SMAIC

STATE MARINE ACCIDENT INVESTIGATION COMMISSION

FINAL REPORT

028/23

Marine casualty

M/V Stena Nordica

Allision of the ferry 'Stena Nordica' with the chemical/oil products tanker 'Bull Kangean' at the Gdańsk Shiprepair Yard on 9 March 2023.

January 2024

SMAIC
STATE MARINE ACCIDENT INVESTIGATION COMMISSION

The investigation of the ferry 'Stena Nordica' accident was conducted based on the Act of 31 August 2012 on the State Marine Accident Investigation Commission (Journal of Laws of 2019, item 1374) and the agreed International Maritime Organisation (IMO) norms, standards and recommended methods of conduct binding on the Republic of Poland.

The objective of the investigation of a marine accident or incident under the above-mentioned Act is to ascertain its causes and circumstances to prevent future accidents and incidents and improve the state of marine safety.

The State Marine Accident Investigation Commission does not determine liability nor apportion blame to persons involved in the marine casualty or incident.

The following report shall be inadmissible in any judicial or other proceedings whose purpose is to attribute blame or liability for the accident referred to in the report (Art. 40.2 of the State Marine Accident Investigation Commission Act).

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1. Facts

On 9 March 2023 at 01:27 commenced the undocking of the ferry 'Stena Nordica', manoeuvring without its own propulsion, from dock No. 3. It was planned to tow the ferry from the Ostrawica I Basin, through the channel at the level of the Ostrawica I quay to the waters of the Dead Vistula (the GSY[1] turntable) enabling the ferry to be turned around, pulled back through the channel and berthed starboard side alongside the corner of the Ostrawica I quay. The towing was carried out with the help of 4 tugs, of which 2 were fast using tug lines and two were in assist. After leaving the dock, while entering the narrowest part of the channel at the level of Ostrawica I quay from one side and the quay belonging to the Hydrobudowa company from the other side, the ferry 'Stena Nordica' hit m/t Bull Kangean[2] overhauled at Ostrawica I quay with her left stern corner, causing damage to the plating in the bow section of m/t Bull Kangean. Subsequent manoeuvres to leave the narrow section of the Ostrawica I quay, turn the vessel on the GSY turntable and reach the quay, where the ferry finally had been moored, took place without problems.

2. General information

2.1. Ship particulars

2.1.1. m/v Stena Nordica

Photo 1 – m/v „Stena Nordica" (www.vesselfinder.com)

[1] GSY – Gdańsk Shiprepair Yard
[2] Chemical/Oil Products Tanker

Flag:	Cyprus
Operator:	Stena RoRo Navigation Ltd/Stena Line Scandinavica
Classification society:	Lloyd's Register
Ship's type:	RoPax ferry
Call sign:	5BGK4
IMO number:	9215505
GT:	24,206
Year of build:	2000
Engine power:	39600 kW
BOA:	24.00
LOA:	169.80
Hull material:	Steel
Type of VDR:	Danelec Marine DM 400

2.1.2. m/v „Bull Kangean"

Photo 2 – m/v „Bull Kangean"(www.vesselfinder.com, author Ruud Coster)

Flag:	Indonesia
Operator:	Citrine Maritime PT Jakarta Indonesia
Classification society:	Nippon Kaiji Kyokai
Ship's type:	chemical/oil products tanker
Call sign:	YBZJ2
IMO number:	9267027
GT:	25,507
Year of build:	2004
Engine power:	7860 kW
BOA:	29.00
LOA:	173.96
Hull material:	Steel

2.2. Voyage details

Both ships undergoing shipyard repairs at the Gdańsk Shiprepair Yard.

2.3. Marine casualty or incident information

Type of accident: accident

Date and time of the accident: 09 March 2023 at about 01:26:55 LT

Position at the time of the accident: φ=54°22,4'N λ=018°39,4'E

Area of the accident: Gdańsk Shiprepair Yard (GSY)

Nature of the water region: Polish internal waters

Weather at the time of the accident: Wind WNW 2°B, visibility good, water depth 525 cm.

Operational condition of the ship: Both ships out of service.

Ship accident site: Damaged side plating due to allision (above the waterline).

Consequences of the accident: Extended scope of yard work.

3. Circumstances of the accident

In connection with the planned course of shipyard works on the Stena Nordica, it was planned for her to temporarily leave dock No. 3 and sail out of the Ostrawica Basin through a narrow channel at the level of Ostrawica I quay, to the turning area. After turning the ship, it was planned to pull her back by stern to the Ostrawica Basin and moor her starboard side alongside in the corner of the Ostrawica I quay. It was not possible to turn the ship immediately after

leaving the dock because of the insufficient clearance between Dock 2 and Dock 3 (160m). The ship was without her own propulsion.

The situation prior to the commencement of manoeuvres and the dimensions of the available manoeuvring area for the assumed isobath H = 6m are shown on figure 1.[3] The water reserve under the keel for the manoeuvring tugboats was set at 1 metre due to their specific type of propulsion and the need to maintain, for manoeuvring reasons, an adequate depth reserve. So, the safe isobath for the tug 'Titan' was 6 m, marked on the figure below by blue line.

[3] Designations on the figures: SN – Stena Nordica, BK – Bull Kangean, KS – Key South, Ty – tug Titan, Ta – tug Taurus, Ve – tug Vega, Pa – tug Panda, To – Tollund, Po – pontoons owned by Hydrobudowa, Dok nr 3 – Dock 3, Dok 2 – Dock 2, Nab. Ostrawica I – Ostrawica I quay, Nab. Nietrwałe (Hydrobudowa) – an impermanent quay belonging to the Hydrobudowa company.

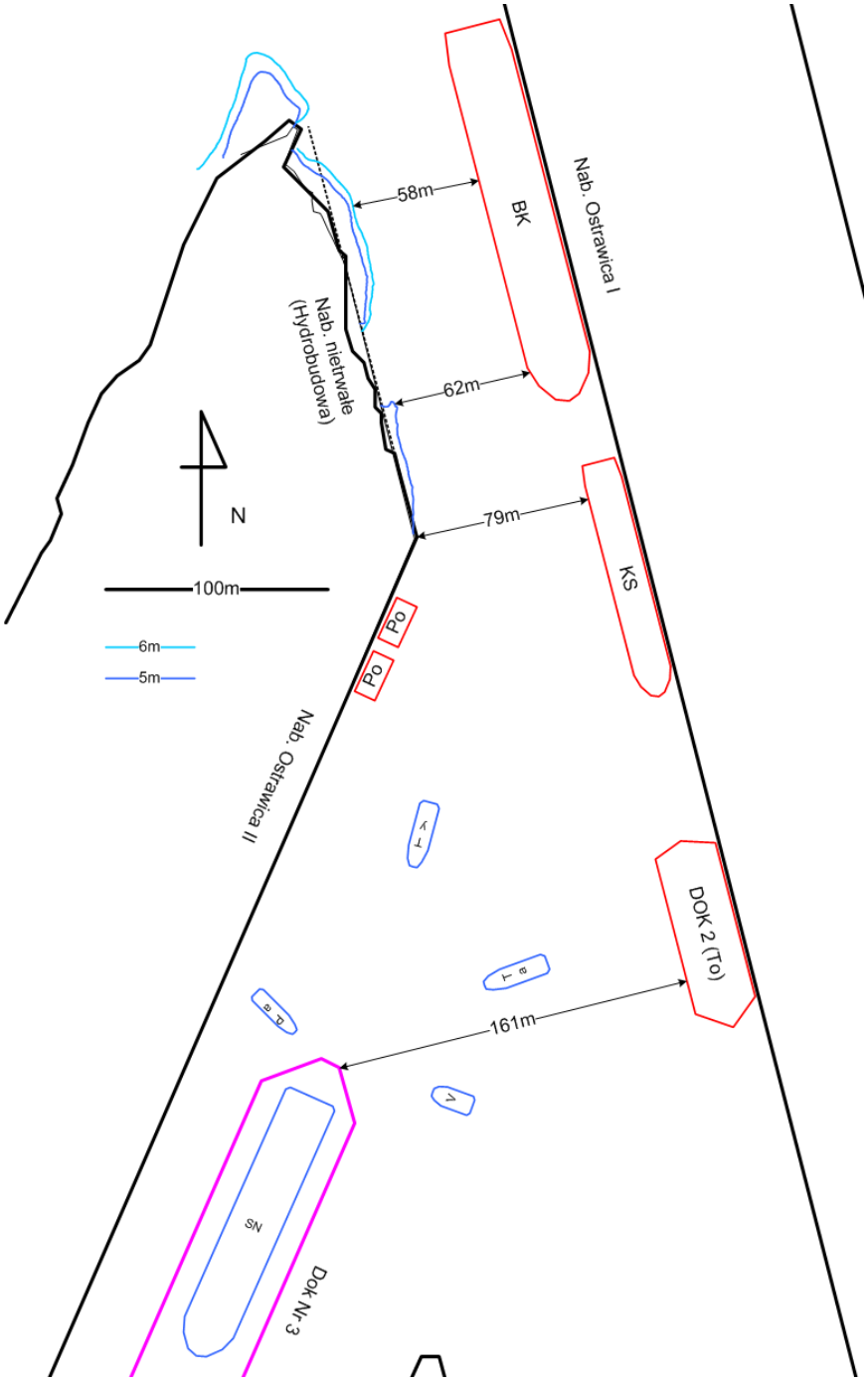

Figure 1 – Accessible manoeuvring area

After the pilot boarded at 01:10, the ship commenced the dock leaving manoeuvre. The Pilot and the Captain were keeping watch on the bridge wing, port side. On the starboard wing the Chief Officer was in charge of the watch. The Second Officer (Safety Officer) initially standing on the starboard side was in charge of the watch at the stern of the ship. For

communication between those taking part in the manoeuvres walkie talkies were used. The dock master was in charge of undocking operations.

After the tug 'Titan'[4] was made fast on the aft, PS fairlead, tug line, the manoeuvre to pull the ship out of the dock began. When the bow of the ferry left the dock at 01:24 a.m., a tug 'Taurus'[5] was made fast on fwd, PS fairlead, tug line.

Two additional tugs were in assistance: Vega[6] and Panda[7].

After fwd tug was made fast, the pilot instructed the tug 'Titan' to 'tow' the ship towards the GSY turntable. Tugs 'Vega' and 'Panda' were ordered to stay inside the Ostrawica Basin and await the ship, to assist her with the mooring at the corner of Ostrawica I quay, after the manoeuvre of turning the ferry on the turntable and returning to the Ostrawica Basin will take place.

At 01:25 hrs, the Captain advised the Pilot that there are cameras on both sides of the aft to give an indicative view of the position of the stern in relation to other objects.

At 01:26:07, the Second Officer standing on the starboard side of the aft reported to the bridge, in English, that the clearance between the stern and the corner of the Ostrawica II and the Hydrobudowa quays was 20 m. Receipt of this information was acknowledged by the Captain and Chief Officer. The view from the port side aft was restricted for the Second Officer by the high and raised stern ramp. At 01:26:36 the pilot instructed the tug 'Titan' to pull 'harder'. At 01:26:45, the Pilot asked the Captain and the Second Officer who was on the aft, will we 'pass' clear. The question was about the situation on the port side aft. In response he received information from the tug 'Titan' that 'we will not pass'. The Pilot immediately instructed the tug 'Titan' to stop pulling the ferry. The Second Officer, after passing to the aft port side at 01:26:55, reported in English that contact will be made. This was in reference to m/v 'Bull Kangean' berthed alongside Ostrawica I quay.

The Pilot at this point ordered the tug 'Taurus' working on forwad to 'brake' the ferry, while the tug working on the aft was ordered to pull the stern back 'on the water' that is, to the middle of the channel. Both actions were undertaken too late and at 01:26:55 the PS aft corner of the ship 'Stena Nordica' struck the shell plating of the ship 'Bull Kangean', in her bow section on

[4] Tug Titan, leading tug, on the aft. LOA 29.8 m, BOA 9 m, Draft 5 m, propulsion – ASD (Azimuth Stern Drive), towing capacity ahead 48 tf, towing capacity astern 42 tf, height of the fairlead above water approx. 3 m.
[5] Tug Taurus, on fwd, LOA 30 m, BOA 10.5 m, Draft 5.4, propulsion – ATD (Azimuth Traktor Drive), towing capacity 42 tf, height of the fairlead above water approx. 2 m.
[6] Tug Vega, in assist. LOA 19.1 m, BOA 9 m, Draft 4.2 m, propulsion – ASD (Azimuth Stern Drive), towing capacity ahead 36tf, towing capacity astern 32tf.
[7] Tug Vega, LOA 25m, BOA 6.8 m, Draft 2.6 m, conventional propulsion.

the starboard side. The aft corner of the ferry 'Stena Nordica' was reinforced so the damage to her plating was minor. As the collision occurred at a significant angular velocity the damage sustained by m/v 'Bull Kangean' included damage to the hull plating and damage to the hull reinforcements in two places:

- fwd tank (Fore Peak) about 8 m above the waterline under the starboard anchor and towards the stern from the stbd anchor[8],
- ballast tank No. 15 approximately 1.5 m above the waterline[9].

Photo 3 – Moment when the 'Stena Nordica' is hitting m/v 'Bull Kangean' based on the ferry's CCTV (the time on the camera does not reflect the time of the collision, tug 'Titan' is working hard on the starboard side)

After rapidly pulling the stern of the 'Stena Nordica' to the opposite side of the channel, at 01:27:55 the Pilot ordered the tug 'Titan' to keep the towed ship in the line of the channel leading to the GSY turntable.

[8] Size of damaged shell plating 5m x 5m, according to captain's information.
[9] Size of damaged shell plating 4m x 4m, according to captain's information.

Photo 4 – View from the quay onto the channel between the Ostrawica 1 quay and the impermanent Hydrobudowa quay

Further manoeuvres took place without problems, and, after the turnover, the ship moored at the planned quay.

4. Analysis and comments about factors causing the marine casualty with regard to results of investigation and expert opinions.

4.1. Reconstruction of the towing set passage

To accurately analyse the movement of the ship 'Stena Nordica' during the manoeuvres, data from AIS-PL and the ship's VDR were analysed in terms of her position, courses and speed, which are crucial for assessing the accident. In the case of AIS-PL, the traffic and parameter assessment was based on data obtained from the National Network of the AIS Shore Base Stations (AIS-PL). Only below-mentioned crafts were analysed:

1. 'Stena Nordica' (hitting ship),
2. 'Bull Kangean' (hit ship),
3. 'Titan' (tug leading the set),
4. 'Taurus' (at the end of the towing set).

A preliminary analysis of the decoded data showed that:

1. 'Stena Nordica' (SN) transmitted a dynamic message just like a moored ship (every 3 min) and even a rise in speed did not automatically increase the frequency of transmission.
2. 'Titan' (Ty) did not transmit the true heading (derived from a gyro compass sensor, GPS compass or similar), only the information 511 indicating the absence of this parameter, which makes it difficult to analyse the position of the craft and the length of the towing rope. However, she was transmitting COG, obtained from satellite positioning systems (GNSS), which in the case of an ASD tug is unreliable for the presentation of her waterline.
3. 'Titan' (Ty) transmitted a dynamic message every 1 min, which is insufficient for manoeuvring analysis.
4. Only 'Taurus' (Ta) transmitted a dynamic message every 3 seconds together with the actual course (gyro compass course or similar).

Geographical coordinates were transformed to the UTM plane coordinate system (UTM zone 34N) for the WGS 84 datum in which shipboard GNSS receivers transmit. Such data is presented on a simplified map.

AIS operates using GMT time, so the difference to local time was taken into account (LT=GMT+1).

The analysis was performed on the expert's own software PKBWM[1010] (*SMAIC* [10]) compiled using the Python version 3 compiler.

Combined data from the AIS and VDR are shown on the figure below (Figure 2).

[10] SMAIC expert Prof. dr hab. inż. Lucjan Gucma.

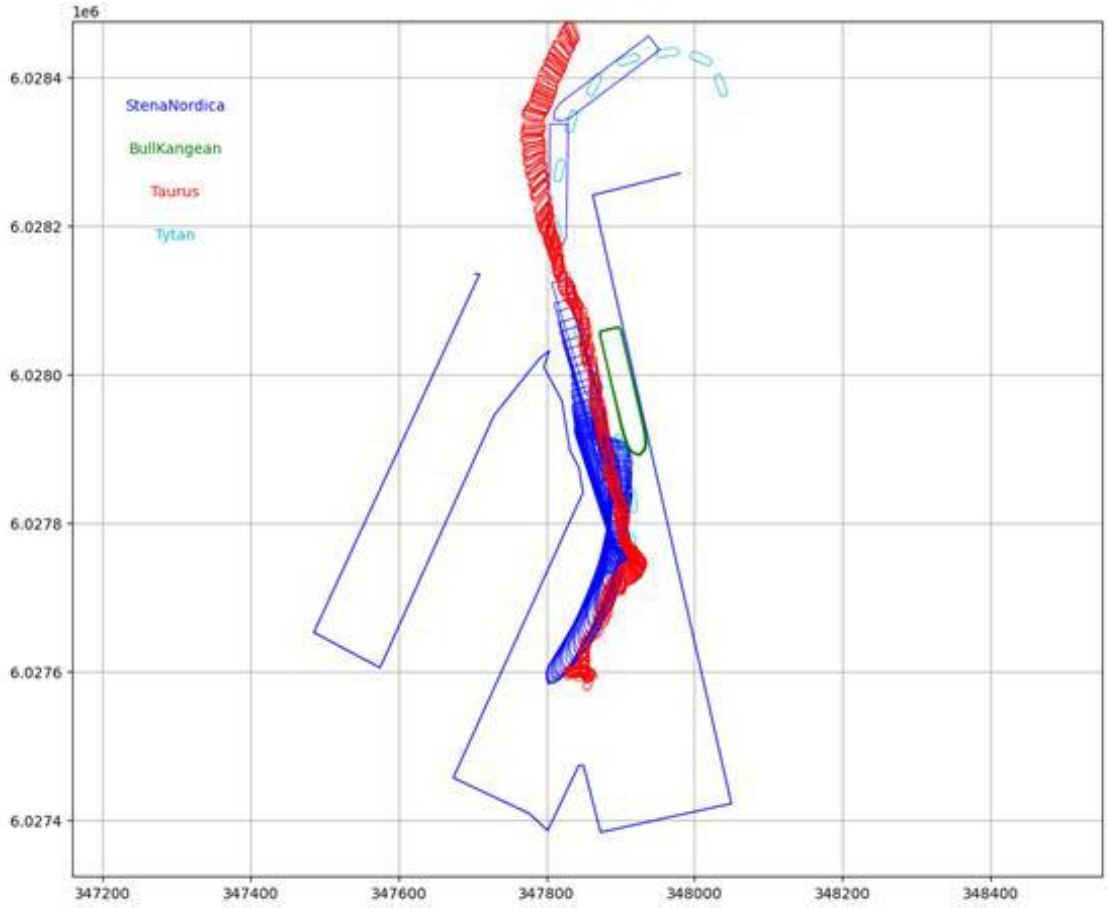

Figure 2 – Reconstruction of the SN towing set passage using combined AIS and VDR information of SN movement from 1:24:30 to 1:32:00 LT/SN (UTM system, grid every 200m).

Due to the high density of craft waterlines, the analysis of the manoeuvres was performed in several time frames, dividing the manoeuvres into stages.

Manoeuvre stage	Name	Start time LT/SN **AIS time UTC***	End time LT/SN **AIS time UTC***
1	From the moment SN bow left the dock to passing the Hydrobudowa south corner	01:24:30 **00:24:45**	01:26:10 **00:26:25**
2	From passing the Hydrobudowa south corner to the collision with BK	01:26:10 **00:26:25**	01:26:55 **00:27:10***
3	From hitting BK to information about stern approaching Hydrobudowa quay	01:26:55 **00:27:10**	01:27:55 **00:28:10**
3.1	After hitting BK to straighten SN course	01:26:55 **00:27:10**	01:32:00 **01:32:15**

Table 1 – Stages, manoeuvres and time range of manoeuvres

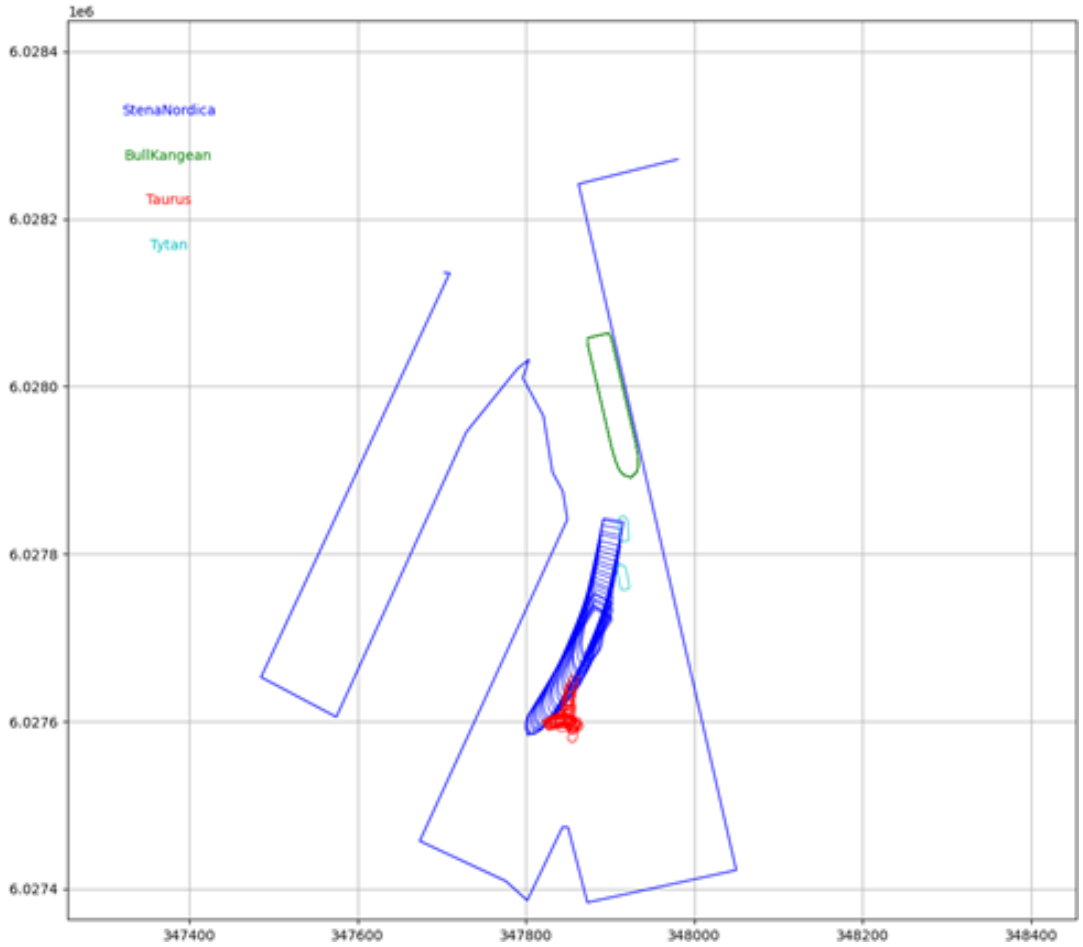

Figure 3 – Reconstruction of the SN towing set passage using combined AIS and VDR information of SN movement for stage 1 (UTM system, grid every 200m).

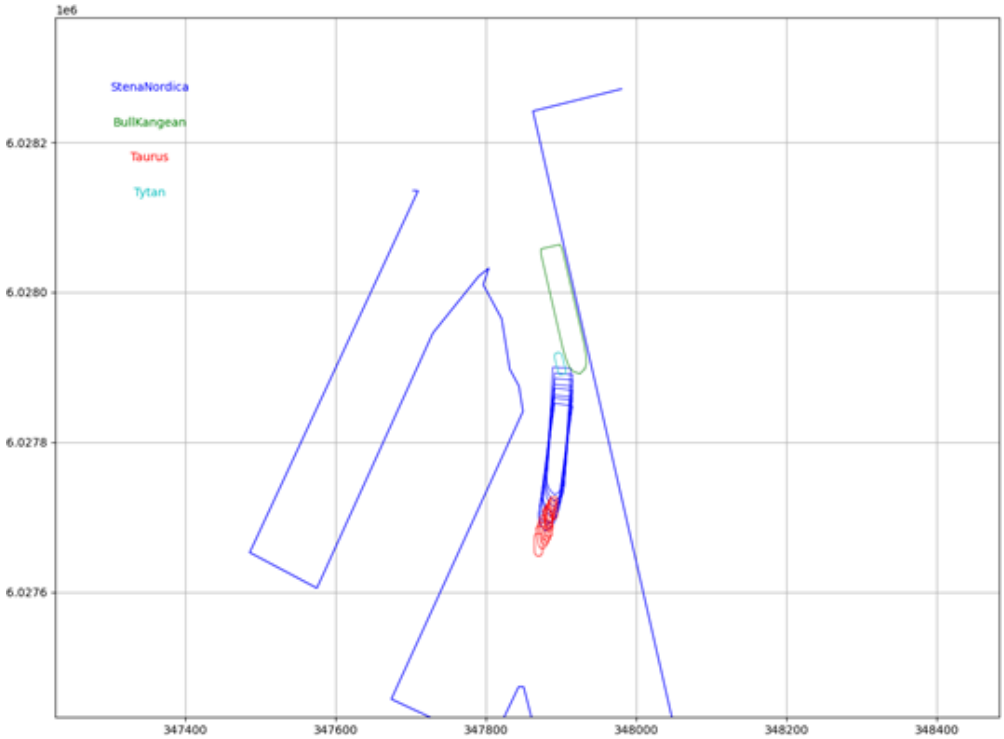

Figure 4 – Reconstruction of the SN towing set passage using combined AIS and VDR information of SN movement for stage 2 (UTM system, grid every 200m).

Figure 5 – Reconstruction of the SN towing set passage using combined AIS and VDR information of SN movement for stage 3 (UTM system, grid every 200m).

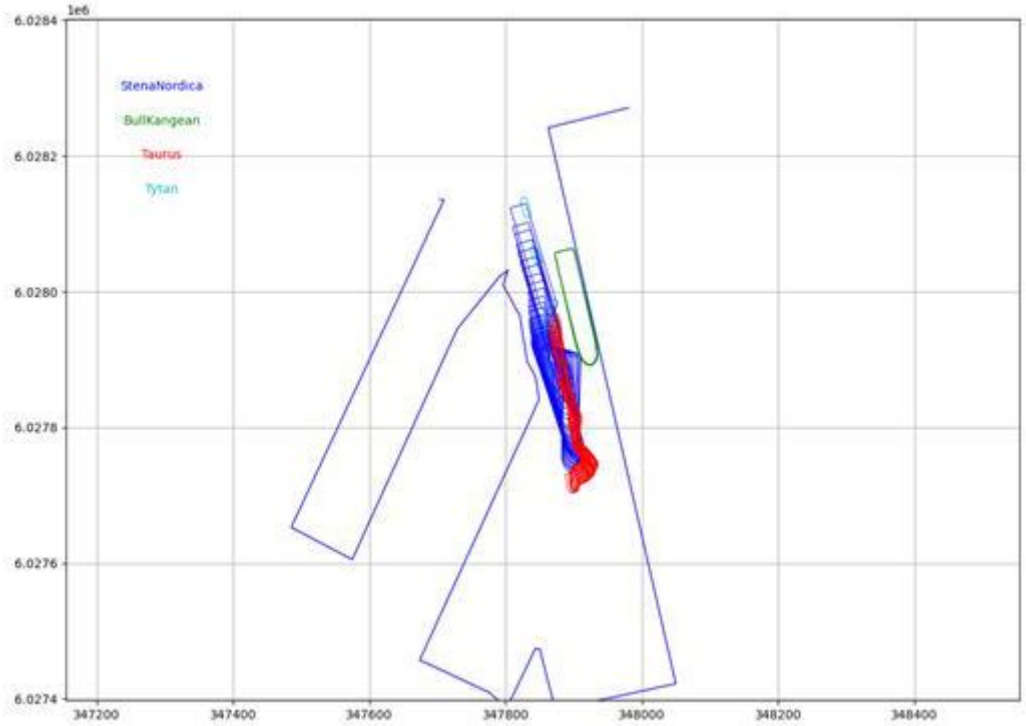

Figure 6 – Reconstruction of the SN towing set passage using combined AIS and VDR information of SN movement for stage 3.1 (UTM system, grid every 200m).

4.2. Reconstruction of the manoeuvring situation

Figures 7,8,9 reproduce the manoeuvring situation of the 'Stena Nordica' towing set.

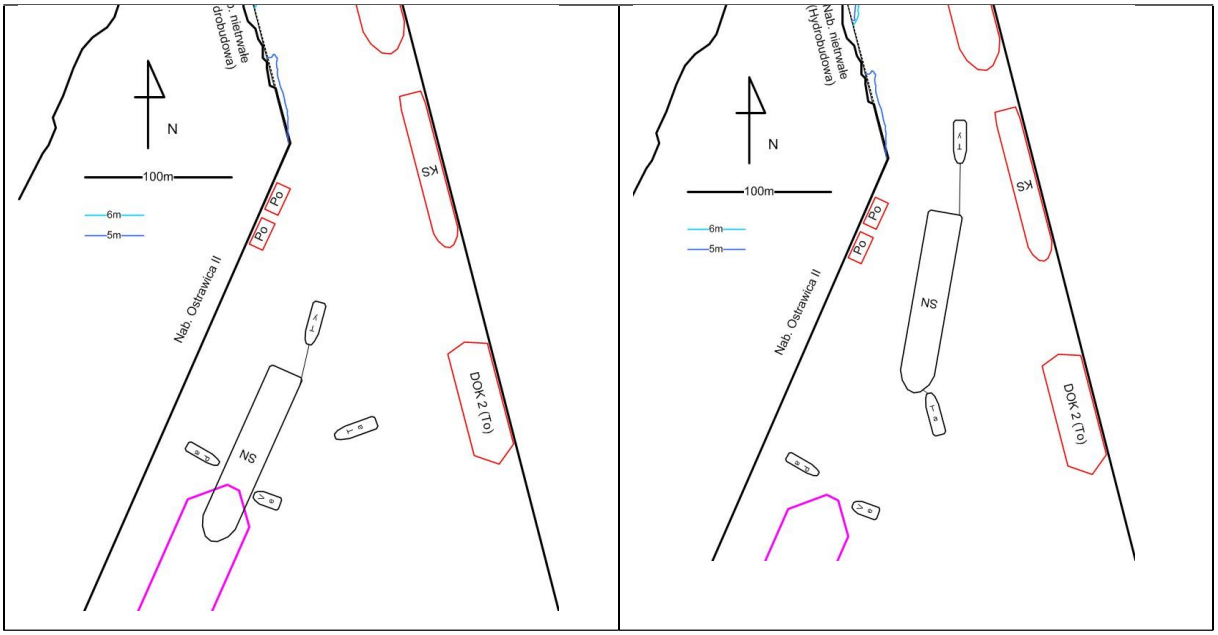

Figure 7 – Reconstruction of the manoeuvring situation Stage 1 (for legend see footnote 3)

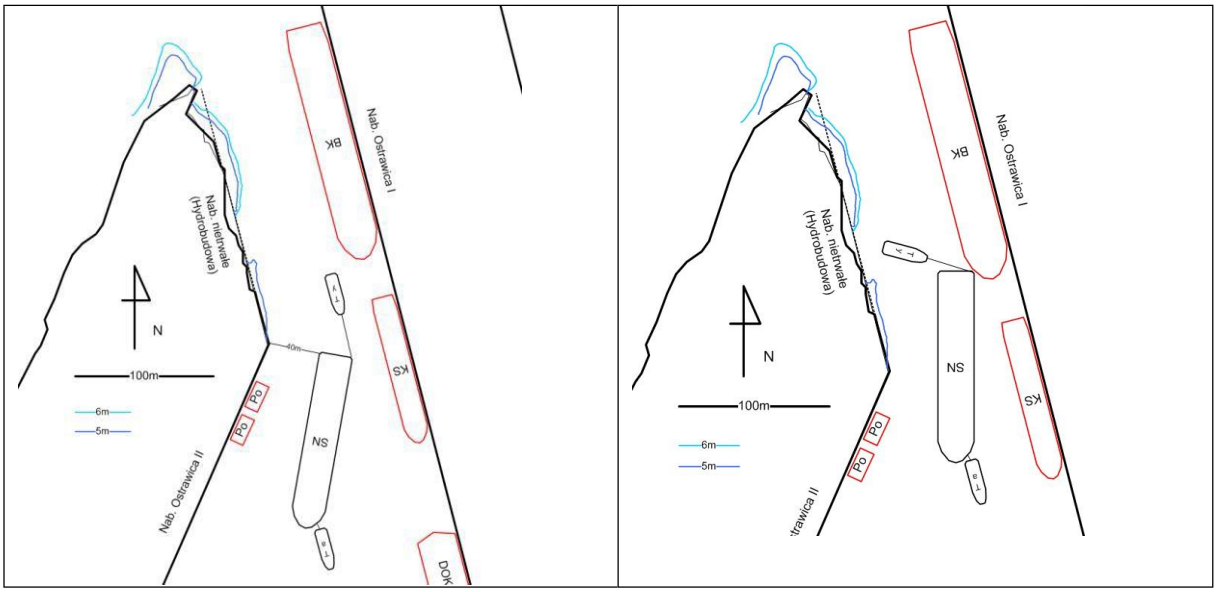

Figure 8 – Reconstruction of the manoeuvring situation Stage 2 (for legend see footnote 3)

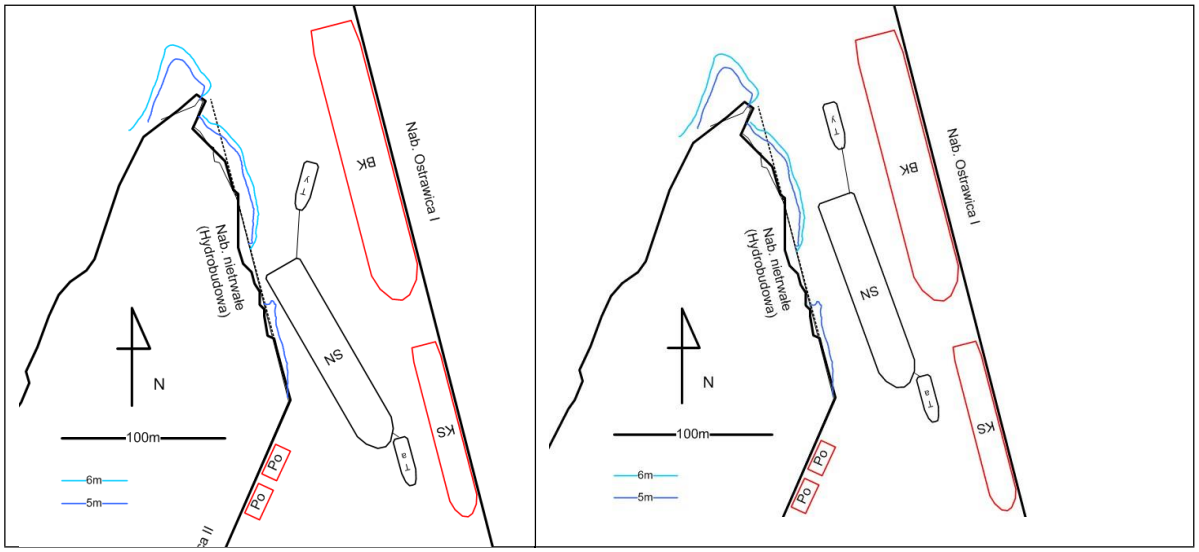

Figure 9 – Reconstruction of the manoeuvring situation Stage 3 (for legend see footnote 3)

4.3. Mechanical factors

'Stena Nordica' has a ramp at the stern and a bow gate, thus lacking Panama-type central fairleads. Photos 5 and 6 show the available side fairleads for mooring/towing on the aft and fwd respectively. For towing at the stern, a large fairlead marked using the red arrow was used. For towing at the bow, the large fairlead, also marked with a red arrow (on the port side), was used.

Photo 5 – Fairleads arrangement and stern ramp, view on the PS aft of the 'Stena Nordica' (www.shipspotting.com, by Willie Ryan) – before rebuilding i.e., without the so-called Duck Tail on the stern.

Photo 6 – Fairleads arrangement and bow gate, view on the stbd bow of the 'Stena Nordica' (www.niferry.co.uk, by David Faerder)

The leading tug 'Titan' gave a towing rope from her bow winch via a central fairlead.

Photo 7 – 'Titan' working as an in-direct assist tug on the aft and its towing equipment in the form of a bow fairlead (www.wobiektywieshipspottera.blogspot.com, by W. Danielewicz).

The tug 'Taurus' which was on fwd, at the end of the tug set (ATD-type propulsion devices closer to the bow section), gave the towing rope from her aft winch via a special deck fairlead.

Photo 8 – 'Taurus' and her aft towing gear (www.shipspotting.pl, by G.Dymek83)

4.3.1. Towing system used.

Asymmetric towing set

When towing a Ro-Ro ship astern, without a Panama (central) aft fairlead, there is a problem with unequal application of forces and asymmetrical water flow along the hull. This causes changes in the course of the towed ship and increases the area (clearance) required for both the ship and the tugs to manoeuvre.

The problem of manoeuvring with an asymmetrical position of the towing rope may be due to the fact that, to compensate the rotation of the hull, the tug must swing to the port side enlarging the manoeuvring area (Figure 10).

In the case under analysis, the rotation of the hull somehow helped the manoeuvre, and the ship entered the bend on her own, which can also be seen on the AIS recording ('Titan' was very close to the 'Bull Kangean' moored at Ostrawica I).

The above deduction is only hypothetical, as due to a number of factors such as: asymmetrical water flow, water flow on propellers and rudders, there is no confirmed behaviour of the ship in such an unusual case.

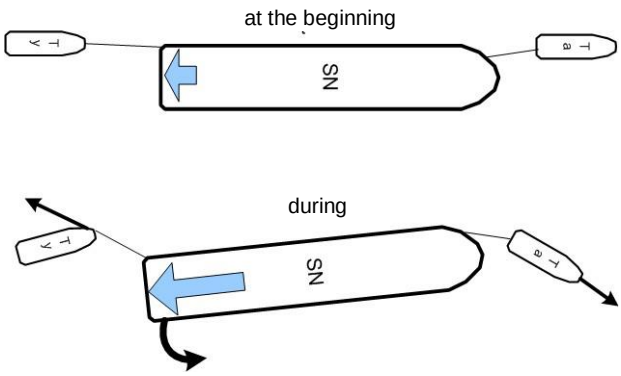

Figure 10 – Diagram of forces and moments that can be generated for asymmetric towing, and counteracting them using tugs, increasing the towing set manoeuvring zone (length).

Choice of tugboats

The choice of the ASD tug as the leading one seems to have been dictated by the final stage of the manoeuvre, i.e., mooring the ship at a very tight corner. In the event of a stern passage through the channel at the level of the Ostrawica I quay, the convoy led by the tug 'Taurus' and closed by the ASD 'Titan' could, theoretically at least, have better manoeuvrability.

In this case, the ASD at the bow (i.e., at the end of the towing set) could more actively manoeuvre the craft's course proceeding forward (shown on Figure 8).

The ASD (here the 'Titan') going astern at higher speeds can be unsteerable, but the speed of the towing set was probably not that high yet.

Of course, the Pilot and tugs' skippers know best their practical capabilities, which often differ from theory.

Angles of towing ropes in terms of their safety

By analysing the vertical angles of the 'Titan' towing ropes and the length of the towing rope as determined by the AIS of approximately 30 m and knowing the heights of the fairleads above the waterline (SN approximately 10 m, Titan approximately 3 m), it is possible to determine the angle of view of the line (Figure 8). This was approximately 10 degrees which is an acceptable value. With the length of the towing rope shortened to a minimum, as the 'Taurus' had (<20m), the angle is still not great and is >15 degrees (Figure 4).

A big angle causes a distribution of unfavourable towing forces. In extreme cases, where the angle is very large (>30 degrees), due to the lifting force of the towing rope and the weight of the tug, the load on the line can increase significantly and the rope or ship bollard can exceed the load limits.

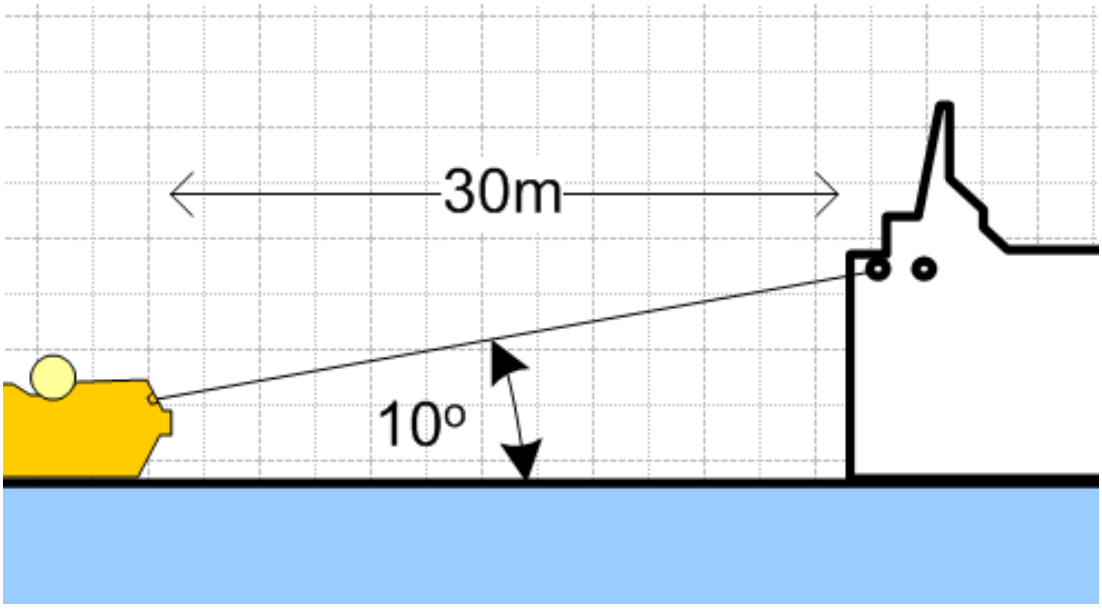

Figure 11 – Determination of towing rope angle for the 'Titan'.

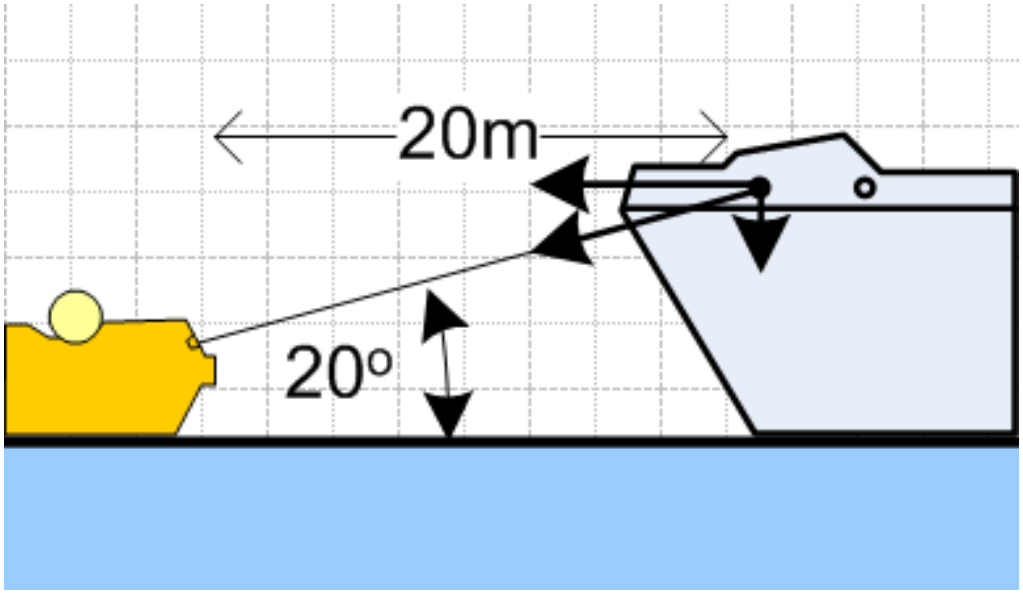

Figure 12 – Determination of towing rope angle for 'Taurus' (based on AIS her towing rope was shorter than 20 m).

4.3.2. Analysis of towing rope work

Based on AIS and VDR data, the length of the towing ropes was determined at 2 critical moments: 1) the collision, and 2) the strong drift towards the Hydrobudowa quay. These amounted to L1 = 30 m and L2 = 29 m (as projected onto the water surface) respectively. With the help of the CCTV camera, just before the moments of collision, the 'Titan' can be seen working at very high angles to the ship's direction of motion. However, assessing the length of the towing rope based only on the camera image may be illusory. For further analysis, it was assumed that the 'Titan' had a length of the towing rope of L = 30 m (as projected onto the water surface). The 'Taurus', on the other hand, based on the AIS, appears to be on a very short towing rope, i.e., shorter even than 20m (as projected onto the water surface). The waterline of the 'Taurus' practically touching the waterline of the 'Stena Nordica'.

It can also be seen that the 'Taurus' often occupies a position from the starboard side of the 'Stena Nordica', which is rather strange due to the impossibility of obtaining torque while operating the towing rope (Figures 13 and 14). It is possible that the 'Taurus' was pushing the 'Stena Nordica' being fast on the towing rope, or there may have been interference in the form of multipath GNSS signals due to the proximity to the Stena Nordica's bow.

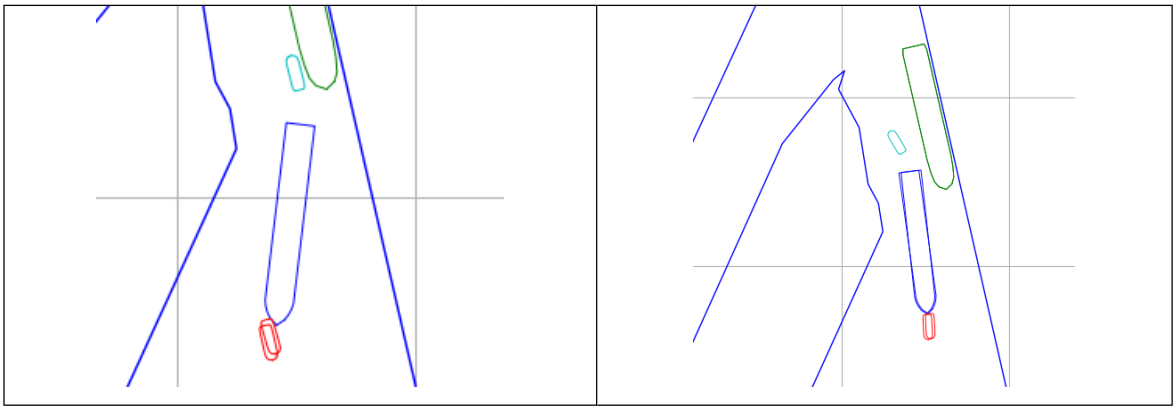

Figure 13 – Analysis of the towing ropes' lengths and the tugs' positions.
On the left before the collision time 01:26:20 – 01:26:30.
On the right from approximately 20 s to 35 s after the collision (waterline every 5 s.)

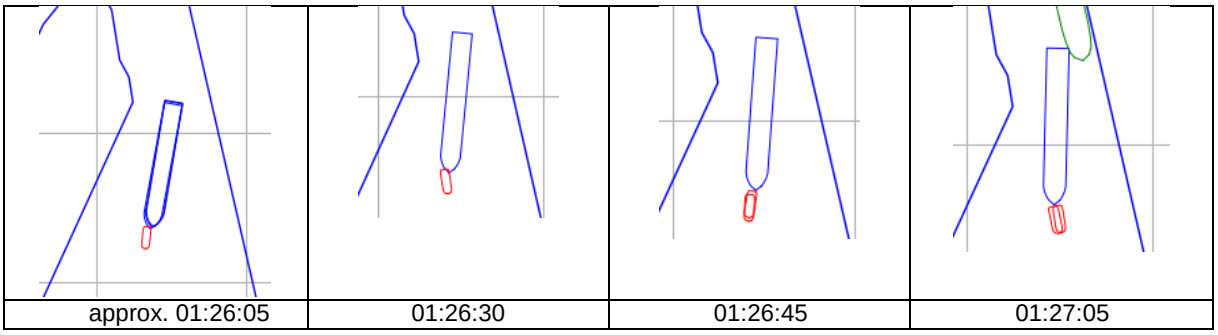

Figure 14 – Position of 'Taurus' in relation to 'Stena Nordica'.

4.3.3. Speed of the towing set

Speed determined by VDR recording

Figure 15 shows the longitudinal and transverse velocities of the ferry calculated from position differences (every 5 sec) determined with the VDR (DGPS ship position sequences were used). Moving averages were also determined to smooth the data. It can be seen that the ferry had a speed of about 3 knots at the critical moment, just before the accident.

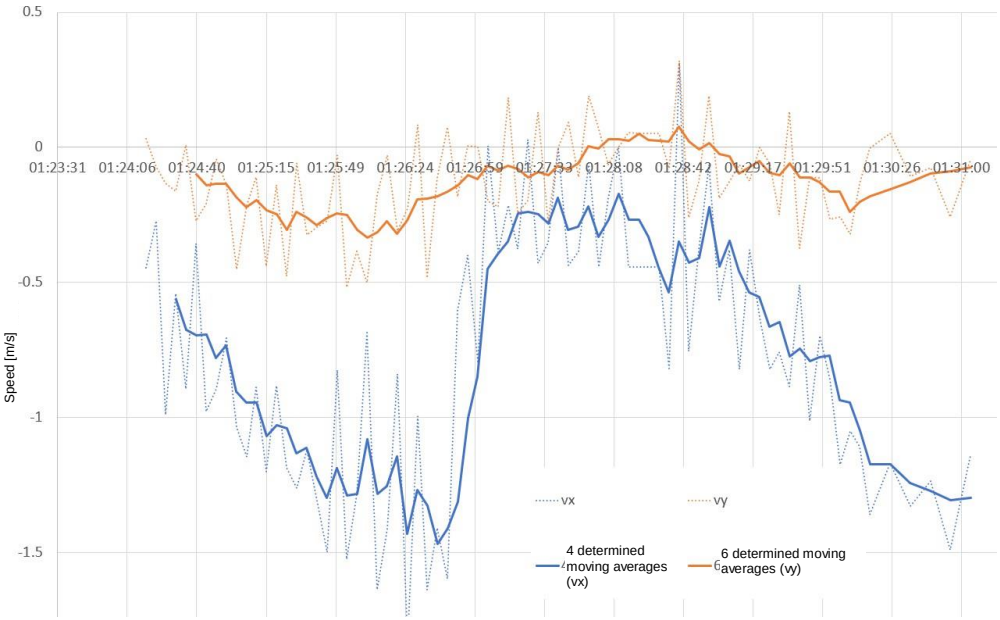

Figure 15 – Longitudinal and transverse speed of the ferry over the bottom [m/s] based on VDR (LT time)

Speed based on VDR log

By analysing the ship's log record (it is not clear whether the speed indicated by the VDR is from the log – over water or from the GNSS – over the bottom) from the VDR, the ship's speeds over time were determined. It can be seen that they increase up to 3 knots and rapidly decrease after collision.

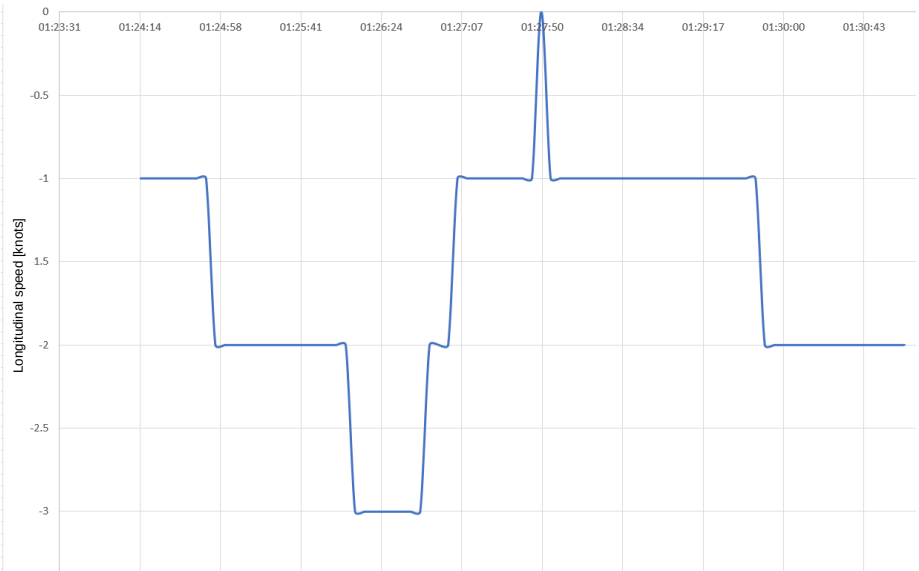

Figure 16 – Ferry longitudinal speed in knots based on log record from VDR (GMT time).

Speed of the tug 'Taurus'

The speed of the 'Taurus' over the bottom as recorded by AIS-PL is shown on Figure 17. It was exactly 3 knots before collision.

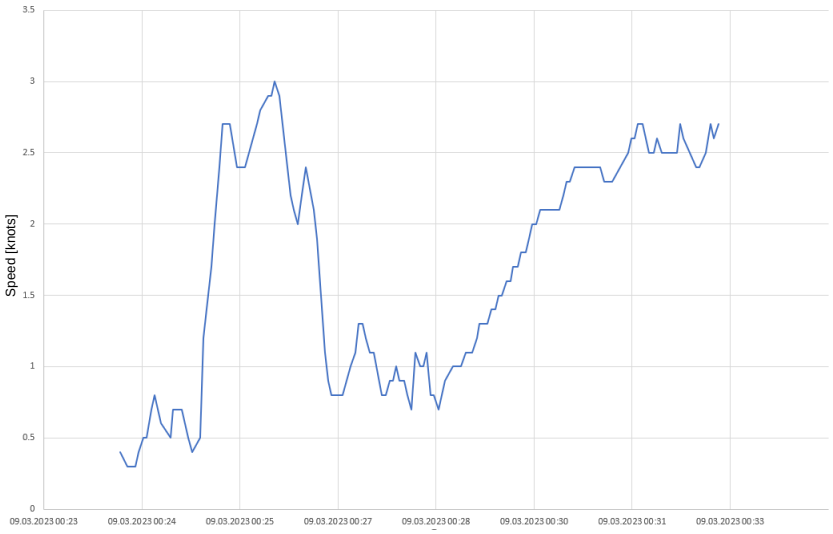

Figure 17 – Speed over water of the tug 'Taurus' – AIS (GMT time)

Speed based on voice communication

The speed estimated roughly from the time difference between the message that the corner of the Hydrobudowa quay had been passed to the time of collision was -3.2 knots (astern).

Angular velocity of the 'Stena Nordica'

The changes in angular velocity based on the ship's gyro compass readings from the VDR are shown on Figure 18. The post-collision velocity increases rapidly due to the operation of the tug 'Titan'.

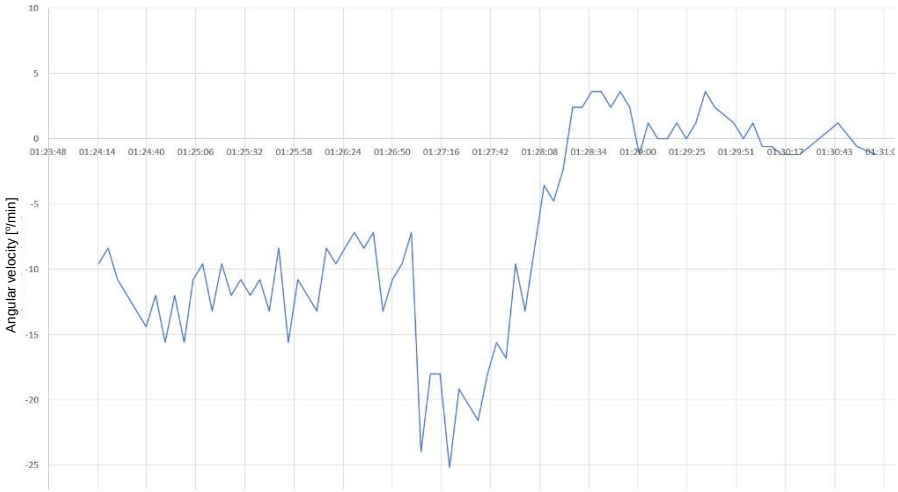

Figure 18 – Changes in angular velocity of the 'Stena Nordica' over time based on the readings from the gyrocompass.

4.4. Human factors

The Captain-Pilot relationship is an extremely important one, a relationship that affects safety during manoeuvres (the performance of the Pilot service). The State Marine Accident Investigation Commission has several times analysed and described in detail the principles of this relationship in its reports[11].

Both the Pilot and the Captain have similar areas of competence, but the Pilot has unique knowledge of the body of water, the manoeuvres and the cooperating tugs. The Captain, on the other hand, has knowledge of the ship's specific, crew and is ultimately responsible for her.

When there is synergy between the actions of the Pilot and the Captain during manoeuvres, the situation is very favourable. Lack of good cooperation can lead to an accident, as it happened in this situation:

1. Pilot did not familiarise the Captain in detail with the manoeuvring tactics and assumptions of the manoeuvres to be performed.
2. Pilot did not indicate what resources on the part of the ship he needed and did not specify the critical points to be observed from the aft and how he wished distances and reports to be given.
3. At the critical moment of entering the channel, there was no question from the bridge to the officer in charge of the aft regarding the distance to the moored ships. Such a question was not asked until 01:26:23 and it is not clear to whom it was directed.
4. In terms of communication with the tug, Pilot used a kind of jargon that could be difficult to understand by third parties. Often before the command/question he did not inform to whom the communication was directed. There were no communications regarding the forces on the towing ropes after leaving the dock – this was particularly true in case of tug 'Titan'.
5. Communication by the ship's crew in English did not seem to be a hindrance, as it was very economical after leaving the dock. It may have seemed artificial, but after all, Pilots are working with crew of varying English proficiency.
6. Captain remained passive and did not attempt to assist or engage the crew in giving distances to moored ships. He did not express his doubts and did not ask the Pilot about the

[11] Final Report WIM 13/2013 – m/v 'Godafoss', Final Report WIM 63/2017 – m/v 'Selfoss', Final Report WIM 041/20 – m/v 'Norman', Final Report WIM 102/20 – 'Enduro Trader'.

manoeuvre details.

7. Pilot's performance after the accident occurred should have been considered inadequate. The Pilot concentrated on the damage to the ship and on his comments to the ferry crew rather than on preventive action. After being informed about the approaching Hydrobudowa quay, he reacted 10 sec later with a command to 'Titan' when this tug was close to entering the shallow water by her stern. From the manoeuvring point of view, the following aspects should be noted:

1. Pilot relied on the experience of the tugs' skippers, especially the 'Titan', leading the set. There was practically no command to the tugs until the moment of collision.
2. Pilot did not command the 'Taurus' to slow down the towing set and transmit the moment to the portside in order to change the course of the towed ship. 'Taurus' was given the first command to stop just 3 sec before impact.
3. After collision, the craft, as a result of the strong turning motion given by 'Titan' to avoid it, almost came aground on the Hydrobudowa quay with her stbd aft. The crew's communication in this respect was initially ignored by the Pilot and the Captain.

4.5. Organisational factors

The following are selected excerpts from the port regulations, particularly concerning the movement of ships in the investigated area, according to Port Regulations – Order No. 9 of the Director of the Maritime Office in Gdynia (dated 17.07.2018).

Part 2
Additional provisions. Chapter 1. Additional provisions for the port of Gdańsk.

§ 102. 1. Ships shall proceed at a safe speed, in accordance with the 'COLREG regulations', not exceeding:
…
(c) for towing sets – 4 knots.

§ 107. 1. Ships without their own propulsion are obliged to use towing assistance:
…
2. The number of tugboats and the necessary towing conditions for ***ships which are difficult to manoeuvre*** *shall be determined each time by the Harbour Master.*

§ 108. The number of tugboats and the necessary towing conditions for damaged and unusual ships (wrecks), large pontoons, docks, etc. shall be determined each time by the Harbour Master.

It should be noted that there are no specific provisions in the port regulations for maximum size ships manoeuvring in the GSY area, including the Ostrawica I basin. The limit is their maximum draft, which is shown in the so-called Draft Atlas.

For example, at Zdobywców Kołobrzegu quay, owned by the GSY, ships with a LOA = 300 m and BOA = 40 m were probably moored based on a single permission from the Harbour Master.

In the ports of the Tri-city, the so-called Draft Atlas, i.e., a low-order document, updated on an ongoing basis and prepared by the harbour master's and boatswain's offices, is used to determine the water clearance under the keel for individual quays. This atlas also covers Ostrawica I and Ostrawica II quays (Table 2).

GDAŃSK-NOWY PORT (NEW PORT)

GSY – OSTRAWICA I QUAY					
Berth No.	Length [m]	Bollards	Max available draft [m]	Max available draft when a/side pontoons	REMARKS
1	85	1/2- 9/10	6.20		From the Front Quay. At bollards 7/8 shallowing at 6.10 m up to 1.5 m from the quay T_{max} = 5.60 m.
2.	160	9/10-23/24	5.20		
3.	70	23/24-29/30	5.00		
4.	295	29/30-55/56	5.40		
5.	205	55/56-73/74	5.00		
6.	20	73/74-75	4.00		

Update: 28.02.2023 (Draft survey: 22.12.2022).

GSY – OSTRAWICA II QUAY					
Berth No.	Length [m]	Bollards	Max available draft [m]	Max available draft when a/side pontoons	REMARKS
1.	400	1-5 and 5-1	3.50		Prohibition of mooring from bollard no. 4 up to the Dock 2 quay – Harbour Master's Notice No. 3/2007/Nb.
2.					

Update: 28.02.2023 (Draft survey: 08.09.2022).

Table 2 – Extract from the Draft Atlas for Ostrawica I and Ostrawica II.

4.6. The influence of external factors, including those related to the marine environment, on the occurrence of the accident.

When analysing the available manoeuvring basin from the point of view of manoeuvring safety, it should be noted that there are no empirical methods to assess the minimum width of such basins for manoeuvring with tugs. This is particularly true for towing the ship astern.

The only acceptable method for assessing safety under such manoeuvring conditions is a real-time simulation method using a manoeuvring simulator that allows the operation of tugs to be taken into account, especially tugs with unconventional propulsion (Tractor, ASD).

However, an approximation of the necessary manoeuvring basin width can be made by adopting certain simplifications. The PIANC method [PIANC 2014] allows a rough estimation of the width of the safe manoeuvring basin for ships with different manoeuvring capacities. The resulting value obtained by the aforementioned method is the ship's beam multiplication factor. The necessary width of the manoeuvring basin for the ship under consideration was determined by assuming that the ship is poorly manoeuvring and by taking into account a number of other assumptions relating primarily to:

- hydrometeorological factors such as wind, current;
- factors related to the shape of the channel banks and the passage speed;
- navigational marks and water clearance under the keel.

Results are shown in Table 2. The wind speed was taken as the maximum permitted during docking the ships (5°B).

Ship's type	Ro-Pax (towed by aft)	value	unit	reason
Length	L	124	m	
Beam	B	24	m	
Draft	T	5.5	m	
Depth	h	8	m	
	h/T	1.45	no propulsion	
Speed	v	< 5	knots	
Main	Wbm	1.8	no propulsion	poorly manoeuvring
Additional	W1 Speed	0	no propulsion	passage at low speed
	W2 wind from side	0.45	no propulsion	vw < 20 knots (5°B)

	W3 Transverse current	0	no propulsion	vpp = 0 knots
	W4 Longitudinal current	0	no propulsion	vpw < 0.5 knots
	W5 State of the sea	0	no propulsion	hf = 0 m
	W6 Navigational aids	0	no propulsion	aids very good
	W7 Seabed type	0.1	no propulsion	soft seabed
	W8 Depth	0.2	no propulsion	Depth compared to draft
	WBL (clearance to shore on PS)	0.5	no propulsion	escarpment/shore/ship
	WBP (clearance to shore on SS)	0.3	no propulsion	escarpment – steep slope
Total	W = Wbm+Sum(W)+WBP+WBL	3.35	no propulsion	Beam multiplication
Necessary width	D=W*B	80.4	m	

Table 3 – Application of PIANC method to assess safe manoeuvring width for SN manoeuvring under 5°B wind.

For a ship with poor manoeuvrability such as the 'Stena Nordica', the minimum width of the waterway under the assumed conditions is D = **80 m**.

For manoeuvring under negligible wind force, as was the case during the accident, we obtain a ship beam multiplication factor equal to: W = 3.35-0.45 = 2.9 (factor for wind force), which gives a minimum width of the basin equal to D = 2.9*B = 2.9*24 = 69.6 m. The Ostrawica I basin had a D = 58 m, which was about 10 m not enough.

The calculations above were performed for straight sections of waterways – the body of water under analysis is more complex and only the use of simulation methods is able to accurately specify its safety level in relation to the conditions and operated ships.

The PIANC method allows to calculate the necessary width of the waterway without considering the tugs. When taking tugs into account, it is necessary to predict how much manoeuvring space they will need to compensate for the effects of wind and current.

For the example towing set-up, assuming that the tractor-type tug is on the bow and towing directly and the ASD tug is on the aft of the ship and assisting 'not directly' (indirect), the minimum basin width should be within 66 m (Figure 5.1). It was assumed that the escort ASD needs a towing rope with the length of 40 m and swings of 45° for optimal operation by the

'indirect' method [Iglesias-Baniela 2021]. Such a method does not take into account errors and human influence on manoeuvring. Going further, it is possible to determine the pressure of the wind and current on the hull and, from the towing capacity of the tugs using appropriate calculations, check whether they are able to counteract the forces on the hull caused by the wind and current and whether they are able to generate sufficient force to move forward at a given speed.

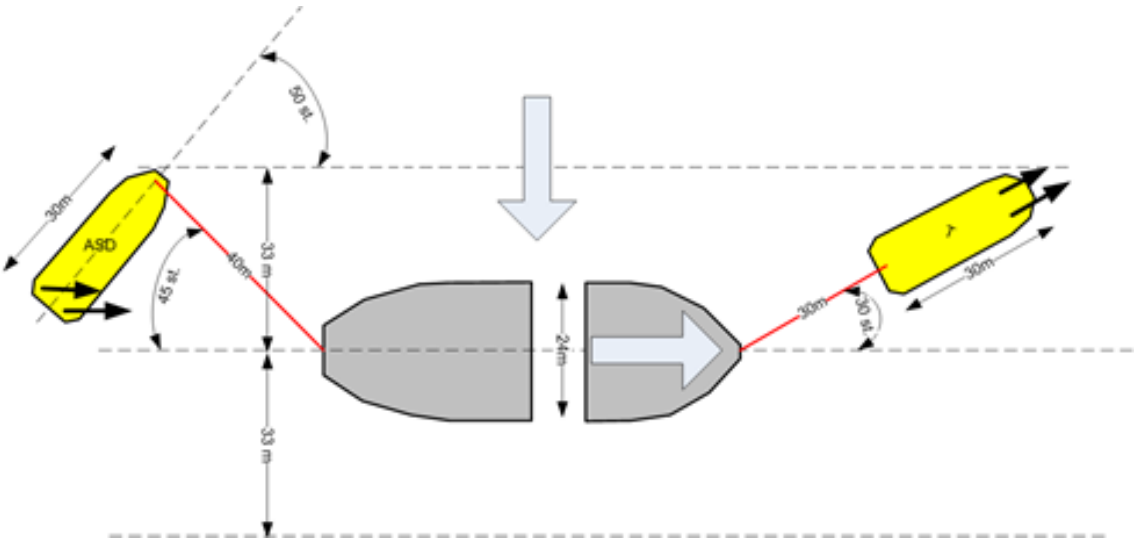

Figure 19 – Example scheme for determining the minimum waterway width for a towing set consisting of a towed ship, a tractor-type tug (leading) and an escort ASD using 'indirect' towing.

It follows that a body of water with an available width of 58 m (2.4B) constitutes a navigational difficulty for the safe manoeuvre of the towing set under consideration going astern.

A basin width of up to twice the beam of the ship (2B) is considered a limit, but only for very well manoeuvring ships going forward in good hydrometeorological conditions.

4.6.1. Bathymetry of the analysed basin and underwater obstacles

Based on draft surveys obtained from the Maritime Office in Gdynia, probably carried out by GSY, and draft surveys on the Navionix navigational chart (Figure 20), it can be observed that:

1. there is shallowing in the area of the northern headland of the Hydrobudowa quay up to 2-3 m,
2. the 5 m isobath in this area extends to approximately 10 m from the shore, which is now considered rather a natural shore.

In addition, based on skippers' testimony and satellite imagery (www.geoportal.pl):

1. there may be stones on the seabed in the area of the whole Hydrobudowa quay for shore protection,
2. remaining of the quay slabs in the middle area of the Hydrobudowa quay, partially submerged, fall into the water,
3. in the water, on satellite images (www.geoportal.pl), the remains of the quay walls can be seen below surface.

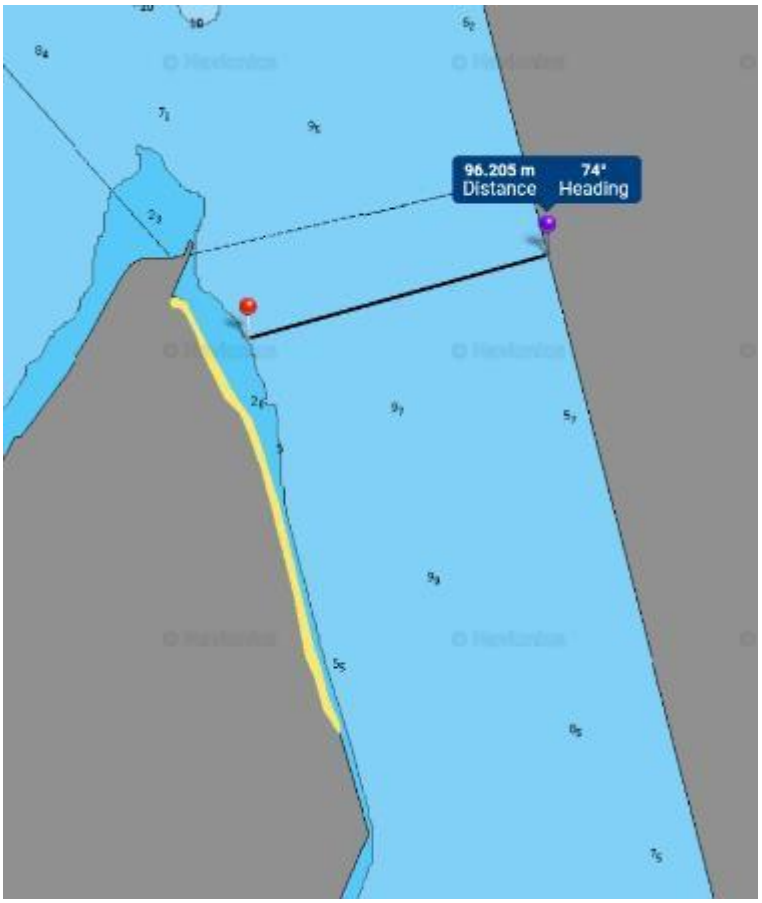

Figure 20 – Bathymetric situation of the accident area, marked isobath H=5 m (Navionix/Garmin chart)(Navionics/Garmin navigation chart accessed via www.navionics.com on 14.09.2023)

The Hydrobudowa quay is not used for mooring ships at it and is in a state of advanced and progressive destruction. It is endangering navigation by uncontrolled sliding of its elements into the Ostrawica I channel. The stones used for temporary protection of the quay endanger the propulsion systems of tugboats and the hulls of ships.

Photo 9 – View of the Hydrobudowa quay showing elements of uncontrolled sliding of concrete elements into the channel current.

4.6.2. Navigational marks and lighting

The main elements of the current navigation markings are 3 lights located at the corners of the entrance to the Ostrawica I basin (Figure 20). They were not used for navigation and had no impact on the accident.

The quays and GSY yard area are well lighted at night by industrial floodlights. The Hydrobudowa quay is unlit except for the southern and northern corners. The southern corner is painted with yellow paint.

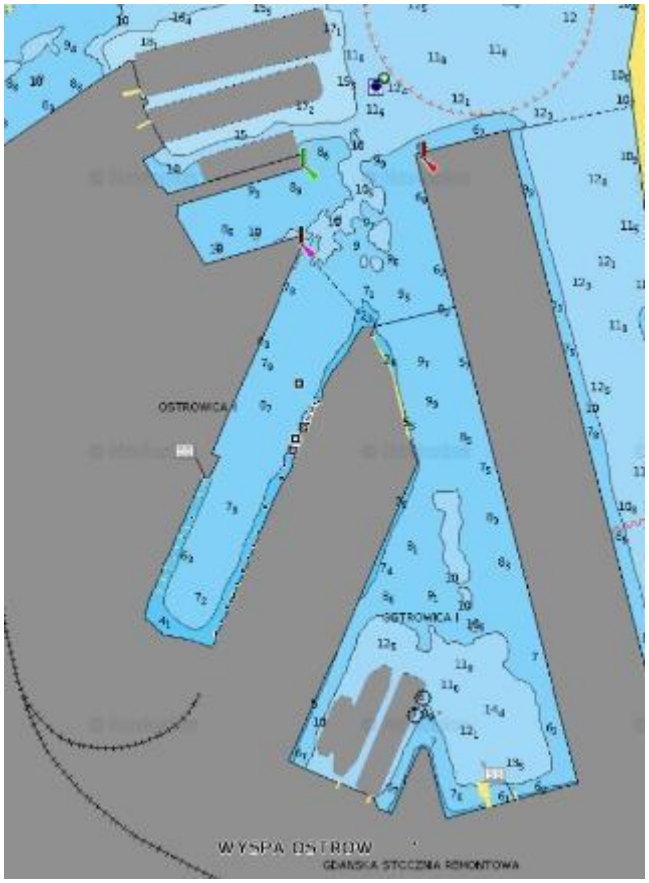

Figure 21 – Navigational markings of the investment area (Navionics/Garmin navigation chart accessed via www.navionics.com on 14.09.2023).

5. Description of Examination Findings Including the Identification of Safety Issues and Conclusions

The Pilot chose to execute the manoeuvre in one decisive and smooth movement. This is a very efficient way to do the manoeuvre, both in terms of time and safety, and is particularly effective in poor conditions when a second approach to the manoeuvre cannot be made. It is also a manoeuvre that requires extreme concentration on the longitudinal speeds and angular velocities of the ship and the work of the tugs.

Making fast the tug on the port side of the 'Stena Nordica' was the only option with this tactic of towing without cutting away the tugs and changing the position of the towing ropes after a turn on the GSY.

The undoubted difficulty in manoeuvring was:

1. Positioning of the 'Stena Nordica' with her stern towards the dock exit.
2. Very high concentration of crafts, including m/v Bull Kangean alongside the Ostrawica I quay, which hampered the safe execution of the manoeuvre.

3. Night time.

According to the Commission, the causes of the accident were:

1. Failure to control the speed of the towing set and increasing its speed up to 3 knots.

Photo 10 – Speed of the ship 'Stena Nordica' as read from the VDR recording at the time of collision.

2. Giving the towed ship too little turn to the port.

This may have been due to the inappropriate use of the forward tug 'Taurus' (at the end of the towing set). The AIS records show that the tug was staying very close to the bow of the towed ship, often being on the starboard side of Stena Nordica, thus having little influence in giving the ship a turn and in stopping her, which was crucial for the proper execution of the one smooth manoeuvre of exiting the basin and entering the channel towards the turntable.

Also contributing to the accident was the aforementioned poor cooperation between Pilot and Captain in informing each other and making decisions. There is a clear lack of designation of the observer's function to give distances on the aft. In addition, the width of the body of water was considerably narrowed by the ships moored at Ostrawica I quay, as well as the Hydrobudowa quay on the opposite side, which was devastated and not well lit, and did not provide safety. It is necessary to add to this the asymmetric (by stern) towing and the night time. Difficult manoeuvres, of which the towing of the ship 'Stena Nordica' was one, should be executed during daylight hours. Human perception of distance and sense of speed are severely affected during the night.

In September of this year, the Commission received information from the Head of the Pilot Station at the Port of Gdańsk that, in consultation with the GSY and WUŻ Port and Maritime Services Sp. z o.o., it had been decided to execute future towing operations in this area using the symmetrical bridle towline (so called 'bridles').

The Commission believes that this kind of solution is appropriate, but does not solve all the problems, because the main cause of the accident was not the asymmetry of the towing.

Bridles towing is a common method used for asymmetrical and unsteerable objects (barges, pontoons). Bridles should be fitted to the fairleads on both sides of the ship and connected symmetrically to the main towing rope. This often requires complicated fitting of them and a problem with uniform loading.

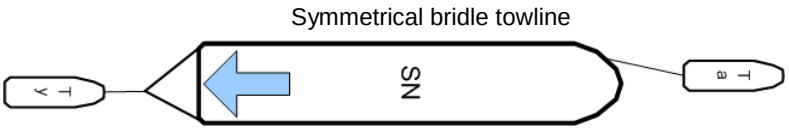

Figure 22 – Diagram showing a 'bridle' type of towing operation.

The 'bridle' should be made of ropes with a high coefficient of elasticity which, through their extensibility, will compensate for the differences in their tension created by the tug working to the right and left of the towing set.

6. Safety recommendations

Shipyard water areas are specific bodies of water. Piloting on such waters is one of the most difficult, and shipyard pilots should have the highest qualifications and experience. This also applies to skippers of shipyard tugs.

To avoid future accidents in the area under consideration, the Commission hereby addresses recommendations to:

6.1. The Director of the Maritime Office in Gdynia

The channel at the level of Ostrawica 1 quay is a particularly difficult and dangerous basin for manoeuvring ships entering and leaving the docks. Taking into account the lack of adequate legal regulations, the State Marine Accident Investigation Commission recommends that at the request of the Director of the Maritime Office in Gdynia, a navigational analysis of this basin indicating safe manoeuvring conditions should be performed. Such an analysis should be

conducted by GSY in cooperation with the Pilot Station in Gdańsk and the Gdańsk Harbour Master's Office.

Such an analysis may be performed by a centre with experience in carrying out similar work, preferably having a simulator with the ability to simulate towing using non-conventional powered tugs. The specific aspects that the analysis should address are:

1. performing some particularly difficult pilotage work at night,
2. determining the required width of available manoeuvring areas depending on the size of the vessel,
3. possibilities of mooring ships at Ostrawica I quay,
4. constraints arising from hydrometeorological conditions,
5. discussing the various variants of manoeuvring tactics.

In addition, during the investigation, a time difference was observed between the time it took to record AIS data to the AIS-PL database and the transmission of the AIS signal from the ships. This amounted to as much as 15 sec and is due to the lack of time synchronisation of the server storing the data. The State Marine Accident Investigation Commission recommends that such synchronisation should be carried out, as some AIS analysis software can malfunction with such a time difference.

6.2. Head of the Port of Gdańsk Pilot Station

The State Marine Accident Investigation Commission recommends to the Head of the Pilot Station to conduct a training course with the implementation of specific solutions, using the knowledge from this accident and from the previous reports made by the State Marine Accident Investigation Commission. During the training, special attention should be paid to the previous comments made in the Final Reports mentioned in Chapter 4.4[12] earlier, and to the following factors that will improve the used procedures:

1. preparation for the manoeuvre by involving the crew, with a specific statement of the duties for each crew member, and what the Pilot expects from the crew in the particular expected manoeuvring situation, if different from the usual one.
2. sharing knowledge with the Masters of the crafts about the planned and detailed tactics for manoeuvring,
3. listening to the comments of the Masters of these ships on the proposed tactics.

[12] The issue of the relationship between the Captain and Pilot is discussed in more detail in Final Report WIM 63/2017 - m/v 'Selfoss', in chapter 6.2 and 6.3.

The Commission also notes that there is a strong tendency for maritime companies to pursue a safety culture by implementing non-statutory safety measures in their operations, thereby enhancing the quality of services provided.

The pilot organisation itself should recognise the need for this and make the appropriate changes. If such actions will be put on the back burner, further accidents will be a matter of time.

The Commission also recommends to the Head of Pilot Station that the content of the Commission's explanation of the work and duties of pilots contained in the Final Report WIM 63/17 on the Selfoss accident be used as part of the training provided. Although the Final Report was drawn up several years ago, the principles of the pilotage service remain the same. The contents of these explanations are referred to in Attachment 2.

7. Safety recommendations

The State Marine Accident Investigation Commission recommends WUŻ Port and Maritime Services Ltd Sp. z o.o. to ensure the correct and reliable operation of the AIS system for its fleet. This system is crucial in the analysis of accidents and can work in the company's favour in the event of disputes, so it is in the shipowner's interest. It is proposed to equip tugs with Class A AIS transmitters broadcasting their parameters at a sufficiently high frequency (Attachment 1). Most ports require their tug fleet to have such solutions because of the improved monitoring of the port support fleet.

8. List of photos

9. List of figures

10. List of tables

11. Information sources

Notification of the accident

Hearing of crew members from the ship 'Stena Nordica'.

Hearing of the tugboat crews.

Hearing of the Pilot.

Materials and information received from the Harbour Master's Office in Gdańsk.

Videos from the cameras installed on board 'Stena Nordica'.

Commission's own photographs.

Expert opinion prepared by Prof. dr hab. inż. Chief Officer Lucjan Gucma.

Data from the 'Stena Nordica' VDR

12. Abbreviation

AIS – Automatic Identification System

CCTV – Closed Circuit TeleVision

COG – course over ground

COLREGS – International Regulations for Preventing Collisions at Sea

DGPS – Differential Global Positioning System – a GPS measurement technique that allows greater accuracy than standard measurement.

GNSS – Global Navigation Satellite System

LB - port side

PB - starboard side

SMAIC – State Marine Accident Investigation Commission

SOG – Speed Over Ground

UM – Maritime Office

UTC – Coordinated Universal Time

UTM – Universal Transverse Mercator – kilometre grid system used on topographic charts in the WGS84 reference system

VDR – Voyage Data Recorder

kn – knot (speed unit)

13. Composition of the accident investigation team

Team leader – Marek Szymankiewicz – Secretary of the SMAIC

Team Member – Tadeusz Wojtasik – Chairman of the SMAIC

14. Attachments

14.1. Attachment 1 – Data transmission times by AIS (Class A and B)

AIS Class A Transponder-Ships Dynamic Conditions	Dual-Channel	Single-Channel
Ship at anchor or moored	3 min	6 min
SOG 0-14 knots	10 s	20 s
SOG 0-14 knots and changing	3.3 s	6.6 s
SOG 14-23 knots	6 s	12 s
SOG 14-23 knots and changing course	2 s	4
SOG > 23 knots	2 s	4 s
Ship static information	6 min	12 min
AIS Class B Transponder-Ships Dynamic Conditions	**Dual-Channel**	**Single-Channel**
SOG < 2 knots	3 min	6 min
SOG > 2 knots	30 s	1 min
SOG		
Ship static information	6 min	12 min

14.2. Attachment 2 – Final Report WIM 22/18 – Chapters 6.2 and 6.3.

Pilot

The port pilot is one of the oldest professions in the world[13]. Over the centuries its role has changed due to the economic conditions governing the pilot service. In the early sailing period, the knowledge of navigation in piloted waters was decisive, thus protecting the vessel from damage and loss of freight. Nowadays, the role of the pilot has grown remarkably and they must be specialists with very high qualifications who know not only navigational conditions on a designated water region, but are able to handle complicated devices for manoeuvring vessels, must protect port infrastructure in critical situations, must know local and international regulations related to the pilotage, must know the rules of communication with other service providers in the port, as well as the rules of cooperation with the crew of the piloted vessel.
In order to be able to perform these duties correctly, the pilot must undergo periodic training resulting from the relevant regulations[14].

The Maritime Code[15] in Article 220 states that pilotage service consists in providing the shipmaster with information and advice in navigating the vessel with respect to navigational conditions on waters on which the pilot performs his service.

Transmission and exchange of information between the shipmaster and the pilot during the pilotage should be a continuous process, not limited to transfer and exchange of basic information when the pilot enters the bridge[16].

Moreover, the pilot station regulations[17] specify basic duties of the pilot, which among others are the following:

a. performing the pilotage with due diligence,
b. keeping track and updating knowledge about navigational conditions,
c. getting acquainted before commencing the service with hydro-meteorological conditions,
d. discussing with the shipmaster of the piloted vessel a plan of manoeuvres, selecting proper tug boats and using them, and discussing the berthing and unberthing plan,

[13]The eldest note about pilot service comes from 7 century BC.
[14] Order of the Minister of Maritime Ecomony and Inland Navigation of 17 November 2017 on maritime pilotage services (Journal of Laws of 2018, item 38).
[15] Maritime code (Journal of Laws of 2013 item 758).
[16] IMO Resolution A.960 (23) art. 5.1.
[17] § 6 of the Szczecin Pilot Station Regulations approved on the day of 23 July 2013 by the director of the Maritime Office.

e. maintaining proper communication during the manoeuvres in the port with wharf managers.[18]

Obligatory Port Pilotage – relations between Master and Pilot

The mandatory pilotage is one of few public legal institutions which are focused on limiting the risk associated with navigation in ports. Provisions regarding the pilotage and the role of the pilot on duty form a complex of issues covering their relations with operators, shipmasters and port authorities and they are sometimes interpreted differently in different ports of the world.

Regarding the legal aspect of the relations between the pilot, the master and the bridge staff, the IMO Resolution A.920(23)[19] defines the position of the crew members of the bridge during the pilotage in the following way:

– *despite the pilot in charge, his presence on the vessel does not absolve the shipmaster or officer responsible for the navigational watch from their duties related to the safety of the vessel. It is important that when the pilot gets on board before the pilotage starts,*

– *the pilot, shipmaster and bridge staff are aware of their roles in ensuring the safe passage of the vessel.*

– *the master and officers on the bridge and the pilot are jointly responsible for proper communication and understanding of mutual roles they play in ensuring the safe passage of the vessel in the water region under pilotage.*

Masters and officers on the bridge are required to support the pilot and ensure that their activities are controlled at all times.

At the same time, the Resolution specifies when the pilot may withdraw from the pilot service. Port regulations are similar[20].

However, mutual relations between the shipmaster and the pilot performing pilotage cannot be fully described by law. The attempts to present this relation in a descriptive way include a simplified statement that the shipmaster is responsible for everything, and the pilot's role is

[18]

[19] IMO Resolution A.960(23), Annex 2 (Recommendation on operational procedures for maritime pilots other than deep-sea pilots) art. 2.1, 2.2, 2,3.

[20] § 89 point 1 and point 2 of the Order No 3 of the Director of the Maritime Office in Szczecin dated 27 July 2013. Port Regulations (Official Journal of the Zachodniopomorskie voivodship of 6 August 2013 item 2932).

limited to giving advice when the shipmaster expects it, to a far reaching assessment of the representative of an American group of pilots:[21]

'In order to understand the relation occurring on the bridge between the shipmaster and the pilot, it is necessary to distinguish between Power and Authority. You can define Power as an ability to act regardless of (regardless of whether it exists) the right to act, while Authority can be defined as the right to act regardless of the way or method to complete the action. At sea the master has both power over the vessel and his crew as well as authority, but when entering the pilotage waters, the authority to manage and control the movement of a vessel pass by law onto a pilot. A common denominator of their relationship is the fact that the pilot's authority can be exercised only in cooperation with the master's power consisting in commanding the crew, and the master's power causing the vessel's movement may only be lawfully carried out in cooperation with the pilot's authority to manage and control the vessel's movement'.

In order to be able to put into practice this interdependence not fully defined by law, it is necessary to be aware of the people on the bridge (bridge crew), that it is necessary to cooperate with each other of the entire bridge crew to which the pilot undoubtedly belongs. In order to learn how to properly maintain this cooperation, the 'Navigational Watch Command'[22] training courses are conducted using simulators in many training centres in the world for officers of merchant vessels and pilots. In the case of some pilot organizations, modified programs of training courses in the pilot version have been prepared, which take into account the complexity of issues and the need to train pilots to conduct the pilotage in cooperation with the bridge crew. These exercises should be done by pilots every 4 or 5 years depending on the requirements of maritime administration.

It is in line with the guidelines contained in the IMO Resolution A.960(23), which clearly indicate that each pilot should be trained as part of the 'Navigational Watch Command' training course, with particular emphasis on the flow of information during the pilotage.[23]

The cooperation of the bridge crew during the exit manoeuvres of Selfoss practically did not take place, which clearly indicates the deficiencies in the training of both the vessel's crew and the pilot performing the pilotage.

[21] Master/Pilot relationship, the role of the pilot in risk management – Capt. George A. Quick (for many years Vice President of the Pilot Membership of the International Organization of Masters, Mates &Pilots of Maryland, USA).

[22] Bridge Team/Resource Management (IMO Model Course 1.22)

[23] Art. 5, Annex 1 – Recommendation on training and certification of Maritime Pilots other than Deep-Sea Pilots, Resolution A.290(23)

The insurance companies also pay attention to the need for proper training. The Swedish insurance company[24], analysing the number of accidents, stated that in 2011, 53% of all reported accidents concerned events during the pilotage[25]. It was found that the basic reason for their occurrence was the lack of cooperation between the bridge crew and the pilot. This state has been summarized in the following way:

- lack of complete exchange of mutual information = lack of a common plan,
- lack of planning = no possibility of effective monitoring,
- no monitoring = no intervention in critical situations.

[24] The Swedish Club.
[25] Navigation Accident and their Causes issued by The Nautical Institute 2015.