

Optimization of Port of "Novi Sad" for the Acceptance of River-Sea Vessels

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ABSTRACT: Ports and wharves are essential parts of the infrastructure that enable the transport of goods on inland waterways. Integrating the network of inland waterways and land modes of transport, the ports are the main hubs of the transport network, they encourage economic activities and enable the development of the region. The port of "Novi Sad" is located on the left bank of the Danube River, river km 1254, and is open to international traffic. This is an exceptional location where water corridor (VII) and Pan-European Corridor X intersect and form a hub for international communication and transport. Novi Sad port's location strength is not only of a geographical nature, it also has excellent transport links as it is only 0.3 km from the railway junction of Corridor X and 3 km from the land Corridor X. The development of the port of "Novi Sad" would be related to the growth of its industry in the background. Considering the favorable geographical position and the growing economic activity, especially in the trade exchange with the countries that are in the Black Sea basin, the port of "Novi Sad" could achieve the status of a river-sea port in addition to its international status. In accordance with the Water Transport Development Strategy of Republic of Serbia, the port of "Novi Sad" could be developed to the extent that it becomes competitive on the market and provides transboatment and storage services in accordance to the world standards.

1 INTRODUCTION

Novi Sad is the second largest city and one of the largest economic and cultural centers of Serbia - the province of Vojvodina. Novi Sad was the European remnant of culture for the year 2022.

Vojvodina's economy is based on rich, high-quality, arable land, which makes up 84% of its area. Cereals make up the largest percentage of yields. A certain part of the product is exported, but the majority is processed in the domestic food industry [9]. The port of "Novi Sad" also plays a significant role in the city's and province's economy of.

Due to its geographical position and the number of territories through which it flows, the Danube

represents a very important lever in the economic life of Serbia [5].

Ports and wharves are the primary elements of the system that enable the transportation of raw materials by rivers, seas and oceans. Connecting a network of inland waterways and land transportation, ports represent crossroads in the transportation network, directly influencing the growth and development of the world economy. Effectively connecting other modes of transport with waterways is a prerequisite for stimulation of traffic on inland waterways and for transformation of the goods flow on inland waterways into an intermodal transport system [8].

The port of "Novi Sad" is situated on the left bank of the Danube River, river km 1254, at the entrance to

the Danube-Tisa-Danube Canal. Like other ports, the development of the port of "Novi Sad" is related to the growth of industry in its background, and with the reduction of industrial activity, transboatment capacities are used mainly for bulk cargo (cereals), for fertilizers and its components, ferrous metallurgy and scrap metal.

Considering the favorable geographical position and the growing economic activity, especially in the trade exchange with countries that are in the Black Sea basin, the port of "Novi Sad" could achieve the status of a river-sea port in addition to the international status.

2 HISTORY OF SEA-RIVER TRAFFIC

Origins of the Serbian river and maritime fleet were initiated in the seventies of the 20th century with the establishment of the company "Beogradska plovodba-Beoplov", which originally had two boats: "Bratstvo" and "Sloboda". Later, this company enlarged its fleet with the following boats: "Jugonavigator", "Novi Beograd", "Skadarlija", "Captain Pavlović", "Jugoagent" and others. A special boat in the Beoplov fleet, important for the economy of Serbia, was the boat "Smederevo" (figure 1), which was used to transport iron ore from Peru to the former Yugoslavia for the needs of iron factory in Smederevo city, but also for other ironworks in the country. At the beginning of the 21st century, this company experienced a downturn, and the boats were gradually scrapped or sold by creditors due to financial problems. In 2007, the Republic of Serbia was left without naval boats under its flag, mostly due to the problem of years of international isolation and a failed attempt at privatization. of the company "Beoplov" [8].

River-sea traffic began with the boat "Kolubara", which was the first river-sea boat whose home port was Belgrade. The boat was sailing on the route Belgrade - Istanbul - Alexandria. In addition to this boat, two more boats of the same class "Mlava" and "Tamnava" were constructed [8].



Figure 1. Boat "Smederevo" [12]

3 HYDRONAVIGATION SAILING CONDITIONS ON THE NOVI SAD –BELGRADE RIVER SECTOR

The navigation sector from Novi Sad to Belgrade is part of the Danube free-flowing sector. This sector is characterized by a sandy and morphologically dynamic riverbed, in contrast to the sector

downstream from Belgrade, which is considered a basin-type waterway, and is characterized by favorable navigation conditions throughout the year. In accordance with the European Agreement on Main Inland Waterways of International Importance (AGN), the Serbian part of Danube meets the requirements of an international waterway of class VI from Bezdán to Belgrade, and downstream from Belgrade of class VII (figure 2).

Downstream from the port of Novi Sad (river km 1254) there are four critical sectors, "Arankina ada" (river km 1247-1244.8), "Chortanovci" (river km 1241.6-1235), "Beshka" (river km 1232-1226.6) and "Preliv" (river km 1207-1195). These critical sectors, according to the representatives of the "Plovput" company, do not represent a major danger or obstacle to navigation, since the depth of the waterway is maintained according to international standards through preventive dredging works. By looking at the maps of the waterway, it can be found that the minimum depth of the Danube in this section is 3.8 meters, at a low navigable water level.

According to the "AGN" agreement, the recommended draft for the Danube through R. Serbia ranges from 2.5 to 4.5 meters. According to the same agreement: "on waterways with variable water levels, the value of the recommended draft must correspond to or exceed the draft provided on an average of 240 days per year (or 60% of the navigation period)" [2]. Also: "the maximum draft (4.50 m) and the minimum height of the navigable opening under the bridges (9.10 m) should be ensured on all parts of the network directly connected to the coastal waterways", and the Danube is connected to the coastal waterway E -90 (from Gibraltar to the south along the coasts of Spain, France, Italy, Greece, Turkey, Bulgaria, Romania and Ukraine, along the southern coast of Crimea to Azov, along the Don River to Rostov - Kalach - Volgograd - Astrakhan, as well as inland waterways that are accessible only from this route) [2].

Waterway type	Class	Motor vessels and barges — type of vessel general characteristics					Pushed conveyer — type of conveyer general characteristics					Min. height under bridges H(m)	Symbol on maps			
		Designation	Max. length L (m)	Max. beam B (m)	Draught d (m)	Tonnage T (t)	Length L (m)	Beam B (m)	Draught d (m)	Tonnage T (t)						
of regional importance	waterline	I	Barge	38.50	5.85	1.80-2.20	250-400						4.00	=====		
		II	Kampine	50-55	6.80	2.50	400-650						4.00-5.00	=====		
		III	Gustav Karmir	67-80	8.20	2.50	650-1000						4.00-5.00	=====		
		IV	Gross Flow	41	4.70	1.40	180						3.00	=====		
		III	Type BM-500	57	7.50-9.00	1.60	500-650						3.00	=====		
		IV		67-70	8.20-9.00	1.60-2.00	470-700	118-132	8.20-9.00	1.60-2.00	1000-1200	400		4.00	=====	
		IV		80-85	9.50	2.50	1000-1500	85	9.50	2.50-2.80	1250-1450	525 / 7.00		4.00	=====	
		Va		95-110	11.40	2.50-2.80	1500-3000	95-110	11.40	2.50-4.50	1600-3000	525 / 7.00 / 9.10		4.00	=====	
		Vb						172-185	11.40	2.50-4.50	3200-6000			4.00	=====	
		Vc						95-110	22.80	2.50-4.50	3200-6000	7.00 / 9.10		4.00	=====	
of international importance	waterline	Vb		140.00	15.00			185-195	22.80	2.50-4.50	6400-12000	7.00 / 9.10		4.00	=====	
		Vc					270-280	22.80	2.50-4.50	9600-18000			4.00	=====		
		Vc					195-200	33.00-34.20	2.50-4.50	9600-18000	9.10		4.00	=====		
		VII					285	33.00-34.20	2.50-4.50	14000-27000	9.10		4.00	=====		
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Va				95-110	11.40	2.50-2.80	1500-3000	95-110	11.40	2.50-4.50	1600-3000	525 / 7.00 / 9.10		4.00	=====	
Vb								172-185	11.40	2.50-4.50	3200-6000			4.00	=====	
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		VII					285	33.00-34.20	2.50-4.50	14000-27000	9.10		4.00	=====		

Figure 2. Classification of European Inland Waterways of international importance [2]

Table 1. Basic characteristics of some self-propelled cargo boats [6]

Name of boat	N _{inst} (kW)	L _a (m)	B _a (m)	H _k (m)	T _{km} (m)	D _m (t)	Q _r (t)	Construction year
"Bačka"	1x129	69,87	8,63	2,31	2,05	989,40	764,76	1970
"Bezdan I"	2x106	69,74	8,62	2,82	2,15	1174,00	886,00	1979
"Belgrade I"	1x184	63,05	8,61	2,21	2,05	903,00	708,74	1970
"Boljevac"	2x265	76,99	10,80	2,62	2,20	2840,00	1173,50	1980
"Detelinara"	2x240	76,82	11,00	2,83	2,63	1891,25	1453,75	1980

4 CHARACTERISTICS OF DUAL PURPOSE SEA-RIVER BOATS

Inland navigation consist of canal and lake boats, which are characterized by a flat bottom, low draft, low hull height, limited maximum height, weaker hull construction etc.

River cargo boats (figure 3) are divided into: self-propelled cargo boats and non-self-propelled cargo boats. Boats without propulsion are divided into: towed freighters (barges) and pushers (thrusters). Towed freighters are pulled by motor boats "tugs", while pusher boats are pushed by pushers. River motor cargo boats (self-propelled motor cargo boats) are a type of cargo boats intended for the transportation of various types of cargo [6]. The main purpose of river-sea boats is navigation on inland and coastal waterways. In order to sail in both environments, these boats must meet the basic characteristics of boats for navigation on the river and boats for navigation on the sea (Figure 4).



Figure 3. Self-propelled river cargo boat

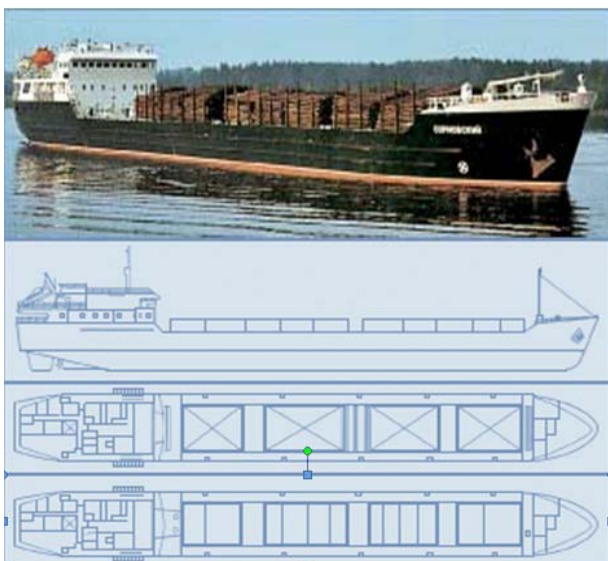


Figure 4. The appearance of a river-sea boat [10]

To sail the river, the boat must have good maneuverability (to avoid shoals, overcome river bends, enter locks, etc.), a small draft and a low superstructure (due to under bridge passing).

As for sea navigation conditions, the boat should possess maritime capabilities for maneuverability during high waves. Thus, according to the height of the waves they can safely overcome, boats are classified into two groups [7]:

- for waves up to 3.5m in height and for sailing at a distance from the coast up to 50 nautical miles, and
- for waves up to 6m in height and sailing at a distance of 50 nautical miles from the coast in open seas or 100 nautical miles from the coast in closed seas.

Table 2. Basic characteristics of river-sea boats [7]

Type of boats	projected boat model	model of tanker boat	model of combo boat
Length (m)	114,20	132,60	119,90
Largest between lpp (m)	110,50	128,60	115,20
Maximum Draft (m)	3,50	3,65	3,50
Width (m)	13,22	16,90	13,40
Height of the hull (m)	5,50	5,50	5,80
Registered Capacity (t)	2700	4875	2700
Storage capacity (m ³)	4300	6740	3556-fuel 1895-dry cargo
Boat Speed in deep water (kn)	10,60	11,00	10,90

5 ACCOMMODATION OF SEA-RIVER BOATS IN NOVI SAD PORT

5.1 Ports

Port is defined as a specific water area with man-designed and natural shores and land, together with devices, facilities and other objects intended for berthing, anchoring, boarding and embarkation, transshipment, storage and goods production finishing processes. In a broader sense, a port is a set of facilities and arrangements designated for transshipment of cargo and transfer of passengers from land to ship and vice versa.

Ports can be classified based on different characteristics (Figure 5). They are most often divided according to the type of waterway on which they are located, then according to placement on the waterway, according to name and according to traffic.

According to the type of waterway on which they are built, ports can be divided into river ports, canal ports, ports on canalized rivers and river-sea ports. The essential differences between these ports are related to the oscillations of the water level [6].

Water level oscillations in the river ports are seasonal and depend on the hydrological regime of the river. Due to the insufficient width of the waterway, harbors on canals are built into the coast and, unlike those on rivers, are not exposed to intense oscillations in the water level. The water level in canalized rivers, apart from natural conditions, depends, on example, from the mode of operation of the power plant and other users-which must be adapted to the needs of navigation. The water level in river-sea ports, in addition to the hydrological regime of the river, is influenced by the tides and ebbs of sea water. According to the placement on the waterway, ports can be: on the open coast, basin and combined [6].

Ports on the open coast are built in places where the river has sufficient width for the normal transshipment of vessels, as well as the necessary width of the waterway for the movement of traffic. In relation to other dimensions, the most commonly expressed dimensions are arc lengths. Places for harbors can be rectilinear, to follow the natural coast, or to be formed stepped. Ports on the open coast are not protected from passing ships, which is why sailing speeds are limited in the port area. This type of port is mostly not protected from wind and waves. As a rule, they are usually located on concave shores, given that the navigable depths are greater along the concave shore and that the water along the concave shore carries river sediment and ice more easily. These ports provide optimal conditions for maneuvering ships and vessels [6].

Basin harbors are located in specially constructed basins, natural depressions or dammed river backwaters. They are protected against the flow of the river (ice, waves, wind...), but the maneuver of entering and leaving ships and vessels is much more complex and longer. Combined ports are built partly on the open coast and partly in the basin for which all facilities from one and the other environment were used.

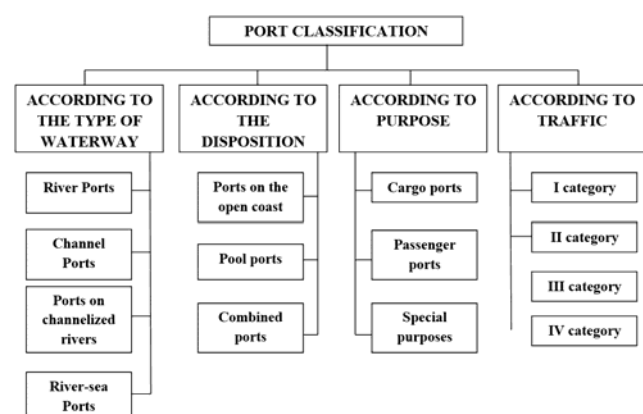


Figure 5. Scheme of Port classification [6]

5.2 Port of Novi Sad

Port of Novi Sad has a significant role in the port sector of the Republic of Serbia with its position, built infrastructure and existing port superstructure. This role was recognized in Regulation 1315/2013/EU, on the basis of which, within the "Study of the European

Commission on the TEN-T basic corridor Rhine-Danube", it was classified in the so-called Inland Core Ports. The port is located on the 1,254 km on the left bank of the Danube River, at the entrance to the DTD channel. The water area of the port is 6 hectares in size where the water depth is 4 to 10 metres.. A 800-metre-long pier can accommodate up to five vessels at a time. The 6,000 m long industrial railway track is connected to the national railway network [8].

Handling and storage of bulk cargo, general cargo, containers and liquid cargo is carried out in the port (figure 6). "Transshipment machinery of this port consists of six portal cranes with a capacity of 5 t to 27.5 t, 14 forklifts with a capacity of 3 t to 12.5 t, one forklift with a capacity of 28 t, 5 loaders, two truck scales, one of which is a road- railway scales up to 100 t, three telescopic hoppers with portals for transshipment of bulk cargo with a production capacity of up to 250 t/h, two devices for packing bags of 50 kg and bags of 1,000 kg, belt conveyor, pneumatic equipment, pumps for oil derivatives, etc. The Port of Novi Sad has 44,000 square meters of closed warehouses and 100,000 square meters of open warehouses in the function of public and public customs warehouses. The storage volume for oil derivatives is 270,000 m³" [11].

Total traffic in 2021 was 1,435,879 tons, while in 2020 more than 1,631,000 tons of various goods were handled. The most frequently processed goods are grains, scrap iron, artificial fertilizer, ferrous metallurgy, etc. The development plans of the port in Novi Sad are based on the increase in the transshipment of the mentioned goods and raw materials and include the extension of the operational waterfront - vertical quay, the reconstruction of the existing cranes and the acquisition of new transshipment machinery with the intention of increasing the carrying capacity, the modernization of the information system and the development of automatic data processing. "It is necessary to approach the reconstruction of industrial tracks and the road network, the construction of grain tank with a holding capacity of 20,000 tons, the construction of a Ro-Ro terminal, a container terminal, a Hucke pack terminal, the expansion of storage capacities, as well as the development of logistics subsystems and additional services. The estimated value of the investment in the port infrastructure is 4.9 million euros, while the investment for the port superstructure is estimated at 9.8 million euros" [8].

In the following period, investments are planned in [4]:

- increasing port capacities,
- construction and modernization of storage systems,
- development of additional logistics services and logistics support,
- port infrastructure,
- reconstruction of existing storage areas,
- adaptation of the passenger terminal.

In first six months of 2022 the transshipment of 223 containers was recorded in the Serbian ports, which shows the increase in demand for this type of transportation by waterways. Also, in the same period, 7.2 million tons of transhipped cargo on the rivers was recorded, i.e. 7% less than in the same

period in 2021. The drop in cargo handling was directly influenced by the situation in Ukraine and the ban on the export of grain. Gravel, sand and stone aggregates are the most frequently transshipped type of cargo, followed by oil and oil derivatives, as well as ores and coal [13].



Figure 6. Port of "Novi Sad" [11]

Figure 7 shows a comparative analysis of the type of water traffic in Serbia for a period of 5 years. What is noticeable is that there is a noticeable increase in transport traffic, but also a noticeable drop in passenger traffic, mostly due to the COVID-19 virus.

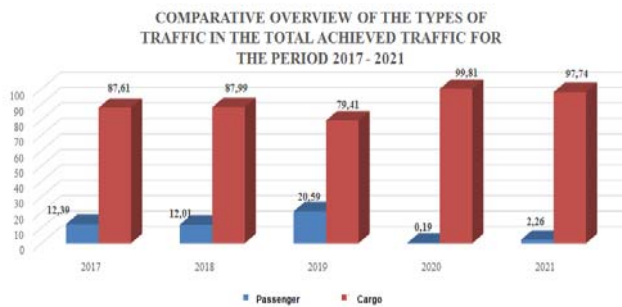


Figure 7. Comparative analysis of water traffic [1]

Figure 8 shows a comparative view of cargo transhipped in ports in Serbia during 2020 and 2021. It can be observed that the largest transshipment was realized in the Port of Smederevo, which is logical because the Smederevo iron factory is located there. The port of Novi Sad is in the third place in terms of number of cargo transhipped, right after the port of Pancevo. Figure 9 shows an overview of the amount of transhipped cargo from the beginning to the end of 2021.

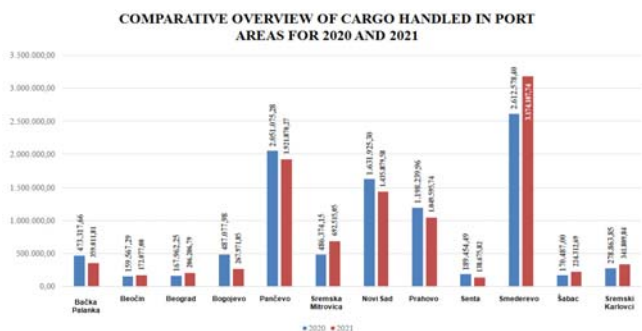


Figure 8. Comparative overview of cargo handled in port areas [1]

OVERVIEW OF THE QUANTITY OF TRANSHIPPED CARGO
In the period from 01.01. - 31.12.2021

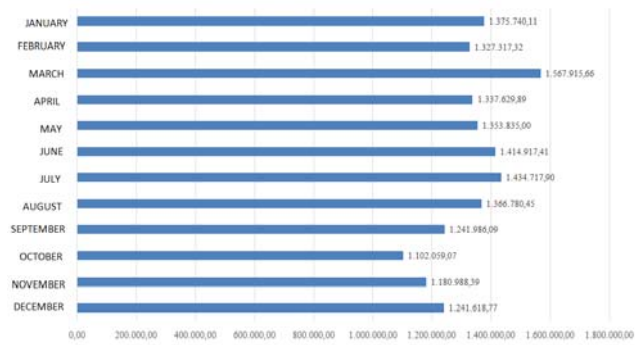


Figure 9. Overview of the quantity of transhipped cargo [1]

6 CONCLUSION

Goods transported by inland waterways mainly involve products that are transported in large quantities (agricultural products, coal, crude oil, metal ores, stone, food products, beverages, tobacco, wood and wood and cork products, etc.).

This does not mean that consumer products cannot be transported by waterways. In order to create the conditions for the transport of such goods, there must be a sufficient amount of consumer goods that can be diverted to water transport (container transport).

Maritime shipping has an important place in the economy of every country, including continental ones, primarily because of its foreign exchange profitability. Maritime companies do most of their business on the world maritime market, which achieves the so-called invisible export that significantly contributes to the reduction of the foreign trade balance deficit. Based on this, the states establish favorable legal and fiscal frameworks for the business of shipowners, because in this way they can count on more favorable freight rates and thus the placement of domestic products on foreign markets under more favorable conditions.

It was precisely the positive effects on the overall economic development of a country that led to the fact that countries without a sea coast (hereinafter: landlocked countries) began to take measures in order to be included in this global industry. This is in an effort to ensure unhindered conditions for the supply of its market, and the placing of its national products on distant markets. The Swiss Confederation, at the peace conference in Paris in 1919, demanded that landlocked countries be granted the right to free transit through the territories of neighboring countries that have access to the sea.

The very fact that goods are brought by water to the center of the continent, to the intersection with road and rail corridor X, to a port equipped and capable of fast transshipment of multimodal transport, would attract foreign shipping and maritime companies.

Also, the construction of the Belgrade-Budapest railroad can have a positive impact on the development of the port, from where it can be connected to corridor V (Bratislava-Žilina-Košice-Uzhorod-Lviv), and further to corridor III (Kiev). The

planned construction of the Novi Sad - Ruma highway would have a positive impact, which improves the connection with the Western branch of Corridor X and facilitates the exploitation of the Srem and Mačva areas.

Considering the fulfillment of all basic navigation conditions on the Danube River from the Black Sea to Novi Sad and the possibility of serving river-sea ships in the port of "Novi Sad", it is considered that the affirmation of this type of transport would greatly contribute to the development of the country's economy.

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