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STATE MARINE ACCIDENT INVESTIGATION COMMISSION

FINAL REPORT

004/22

serious marine casualty

m/s SMP Novodvinsk

Grounding by a vessel passing the Świnoujście-Szczecin Fairway on 12 January 2022

September 2022

The investigation of the serious grounding accident of the vessel SMP Novodvinsk was conducted under the State Marine Accident Investigation Commission Act of 31 August 2012 (Journal of Laws of 2019, item 1374) as well as norms, standards and recommended procedures agreed within the International Maritime Organisation (IMO) and binding 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 accident 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 12 January 2022 at 13:00 LT[1], the Russian-flagged vessel SMP Novodvinsk heaved up anchor on the Świnoujście road and, after picking up pilot at 13:10, proceeded to the Finnish quay in the port of Szczecin to discharge a cargo of steel plates. While sailing on the road, the gyrocompass indication was found to be erroneous and the autopilot not working properly. It was decided to steer manually using a magnetic compass. At 13:30, the vessel passed the head of the Świnoujście port's eastern breakwater and continued at a speed of 7-8 kts. Due to visibility limited to approximately 4 cbl, navigation was carried out using radar and ECDIS. After passing the breakwaters of the 1st Route Gate at 14:42, visibility was still limited to 3-4 cbl.

Photo 1. Image of vessel's movement and grounding area (ECDIS)

As the vessel drifted to the eastern side of the fairway, a course correction to the starboard side was made. As a result of this, the vessel found itself on the west side of the fairway, requiring a course correction to the port side, which was executed. The vessel began to turn rapidly to the port and as a result moved to the eastern side of the fairway. Attempts made to correct the course to the starboard,

[1] Local time (LT = UTC + 1h) is reported throughout. Vessel time ST = UTC + 3h. A list of abbreviations is provided in chapter 9 of this report.

including the use of the bow thruster, proved insufficient. The vessel drifted out of the fairway and went aground at 14:45 having COG of approximately 130°.

Attempts made on the same day to take out the vessel from aground using a tug were unsuccessful. A visual inspection by a diver of the underwater part of the hull, rudder and propeller showed no damage, apart from a dent in the plating of the bulbous bow. After the vessel was lightered[2] and using a tugboat, the SMP Novodvinsk regained buoyancy at 07:40 on 11 February 2022 and resumed its voyage to Szczecin.

2. General information

Photo 2. SMP Novodvinsk

2.1. Vessel particulars

Vessel's name:	SMP Novodvinsk
Flag:	Russian
Owner:	TransFin-M Public Company
Company:	JSC Northern Shipping Company

[2] Lightering - partial unloading of the vessel to reduce her draught.

Operator:	JSC Northern Shipping Company
Classification society:	RMRS
Vessel's type:	general cargo vessel
Call sign:	UBNV6
IMO number:	9398046
GRT:	4106
Year and place of build:	2008 Kampen NL
Engine power:	2040 kW
Bow thruster:	280 kW
LOA:	118.90 m
Width:	13.43 m
Draught:	for / 5.72 m, aft / 6.50[3] m
Hull material:	steel
Minimum safe manning:	9 crew
Type of VDR (S-VDR):	FURUNO VR – 3000

2.2. Voyage particulars

Ports of call during the voyage:	St. Petersburg, Russia
Destination port:	Szczecin, Polska
Type of voyage:	international
Cargo o/b (qty, type):	6148.9 t of steel plates
Crew details (number, nationality):	9 crewmembers (all from Russia)
Passenger details (number, nationality)	no passengers on board

[3] Value from information given to the pilot, with the master's report stating a draught aft of 6.35 m.

2.3. Marine accident information

Type:	serious marine accident
Date and time of accident:	12.01.2022 at 14:45 LT
Position at the time of the accident:	φ=53°47.9'N λ=014°21.2'E
Area of the accident:	Świnoujście-Szczecin fairway
Nature of the water region:	internal waters
Weather at the time of the accident:	wind W 4° B, sea 1, visibility reduced to approx. 3 cbl
Operational condition at the time of the accident:	vessel loaded
Consequences of the accident:	no damage to the vessel

2.4. Shore Services and Rescue Action Information

Entities involved:	Szczecin Harbour Master, Border Guard, UW Service
Means used:	tugs: Centaur II and Fairplay VI, plus two UW Service barges to unload the vessel
Response time, search and rescue service:	search & rescue units were not involved
Action taken:	lightering and taking the vessel away from aground operations
Results achieved:	vessel regained buoyancy and continued voyage (entering the port of Szczecin)

3. Circumstances of the accident

On 12 January 2022 at 13:00, the vessel SMP Novodvinsk, after being on the road for several hours, heaved up anchor and proceeded towards the entrance to Świnoujście port. A boatswain (bosun) on the fwd manoeuvre station prepared both anchors for dropping and remained there ready to follow the orders from the bridge. After picking up the pilot at 13:10, there was an exchange of information between master and the pilot. Master confirmed that all vessel's equipment is in good working condition and the pilot reported on the route and the expected mooring time and place at the Finnish Quay in Szczecin. On the bridge were, in addition to the pilot, the OOW and the master, who was also a helmsman. At around 13:20, the pilot suggested switching on the autopilot (gyro-pilot) and the master did so. The vessel was then found to be changing course to the starboard. It was determined that the cause of the error is a gyrocompass malfunction. Master switched the steering to manual mode and continued to steer the vessel towards the harbour heads. The vessel exhibited excessive – in the opinion of the master and pilot – heading instability, necessitating large rudder angles to initiate course changes. The pilot and master agreed that with the navigational equipment in good working condition: radar, ECDIS, GPS and magnetic compass, they are able to continue safely to Szczecin. At that time, visibility in Świnoujście was limited to about 4-5 cbl and further along the planned route variable visibility was indicated. The VTS was not informed about the gyrocompass failure. Vessel passed the eastern head of the Świnoujście breakwater at 13:30 and continued to navigate using manual steering at a speed of approximately 8 kts. While navigating in the Piastowski Channel, at 14:00 LT (16:00 vessel's time) the watch on the bridge was changed and the chief mate took over the helm from the master. The officer on watch (OOW), who had completed his watch, remained on the bridge due to the master's order and attempted to restore the correct operation of the gyrocompass. In the Piastowski Channel and on the route to the 4th Route Gate, navigation is on a steady course of 141°. The pilot asked the chief mate to maintain such a course. Steering was done using a joystick located on one of the panels, just below the magnetic compass electronic repeater with an additional digital display of the compass course (CC).

Photo 3. Magnetic compass repeater

When leaving the Piastowski Channel, instead of the expected improvement in visibility, it worsened and, according to various estimates by the crew and the pilot, was up to 1 to 4 cbl. It was not possible to verify the correctness of the visibility calculation due to the lack of navigational objects in front of the vessel's bow at this distance. After passing the breakwaters of the 1st Route Gate and the pair of buoys No 1 and No 2, at 14:42 the vessel began to approach the port (east) edge of the fairway. Accordingly, the pilot instructed the vessel to change the course to 146°[4].

The following figures present, for selected moments, a description of the situation based on data from VTS, ECDIS, master's and pilot's explanations. Due to the lack of dependable real, gyrocompass and magnetic heading information, the vessel's silhouette has been oriented with respect to the course over ground (COG – purple colour). The red vector shows erroneous gyrocompass indications.

[4] According to the master and chief officer statement, the command 'starboard 15' was ordered.

Figure 1. VTS at 14:42:14, COG = 135.4°, SOG = 8.7 kts, ROT = -0.7°/min[5]

The master and pilot watched the vessel's movement on the ECDIS chart and when the vessel was in the middle of the fairway the pilot ordered 'midships'[6].

[5] A negative value of ROT indicates a turn to port and a positive value to starboard.
[6] Command to helmsman – 'midships'.

Figure 2. VTS at 14:43:08, COG= 156°, SOG = 8.94 kts, ROT = 15.2°/min

The further passing of the vessel to the starboard side of the fairway caused the pilot to react and give the command to helm – port 10[7]. The vessel braked the turn to the starboard and, according to the consensus account of witnesses, quickly began to change course to the port and proceed again towards the port (east) edge of the fairway.

[7] According to the master statement, the command 'port 10' was ordered.

Figure 3. VTS at 14:43:54, COG = 147°, SOG = 7.97 kts, ROT = -53.1°/min

Figure 4. VTS at 14:44:18, COG = 131°, SOG = 8.16 kts, ROT = – 39.3°/min

Pilot gave a command on the helm – starboard 15, and a moment later – hard to starboard. The vessel continued to make a port turn crossing the boundary of the fairway.

Figure 5. VTS at 14:44:54, COG = 115.3°, SOG = 7.97 kts, ROT = -20°/min

The pilot instructed to run the bow thruster to maximum starboard. The captain decided to set the propeller pitch to '0' and then to 'slow astern'. These actions were taken simultaneously. Being already off the fairway, the vessel started to change course to the starboard but finally grounded at 14:46.

VTS and the operator were notified about the accident, and in the meantime a tank sounding and visual inspection of accessible parts of the hull was carried out. No hull unsealing as well as no water pollution was observed. Determined the draft of the vessel when aground – fwd 4.70 m and aft 4.30 m. On the same day, unsuccessful attempts were made to take the vessel from aground using the tug Centaur II. A diver's examination of the underwater part of the hull showed that the vessel's rudder and propeller were off the sand bank.

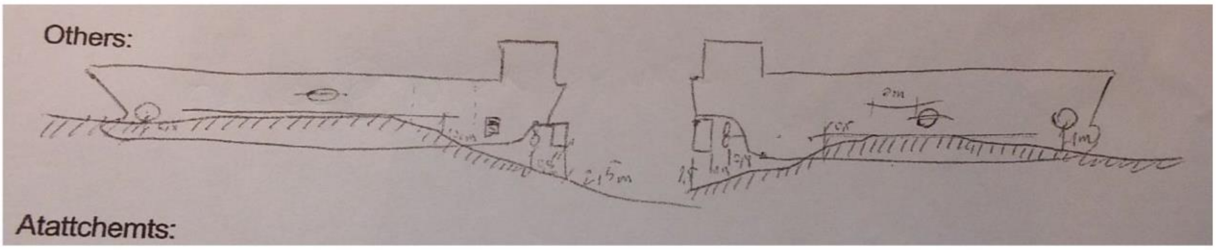


Figure 6. Sketch made by a diver showing location of vessel when aground

The ground pressure caused by the vessel's reduction in draft by approximately 1.5 m after running aground required the vessel to be unloaded, which was commenced on 10 February 2022. Approximately 1,500 tonnes of steel plates were discharged onto two UW Service barges, after which the vessel regained buoyancy the following morning at 07:40 with the assistance of the tug Fairplay VI and resumed proceeding to the port of Szczecin, assisted by the tug. Inspection of the underwater part of the hull showed a dent on the starboard side of the bulbous bow with a size of 1.5 m x 2.0 m and a deflection arrow of 0.4 m, as well as other minor dents and abrasions on the paint coatings.

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

The Commission conducted the analysis using the VTS traffic log, the ECDIS logs, the opinion of the Commission's expert as well as statements by the pilot and crewmembers of the vessel.

Accurate reconstruction of the accident and its causes was hampered by the following limitations of the source materials:

- no recordings from the VDR (device failure) – it was not possible to reconstruct the commands given, to determine their time and instrument indications (e.g., regarding rudder, engine, radar, etc.),
- the gyrocompass course was wrongly determined due to a gyrocompass malfunction, and at the same time there was no recorded course information from the magnetic compass anywhere – so there was no way to reconstruct the vessel's heading or exact angular velocity,
- there was no information from the VTS tracking system on the VTS recording, the data provided was from the AIS system – lack of indications of the vessel's position and movement independent of her systems,

- lack of continuous recording from the ECDIS system, only tabular information from the log at 1-minute intervals was available – inability to reconstruct in detail the situation as seen on the equipment on the bridge in the absence of the radar recording,
- there was a lack of information about the location of the CCRP (Consistent Common Reference Point) on the vessel in the available documents – it was difficult to analyse the position of the vessel on a large scale, as it was not known how the vessel's silhouette is located in relation to the position defined by the navigation system.

In addition, during the data analysis it was found that the vessel's positions as determined by the AIS system (available in the VTS) and those available in the ECDIS are offset from each other by approximately 40-50 m.

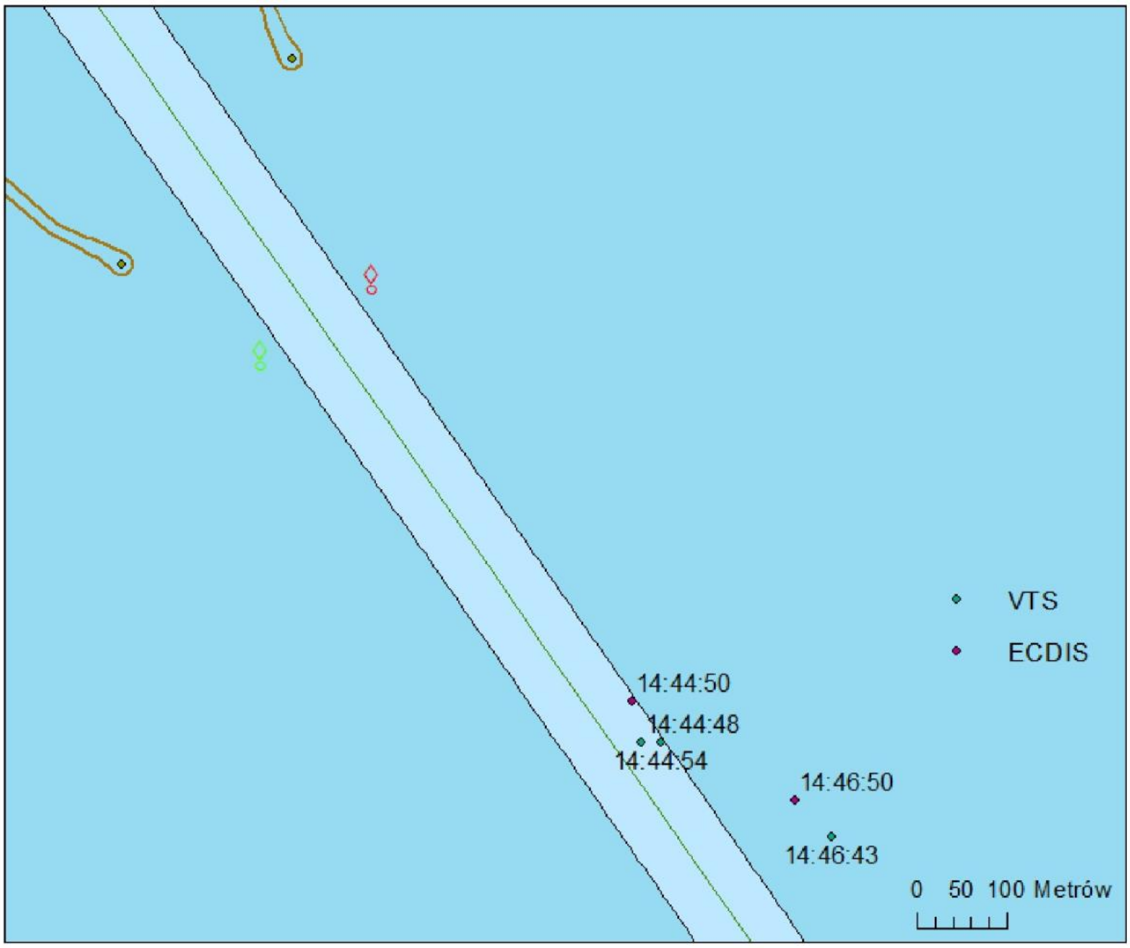


Figure 7. Example of position differences from VTS and ECDIS in the final stage of an accident

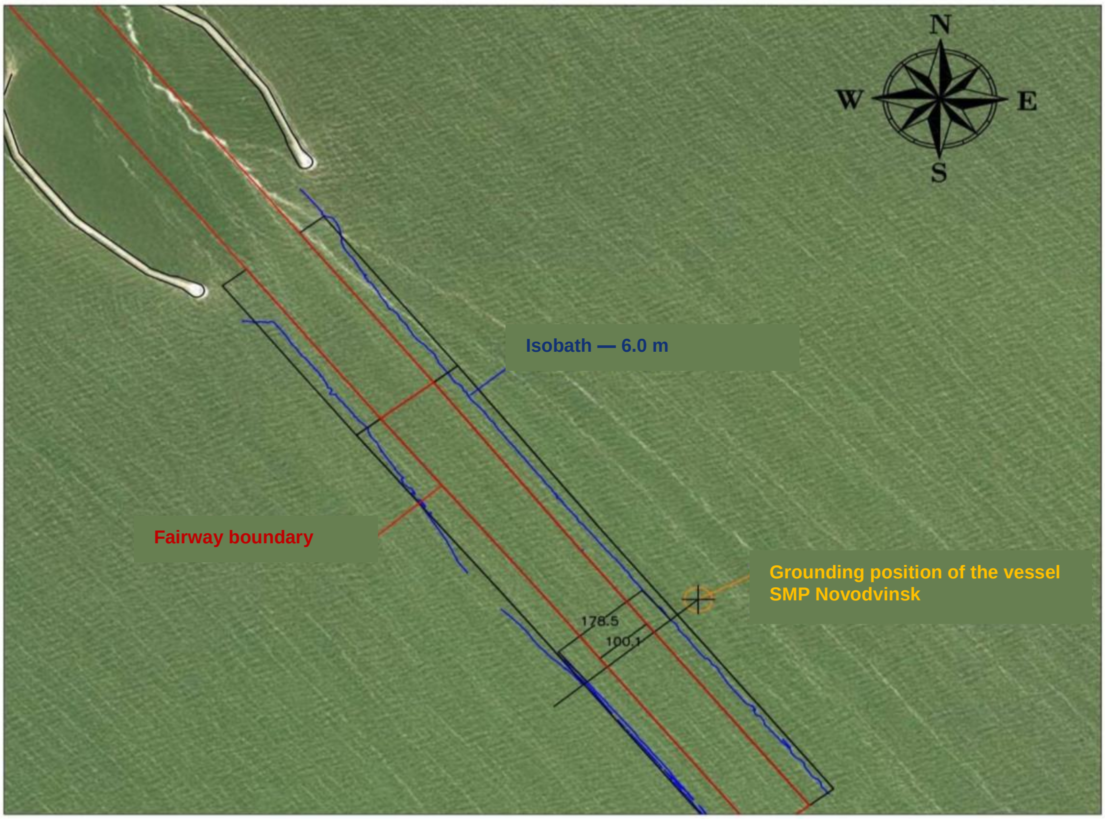
4.1. Influence of the External Factors including Factors Related to the Marine Environment on the Occurrence of the Accident.

The hydrometeorological conditions were determined from the pilot and captain’s testimony and logbook records on board and in the VTS. The air temperature was about 0 °C and there was fog over the water. Visibility after leaving the anchorage was reduced to 4-5 cbl. At the start of the voyage, information was received via VHF that visibility had improved and is approximately 1 Nm in the Szczecin Lagoon. However, when the SMP Novodvinsk entered the Lagoon the visibility decreased. According to the master’s statement, to 1-2 cbl. Although the exact value of the visibility cannot be clearly determined, it is known (from the pilot’s and master’s unanimous opinion) that after passing buoys 1-2, no navigational marks ahead of the bow were visible, so the navigation was in conditions of restricted visibility. The exact value of the visibility in this case did not matter so much. At both 1 and 5 cables, further navigational marks on the fairway could not be seen. This meant that navigation had to be carried out solely based on navigational equipment, in particular radar and ECDIS, without the possibility of effective visual observation. This made the ongoing control of the vessel’s position, and in particular its orientation in relation to the axis and edge of the fairway, much more difficult.

The wind was, according to the VTS records, from the W direction of 4°B but, according to the master, from the SW direction of 5°B. The current in the Piastowski Channel was outgoing, about 0.2-0.5 kts, with the possible occurrence – indicated by the captain – of a cross-current after the vessel left the 1st Route Gate. This current, together with the wind from the starboard side, may have contributed to the vessel’s drift to the port (towards the east) and may have influenced the rate of turn when exposing the rudder to the starboard or port side. It was established from the consensus statements of the pilot and crew that the vessel changed course faster to the port than to the starboard at the same rudder settings. The wind and potential cross-current from the starboard side caused the vessel to drift towards the eastern edge of the fairway, forcing a course correction to the starboard side, and commencing a whole series of course changes that finally led to the accident.

The fairway in the Szczecin Lagoon is 100 m wide with a depth of over 12.5 m, and the width of the fairway between the 6 m isobaths is 178.5 m at the point of aground entry.

Prepared using authorised bathymetric data
no PL5621 —DIVO—SV—DWG—0051 7 of 07. 01. 2022.



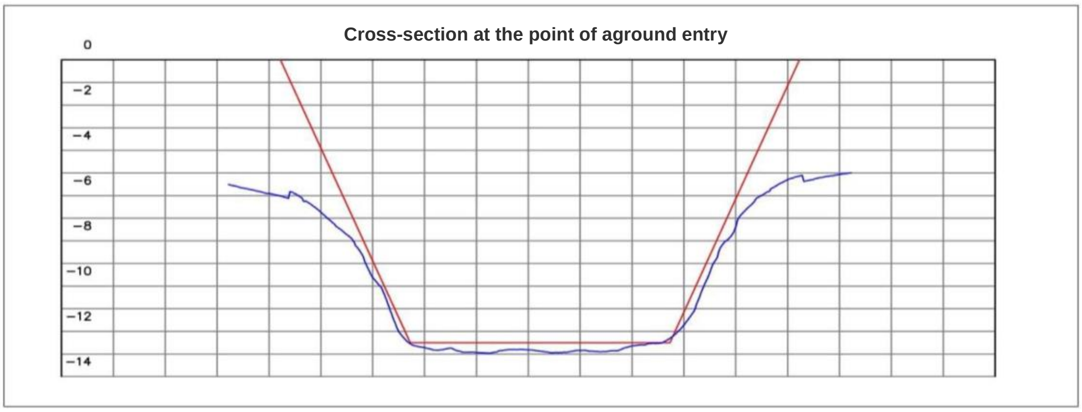


Figure 8. Fairway characteristics at the point of grounding

The SMP Novodvinsk is 118.9 m long, 13.43 m wide, and the maximum draught according to the vessel’s information when it ran aground was 6.35 m. The pilot card gives draught values of 5.72 m fwd and 6.5 m aft. When the vessel ran aground, the draughts were 4.3 m on aft and 4.7 m on fwd. The Szczecin Lagoon is difficult in terms of navigation. The available channel depths in relation to the vessel’s draught may have caused channel effects, while depth restrictions outside the fairway may have caused shallow water effects. In the case under analysis, the impact of these factors appears to be minor, but the occurrence of these adverse factors in the final phase of the accident cannot be ruled out.

4.2. Mechanical factors

The vessel, built in 2008, is equipped with a Wartsila 6L26A2 right-hand-drive 2040 kW main engine and a pitch propeller allowing the propulsion to be switched from full ahead to full astern in 30 sec. Steering of the vessel is provided by a Becker rudder with a maximum 45° pivot to both sides and a turnaround time from one side to the other of 38 sec with one rudder pump switched on and of 19 sec when two pumps are in operation. In addition, the vessel is equipped with a 280 kW bow thruster. Electricity supply is provided by two auxiliary engines and a shaft generator switched on during manoeuvres when the bow thruster is used. According to the crew, two generators and both rudder pumps were switched on when navigating with the pilot. No information on signalled alarm conditions has been found in the equipment recorder logs. All equipment was operational before and during the accident.

Photo 4. Port side of the vessel’s bridge

Photo 5. Starboard side of the vessel's bridge

The vessel is equipped with radio and navigation equipment, as required by regulations. The radio equipment was in working order. The navigational equipment is from FURUNO and includes two radars with ARPA and ECDIS, one being a 3 GHz (10 cm) radar and the other a 9 GHz (3 cm) radar. In addition, there is a Doppler log and two GPS units. All the navigation equipment listed was operational at the time of the accident.

A failure of the 'TOKIMEC ES 160' gyrocompass was detected on the Świnoujście road, which was giving incorrect course indications. The gyrocompass signal is delivered as Heading (vessel's course) to both the radar and ECDIS. As a result, both instruments were showing the wrong true course. On the radar it was impossible to use a North Up orientation, and on the ECDIS the silhouette of the own ship, even if there was one, was incorrectly oriented.

The gyrocompass failure also affected the control of the vessel. This was because the autopilot, linked to the gyrocompass, was not used. Despite the possibility of autopilot operation based on the magnetic compass signal, this option was also not used. The last annual inspection of the gyro-pilot was carried out on 8 July 2021 and confirmed the good condition of the gyrocompass.

Photo 6. Autopilot panel with visible below instruction for selecting gyrocompass or magnetic compass signal

Steering was manual with the helmsman using a magnetic compass due to a gyrocompass failure. Due to the position of the compass repeater on the panel, it was not possible for the master or pilot, who were observing the ship's movement on the ECDIS screens, to read the displayed compass course values. This lack of continuous course change information was significant to the unfolding of events and the accident itself.

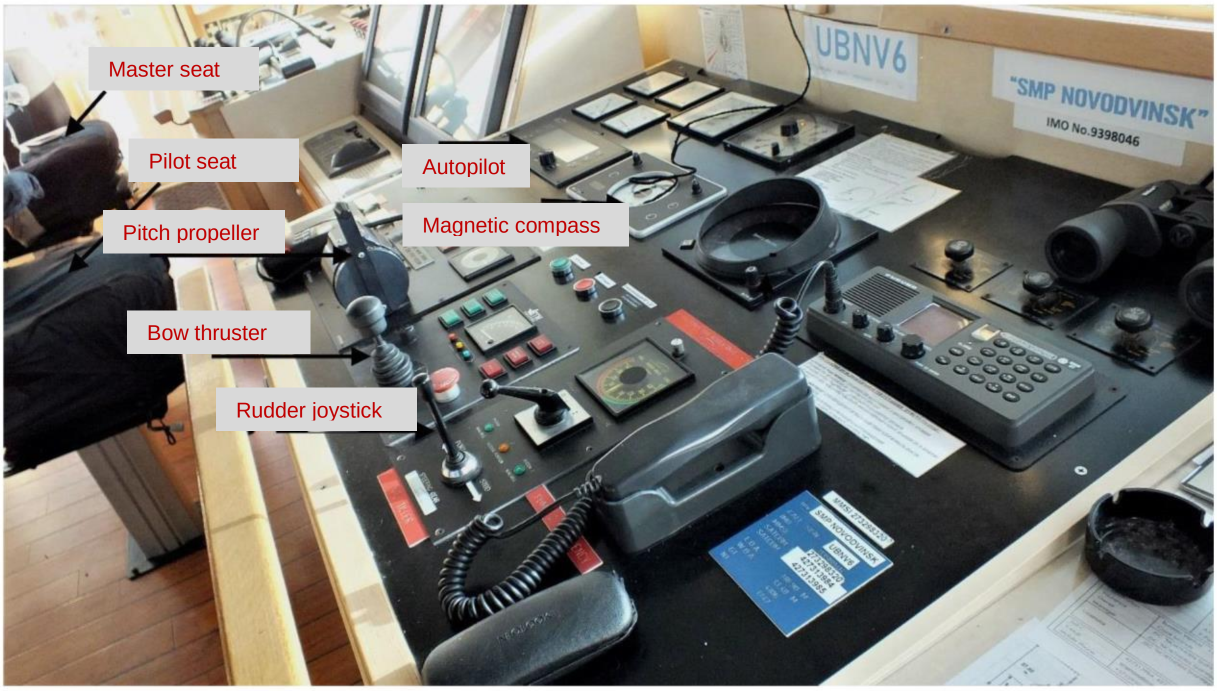


Figure 9. Control panel

According to the documentation, the total magnetic compass correction (deviation + declination) was determined the last time at midnight in the southern Baltic Sea and amounted to +6°. A similar correction of a few degrees was to be expected in the Szczecin Lagoon at a course of about 140°. The pilot informed the helmsman that the course through the Lagoon is 141.5°, having in mind the course over ground (COG), while the helmsman steered using a compass course. These differences were not crucial to the development of the accident, but there was nevertheless some inaccuracy in the communication of information.

The pilot identified another technical problem in his report, namely that the vessel slowly responded to the rudder. He suggested that there may have been some problems with the rudder, but this was not confirmed by crew members and there were no alarms related to this either. Given that the pilot personally checked the manual steering at the Świnoujście road and decided to continue the voyage, it is assumed that the rudder was working correctly and that any steering difficulties were due to the nature of the vessel in this loaded condition.

Technical problems also included a non-functioning VDR recorder. Service which arrived after the accident confirmed the absence of VDR records from 6 October 2021, with no crew response during this period due to the lack of status alerts on the device. The functionality of the VDR recorder did not affect the accident itself, but the lack of data from VDR significantly hampered its investigation.

In conditions of reduced visibility, when it is not possible to visually verify the vessel's position and direction, navigation is mainly carried out based on the indications of technical navigation devices. In such a situation, the accuracy of the indications of such devices is of particular importance, resulting from the characteristics of the sensor used and the way the signal is processed in the respective system or device.

Both the ECDIS and radar system use connected GPS and a gyro compass to determine position as well as direction. A detailed analysis of the accuracy of the vessel's existing navigation equipment has been described in Attachment 1 (section 12 of the report).

4.3. Human factors

Crew members and the pilot were properly qualified for their duties. Crew manning was in accordance with the Minimum Safe Manning Certificate (MSMC). The working time analysis did not reveal any exceedances of the permitted working hours. Pilot had 20 years of experience in piloting vessels in this area. Captain had been acting as a master for 7 years, including 1.5 months on board this vessel. The analysis of human factors has been limited to the following aspects:

- impact of human activity on the gyrocompass failure,
- decision to continue the voyage,
- use of navigational equipment.

The gyrocompass failure occurred at the very beginning of the voyage, while still at the Świnoujście road. Collected vessel documents show that the device had the appropriate/required survey certificates, so it was assumed that this failure was not the result of human error.

In the regulations applicable in the Szczecin-Świnoujście pilot area there are requirements for notification of vessel equipment failures and how to deal with such cases. These requirements are described in Attachment 2 (section 13 of the report). The pilot did not inform VTS about the gyrocompass failure. This lack of information flow was linked with further events.

The pilot suggested that the captain had already experienced doubts about the proper functioning of the equipment, but this is not reflected in the documents. Instead, it is a fact that the electrician was not notified about the gyrocompass malfunction and several attempts were made to rectify it by resetting of the device by the OOW only. It was assumed that the magnetic compass would be a sufficient substitute for the gyrocompass. The pilot and captain unanimously made the decision to continue the voyage with a faulty gyrocompass, without autopilot and in conditions of reduced visibility. Already at the start of the voyage with the pilot, it was clear that if conditions will not change (and no changes were forecasted), no consecutive navigational marks will be visible in the Szczecin Lagoon, as the visibility was more reduced than the distance between them. In their statements and reports, both the pilot and the captain did not consider to not continue the voyage. They considered that the operational equipment on their hands – radar, ECDIS, magnetic compass and manual steering are sufficient to complete the voyage to Szczecin.

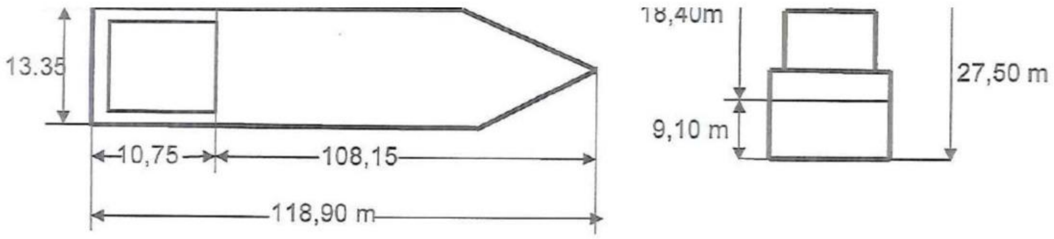
The radar picture taken after the accident showed a range of 1.5 Nm, relative motion and Head Up orientation. It is likely that these were the settings used. It should be noted that the use of Head Up orientation in the case of manoeuvres undertaken shifts the overall picture making the interpretation of the vessel's drift exceedingly difficult. In the absence of reliable gyrocompass information, it was not advisable to use the North Up orientation, but a Course Up one could be used. Relative trails analysis in this orientation would have allowed control of the vessel's drift. In addition, the parallel indexing technique, which is dedicated for such purposes, should have been used in this situation. Unfortunately, both parallel indexing and Course Up orientation are not widely used in navigational practice. ECDIS became the main tool for navigation. Decisions on subsequent manoeuvres were mainly based on the position of the ship, e.g., the command 'midships' was given in the middle of the fairway. Meanwhile, with a 100 m fairway width, the uncertainty of position determination (10 m) amounted to 10%, or perhaps even more due to offset and smoothing errors. In the absence of radar image stabilisation and with reduced visibility, there was essentially no other option in this regard. In spite of such limitations, it was not decided to reduce the speed, which, among other things, would have increased the readability and accuracy of the radar image.

4.4. Organisational factors.

From the reports and interviews, it appears that the pilot was giving commands, with no questioning them by the captain. In the final phase before running aground, the captain started to change the pitch of the pitch propeller and power of the operating bow thruster – but it is not clear if this was consulted with the pilot. Decisions made were based on available indications, mainly on the ECDIS screen. Commands to the rudder were executed by the Chief Mate who was a helmsman. There were too late counter manoeuvres following the drift, resulting in high angular velocities and the need for further large counter manoeuvres, and ultimately the inability to return to the fairway and to run aground. It has not been possible to establish what the need to swing the rudder hard was due to and whether this was indeed the case. The pilot claimed that the vessel was slow in responding to the rudder and that the helmsman had to swing the rudder hard for the vessel to respond. However, no problems with the manoeuvrability of the vessel were reported. The fact is that on the very first correction due to the wind, the helmsman swung the rudder 15° to starboard, even though the correction itself was supposed to be small. The command ‘port 10’ proved to be an insufficient countermove and the vessel continued to turn to starboard. The statements indicate that those on the bridge were surprised by this behaviour of the vessel, expecting stronger her reactions for the rudder angles. As a result, the final decision to counter to starboard and the vessel’s reaction were also too late. Given the extensive experience of the pilot, a possible reason for the late decisions and a kind of surprise about the vessel’s reaction is that a delayed situation compared to real ones was observed on the ECDIS screen. Due to the previously described errors and limitations of the equipment, decisions were made using delayed information. This thesis cannot be unequivocally confirmed based on the available information (no sources other than ECDIS and VTS), but it is highly probable.

Cooperation on the bridge went well most of the time. The pilot had no comments about the steering before entering the Szczecin Lagoon. The helmsman and captain also had no comments on the pilot’s commands. Before the accident itself, there are some doubts about the pilot-helmsman cooperation. In the case of the first correction after entering the Lagoon, the pilot claims that he gave the command to change to the course 146° and the helmsman himself selected the rudder angle (first to starboard 10° and then to starboard 15°). The helmsman (chief mate) claims to have received a command ‘starboard 15’ from the pilot. The biggest differences are during the final phase before the accident, when the vessel was turning hard to port, and a strong starboard correction was necessary. The pilot and the captain unanimously claim that they gave the command ‘hard to starboard’.

While the captain claims that the command had been executed, the pilot has doubts about this, pointing out that the rudder was at the 15° to the starboard when the vessel grounded.



Type of engine: Wartsila 6L26A2 maximum power **2040 kW / 2736 H.P.**			
Propeller : **1 Controllable pitch Screw Propeller**			
Maneuvering engine order	pitch	**Speed (knots)**	
		Loaded	Ballast
Full ahead	100	12	13
Half ahead	70	9	10
Slow ahead	40	5	6
Dead slow ahead	20	Full ahead to full astern	30 sec
Dead slow astern	20	Time limit astern min	15 sec
Slow astern	40	Stop to full astern	15 sec
Half astern	70	Astern power 80 % ahead	
Full astern	100	Time limit at minimum revolutions	

Steering particulars

Type of rudder : Becker Flap/1	Hard-over to hard-over: one unit 38 sec. two units 19 sec.
Maximum angle: 45	
Bow thruster – yes 280 kW / 375 H.P.	

Figure 10. Part of the Pilot Card

Approaching the eastern limit of the fairway, with a high port-turn angular velocity and the vessel's linear speed, the master, at the pilot's suggestion, activated bow thruster as much as possible to the starboard and, without consulting the pilot set, to reduce the vessel's speed, the pitch of the pitch propeller to zero and then to the 'slow astern' position. Pitch propeller, running at zero pitch, generates only a minimal amount of water jet directed at the rudder and, in addition, causes a break in the stream of water running along the hull which, acting on the rudder, allows the vessel to change her course. With such a vessel propulsion unit, the zero pitch of the propeller causes the vessel to be unreactive to rudder angles. In the Commission's opinion, this action was the cause of insufficient stopping of the ship's turn to the port despite the rudder being set to starboard.

When the vessel moved out of the fairway, her speed was high enough (7.6 kts) that the activation of the bow thruster was not able to alter the direction of the vessel. The response to the bow thruster began to be clearly visible during the last phase of events before the grounding, when the effectiveness of the bow thruster increased as the vessel's speed decreased. It must be assumed that the changes in the vessel's course since leaving the fairway and changing the pitch of the propeller to zero and then astern, were only minimally due to the vessel's response to the rudder angle because of the loss of the propeller wash influence.

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

The Commission concluded that the factors directly causing the SMP Novodvinsk to run aground were collectively:

- **technical problems** (gyrocompass failure),

- **difficult hydrometeorological and navigational conditions** (reduced visibility after entering the open waters of the Szczecin Lagoon without the possibility of visually observing the navigational marks, limitation of manoeuvrability of the 118 m long vessel in relation to the width of the navigational channel, the effect of the wind and possible cross-current after passing the 1st Route Gate),

- **accuracy of navigation equipment indications,**

- **human factors** (misunderstandings about commands on the rudder, lack of flow of information about changes in compass course values, maintaining excessive vessel speed, operation of the vessel's propulsion propeller astern by the captain without consulting the pilot).

The grounding accident in the Szczecin Lagoon of the vessel SMP Novodvinsk occurred on 12.01.2022 at 14:45.

The vessel's voyage from the Świnoujście road towards Szczecin started with the pilot being picked up at 13:10. It turned out that the vessel had a faulty gyrocompass (wrong indications), and it was assumed that manual steering would therefore be necessary. At the same time, visibility was reduced to 4-5 cables. Despite these circumstances, the decision was made to continue the voyage. By necessity, navigation was based on magnetic compass, ECDIS and radar, with magnetic compass information not available on radar and ECDIS. The radar was most likely Head Up oriented and there is no information that assistive techniques such as parallel indexing were used. Upon entering the Lagoon, a further reducing of visibility was observed. At the same time, it was noticed that the vessel drifted to the eastern side of the fairway. Consequently, a decision was taken to correct the course. From this point, the vessel, as a result of manoeuvring, moved from the port side of the fairway to the starboard side and then back to the port side again and then passed port border line of the fairway and ran aground. The counter steering actions taken in the meantime were too late and/or insufficient, with the result that the vessel was gaining angular velocity due to inertia. As a consequence, the strong counter steering actions taken when passing the fairway boundary (hard to starboard + bow thruster), offset partly by changing the pitch propeller to zero pitch and then astern, did not have sufficient effect and the vessel did not even manage to get parallel to the axis of the fairway when she ran aground.

Significant factors contributing to the occurrence of the accident were the heavily reduced visibility, which forced navigation based only on technical means, and the simultaneous occurrence of a gyrocompass malfunction, which rendered the information available on these technical means incomplete, as they did not receive real course information. The pilot and the captain placed excessive reliance on the ECDIS system. The radar image using Head Up orientation, when manoeuvring the vessel is of little use. It is likely that decisions at the helm were made too late due to the limited information read from the devices. The situation presented on the screens, in addition to the standard measurement errors (position up to 10 m, course up to a few degrees), was possibly affected by the delay due to the smoothing filtering used in these devices. This was particularly true for heading indications and their delay, especially during manoeuvres. These inaccuracies in good visibility conditions would have been easily compensated for by visual observation, but may have been critical in reduced visibility conditions. Based on the available material, this thesis cannot be confirmed definitively, but it is the most probably one. Both the captain and the pilot did not clearly indicate the cause of the accident. Both were surprised that the vessel did not react in time. The pilot suggested steering problems, but these were not confirmed. Late decisions due to the delay of the situation presented on the ECDIS screen and changes in the pitch propeller settings could have been an explanation for this behaviour of the vessel. Another cause could have been an erroneous action by the helmsman (too little correction, failure to execute the hard to starboard command), but there is no evidence to support such a thesis, especially in view of the correct steering earlier. But it is possible that from the very first correction too much rudder angles were taken, which led to an angular acceleration of the ship. Such a movement was then difficult to decelerate, due to the inertia of the vessel. Especially when there were no reference points visible around vessel. An additional cause was the westerly wind and a potentially possible cross current, which carried the vessel to the eastern side of the fairway. It was as a result of the wind and possibly the current that the first correction was necessary, which then led to a sequence of manoeuvres that ended with the vessel running aground.

In summary, it can be concluded that the voyage in conditions of reduced visibility, based only on ECDIS and Head Up oriented radar, without reliable information from gyrocompass while steering manually on a slow-reacting for rudder vessel, with a westerly wind on the Szczecin Lagoon proved to be too risky and ended in running aground.

6. Safety recommendations

The State Marine Accident Investigation Commission considered it reasonable to address safety recommendations, which are suggestions for actions that could help prevent a similar accident in the future, to:

6.1. Pilot Station – Szczecin Pilot

The Commission recommends the Szczecin Pilot Sp. z o.o. to familiarise all pilots with this report, in particular with the obligation to report malfunctions of vessel's equipment, discussed in section 4.3, which are critical for safe navigation of the vessel in the pilotage area. The presented analysis of the causes of the accident should be taken into account when estimating the risk for the safe performance of the pilotage service with a malfunctioning gyrocompass and reduced visibility.

7. List of photos

8. List of figures

9. Used abbreviations

AIS – Automatic Identification System

ARPA – Automatic Radar Plotting Aid

B (Beaufort) – wind force scale

BT – Route Gate (RG I to IV) on the Szczecin Lagoon

cbl – cable – unit of length equal to 1/10 of a nautical mile

CN – full ahead

COG – course over ground

CW – full astern

Course Up – orientation of the radar image in relation to the vessel's course

DGPS (Differential Global Positioning System) – a method involving the use of a base station (so-called reference station) to increase the accuracy of GPS indications.

DOP (Dilution of Precision) – a parameter describing the influence of the geometry of the satellite constellation on the GPS position determination. The following types of DOP can be distinguished:

- GDOP (geometric dilution of precision) – geometric parameter describing the accuracy of a point's position in 4 dimensions (3 spatial dimensions + time).
- HDOP (horizontal dilution of precision) – for horizontal coordinates
- VDOP (vertical dilution of precision) – for vertical coordinates
- TDOP (time dilution of precision) – for time measurement
- PDOP (position (3D) dilution of precision) – a coefficient describing the ratio between the user's position error and the satellite's position error.

ECDIS – Electronic Chart Display and Information System

GPS – Global Positioning System

GT – Gross Tonnage

Head Up – orientation of the radar image in relation to the vessel's bow

kW – kilowatt (unit of power)

LAT – φ – latitude

LOA –length over all

LON – λ – longitude

LT – local time

Nm – nautical mile

North Up – orientation of the radar image in relation to the north

PS – port side

RMRS – Russian Maritime Register of Shipping

ROT (Rate of Turn) – angular rate of course change (here – COG change)

SAR – Search and Rescue (Service)

SMAIC – State Marine Accident Investigation Commission

SOG – Speed Over Ground

SS – starboard side

S-VDR – Simplified Voyage Data Recorder

SW – south-west direction

UTC – Universal Time Coordinated

VHF (very high frequency) – frequency band 30-300 MHz

VTS – Vessel Traffic Service

w – knot(s) (kt/kts) – unit of speed

W – west direction

WGS-84 (World Geodetic System ‘84) – a set of parameters (from 1984) defining the size and shape of the Earth

10. Information Sources

Notification of the accident

Documents of the vessel SMP Novodvinsk

Documents received from VTS, Szczecin Harbour Master and Border Guard

Expert opinion by Witold Kazimierski, expert of SMAIC

Commission’s own photos

Pilot and crew hearings and reports

11. Composition of the Accident Investigative Team

Team Leader – Tadeusz Wojtasik – President of the Commission

Team Member – Grzegorz Suszczewicz – Vice-President of the Commission

12. Attachment 1 – Accuracy of navigation equipment indications

Both the ECDIS and radar system used connected GPS devices and a gyrocompass to determine position as well as direction. The accuracy requirements of these devices were analysed as having the potential to influence the accident.

12.1. Positioning system

The pilot card indicates that the vessel has 2 electronic positioning systems of the GPS type. At the same time, a picture of the ECDIS system shows that there was an indication on the screen that a DGPS system was being used. It is assumed that the differential version (DGPS) was being used. The accuracy requirements for shipboard GPS receivers are defined in Resolution MSC.112(73) as follows:

- the GPS receiver should provide antenna position (static and dynamic) with respect to the WGS-84 system with an accuracy of 100 m (95%) at horizontal dilution of precision HDOP = 4 (or PDOP = 6),
- when using differential corrections (DGPS), the static and dynamic accuracy of the position determination should be 10 m (95%),

- new position solution should be sent to the external device at least once per second,
- have a minimum resolution of position, i.e. latitude and longitude, of 0.001 minutes.

The ECDIS system, in accordance with Resolution A.817(19), as amended, should enable such a position to be displayed or, if not, an alarm shall be displayed.

For navigation in the Szczecin Lagoon, DGPS corrections are available. No problems with the positioning system or displayed ECDIS alerts were reported for the accident in question. It should therefore be assumed that the position of GPS antenna was available in the ship's ECDIS system and on the radar (DGPS position updated every 1 second with an accuracy of 10 metres).

12.2. Transmitting Heading Device

Resolution MSC.116(73) contains requirements for electronic devices transmitting true heading information. It therefore refers directly to the gyrocompass installed on board the vessel. At the same time, Resolution MSC.112(73) on requirements for GPS, states that the COG determined by these devices should meet accuracy requirements not worse than the corresponding requirements for devices determining the ship's true heading. In this situation, the requirements of MSC.116(73) can also be applied to the transmitted course over ground (COG). These requirements are as follows:

- the static error should be less than ±1.0º,
- the dynamic error amplitude should be less than ±1.5º, with additional limits on the frequency of this error,
- the follow-up error for different rates of turn should be less than ±0.5º at rates up to 10º/s; and less than ±1.5º between a rate of 10º/s and 20º/s,
- the transmission error including the resolution error should be less than ±0.2º.

The above requirements at the time of the accident were not met for the gyrocompass due to its failure.

The above requirements are worth commenting on in the context of course over ground in ECDIS. Static error for a calculated quantity such as COG in GPS is unlikely to be present. It can therefore be assumed that the COG was subject to a dynamic error of up to 1.5° with a variable heading, with this error likely to be lower when using DGPS. An important requirement in the context of the accident in question is the follow-up error, which increases with rising rate of turn. At speeds up to 20°/s it should not be greater than 1.5°, but for more dynamic turns it has not been determined. It is to be expected that its value will increase significantly. It can therefore be assumed that for dynamic turns, the error in the determination of the COG was at least at the level of several, if not more than a dozen degrees.

When analysing the accuracy of the course determination during the analysed situation, it should also be pointed out about the difference between the actual course, the magnetic compass course and the COG. These differences became apparent when the vessel entered the Lagoon and, due to a westerly wind, she was to the port of the fairway axis. The helmsman maintained a steady compass course, but the vessel was moving on a more easterly course over ground. The COG therefore did not reflect the direction of the ship's alignment and its accuracy in this aspect was even less.

In addition, it is worth remembering that the accuracy requirements are set at a 95% confidence level. Therefore, from time to time it may happen that a measurement (calculation) does not meet the required condition. An example would be the situation at 14:43:08, where there was a momentary course jump of 15 degrees and a sudden instantaneous speed change of 2 knots (approximately 25%).

12.3. GPS smoothing phenomenon

When analysing an accident in which the only available source of position and direction information was the satellite positioning system, it is also worth bearing in mind the smoothing filters used in GPS receivers, which cause additional delays and inaccuracies in the results provided (so-called GPS smoothing). This phenomenon is not included in standardisation documents, but is well known to GNSS receiver manufacturers and is also increasingly being considered by researchers. An analysis of specific cases and the conclusions of these analyses are presented in condensed form in the CHIRP organisation's article https://www.chirpmaritime.org/wp-content/uploads/2019/12/2019-12-12-GPS-smoothing.pdf.

The purpose of GPS signal smoothing is to provide the user with stable and useful information on position and movement parameters. Due to imperfections in the transmission of the signal from the satellite, the position determined by the GPS is somehow imprecise and even for a stationary receiver the position 'jumps' by a few metres in subsequent measurements. Such a position is filtered out in order to avoid the impression of constant random movement of the receiver. Filtering involves smoothing the signal by 'averaging' (according to some algorithm – usually a Kalman filter) the values over a certain period of time in the past (e.g., 30 seconds). The calculations for COG and SOG are done in a similar way, with the smoothing time usually being longer because the impact of sudden position jumps is bigger. The application of a smoothing filter makes the initial position and vector more stable, but at the same time it is slightly delayed and reacts later to turns, because as long as they are not significant, they are smoothed. Without a detailed case-by-case study, it is not possible to indicate what the specific delay values and resulting errors are (probably around the few/several seconds). Certainly the greater the dynamics of the movement, the greater the significance of this phenomenon. The CHIRP report indicates that the errors involved can be as high as over 100 metres. At the same time, the CHIRP report indicates that with DGPS this problem should not occur, which does not seem to be a fully justified opinion. Signal filtering inside the receiver also occurs with DGPS.

Figure 11 shows, for example, the differences in the determination of the COG course plotted in ECDIS and transmitted via AIS to VTS. In addition to the fact that the ECDIS course is only determined every minute, it is clear that the course transmitted by AIS has a certain lag in relation to the ECDIS course, of about half a minute. And yet both values are calculated for the same vessel using DGPS satellite positions. It is the different internal filtering algorithms that may be the cause.

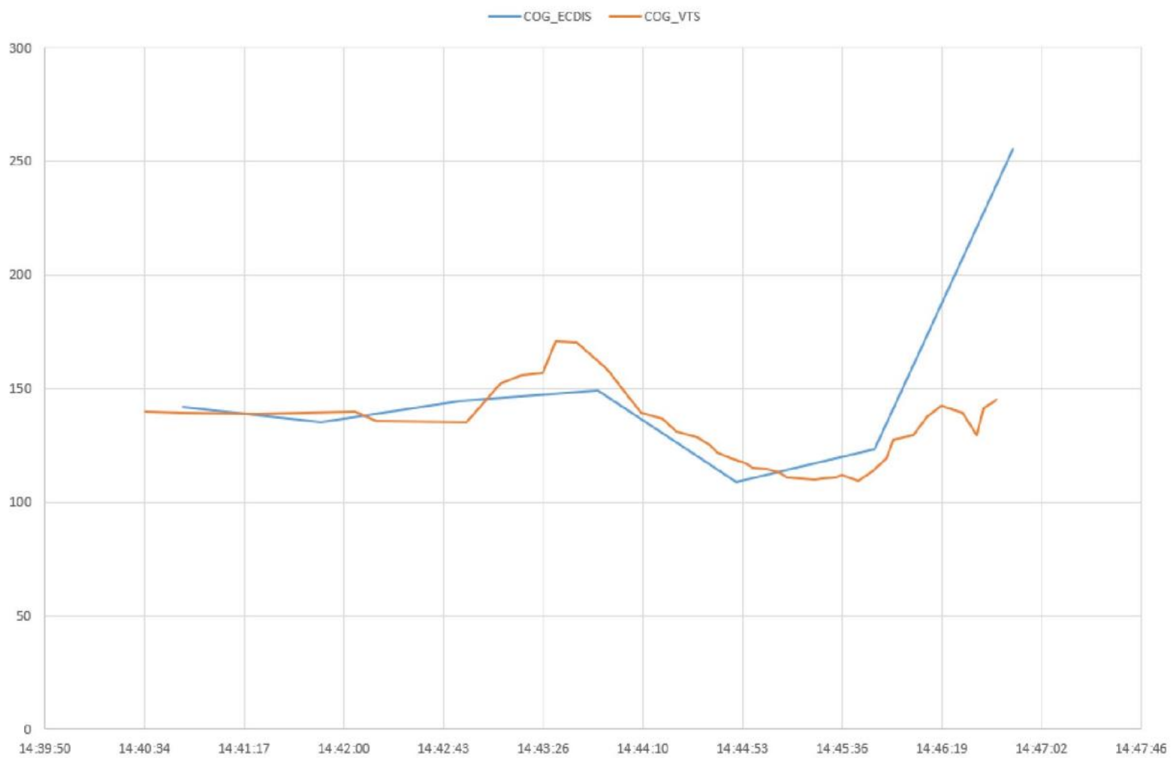


Figure 11. Comparison of the COG course in ECDIS and VTS

When navigating by technical devices alone, the phenomenon in question can have a significant impact, as decisions are made on the basis of smoothed data.

12.4. Offset problem

In section 4, Figure 7 shows the differences in position determination between the signal from AIS and on ECDIS. There is insufficient data to give a clear cause. The most likely one is that the signal is coming from different antennas that are referenced to a different location on board the vessel, i.e. badly entered offsets in the system. The probable cause could also be the aforementioned GPS smoothing, or a signal time offset (lack of synchronisation). The magnitude of this problem is minor in the case of classic navigation, but when navigation equipment becomes the only source of information, it increases significantly.

13. Attachment 2 – Information on condition of vessel's equipment

The Commission posed the following questions to the Director of the Maritime Office in Szczecin in connection with the investigation of the grounding accident of the vessel SMP Novodvinsk:

1/ What regulations govern the pilot's obligations to inspect the condition of the equipment prior to the start the pilotage service and do they include a duty to report any irregularities to the maritime administration?

2/ Are there procedures in place for the administration to deal with cases where:

- information on malfunctioning vessel's equipment reaches the administration before the vessel starts navigating in port waters,

- information on malfunctioning vessel's equipment reaches the administration while the vessel is navigating in internal (port) waters?

3/ In which cases of malfunctioning vessel's equipment is an absolute ban on entering the port applied, or in the case of already continued entry of the vessel into the port an order to berth at the quay in Świnoujście (concerning passages to Szczecin), to anchor on the Szczecin Lagoon or an order for a tug assistance?

In his reply, the Director of the Maritime Office in Szczecin outlined the position of the maritime administration:

'Re. 1. Pursuant to Order No. 3 of the Director of the Maritime Office in Szczecin of 26 July 2013 (as amended) on Port Regulations, it is the pilot's duty to refuse to perform pilotage services if he/she considers that this would result in a breach of port regulations or that the vessel is not seaworthy, and in addition pilot is obliged to report the irregularity to the Harbour Master or VTS, if this system is in force, and to comply with the orders issued (§ 89(1) and (2)). This legislation also contains a provision stating that a vessel that has suffered a breakdown of ship's equipment that has a significant impact on the safety of navigation shall not enter the port or navigate within the port area without the Harbour Master's permission and determination of conditions (§ 21(2)(5)). These issues are also regulated by the Rules and Regulations of the Pilot Station in Szczecin (§ 6.5.9), and the basis is the Maritime Safety Act (Art. 55.1 and 55.2).

Re 2. Referring to the regulations cited above, the administration performs its tasks based on them. In the situation when VTS obtains information on the malfunctioning of equipment having a significant impact on the safety of the vessel, the vessel is informed of the ban on entering the port and is directed to the anchorage, and then the information is transmitted to the duty service of the Harbour Master and a report of the discrepancy is made using the SWIBŻ application, which ultimately reaches the Port State Control (PSC). If the situation occurs while navigating in the fairway, then the action of the administration depends on the size of the vessel, which affects the possibility of turning back, anchoring the vessel at one of the anchorages located along the Świnoujście-Szczecin fairway or mooring to a particular quay. The Harbour Master, in determining the sailing conditions, may also order the use of a tug assisting the vessel during the fairway passage.

Re 3. The Harbour Rules (§§ 21 and 22) regulates this issue. It should be highlighted that each decision to grant permission to navigate in spite of reported or demonstrated non-conformities on board and the necessity to detain the vessel depends on the individual assessment of the, territorially competent, Harbour Master and, until such a decision will be taken on the assessment of the situation by the VTS operator.'[8]

[8] Extract from letter of the Director of the Maritime Office in Szczecin (Sign: IRM.0786.25.22.DL(2)) dated 26.07.2022.