behind the TYUMEN-2, the CLIPPER SUND was made aware at 0705 of both the collision and the imminent contact with the embankment by the ESHIPS BAINUNAH by the VTS. Following that, the CLIPPER SUND stopped and kept at a distance of about 0.5 nm from the TYUMEN-2. The ship later anchored at this position.

The passages of the NORDIC DIANA and the TRANSANUND were not affected by the collision. Since it was not possible at this point to determine whether the recordings of the voyage data recorders on the ships immediately involved in the accident would be usable, the TRANSANUND was requested by the WSP, at her arrival in Kiel, in consultation with the BSU to surrender the data of her voyage data recorder. This was complied with and a service technician read the data. However, the data were neither required nor evaluated.

3.1.4 Subsequent events

3.1.4.1 VTS NOK

Ships approaching the scene of the accident were warned by VTS NOK immediately after the collision. The VTS also tried to make contact with the TYUMEN-2. However, it was unable to. After the accident was reported by the pilot of the OOCL FINLAND, the VTS was unaware of the position of the TYUMEN-2 because her AIS signal was no longer available.

At the time the accident became known, it was apparently assumed that the TYUMEN-2 would be on the northern side of the canal because of her direction of travel. This is indicated by a corresponding entry in the log book of the VTS (0700). Communication with vessels in the area of the accident did not clarify the issue. Although the ESHIPS BAINUNAH grounded temporarily on the northern embankment in close proximity to the TYUMEN-2, the ship's command and the pilot were apparently not in a position to appreciate the situation on board the TYUMEN-2 while sailing past her and later the superstructures of the TYUMEN-2 concealed the remains of the demolished wheelhouse. At 0710, the pilot on the ESHIPS BAINUNAH was asked for information about the TYUMEN-2. Basically, the pilot said that the TYUMEN-2 was on the embankment at the wrong side and that smoke was rising from the superstructures. After the ESHIPS BAINUNAH resumed her voyage, it was also not possible to obtain further information from this ship due to the limited visibility.

The CLIPPER SUND had stopped out of sight of the TYUMEN-2.

At 0716, the VTS addressed the BRANDGANS, which had stopped at a distance of about 400 m from the TYUMEN-2. However, due to fog she was initially too far away to recognise any details. The BRANDGANS was requested to move closer to the scene of the accident to obtain information on the state of the TYUMEN-2. The VTS assumed that a blackout had occurred on board. At 0719, the BRANDGANS reported that the TYUMEN-2 had grounded on the embankment and was crossways to the canal. This information contained no reference to the side on which she had grounded and it was only possible to make out the shadow of the hull because of the remaining distance. At 0720, the SWINEMÜNDE, a ferry operating on the Fischerhütte crossing, asked the VTS whether she should assist in the effort to obtain information. The VTS agreed. Following that, the ferry discontinued her work and proceeded to the scene of the accident, which was about 1.8 nm away. At 0725, the BRANDGANS stopped at a distance of about 0.1 nm from the TYUMEN-2.

During her approach, the SWINEMÜNDE noticed fuel on the canal and reported this to the VTS (0741). The report on the position of the TYUMEN-2 (0743) follows: "The ship has grounded to the right, to the right here on the bank [...]." Thus, the northern bank was still indicated. The entry on the position of the TYUMEN-2 was not corrected in the log book of the VTS until 1000.

3.1.4.2 TYUMEN-2

The SWINEMÜNDE reached the TYUMEN-2 at 0743, made fast on her starboard side, and immediately after reported her initial impression of the damage to the VTS. At 0745, the VTS requested the SWINEMÜNDE to return to the berth at Fischerhütte to take the fire brigade on board there. At 0746, the BRANDGANS reported "the bridge has taken a pounding." In the minutes that followed, it was arranged that the BRANDGANS would send her workboat to the northern side to pick up firefighters and rescue workers. First of all, two officers from the waterway police were put on board the TYUMEN-2, respectively, the ferry. The manoeuvrability of the BRANDGANS was initially restricted due to a working platform she was carrying. The VTS was made aware by the SWINEMÜNDE of the actual state of the wheelhouse on the TYUMEN-2 only at 0752.

The SWINEMÜNDE cast off from the TYUMEN-2 at 0758 and reached the berth on the northern side of the ferry crossing at Fischerhütte at 0817. The two seriously injured crew members, who had been on the bridge of the TYUMEN-2 at the time of the accident, were on board the ferry. After transferring the casualties to waiting rescue workers and taking a fire engine and rescue vehicle on board, the SWINEMÜNDE cast off at 0830 and headed for the TYUMEN-2 again. She reached the TYUMEN-2 at 0850. In the meantime, other rescue units had already reached the TYUMEN-2 via the track that runs parallel to the canal and from there had been put on board with the help of the workboat belonging to the BRANDGANS.

At 0755, the VTS began to order the ferries of the crossings Hohenhörn, Hochdonn, Burg and Kudensee to proceed to the scene of the accident. These were to pick up additional firefighters and rescue workers as well as their vehicles and transport them directly to the TYUMEN-2 (Figure 9). The closest ferry (Hochdonn) had to cover 4 nm at a speed of about 6 kts. At about 0831, it became apparent that the requested ferries were no longer needed. Therefore, the VTS terminated their task, respectively, approach.

By 0737, the VTS had already ordered a tug via a shipbroker. The tug BUGSIER 14 began her voyage to the scene of the accident at 0800. Shortly afterwards, the tug PARAT followed. The BUGSIER 14 reached the TYUMEN-2 at 0948. The PARAT was at the scene of the accident by 1005.

At 0810 an employee of the WSA Brunsbüttel reached the TYUMEN-2 and assumed the operational control[6]. At about the same time forces of the waterway police, fire brigade and rescue service arrived at the scene. After having carried out a situation assessment, the VTS Kiel Canal was informed about the situation at 0830. Thereby

[6] These and the following information in this section were taken from the joint statement pertaining to the draft given by the Directorates General Waterways and Shipping, branch Kiel, and the WSA Brunsbüttel.

the order for the ferries to the scene of the accident which were already on their way was cancelled.
The situation on board the TYUMEN-2 was as follows: “Vessel is in the southern embankment. Bridge largely destroyed, large parts of the bridge walls on starboard side, in the front and on the port side and the navigation deck are missing. Tanks are sounded by the first officer upon request of the head of operations. However, no water ingress could be detected. Slight smoke emission from the destroyed bridge, minor oil leakage (presumably hydraulic oil from a burst pipe) into the Kiel Canal […]. Two injured persons were recovered by the ferry Fischerhütte and taken to the ferry berth. Another less serious injured crewmember refuses to disembark. Ten other crewmembers are on board, but are obviously in a state of shock. It is only possible to communicate with the vessels crew to a limited extent.”

Since only a small quantity of oil escaped and the TYUMEN-2 should be towed, it was abstained from deploying oil barriers.

Figure 9: The SWINEMÜNDE at the TYUMEN-2 during her second call

At about 1000 the sounding vessel ORCA was instructed to proceed to the scene of the accident.

At 1009, the water pollution control ship NEUWERK entered the canal at Brunsbüttel and began her voyage to the scene of the accident. The ship was ordered to proceed to the scene of the accident as it was initially assumed that the water pollution was more severe and the ship is equipped with the appropriate facilities for taking it up.

At 1019, the SWINEMÜNDE discontinued her task and returned to the ferry crossing.

At about 1030, both tugs had made fast to the TYUMEN-2 and began the towing operation to the siding at Fischerhütte. To enable the tug-and-tow combination to pass, the CLIPPER SUND initially weighed anchor and moved to the northern side of the canal. The CLIPPER SUND anchored again at about 1045 after the tug-and-tow combination had passed. Situated on the northern side of the siding at Fischerhütte in the meantime, the vessels ANDREA, BALTIC NEWS, GRACHTBORG and NOVA CURA had already moved to the southern side at the direction of the VTS. This made it possible to make fast the TYUMEN-2 on the northern side of the siding at about 1105. A jetty is also located there, which made it easy to reach the ship.

At 1120, the NEUWERK was stood down level with Hochdonn as there was no need to prevent oil pollution.

At about 1130, WSA Brunsbüttel's sounding ship ORCA reached the scene of the accident and took part in the sounding activities – which the BRANDGANS had already started – being carried out to assist in recovering the wheelhouse.

At 1153, the CLIPPER SUND received permission to proceed westward.

Since there was no further work to be done on the TYUMEN-2, the tugs were stood down at about 1200.

At about 1219, the ORCA stated that she had found the TYUMEN-2's wheelhouse and would drop a small buoy to mark the position.

The vessels laid up in the siding at Fischerhütte were allowed to proceed at 1223. At 1240, the vessels waiting to the west of the scene of the accident were also allowed to proceed. Converging traffic was not permitted at the site of the wheelhouse as this had been located in the bottom bend some 30 m away from the bank.

On the evening of that day, the shipowner and their underwriter decided to arrange for the TYUMEN-2 to be towed to the Nobiskrug shipyard in Rendsburg. The tugs PARAT and BUGSIER 15 were tasked to do this. The tug-and-tow combination reached the shipyard at about 0245 on 15 April 2011.

The TYUMEN-2's wheelhouse was recovered by a salvage company on behalf of her operator on 16 April 2011 (see Figure 10). Two tugs and a mobile crane on a pontoon were tasked to do this. After it was recovered, the wheelhouse was also transported to the Nobiskrug shipyard and left there.

Figure 10: Recovery of the TYUMEN-2's wheelhouse

3.1.4.3 OOCL FINLAND

The pilot of the OOCL FINLAND reported the collision with the TYUMEN-2 immediately afterwards to VTS NOK. Shortly afterwards, he asked the third officer to call the master to the bridge. Soon after that crew members were ordered to proceed to the forecastle to inspect the damage at the suggestion of the pilot. At 0718, they found the canal helmsman of the TYUMEN-2 in the rubble of her wheelhouse and began cardiopulmonary resuscitation. At 0726, the pilot on the OOCL FINLAND reported to the VTS that an unconscious person was located on deck and that the ship would stop in the siding at Oldenbüttel. The ship laid in the siding at about 0737. At 0741, the pilot asked the VTS for confirmation that rescue workers would come to the OOCL FINLAND with the aid of the ferry.
At 0802, the VTS addressed the ferry TILSIT, which operated on the crossing at Oldenbüttel, and reported that the OOCL FINLAND was waiting for an ambulance, which the ferry was to take to the ship.

After officers of waterway police Rendsburg received knowledge of the collision at 0735, they crossed to the southern side on the ferry at Oldenbüttel to go from there to the siding at Fischerhütte via the parallel track. The OOCL FINLAND was then seen by them in the siding at Oldenbüttel.

To enable the arriving units to board, the OOCL FINLAND moved to the pile level with the siding area station. The police and later the rescue workers were thus able to board the ship via the jetty located there. One of the officers climbed on board the ship at about 0800. Upon arrival at the ferry crossing, the vehicle carrying the emergency physician was immediately directed to the ship via the overland route. The emergency physician reached the OOCL FINLAND at about 0815. On board, the emergency physician was only able to confirm the death of the helmsman.

The OOCL FINLAND continued her voyage at 0859 and arrived at Rendsburg at around 1330, where she made fast for the accident investigation. On the evening of the same day the ship left Rendsburg for the port of destination.

3.1.4.4 Firefighters, rescue services, police

According to the log book of waterway police Brunsbüttel, it was informed about the accident by VTS NOK at 0710. Following that, a patrol car was deployed to the scene of the accident. The patrol car arrived at the scene of the accident at about the same time as the SWINEMÜNDE. The WSP informed Police Control Centre in Elmshorn about the collision at 0728. At the same time, VTS NOK informed the Joint Regional Control Centre West (KRLS West) about the incident. KRLS West then alerted the firefighters and rescue workers stationed in the vicinity of the scene of the accident. At the time the accident became known, it was apparently assumed that the TYUMEN-2 would be on the northern side of the canal because of her direction of travel.

To obtain an overview on the handling of the accident by the firefighters, rescue services and police, the BSU requested the mission log from each of the control centres.
According to the log, it was known to the police at 0756 that the Russian ship was on the southern side. At 0805, the position of the OOCL FINLAND was also known. The police control centre dispatched a large number of police units to secure the scene of the accident and for traffic control measures.

The mission log of Joint Regional Control Centre West was opened at 072849. From 0731, a lot of units from the northern side were initially alerted in accordance with the assumption relating to the scene of the accident. An emergency physician's vehicle from the hospital in Itzehoe, i.e. from the area of responsibility of Integrated Regional Control Centre Middle[7], also arrived at 0732.

It became known that the scene of the accident was on the southern side at 0746 following a message from a fire engine. In the period that followed, Integrated Regional Control Centre Middle and Joint Regional Control Centre West agreed that Joint Regional Control Centre West should stay in command of the operation.

[7] See section 4.10.2, p. 98, for the organisation of the control centres.

Due to the water pollution caused by the TYUMEN-2, the oil emergency team of Rendsburg Fire Brigade was also alerted at 0845.

After receiving feedback from the emergency physician deployed on the OOCL FINLAND after the operation finished there, the rescue control centre had a complete picture of the situation at 0922. All the casualties had been cared for, respectively, taken to a hospital. Following that, the rescue helicopter and divers from the fire brigade were stood down.

The task of the oil emergency team was handed over to Integrated Regional Control Centre Middle at 1033.

3.1.4.5 German Central Command for Maritime Emergencies (CCME)

According to the log book of VTS NOK, it informed the waterway police coordination centre at 0712 that the two ships had collided.
According to its own log book, the Maritime Emergencies Reporting and Assessment Centre (MERAC), part of the CCME, was informed about the incident at 0752 by the waterway police coordination centre in Cuxhaven and at 0804 by VTS NOK. Firefighting Unit Brunsbüttel also notified MERAC that it had been alerted by its own control centre at 0758.
At about 0830, CCME alerted the casualty care teams at Kiel, Lübeck and Hamburg, and contacted the Fleet Command of the German Navy to obtain an aircraft from there to investigate possible water pollution. Other tasks in the initial phase included the requisition of transportation for the casualty care teams, sharing information with the State Agency for Coastal Protection, National Park and Marine Conservation of Schleswig-Holstein, and making arrangements with respect to organisation of the psychosocial emergency care. CCME assumed overall control of the operation at 0850, after which the points mentioned were monitored further.
The aerial investigation of the water pollution by a pollution control plane was not possible to begin with due to visibility. Nevertheless, arrangements were made and measures initiated that would have been implemented in the event of extensive water pollution. For example, the oil emergency team of Technical Relief[8] Meldorf was alerted.
A staff member of WSA Brunsbüttel was tasked with the role of on scene coordinator (OSC) until the CCME's operational commander arrived at the scene at 1050. Other staff members of WSA Brunsbüttel were also involved in dealing with the consequences of the accident.
The head of Firefighting Unit Brunsbüttel was responsible for casualty care and coordination of the fire brigade on behalf of the CCME from 0900. Prior to that another member of Firefighting Unit Brunsbüttel, who happened to be near the scene of the accident, supported the command and control post of the local fire brigade as technical adviser.
Casualty Care Team Kiel deployed at 0920 and reached the location in Oldenbüttel at 1000. At about 0930, the alerts for Casualty Care Team's Hamburg and Lübeck were cancelled. Casualty Care Team Kiel was stood down at 1038.
At about 1130, it was clear that oil defence measures would not be necessary after an aerial investigation and the inspection of the water and ship. The units alerted for

[8] Technisches Hilfswerk (THW)

that were then stood down. Firefighting Unit Brunsbüttel along with other firefighting units and Technical Operation Management Dithmarschen were stood down at about 1200.
CCME discontinued overall control of the operation at 0900 on 18 April 2011.

3.2 Investigation

The investigation was conducted in cooperation with the United Kingdom's Marine Accident Investigation Branch (MAIB). The MAIB provided technical support and this report was coordinated with it. The Russian Federation conducted its own investigation and the final report was made available to the BSU.

Officials from the Federal Bureau of Maritime Casualty Investigation arrived at the TYUMEN-2 on the morning of the day of the accident and started the investigation there. First of all, attempts were made to find the voyage data recorder's central processing unit. However, this could not be found among the debris. The final recording medium sank with the wheelhouse as it was mounted on its roof.

After the OOCL FINLAND made fast in Rendsburg, she was visited by investigators from the BSU. Data from the voyage data recorder were secured and the first interviews held.

An official from the BSU was also present at the recovery of the TYUMEN-2's wheelhouse from the NOK on 16 April 2011. Together with an officer from the WSP, he was able to remove the CompactFlash memory card (CF card) from the voyage data recorder's central processing unit and secure it properly while still on the salvage pontoon. The central processing unit was mounted on the rear wall of the wheelhouse.

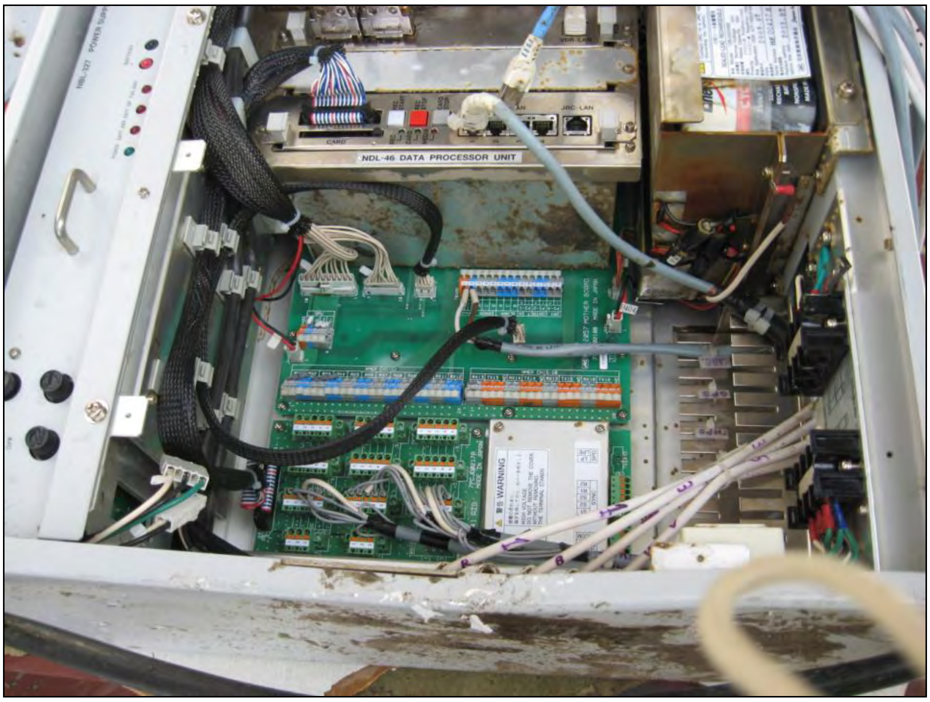

Figure 11: Central processing unit of the TYUMEN-2's voyage data recorder

Figure 12: CompactFlash memory card from the voyage data recorder's central processing unit in the water-filled shipping bag

After the wheelhouse was deposited on the grounds of the Nobiskrug shipyard, the final recording medium was removed from the roof of the wheelhouse and secured.

Figure 13: Removal of final recording medium

3.2.1 Kiel Canal

The collision between the OOCL FINLAND and TYUMEN-2 occurred on the Kiel Canal. This canal "[...] is a man-made waterway and connects the Elbe, respectively, North Sea with the Baltic Sea. It stretches from Brunsbüttel in the west to Kiel-Holtenau in the east. The total length is 98.6 km (53.3 nm). The water is kept at a constant level by locks at each end of the canal." [9]
The developed part of the NOK, also where the accident took place, "[...] stretches from Brunsbüttel to the siding at Königsförde to the east of Rendsburg (ckm 80). In this section of the canal, the cross-section has [...] a bed width of 90 m, a width at water level of 162 m and a depth of 11 m. On the course up to the lock at Kiel-Holtenau, the so-called eastern stretch, […] the canal still has the dimensions[10] of 1914."[11]

The number of ships transiting the NOK is dependent on the economic situation. For example, 43,378 ships transited the canal in 2007. In 2011, 33,522 ships used the canal[12]. However, the volume of goods transported shows that ship size has increased significantly in recent years. 7,435 ships belonged to Traffic Group 4 and 4,683 ships to Traffic Group 5. That represents increases of 14% and 27% respectively for these groups. In addition, approximately 19,000 recreational craft transit the canal each year. Altogether the accident figures are low.

The summary of contacts with the embankment and accidents in the area of WSA Brunsbüttel provided by WSD North[13] for the period from 2006 to 2010 permits an overview of the accidents on the developed western stretch of the NOK.

	TG 1	TG 2	TG 3	TG 4	TG 5	TG 6
Steering error; mostly resulted in an embankment contact	1	-	9	2	2	1
Steering error during or after the passage of an oncoming vessel; all resulted in an embankment contact	1	-	2	-	-	-
Navigational error	1[14]	-	3	3	-	-

Table 1: Summary of accidents at the area of WSA Brunsbüttel for the period from 2006 to 2010

It can be derived from the table that ships in the higher traffic groups do not have a disproportionately high involvement in accidents in the period considered.

[9] http://www.wsa-kiel.wsv.de/Kanal/index.html, retrieved on 14 June 2012.
[10] Width at water level: 102.5 m; width at bed: 44 m; depth: 11 m.
[11] http://www.wsa-kiel.wsv.de/Kanal/index.html, retrieved on 14 June 2012.
[12] http://www.wsd-nord.wsv.de/Service/Broschueren__Flyer_etc/Anlagen/Jahresbericht_2011.pdf, retrieved on 09/01/2013.
[13] Today: Generaldirektion Wasserstraßen und Schifffahrt – Außenstelle Nord = Directorate-General Waterway and Shipping – Branch Office North.
[14] Tug and tow.

3.2.2 Vessel Traffic Service NOK

VTS NOK is an organisational unit of Waterways and Shipping Office Brunsbüttel, which, in turn, is subordinated to Waterways and Shipping Directorate North and is responsible for those tasks typically associated with a vessel traffic service (VTS). It provides a 24 hour service and has the following objectives[15]:

- prevention of threats to the safety and efficiency of vessel traffic;
- prevention of risks originating from the shipping industry, including those to the marine environment, and
- maintaining waterways in the condition necessary for shipping.

VTS NOK is responsible for the entrances of the locks at each end of the canal and for the entire stretch of the NOK.

To perform its tasks, monitoring of the traffic on the area of operation takes place. This monitoring is essentially carried out using the AIS signals transmitted from ships. Only a small part of the canal is monitored by radar. The AIS data transmitted by the ships and the VHF channels used by the VTS are recorded. Here, the canal stretch is split into two areas of operation, each with an independent radio channel. The call sign of the so-called western stretch (km 0 to km 49.5) is 'Kiel Canal II'.

The AIS data of the ships are used simultaneously in a computerised system for planning ship traffic, i.e., passages and encounters on the NOK, by means of a distance-time graph. Based on that, ships are given instructions directly or guided by means of the traffic light installations erected in the siding areas.

The VTS also records environmental data and conditions that affect the flow of traffic, such as construction sites or defective light installations. All the information is analysed, summarised and then included in the situation reports transmitted every half-hour. The situation report, referred to here as 'collective call', is invariably sent in German.

For the personal of the VTS apply "To identify potential risks and disruptions, the overall situation must be continuously evaluated having regard to the data on traffic, area of operation and environment as well as the following boundary conditions:

- quality of the radar information;
- availability and quality of other technical aids;
- manoeuvrability of the vessels involved;
- communication problems;
- discernible deficiencies in the ship's command;
- legal requirements;
- enactments, orders and administrative provisions."[16]

The duty personnel take a staged approach in a type of control cycle when responding to a detected inconsistency by providing information and warnings as well as advices or instructions.

[15] Article 2 Administrative regulation of the Federal Waterways and Shipping Administration (Verwaltungsvorschrift der Wasser- und Schifffahrtsverwaltung des Bundes - VV-WSV-2408).
[16] Article 18 VV-WSV-2408.

"[...] there is basically a need for action by the Vessel Traffic Service in relation to direct traffic [on the NOK] if:

- traffic regulations are infringed;
- safe passage cannot be expected due to the particular conditions;
- the berthing or casting off manoeuvre is not possible without consideration for other traffic, […];
- vessels with special status requiring consideration are in the operating area, and
- any other behaviour inconsistent with the norm is identified."[17]

The traffic management's aim is to enable ships to transit the canal without stopping. This is not always guaranteed due to the rising number of high traffic group ships and the increase in slow-moving vessels[18]. This leads to congestion and delays in the siding areas.

Basically, one nautical supervisor and two VTS operators are responsible for the entire canal (eastern stretch and western stretch). Because of the ongoing implementation of the personal concept, at the time of the accident the VTS NOK was manned by one nautical supervisor, one VTS operator and one experienced nautical assistant. Therefore the VTS was manned in compliance with the requirements applicable at the time of the accident.

The mission records, i.e., a copy of the watch incident log, the distance-time graph for the accident period, a copy of the recording of the VTS's VHF channel and other documents were submitted by WSD North.

3.2.3 Traffic regulations

In the area of the NOK, the SeeSchStrO in conjunction with the Notice of the Waterways and Shipping Directorate (WSD) North apply. The Notice puts the regulations of the SeeSchStrO into specific form for the NOK.

The following issues were relevant for the collision of the TYUMEN-2 with the OOCL FINLAND:

1. By derogation from the rules 11 and 19 Collision Prevention Regulations[19], article 21 para. 1 Traffic Regulations for Navigable Maritime Waterways stipulates for the encounter in the fairway, that rule 14, letter a and c COLREGs apply when vessels detect one another by radar and not by sight. That means that vessels proceeding on reciprocal courses with a risk of collision shall carry out their evasion manoeuvre to starboard. Both vessels under consideration were in the fairway, which was limited by the canal shore in this area. Thereby the selection of course was predetermined within narrow boundaries. Both vessels approached each other on reciprocal courses. A risk of collision did basically exist. Both vessels had detected each other by means

[17] Article 20 VV-WSV-2408.

[18] Article 26(3) Traffic regulations for navigable maritime waterways (Seeschifffahrtsstraßenordnung - SeeSchStrO) in conjunction with Part A, No 12.13.1.1 of the Notice – vessels for which, due to her dimensions or draft (more than 8.5 m), the speed is limited to 12 km/h (6.5 kts).

[19] Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs)

of the radar and were additionally made aware of each other by the Vessel Traffic Services within the framework of the situation reports. Both vessels were able to identify each other clearly due to the transmitted AIS information and the situation reports from the VTS. Both vessels were on their respective side of the fairway during the approach and thus satisfied the request for an evasive manoeuvre to starboard as much as possible.

2. Article 21 para. 2 Traffic Regulations for Navigable Maritime Waterways stipulates that according to rule 8 point d Collision Prevention Regulations, a safe passing distance has to be kept on encounters. The safe passing distance in a canal is not comparable with the safe passing distance on sea. It is limited by the canal conditions. Influencing factors are the dimensions of the encountering vessels and their speeds. The question as to whether a passing distance was safe can only be assessed in the single case.

3. Article 26 Traffic Regulations for Navigable Maritime Waterways stipulates that every vessel shall, in compliance with rule 6 KVR, proceed with a safe speed. Rule 6 COLREGs specifies the safe speed further: "Every vessel shall at all times proceed at a safe speed so that she can take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and conditions." The following circumstances have to be taken into account from all vessels:
   - the state of visibility,
   - the traffic density, this is the type and number of vessels in the area,
   - the manoeuvrability of the vessel with special reference to stopping distance and turning under the prevailing circumstances
   - the character of the waterway
   - the draft in relation to the water depth.

   Special conditions apply to the navigation in a limited fairway such as a canal. These conditions partially deviate from the requirements on sea. This is, inter alia, due to the fact that courses and speeds of the vessels involved are basically known. Thereby the significance of the prevailing visibility conditions for the selection of the safe speed declines, since the occurring encounter situations are relatively clear. The traffic density is of less importance as on the sea. Contrary to this, the wind and tidal conditions and the relation of the draft to the existing water depth (shallow water influence) are more significant. In the case reviewed the wind could be neglected due to the lower wind forces. Possible current can also be neglected.
   On the contrary, particular emphasis has to be put on the manoeuvrability in relation to the ratio of draft to the water depth when navigating on a canal due to the shallow water influence.
   For the shallow water influence the following applies: "As a result of the shallow water influence the speed reduces with otherwise steady engine

power. The vessel steering deteriorates, the trim changes, many manoeuvre characteristic values deviate from the ones in sufficient deep water."[20] The critical speed range and the loss of under keel Clarence are importance characteristics.
Thereby critical speed means that "the water quantity displaced by the vessel is not discharged fast enough to the aft between vessel and fairway. Then a bow wave is pushed in front of the vessel. This can lead to difficulties in steering the vessel and, under unfavourable circumstances, to grounding."[21]
The manoeuvre characteristics of a vessel subject to shallow water influence is not determined by trials and cannot, since it is subject to changes, read be read about in tables. The behaviour of a vessel in shallow water must be newly "experienced" in every single case. For this reason the safe speed as well as the safe passing distance, is not a solid parameter.

The influential factors mentioned in rule 6 b Collision Prevention Regulations are to be observed when determining the safe speed on navigating with radar. Following points have an effect upon.

- the characteristics and die efficiency of the radar
- the influence of the weather and other dysfunctions of the display
- problems in covering small vessels
- the number, the position in the fairway and the movements of the detected vessels.

Rule 19 b Collision Prevention Regulations shall be additionally adhered to when navigating in restricted visibility: "Every vessel shall proceed at a safe speed adapted to the prevailing circumstances and conditions of restricted visibility. A power-driven vessel shall have her engines ready for immediate manoeuvre."
The following conditions shall be considered when determining the safe speed on navigating with radar:

- Are low reflecting vessels to be expected in this sea area?
- How are the radar cover conditions?
- Is it possible to take action for a safe passing in due time when vessels in greater distance are covered?
- The safe speed depends on the low reflecting vessel, which might only be detected within a close quarters situation[22],
- If a vessel is initially detected in a close quarters situation, it might be possible to prevent a collision with a stop- and full astern manoeuvre. Furthermore a deliberate evasive manoeuvre towards the embankment can be carried out. However, the measures shall be taken in conformity

[20] Hilgert, Helmut /Schilling, Rolf: Kollisionsverhütung auf See. Teil 1: Rostock 1992, S. 29. [rough translation by BSU]
[21] Ibid. [rough translation by BSU].
[22] The term close quarters is used in the report depending on the confinement of the fairway in the Kiel Canal.

with the law and shall meet the spatial conditions of the fairway of the Kiel Canal and the traffic situation.

The engine on OOCL FINLAND was held ready for immediate manoeuvres, since the vessel was equipped with a controllable pitch propeller and the engine was additionally run in manoeuvre operation.

4. The German Traffic Regulations for Navigable Maritime Waterways[23] and the announcements do not contain limitations for vessels which are not tankers or push tows or tug and tows, respectively, with respect to the behaviour on the stretch and in the sidings in restricted visibility. Therefore rule 19 b s. 1 Collision Prevention Regulations apply. This rule stipulates that the vessels speed shall be adapted to the restricted visibility.

5. According to article 24 para 1 Traffic Regulations for Navigable Maritime Waterways evasive action shall be taken to starboard if courses are straight head-on or nearly straight head-on. Head-on situations are clearly defined under article 24 para. 4 Sentence 2 Traffic Regulations of Navigable Maritime Waterways for the Kiel Canal: “When a vessel of categories 4 to 6 is involved, way shall be given to such vessel.” For this reason the TYUMEN-2 had to give way to the OOCL FINLAND.
Both vessels were on their respective fairway side. OOCL FINLAND carried out an evasive manoeuvre much more to starboard before the collision occurred. The TYUMEN-2 maintained a constant distance to the northern shore while approaching the OOCL FINLAND. The TRANSANUND had already been passed at 065730 in this way (figure 31).

The encounter on the Kiel Canal (NOK) is furthermore substantiated by the announcement[24]. Vessels transiting the NOK are classified into six traffic groups. Classification is based on the length, breadth, draught and type of cargo[25]. Each traffic group affects the management and flow of traffic because on certain sections and having regard to certain maximum draughts, the sum total of the traffic groups that encounter may not exceed eight. It may only be seven or six[26] on all the other sections. Restrictions of this kind also exist when overtaking[27]. Sidings are exempted from these restrictions.
The allocation to the traffic groups or the admissible sum of the traffic groups does not change in restricted visibility.
If the safety of traffic requires this the VTS can allocate vessels to a higher traffic group[28]. As regards both vessels the administration had no information whatsoever which would have required an upgrade. However, the pilots are

[23] Article 30 SeeSchStrO.
[24] Article 24(4) SeeSchStrO.
[25] Article 2(1) No 18a SeeSchStrO in conjunction with Part A, No 5 of the Notice.
[26] Article 24(4) SeeSchStrO in conjunction with Part A, No 11 of the Notice.
[27] Article 23(5) SeeSchStrO in conjunction with Part A, No 9 of the Notice.
[28] Article 56 SeeSchStrO in conjunction with Part A, No 5.9 of the Notice.

entitled to ask for an upgrade during the canal passage if they deem it necessary.
None of the vessels applied for an upgrade during the canal passage.

The TYUMEN-2 belonged to the Traffic Group 3 and the OOCL FINLAND to Traffic Group 5. Hence, the sum total of the two traffic groups was eight. The maximum draught of the OOCL FINLAND was 7.80; therefore, it was lower than the limit value of 7.90 m. This means that both ships were allowed to encounter in the bend at Grünental.

The maximum draught permissible for encounters between ships of Traffic Groups 3 and 5 was changed from 7.00 m to the 7.90 m discussed above in 2008. Therefore, the two ships would not have been allowed to encounter before the change. During the investigation, WSD North was asked about the cause and effect of this change. WSD North stated the following in this regard: "The reason behind the considerations in relation to modifying the rules for encounters was increased encounters of ships of the higher traffic groups in the sidings on very confined traffic areas with extremely low passing distances. 'Hold-ups' in the siding areas were triggered by the growth in vessel size in conjunction with the former rules for encountering on open stretches. A ship in controlled canal navigation is basically easier to manoeuvre than a ship that has stopped, which must be kept in a confined space at minimum speed and with different manoeuvres in this confined space, possibly also in adverse weather conditions like fog or a storm."

A risk assessment was carried out by a working group before the change. This working group consisted of representatives of WSD North, WSAs Brunsbüttel and Kiel-Holtenau, NOK I and II pilot brotherhoods, and the canal helmsmen. Compared to the risks in the siding areas, the change in the permissible draught appeared to be warranted. After a trial period of one year, the conclusion drawn by the stakeholders was clearly positive.

6. The maximum speed on the NOK is also laid down. It is 15 km/h, respectively, 8.1 kts[29] over ground for the ships considered here.
   As regards the speed of the TYUMEN-2 see diagram 1 (page 48).
   As regards the speed of the OOCL FINLAND see diagram 3 (page 70).

7. Due to her size, the OOCL FINLAND was required to make use of canal helmsmen on the entire stretch[30]. This obligation did apply to the TYUMEN-2 only for the eastern stretch. The TYUMEN-2 made use of the canal helmsman for the western stretch voluntarily. Each ship had a canal helmsman on board for the complete stretch.

[29] Article 26(3) SeeSchStrO in conjunction with Part A No 12.13.1.2.
[30] Article 42(5) SeeSchStrO in conjunction with Part A, No 25.2 in conjunction with 25.4 of the Notice.

8. All the ships considered in this investigation were required to make use of a pilot[31] and complied with that obligation.

9. The minimum distance to be kept to the vessel proceeding ahead by the OOCL FINLAND shall at least be 1000 m[32]. The TYUMEN-2 shall at least keep a distance of 600 m. The distance to the vessel proceeding ahead was selected by both vessels with 1400.

10. Article 21 para. 3 Traffic Regulations for Navigable Maritime Waterways demands that the bow anchors are clear to be cast immediately when in a fairway.
The documents available, relating to both ships, do not indicate any information about the readiness of the anchor equipment. In its statement pertaining to the draft report the operator of the OOCL FINLAND indicated that the anchors were reportedly "ready to be dropped".

3.2.4 TYUMEN-2

The TYUMEN-2 is a ship with three hatches and aft superstructures. The shipyard built a number of ships of this type. The superstructures were kept low for operation as a seagoing inland waterway ship. The A-mast on the roof of the superstructures can be tilted by means of a hydraulic system.
The class certificate contains the following restriction: „River-sea navigation at seas with a wave height with 3 per cent probability of exceeding 6.0 m with ships proceeding from the places of refuge: in open seas up to 50 miles and with an allowable distance between the places of refuge not more than 100 miles; in enclosed seas up to 100 miles and with an allowable distance between the places of refuge not more than 200 miles. When acceleration criterion[33] is from 1.0 to 0.75 the permissible height of 3 % probability wave should not be greater than 5.0 m."
The crew members were all citizens of the Russian Federation. Over and above the minimum safe manning, two cadets were on board.
The ship was in possession of valid ship papers and equipped in accordance with regulations. Witnesses confirmed the operability of any facilities necessary for commanding the ship.
Part of the lumber cargo was stowed on deck and covered by tarpaulin. The view from the bridge was not impaired by the cargo on deck.

[31] Article 6 Pilot ordinance (Lotsverordnung) Kiel Canal/Kiel Firth/Trave/Flensburg Firth.
[32] Article 48(1) SeeSchStrO.
[33] Criterion based on roll amplitude, free surfaces, and other; see also Section IV, Chapter 3.12 of 'Rules for the classification and construction of seagoing ships' of the Russian Maritime Register of Shipping.

Figure 14: TYUMEN-2 after the collision. Photo taken in the siding at Fischerhütte

3.2.4.1 Structural assessment of the ship

The entire wheelhouse of the TYUMEN-2 was torn off due to the force of the collision. This exceptional incident made it necessary to assess the design of the superstructures and the connection between the deckhouse and wheelhouse. Naval architect Dipl. Ing. Manfred Stryi was commissioned by the BSU to carry out the assessment. The assessment took place on 20 April 2011 on the grounds of the Nobiskrug shipyard, which is where the ship and wheelhouse were located. A comparison with an intact structure was possible as the cargo of the TYUMEN-2 was being transferred to the sister ship, TYUMEN-3, at the time.
The opinion[34] contains the following remarks vis-à-vis the deckhouse:
"[...] the helm has been produced separately and bolted onto the foundations and deck superstructures, which are welded to the boat deck.

That the most important joins were made horizontally on welded angles and folded coamings by means of vertically arranged M12 screws is particularly striking. An 80 x 5 mm rubber layer was placed between the joins. It is not possible to establish whether the rubber was intended to prevent vibration and noise or just act as a seal.
If the purpose of the rubber layer was to prevent noise or vibration, then it would have been insufficient in this form and cancelled out by the direct bolting.
Furthermore, in this case mechanical safeguards against rising or shifting during abnormal movements of the ship (swell, pitching, rolling, storm) were absent.
If the existing joins are supposed to be properly proportioned for stress and strain, then the following merits criticism:

1. the spacing between screws of approximately 300 mm shown in the drawings is insufficient according to German regulations. For solid joins a minimum spacing

[34] Report on the assessment of the damage to the deckhouse connection to the boat deck of the motor vessel 'TYUMEN-2' on 20/04/2011 at the Nobiskrug shipyard in Rendsburg.

between holes of 3 d (3 x 12 = 36 mm) and maximum of 8 d (8 x 12 = 96 mm), respectively, 15 t (15 x 5 = 75 mm) is required. Hence, almost three times more screws would be needed as compared to those currently installed;

2. the mounting of the base angle and folded coamings by means of toe brackets and substructures should have been more extensive;

3. there is no information about screw quality, standards or possible tightening torques in the drawings.

The relatively small deformations seen on the base structure stand out. In a force-locking connection the screws should have provided more resistance and would not have sheared so smoothly without deforming the screw holes. Here, severe deformations only occurred in the immediate area of the collision point; after that it appears that the entire helm was pushed over the rubber seal (no high friction losses). […]"

The helm was assessed as follows:

"It should be added to the above that the state of the wheelhouse's substructure was similar. The mounting levels at the corner points have been severely deformed, while the central section has no or only minor deformation. The screws sheared off smoothly there. […]"

Assessment of the screws:

"Three screws were retrieved on deck beneath the connecting straps. It is evident that two of the screws that sheared off did not have any earlier damage caused by corrosion, vibrations, etc.

One screw that was below a turned up corner was destroyed by bending and shear stress. A brittle fracture due to cold can be excluded because the temperatures were in the positive range at the time of the collision."

The expert came to the following conclusion:

"An accurate technical assessment is not possible without precise knowledge of the Russian regulations. It is probable that the design is appropriate for a ship engaged in coastal trade and protected waters. Due to the net weight and broad pressure distribution over rubber pads, the selected screw connections may be secure enough. However, for ocean-going ships the design is questionable.
Of course, a wheelhouse cannot be measured against a collision; large windscreens and aluminium structures would be inconceivable were that the case. However, forces should be absorbed by means of the deformation behaviour, amongst other things. That entire deckhouses are pushed overboard in confined areas of operation with speed restrictions is uncommon."

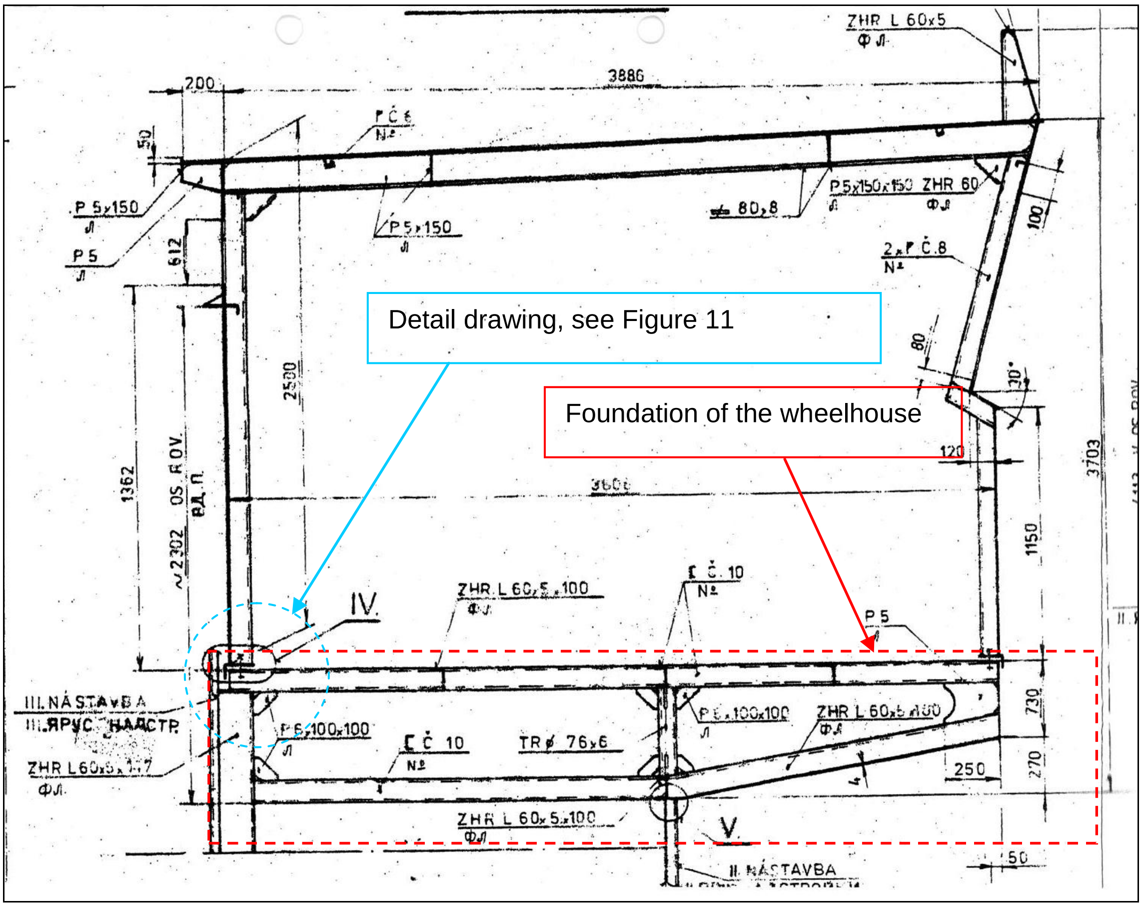

Figure 15: TYUMEN-2, drawing of the wheelhouse (side view)

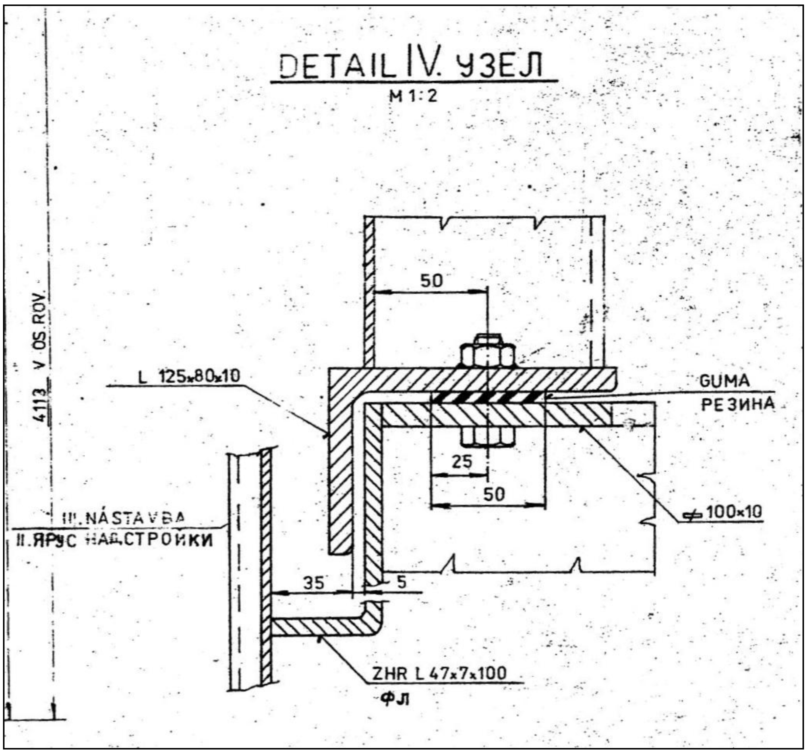

Figure 16: TYUMEN-2, detail drawing, wheelhouse/deck house connection

Figure 17: TYUMEN-2, point of impact on the port side front of the wheelhouse

Figure 18: TYUMEN-2, installation cone at the outer corners of the foundation of the wheelhouse, irregular hole spacing of the screw connection and rubber layer

To determine the strength of the deck connection, Germanischer Lloyd was requested to make a corresponding calculation. The opinion on the assessment of the wheelhouse mounting notes that:

"The calculation of the strength of the screwed connection was made for the dimensions shown in drawing **040-100-965 Konstrukcia Kormidelne**[35] for a seagoing ship with a restricted range of trade of 50 nm (RSA (50)). […]
Our calculation has revealed that with the design loads according to our 'Rules for Classification and Construction' for seagoing ships (I-1-1), the connection shown (M12, distance of 300 mm) is adequately proportioned for a strength class of at least 3.6. Due to the absence of specifications of the rubber layer used between the flanges and the torque, we recommend screws with strength of at least 4.6 (order of magnitude: standard strength shipbuilding steel). The weight of the bolted structure (estimated with a smeared plate thickness of 8 mm – twice the thickness of the plate used) does not result in a dimensioning load on the screw in swell.

We assume that the shear plane is not on the threaded part of the screw.

Statutory issues (e.g., possible requirements vis-à-vis weather tightness) did not form part of the assessment."

3.2.4.2 Evaluation of the TYUMEN-2's voyage data recorder

The ship was equipped with a type JRC 1850 voyage data recorder manufactured by Japan Radio Co., Ltd. (JRC). It was a simplified voyage data recorder (S-VDR), which has a much smaller range of features[36].

A CF card within the computer, respectively, central processing unit, was the storage medium for the TYUMEN-2's voyage data recorder. To facilitate the reading process the CF card was removed from the water-filled shipping bag on 18 April 2011 by the BSU and then dried and cleaned with compressed air. This was initially unsuccessful, i.e., the card was not readable. Following that, the IT department of the Federal Maritime and Hydrographic Agency (BSH) disassembled the card, rinsed it with deionised water and then cleaned and dried it. The card was then readable and the data could be imported into the playback software.

[35] Provided by the BSU.
[36] See IMO Resolution MSC.163(78) – Performance Standards for Shipborne Simplified Voyage Data Recorders (S-VDRs).

Figure 19: CompactFlash memory card; disassembled in the image to the right

While replaying the backed up data from the CF card, the functioning clock indicated that the data stored covered the period 163000[37] on 13 April 2011 to 050021 on 14 April 2011. However, the audio recording stopped at 045900 and rendering of the other data at 045959. The image then freezes and the time jumps forward to 050059.

The manufacturer was initially unable to explain this 'data loss', i.e., the absence of the audio recording up until the time of the collision. According to JRC, respectively, L-3, the manufacturer of the final recording medium hardware, there was a possibility that the missing data could be found on the memory within the FRM. Therefore, technical assistance was obtained from L-3 in Florida.
A engineer of the BSU and a engineer of the MAIB[38] travelled there for that purpose. The FRM's storage module was disassembled properly in a laboratory
and prepared for the data readout with much technical input. The outcome of the readout was that the FRM only contained data that started to be recorded earlier. However, the recording on the FRM finished at the same time. The manufacturer later stated that the data were absent because of the type of storage. To begin with, data packets are formed in a volatile buffer memory. The data are then transferred to the main memory at a specific time, which had evidently not been reached, meaning the data were lost when the power supply was interrupted.

Specifically, the following data were stored by the S-VDR on board the TYUMEN-2:

- position,
- speed over ground according to GPS,
- AIS data and rendering with symbols and vectors,
- radar image of one radar unit,
- a VHF marine channel,
- recording of the microphones in the wheelhouse.

[37] The times shown in this paragraph are UTC.
[38] MAIB – Marine Accident Investigation Branch, investigating authority of the United Kingdom. Participating in the investigation as 'state with a substantial interest'.

In addition to other displays, the following, meaningful views are provided by the playback program, the so-called replayer, for this case:

- The 'Conning' view provides a very simple display of the position and speed data.

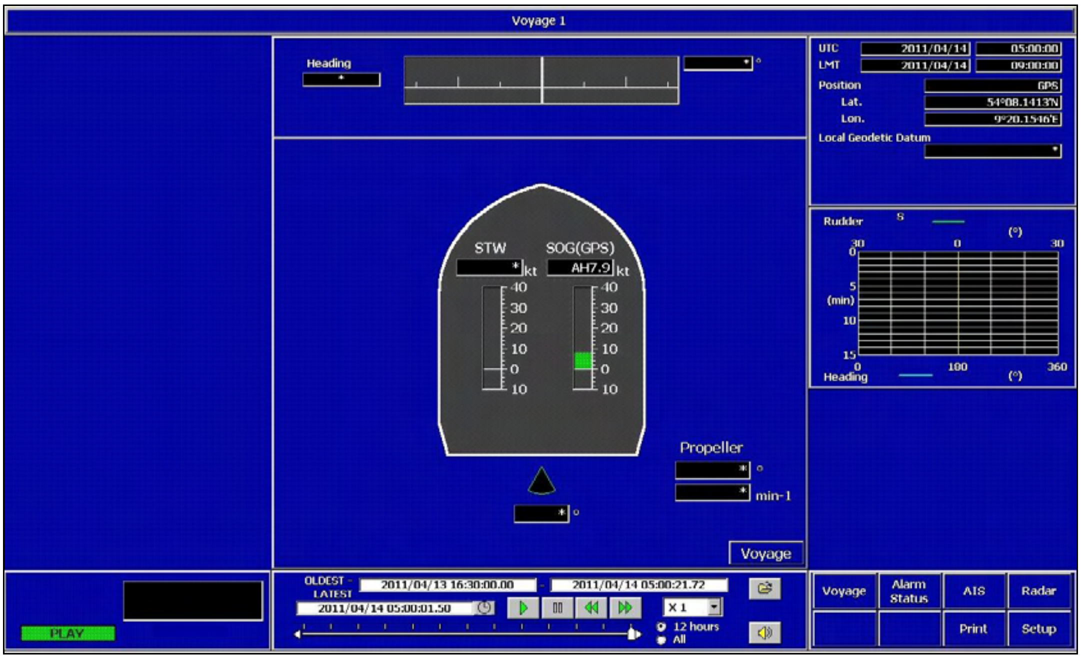

Figure 20: TYUMEN-2, S-VDR, 'Conning' view[39] [40]

- The 'AIS' view displays vessels transmitting AIS[41] signals. The right column displays 'own ship' and the data of the two closest vessels. For the analysis, it is possible to modify the range displayed in the top left corner. There is also the option to view detailed data of 'own ship' and that of the two closest vessels. Data of other vessels can be displayed in a list.

[39] The buttons at the bottom are used to control the replayer.
[40] A time lag exists between the time at the bottom and all the other times displayed in the replayer. This is due to the playback software.
[41] AIS – Automatic Identification System.

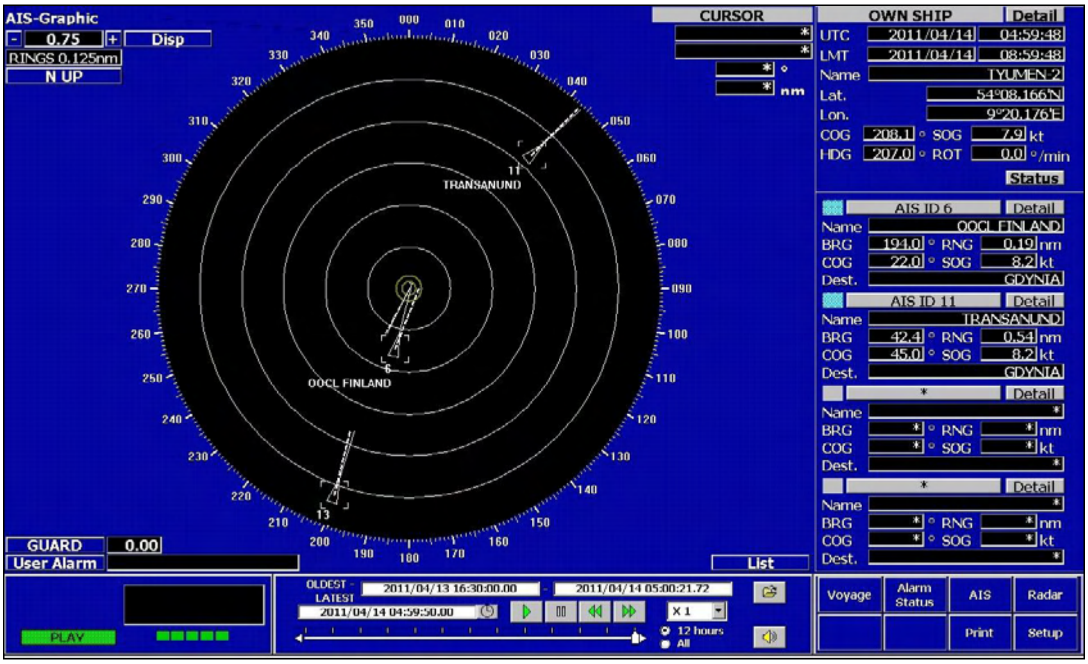

Figure 21: TYUMEN-2, S-VDR, 'AIS' view at 065948

– The replayer's display of the radar is unusable for an analysis because the upper and lower halves of the radar image are composited incorrectly (see Figure 22). Moreover, areas in the centre and on the left border are not shown. This may be caused by an error or a wrong setting while accessing the image data in the radar or saving the radar data.

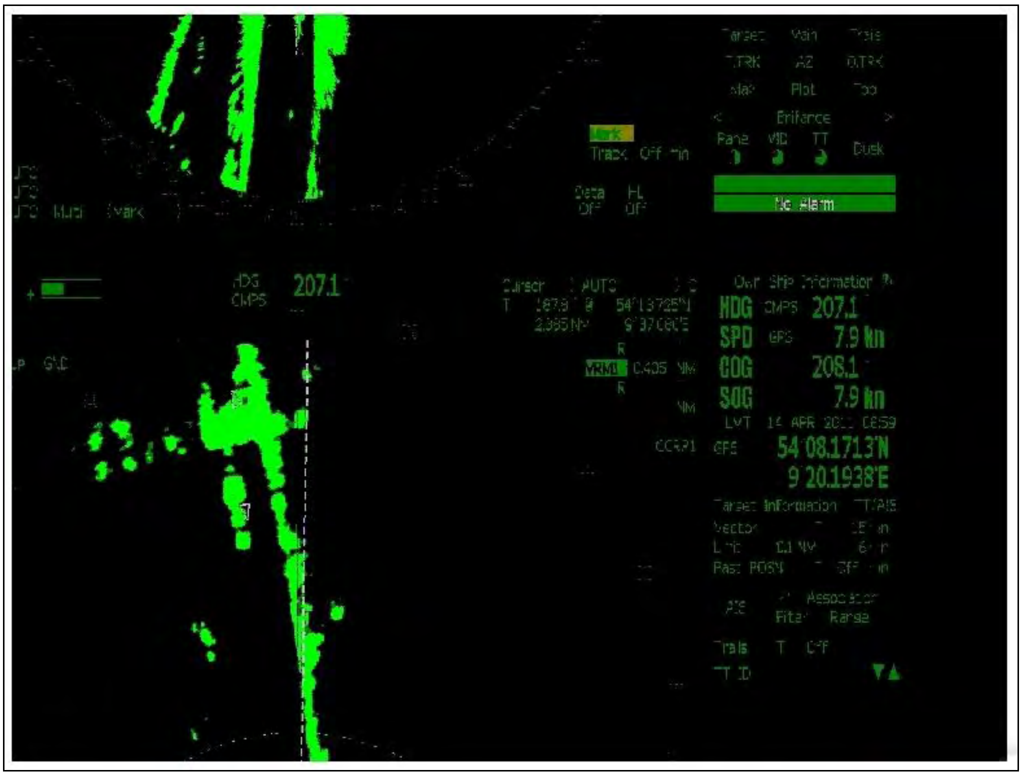

Figure 22: TYUMEN-2, S-VDR, 'Radar' view at 065947, ahead (distance about 0.7 nm)
Passage of the OOCL FINLAND and NORDIC DIANA with corresponding AIS symbols

The detailed analysis of the VDR's audio recording by the investigators began at shortly before the time of the pilot change in Rüsterbergen. A new pilot and a new canal helmsman boarded in Rüsterbergen. Upon assuming his advisory role, the pilot started by specifying the required courses to the helmsman. The ship's command was informed of any special occurrences during the passage. The passage passed without any irregularities up until the audio recording was interrupted.

The immediate approach of the TYUMEN-2 and OOCL FINLAND is illustrated by the following figures. The transmitted AIS data of the TYUMEN-2 (Own Ship) is displayed on the left side and on the right side the data of the OOCL FINLAND.

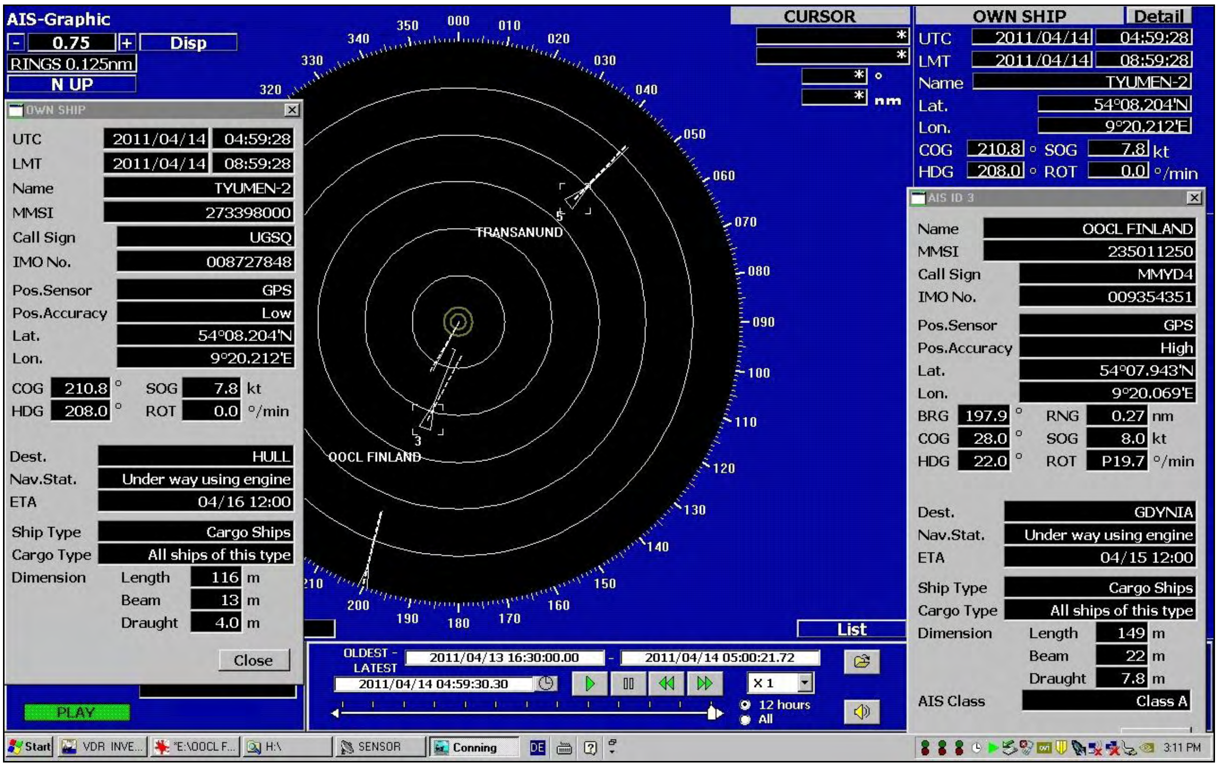

Figure 23: TYUMEN-2, S-VDR, AIS replay, 065928

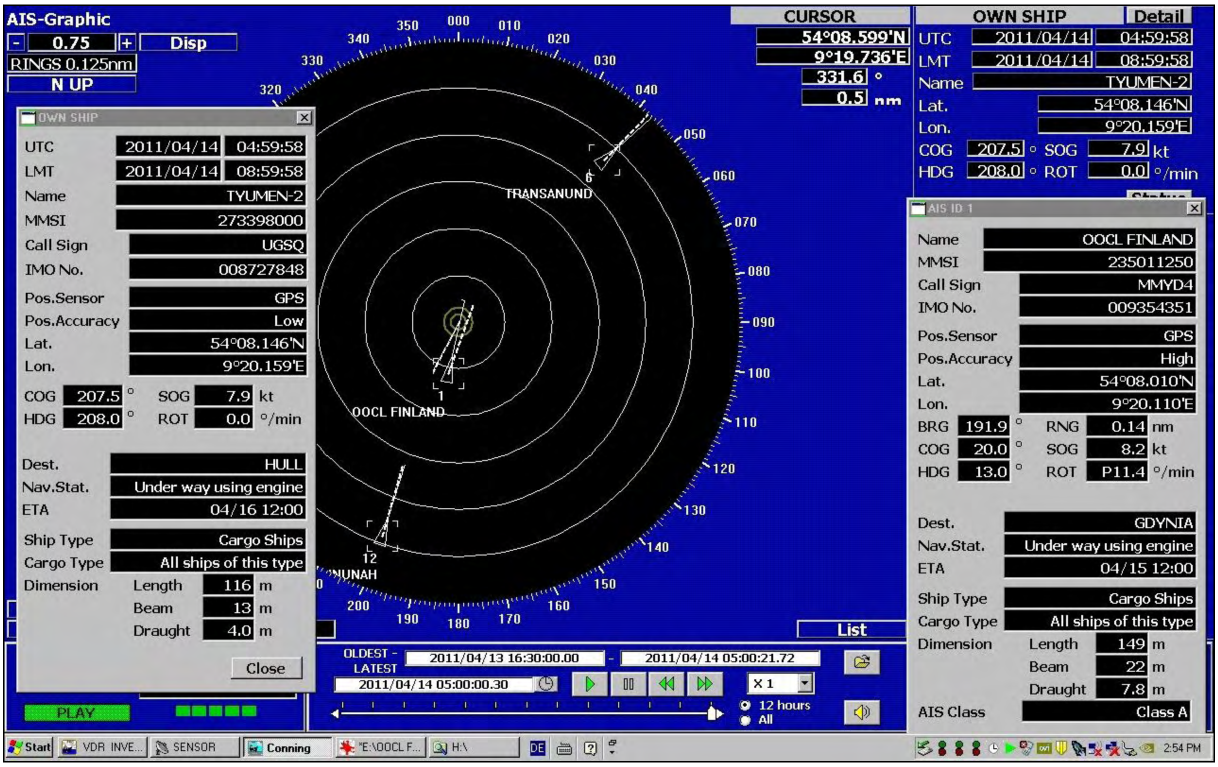

Figure 24: TYUMEN-2, S-VDR, AIS replay, 065958

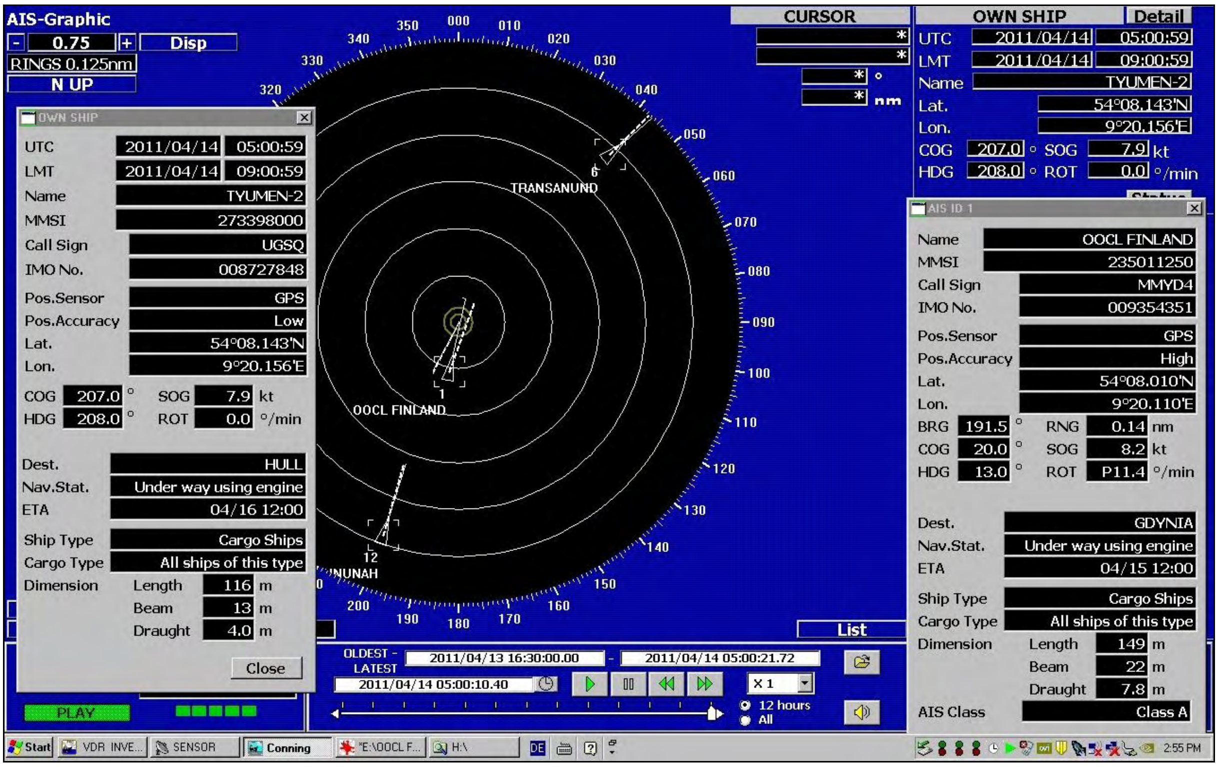

Figure 25: TYUMEN-2, S-VDR, AIS replay, 070059

The TYUMEN-2 ran at the following speeds during the convergence (see Diagram 1)

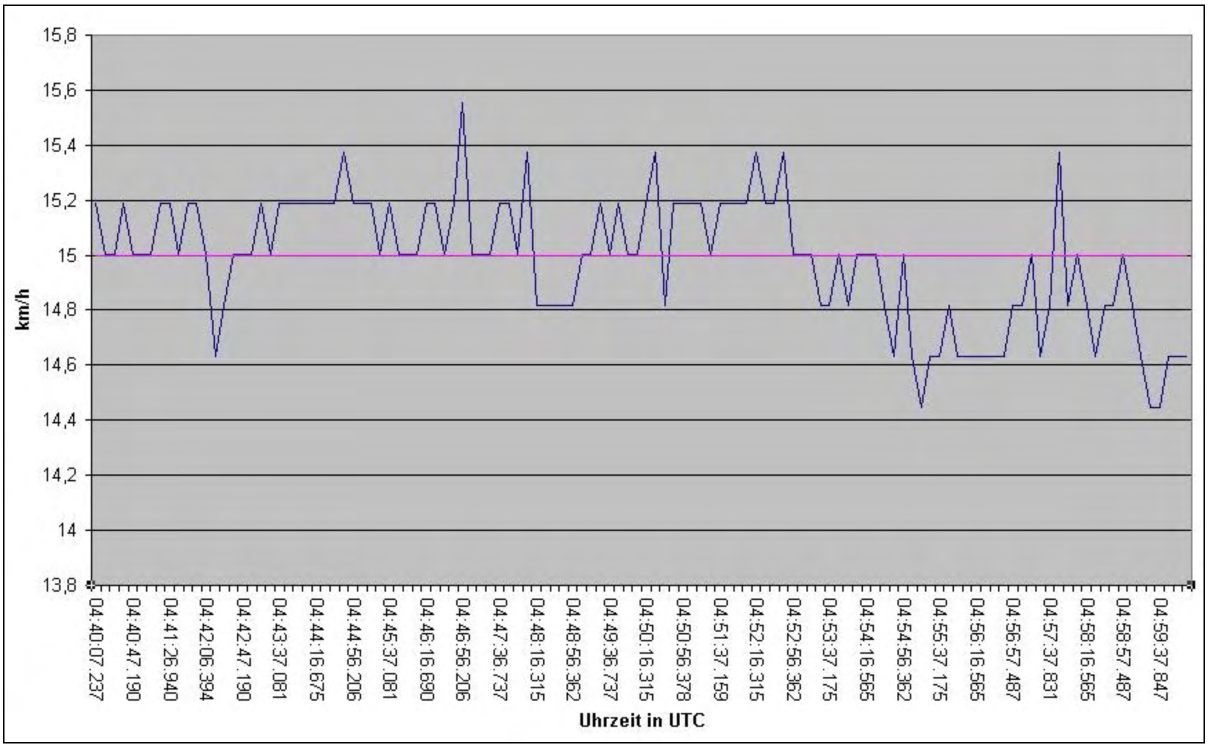

Diagram 1: TYUMEN-2, speed diagram from 064007 to 065937[42] [43]

The TYUMEN-2 was approximately one ships breadth north of the conceived centre line of the canal at the time of the collision. Thereby the distance to the northern shore was about 50 m. This distance remained approximately the same during the time period observed (from 0657 onwards).

3.2.4.3 Other inquiries

The Russian master of the TYUMEN-2 had served as a master since December 1998 at the time of the accident. He assumed command of the TYUMEN-2 for the first time in December 2010.
It was not possible to obtain the timesheets of the crew; however, they were only of secondary importance to this investigation as the ship's command was advised by a pilot and the helm was operated by a canal helmsman. Furthermore, due to the manning level and the route, it is assumed that the crew was not subjected to excessive working hours during the voyage.

The pilot on the TYUMEN-2 had operated in this area for 21 years. The canal helmsman had 10 years experience as a helmsman. An analysis of the working hours of the pilot and helmsman revealed no indication of fatigue.

During the period under consideration from Rüsterbergen until the collision, the master stayed on the port side of the bridge, where he also had access to one of the

[42] Underlying data: AIS recording of the Federal Waterways and Shipping Administration.
[43] The coloured line at 15 km/h indicates the maximum speed permitted on the NOK.

three control options/conning positions for the main engines. The cadet remained near the conning position on the starboard side. The chief engineer was on the port side in the aft area.
The river radar unit on the starboard side of the bridge was used by the pilot. The AIS unit with small display was also situated there. The helm was installed amidships. This is where the canal helmsman operated. The radar unit on the port side was switched off.

According to the master, visibility stood at about 500 m. He had already seen the oncoming OOCL FINLAND on the radar. His ship followed the course of the bend to port. When he noticed the shadow of the other vessel involved in the collision, he attempted to reach the wheel. This was confirmed by the investigation on board the TYUMEN-2. During the investigation of the wreckage of the TYUMEN-2's bridge, it was found that the wheel was set to 'hard to starboard'. The rudder angle indicator was at 5° to starboard.

3.2.5 OOCL FINLAND

The OOCL FINLAND is a container ship with a conventional design. She is engaged in feeder service to/from ports in the Baltic and North Seas. For the cargo, the ship has two lockable hatches with covers in the forward section, a large coverless hatch with a high coaming amidships and a section in front of the superstructures on which containers can be stowed on deck. To protect the forecastle, respectively, the forward deck containers, the ship has a covered forecastle and a large breakwater at the aft edge of the forecastle (see Figures 6 and 26).

The ship was extended by approximately 15 m at the Norderwerft shipyard in 2008 so as to increase cargo capacity. The conversion did not include changing the size of the rudder. The rudder of the original design was calculated by the company IBMV Maritime Innovationsgesellschaft mbH (IBMV). IBMV was not involved in the project to extend the ship as it had since been taken over by another company, which was in competition with the shipyard.

On being questioned, Germanischer Lloyd stated that its rules did not include guidelines for the rudder area. Manoeuvrability could be substantiated by a sea trial after the conversion. The shipyard would be responsible for updating the manoeuvring data. The accuracy thereof would be the responsibility of the owner.

The extension was carried out by the Norderwerft shipyard in Hamburg, which at that time was a subsidiary of the original shipyard. The Norderwerft was requested to answer the following questions, amongst other things:

- What impact did the extension of the ship have on the size of the rudder blade?
- Who carried out the calculation?
- What was the result of the calculation?

The BSU received no answer even on demand.

The view ahead was not obstructed by the cargo on the day of the accident (see Figures 26 and 27). The cargo was evenly distributed across the ship and would not have created an exceptional windage area at higher wind speeds.

Figure 26: OOCL FINLAND, load situation on the day of the accident

The bridge of the OOCL FINLAND is completely closed. It has a conning position from which the ship can be controlled alone or by two people.

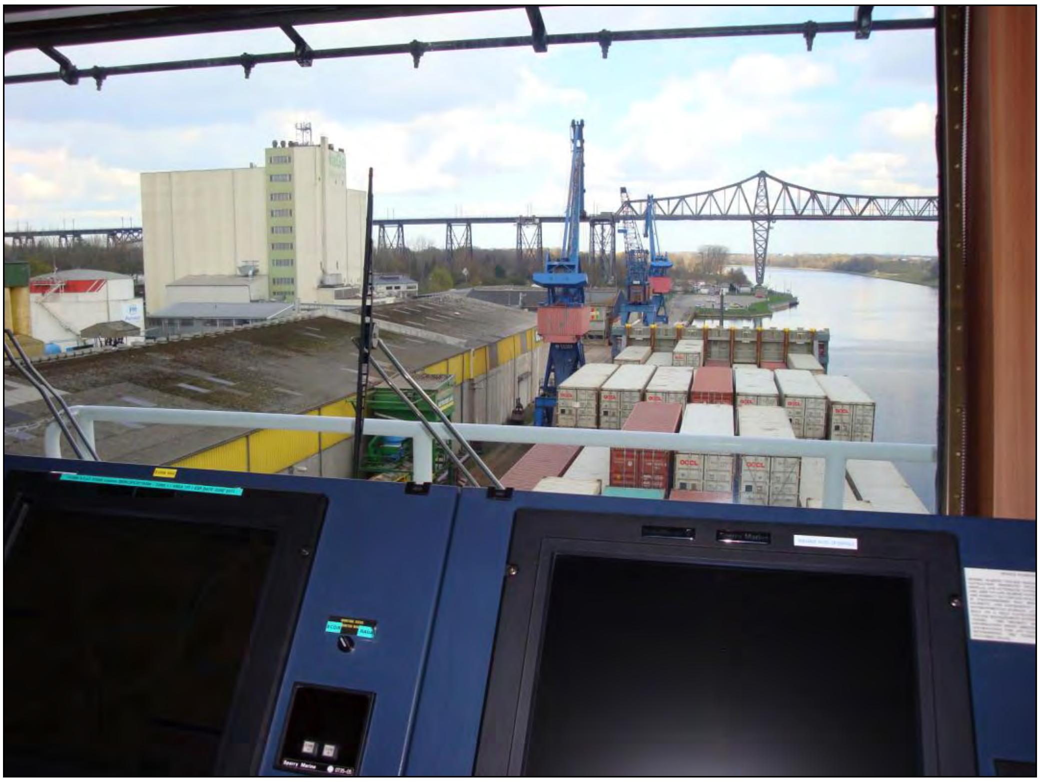

Figure 27: OOCL FINLAND, Rendsburg, view ahead from the pilot's work station

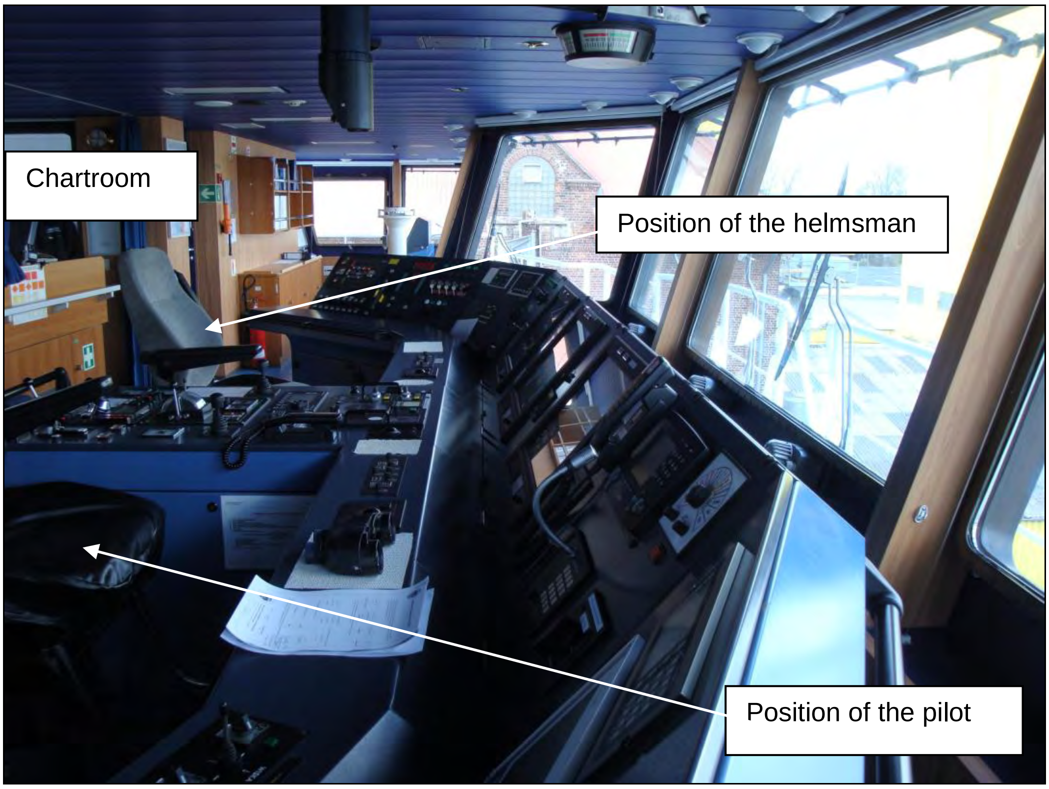

Figure 28: OOCL FINLAND, bridge, view to port

The ship was fully equipped at the time of accident. There was no evidence of defects in the equipment immediately required for commanding the ship. Paper Chart 2469 of the United Kingdom's Hydrographic Office and an electronic chart system were used to navigate through the Kiel Canal. However, this electronic system did not meet the ECDIS[44] functionality approved according to the ship documents[45]. Firstly, it was not possible to exhibit a certificate for the hardware. Secondly, the version of the underlying chart of the manufacturer, C-Map, did not satisfy the requirements of an official ENC[46]. The paper chart corresponded to the latest issue and revision status.

3.2.5.1 Manning on the bridge

The crew of the OOCL FINLAND consisted of seamen of different nationalities. The Polish master's professional experience spanned more than 25 years. He was issued an unrestricted master's license in 1996. He has served as master on the OOCL FINLAND since 2008. Since then, he has transited the NOK regularly.

At the time of the accident, only the third officer, pilot and one of the two canal helmsmen were on the bridge of the OOCL FINLAND. The third officer was Romanian. He began his career as a cadet in 2008 and has worked on the OOCL FINLAND since November 2010. He has served as third officer since February 2011.

[44] ECDIS – Electronic Chart Display and Information System.
[45] Cargo Ship Safety Equipment Certificate and associated Record of Equipment (Form E), issued by MCA on 16 July 2006, latest annual review on 7 September 2010 by a representative of Germanischer Lloyd.
[46] ENC – Electronic Navigational Chart.

According to the ship's command, one of the able seamen was constantly on standby and could have been called on VHF. In the view of the master, there was no need to have a lookout on the bridge for the following reasons:

- information on the traffic situation constantly updated by the VTS,
- coordination of all manoeuvres by the pilot in German,
- the number of officers on the bridge,
- fully operative equipment.

The pilot began his maritime career in 1969 as a trainee able seaman. He served as a deck officer after completing his studies in 1997. From 2004 to 2005, he trained as a pilot at the Lotsenbrüderschaft NOK I (Brotherhood of NOK I Pilots [sic]) and has worked there as a pilot since 2005. He has attended various training courses during this period, such as a course at the Marine Training Center in Hamburg focusing on hydrodynamic effects, navigating in difficult traffic/weather conditions and visibility below 50 m as well as stress, limit and emergency situations in 2009.
According to his submitted records, the pilot has advised on ships of this extended type four times and on ships of a similar size 19 times since 2008.

The canal helmsman began his career in 1986 on German naval ships. This saw him working for a long time as a so-called combat helmsman. He began his training as a canal helmsman in April 2004 and completed this with an examination in September of the same year. Up until the accident, he had completed about 1,600 passages with no accidents. He had steered ships of the same type as the OOCL FINLAND through the NOK some 80 to 100 times.

The submitted timesheets revealed no evidence of fatigue among the people present on the bridge of the OOCL FINLAND at the time of the accident.

3.2.5.2 Performance of the navigational watch

To assess the basic obligations of the ship's command as specified by the operator of the ship when conducting the navigational watch, the relevant excerpts of the manual, which exists in accordance with the ISM Code[47], were submitted by the owner of the OOCL FINLAND. This manual contains, inter alia, the following rules of relevance to the marine casualty investigated:

Section 4.1.2 Navigation:

- “Contents
  The Master’s Standing Orders shall include, but is not limited to,

[47] ISM Code – International Safety Management Code

information on the following:

- […]
- Course position and speed checked frequently
- When to call the Master
- Recording weather conditions and other activities
- […]

- Navigation in Restricted Visibility

  […] When from observation of rain storms or other weather conditions, it becomes apparent that the vessel may encounter restricted visibility, the Officer of the Watch is to call the Master IN GOOD TIME. When restricted visibility is suddenly encountered, he shall call the Master at once. […]

- Navigation with Pilot embarked

  Officers of the Watch are reminded that, despite the duties and obligations of a pilot, his presence on board does not relieve the Officer of the Watch from his duties and obligations for the safety of the ship. He is to co-operate closely with the pilot and maintain an accurate check on the vessel's position and movements. […] Master and Deck Officers must be aware of the dangers associated with hydrodynamic interaction and with the increase of draught due to squat.

- Taking over the Navigational Watch

  […]

  The reliving officer should not take over the watch until […] he has personally satisfied himself regarding:

  - Standing orders and other special instructions from the Master relating to the safe navigation of the ship
  - Position, course, speed and draft of the ship
  - Prevailing […] weather, visibility and the effect of these factors upon course and speed
  - […]"

On board the OOCL FINLAND, the investigators were given copies of the applicable instructions of the master (Master's Standing Orders) and the applicable instructions of the master for the night watch (Master's Night Order Book).

The instructions for the night watch contained a large number of standing orders. None of the instructions concerned voyages on the NOK in the absence of the master.

The applicable instructions of the master contained a plurality of instructions for the watch at sea and in port. Particularly relevant in the case investigated were:

Item 7: “Officers are to read the Company […] regulations and carry out duties prescribed therein.”

Item 8: “CALL THE MASTER TO THE BRIDGE WITHOUT ANY DELAY IF: A/ restricted visibility encountered […]”

Item 11: “UNDER PILOTAGE. An accurate record of the Ship’s passage […] is to be kept in the Movement (Bell) Book and the Deck Log Book. Pilot does not relieve use from our duties. The ship’s safety during the whole passage should be monitored and supervised both by Master and OOW.”

Both instructions were acknowledged and signed by the third officer.

3.2.5.3 Statement of the ship's command

In his statement, the master essentially referred to the time before and after the accident when he was present on the bridge.

In his statement, the third officer addressed the situation on the bridge, amongst other things. According to his statement, shortly before the accident the third officer noticed a movement of the ship to port. The conversation held between the pilot and helmsman in relation to that was in German and therefore not understood by him. However, he noticed that the rudder was set to 'hard to starboard'. He was unable to judge the position of the ship in the canal due to visibility. Immediately after the collision, he noticed the TYUMEN-2 heel heavily to starboard and an abrupt course alteration to starboard. The third officer started the bow and stern thrusters immediately after the collision and informed the master about the incident. Later, he was sent to the chief officer to assist him in establishing the damage to the ship.
In an additional statement, he reported that he did not inform the master about the deterioration in visibility because he had assumed that this had already been done by the second officer. The second officer had not informed the master.

3.2.5.4 Statement of the pilot

The pilot stated that the following tools had been at his disposal: radar, display of ship's rate of turn, electronic chart and gyro compass with analogue 10° graduation. According to the pilot, the radar unit he was using was set to the following operating mode: head-up display, 0.5 nm range, first variable range marker (VRM) at 0.37 nm

to assist in course alterations in bends, second variable range marker at 0.03 nm to determine lateral distance. The pilot pointed out in his statement pertaining to the draft report that the distance to the embankment was continuously monitored by means of the range marker and never fell below the margin.
The radar unit located on the left side was, as usual, set to standby so as not to interfere with the helmsman sitting in front of it. Due to the visibility (between 50 m and 150 m), orientation was carried out solely by means of the right-hand radar unit.
At a propeller pitch of less than 40%, corresponding to a speed of about 8.3 kts, he estimated the steerability of the OOCL FINLAND to be poor. He stated that directional stability would have only been attainable with rudder angles of 20° to each side.

3.2.5.5 Statement of the helmsman

The helmsman stated that visibility was good until canal kilometre 20 and then started to deteriorate. From kilometre 27/28, the route ahead was no longer discernible. Visibility had deteriorated to about 100 m at the time of the accident.
The following equipment was used at the time of the accident: gyro compass, radar unit and a rudder angle indicator. The gyro compass course and the radar track display were coupled at the time of the accident.
He steered according to the instructions of the pilot and while doing so made use of the gyro compass and rudder angle indicator.
The helmsman stated that depending on the load and draught and as compared to the non-extended type, these ships are more difficult to manoeuvre. Their response to course alterations was significantly poorer.

The second helmsman of the OOCL FINLAND said something similar. He stated that after the extension, the ship was significantly harder to steer and could be controlled only with relatively large rudder angles when at lower speeds and close to the embankment.

3.2.5.6 Analysis of the OOCL FINLAND's voyage data recorder

The ship was equipped with a type 100 G2 voyage data recorder manufactured by Rutter, which had the full range of features. Hence, data for the rudder, main engine and propeller pitch, for example, were also available.
The VDR on board the OOCL FINLAND was read with the help of a service technician. The data were copied directly from the hard drive of the central processing unit to a portable storage medium belonging to the BSU. Since the control panel of the VDR on the bridge was defective, it was not possible to effect an emergency backup. The data were analysed at the BSU.

The VDR only recorded the data of the radar not used by the pilot on the left side of the bridge console, and thus located in front of the canal helmsman. This radar was operated in the following mode: centred north-up display, 1.5 nm range, no range markers.

The detailed investigation of the course of the voyage of the OOCL FINLAND began with the ship's call at the lock in Brunsbüttel. The helmsman boarded at 0437 and soon after that the pilot also reached the bridge. The pilot was thus able to hear the situation report at 0446. This made reference to restricted visibility of 300 m in the area of Breiholz. The ship left the lock at 0451. After discussing the further course of the voyage, the master left the bridge at 0500. From that point, the bridge of the OOCL FINLAND was manned by a watchkeeping officer, the pilot and a helmsman. In the situation report of 0515, the restricted visibility was extended to the area "from east to beyond Burg."
The ship passed the viaduct at Brunsbüttel at 0520. Visibility worsened at 0525. The speed at this point was 8.5 kts. The pilot told the helmsman that he would not proceed at this speed in fog since with this ship any manoeuvre had to be initiated promptly when in a convoy. The statements below followed: "She turns quite well. She also has a few small problems with the air."
The ship ran at between 8.5 and 8.9 kts up until 0550. At 0550, the pilot started to announce the required courses for the canal helmsman due to the continuing deterioration in visibility. From that point, the speed stood at between 8.4 and 8.5 kts.
The upcoming vessel RHODANUS[48] on the canal stretch between the ferry Burg and the viaduct Hochdonn (approx. ckm 17) was passed with 8.5 kts. The visibility was about 0.25 nm.
At 0600, the third officer relieved the second officer and 12 minutes later the viaduct at Hochdonn was passed.
The following restrictions in visibility were announced in the 0615 situation report: Kudensee 200 m eastward, Hochdonn 200 m to 300 m, Burg 300 m, Oldenbüttel 300 m and Breiholz 300 m.
At 0617, the ship sailed into the siding at Dückerswisch. To improve steering behaviour, the speed was increased by adjusting the propeller's angle of attack[49] shortly beforehand. That resulted in an increase in speed to 9.2 kts.
At 0632, the ship passed the viaduct at Hohenhörn at 8.4 kts.
At 0648, the pilot of the OOCL FINLAND asked the VTS to reactivate the canal lighting and it was put back into operation.

The course of the voyage between 064909 and 070100 is shown in Spreadsheets 1 and 2 below. In the 'Action' column, 'H' stands for the canal helmsman and 'P' for the pilot.

[48] Gross tonnage: 2056, Length: 89 m, Breadth: 12 m, Draught: 4.5 m.
[49] Propeller pitch.

Time	Action	Speed [kts]	Pitch - Order	Pitch - Response	Rudder angle [°]	Rate of turn [°/min]	Distance to TYUMEN-2 [nm]
06:49:09	H: "*Yes, now you can give courses directly* ." P: "*Yes, I can already see that you wobble around*.	8,3	41,36	34,5		3,3	
06:50	The pilot increases the pitch because of the oncoming vessel in the bend.	8,1	42,57	34,52		9,3	
06:52	P: "*He will lose speed as soon as he gets to the edge* ."				8,1	-1,3	
06:55		8,3	42,69	34,52			
06:55:30	P: "*Move round to 16° now so that we give the other one some space* ."						
06:55:41	P: "*The one in front has also moved to the edge a bit* ." The viaduct at Grünental is passed.						
06:56:49	The NORDIC DIANA is now visible at 0,18 nm.						
06:57:38	The NORDIC DIANA is passed.	8,3	42,69	34,52			
06:58:09	P: "*We still need 28°* ." "*Yes, go to 30 directly, yes; otherwise there will be a problem with the other one* ."	8,4	42,69	34,52	25		
06:58:32	P: "*Yes, perfect. 30 is good* ."	8,4	42,69	34,52	2		
06:58:43	P: "*We are on the edge, but that will be balanced out directly when it has passed* ."	8,1	42,69	34,52	1,5		0,48
06:58:56	P: "*Must compensate a lot.*"	8,1			16	-13,1	0,41
06:58:59	H: "*Yes* ."				35	-11,1	

Table 2: Course of the voyage of the OOCL FINLAND between 064909 and 065859

Time	Action	Speed [kts]	Pitch - Order	Pitch - Response	Rudder angle [°]	Rate of turn [°/min]	Distance to TYUMEN-2 [nm]
06:59:02	P: "*I will give him one on the head*."		53,24	44,03	35	-15	0,36
06:59:32		8,1	54,89	45,21	35	-16,7	0,26
06:59:34	P: "*He is coming?*" H: "*No.*"	8,1	54,89	45,21	35	-19,3	0,23
06:59:39	P: "*Not coming?*" H: "*Still turning to port*."	8,1	56,29	45,21	35	-21,6	
06:59:48	P: " *He is right ahead of us*."	8,2	61,44	50,69	35	-17,6	0,2
06:59:52	P: "*(Violent reaction)*"	8,2	61,44	50,69	35	-11,9	0,18
06:59:58	P: "*I will slow down*." H: "*Yes.*"	8,2	61,69	50,69	35	-9,8	0,14
07:00:09			32,4	26,4		16,4	
07:00:12	P: "*(Violent reaction)*"	8,1	42,69	30,83	32,6	6,3	0,09
07:00:14	Something falls to the ground.	7,9	46,76	38,02	32,4	3,2	
07:00:16	P: "*Are you hard-over?*" H: " *Yes, hard-over.*"				32,4		
07:00:25	P: "*We will be on the embankment in a minute. I will reduce the speed*"	7,9	35,9	40,86	26	22,1	
07:00:29	P: " *Kiel Canal 2 - OOCL FINLAND, Kiel Canal 2 - OOCL FINLAND, we have just had an accident with the TYUMEN-2*."	7,8	0,7	0	35	40,8	
07:00:49	P: "*OOCL FINLAND has just rammed the TYUMEN-2*."						
07:01:00	P: "*Now I will give him another one on the head*." H: "*Yes, it's coming*."	7,1	4	0	26,1	50,7	

Table 3: Course of the voyage of the OOCL FINLAND between 065902 and 070100

Diagram 2 provides the presentation of Rate of Turn and ruder angel from 0640 to 0713.

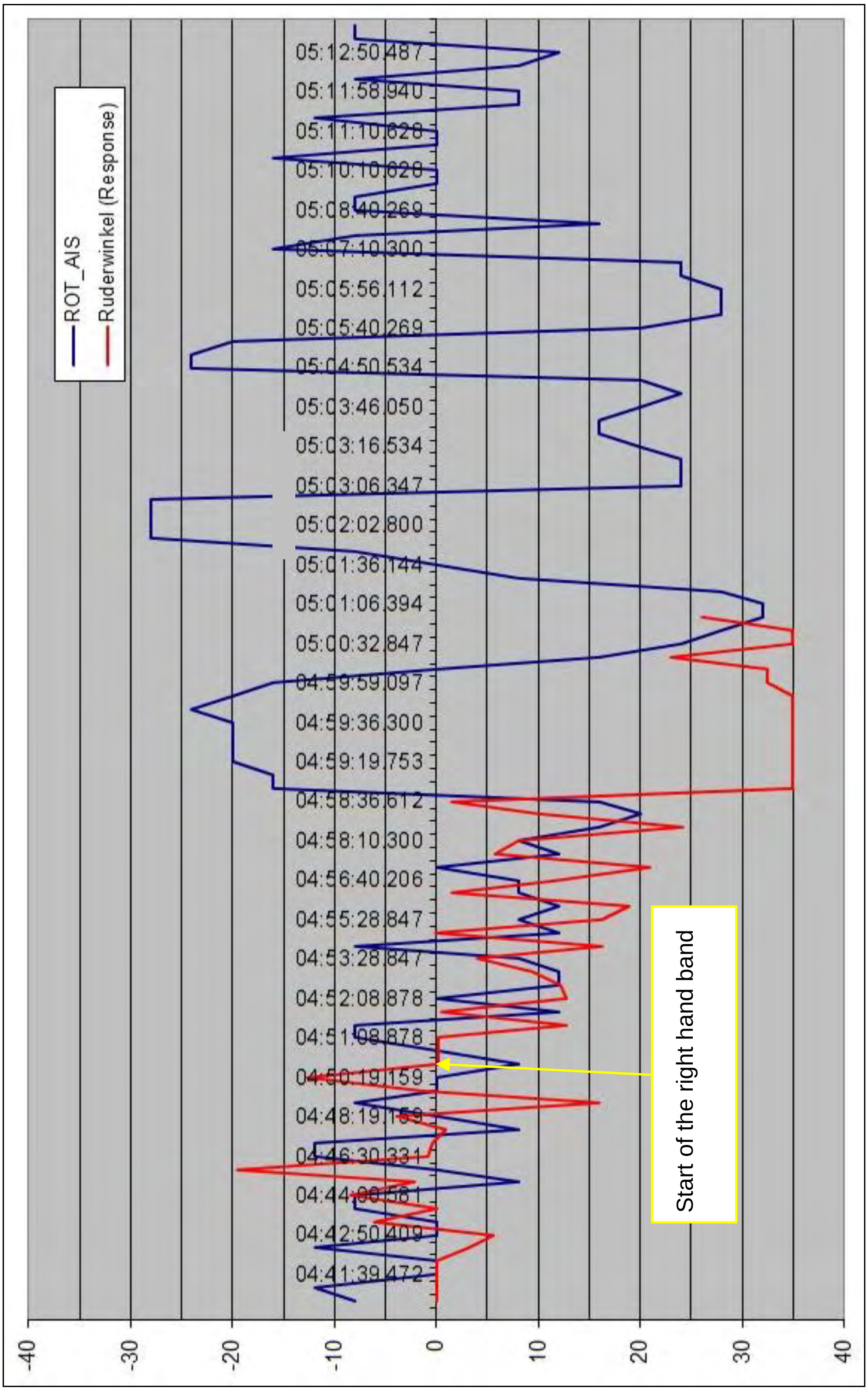

Diagram 2: OOCL FINLAND, rate of turn [°/min][50] and rudder angles [°]

[50] Rate of turn from the AIS recording and rudder angle from the VDR.

In the period after 0701, the pilot and helmsman attempted to stabilise the course of the OOCL FINLAND again to prevent a collision with the CLIPPER SUND or the embankment. They communicated with each other accordingly. The collision with the TYUMEN-2 and its impact were also the subject of brief remarks. Meanwhile, at 070126, the pilot asked the third officer to call the master to the bridge.

At 070130, the pilot announced that the OOCL FINLAND would continue her voyage on the VHF channel used by pilots. In doing so, he had erroneously responded to the call by the ESHIPS BAINUNAH, which had called the TYUMEN-2 on the same VHF channel to establish her position on the canal. The reason for the error was that the pilot of the ESHIPS BAINUNAH called the pilot of the TYUMEN-2 to ask him if he was on the right side[51] without naming his own ship.

The master entered the bridge at 070425 and soon after that the CLIPPER SUND was passed without incident.
At 070632, the pilot asked to the master to send a crew member to the forecastle to sound the tanks. The ship's command then started to organise initial actions.
At 0714, the ship passed the ferry at Fischerhütte. Shortly afterwards, the pilot gave the helmsman the required courses again.

At 0718, the master was informed that a person had reportedly been found on the forecastle. The master informed the pilot of this with the following words: "We have a man on board. He is moving. Forward looks like some scratches." The pilot then asked: "But no leakage?" The master replied: "No, no, looks like one container is damaged and some damage to the vessel."

After conferring with the pilot station, the pilot notified the master at 0719 that he would accompany the ship to Kiel because of the collision.
At 0721, the pilot informed VTS NOK (call sign: Kiel Canal 2 – KC2): "No water ingress found. Only damage to the ship and a container." The question about the cause of the collision by the VTS was answered with a concise "Pushed away." The remainder of the conversation was as follows:

KC2	"You've pushed away?"
Pilot	"Yes."
KC2	"Where hit?"
Pilot	"On the area of the superstructures. With the forecastle, with my forecastle, the area of the superstructures."
KC2	"Yes, because nothing's happening there. I suppose it's a blackout."
Pilot	"Yes, that didn't look good."

[51] The first call at 070130 (see also Figure 7): "TYUMEN, where are you now?" Following that, two calls on the pilot channel without stating any name ("On the right side?"). Then (070209 and 070240) calls without naming the calling ship.

At 0725, the master received further information about the person on the forecastle. At 0726, the pilot was given to understand that the ship had an unknown person on the forecastle who needed "emergency assistance." The master added that the person is unconscious but breathing.
At 0726, the pilot forwarded this information to Kiel Canal 2:

Pilot	"We have an unconscious person on deck."
KC2	"You have an unconscious person on deck. Okay, I'll call the fire brigade."
Pilot	"I'll stop in Oldenbüttel so that the ferry can approach."
KC2	"Okay."

In the further course of events, the condition of the person found, continuation of the voyage and making fast in Oldenbüttel were discussed between the pilot and ship's command. The ship was moored in the siding at Oldenbüttel at 0737.

3.2.5.7 Analysis of the AIS

The AIS data were made available by the Federal Waterways and Shipping Administration. Excerpts of a video prepared from that by WSA Brunsbüttel are used to illustrate the course of the voyage below.

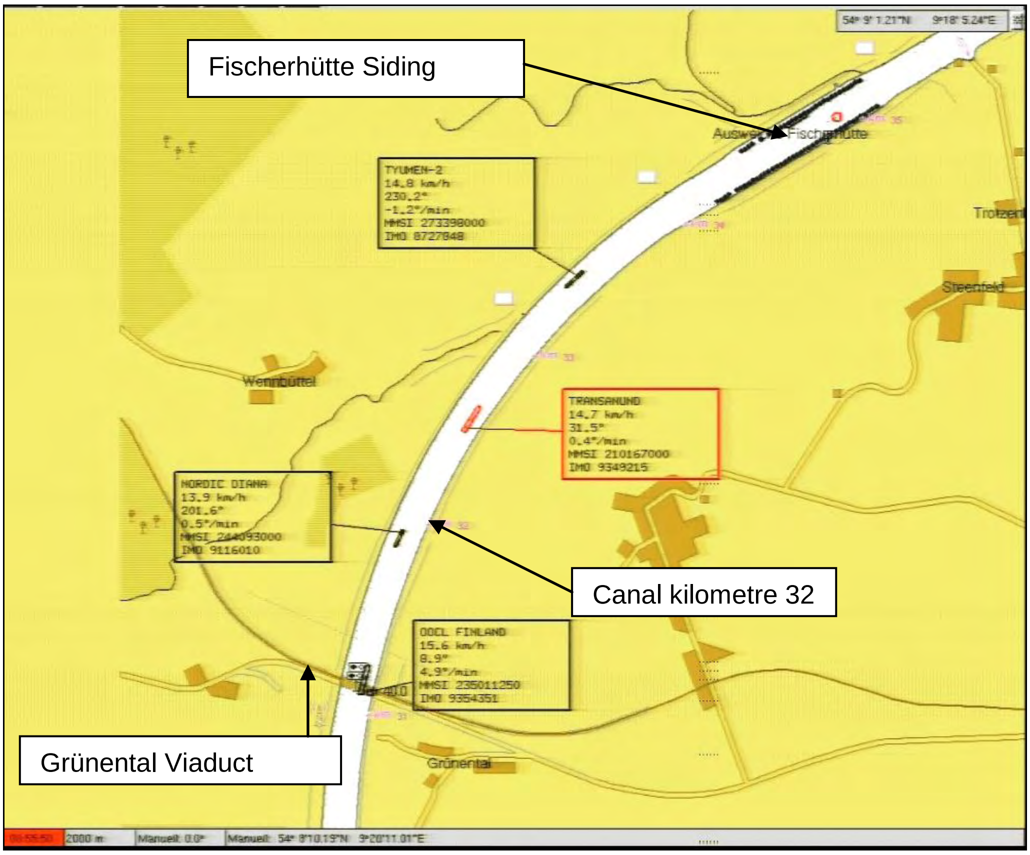

Figure 29: AIS display at 065550, overview

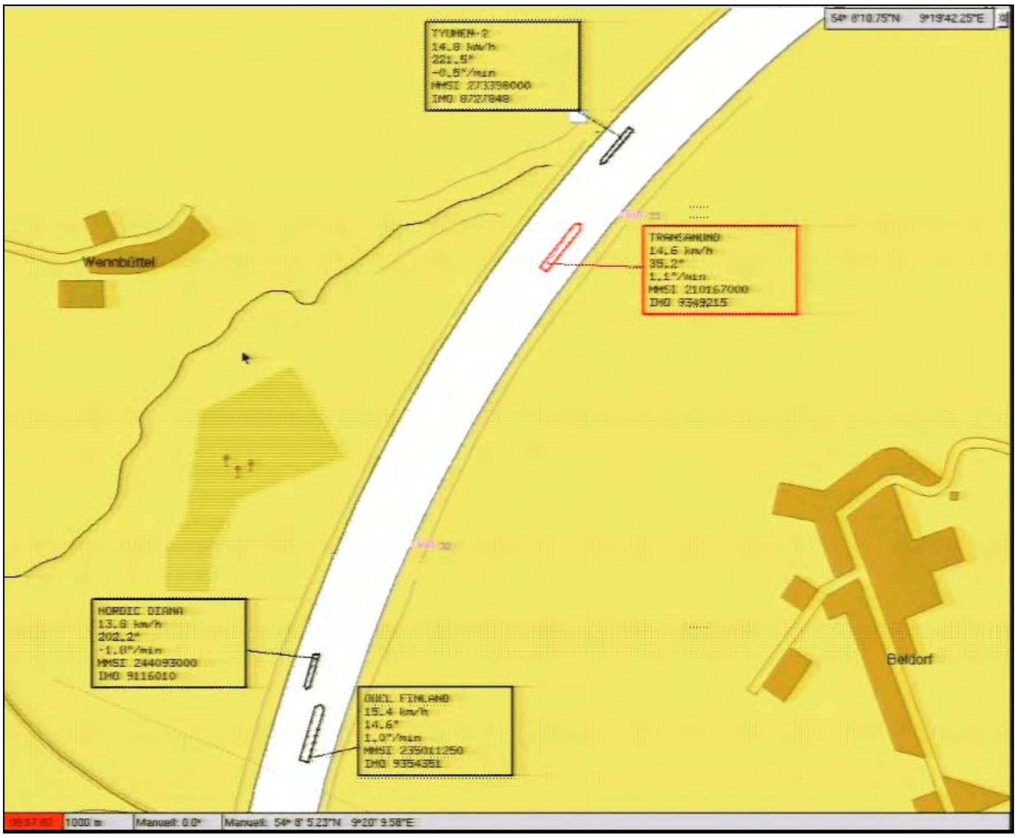

Figure 30: AIS display at 065700

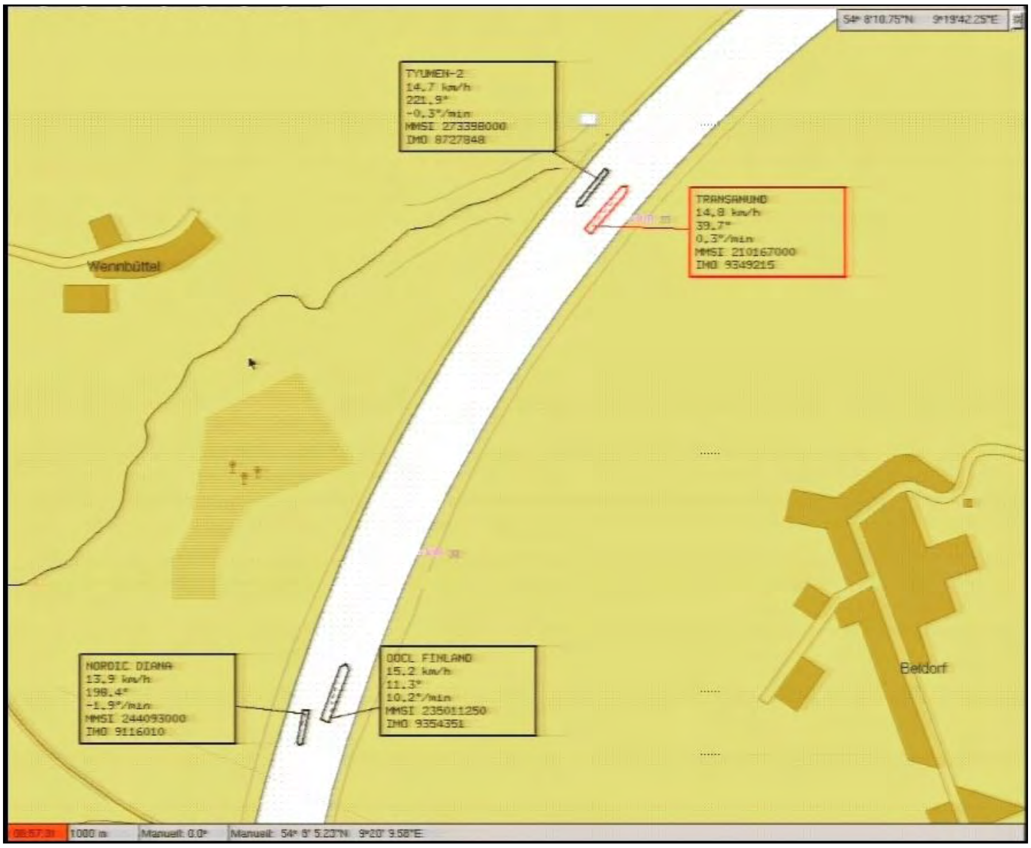

Figure 31: AIS display at 065730

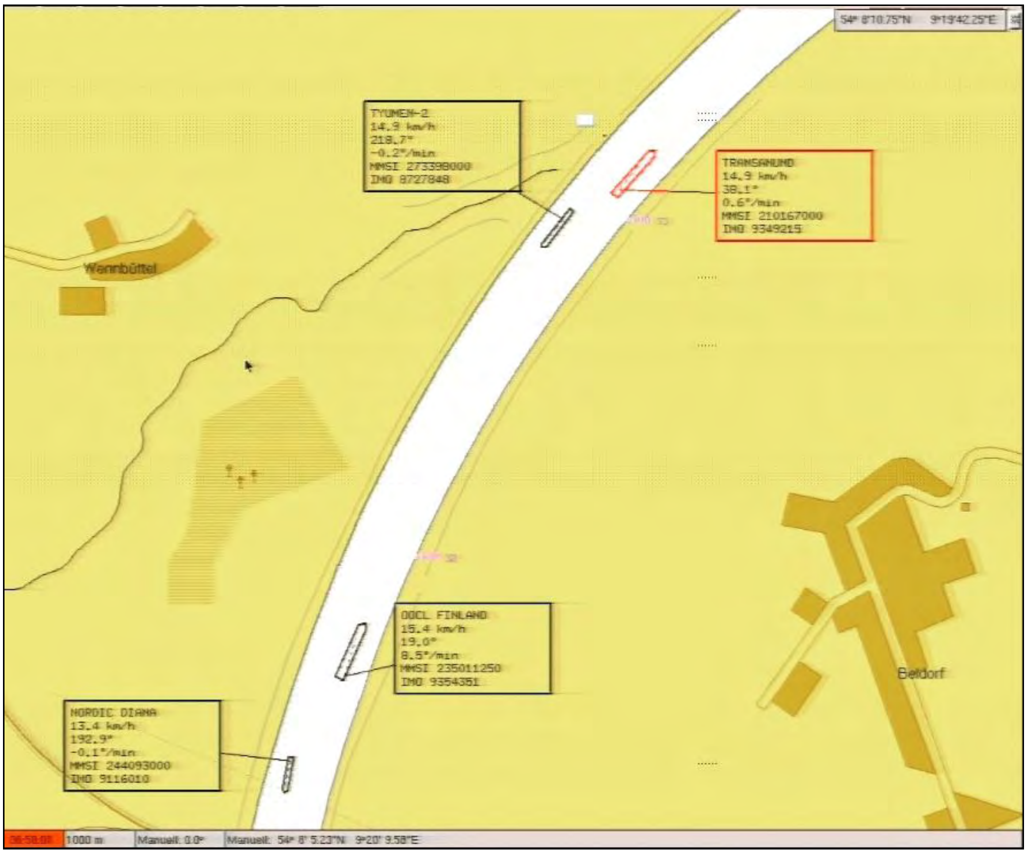

Figure 32: AIS display at 065800

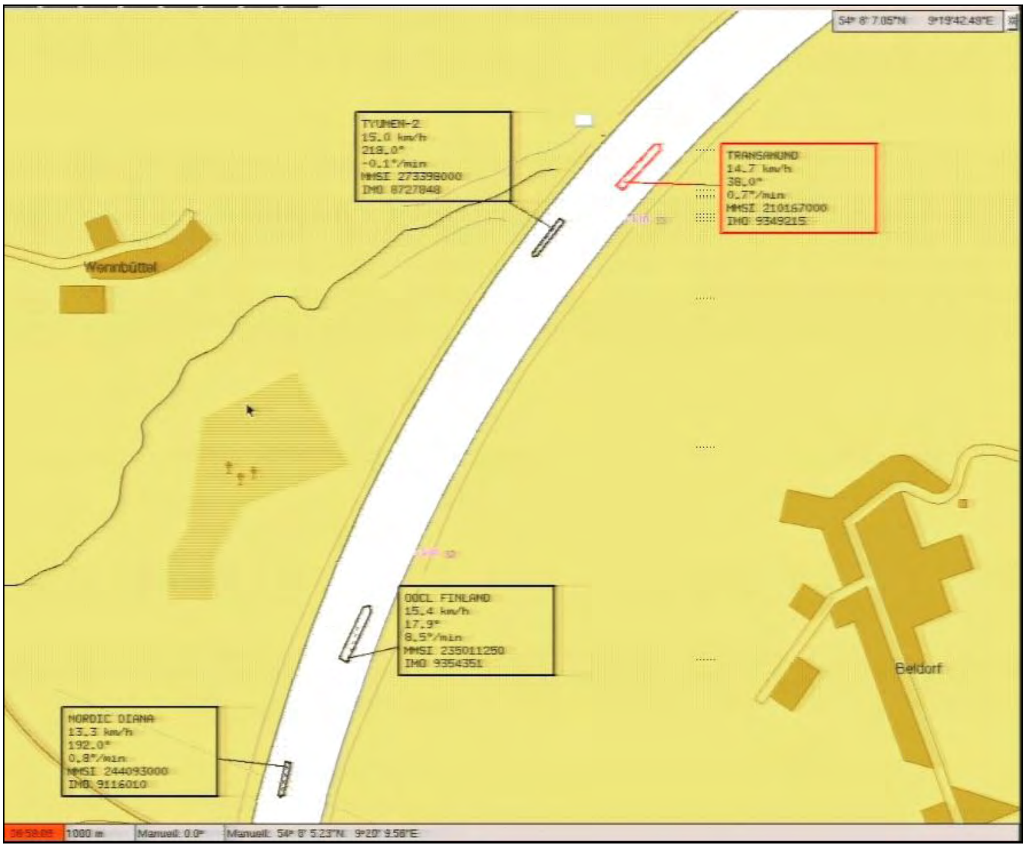

Figure 33: AIS display at 065809

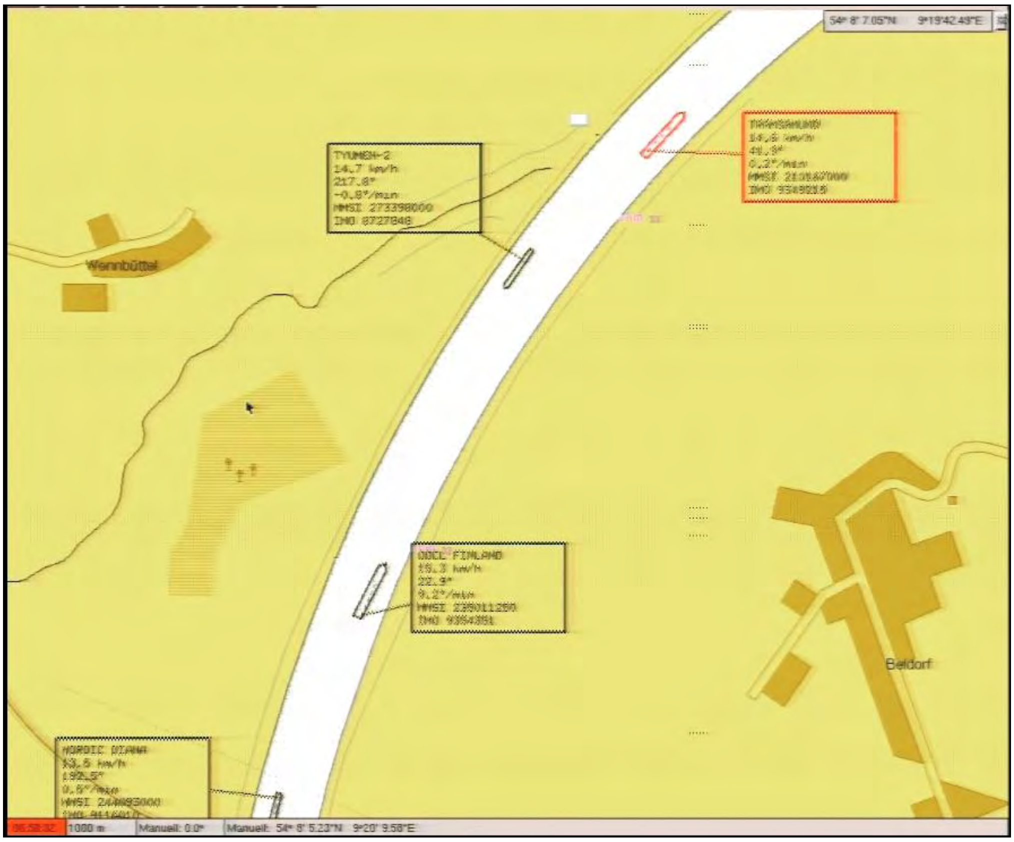

Figure 34: AIS display at 065832

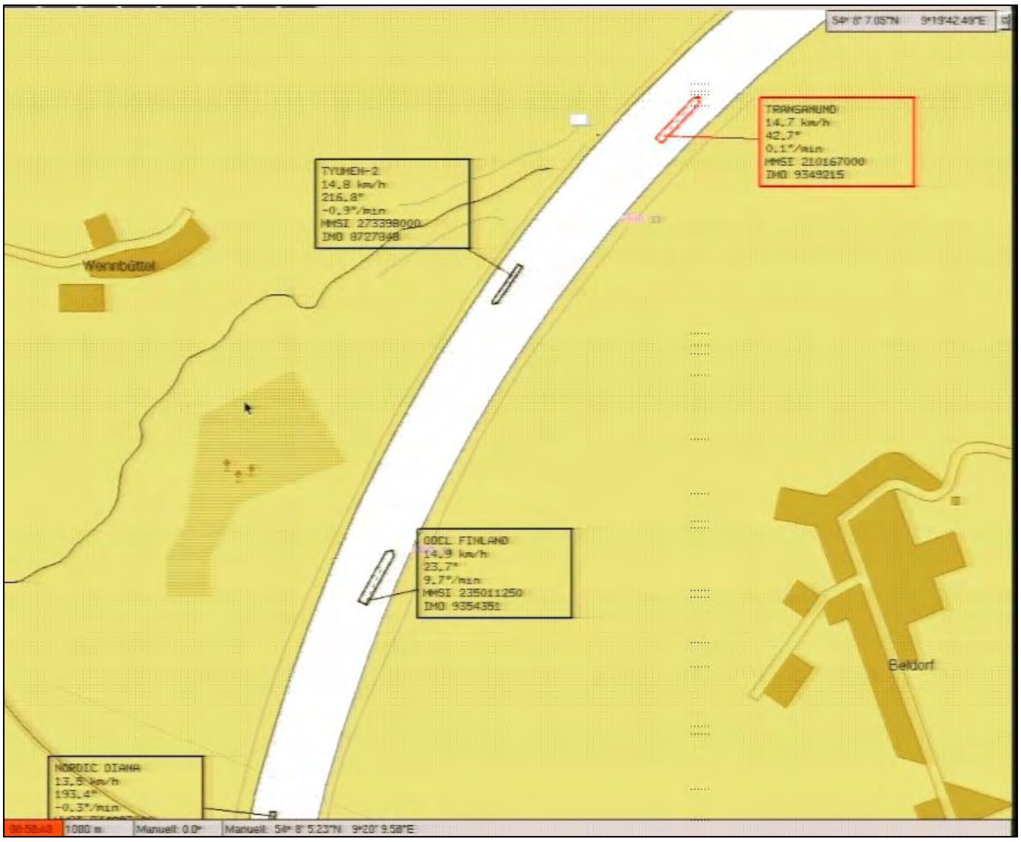

Figure 35: AIS display at 065843

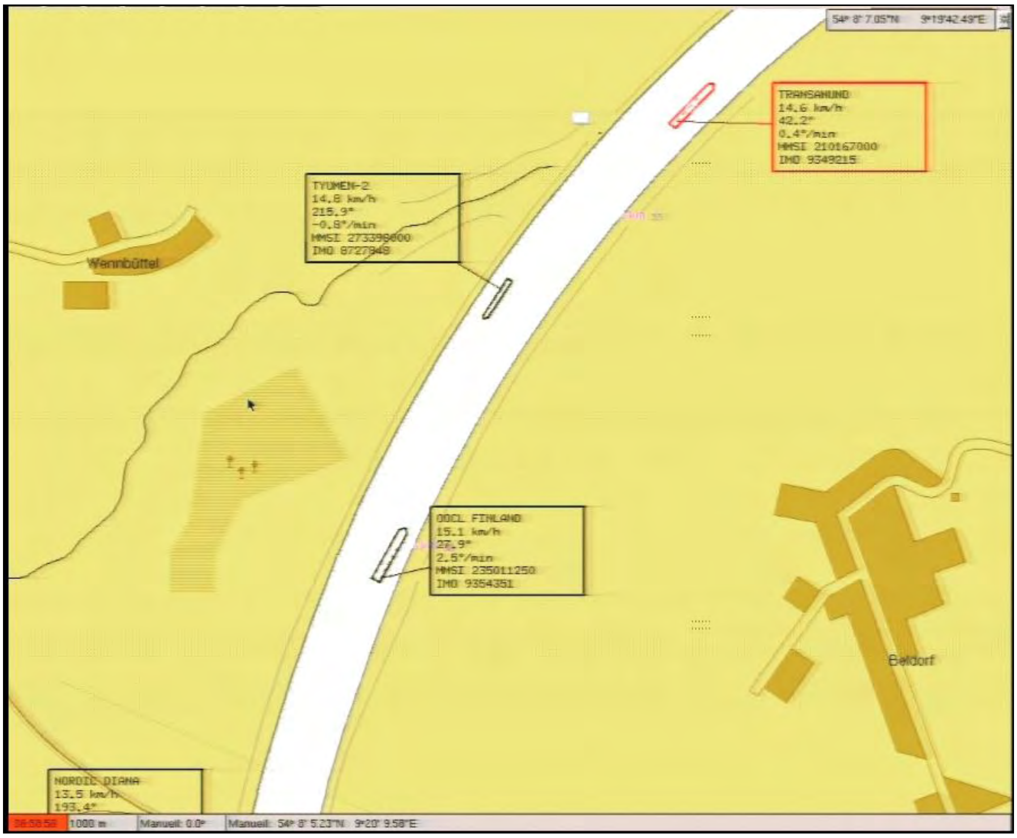

Figure 36: AIS display at 065856

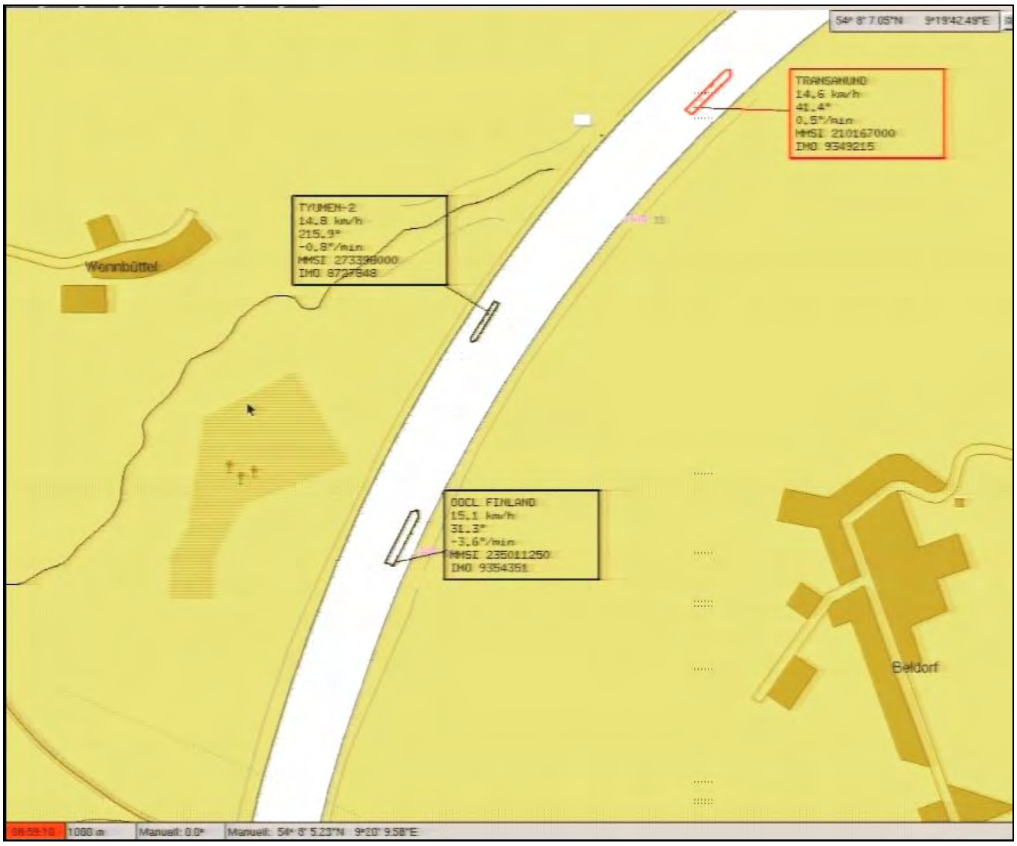

Figure 37: AIS display at 065910

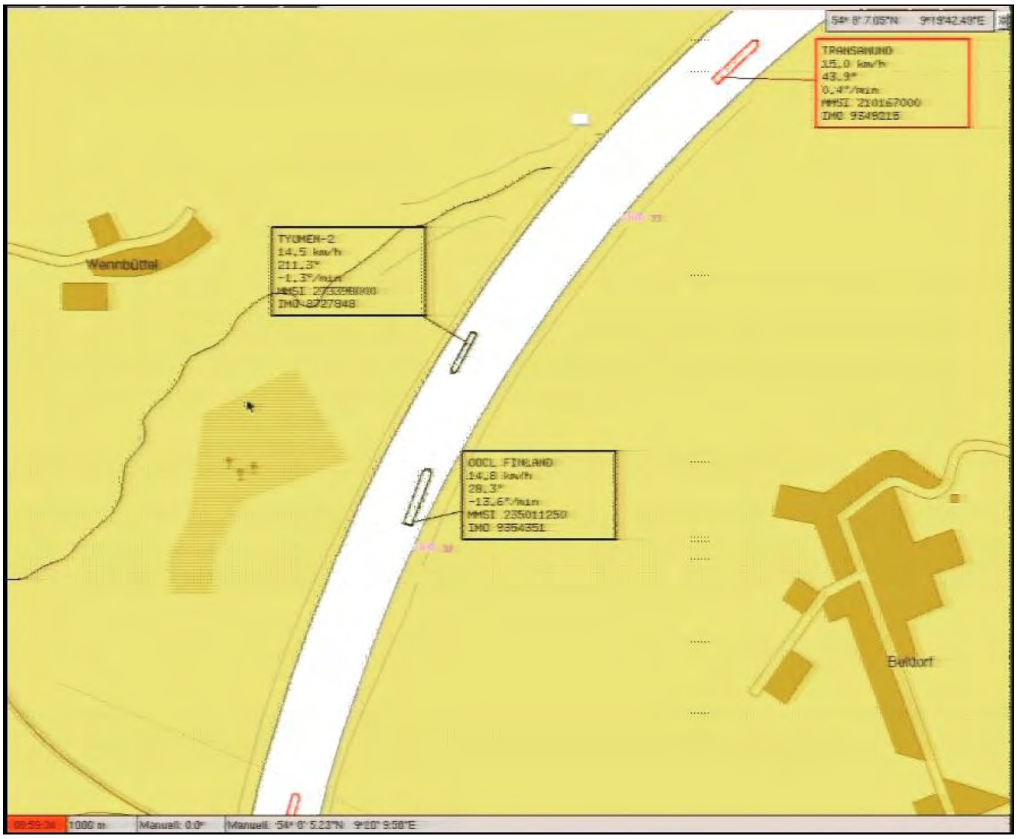

Figure 38: AIS display at 065934

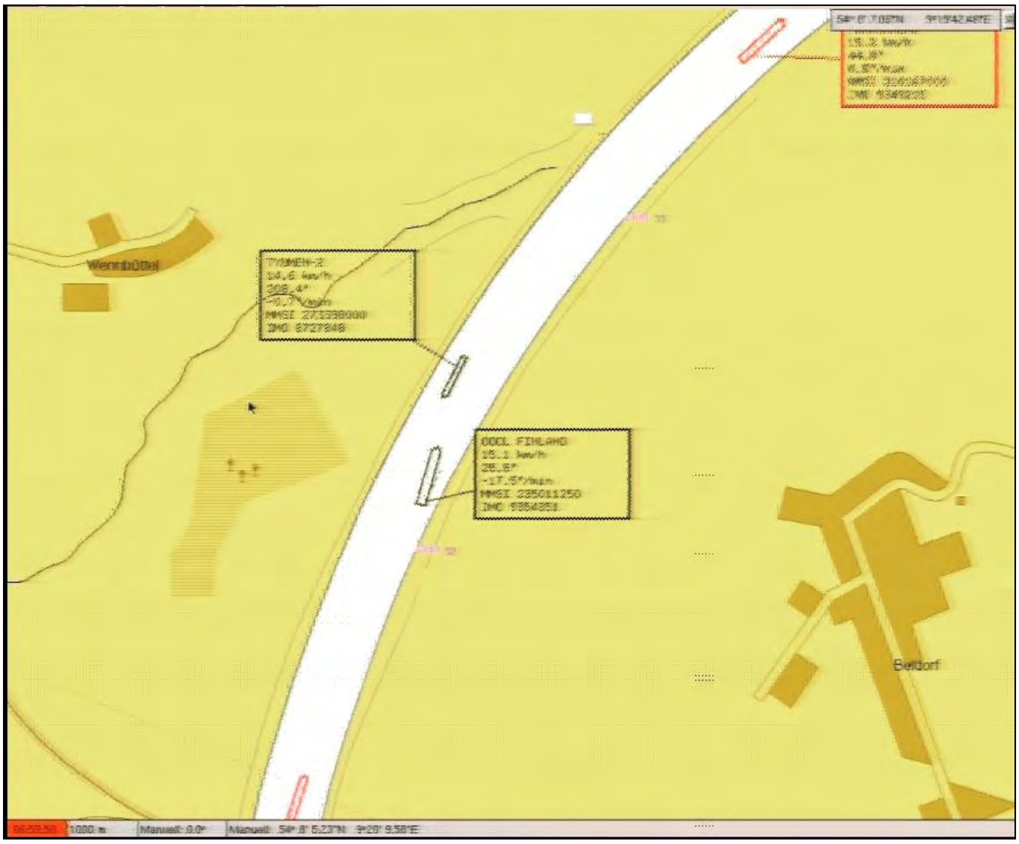

Figure 39: AIS display at 065950

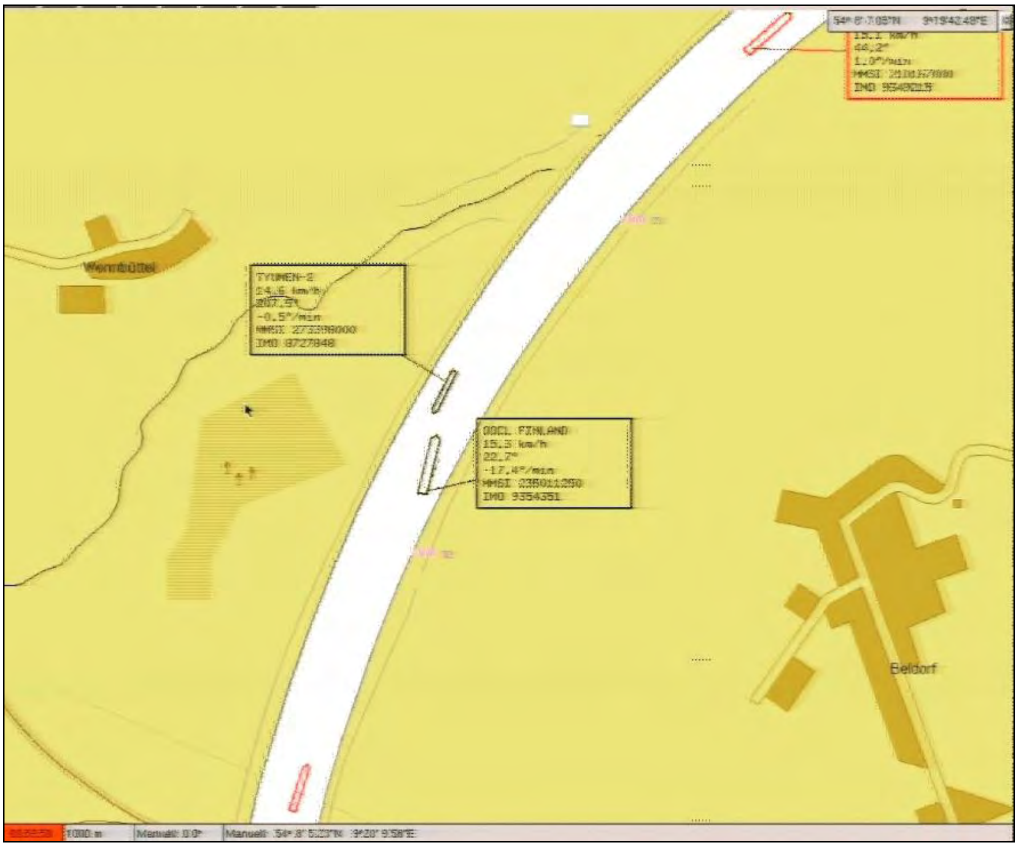

Figure 40: AIS display at 065958

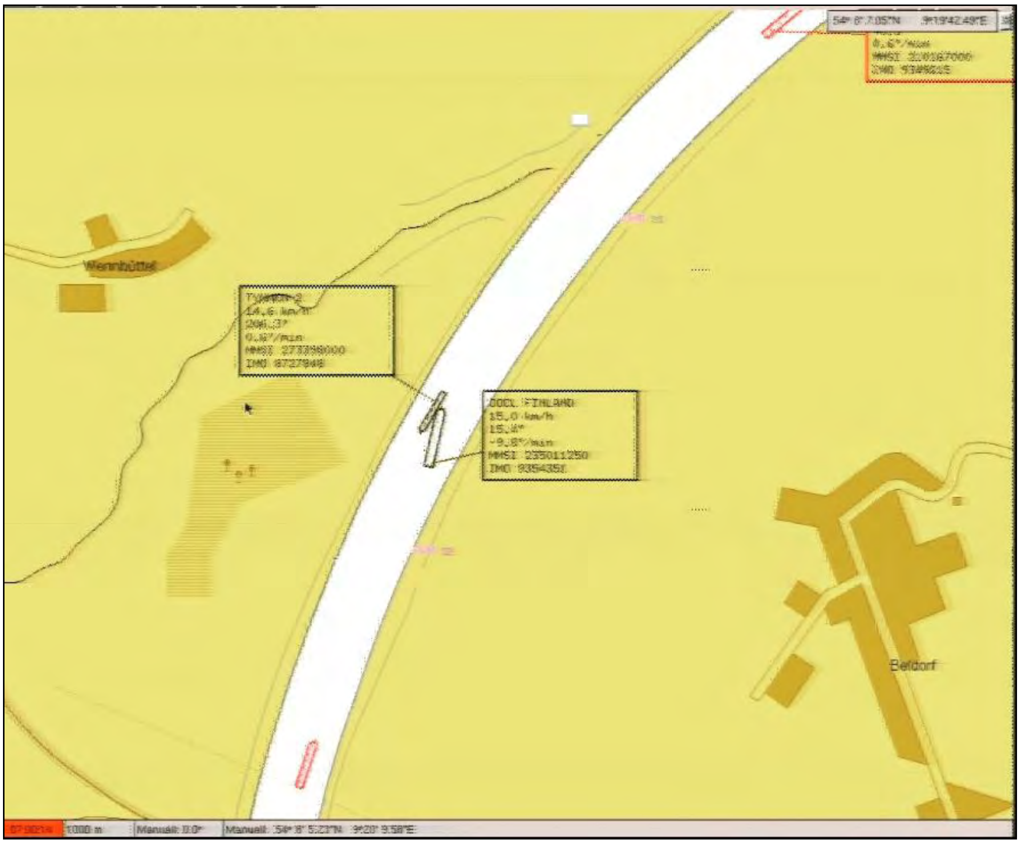

Figure 41: AIS display at 070014

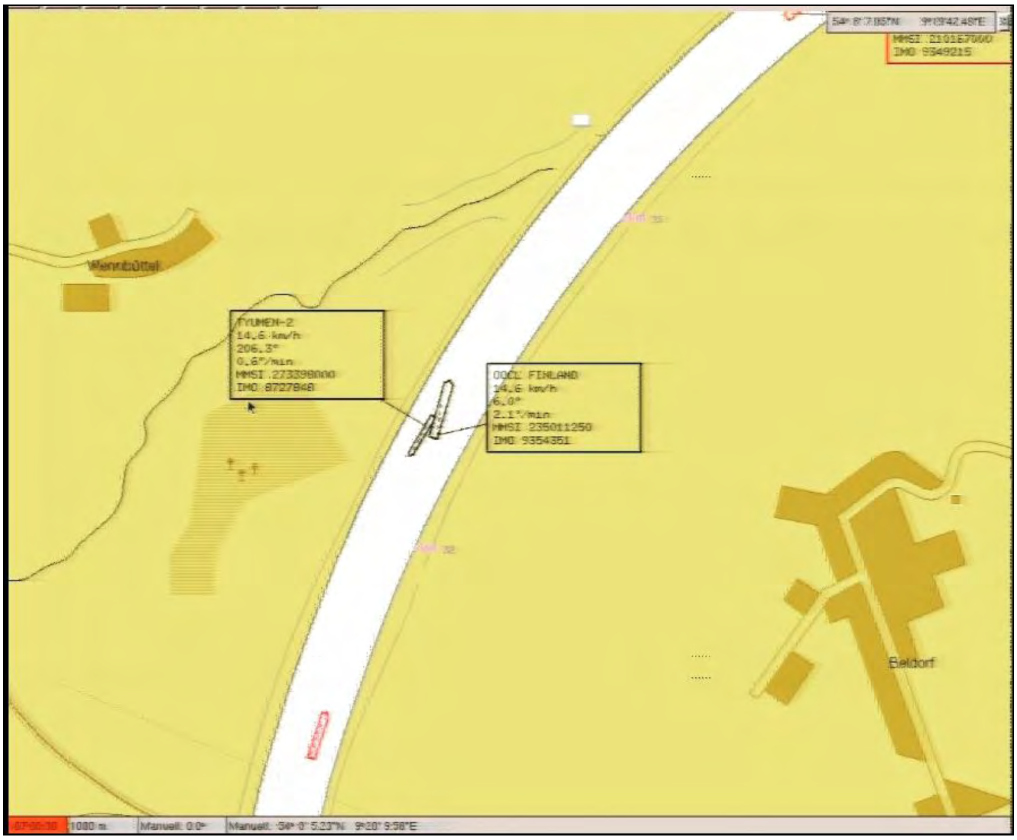

Figure 42: AIS display at 070030

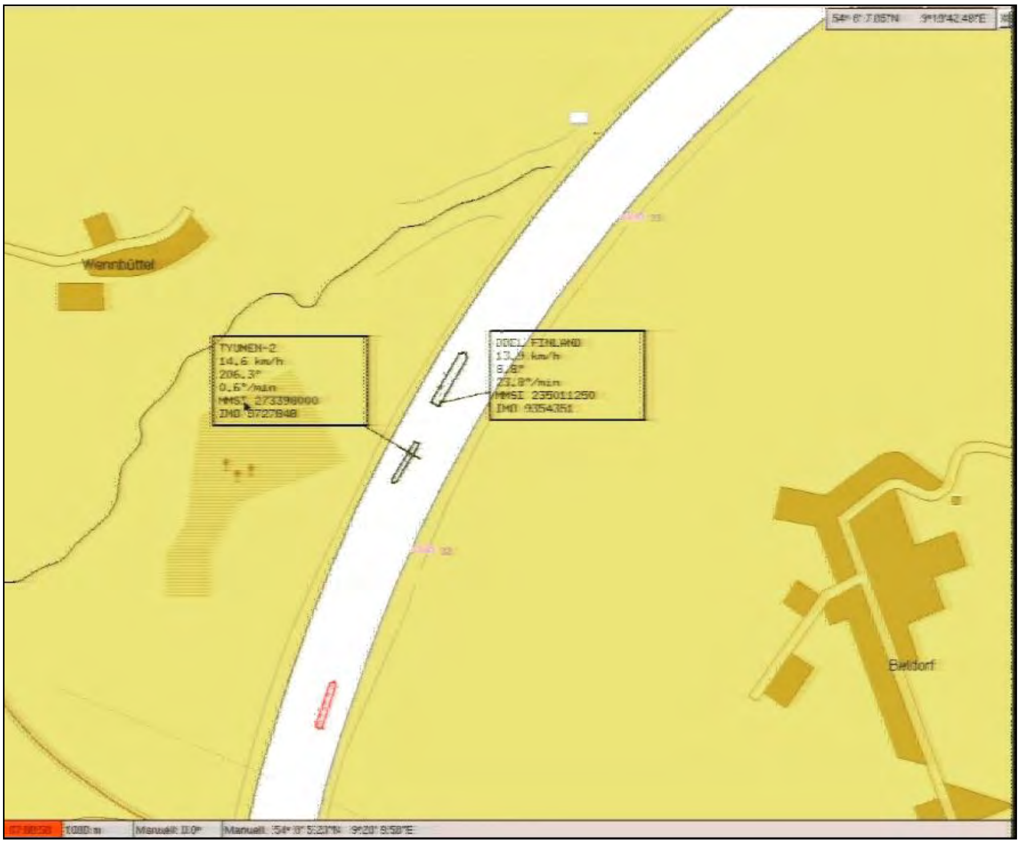

Figure 43: AIS display at 070050

Diagram 3 on the speed variation between 0640 and 0714 has also been prepared using the AIS data from the OOCL FINLAND.

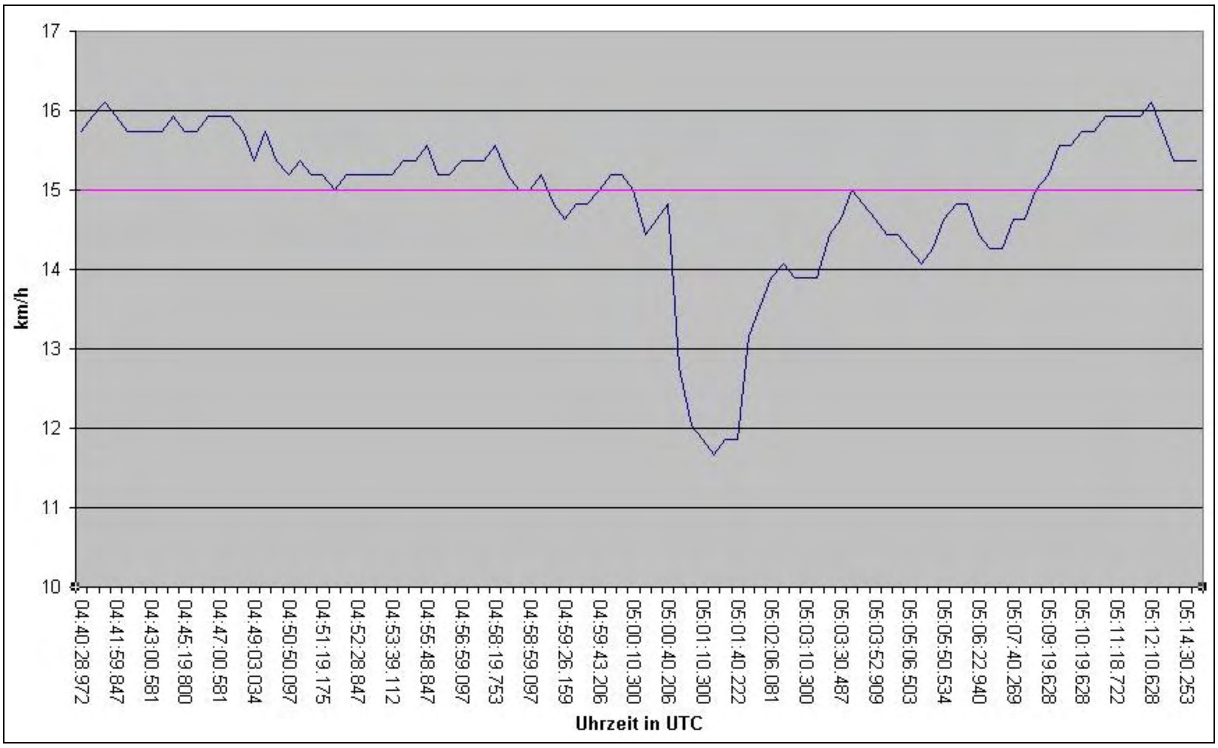

Diagram 3: Speed diagram, OOCL FINLAND from 064028 to 071430[52] [53]

3.2.5.8 Hydrodynamic expert opinion

The Federal Waterways Engineering and Research Institute (BAW) prepared an opinion on the hydrodynamic boundary conditions at the request of the BSU. Excerpt from the opinion is reproduced below:

"The VDR and AIS recordings of the vessels involved [...] provided by the BSU and the use of up-to-date nautical charts as well as sounding data of the Federal Waterways and Shipping Administration (Verkehrssicherungspeilung (traffic safety sounding [sic]) 2010) made it possible to display the passage of the ships graphically using the AIS/VDR viewer developed by the BAW [...].

To evaluate the hydrodynamic interaction (ship/waterway), the following additional time-dependent information and further evaluations were included in the diagrams:

- course [°][54] and heading [°][55], and their difference (in graphic form);
- ship speed over ground [kts] and rate of turn [°/min];
- rudder angle [°] and engine power [%];

[52] Underlying data: AIS recording of the Federal Waterways and Shipping Administration.
[53] The coloured line at 15 km/h indicates the maximum speed permitted on the NOK.
[54] Course = course over ground.
[55] Heading = course applied.

- closest point of approach of the MV OOCL FINLAND to the canal's embankment [m] based on the length of the hull to the 4 m contour line (4 m contour line ≈ 0.5 • draught).

[…]

Furthermore, inter alia, empirical knowledge on seagoing ship/navigable waterway interaction (e.g., the squat) was available for assessing the hydrodynamic boundary conditions. This stemmed from an opinion prepared by the BAW on the NOK (Erosionsverhalten von Böschungen am NOK – Untersuchungen im hydraulischen Model zur Ermittlung schiffserzeugter Belastungen (erosion characteristics of embankments on the NOK – studies in a hydraulic model to determine ship-induced stresses), BAW 97 52 3449, Hamburg, 1998).

Regarding ship/waterway interaction, from a hydrodynamic perspective the following relationships are seen with the MV OOCL FINLAND:

- At 065730[56], the passing clearance to the 4 m contour line at a slightly off-centre course to starboard was about 36 m. The rudder angle of approximately 8° starboard at a speed of approximately v_s ≈ 8 kts indicates a moderate bank effect, which could easily be offset by the rudder force.

- Up until the rudder manoeuvre initiated at 065852 to finally 35° to starboard at 065900, the vessel closed in almost parallel to the bank to approximately 12 m to the 4 m contour line. At a speed of v_s ≈ 8 kts, it can be assumed that the flow acceleration on the starboard side between the bank and ship's shell plating caused by the movement of the ship induced high speed and distance-dependent flow and pressure differences between starboard and port side, and thus considerable bank effects.

- To illustrate the narrow waterway cross-section available on the starboard side, a sectional drawing at 065920, which was based on the sounding data, the ship's main dimensions and the position data, was superimposed at the level of the midship section of the ship [...][57].

  - At a draught (d) of 7.8 m and a mean squat (s) of about 0.3 m (according to the BAW, 1998), the calculated horizontal distance from the vessel to the 4 m line stood at approximately 12.5 m.

  - Proceeding parallel to the bank, the starboard bilge had a diagonal distance from the embankment of about 0.8 m in the midship section.

  - Because of this narrow localised underkeel clearance, the ship parted the waterway such that the transverse face of the part section on the starboard side was only 1/10 of the total cross section to allow for the speed-dependent flow around the ship and also the propeller suction aft.

[56] See Figure 45.
[57] See Figure 44.

- The increase in engine power from about 35% to 44% initiated at approximately 065903[58] intensified the bank effect due to the rising propeller suction aft on the starboard side. Accordingly, the suction effect aft and the induced yaw moment could not be offset despite the flow-induced increase in rudder force, and the ship turned to port. Due to the increased flow and pressure difference aft, the vessel was 'sucked' towards the bank even more severely and the lowest distance to the 4 m contour line at 065945[59] was down to only about 8 m.

- Despite the increasing (mean) passing clearance to the bank at 070001, the helm action was not sufficient to steer the vessel to starboard. This is because a very high pressure difference with considerable suction to the starboard bank existed as a result of the continued low distance of the stern of only about 16 m aft.

- The stern section of the vessel still had a passing clearance to the bank of only about 24 m (about the breadth of the ship) at 070010[60], which at a speed of about 8 kts resulted in significant bank induced forces on the stern and thus continued to prevent a change in the rate of turn to starboard.

- Ship/ship interaction with the MV TYUMEN-2 only occurred shortly before the collision at about 070006, at which the bow waves of the approaching vessels overlapped each other and briefly caused the forecastles to drift slightly apart."

[58] See Figure 54.
[59] See Figure 56.
[60] See Figure 57.

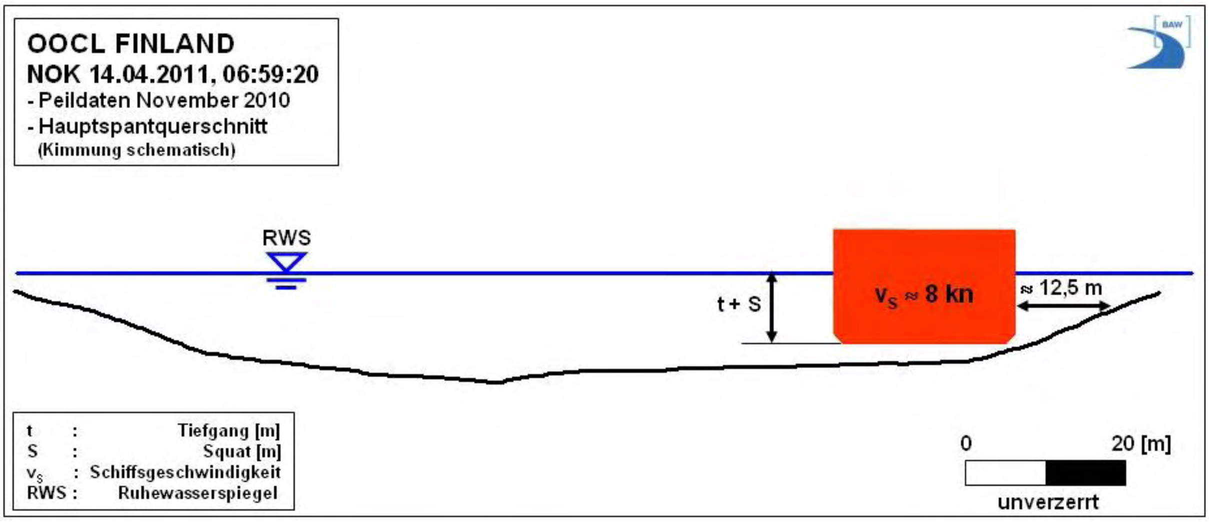

Figure 44: Sectional drawing: OOCL FINLAND in the canal moving[61] parallel to the bank, distance to the bank at 065920

Figures 45 to 57 below were selected from the BAW's AIS/VDR viewer. The blue field shows the distance to the 4 m contour line. The direction of the red arrow/vector indicates the course over ground (named as "Kurs" at the left), the black arrow/vector the rate of turn (ROT). The heading course is indicated as "Hd" (Heading) in the left column.

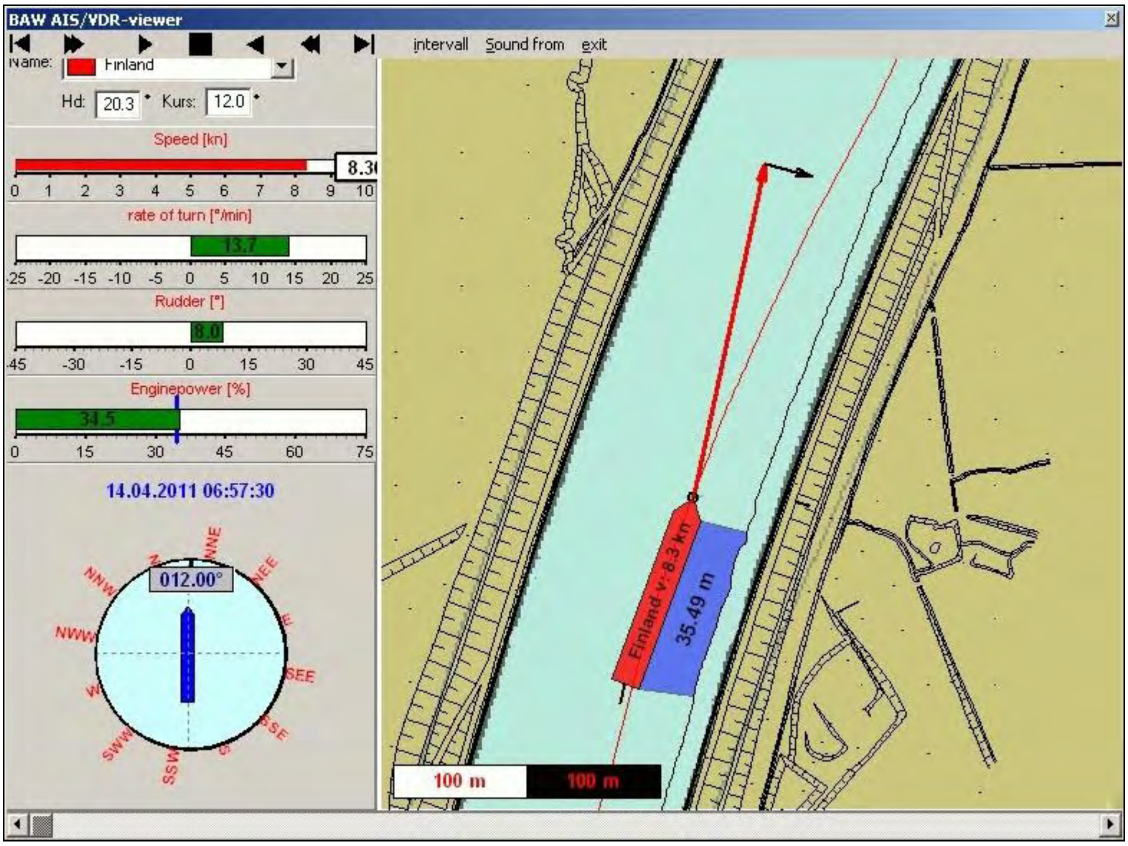

Figure 45: OOCL FINLAND, 065730

[61] Bathymetry after sounding, November 2010.

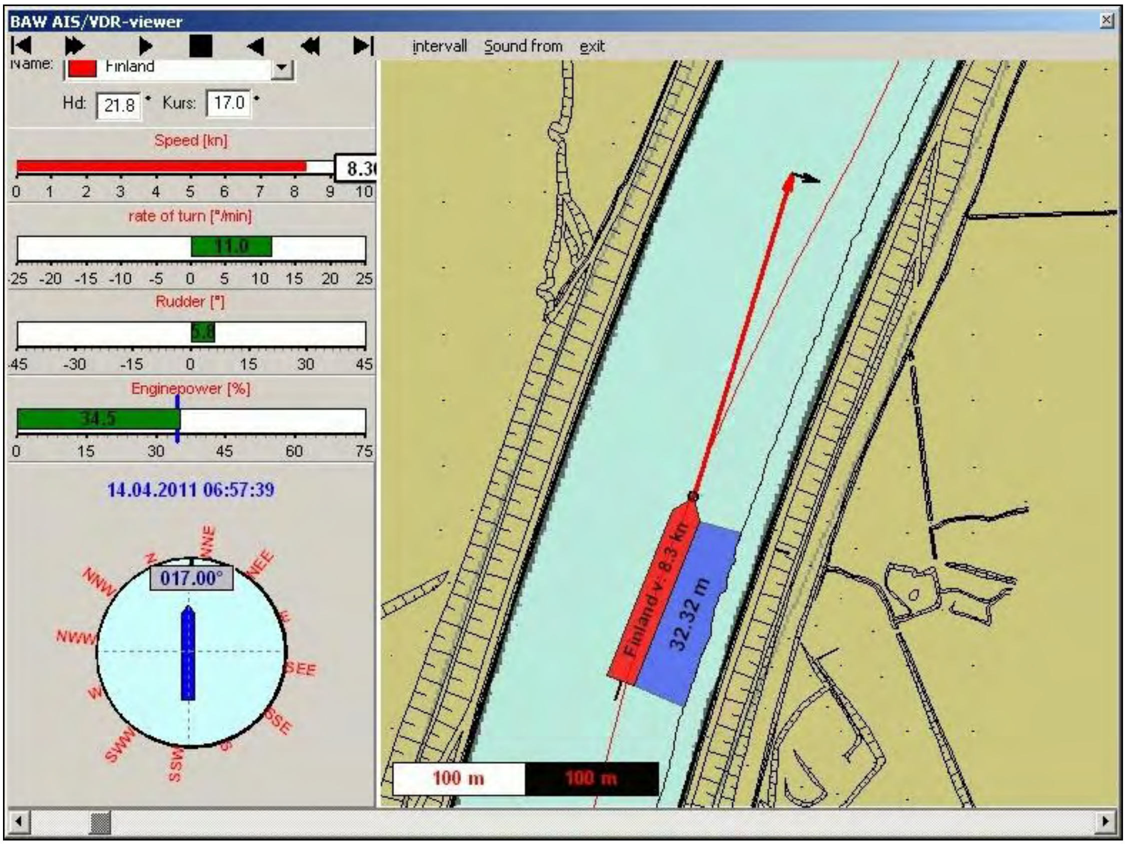

Figure 46: OOCL FINLAND, 065739

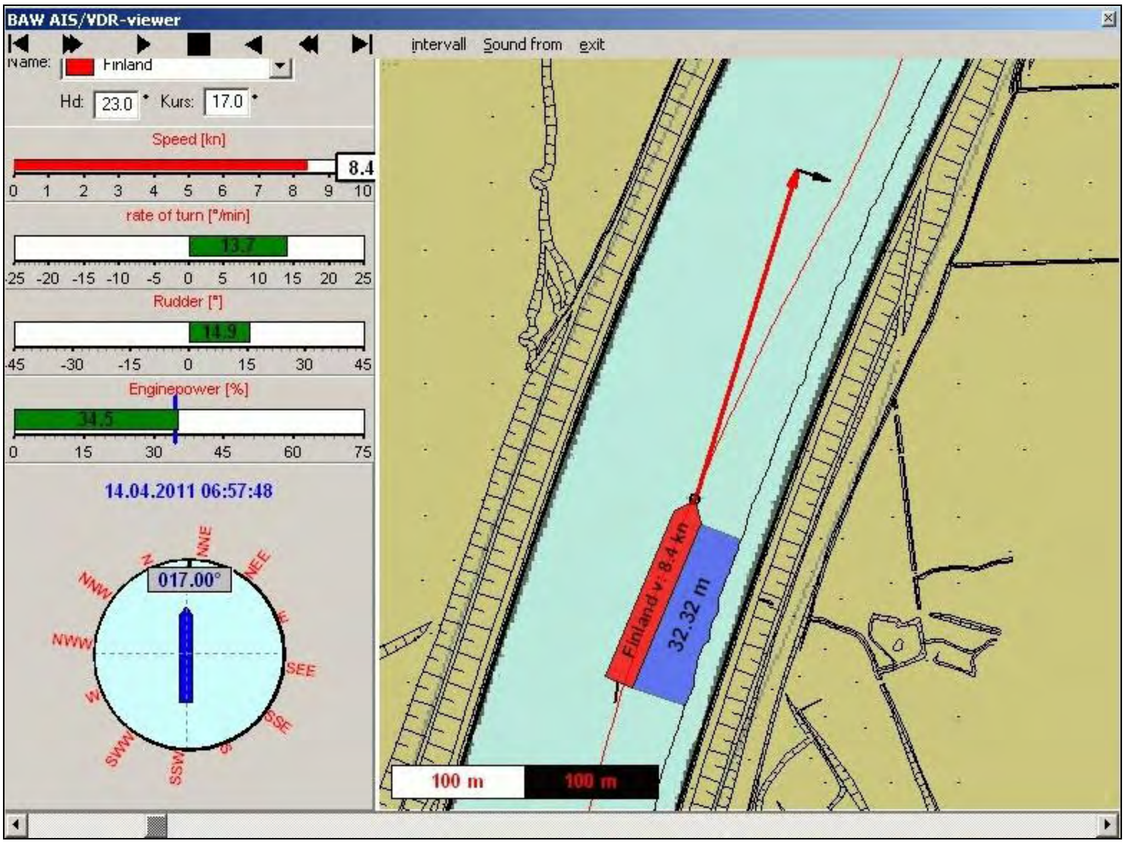

Figure 47: OOCL FINLAND, 065748

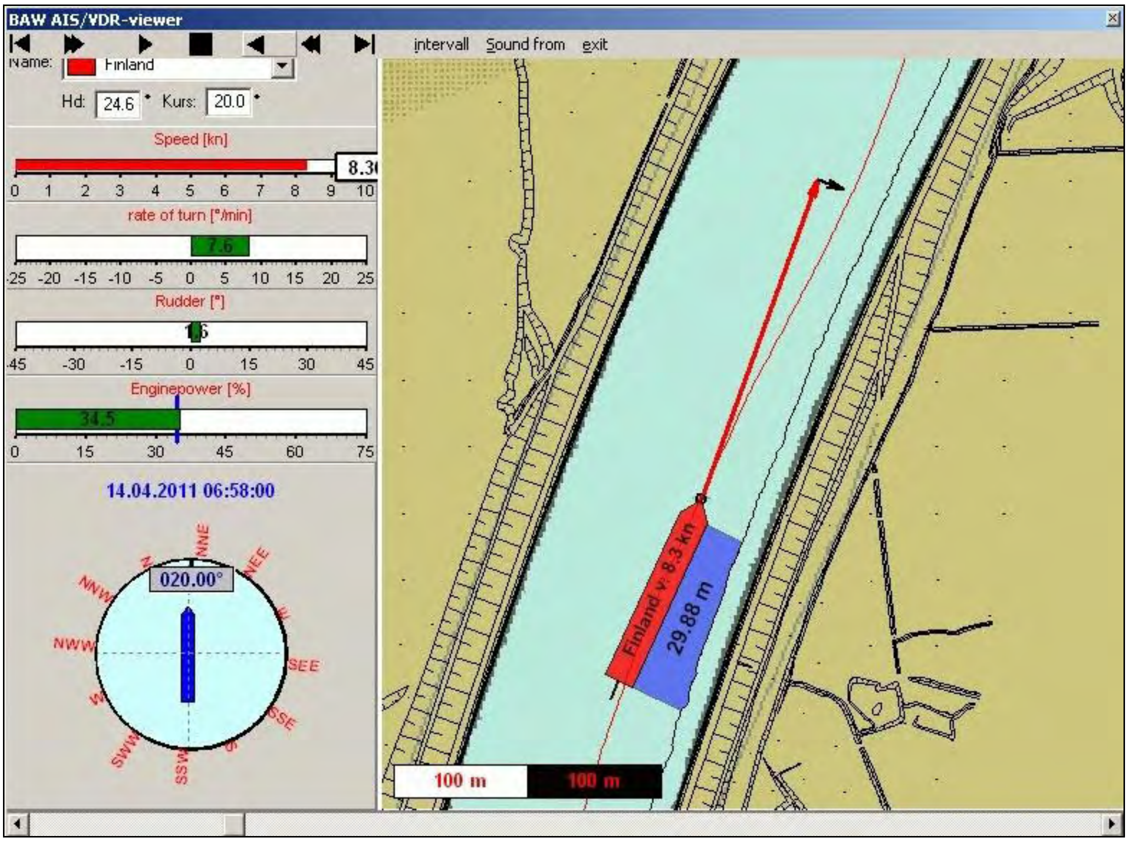

Figure 48: OOCL FINLAND, 065800

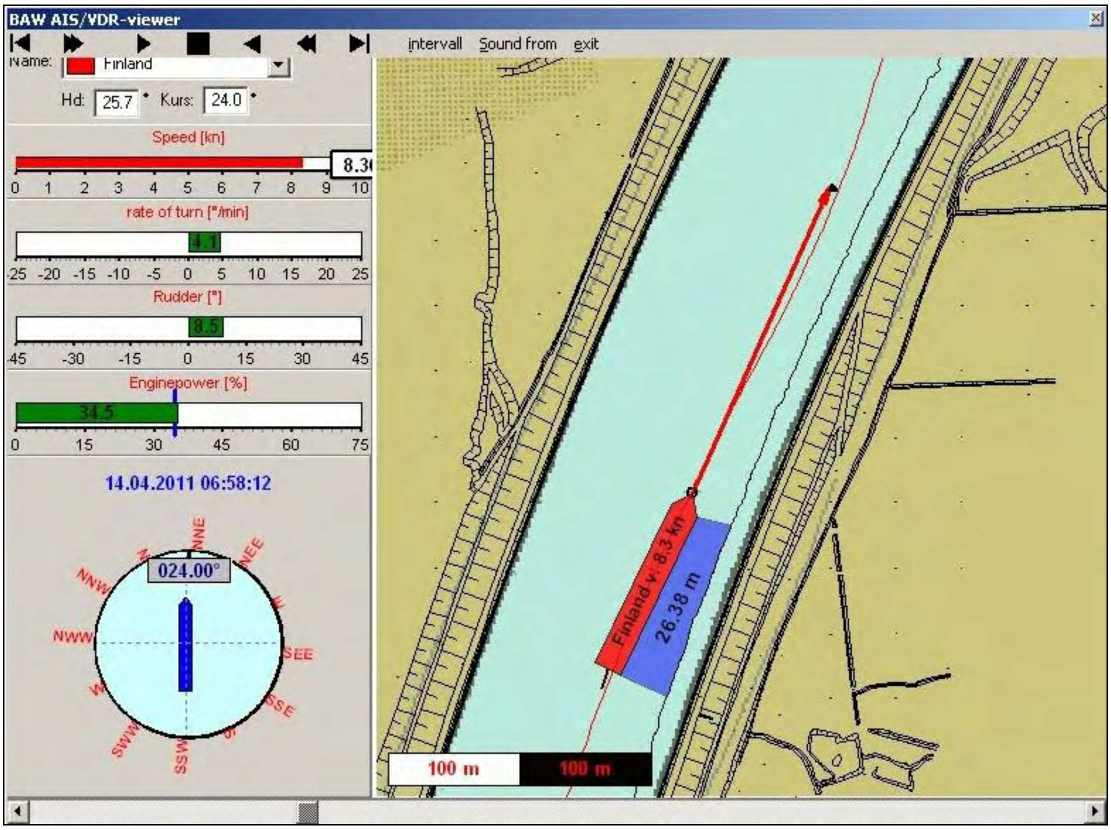

Figure 49: OOCL FINLAND, 065812

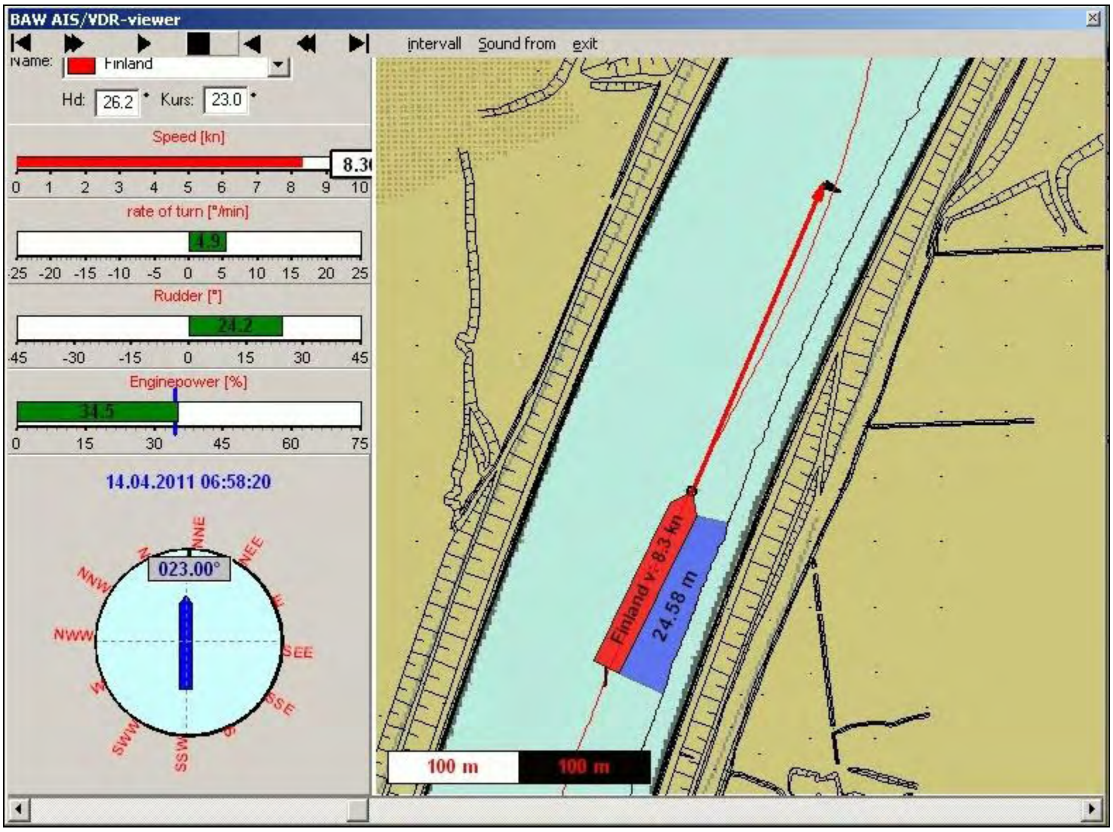

Figure 50: OOCL FINLAND, 065820

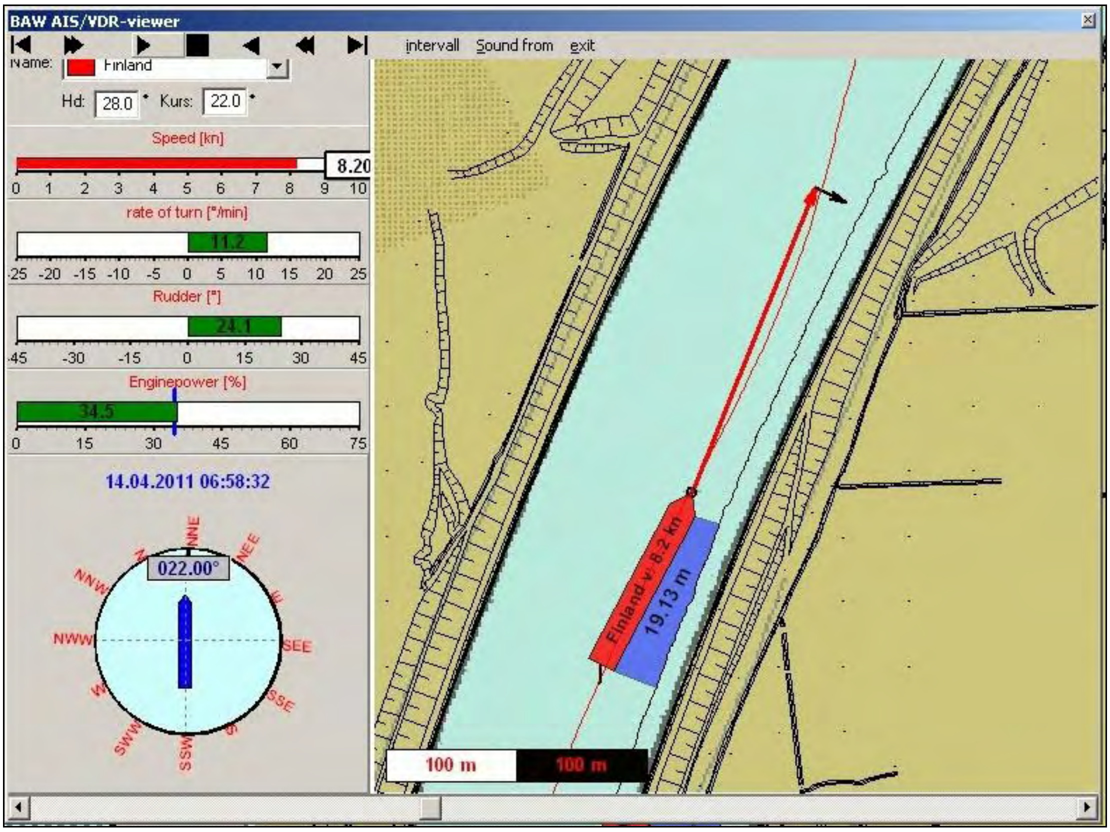

Figure 51: OOCL FINLAND, 065832

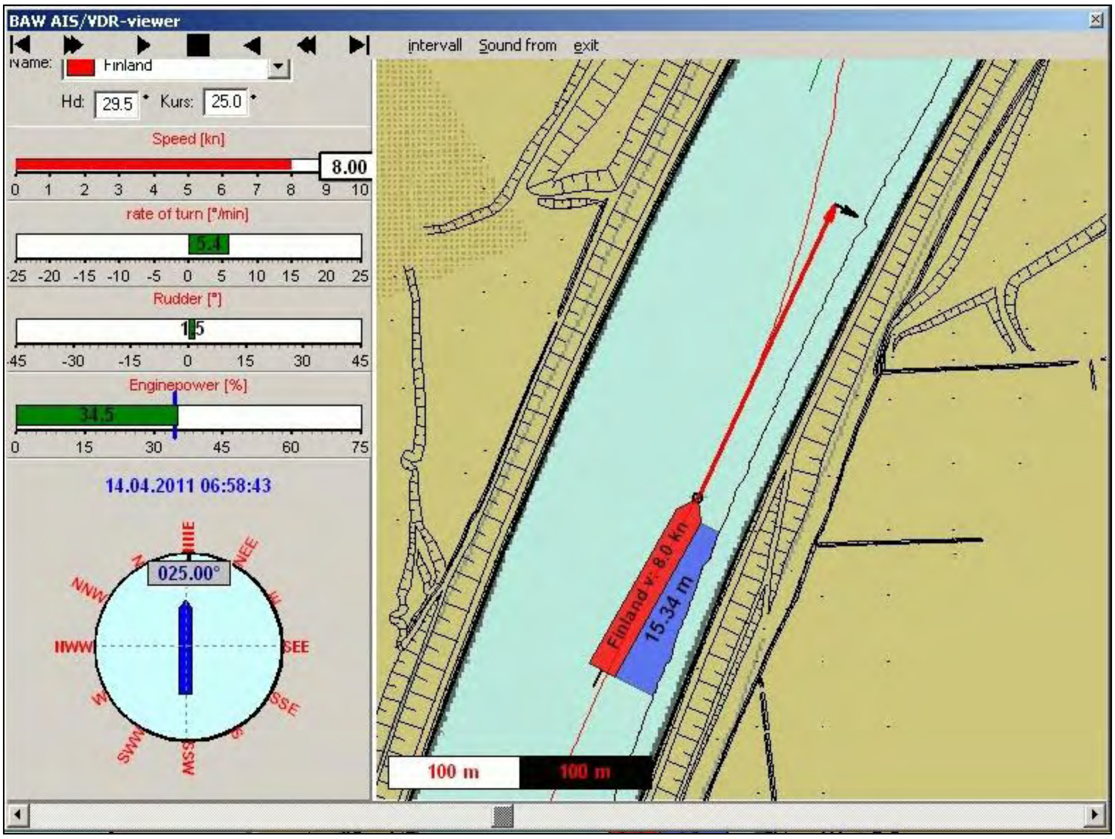

Figure 52: OOCL FINLAND, 065843

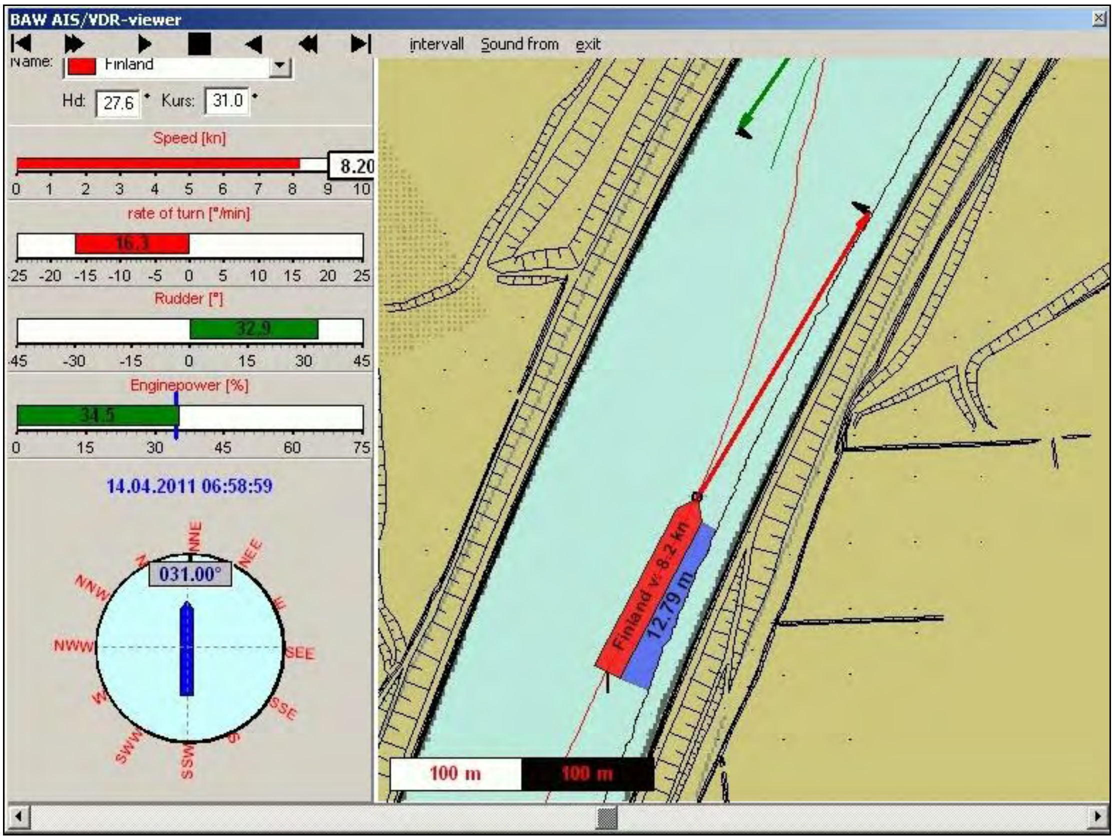

Figure 53: OOCL FINLAND, 065859

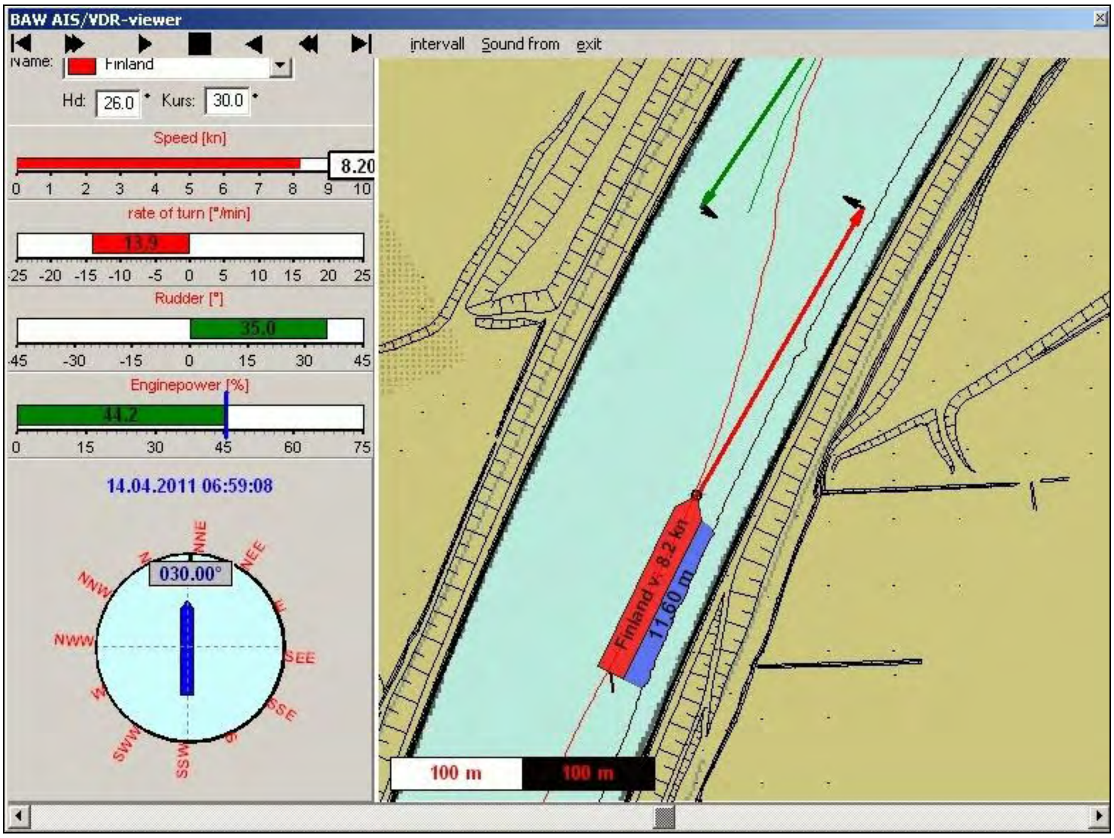

Figure 54: OOCL FINLAND, 065908

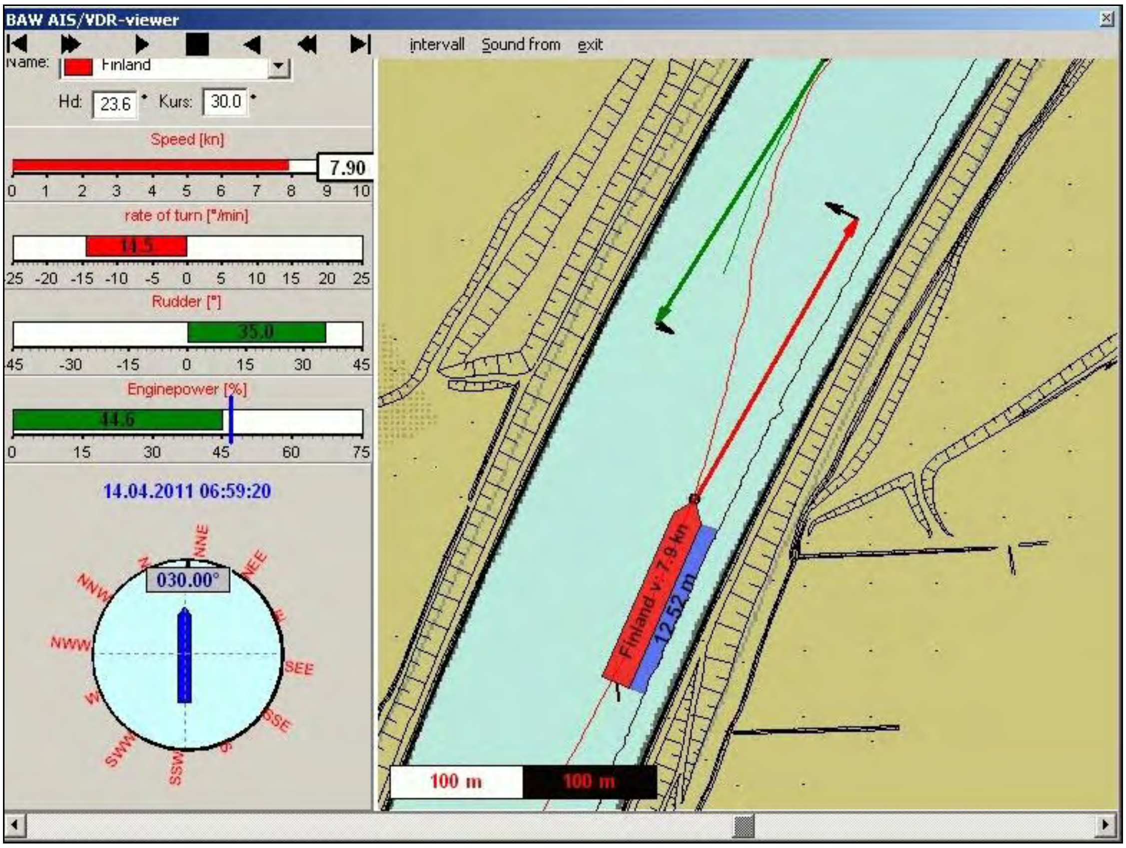

Figure 55: OOCL FINLAND, 065920

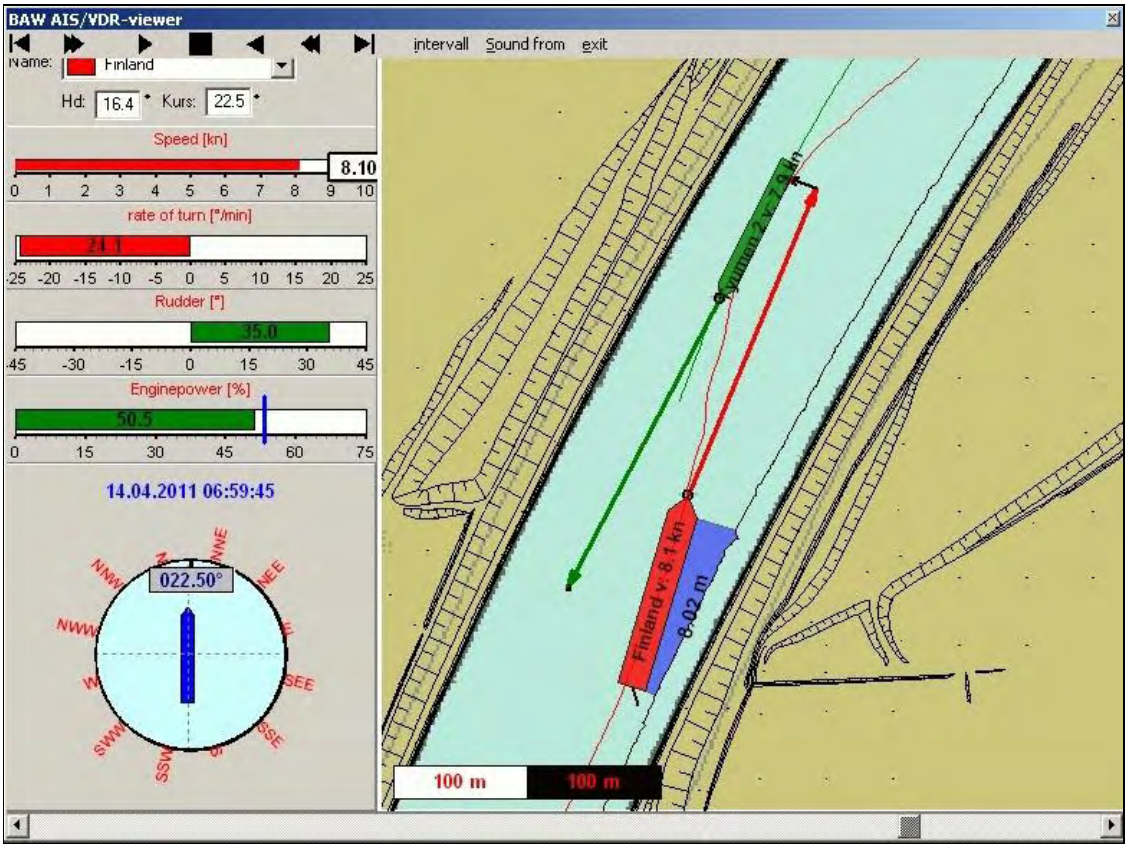

Figure 56: OOCL FINLAND, 065945

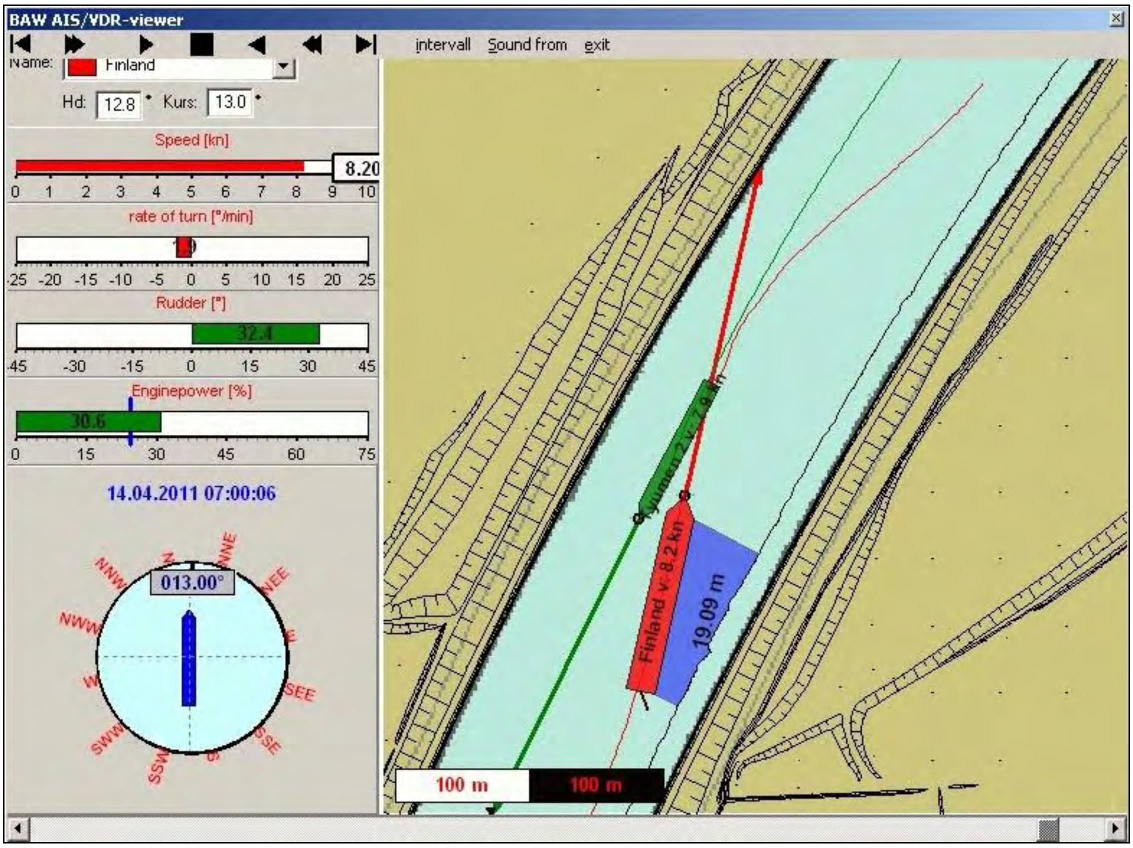

Figure 57: OOCL FINLAND, 070006

The traffic safety soundings for the canal section km 31.2 to km 33.7 and the test sounding following the accident for the section km 31.9 to km 32.4 were provided by the Waterways and Shipping Directorate (WSD) North. These were carried out in the period 6 April to 16 April 2011, respectively, on 15 April 2011. No unusual changes to the bed of the canal in the area relevant to the accident can be seen on the graphic representation.

The pilot and his attorney at law, respectively, claimed in the statement pertaining to the draft report that the stretch between Canal km 27 and 29 was declared an embankment slumpint section shortly after the collision. Since then “single-lane” traffic takes place. This slumping was said to have an influence on the OOCL FINLAND.
The Directorate-General Waterways and Shipping – Branch North – explains that the slumping of the embankment in the area between Canal km 28.1 and 28.5 exists since 1230 on 9 December 2010. The stretch is since then only opened for single-lane passages. Since March 2011 a regulation on the reduction of the amounts of encounters from 8 to 6 has entered into force.

3.2.5.9 Manoeuvrability of the OOCL FINLAND

For an assessment of the manoeuvring behaviour of the OOCL FINLAND, extracts from the ship's manoeuvre manual were copied on board to begin with. The entire manual was later provided by the Norderwerft shipyard. From that it was apparent that, admissibly, some of the manoeuvring data were gathered during the sea trials for sister ships. The manoeuvre manual applicable to the period before the extension was provided by 'Nautische Büro Bremen', which prepared the manoeuvre manuals on behalf of the shipyard before and after the extension.

The data taken from the manoeuvre manuals were evaluated on the basis of the applicable IMO Resolution[62].

- **Directional stability**
  "This defines the ability of the ship to maintain or move onto a specified course with minimal effort [...]. This ability is verified by means of zigzag manoeuvres, [...][63]." Based on the ratio L [m] / V [m/s], i.e., ship length[64] to speed, the data for the 10°/10° zigzag manoeuvres were evaluated. The L_{pp} after the conversion stands at 139.76 m. The speed during the manoeuvre was 17 kts. The engine power applied for this was stated with 8400 kW. That is equivalent to maximum power. Therefore, the investigators took the value for the speed

[62] IMO Resolution MSC.137(76) – Standards for Ship Manoeuvrability, adopted 4 December 2002.
[63] Kruger, Stefan: Manoevrieren und Manoevrierorgane (manoeuvring and manoeuvring agents [sic]). 2001. URL: http://www.ssi.tu-harburg.de/doc/webseiten_dokumente/ssi/vorlesungsunterlagen/manoe.pdf, retrieved on 27 December 2012.
[64] Actual L_{pp} – Length between perpendiculars, see also section 4.1.1 Res MSC.137(76).

attained in a near headwind of 5 Bft from the sea trial for the maximum speed on the same day. The speed attained was 18.3 kts = 9.41 m/s
During the zigzag manoeuvre, the wind blew at 5 Bft from a relative bearing of 75° to port.
Based on the above values, the L/V ratio is 7.64 s. This value is less than 10 s. Hence, the first overshoot angle should not be more than 10°. During the sea trial an overshoot angle of 6.4° was determined.

Based on L_{pp} = 124.41 m, V = 19.2 kts = 9.87 m/s, the following value was determined before the ship was extended: L/V = 12.6 s.
Therefore, the overshoot angle should correspond to a value that must not be greater than the result of the formula (5 + ½(L/V)) in [°]. 11.3° is the result of the formula. During the sea trial, the first overshoot angle was 9°.

The result for the second overshoot angle during the 10°/10° zigzag manoeuvre was 7.8° and thus substantially less than the permitted maximum of 25°.
During the sea trial before the conversion, the value for the second overshoot angle was 11°. In this case, the maximum permissible value of 26.95° was observed.

At 15.5° in the new sea trial and 22° in the old one, the maximum permissible value of 25° for the first overshoot angle during the 20°/20° zigzag manoeuvre was not exceeded.

- **Initial turning ability**

  The initial turning ability is defined by the change of course response to a moderate helm. The following limit value applies for initial turning ability: with the application of a 10° rudder angle, the ship must not travel more than 2.5 ship lengths before her course has changed 10°.

  After the conversion, the initial turning time t_l[65] during the 10°/10° zigzag manoeuvre took 30 s. At a speed of 18.3 kts (9.41 m/s), 282.3 m was travelled in 30 s. 2.5 x ship length (L_{pp}) equals 349.5 m. Hence, the criterion was met.
  t_l = 26 s was measured before the extension. At a speed of 19.2 kts, the distance covered in 26 seconds is 256.6 m. 2.5 x ship length = 311 m. The criterion was met here, too.

  The initial turning ability can also be calculated. To do this the Norrbin formula is applied:

  $$P = t_l \times V / L_{PP}$$

  P represents the distance travelled in ship lengths and should be less than 2.5.

[65] t_l = Initial turning time.

The result for the extended ship is 2.02.
The value for the non-extended ship is 2.06.
Hence, the value was observed in both cases.

- **Turning ability**

  "This refers to the ability of the ship to quickly leave a given course and initiate a (preferably small) turning circle. This ability is tested by means of the turning circles at hard-over rudder:
  - the advance (beginning of the turning manoeuvre until a 90° course alteration is implemented) should not exceed 4.5 ship lengths;
  - tactical diameter: measured as the transverse distance from the start of the manoeuvre until a 180° course alteration is implemented, the tactical diameter should be no more than 5 ship lengths."[66]

  The following values should be attained for the extended ship:

advance: (139.76 m x 4.5)	628.9 m,
tactical diameter: (139.76 x 5)	698.8 m.

  The values measured for the starboard turning circle were:

advance:	558 m,
tactical diameter:	640 m.

  The values for the port turning circle were lower.

  The following values should be attained for the ship before the conversion:

advance: (124.41 m x 4.5)	559.8 m,
tactical diameter: (124.41 m x 5)	622 m.

  The values measured for the starboard turning circle were:

advance:	765 m,
tactical diameter:	655 m.

  The values measured for the port turning circle were:

advance:	761 m,
tactical diameter:	651 m.

  This did not satisfy the required criterion. However, it is noted in the manoeuvre manual that the tactical diameter for the sister ship with the yard number 1128 was 364 m during the sea trial.

- **Yaw checking ability**

  In addition to the above values required by the IMO Resolution, the yaw checking ability could also be calculated using the manoeuvre manuals. The yaw checking ability defines the ability to stop an existing turn using the helm.

[66] Kruger, Stefan: Manoevrieren und Manoevrierorgane (manoeuvring and manoeuvring agents [sic]). 2001. URL: http://www.ssi.tu-harburg.de/doc/webseiten_dokumente/ssi/vorlesungsunterlagen/manoe.pdf, retrieved on 27 December 2012.

"As a dimensionless parameter, the turning value is formed using the oscillation period with the formula:

$$\text{turning value} = t_{OP} \times V / L_{PP}$$

It represents the time period for a full oscillation[67] measured in ship length travel time or describes the number of ship lengths covered during a heading oscillation. [...] However, experience has shown that this turning value is more a reflection of the yaw checking ability [...]. A lower turning value indicates better yaw checking ability and a higher turning value poorer."[68]

At a t_{OP} of 152 s, the turning value for the extended ship is 10.2.

At a t_{OP} 134 s, the turning value before the ship was extended is 10.6.

The yaw checking ability is presumed to be good at a turning value of $\approx$ 10.

A comparison of the data for the **pull-out manoeuvre** (also not required) was not possible because the data recording in the manoeuvre manual prepared after the conversion was discontinued after 30 seconds for the starboard manoeuvre and after 35 seconds for the port manoeuvre. At this point, the rate of turn during the manoeuvre to starboard was still 15.3°/min and to port still 40.8°/min. Inasmuch, the recording was incomplete.

The measurement data for zigzag manoeuvre 10°/10° and 20°/20° present in both documents were merged by the investigators for a graphical representation. That represents the basis for Diagrams 4 and 5.

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[67] t_{OP} = time period for full oscillation.

[68] Bendict, Knud/Wand, Christoph (publ.): Handbuch Nautik II. Hamburg, 2011, pp. 374-375.

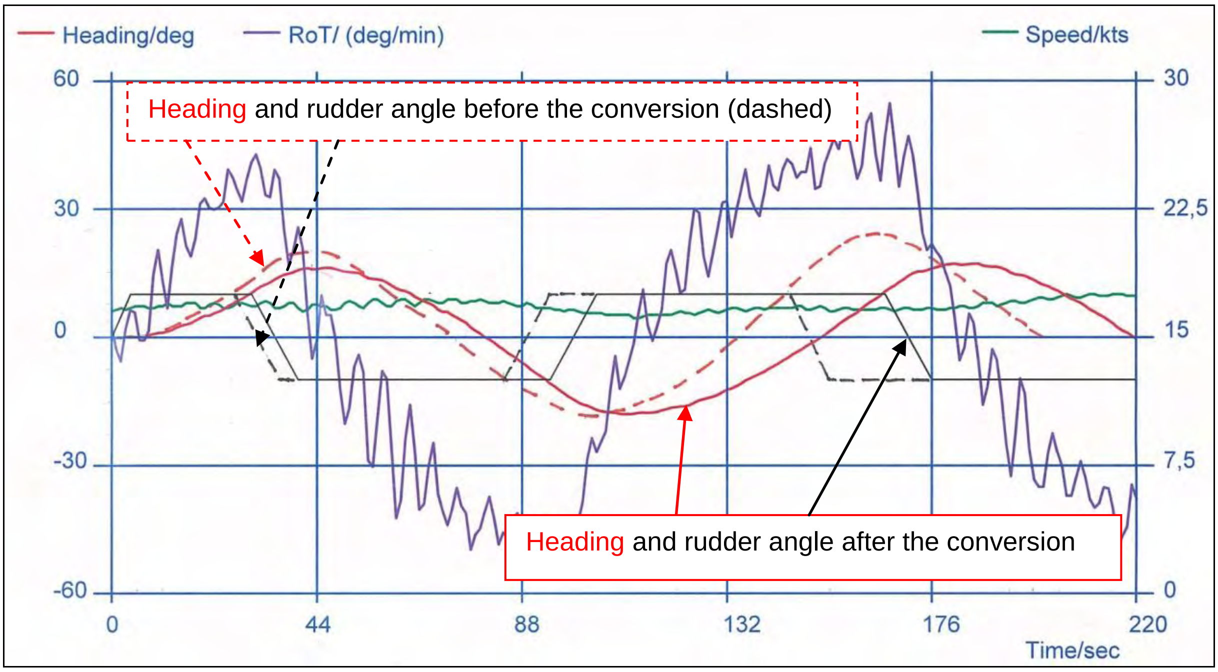

Diagram 4: OOCL FINLAND, zigzag manoeuvre 10°/10°[69]

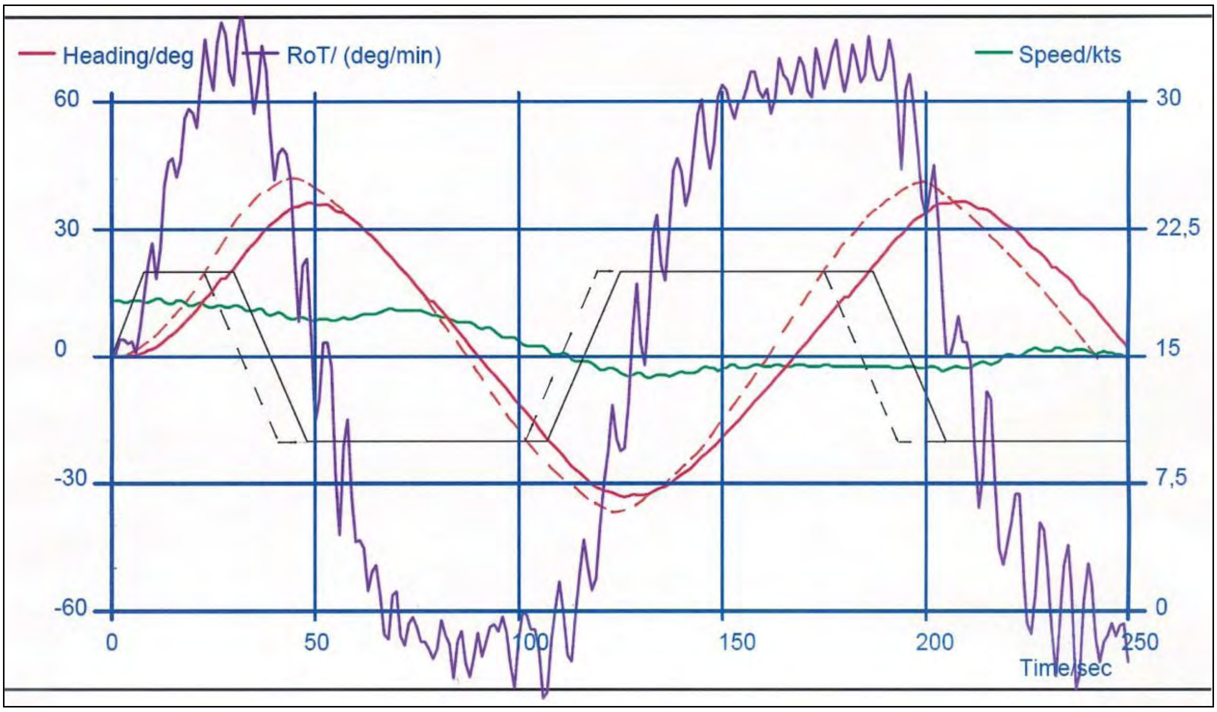

Diagram 5: OOCL FINLAND, zigzag manoeuvre 20°/20°

It can be summarized that on one hand the manoeuvre characteristics of the extended vessel complied with the criteria of the IMO Resolution. Thereby an adaption of the rudder area was not required. On the other hand the manoeuvre characteristics of the initial vessel and the extended vessel do not seriously deviate under trial conditions.

[69] Diagrams 4 und 5: values/curves for speed and rate of turn for the extended ship.

3.2.6 Pilot service and canal helmsmen

3.2.6.1 Pilots

Pilotage on the NOK is provided by pilots who are organised in two pilot brotherhoods. The pilots work on a freelance basis but are subject to state supervision. The brotherhood represents the collective interests and the service organisation.
The Brunsbüttel-based Brotherhood of Kiel Canal I (NOK I) Pilots is responsible on the western stretch, i.e., from Brunsbüttel to Rüsterbergen. The Kiel-based Brotherhood of Kiel Canal II/Kiel/Lübeck/Flensburg Pilots is responsible on the eastern stretch. The accident happened in the area of the Brotherhood of NOK I Pilots.
The Law on maritime pilots[70] provides for the training and appointment of pilots. Trainee pilots usually undergo an eight-month training programme, which consists of practical and theoretical components. Bridge team management and contingency scenarios are part of the training. In addition to operating on real ships under the guidance and supervision of an experienced pilot, the training also involves practising on ship-handling simulators. Here, Brotherhood NOK I make use of its own simulator and that of the Marine Training Center in Hamburg.
During the investigation, a team of investigators viewed the ship-handling simulator belonging to the Brotherhood of NOK I Pilots in Brunsbüttel.
The training concludes with an examination. After the first appointment, a pilot may only advise on ships up to a certain size[71] for a transitional period of up to three years.

Advanced pilot training is the responsibility of the individual pilot and results from his position as a freelance worker. Each pilot brotherhood offers appropriate opportunities for advanced training and, as with the Brotherhood of NOK I Pilots, arranges the technical or contractual prerequisites needed for this by means of agreements with external providers and its own simulators.

The investigators assume that the pilot of the OOCL FINLAND possessed sufficient experience as a navigator and pilot. Two years before the accident, he attended an advanced training programme that focused on mastering hydrodynamic effects, amongst other things.

That the discovery of the canal helmsman on the forecastle of the OOCL FINLAND could not be reported by the pilot to the VTS immediately was due to the fact that the master of the ship did not express himself clearly and omitted to indicate that the person discovered was not part of his crew. For his part, the pilot did not ask the master for clarification.

[70] Section 2(2) of Germany's Law on maritime pilots (Gesetz über das Seelotswesen - SeeLG).
[71] Article 19 SeeLG – Tasks of a pilot after the first appointment.

3.2.6.2 Canal helmsmen

Canal helmsmen on the NOK are controlled by the Verein der Kanalsteurer e.V. (Association of Canal Helmsmen). The legal status of the canal helmsman on board is legally disputed. This point was of no relevance to the investigation.
A nautical certificate is required to join the profession. Canal helmsmen are trained in accordance with the association's charter. Training lasts between 12 and 16 weeks and concludes with an examination conducted by the Federal Waterways and Shipping Administration.

The canal helmsman on the OOCL FINLAND possessed the necessary experience and due to numerous voyages was familiar with the type of ship. He was unable gain visual orientation because of restricted visibility. His actions were based on the instrument displays, the compass in particular, and the course instructions of the pilot.

3.2.7 Statements by the pilot and the canal helmsman

As part of the investigation, the Bundeslotsenkammer (Federal Chamber of Pilots), the NOK I and II pilot brotherhoods, the Bundesverband der See- und Hafenlotsen (Federal Association of Maritime and Harbour Pilots) and the Association of Canal Helmsmen were asked to comment on a list of questions from the BSU. The federal chamber of pilots forwarded the questions to the Brotherhood of NOK I Pilots.
The questions addressed the following points, inter alia:

- How is the present and future risk potential assessed?
- How could this risk potential be reduced?
- What would be the impact of a basic reduction in the permissible speed?
- What is the influence of the ship's command on the 'closed loop' between pilot and canal helmsman?
- Are existing rules on the requirement to make use of canal helmsmen considered to be sufficient?

A summary of the reply from the Brotherhood of NOK I Pilots follows:

- If the ordinary practise of seamen is observed, encounters between ships on the NOK in all weather and other conditions are not considered to be problematic. "In accordance with good seamanship practises, encounters are organised so that safe passage at an appropriate distance is possible. The speed of encountering vessels must be adjusted (reduced) such that hydrodynamic interactions (ship/ship and ship/bank) can be avoided at all times. The developed cross-section of the NOK is wide enough for encounters in the canal cross-section to take place safely."
- The growth in ship size is not concomitant with an increase in risk potential. Larger ships also mean a reduction in the number of ships. The pilot brotherhoods are in close contact with WSD North and the various waterways and shipping offices and regularly discuss issues relating to the traffic safety and control system on the NOK.

- An increase in risk potential has not resulted from the change in the rules on encountering outside the siding areas on the NOK. However, restrictions based on draught or speed[72] give rise to several possible configurations for passage and encountering, which, in turn, result in different navigating and steering patterns. The Brotherhood sees potential for improving safety in this regard.
- "The Brotherhood of NOK I Pilots believes that a uniform speed to simplify traffic control is certainly worth considering. Regarding this, we are actively sharing ideas with the competent supervisory authority and would generally support an examination of the impact a uniform speed would have on safe ship traffic on the NOK."
- Basically, every pilot has modern radar equipment at his disposal on board a ship. Every pilot has the option of having the ship requiring pilotage classified to a higher traffic group, which reduces the number of encounters on the stretch. A pilot can reduce the speed or even interrupt the voyage at any time. Hence, there is no reason to reduce the maximum speed or permissible sum total of the traffic group numbers in restricted visibility.
- Although in certain circumstances, such as restricted visibility, intense cooperation occurs between pilot and canal helmsman and the German language used may preclude the participation of the actual ship's command, the ship's command does have the option to intervene in the pilotage in all circumstances or to oppose this. Inasmuch, the Brotherhood of Pilots does not recognise a 'closed loop'.
- The Brotherhood of Pilots advocates a uniform rule on the requirement to make use of a helmsman for the entire canal. The exemptions currently in place on the western stretch should be reconsidered.

A summary of the statement from the Brotherhood of NOK II Pilots as follows:

- An analysis of accident statistics on the NOK reveals a risk potential that is basically low.
- Growing ship sizes in conjunction with the resulting restrictions on encountering will lessen the risk potential on the stretch. At the same time, it will rise in the siding areas as large ships require more space for manoeuvring.
- The change in the rules on encountering had very little impact on the eastern stretch. The rule only takes effect at about 7.5 km.
- The Brotherhood seeks to minimise the existing risk potential through sound education and training. Moreover, the restrictions on ship size for young pilots have tightened. The Brotherhood uses simulators for ship-handling and resource management courses. Since this year, canal helmsmen have also been included in this.

[72] For Traffic Group 6 vessels and those with a draught greater than 8.50 m, the maximum speed is 12 km/h (6.5 kts).

- In principle, the Brotherhood of Pilots does not view a general reduction in speed negatively. However, it does point out that:
  - its observations suggest that in general the speed is already reduced and adapted in fog during passing manoeuvres and otherwise;
  - the reduced uniform speed would only lessen the number of overtaking manoeuvres in relation to slow-moving vessels;
  - the waiting times would increase in the siding areas, which would involve an increased risk there;
  - there would be an increase in the formation of convoys, which, in turn, would affect handling in the locks. Moreover, the convoys would cause an increase in the rapid succession of the ship/ship interactions, which would also represent an increase in risk;
  - small vessels with a shallow draught would be disproportionately penalised, and
  - with prolonged passage times, the economic advantage of canal passages may be lost.
- Regarding a reduction in speed in restricted visibility, the same comments as before apply. In the experience of the Brotherhood, the encounter-figure is already reduced voluntarily in its area if ship or situation so require.
- For the Brotherhood, a basic problem exists in all areas of operation with regard to the scope for exerting influence of the ship's command. This is affected by the following factors:
  - lack of knowledge of the area;
  - declining competence of ship's commands;
  - growing ship sizes with operating areas that are unchanged in terms of size, and
  - reduction in the scope for decision-making in the manoeuvring space available.

  Solving the problem requires a qualified pilot at any event. However, he must cooperate with the ship's command so that their scope for exerting influence – as a 'correcting element' and in accordance with their fundamental responsibility – remains intact. To do this, an active approach is necessary from both sides.
- The Brotherhood believes that a widening of the responsibility of the pilot by extending his personal liability is not practicable. A revision or interpretation of Article 23(2) SeeLG[73] should be discussed.
- The exemptions from making use of canal helmsmen on the western stretch should be reviewed for the following reasons:
  - the manning levels on the affected ships are so small that a watch system consisting of officer on watch/master, helmsman and lookout cannot be sustained for the long periods necessary in estuary trading;

[73] Article 23(2) Law on maritime pilots – "The master remains responsible for navigating the ship even if he permits the maritime pilot to issue orders relating to navigation of the ship independently."

- the ability to navigate in the area of operation safely and quickly by compass is now barely existent;
- the increase in safety should be weighed against the cost.

"An additional crew member (canal helmsman), who is rested and trained for his task, can be a solution that enhances safety." At the same time, the canal helmsman can also carry out a monitoring/information function for the pilot. Other areas of operation make use of a second pilot for that.

The Brotherhood of NOK II Pilots also addressed additional scope for improvement in other basic comments, which included the introduction of portable computers, for example. These portable pilot units (PPUs) are designed to assist pilots by providing highly precise charts, up-to-date information on the operating area and data from other ships in real time. Other points included the need for practical gyrocompasses with a 1/10° analogue scale, rate-of-turn indicators on ships over a certain size[74], and visibility forecasts for the NOK for ships carrying dangerous cargo[75], which have registered for the passage, to prevent them from entering the canal during fog situations and then being forced to lay up there.

As a professional body for pilots, the Bundesverband der See- und Hafenlotsen (Federal Association of Maritime and Harbour Pilots - BSHL) views the overall problem in the same way as the pilot brotherhoods. Beyond that, the following points should also be mentioned:

- in the opinion of the BSHL, the 'Ship-handling Simulation' training module agreed with the supervisory authority should be stepped up to three days in three years to satisfy the complex requirements;
- the use of PPUs is also important to the BSHL. Here, it would like to see extended access to the data of the Federal Waterways and Shipping Administration;
- the initiative of some shipowners to soften the requirement to make use of a canal helmsman for certain ships is viewed very critically.

The Association of Canal Helmsmen did not deliver an opinion.

The responses of the two brotherhoods and the BSHL show the diversity of the problems and interdependence of cause and effect in the different areas. The responses also make it clear that pilots deal critically with the conditions on the canal and are interested in finding constructive solutions. Representatives of the brotherhoods are in close contact with Waterways and Shipping Directorate North and their administrative bodies. The field of conflict between preserving the appeal of the canal for shipping in terms of time advantage and cost, maintaining traffic flow and safer passage presents all parties with new challenges time and again.

3.2.8 Ship-handling simulator

A number of simulation runs were carried out on the ship-handling simulator of the University of Bremen's Nautical Science Department in June 2011 at the suggestion

[74] The first two points intended as part of the approval under Article 42 SeeSchStrO.
[75] Article 30 SeeSchStrO – Movement restrictions and bans.

of waterway police Brunsbüttel. This was attended by representatives of Brotherhood of NOK I Pilots, WSA Brunsbüttel, public prosecutor's office in Kiel, waterway police, and the BSU. The model of a type Sietas 168 ship (non-extended) was used for the simulation. The other vessels were represented by ship models that corresponded with the dimensions of the other ships involved. It was possible to reproduce the occurrence of the bank effect in this simulation. The cooperation between pilot and helmsman necessary in all conditions and the impact of restricted visibility on navigating the ship were explained by the representative of the pilot brotherhood.
In summary, it can be concluded that simulators are generally suitable for practising canal navigation and they can be used to reproduce the occurrence of bank effects. The bridge team management necessary, in reduced visibility in particular, can also be trained on simulators.

3.2.9 Weather and visibility

A weather report was prepared by Germany's National Meteorological Service (DWD) for the period in which the accident occurred. This set out the weather conditions as follows:
"On 14 April 2011, the corresponding area was covered by 'Stephanie', an extensive high pressure system. This stretched from the Azores across central Europe up to Scandinavia. After initial patches of fog, the weather alternated between sun and clouds. It remained dry."
The following was stated with regard to the weather conditions at 0700:
"At the time of the marine casualty at 0700 CEST, there was widespread fog in the region around Beldorf. Visibility stood mostly at 200 m, even less in places. Furthermore, there was a weak to moderate westerly wind of 4 to 6 kts (2 to 3 Bft). There were no gusts. The morning temperature showed values of plus 1 degree and there was ground frost in places."

Specific visibility measurements are taken by WSA Brunsbüttel in the sidings at Dückerswisch and Oldenbüttel. The per minute recordings for the accident period (0600 to 0759) were made available. During the analysis, it was found that visibility could change dramatically within short periods. For example, the visibility measured in Dückerswisch still stood at 1,000 m at 0603. However, the visibility at 0606 was only 85 m. Visibility at the time of the accident at the measurement point, which was about 8.5 km away from the scene of the accident, stood at between 285 m (0654) and 1,000 m (0701). Visibility at the measurement point in Oldenbüttel, which was about 8 km away, stood at between 338 m (0653) and 1,000 m (0702). An analysis of the discussions on the bridge of the OOCL FINLAND indicates that the NORDIC DIANA came into the sight of the ship's command of the OOCL FINLAND at 065649 at 0.18 nm, which is about 330 m.

Visibility was less than 100 m according to the officer on watch on the OOCL FINLAND.

The crew of the ferry SWINEMÜNDE was also asked about visibility and stated that it was less than 50 metres.

The sun rose at about 0629 on the day of the accident.

3.3 Fire brigade, rescue services, police

3.3.1 Legal framework for the fire brigade and rescue services

Due to existing legislation[76], the municipalities are basically responsible for firefighting[77] on the Kiel Canal. The districts, respectively, independent cities are responsible for the rescue services[78]. Over and above that, the CCME has responsibility in complex damage scenarios[79].

3.3.2 Deployment of the fire brigade and rescue services

Alerting is always carried out via central control centres, which now cover the areas of several districts. Due to existing agreements, the Elmshorn-based Joint Regional Control Centre West[80] is responsible for the districts of Dithmarschen, Steinburg and Pinneberg. The Kiel-based Integrated Regional Control Centre Middle is responsible for the districts of Rendsburg-Eckernförde, Kiel and Plön.
Joint Regional Control Centre West is unique in that it cooperates with the Police Control Centre, which is located in the same building, albeit in different offices.

The fire brigades and rescue services along the Kiel Canal are basically not fit for deployment on ships due to the absence of training. Nevertheless, members of the largely volunteer fire brigades have been and are deployed for operations of ships. However, these should only play a supporting role. With one firefighting unit each, only the fire brigades in Brunsbüttel and Kiel had a special task force for firefighting on ships at the time of accident. Their equipment and training is supported and promoted by the CCME under existing agreements. One firefighting unit consists of an operational commander, a group commander and eight firefighters. In Schleswig-Holstein, special firefighting units are stationed in Brunsbüttel, Flensburg, Kiel and Lübeck.
The casualty care teams were also formed with the support of the CCME. They are also educated and trained specifically for deployment on ships. One casualty care team consists of an emergency physician, an auxiliary and three paramedics. In Schleswig-Holstein, casualty care teams are stationed in Flensburg, Kiel and Lübeck. Two other casualty care teams are stationed in Hamburg.

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[76] Article 35(2) Law on federal waterways (Bundeswasserstraßengesetz - WaStrG) not applicable.
[77] Article 6(1) Law on fire protection (Brandschutzgesetz - BrSchG-SH).
[78] Article 6(2) Law on rescue services (Rettungsdienstgesetz - RDG-SH).
[79] See also Law on establishing a central command for maritime emergencies (Havariekommandoabkommensgesetz - HavkomAbkG.)
[80] Near Pinneberg (see Figure 59).

Figure 58: Chart of Schleswig-Holstein with districts

An important operational resource for fire brigades and rescue services are the ferries used at crossings on the NOK. It is usually not possible to reach ships requiring assistance from the bank because of the underwater embankment. Technical equipment such as turntable ladders are not available to all fire brigades, doesn't have the necessary reach or cannot be used on the terrain. A fireboat is available only in Kiel. Tugs with fire extinguishing capacity are stationed only in Brunsbüttel and Kiel. Hence, only the ferries offer a reliable and relatively quick way of getting firefighters and rescue workers on board a ship or starting to fight a fire from outside.

However, the spending cutbacks required within the Federal Waterways and Shipping Administration to increase economic efficiency may result in a step backward as changing a part of the existing ferries on the NOK to one-man operation is being considered. In fact, this has already happened in the case of the ferry berth at Breiholz and of the ferry STRALSUND[81].

12 none cable-guided ferries, suitable for the transport of truck, are run on the Kiel Canal. Three such ferry lines are operated on the eastern stretch as inland waterway vessels under a licence issued by the ZSUK[82]. The external operator on the eastern stretch is obliged to employ at least a qualified deckhand as second crewmember. A lower qualification regarding the second crewmember is required on the western

[81] The investigators assume that the ferry at Burg was sufficiently manned at the time of the accident because she also headed for the scene of the accident.

[82] ZSUK – Zentralstelle Schiffsuntersuchungskommission (inspection body for inland waterway vessels).

stretch. That means that this licence does not cover longitudinal movement in one-man operation or manning by an under-qualified second person in individual cases.
Consequently, these ferries will no longer be available for the operations discussed above or would require additional manning if the spending cutbacks are further implemented. According to WSD North, basically it is under no obligation to uphold the option of longitudinal movement for the ferries, since it is their traditional task to enable only cross traffic and thereby the maintenance of the previous route linking. The Waterways and Shipping Administration does furthermore have no obligation to provide the canal ferries as a platform for operation and rescue forces.
After the contract for operating the large ferries in Brunsbüttel was awarded to an external provider, the restriction on the deployment of ferries already applies there.[83]

The Directorates-General Waterways and Shipping, branch Kiel, explained in its statement pertaining to the draft report, the authority suggested that the Federal State Schleswig-Holstein shall provide the second qualified crewmember required for the longitudinal traffic in the appropriate cases.

[83] See also Nolte, Martin: Evaluierung des Gefahrenpotentials und Erarbeitung eines Rahmengefahrenabwehrplans zur Verbesserung der maritimen Notfallversorgung auf dem Nord-Ostsee-Kanal (evaluation of the potential risk and formulation of a general emergency plan to improve maritime emergency care on the Kiel Canal). Unpublished bachelor thesis, Hamburg 2011, pp. 69-72.

4 ANALYSIS

4.1 Kiel Canal

4.1.1 VTS Kiel Canal

It was found during the investigation that the staff of the VTS handled the consequences of the accident proficiently. The staff attempted to establish sound facts so as to make informed decisions on that basis. That the total extent of the damage became clear only after a relatively long period was outside the control of the staff of the VTS and justified by the distance to the scene of the accident and lacking infrastructure in this area. Restricted visibility additionally impeded the assessment of the extent of the damage through the vessels in the proximity.

The BSU presumes that the notification of the waterway police coordination centre at 0712 (see section 3.1.4.5) referred to in the log book of the VTS actually relates to the WSP station in Brunsbüttel and not the waterway police coordination centre in Cuxhaven. Notification of the waterway police coordination centre in Cuxhaven would have resulted in an entry in the computerised log of the Maritime Emergencies Reporting and Assessment Centre (MERAC), which must be used in such case. However, the first entry regarding the collision was not made there until 0752 when the information about the collision was forwarded to the waterway police coordination centre by WSP Brunsbüttel.

The alerting plan of the VTS for marine casualties on the western stretch of the NOK was also looked at in the course of the investigation. On the one hand, it was evident that alerting the responsible control centre of the fire brigade is based on the kilometre posts of the NOK. Accordingly, Joint Regional Control Centre West would be responsible for kilometre 0 to kilometre 41. The remainder of the canal stretch would be covered by Integrated Regional Control Centre Middle. Due to the district boundaries and actual responsibilities of the control centres resulting from that, this is rather impractical as it is not consistent with the existing responsibilities of the control centres, because the Canal divides the administrative districts Dithmarschen and Rendsburg-Eckernförde with their different responsible control centres at the north and the south side from kilometre 24 to 41 (see also section 3.2.10.2 and Figure 58).
On the other hand, it transpired that other reporting channels evidently apply in the event of a major incident. In such a case, the VTS is required to report directly to the Emergency and Command Centre of the Ministry of the Interior of the State of Schleswig-Holstein. Anything below a major incident is the responsibility of the police. For incidents that start with an inadequate information base, the BSU sees the difficulty for all involved in maintaining the proper reporting channel.

4.1.2 Traffic regulations

The traffic regulations require that all vessels keep a safe speed. The question as to whether a speed can be considered a safe speed within the meaning of the COLREGs depends upon the stipulation of the maximum speed on the NOK. The Shipping Administration reduced the maximum speed permitted on the canal to 15 km/per hour. The maximum permitted speed applies in any case, even if the limited speed fall below the actual possible speed (with respect to the critical speed) upon proceeding under shallow water influence or even if the conceivable safe speed, exclusively applying during navigation on radar[84], which might result in a higher speed[85].

The fact that die maximum speed permitted does not reduce during the night or with restricted visibility does not mean for the vessels command, to take over the permitted speed under all circumstances without critical review. This only implies that the Shipping Administration doesn't see any basic problems, if this speed is applied during the night and in restricted visibility. Every vessels command is, to the contrary, required to determine the safe speed for their passage and constantly review this decision during the passage.
In determining the safe speed in restricted visibility the following aspects could serve for an argument for high speed:

- the traffic direction and the speed of most of the vessel are known and clearly visible on the radar image
- small targets are not superimposed by sea clutter, since this does not occur on the canal

The following aspects may, on the other hand, speak against keeping the permitted speed:

- enhanced hydrodynamic effects during the encounter with other vessels and under shallow water effects with reduced possibility of optical control due to the restricted visibility
- basically reduction of possible means to act when hydrodynamic effects act on the vessel with higher speed
- enhanced dependence on an efficient working radar set, since situations, which are only perceived as critical as soon as they are in sight, can be counteracted more difficult
- greater dependence on a functioning engine if the vessel has to be stopped on a short distance

In the case under consideration the permitted maximum speed on the NOK was slightly exceeded by the vessels command of the TYUMEN-2 and largely significant by the vessels command of OOCL FINLAND. The pilot of OOCL FINLAND was aware of this. He had initially informed the canal helmsman at the beginning of the passage in restricted visibility (section 3.2.5.6 at 0525) that he did not intend to sail that fast in the fog, because the vessel would react poor. However, the speed was de facto not reduced. This was justified with the maintenance of a good steerability. This was the unanimous opinion of the pilot and the canal helmsman.

Both vessels were not subject to restrictions in restricted visibility with respect to their cargo or other circumstances.

[84] Rule 19 b COLREGs.
[85] Hilgert, Helmut /Schilling, Rolf: Kollisionsverhütung auf See. Teil 1: Rostock 1992, S. 127.

In every case, the speed should have been agreed with the vessels command of the OOCL FINLAND, since they had to make the ultimate decision. This applies particularly after the visibility reduced. The master of the vessel was informed about the deterioration of the visibility by the watch officers of the vessel. The officers did not broach the issue of the speed applied to the pilot. Thereby neither the requirements of the ISM handbook of the vessels operator nor the effective instructions of the master were complied with. The master's instructions regarding the watch during the night did not contain any entries for reduced visibility during the passage of the NOK.

The speed kept by the OOCL FINLAND had apparently no critical effects on the safety of the vessel over a long period of time. The investigators evaluated the VDR recording until 0655 and did not detect any indication of an extraordinary hydrodynamic influence exerted on the OOCL FINLAND. However, the NORDIC DIANA was on 0657 (km 31) only the second large vessel encountering the OOCL FINLAND after the RHODANUS on the free stretch. Therefore the OOCL FINLAND could use the mid of the canal almost the complete time, so that the hydrodynamic influence was low.

From 065843 on and until the collision the speed of the OOCL FINLAND was within the admissible range. Shortly afterwards the propeller pitch was increased in order to escape the bank effect. This had no influence on the speed any longer.

The traffic regulations basically require an evasive action to starboard on vessels encounter on reciprocal courses and the maintenance of a safe passing distance. The traffic regulations applying to the Kiel Canal required an evasive action by the TYUMEN-2 vis-à-vis the OOCL FINLAND.
As already depicted, a different behaviour resulted from the special of a canal compared with those on sea. This particularly applies to the conduct during passages in a close quarter, which is the normal case in a canal. Proceeding on the respective starboard side of the canal may be considered as fulfilment of the requirement of a safe passing distance and the evasive action to starboard. The hydrodynamic interactions during the encounter usually enable a safe encounter of the both vessels. Keeping a sufficient speed, which might fall below the compulsory maximum speed, has a positive effect on the strength of the hydrodynamic effects. It reduces it.

The OOCL FINLAND proceeded in the midst of the canal on the section of the canal without upcoming vessels. When encountering vessels the OCCL FINLAND took evasive action to the starboard side. All encounters with upcoming vessels went without any noticeable problems.
At the time of the collision the TYUMEN-2 was on her side of the Canal. She had proceeded with almost the same distance to the shore up to the collision. The distance to the conceived centre line of the canal was about one ships breadth. The distance to the northern shore was about 50 m. Even though the underwater embankment in this area has a greater extension towards the centre of the canal

than the embankment on the southern side, a slightly more northern passage would have been feasible due to the lower draught of the TYUMEN-2. It is conceivable that the restricted visibility had an influence on the distance selected.
The OOCL FINLAND took evasive action further to starboard prior to the collision.

4.2 TYUMEN-2

4.2.1 Structural condition

It was found during the investigation that the structural design quality of the connection between the wheelhouse and rest of the superstructures was less than high. However, it corresponded with the required strength for the intended area of operation. That the entire wheelhouse tore off as a result of the collision between the two ships was an unpredictable and atypical event. The course of the accident would probably have been less severe if the connection between the wheelhouse and superstructures had been welded instead of bolted. The effect of the exceptionally rigid design of the OOCL FINLAND's breakwater was additionally negative. The marine casualty investigators assume that the port side corner of the breakwater of the OOCL FINLAND struck the wheelhouse of TYUMEN-2 and did not gave way because of its solid design. All the impact energy was thus absorbed by the 'softer' design of the wheelhouse of the TYUMEN-2, which resulted in the immediate failure of the bolted connection.

4.2.2 Course of the accident

At the time of the accident, the manning on the bridge of the TYUMEN-2 exceeded that laid down in the rules. The investigators found no evidence of defective equipment or other factors that impeded safe navigation. The ship sailed on the 'correct' side of the fairway during the period under consideration. Prior to the collision, the TYUMEN-2 was not exceptionally affected by the bank effect. She followed the course of the canal in the usual manner. The permissible speed was exceeded in places. The ship's command was surprised by the sudden approach of the OOCL FINLAND.

4.2.3 VDR

The unusable display of the radar image was apparent when replaying the data saved by the VDR. The investigators also found that the entire VDR was installed on 29 June 2010 in Kaliningrad by a service technician approved by the manufacturer. The associated report confirms that radar image recording was operable. The accident happened before the date of the first annual inspection by a service technician. The error was not noticeable during normal operation. The Russian Maritime Register of Shipping explained in its statement pertaining to the draft report, that the manufacturer JRC attributes the error to the type of storage and that the error had not been noticed by the manufacturer before.

During the first analysis of the data stored on the CF card, the investigators detected

the absence of audio data for a period of one minute and 21 seconds. All the remaining data were absent for a period of 22 seconds.
It was revealed during the analysis of the data structure on the storage media that the data for radar, audio and NMEA[86] were stored in three different folders. Here, each folder invariably contained data for a period of 30 minutes.
The information from the radar was stored in 15-second intervals as an image in PNG format[87].
The audio data were stored in files in DAT format[88]. Each file covered the period of one minute and contained data from four audio channels (three channels for the bridge microphones and one for the VHF recording).
Each folder for the NMEA data contained 30 log files, each of which contained the data set for one minute.
The storage of any data was such that the incoming data were gathered in the processing unit and then saved as a package/file on the storage media at the start of each new minute. During the investigation it was found that data sets relating to radar and NMEA for the period 0559 to 0600 were present. However, the audio data set for this period had not been saved before the power supply was interrupted at 070021. On closer inspection it transpired that the file for the VHF recording had already been created but was not populated. The files for the bridge microphones were missing in their entirety.

An enquiry with the manufacturer, JRC, revealed that the final recording medium (FRM) would take priority in the handling of the data and thus in the storage. It was on that basis that the FRM was read by its manufacturer, L-3. In the process, the statement of JRC was not confirmed. The recording of the audio data ended at the same time as on the CF card. However, the file for the VHF recording had still not been created. The following storage sequence could be derived from that: CF card before FRM, VHF recording before bridge microphones recording.
Resolution MSC.163(78)[89] forms the basis for the performance standards for S-VDR devices. In the EU, EN 61996-2[90] applies simultaneously. Here, the following is laid down in section 5.1.1:

> “The S-VDR should continuously maintain sequential records of preselected data items relating to the status and output of the ship's equipment, and command and control of the ship, referred to in 5.4.”

[86] NMEA – National Marine Electronics Association.
[87] PNG – Portable Network Graphics.
[88] DAT – Digital Audio Tape.
[89] Performance Standards for Shipborne Simplified Voyage Data Recorders (S-VDRs), adopted 17 May 2004.
[90] Maritime navigation and radiocommunication equipment and systems – Shipborne voyage data recorder (VDR) – Part 2: Simplified voyage data recorder (S-VDR) – Performance requirements, methods of testing and required test results (IEC 61996-2:2007).

The relevant text of said European standard is more or less the same. The technical requirements for VDR's are identical[91] [92]

An enquiry with the German approval and licensing authority for such systems, the Federal Maritime and Hydrographic Agency, revealed that 'uninterrupted', i.e., continuous storage of the data, is interpreted differently by the manufacturers of the different VDRs. For example, in the case of some manufacturers radar data are stored only in 15-minute blocks. With some manufacturers, there are even delays when data are stored on media other than the FRM. With the exception of the case under investigation, the BSU has no further knowledge in this regard. Until now, VDRs have only been read and analysed during normal operation or after an emergency backup.

4.3 OOCL FINLAND

4.3.1 Hydrodynamics

The course of the collision was marked by the hydrodynamic effect on the OOCL FINLAND. The hydrodynamic effects acting on the ship are explained in more detail below:
"Due to the confinement of a fairway in depth and breadth, the handling and manoeuvring characteristics of a ship are changed in many ways. The reduced cross-sectional area beneath and next to the ship as compared to the open sea changes the flow around the hull. This causes forces and torques existing in deep water to change, which has an effect on the floating condition, speed and steerability of the ship. [...] the drop in pressure beneath the ship [...] and lowering of the water surface cause a reduction in the underkeel clearance and changes in the trim.

Due to hydrodynamics, a moving ship immerses deeper in the water than one that is stationary. This also changes the trim. Both effects are summarised by the term squat [...]. For large and fast moving ships, the draught increases in deep water by centimetres to decimetres; under certain circumstances, it may be considerably more than a metre in shallow water. Hence, squat is crucial to underkeel clearance when moving in shallow water."[93]

The discussed changes in the trim lead to a shift of the pivot point to aft, especially when the ship trims forward. This causes a reduction in the effectiveness of the rudder due to the shortened lever arm.

"A hydrodynamic phenomenon associated with squat is the canal effect (or bank effect). This occurs when a ship is moving outside the middle of the fairway near the bank. In such a situation, forces and torques act on the ship and move her in the direction of the nearby bank.

[91] Resolution A.861(20), adopted on 27 November 1997.
[92] As well as the updated Resolution MSC.333(90), adopted on 22 May 2012.
[93] Benedict, Knud, Wandelt, Ralf: Einfluss von Fahrwasserbegrenzungen auf Fahrt und Steuerung (impact of confined fairways on handling and steering [sic]). In: Bendict, Knud/Wand, Christoph (publ.): Handbuch Nautik II. Hamburg, 2011, pp. 337-338.

For example, if the nearest bank is on the starboard side, then the cross-sectional narrowing caused by the underwater hull is more pronounced there than on the port side. Consequently, acceleration on the starboard side is greater than on the port side. Therefore, the water flows faster on the starboard side than on the port side, causing the pressure on the starboard side to drop more sharply. This hydrodynamic pressure difference accelerates the ship towards the closest bank. The extent of the difference in pressure differs based on the shape of the hull along the ship's longitudinal axis. This spatial distribution causes torque in addition to the force.
Typically, the stern is accelerated towards the near bank more than the bow. Therefore, the risk of contact with the canal wall or grounding is greater sternward than at the bow, where a 'cushion effect' at the stem of the ship tends more to push her away from the bank. If in such a situation undue proximity to the bank is noticed on the bridge, then the ship's command could be tempted to increase the distance by means of a port rudder angle. However, this greatens the risk of grounding at the stern because this manoeuvre increases the hydrodynamically induced torque. The most appropriate course of action in this case is a significant reduction in speed because the canal effect also depends on the speed quadratically. However, it must be remembered that a reduction in the rate of speed may give rise to a temporary reduction in steerability."[94]

"As a result of the low pressure, the ship slowly draws herself closer to the near bank. In the process, the stern of the ship tends to turn towards the near bank because of the asymmetrical distribution of pressure and is at risk of grounding at the stern or veering out and crossing onto the opposite side of the fairway. [...] This effect is referred to as the bank effect or effect of one-sided nearness to the bank. Pilots often speak of 'push away'. When it is initially noticed that the ship is moving towards the bank, roughly parallel and slowly at first, but that the rotational tendency has yet to indicate an imminent danger veering out to the opposite side, then a sharp reduction in speed is sufficient. As with all manoeuvres, it should be remembered that the Bernoulli equation applies to the speed quadratically, i.e., reducing to half the speed reduces the phenomenon to about a quarter.

Steering the ship away from the bank by means of the rudder angle without reducing the speed must always be avoided as the turn would intensify the effect.
If there is a risk of veering out or pushing away towards the opposite bank (especially dangerous if there is oncoming traffic), this can only be avoided by implementing a hard-over rudder towards the bank (i.e., usually 'hard to starboard') and significantly increasing thrust. As with all manoeuvres dependent on rotational tendency: first put the helm and then increase engine power if necessary.

The effect may also occur in the event of an invisible narrowing of the fairway due to areas of shallow water ('sagging') below the water surface. In such cases, [...] the helm should be set in the direction of the near bank/shallow water to deaden the

[94] Ibid. pp. 344 and 345.

emerging bank effect early on, i.e., where appropriate shortly before reaching the narrow section. The engine may have to be set to a higher rate of speed for a short duration. Otherwise, after the onset of the bank effect neither helm nor engine manoeuvres may be sufficient under certain circumstances and the ship may run out of the rudder."[95]

4.3.2 Navigation on the NOK

The ship/ship interactions resulting from encounters on the NOK as well as the hydrodynamic effects on the hull during canal passages, especially due to the bank effect, discussed in the preceding paragraph and the ensuing limitations in manoeuvrability are complex. The less manoeuvring space available and high traffic density increase complexity and therefore require experienced navigation. In actual fact, some captains use the passage as rest period. The Federal Waterways and Shipping Administration has responded to that with the basic requirement to make use of a pilot and a canal helmsman. The schooling for NOK pilots and helmsmen focuses on teaching trainees the specifics. By progressing through levels of experience in the form of gradually increasing size restrictions, the necessary skills of a pilot are developed.

The navigation process in the proper sense, i.e., navigating the ship in the canal, requires close cooperation between pilot and helmsman. The helmsman is able to determine the course relatively independently in good visibility by means of the visible canal section ahead or the installed lighting on the banks. This change in restricted visibility. The pilot then uses the radar to monitor the stretch immediately in front of the ship, her position in the canal and movements in respect of speed and rate of turn. This monitoring results in course instructions to the helmsman.
The rudder angle required to maintain the specified course is again an indication of the strength of the bank effect. If the specified course can be maintained by the helmsman with small rudder angles, then the bank effect is only minor. When proceeding off-centre, the bank effect increases as described and requires a fuller rudder angle to compensate. Here, rudder angles of 20° to 25° are acceptable. However, the helmsman should notify the pilot of this. Notification of the pilot is required at the moment rudder angles beyond that are necessary as a response by the pilot is needed. This is especially valid when it is not possible to maintain the required course. By that it is meant that the stern of the ship is sucked in, causing the ship to turn towards the middle of the canal, respectively, towards the opposite side of the canal. As already discussed, the possible responses to being pushed away are limited as the only options available are increasing or reducing the rate of speed. In most cases, attempts are made to address the problem by increasing the rate of speed.

[95] Wand, Christoph: Manövrieren in engen Gewässern (manoeuvring in confined waters). In: Bendict, Knud/Wand, Christoph (publ.): Handbuch Nautik II. Hamburg, 2011, p. 421.

When transiting a canal, a ship is always exposed to the bank effect when she leaves the middle of the canal. The task of the ship's command is to keep the forces arising controllable by choosing the right course, respectively, rudder angle and speed. High speed and/or coming too close to the bank signify high forces of attraction. This is set against the decreased steerability at low speeds seen on many ships and space requirements of oncoming ships. This may be complicated by the draught limiting the own ship's scope for action and/or her space requirements.

In restricted visibility, the task may be complicated further by the following points:

- distortion of the radar image at the centre point; the canal bank is displayed widened (see Figure 59) or constricted at the centre point (see Figure 60). Both affect determination of the ship's position on the canal;
- limited or no view of the canal ahead or the lighting marking the course of the canal[96] and with that lacking options for monitoring the ship's position on the canal;
- due to the high position of the wheelhouse in the case of high superstructures, the view on the bank located abeam is restricted or non-existent as the bank boundary, the illumination or trees growing there are out of sight. This means that it is only limited possible to monitor lateral distance visually;
- improperly configured radar system and therefore erroneous rendering of the heading;
- compass display with an excessively rough scale or only with digital display cannot be used to determine the behaviour of the ship.

[96] The lights are installed at a distance of 250 m from one another.

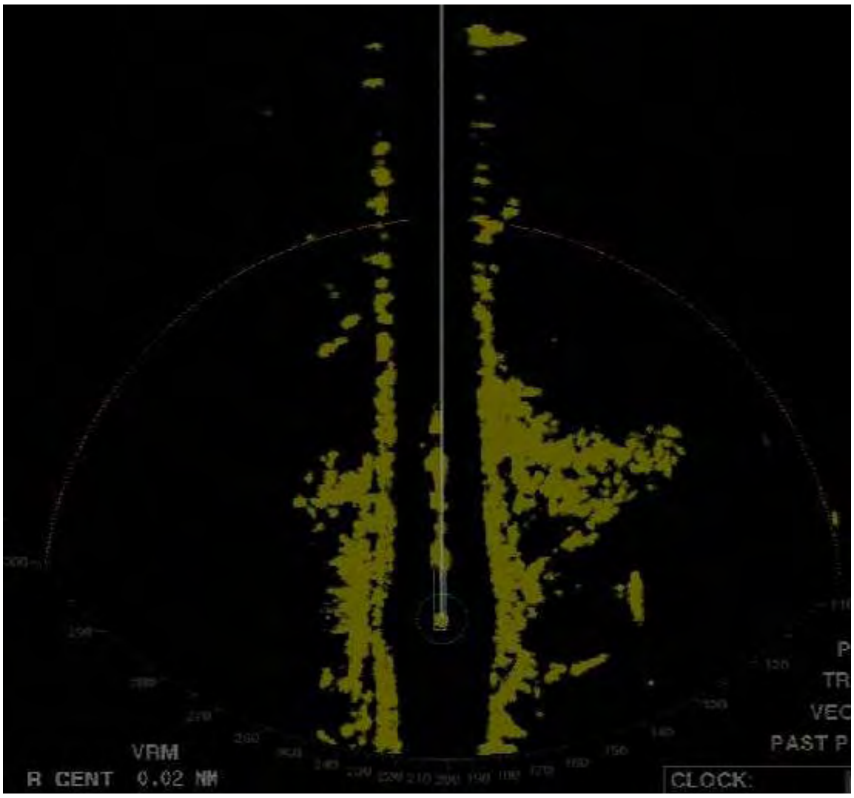

Figure 59: Example: outwardly distorted radar image at the centre point

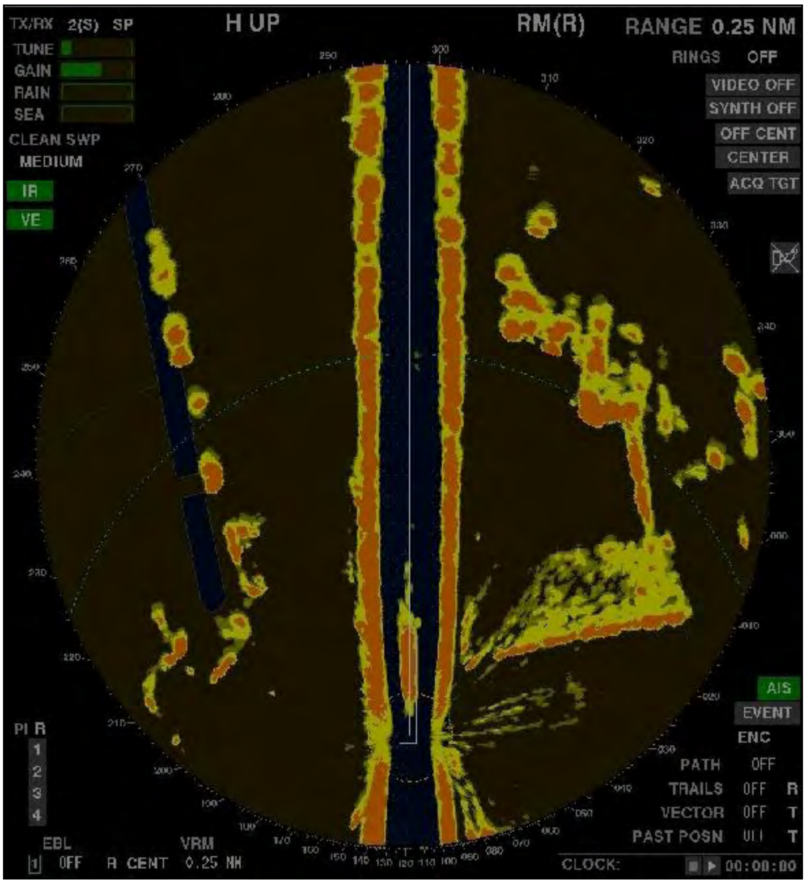

Figure 60: Example: inwardly distorted radar image at the centre point

To assess the basic manoeuvrability of the OOCL FINLAND the deliberations referred to in section 3.2.5.9 were made. Based on the manoeuvring documents available, two conclusions may be drawn:

- the OOCL FINLAND satisfies the criteria of the IMO Resolution[97] after being extended, too;
- the manoeuvring data of the non-extended and extended ship do not differ from each other considerably.

However, in general it should be noted that the manoeuvring data drawn up according to the standard can only be indicative. The actual behaviour of the ship in the canal when influenced by shallow water may deviate seriously and is also dependent on the actual draught and trim.

During talks with pilots the investigators gained additional subjective impressions of the steerability of this extended ship type. Overall, it was given to understand that steerability is reportedly worse when compared to the non-extended ship. However, the OOCL FINLAND reportedly did well as compared to other ships that were difficult to steer.

4.3.3 Course of the collision

To illustrate the situation more effectively, the data for the rate of turn (ROT), rudder angle, course over ground (COG) and current heading (HDG) for the period in which the accident developed are shown in Diagrams 6 and 7 below.

[97] IMO Resolution MSC.137(76) – Standards for Ship Manoeuvrability, adopted 4 December 2002.

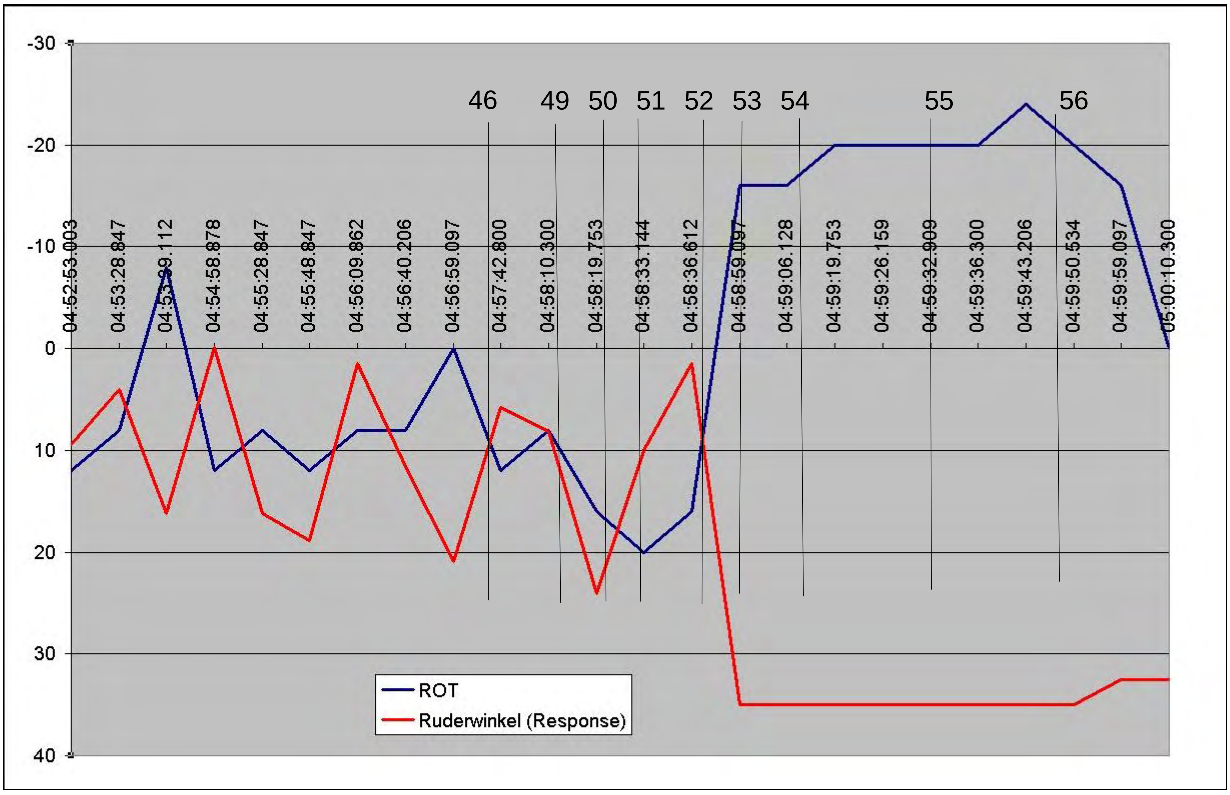

Diagram 6: OOCL FINLAND, ROT [°/min] and rudder angle [°] from 0452 to 0500 UTC[98]

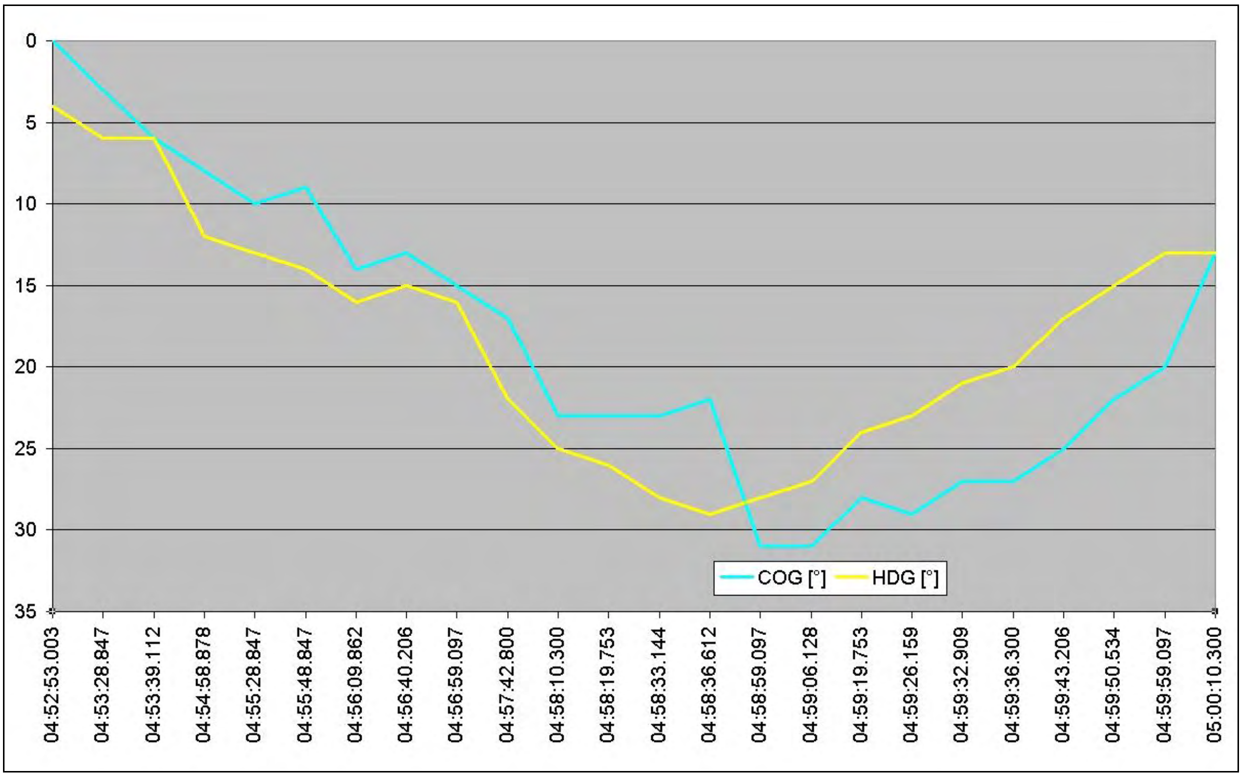

Diagram 7: OOCL FINLAND, COG [°] and HDG [°] from 0452 to 0500 UTC

[98] The numbers on the markers in the diagram relate to the numbering of figures in the report.

The area of the embankment slumping in the stretch between canal km 28.1 and 28.5 was passed by the OOCL FINLAND at about 0645 with a speed of 8.5 kts. The VDR-recordings for this period of time did not show any particularities .This means that there was not communication between the pilot and the canal helmsman pointing to a special situation. The scene of the accident was still more than 3 km ahead. The investigators were of the opinion that the passage with the embankment slipping had no influence on the further course of the voyage or the collision.

Upon request of the canal helmsman, the pilot indicated the course to be steered again. Since the activation of the canal illumination was requested already at 0649, it can be assumed that the visibility had significantly deteriorated.

The pilot monitored the unfolding situation. At the same time, he communicates actively with the helmsman and thus obtains the information important to him about the behaviour of the ship and with that also the 'perceived' distance to the bank.

The course of the voyage was uneventful up until the passage of the viaduct at 0655. At 065809, the pilot instructed the helmsman to steer a compass course of 28°. Shortly afterwards, 30° was specified. In this regard, the pilot said to the helmsman: "[...] otherwise, that will not be okay with the others." (See also Spreadsheet 1 and Figure 49.) It is not known whether this statement was based on the fact that the pilot assumed that the OOCL FINLAND or the oncoming TYUMEN-2 was too far towards the middle of the canal. The AIS recording of that time (Figure 33) does not permit such a conclusion.

The helmsman responded to the instructed course of 30° at 065810 by altering the helm from 10° starboard to 25° starboard. This caused the rate of turn to increase from about 10°/min to 20°/min to starboard. This course alteration resulted in movement towards the right-hand bank, since the selected course was set very close to the embankment. The pilot was aware of and tolerated this because he assumed that it would be compensated subsequently or as they passed through the bend (see Spreadsheet 2: remark at 065843).

The course selected would have had its closes point of approach to the embankment curve approximately 500 in front of the vessel bow. With a speed of the vessel of 8.1 kts this point would have been reached after 1’59’’ (070008).

The helmsman responded to the increase in the rate of turn to starboard at 065819 by reducing the rudder angle. The ship then began to turn to port. However, she continued to move towards the right-hand bank. At 065836, the specified course of about 29° was attained. The rudder angle had just reached 3° to starboard. Due to the movement towards the embankment in the meantime and ensuing onset of the push away effect, the ship turned further to port. The helmsman responded with the rudder angle 'hard to starboard', which was also noticed by the pilot (065856). However, due to the bank effect the ship continued to turn to port and moved further

in the direction of the embankment (see diagram 7). The increase in propeller thrust by the pilot at 065902 and again from 065948 did not have a positive effect. The opinion of the BAW concludes that the bank effect was actually intensified by this.
Shortly before the collision the propeller thrust was reduced. However, this did not have any influence on the further course. The vessel kept a decreasing turn to port until shortly before the collision.

The pilot led the vessel further to the embankment with the course alteration of 30°. The vessel should in fact have followed the embankment curve. This would possibly have required a course alteration after a respective approach of the embankment. To 'perceive' the distance to the bank, inter alia, by monitoring the necessary rudder angle with which the ship can be kept on course (see also section 4.3.2) is associated with the risk of moving too close to the bank. This results in the existing bank effect being intensified to the point that it can no longer be controlled, which was the case here.

The pilot and canal helmsman were able to orient themselves in respect of the position on the canal and monitor convergence with the bank based on the impression gained visually only to a limited degree. Firstly, it was not possible to make out the course of the canal because of low visibility. Even the activated canal lighting is unlikely to have added any real value because visibility was less than the distance between the lights. Secondly, the bank next to the ship was visible only to a limited degree because of the height of the wheelhouse and the steering console located in front of the pilot.

The position of the ship on the canal was determined by the pilot using the radar. A radar set operated on the 0.5 nm-range like on the OOCL FINLAND, is basically appropriate to provide sufficient information about the position of the vessel in the canal and the other vessels. However, as regards determining the actual distance to the bank, the investigators believe that the existing radar information is only of insufficient value because of the system's limitations, which arise from the height of the radar antenna and small distance to the bank. Owing to the circumstances and due to the limitations inherent to the system, resulting from the height of the radar antenna and the short distance to the shore, the real distance to the embankment can only be determined to a limited extent. Restrictions in displaying the radar image, especially around the display center, (see figure 59, 60 and 61), lead to the fact that the real distance to the shore can only be determined by the head line and the position of this to the shore.

The following radar exemplifies the orientation possibility by means of a radar set operated in the 0.5 nm range:

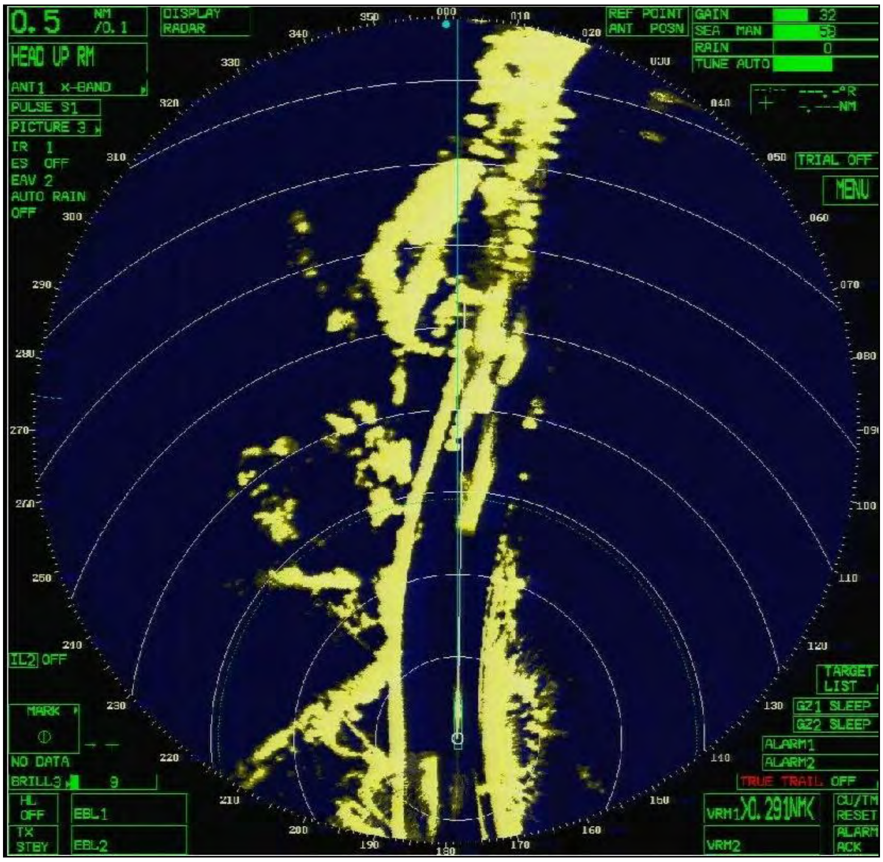

Figure 61: Example of radar image in 0.5 nm range

The investigators have no backed up information about the quality of the radar image or the radar range used by the pilot on OOCL FINLAND. The statement of the pilot on his configuration of the radar was justifiable and appropriate. Moreover, there was no evidence of any technical deficiencies.

Other conventional options for monitoring the course of the voyage, respectively, convergence with the bank using technical means were not available or could not be used. The pilot only had the compass display with analogue 10° graduation and the display of the ship's rate of turn at his disposal.
The right-hand bend that had to be navigated has an almost constant curve radius in the area between ckm 30.3 and ckm 33. In the open sea and with sufficient depth of water, it would have been possible to navigate this bend with a small rudder angle, which would have resulted in a controllable and steady rate of turn of 3.3°/min. However, due to the bank effect this approach was not possible. The rate of turn and rudder angles changed rapidly (see Diagram 2) and therefore provided no indications vis-à-vis course of the voyage or position on the canal.

While assessing the recorded discussions on the bridge of the OOCL FINLAND, the investigators had the impression that the pilot did not adhere to the maximum speed permitted intentionally. Although at 0525 the pilot initially determined that the speed would be reduced in fog, the maximum speed permitted was actually slightly exceeded regularly. In the conversation between the pilot and helmsman, the view was expressed that the ship's steerability could only be maintained at a higher speed. Another upcoming convoy between the ferry Burg and the viaduct Hochdonn was passed with an average speed of 8.5 kts. The existence of a possible relationship between ship speed and improved steerability/manoeuvrability cannot be excluded. This could not be reviewed by the investigators retrospectively. Basically, this statement is viewed with caution, especially in the light of the fact that speed contributes significantly to the strength of the bank effect. At reduced speed a deterioration of steerability would possibly need to have been accepted. On the other hand, the impact of the bank effect would have decreased.

The “lumbering” steering of the vessel determined by the pilot and the canal helmsman did not lead to a request to the VTS for upgrading the traffic group. The OOCL FINLAND would have likely passed the NOK without further upcoming vessel if the traffic group had been upgraded.

Shortly before the collision, from 0658 and up to the collision, the ship's speed stood then at the maximum speed permitted. If the course alteration to 30° was accompanied by a further reduction in speed, then the bank effect would probably have been less. The basic assumption of the pilot vis-à-vis the relationship between the speed and steerability of this ship possibly opposed an alternative approach.

In summary, it can be stated that the events at 065809 developed at the beginning of the course alteration to starboard. This caused the ship to be taken closer to the right-hand bank and thus to within the influence of the intensifying bank effect. At 0659, the point was reached where the number of options for action was limited to changing the speed since from this point the helm was set to 'hard to starboard'. The pilot decided to increase the propeller thrust. However, the push away effect could not be prevented. It was an unfortunate circumstance that the TYUMEN-2 was then in the area of the uncontrollable course of the OOCL FINLAND and thus both ships collided.

Basically, it should be noted that a canal passage does involve a potential risk beyond the norm and that despite the existing limitations due to only marginal technical and nautical assistance in navigating the ship and limited space for manoeuvring, the forces acting on the ship are usually only controlled by sea pilots deployed on board and canal helmsmen familiar with the canal voyage.
This is demonstrated not least by the small number of accidents in relation to the high volume of traffic.

4.4 Performance of the navigational watch

The members of the ship's commands of the OOCL FINLAND and TYUMEN-2 were in possession of the necessary licences and thus sufficiently qualified.
The STCW Code[99] governs watchkeeping on seagoing ships.
The manning of the bridge during the passage of the ship is dealt with in Section A-VIII/2, Part 3, Nos 9 and 12. This states that the master is not required to navigate the ship for the entire duration of the voyage. He may assign the navigational watch to one of the deck officers:

"9 The master of every ship is bound to ensure the Watchkeeping arrangements are adequate for maintaining a safe navigational watch. Under the master's general direction, the officers of the navigational watch are responsible for navigating the ship safely during their periods of duty, when they will be particularly concerned with avoiding collision and stranding."[100]

"12 The officer in charge of the navigational watch is the master's representative and is primarily responsible at all times for the safe navigation of the ship and for complying with the International Regulations for Preventing Collisions at Sea, 1972."[101]

On the TYUMEN-2, the master had the navigational watch. The bridge was fully manned.

On the OOCL FINLAND, the master handed over the watch to the second officer at about 0500 and then left the bridge. One hour later, the second officer handed over the watch to the third officer.

As a rule, a lookout must be posted on the bridge when the vessel is under way:

"13 A proper look-out shall be maintained at all times in compliance with rule 5 of the International Regulations for Preventing Collisions at Sea […]

14 The look-out must be able to give full attention to the keeping of a proper look-out and no other duties shall be undertaken or assigned which could interfere with that task."[102]

The exemptions in No 15, which state that the officer on watch may also perform the role of lookout simultaneously, are basically limited to daylight and, inter alia, only when visibility permits.

[99] STCW Code – International Convention on Standards of Training, Certification and Watchkeeping for Seafarers.
[100] Section A-VIII/2 STCW – Watchkeeping arrangements and principles to be observed (Part 3 – Watchkeeping at Sea).
[101] Section A-VIII/2, Part 3-1 STCW – Principles to be observed in keeping a navigational watch.
[102] Ibid. Part 3-1 – Lookout.

However, a lookout was neither on the bridge of the OOCL FINLAND at the time of the collision nor for the entire period beforehand during the night. The marine casualty considered here occurred during daylight, but in restricted visibility. Indeed, it could be argued that with the pilot, canal helmsman and officer on watch, there were enough people on the bridge. In fact, each person had their own particular duty, however. Moreover, the officer on watch was fully occupied with the duties incumbent on him and thus unable to perform the role of lookout.

The ship's command of the OOCL FINLAND said in their statements that the designated crew member was on standby in the superstructures.
The investigators consider that the reasons for the absence of a lookout on the bridge[103] stated by the master are irrelevant; more importantly, there are no exemptions from the requirements of the STCW or the COLREGs for ships on waters such as the NOK.

The tasks to be performed during a watch are described in the STCW Code[104]:

„24 During the watch the course steered, position and speed shall be checked at sufficiently frequent intervals, using any navigational aids necessary, to ensure that the ship follows the planned course."

"29 In case of need the officer in charge of the navigational watch shall not hesitate to use the helm, engines and sound signalling apparatus. […]"

"31 A proper record shall be kept during the watch of the movements and activities relating to the navigation of the ship."

During the canal passage of the OOCL FINLAND, positions were entered in the bell book and in the log book at larger intervals.

It appears that the speed of the ship was not monitored further by the ship's command. The maximum speed permitted was exceeded regularly. However, this fact was not discussed with the pilot.

„45 When restricted visibility is encountered or expected, the first responsibility of the officer in charge of the navigational watch is to comply with the relevant rules […] (COLREGs) with particular regard sounding of fog signals, proceeding at a safe speed and having the engines ready for immediate manoeuvre. In addition, the officer in charge of the navigational watch shall:

.1 inform the master;

.2 post a proper look-out […][105]

[103] See section 3.2.2.1 of the report.
[104] Section A-VIII/2, Part 3-1 STCW – Performing the navigational watch
[105] Ibid. - Restricted visibility.

The investigators assume that by the time the ferry at Burg was passed at the latest, visibility had deteriorated to such an extent that restricted visibility prevailed. The onset of restricted visibility did not lead to the posting of a lookout on the OOCL FINLAND. The master was not notified by the officer on watch.
Anyway, the investigators assume that a lookout would have had no influence on the collision.

That the third officer had only recently taken on this function might suggest that he was not equal to the situation.
Earlier marine casualty investigations have reinforced the opinion of the investigators that this reluctance displayed by officers on watch towards pilots is a pattern of behaviour/issue that occurs frequently. But in the end, the investigators assume that the master of the OOCL FINLAND was able to assess the capabilities of the officer on watch sufficiently and therefore assigned him the responsibility.

4.5 Cooperation between the pilot and officer on watch

As already discussed, shipping on the NOK is subject to special conditions resulting from structural aspects and traffic conditions. These conditions include the hydrodynamic effects on the ship and the resulting special kind of pilotage and support thereof by canal helmsmen. Navigation of the ship by the crew and the pilotage deviates widely from the usual procedures when operating on rivers or narrow sea areas. On the NOK, the involvement of the pilot and helmsman in the actual navigation of the ship is significant and this involvement increases in restricted visibility. Here, the crew's scope for exerting influence is limited. This is partly because the pilot and helmsman communicate with each other in German, which makes it difficult for the crew, who generally speak a different language, to participate in navigating the ship. Secondly, the limited room for manoeuvre on the canal, which due to the confined space offers few options for action and little time for discussing possible options during the navigation process. Apart from that, the investigators believe that it is virtually impossible for inexperienced crews, who do not have a command of the German language, to grasp the meaning of the content of situation reports of the VTS. However, it is also a fact that masters and chief officers frequently use the passage of the NOK for periods of rest. This means that relatively inexperienced officers are alone on the bridge during such a period. However, in the present case an experienced ship's command would not have been able to avoid the collision.

With respect to cooperation between the officer on watch and pilot, the requirements of the STCW Code[106] are binding as a fundamental principle:

„49 Despite the duties and obligations of pilots, their presence on board does not relieve the master or officer in charge of the navigational watch from their

[106] Section A-VIII/2, Part 3-1 STCW – Navigation with pilot on board.

duties and obligations for the safety of the ship. The master and the pilot shall exchange information regarding navigation procedures, local conditions and the ship characteristics. The master and/or the officer in charge of the navigational watch shall co-operate closely with the pilot and maintain an accurate check on the ship's position and movement.

50 If any doubt as to the pilot's action or intentions, the officer in charge of the navigational watch shall seek clarification from the pilot and, if doubt still exist, shall notify the master immediately and take whatever action is necessary before the master arrives."

The pilots were briefed on the technical data and controls on the bridge necessary for navigation on both ships. The up-to-date, completed pilot cards were handed over.

Further information on cooperation between pilots and ship's commands can be found in IMO Resolution A.960(23)[107]. Here, Annex 2 No 6.3 states the following:

> „When a pilot is communicating to parties external to the ship, such as vessel traffic services, tugs or linesmen and the pilot is unable to communicate in the English language or a language that can be understood on the bridge, the pilot should, as soon as practicable, explain what was said to enable the bridge personnel to monitor any subsequent actions taken by those external parties."

The pilots on the TYUMEN-2 and the OOCL FINLAND informed the ship's commands about forthcoming changes in the course of the voyage. They had been informed about these changes previously by the situation reports of the VTS, which are transmitted only in German and thus not understood by the ship's command.

The pilots and canal helmsmen on both ships communicated in German. The practised vernacular was concise and directed towards the task. The choice of words was specific and difficult to understand for the uninitiated listener. Consequently, it would even be hard for an inexperienced German officer on watch to follow a conversation between pilots and canal helmsmen. Neither pilot gave the ship's command of his ship any indication of the events as they were unfolding, and for their part, those responsible did not request this.

Operation of the engine telegraph was also considered by the investigators. On the OOCL FINLAND, the propeller pitch was set by the pilot. This means that he had direct influence on the speed of the ship. Unlike other operating areas, operation of the engine telegraph by a pilot on the NOK in restricted visibility is on the one hand not viewed with much criticism because this is directly related to the style of

[107] Recommendations on Training and Certification and on Operational Procedures for Maritime Pilots other than Deep-Sea Pilots.

navigation practised. On the other hand, the pilot has a duty to advise[108] the ship's command. Such advice includes assisting the ship's command in complying with traffic regulations[109]. Therefore, the pilot of the OOCL FINLAND would have had a basic obligation to inform the ship's command if the maximum speed permitted was exceeded or take positive steps to comply with the permitted speed if the ship's command had granted him the power to issue orders independently. Discussions relating to this or justification for the speed selected cannot be derived from the recording of the voyage data recorder available.

4.6 Fire brigade, rescue services and CCME

The firefighters and rescue workers were alerted at 0728 by a call from the waterway police and VTS NOK to Joint Regional Control Centre West. The reason for that was evidently the report of the pilot on the OOCL FINLAND about the injured person discovered on the forecastle. Control Centre West was informed as a result of the presumed position of the TYUMEN-2 on the northern side. In fact, information about the collision should have been given to Integrated Regional Control Centre Middle because the TYUMEN-2 was on the southern side of the canal. This confusion is due to the fact that the canal forms the boundary between the districts of Dithmarschen and Eckernförde in the area of km 25 to 40, which results in the control centres having different responsibilities (see also Figure 58).

Based on the lack of information available, the operation was started with only limited details. Joint Regional Control Centre West triggered the alert 'Technical assistance on the water, life at risk (TH Water Y)' for the units from the district of Dithmarschen. As a result of the varying reports received as the situation unfolded and the ensuing vague picture, operational units from the district of Steinburg were also alerted during the course of the operation. 'Technical operational commands' were set up on both sides of the canal to compensate for the existing and known problems when using public communication networks (especially mobile phone and data communications) along the canal, in particular. The rescue service set up a technical operational command (TEL Rescue Service) with one senior emergency physician and an organisational commander.
Overall, two emergency physician's vehicles carrying five emergency physicians as well as six ambulances, a team of divers, Firefighting Unit Brunsbüttel and units from the Albersdorf, Burg, Hademaschen, and Rendsburg fire brigades as well as the TELs Dithmarschen, Steinburg and Rescue Service were deployed. The rescue helicopters that flew from Hamburg ('Christoph Hansa' and 'Christoph 29') landed in Hohenlockstedt and were put on standby. However, they were not used in the operation because of the restricted visibility initially at the scene of the accident.

[108] Article 23(1) (1) Law on maritime pilots (Seelotsgesetz - SeeLG).
[109] Article 4(2) SeeSchStrO and Article 4(2) Ordinance on COLREGs (Verordnung zu den Kollisionsverhütungsregeln - VOKVR).

The police deployed with a large number of officers. While the waterway police worked through the measures necessary for the collided ships, the civil police carried out the extensive traffic control measures necessary due to the loss of the ferry service and influx of onlookers. Units of the reserve police were deployed to provide shore-based security for the berth of the TYUMEN-2 in the siding at Fischerhütte.

The BSU first considered the seemingly long travelling time of the emergency physician to the OOCL FINLAND. As a general point, it should be noted that there is no specified period within which emergency physicians must arrive at a location. Ambulances are required to arrive within 12 minutes. However, this requirement is an average that should be achieved in 90% of all operations.
The distance to be covered by the emergency physician from Itzehoe to the siding at Oldenbüttel was about 36 km. Although the distances from Heide (30 km) or Rendsburg (24 km) to the northern ferry berth in Oldenbüttel would have been shorter, that direction would have necessitated a ferry crossing or the ferry would have had to take the emergency physician directly to the OOCL FINLAND. The time required would therefore have been at least as long from all the other locations. The travelling time of 37 minutes actually required corresponds to the existing situation in the area. The tasking of a rescue helicopter was not possible due to the prevailing visibility.

The investigators view the coordination and information problems between the deployed units and control centres, including the CCME, as well as the communication problems, the cause of which was of a technical nature, as being the underlying cause of occasional instances of duplication vis-à-vis tasking and overlaps, and of certain participants not being informed about the basic situation as it evolved for a prolonged period (until after 1000). For example, a fireboat carrying a firefighting unit was still en route to the OOCL FINLAND at 1044 to clarify the situation there. The situation on board, which necessitated no further action, could have been known as early as 0849 when the ship proceeded from the siding at Oldenbüttel. Moreover, deployment of the casualty care team from Kiel at 0922 could have been cancelled because at 0920 Joint Regional Control Centre West was aware that casualty care was no longer needed. However, the casualty care team was tasked by CCME, which apparently was not in possession of this information.

In the case investigated, the SWINEMÜNDE participated in gathering information and transported casualties during her first call. During her second call, she carried a firefighting and an emergency vehicle to the TYUMEN-2. This once again proved the very high value of the ferries during an operation. The use of other ferries by the VTS confirmed the positive experience made in the past. The small boats taken by the fire brigade do not achieve the worth of the ferries as they are only suitable for passenger transport.

4.7 Investigation by the Russian Federation

The marine casualty investigation of the Russian Federation stands for itself. Issues having led to the similar conclusions and recommendations are also included in the investigation report of the BSU.
The office of the harbour master of the port of Kaliningrad conducted the investigation on behalf of the Russian Federation at the request of the Maritime Administration of the Russian Federation. The final report was handed over to the BSU in Russian and English. The documents provided by the BSU formed the basis of the report. There was no cooperation with the BSU beyond that. Crew members of the TYUMEN-2 were questioned in the course of the Russian investigation. None of those questioned was on the bridge at the time of the accident.
In the Russian investigation report, the position of the TYUMEN-2 is described as being in a siding area. The OOCL FINLAND then reportedly collided with the TYUMEN-2 in this situation.

The investigation of the Russian Federation comes to the following conclusions:

- “Master of the m/s Tyumen-2 […], Kiel Canal Pilot on board m/s Tyumen-2 […], Kiel Canal Helmsman on board m/s Tyumen-2 […] – The Marine Safety Investigation Commission finds no mistakes in their acting.
- The master of the m/v OOCL FINLAND […] left the bridge to get a rest in his cabin and did not reserve the Chief Mate for himself. The Third Mate […] could not have enough experience as having had obtained his Certificate of Competency and respective position only in 2011. The Master entrusted completely the ship’s control to the Pilot. Obviously in the extreme cases a pilot cannot operate a wheel, bow- and stern thrusters, a main engine, anchor device as good as the master; neither a pilot could known good enough all the particulars of ship in question. Same provides presence of a Master or at least a Chief Mate on bridge absolutely necessary.”
- “[…] the vessel came into dense fog […] but the master was not advised of it. […] All the states of poor organization of service on bridge, and the Master is the one being responsible for this.”
- […] the Third Mate […] did not advise to the Master of the vessel entering dense fog. He was not controlling the ship’s position independently. He tried to use the thrusters after the collision with another ship, but not before when that ship was found visible.”
- “The Kiel Canal Pilot on board m/v OOCL Finland was acting with excessive risk. Knowing of the presence of oncoming ship in the siding, taking in account the crook of the Canal in that place., he had to reduce the speed down to dead slow and to be ready to the thrusters. The ship’s speed of 7.5 knots is considered as excessive.”

The following recommendations are made to prevent accidents in the future:

- „Navigation in the Kiel Canal under condition of a restricted visibility requires special attention in choosing speed, passing clear of oncoming vessel, watching distances between ships, watching for the visual signals and radio communications.

- The ships have to follow strictly to Navigation Rules of the Kiel Canal and comply with the orders of the Canal authorities.
- The ship's Master must not leave the bridge handing responsibility over to junior mates."

5 CONCLUSIONS

5.1 TYUMEN-2

The vessels command of the TYUMEN-2 had no influence on the collision. The time period for a nautical reaction on the veering of the OOCL FINLAND available to her, was much too small and the fairway to limited to prevent the collision or significantly influence the collision angle. A course of the voyage closer to the shore could possibly have reduced the consequences of the accident.

The recordings of the VDR could be evaluated. However, the radar image of the TYUMEN-2 stored in the voyage data recorder was rendered incorrectly when it was replayed using the playback program. This was not caused by the software. Errors already existed during the storage of the data. It was not possible to establish the cause of the incorrect recording of the radar image doubtless.

When replaying the data in the voyage data recorder a data loss was discovered at the time the recording was interrupted. This was caused by the type of memory management. In the case investigated, the absence of data from the audio recording for one minute and 21 seconds and the absence of any other data over a period of 22 seconds on both storage media had no effect on the findings of the investigation. Nevertheless, the BSU believes that the obviously possible interpretations of the phrase 'continuously' in the performance standards merit regulation. The recording interval between each data block should be as small as possible so that the largest possible amount of data is available even if the recording is completely interrupted due to the destruction of the system.

5.2 OOCL FINLAND

On the opinion of the BSU the rudder angle orders of the pilot to give way before the encounter with the TYUMEN-2 led the vessel to close to the southern shore. This ultimately resulted in the deviation and consequently to the collision. This order, like the previous orders, was communicated to the canal helmsman in German. This was not questioned by the watch officer.

The crew of the OOCL FINLAND manned the bridge in accordance with the requirements of the ship's command. The investigators take the view that in this regard the deliberations of the ship's command were less than appropriate as they did not satisfy the requirements due to the absence of a lookout. It is highly unlikely that the lack of a lookout had an influence on the course of the accident. Irrespective of the missing lookout, the BSU assumes that the watch officer was not prepared or unable to cooperate and especially communicate with the pilot in a way required for the command of a vessel.

The canal passage of the OOCL FINLAND exceeded the maximum speed permitted at times and neither the pilot nor the ship's command worked towards adhering to it.

The pilot was apparently of the opinion that only a high speed would allow for sufficient steerability of the ship. This assumption is not supported by the investigation result.
At the time the collision was developing, the permitted speed was adhered to. There was no reduction in speed during the intended approach to the canal bank to the right of the direction of travel. This possibly intensified the bank effect and resulting push away effect on the ship.

5.3 Vessels speed

Due to the traffic regulations applying on the NOK the permitted speed of 15 km/per hour is not being reduced. The Shipping Administration and the pilots assume, that the geographical conditions of the canal, the capability of the radar sets and the manoeuvre characteristics of the vessels enable the maintenance of the speed also in restricted visibility. Every vessels command and every vessels command, advised by a pilot, respectively, has the opportunity to pass the canal with a lower speed or reduce the speed prior to the encounter with another vessel. The most effective means can be the upgrading of a traffic group or the interruption of the passage. Altogether the respective vessels command has to make the decision. She is, as in many other areas, required to deal with the situation in a responsible way. The advising pilot is, at least, required to support this decision with his experience and knowledge of the area. He is, as the case may be, also required to challenge the decision, of necessary. There was no discussion on the OOCL FINLAND. This was supposedly also due to the fact, that the master was not informed about the deteriorating visibility.
The assessment of the speed applied is difficult for the investigators since the steering behaviour of the vessel cannot be judged about later and externally. Even though not every veering can be attributed to an inappropriate speed, the BSU presumes a connection.

Basically, emphasis should be put on the speed permitted on the NOK by the Shipping Administration and other parties involved, when considering the case. For this reason the BSU is in favour for a possible study of a uniform speed in the Kiel Canal.

5.4 Ferries as an operational resource

The SWINEMÜNDE played a key role in dealing with the consequences of the accident. In the view of the BSU, the ferries on the NOK represent a universal, very valuable platform during an operation. Inasmuch, measures that reduce their operational value are impossible to comprehend, in particular, against the backdrop of there being no replacement of equal value. This is not provided by the turntable ladders belonging to the fire brigades.

6 Actions taken

6.1 Ministry of the Interior of Schleswig-Holstein

A representative of the Department of Firefighting, Emergency Management and Civil Protection of the Ministry of the Interior of Schleswig-Holstein said in an interview that as a result of their own analysis of the accident, a series of changes are planned or already being implemented for the area of the NOK. Amongst other things, the differing reporting channels currently in place for events below a major incident are being addressed. The following changes are planned or being implemented:

- The Ministry of the Interior conducted conversations with the residents of the NOK concerning a required alteration of the "alarm plan and the plans of action for the fire-fighting and the technical assistance rendered by the fire brigades on the Kiel canal" and the independent city of Kiel
- Updating of the superior alarm plan of the Ministry of the Interior will be concluded soon
- In this connection, alerting shall jointly be reviewed, coordinated and adapted if required by the Ministry of the Interior and the Central Command for Maritime Emergencies. The aim is to nominate a headquarter acting as a control centre for the entire area of the Kiel canal and thereby interface to the Central Command for Maritime Emergencies. The requirement for the definition of uniform alerting keywords is associated with this.
- The operation forces of the voluntary fire brigade in Rendsburg were trained for the fire-fighting on vessels with budget funds of the Federal State Schleswig-Holstein.
- Under the chairmanship of the representative of Schleswig-Holstein in the coordinating committee fire-fighting and care of the injured the" professional conception fire-fighting and care of the injured on sea" will be revised by a joint working group of the Coastal States and the Federal Ministry of Transport and Digital Infrastructure. Particular attention will be paid to the risk situation on the Kiel Canal. Depending on the investigation results it will be checked to what extent the fire brigade Rendsburg will provide their SEG "fire-fighting on vessels" to the Central Command for Maritime Emergencies within the framework of the professional conception. This was also agreed on by the Ministry of the Interior of Schleswig-Holstein and the Federal Ministry of Transport and Digital Infrastructure.

6.2 Federal Waterways and Shipping Administration

WSD North has announced that it will respond to the changes in the operational structure of the fire brigade and that the reporting channels will be adjusted accordingly.

Continuous monitoring and assessment of traffic on the NOK is one of the inherent tasks of WSD North. A new working group consisting of representatives of WSD North and WSAs Brunsbüttel and Kiel-Holtenau was set up at the beginning of 2012. Its objective is to make an overall assessment of the traffic safety and control system on the NOK. This will be carried out with due regard to the changing traffic patterns in terms of the sizes, draughts and number of ships. The issue of ship speed (descriptors in this case: uniform speed or reduced speed in restricted visibility) is part of the investigation. Hydrodynamic effects and the impact on the canal bed are to be looked at with the involvement of the Federal Waterways Engineering and Research Institute.

6.3 Russian Maritime Register of Shipping

The classification society explained in its statement pertaining to the draft report that they checked the state of the connection of the wheelhouse with the superstructure on all vessels which are subject to the same permanent restrictions with respect to the area of trade in the past two years. The classification society did not detect any deficiencies.

6.4 Central command

The Central command for Maritime Emergencies explained in its statement pertaining to the draft report that, on the occasion of communication problems having occurred during the tackling of the accident, particularly further improved the equipment of the head of the action forces with communication technology not depending on terrestrial conditions

On the basis of a statement made by the WSA Brunsbüttel the Havariekommando explained that a telecommunication company has already took measures in order to close the dead spots at the canal.

7 SAFETY RECOMMENDATIONS

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

7.1 Federal Ministry of Transport and Digital Infrastructure

The Federal Bureau of Maritime Casualty Investigation recommends that the Federal Ministry of Transport and Digital Infrastructure encourage the appropriate committees of the International Maritime Organisation (IMO) to define the performance standards for VDRs in greater detail in respect of data storage. The recording interval between each data block should be as small as possible so that the largest possible amount of data is available even if the recording is completely interrupted due to the destruction of the system.

7.2 Federal Ministry of Transport and Digital Infrastructure and Directorate-General Waterways and Shipping

The Federal Bureau of Maritime Casualty Investigation recommends that the Federal Ministry of Transport and Digital Infrastructure as well as Directorate-General for Waterways and Shipping maintain the option of immediately tasking ferries on the NOK as a platform for fire and rescue operations.

7.3 Directorate-General Waterways and Shipping

The Federal Bureau of Maritime Casualty Investigation recommends that the Directorate-General for Waterways and Shipping, with the participation of the representatives of the pilots and the canal helmsmen, carries out an examination of the consequences of a compulsory speed on the NOK.

7.4 Ship's command and operator of the OOCL FINLAND

The Federal Bureau of Maritime Casualty Investigation recommends that the ship's command of the OOCL FINLAND and the operator of the vessel review the accident as part of their safety management. Here, the principles to be observed in keeping a navigational watch, conduct in restricted visibility and heavily used, narrow waters as well as navigating with pilot advice should be addressed, in particular.

8 SOURCES

- Investigation by the waterway police
- Written statements
  - Ship's commands
  - Shipping companies
  - Classification societies
  - Canal helmsmen
  - NOK I and II pilot brotherhoods and the BSHL
- Witness accounts
- Ship documents and other evidence from the OOCL FINLAND and her crew
- Investigation by the Russian Federation
- Mission logs of VTS NOK, the CCME, the control centres of the police, the fire brigade, and the rescue services
- Opinion of the naval architect
- Opinion of the Federal Waterways Engineering and Research Institute
- Nautical charts and ship particulars, Federal Maritime and Hydrographic Agency (BSH)
- Official weather report by Germany's National Meteorological Service (DWD)
- Sounding data of WSD North
- Figures 1 and 2: Hasenpusch; Figures 9, 11, 17: WSP Brunsbüttel; Figure 18: Dipl.-Ing. Manfred Stryi; Figure 58: Westermann Verlag; all others BSU.