

# Analysis of Traffic and Navigation Conditions on Nowy Świat Canal

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**ABSTRACT:** The issue of safety and free navigation near the Vistula Lagoon for many years was a dispute between Poland and Russia. The most debatable and conflicting topic, especially in Poland, was building a new connection between the Gulf of Gdansk and the Vistula Lagoon. This paper describes the functional processes and mechanisms of the new lock installed at the harbour Nowy Świat and the results of quantitative analysis of traffic changes resulting from that addition (from the beginning of their operations through January 2023). The next part of the work focuses on safety navigation analysis for typical vessels which operate on this newly built waterway. Underkeel clearance analysis and the channel's minimum safety width were carried out, assuming the most common types of ship. The research results provide the foundation for further potential analysis of the Nowy Świat Canal transport possibilities.

## 1 INTRODUCTION

Currently, many acts of investigation are carried out to enable more efficient and sustainable distribution of transportation modes: from roads to water. One of the European Agreement on Main Inland Waterways of International Importance (AGN) goals is to establish a legal framework for implementing the development plan and construction of the inland waterways network of international importance [1]

For decades the possibility of free movement of national and foreign vessels throughout the Vistula Lagoon was an unsolved problem. In February 2017, the Polish Government decided to crosscut the Vistula Lagoon, one of the decade's biggest navigational investments. Crosscut enables better connection maritime, inland, road, and railway transport and consequently drives the development of intermodal transport. The realization of building a waterway through the Vistula Spit involves many stages and

requirements to be met; however, the initial components of the project were finished in September 2022, and part of the new waterway with a new lock and harbour was opened [2,3].

In water transport, navigational safety is the most important factor determining a ship's exploitation on the waterway. One of the ways for ships' safety assurance is precision navigation planning. The ship, during the process of navigation, must implement safe shipping conditions such as keeping an under-keel clearance (distance between the lowest part of the hull and the top of the bottom), the proper distance of navigational obstruction, the adequate air draught, and avoidance of collision with other floating craft. Limitations of shallow water areas relate to seaside and canal effects and refer to the vertical and horizontal plane of the waterway. The dimensions of the hydrotechnical infrastructure in the rivers and canals determine the maximum length,

width, and draught of inland waterway vessels [4,5,6]. These values are implemented in local laws.

Based on the real-world data from the Harbourmaster Office of Nowy Świat, traffic analysis of typical ships utilizing the new Canal was conducted. Next, navigational conditions were calculated using parameters defining the constraints for a maximal ship, which can operate via Nowy Świat Canal according to the harbour laws.

## 2 STUDY AREA

The Vistula Lagoon is located on the southern coast of the Baltic Sea, in the east part of the Gdańsk Gulf. The length of the lagoon is 90.7 km, and its width varies from almost 6 km up to 13 km. The mean width is 8.9 km. The lagoon is a very shallow basin with a mean depth of only 2.75 m. Vistula Spit separates Vistula Lagoon from Gdańsk Gulf, creating specific navigational conditions on Vistula Lagoon and local waterways [7,3]. Figure 1 presents new buildings of infrastructure and a canal.



Figure 1. The lock and canal Nowy Świat (Fot. M.Schoeneich)

The navigational route, which connects the Baltic Sea with Elbląg Harbour, and the new canal Nowy Świat was based on the winning project selected from the three competitive proposals. The specifications of the final design outlined: the total length of the new waterway (22,880m) and the width of the channel (designated for 60m with some areas reaching 120m). From the navigational perspective, passage along the Nowy Świat–Elbląg waterway can be divided into three legs: Vistula Spit and locks, Vistula Lagoon, and the Elbląg River [2,8,9]. Furthermore, for all new routes, navigational buoyage was situated: 50 lateral marks and navigational lights at the entrance to the canal. It should be noted that entire described waterway is not only important for north part of Poland but is also the part of international inland waterway E70 and at E40 [2,9,10], so it could be provides economic advantage.

Like the Baltic Sea, the Vistula Lagoon is mostly influenced by predominantly westerly atmospheric circulation. As a result, almost 50% of the region's wind direction is from the SW-NW sector, and wind

speed oscillates within the range of 2–4 Beaufort. Due to its location, the Vistula Lagoon is not characterized by high waves and strong currents; based on the observational data, the average maximum wave height does not exceed 1,5 m. As a result, the water level is relatively stable, and the highest recorded amplitude was around 1,5 m (mostly due to wind activity). In the central area of the lagoon, the minimal water level falls in March and April, then rises systematically in July and September. The average water level amplitude from 2016 to 2018 was 1,3 m. In such conditions, assuming an average vessel speed in the N-S axis is around 5 knots, the vessel's drift equals approximately 0,3°. The visibility characteristics of the region are similar to the Bay of Gdańsk. Occasionally, mostly during autumn and springtime, there are days with a dense fog. They are icing in wintertime, starting on Vistula Lagoon in early December. Depending on the severity of the winter, the ice thickness ranges from 30 to 60 cm. Ice cover appears almost yearly; ice condition is differential and fluctuates from some days to even 140 days. The mean length of ice season equals approximately 100 days [9,11,12].

Based on the conditions uncovered by the above-cited studies, the new Port Regulations were introduced and officialised for the Nowy Świat Canal. The maximal vessel which can operate in this area is a ship with a length of 100m, a beam of 20m, and a draught of 4,5m. Maximum speed at harbour equals 7 knots and during lock operation, 3 knots [13].

## 3 QUANTITATIVE ANALYSIS OF TRAFFIC

According to data received at the Nowy Świat Harbourmaster Office, 842 vessels used the hydrotechnical facility from its opening until 27 January 2023, including:

- 381 ships supporting the construction,
- 380 pleasure crafts,
- 78 state-owned vessels,
- 3 fishing vessels.

It should be noted that only some of the above vessels used the lock. Some vessels used the harbour to stay overnight or entered the outport for recreational purposes, i.e., sightseeing. Figure 2 shows the number of construction support vessels using the lock according to their length.

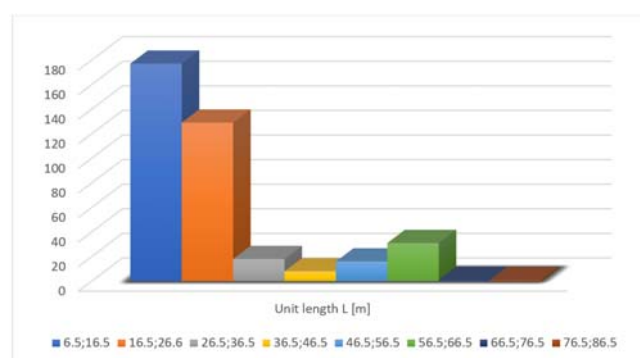


Figure 2. Number of construction support vessels using the port and lock according to the overall length. Source: Own work based on data from the Harbourmaster Office of "Nowy Świat."

As reflected in Figure 2, the surveyed traffic flow in the harbour and Nowy Świat lock was dominated by vessels between 6.5m and 26.5m in length, accounting for about 47% of all construction support vessels. This is because the lock was used most frequently by tugs and pusher boats participating in dredging the fairway on the Vistula Lagoon and the Elbląg River. It is worth noting that once all three stages of the 39 investments have been completed, vessels up to 100m in length can manoeuvre there, and in the case of pushed convoys, even 180m in length.

In the case of the analysis of pleasure crafts traffic, the breakdown of craft by length is different from that of construction support vessels. Figure 3 shows the number of recreational crafts using the lock according to craft length.

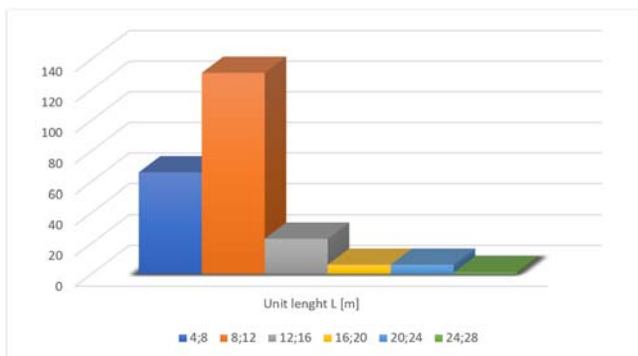


Figure 3. Number of pleasure crafts using the harbour and lock according to unit length. Source: Own work based on data from the Harbourmaster Office of "Nowy Świat."

Based on the data given in Figure 3 on the movement of pleasure boats, most crafts, over 56%, are between 8m and 12m in length, and those are mainly motor yachts and sailing yachts. Many units are small boats of length less than 8m.

It is worth mentioning that more than half of the vessels that used the lock, passed through to the north, i.e., to the Gulf of Gdansk, and the remaining ones to the south, i.e., to the Vistula Lagoon, as shown in Figure 4.

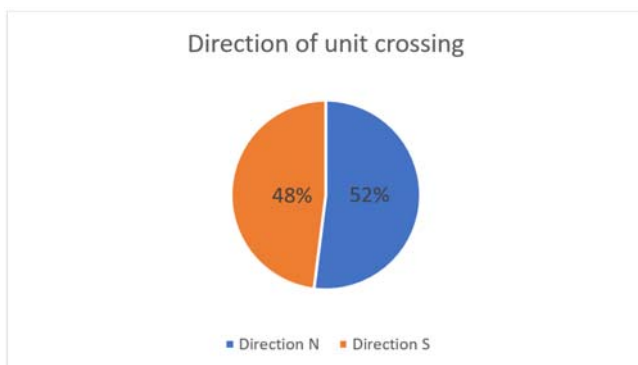


Figure 4. Direction of vessels passing through the lock. Source: Own work based on data from the Harbourmaster Office of "Nowy Świat."

Figure 5 shows the exact times each unit crossed the breakwater heads of the Port of Nowy Świat, the time it left the port, and the time it spent there.

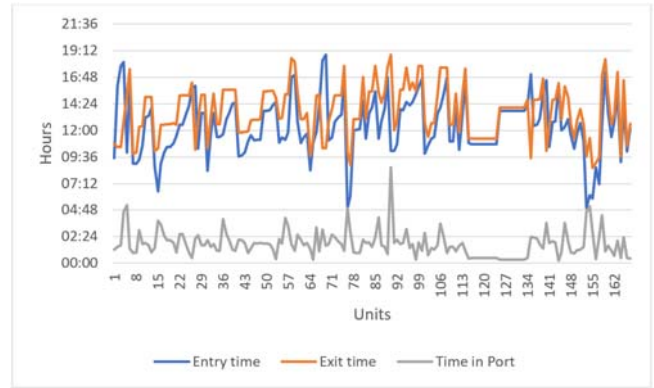


Figure 5. Times of entering and leaving of vessels from the port and duration of stay in the port. Source: Own work based on data from the Harbourmaster Office of "Nowy Świat."

Fig. 6 shows the mooring times of the individual vessels, their casting-off times, and the duration of the locking operations of the individual vessels.

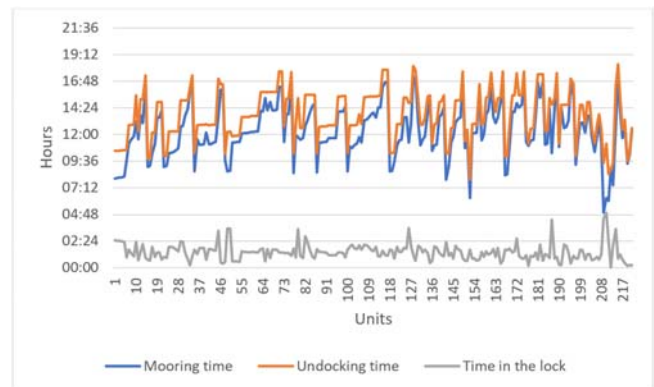


Figure 6. Times of mooring and undocking of vessels and duration time in the lock. Source: Own work based on data from the Harbourmaster Office of "Nowy Świat"

Table 1 shows some statistical measures for the duration of vessels' stay in the harbour, the mooring times, and times in the lock.

Table 1. Statistical measure

Statistical measure	Time of units within the canal	Mooring and lock times for vessels
Mean values	1hr 45 min	1hr 26 min
Standard deviation	1hr5 min	0 hr 53 min
Median	1 hr40 min	1 hr 24 min
Dominant	0 hr30 min	1 hr40 min
Coefficient of variation	61,9%	61,6%

Based on the data in Table 1, we can conclude that the differences in vessel times within the canal and unit locking times are similar at around 62%.

Based on the available data, the destinations were mainly Elbląg and Krynica Morska on the Lagoon side and Gdansk and Gdynia on the Bay side.

#### 4 NAVIGATION CONDITIONS ANALYSIS

Typical characteristics of the vessels operated in the reviewed area were used to analyse safety conditions, and vessels A, B, C, and D were chosen based on

traffic analysis. Vessel E is a maximal ship that can operate on a waterway (a typical cargo vessel with a length of 100m). The parameters of the vessels are presented in Table 2.

Table 2. Characteristic vessel using at further analysis

	A	B	C	D	E
Ship	Marcel – tug vessel	Zosia – motor barge	Jola 1 – tug vessel	SM-PRC -107 – dump barge	MAX SHIP cargo vessel
L[m]	21,16	56,74	9,5	59	100
B[m]	8,06	7,74	5	10	20
T[m]	1,75	1,62	1,2	1,5	4,5

Because in the reviewed area there are only opening bridges and over the river is a power transmission line with an overhead clearance of 24 m, there is no taking account as an obstruction for height.

Assessment of the safety of ship navigating on Nowy Świat Canal was carried out based on two navigation safety criteria, recommended in [4,5]:

1. Underkeel clearance,
2. Dimensions of the ship's manoeuvring area (minimal waterway width).

Mean conditions for Vistula Lagoon were used as characteristics for analysis:

- wind to 5 m/s (to 3°B);
- current to 0,1 m/s;
- good visibility.

Minimal and the mean exploited underkeel clearance for the most common types of ship on newly built waterway were calculated on the basis of recommendations in [5,14]. Research results are presented in Table 3.

Table 3. Results of empirical methods used for minimal underkeel clearance calculations for typical vessels.

Ship	A	B	C	D	E	[m]
Method of components	0,966	0,981	0,961	0,981	1,04	
Method of constant clearances	0,94	0,93	0,93	0,94	1,01	
Mean underkeel clearance	0,93	0,931	0,917	0,934	1,013	
Probabilistic Method	2,9	3,0	3,4	3,2	0,08	

Analyses of the results of the empirical method point to very similar values.

Minimal underkeel clearance for the maximal vessel is equal to max. 1,04 m. This reaffirms the port's regulations rule requiring speed reduction by the Port's Captain to secure the lock and subsequently, the port specific harbour conditions[13].

The findings suggest that the parameters of the method of constant clearance might require change so that the safety depth condition as a sum of the actual ship's draught (4,5 m for max vessel) and underkeel clearance is fulfilled (but at a water level of more than 500 cm). The results derived from the probabilistic method and modelling presented in [5,15,16] confirmed the above findings with the value of 0,08m (the mean exploited underkeel clearance). Further, regulation concerning a maximum speed as 7 knots will be met if the waterway is dredged to a depth 6-6,5 m.

Next, the width waterway for safety navigation for analysed characteristic vessels was calculated within recommended empirical methods – PIANC, Canadian, Panama Canal, and USACE Methods [5,15,16].

Behind at safety, minimal width one and two-way traffic was considered. The results of the research are presented in Table 4.

The above tabulation provides data and can be used to assess the minimal safety width (a 47,05m mean) for the maximal vessel operating one-way between Vistula Lagoon and Gdańsk Gulf. The two-way waterway traffic analysis found the same outcomes, leading to the conclusion that utilizing the empirical method for width waterway analysis confirms safety navigation on the newly opened waterway.

## 5 CONCLUSIONS

Newly built waterway and Nowy Świat Canal is not only important for north part of Poland but is also the part of international inland waterway E70 and at E40, so it could be provides economic advantage. the new Port Regulations were introduced and officialised for the Nowy Świat Canal indicated the maximal vessel which can operate in this area as a ship with a length of 100m, a beam of 20m, and a draught of 4,5m.

Since the opening of the Vistula Spit canal until January 27th, 2023, 842 vessels used the canal, of which more than 45% were construction support vessels, most of which, about 47%, were less than 26.5 meters long. The second group utilizing the canal was the pleasure crafts which accounted for 45%. Among the pleasure crafts, boats of 8 to 12m in length dominated and accounted for 56% of all pleasure boats. They were followed by boats less than 8m long, accounting for 28% of pleasure crafts.

Table 4. The comparison of empirical methods' results for width waterway determination (one- and two-way traffic).

Method	A		B		C		D		E		[m]
	One way	Two way	One way	Two way	One way	Two way	One way	Two way	One way	Two way	
PIANC	18,538	29,016	21,672	35,604	11,5	18,0	28,0	46,0	52,0	88,0	
Canadian	16,12	24,18	19,01	30,96	10,0	15,0	25,0	40,0	48,0	76,0	
Panama Canal	17,732	35,454	21,672	43,344	11,0	22,0	28,0	56,0	44,0	88,0	
USACE	32,26	43,32	31,94	42,68	29,2	37,2	34,2	47,2	44,2	67,2	
Mean	21,163	32,993	23,574	38,397	15,425	23,05	28,8	47,3	47,05	79,8	

From the ships observed 5 were chosen for further analysis. Recommended empirical methods were used for width waterway determination and empirical and probabilistic method for underkeel clearance assessment. The results derived from the probabilistic method and modelling confirmed the above findings with the value of 0,08m (the mean exploited underkeel clearance). It should be noted that further, regulation concerning a maximum speed as 7 knots will be met if the waterway is dredged to a depth 6-6,5 m.

Utilizing the empirical method for width waterway analysis for characteristic vessels confirms safety navigation on the newly opened waterway.

The research results could be helpful for inland transport management, risk assessment of ships entering ports, and navigation safety procedures on newly built waterways

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