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Franko Sušić
E-mail: franko.susic@pomorstvo.hr
Ministry of the sea, transport and infrastructure, Maritime safety directorate, Prisavlje 14, 10000 Zagreb, Croatia
Renato Ivče
E-mail: rivce@pfri.hr
Astrid Zekić
E-mail: astrid.zekic@gmail.com
University of Rijeka, Faculty of Maritime Studies, Studentska 2, 51000 Rijeka, Croatia
Dominik Paparić
E-mail: paparicdominik@gmail.com
Faculty of Economics in Osijek, Trg Ljudevita Gaja 7, 31000 Osijek, Croatia

An Overview of the Main Croatian Ports Important in Connecting Islands and the Mainland through the Prism of the RO-RO Technology

Abstract

Croatia has well-indented coast and numerous islands and it is challenging to connect 48 permanently inhibited islands and at the same time respond to the requests of the population of the islands and their tourists in the maritime passenger transhipment. Although the liner passenger shipping has been established for series of years, it nevertheless requires a systematic approach to future development. Quite a number of scientific and technical papers have been written about the elements and the factors of the RO-RO liner passenger shipping significance. In this article authors examine the importance and role of the liner passenger shipping in connecting the islands with its mainland. This paper aims to evaluate the existing state of the port capacities for accommodating the RO-RO ships in order to modernize it and to emphasize the need for the improvement of the liner passenger shipping. Further in the paper, the maritime traffic of passengers and vehicles in the permanent line connection of the island and the mainland and the islands with each other in the Republic of Croatia. Particular attention has been paid to the level of development of the existing infrastructure for the accommodation of the RO-RO ships in the most significant Croatian ports. RO-RO passenger shipping is one of the key factors of the development of the Croatian islands. Authors point out the need to strengthen the role of the RO–RO passenger shipping as important part of maritime sector in the development and competitiveness of the Republic of Croatia through initiatives of sustainable growth of economic activities on islands and in the coastal area. The RO-RO passengers traffic simulations system would result in better insight into the possibilities for a more flexible connection of islands and mainland.

Keywords: islands, liner passenger shipping, the RO-RO ships, maritime transport

1. Introduction

Liner passenger shipping implies the transport of passengers and goods (cargo) from one port to the other. The operating schedule, and the initial and the final ports are defined, as well as some potential ports of call during the navigation.

Maritime ports are a particularly significant part of the transport network. They are important for both passenger traffic and connection of the islands to the mainland. The Republic of Croatia has six ports in its continental coastal region, which are open for public transport and are internationally significant for the country. From the north to the south these are Rijeka, Zadar, Šibenik, Split, Ploče and Dubrovnik in consecutive order, under the direct authority of the Ministry of the Sea, Transport and Infrastructure.

There are approximately 125,000 people who permanently live on the inhabited islands. The need for the services of the passenger liner shipping in some areas is defined by the number of inhabitants and the tourist valorisation of every single island. Shipping services are offered by the RO-RO passenger ships which are used for the transport of passengers and vehicles, as well as small quantity of cargo.

For the development of an island, passenger liner shipping is very important, which is taking place on a total of 51 public lines of national importance. During 2019, 13.8 million passengers and 3.5 million vehicles were transported on mentioned lines [1].

The paper is structurally divided into five main parts. After the introduction, the second part defines maritime and passenger transport, as well as transport in general, by giving an overview of the previous research. Special emphasis is given to the role of the liner and passenger shipping, crucial in connecting the islands to the mainland. In the third part of the paper the importance of the liner and passenger shipping for the development of islands is explained. The fourth part analyses the liner RO-RO passenger transport in the Republic of Croatia, while the fifth part gives an overview of the most significant Croatian ports in terms of RO-RO passenger transport. A comparative analysis of the two biggest RO-RO passenger ports for the five-year period is made in the sixth part. The final, seventh part, consists of the final comments.

2. Significance of the RO-RO passenger transportation for the island`s development

Transport as a business and the related transport system present the foundation of the contemporary economy of any region [6]. At the same time transport is a key factor of success of the unique market as it enables two out of three fundamental objectives of European integration: free circulation of passengers and free circulation of goods [3]. The main force of the transport sector of Croatia is evident in its geostrategic location as a natural access point to the Balkans and as the region where Europe exits towards the East [4]. By its quality and adaptation to the regional needs transport as the specific economic activity of the transportation or transfer of people and goods significantly contributes to the formation and valorisation of any area, as well as the

overall economic and social development of Croatia [24]. Recognizing the importance of maritime transport for national cohesion and the economy of coastal and island regions, there is a need to analyse its effectiveness [20].

Maritime passenger transport implies the transportation of people and goods from one port to the other and it is considered a separate maritime activity. When talking about the contemporary sea transportation of passengers, it requires to make a distinction between:

- liner passenger shipping and
- cruises [7].

In the past, liner passenger shipping used to be the only possibility of intercontinental transportation. However, today intercontinental air transportation takes precedence. It should also be noted that road transport and railway transport are in fierce competition with scheduled passengers liner shipping transportation services along the coast. Growing demand for cruises has decreased the amount of scheduled maritime transportation. Although cruises make up the largest part of the passenger shipping offer, a need for liner type of passenger shipping is still present, especially in connecting the islands with its mainland.

Generally RO-RO shipping is suitable for diversified kinds of dry break bulk cargo but on routes longer than 1,200 nm is less competitive and profitable than LO/LO services (usually container shipping). RO-RO liner shipping as the service of transporting goods should adhere to the following requirements:

- frequency of services,
- carrying capacity of vessels,
- sailing speed,
- punctual service,
- late cut-off time,
- revenue structure [5].

The liner passenger fleet comprises of the classic passenger ships and the RO-RO passenger ships. In the last 20 years, the fleet has been increased by the high-speed RO-RO passenger ships (from 30 to 50 knots): twin-hull ships, hydrofoils, hydro buses, catamarans, and similar. Also, connecting overseas cargo transportation with the maritime liner passenger transportation shouldn't be neglected. Placing a part of the capacity at disposal for passenger transportation is a common practice on more frequent lines. Depending on the level of the transport demand and the conditions which govern the place where a certain line is in operation, ships are often purpose-built for a specific line, whereby its maritime characteristics (height of the decks, draught, type of engines, number of thrusters, passenger accommodations, etc.) are adapted to this line [23].

RO–RO passenger transport is considered to be the key factor in permanent and regular connection of islands with the mainland and between the islands, without which there would be no sustainable development of inhabited islands in the Republic of Croatia.

The only option of transporting goods by freight vehicles on the mainland-islands

route and vice versa is with RO-RO passenger ships [2]. According to the Croatian national strategy of sustainable development, great bio-diversity, clean sea, the living environment and organization are the main advantage of islands. In the considered areas, a special planning and program approach of the policy makers of regional and island development are determined [22]. Technological, industrial, transportational, as well as cultural development has bypassed islands to a large extent, and the transport isolation has been present. Island settlements have been gradually dying away for years. One of the main objectives of the island development should be the increase in the quality of life and the prevention of further depopulation. According to the 2011 population census, there were 124,955 people living on the Croatian islands [14]. However, during the tourist season, this number is multiplied.

One of the main motifs for the arrival of tourists are the extraordinary natural beauties of Croatian coast and islands [8]. Islands, as the most exploited tourist regions, demand a suitable transport connection. As a rule, an island with a better transport connection is characterized by better-developed tourism as well, more favourable demographic trends and structure in comparison with the more isolated island with more noticeable depopulation effects [17]. In this respect, a better transport connection can stimulate the development of tourism both during the high and low seasons.

Transport connections vary significantly for each island according to its type, capacity, ability to transport vehicles and cargo, the age of the fleet, the price of transportation and other features and the additional factor of connecting the islands with the mainland and its efficiency from the perspective of the local population is the dependence on the weather conditions at sea and the operating schedule [15]. A significant share of the RO-RO passenger traffic, especially during the summer months, is made of tourists who arrive or depart from the islands [9, 19].

Jadrolinija is the biggest Croatian passenger ship operator. The business activity of the company includes liner (regular) maritime transport of passengers and cargo [21]. Until recently, Jadrolinija used to have total supremacy in terms of passenger transport in the Republic of Croatia. Having entered the European Union, the situation has changed since the passenger transport market is now opened for new companies (both domestic-owned and foreign-owned), which have been competing for obtaining the concession and the passenger transport authorization, as well as for the establishment of new lines that could connect the island and the mainland more efficiently.

Therefore, further development of the Croatian islands should be based on the sustainable development of transport and tourism, following the needs and demands of the island population. The RO-RO passenger transportation is a suitable solution, which is a predominant solution for connecting the islands and the mainland today. High traffic seasonality can be seen in connecting islands and mainland (especially during summer and winter months). This fact represents a need for optimization of RO–RO passenger's lines.

4. Costal liner RO-RO passenger transport in the Republic of Croatia

Liner maritime transport along the coast is maintained by the RO-RO passenger lines, classic shipping lines and high-speed lines. The classic shipping lines are carried out by the smaller classic passenger ships. On the high speed shipping lines passengers are transported by High-Speed Crafts. Smaller and medium-sized RO-RO passenger ships usually navigate at short-haul distances and relatively on small speed (10 knots on average). The RO-RO passenger ships in Croatia usually have a single deck for the transportation of the RO-RO cargo. On some of them cars can be stowed into the hold below the main deck. Smaller and medium-sized RO-RO passenger ships are mainly equipped with a stern ramp and a bow ramp, located exclusively in the direction of the longitudinal ship's axis. These types of ramps, which are raised and lowered fast, are suitable for quick load and unload.

The quays for RO-RO passenger ships are constructed in pretty much the same way throughout Croatian ports. The only difference lies in the width of the RO-RO ramp, which depends on the size of ships that will be berthed at the location.

The existing RO-RO passenger ships can be divided into three basic categories, depending on the size of the line that needs to be maintained, which is again a foundation for determining their fundamental features. These are: [23]

- smaller RO-RO passenger ships intended for the navigation between nearby ports, straits and, in general, between the ports separated up to a few nautical miles;
- RO-RO passenger ships for medium distances intended for the lines between the ports separated up to 50 nautical miles;
- larger RO-RO passenger ships intended for connecting the ports separated more than 50 nautical miles

Coastal Liner Service Agency monitors the number of passengers and vehicles on RO-RO passenger, high-speed and classic domestic shipping lines. RO-RO passenger transport was being carried out on 25 lines in 2015, 2016 and 2017, while it had 24 RO-RO passenger lines in 2018 and 2019. In the same period, 15 high-speed shipping lines were established, except for 2017 when there were 16 of them. There were 12 classic shipping lines in the five-year period. On the other hands Italy has 12 domestic ro-ro routes that connect exclusively Italian ports. These are managed by 3 shipping companies, with 31 departures per week and connect 10 Italian ports [13]. The total number of passengers and vehicles on the RO-RO passenger lines for the five-year period according to [1] was presented in Table 1.

Table 1: Total transport of passengers and vehicles on state lines, 2015 – 2019.

Year	2015	2016	2017	2018	2019
Passengers	12,500,172	13,054,569	13,506,173	13,755,848	13,808,890
Vehicles	2,993,793	3,102,264	3,294,172	3,454,950	3,539,942

Source: Authors according to [1]

When analysing a five-year period, a slight increase in the number of passengers and vehicles can be seen in the given period. The total number of 13,808,890 passengers and 3,539,942 vehicles were transported in 2019 on the national shipping lines in the coastal liner maritime transport. This represents an increase of 0.4% for passengers and 2.5% for vehicles in relation to the previous year.

5. Analysis results and discussion

5.1. Characteristics of the of major RO-RO passenger ports

In the Republic of Croatia six ports have major significance for the development of the economy and other industrial branches. These are in consecutive order: Rijeka, Zadar, Šibenik, Split, Ploče and Dubrovnik.Their location near city centers is conditioned by the necessary infrastructure requirements. It should be pointed out that the port of Gaženica gives a successful practical example of a port dodged from the city center.

The Port of Rijeka

In the maritime passenger section of the Rijeka port there is no RO-RO passenger traffic. The coastal line between Rijeka and Dubrovnik has been cancelled in 2014, because it was unprofitable. Mentioned line by the decision of Parliament at the beginning of 2017 should be re-established, but it has not happened yet. The reason for this is that the liner shipping company that should have established this line again currently has no suitable ships that would correspond to the requirements of the line.

The Gaženica Port Zadar

The Zadar passenger port is situated on a peninsula, just in the Zadar town centre, in a very confined area. The port coastal length is around 900 meters. The average maritime traffic is around 2.7 million passengers and 350,000 vehicles, with constant annual growth of 8%. In April 2015 the total local and international RO-RO passenger traffic, as well as most of the cruising traffic, was transferred to the new location in Gaženica. The berths in the old city port have been used to accommodate tourist ships, yachts and smaller cruise liners. Local high-speed lines continue their operation from the old city port. Also, it should be pointed out that the security of manoeuvring within the old city port has been improved since.

The Gaženica port complies with multiple traffic requirements: island, coastal, international RO-RO passenger traffic, (mega) cruise liner passenger transport and local RO-RO passenger transport. The port has been equipped with the entire necessary infrastructure and the accompanying building extension [12]. The purpose of individual berths in the Gaženica passenger port is as follows: [18]

- berths 1, 2 and 3 – intended for the accommodation of passenger ships in regular service on domestic voyages,
- berths 4, 5, 6, 7 – intended for the accommodation of passenger ships on regular shipping lines on domestic voyages,
- berths 8, 9, 10, 11 and 12 – intended for accommodation of passenger and RO-RO passenger ships in international traffic. Ships scheduled in the international traffic have been accommodated on Berths 8 and 9.

Technical characteristics of berths are shown in Table 2.

Table 2: Technical characteristics of the berths in the Gaženica passenger port

Berth No.	1	2	3	4	5	6	7	8	9	10	11	12
Length (m)	63	86	86	98	981	170	170	180	180	235	275	180
Depth (m)	5	5	5	7	7	8	9	10	10	10	12	12

Source: Authors according to [12]

The dynamics of passenger transport for the period between 2015 and 2019 is shown in Table 3. The data include total domestic and international transport of the old city port and the Gaženica port.

Table 3: Passenger and vehicle transport, 2015 – 2019.

Year	Domestic transport		International transport	
	Passengers	Vehicles	Passengers	Vehicles
2015	2,156,480	360,474	33,215	5,580
2016	2,238,312	397,618	30,637	5,496
2017	2,348,950	429,321	38,532	8,116
2018	2,351,095	457,117	38,632	8,218
2019	2,390,575	484,690	38,335	7,263

Source: Authors according to [12]

In five years an increase in the number of passengers and vehicles has been noticeable. The Port of Zadar contributed to the overall domestic traffic of passengers by 17.3% in 2019 and by 13.7% to the domestic vehicular traffic. When observing the five-year period of the generated international transport, the highest number of passengers and vehicles was transported in 2018.

The Port of Šibenik

The passenger terminal in the Port of Šibenik is located on the Vrulje wharf, which is used for the accommodation and transfer of passengers and vehicles. The wharf has the berths for liner passenger ships and the ships on cruises.

The total length of the wharf is 519 m. There are five berths on the wharf. Berth No. 1 – Vrulje W1 and berth No. 2 – Vrulje W2 are intended for berthing passenger liner ships. The length of berth No. 1 is 114 m and it can accommodate ships with draught up to 10 m. The length of berth No. 2 is 50 m and the ships with draught up to 10 m can also be berthed there. Both berths have RO-RO ramps. In exceptional circumstances, berth No. 3 can be used for berthing passenger liner ships. This berth is also equipped with a RO-RO ramp. The berth No. 3 is 135 m long and ships with a draught up to 8 m can be berthed there.

There is only a single RO-RO passenger line operated from the Port of Šibenik to the islands of its aquatorium. The number of passengers and vehicles on the RO-RO passenger line Šibenik – Zlarin – Obonjan – Kaprije – Žirje for the five-year period is shown in Table 4.

Table 4: The transport of passengers and vehicles, 2015 – 2019.

Year	2015	2016	2017	2018	2019
Passengers	41,529	42,259	44,118	46,084	46,078
Vehicles	5,391	5,813	6,308	6,722	6,513

Source: Authors according to [1]

The Port of Split

The Port of Split is the most significant passenger port in the Republic of Croatia. It is the port with the largest number of passengers and vehicles carried on annually basis. The port area of the Port of Split consists of: [16]

- City Port basin,
- Vranjic basin,
- Solin basin,
- Kaštela basin.

The passenger port is located in the City Port area, right beside the city centre and is intended for passengers and vehicles transhipment. The mainland part of the City Port extends to around 2,136 m.

Primacy in RO-RO passenger's service is held by Jadrolinija with its 10 domestic lines and 1 international line. The passenger port of Split officially owns 27 berths of different sizes and characteristics. Wharfs Sveti Petar and Sveti Duje are located in the central part of the port. Both wharfs provide accommodation for RO-RO passenger ships. Two summer berths are located on the breakwater (No. 26 and No. 27). Each berth has a ro-ro ramp, which can accommodate RO-RO ships navigating on international lines.

The dynamics of passenger transhipment for the period between 2015 and 2019 are shown in Table 5. The data includes both domestic and international traffic of the Port of Split.

Table 5: Passenger and vehicle traffic, 2015 – 2019.

Year	Domestic traffic		International traffic	
	Passengers	Vehicles	Passengers	Vehicles
2015	4,286,316	647,867	506,910	38,182
2016	4,510,166	689,992	472,486	43,277
2017	4,868,980	738,463	392,186	36,933
2018	4,934,534	769,102	488,055	42,112
2019	5,064,551	786,399	543,238	43,195

Source: Authors according to [11]

The table clearly shows a rising trend in the number of passengers and vehicles in domestic traffic. In the international traffic, the largest number of transhipment passengers was in 2019, while the busiest traffic in terms of the vehicle number was generated in 2016.

The Port of Ploče

The Port of Ploče is the port of particular (international) economic significance for the Republic of Croatia, primarily because of its geographical and strategic position. The Port of Ploče is important due to the transhipment of bulk and liquid cargo and due to the proximity of the border with Bosnia and Herzegovina. Generally quantity of transhipment cargo and passengers has not been significant.

Through the passenger terminal of the port of Ploče operates only one RO-RO passangers line. Mentioned line connects the port of Ploče and port of Trpanj on peninsula Pelješac on daily basis. During the high tourist season, line operates 7 times a day, during the low season 6 times a day. Terminal extends on 10,000 and it is equipped with 3 RO-RO ramps.

Data related to passengers and vehicles traffic on the Ploče - Trpanj RO-RO passenger line are shown in Table 6.

Table 6: The traffic of passengers and vehicles, 2015 – 2019.

Year	2015	2016	2017	2018	2019
Passengers	313,054	335,081	370,499	377,691	388,022
Vehicles	125,032	129,866	143,903	146,134	152,911

Source: Authors according to [1]

The Port of Ploče records a continuous growth of passenger and vehicle traffic on the Ploče-Trpanj line.

The Port of Dubrovnik

The Port of Dubrovnik is the port of special interest for the Republic of Croatia. It is focused primarily on the accommodation of cruise ships. In comparison with the generated passenger traffic, freight transport is almost negligible. In Dubrovnik, there are two spatially separated ports for passenger transport. These are the City Port of Dubrovnik and the Port of Gruž.

The City Port of Dubrovnik is situated in front of the city center. On their international cruises, ships are accommodated at the external anchorage and passengers are transferred with smaller boats.

The Port of Gruž is situated at the southeastern end of the Koločep Channel, north-west of the city of Dubrovnik. It is located in a natural bay and is oriented in the direction north-west – south-east. The depths in the port area of the Port of Gruž vary from 29m at the Kantafig Cape up to 5.8 m at the Petka Wharf. More than one million passengers pass through the port annually. This fact places it in the world top ten ports and top three Mediterranean ports in terms of the passengers number in a one-day visit. Table 7 shows the characteristics of operational berths in the Port of Gruž.

Table 7: Characteristics of operational berths, the Port of Gruž

Bert No.	Berths 4-6	Berths 7-9	Berths 10-11	Berth 12	Kantafig berth	Batahovina I
Length (m)	120	305	605	180	50	220
Depth (m)	2.0–4.0	5.0–6.5	11.0	11.0–11.5	11.0	8.5

Source: Authors according to [10]

The developmental plans of the Port of Dubrovnik Authority aim to ensure high-quality conditions in regard to the number of passengers. According to the existing visions of development these facilities would be divided into basic structural objects and necessary investments for the functioning of the port, which could enrich and improve the tourist offer of the entire area of the city of Dubrovnik. For berths 4 to 12, the area of the Port of Dubrovnik has planned to define itself as the area for the accommodation of all types of ships intended for the transport of tourists. The Batahovina area is ultimately going to support local, coastal and international RO-RO passenger transport. Major objects include: passenger terminal for serving the passengers on their cruises, passenger terminal for the local, coastal and international liner transport, bus terminal for the buses of tour operators, commercial area, garages, catering and tourist facilities necessary for both the port traffic and local population.

The development of the port is aimed at unburdening the Port of Gruž by constructing the RO-RO passenger port in the Rijeka Dubrovačka zone. The first part of the project was built in 2011 with 220 m operational berths and the coastal RO-RO ramp. The second part of the project ("Batahovina II") will be finished in 2021.

A 400-meter wharf will be equipped for the accommodation of all types of passenger and RO-RO ships. The fact that the construction of the highway leading to Dubrovnik will inevitably increase the traffic of vehicles is not to be ignored.

Two RO-RO passenger lines are operating from Dubrovnik. Within the Croatian territorial waters, Dubrovnik is connected with the island of Šipan and by the international RO-RO passenger line with the Port of Bari. A graphic representation of the number of passengers and vehicles in the period between 2015 and 2019 is listed below.

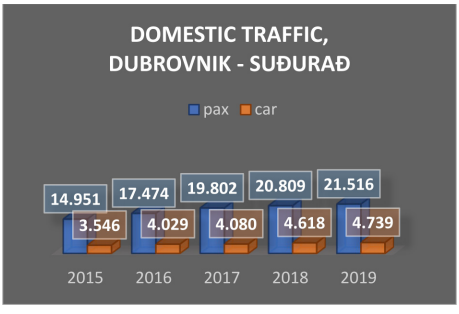

Figure 1: Domestic transport of passengers and vehicles on the line Dubrovnik-Suđurađ
Source: Authors according to [10]

The graph in Figure 1 shows a slight increase in both, the number of passengers and vehicles.

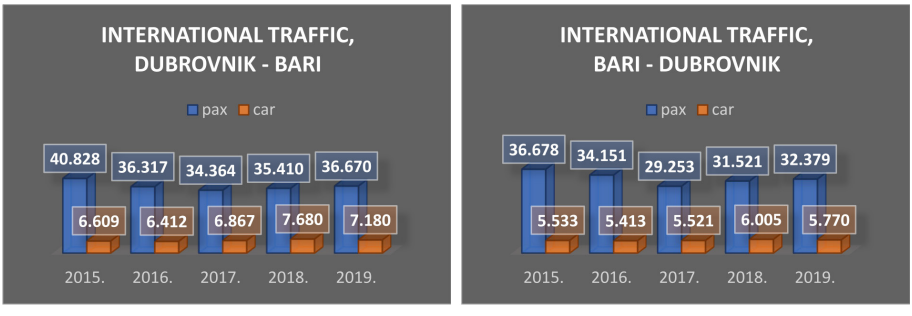

Figure 2: International traffic of passengers and vehicles on the line Dubrovnik – Bari and vice versa, 2015 – 2019.
Source: Authors according to [10]

The graphs in Figure 2 show data related to the number of passengers and vehicles in the five-year period in the international RO-RO passenger transport of the Port of Dubrovnik. A larger number of passengers and vehicles are transported from Dubrovnik to Bari than vice versa. In the Dubrovnik – Bari direction the greatest

number of passengers was transported in 2015, while the largest number of vehicles was transported in 2019.

5.2. A comparative analysis of the maritime coastal liner passenger transport of the most significant maritime passenger ports of the Republic of Croatia

Maritime liner passenger transport is a significant factor of the economic activity in every country which has the sea and indented coast with islands, and, as such, is of public interest. In most cases, coastal states, just like the Republic of Croatia itself, offer financial support to non-profitable lines and stimulate liner passenger shipping companies to let them operate with the highest possible quality. The purpose of the liner RO-RO passenger connection is addressing the economic and personal needs of the local population and, in doing so, making the conditions of life on islands as similar as possible to the ones on the mainland. Also, the fact that the liner passenger traffic is a highly important part of the tourist offer is constantly being pointed out in public. As such it enables the island population to find a solution to existential questions and, in that manner, prevents the drain of the primarily younger, working-age population.

For carrying out various economic activities, including tourism, and for life on the islands in general, frequency, structure, security and quality of the liner passenger traffic are highly important. Improving the quality and competitiveness of the Croatian island tourist product and its recognition on eminent European and world markets would be unthinkable without the adequate level of maritime liner transport service. However, the liner passenger shipping industry in the Republic of Croatia is characterized by uneven transport demand. Because of the influence of tourism, transport demand is increased in the summer months, mostly in July and August (especially at weekends). To get an insight into the maritime liner RO-RO passenger transport in the considered period of five years (2015 to 2019) in the Republic of Croatia and to carry out a comparative analysis of the two biggest RO-RO passenger ports, the terms for the arithmetic mean, standard deviation and coefficient of variation will be used and presented by the expressions 1, 2, 3.

$$\bar{X} = \frac{\sum X_i}{N} \tag{1}$$

$$\sigma^2 = \frac{\sum (x_i - \overline{X})^2}{N} \tag{2}$$

$$\mathrm{V} = \frac{\sigma}{\bar{X}} \tag{3}$$

In the period from 2015 to 2019, according to Coastal Liner Services Agency, a total number of 66,625,652 passengers and 16,385,121 vehicles were transported. On average, on the annual level (arithmetic mean), this is 13,325,130 passengers and

3,277,024 vehicles. There is an average deviation from the arithmetic mean in the number of passengers by 491,136 passengers or 3.7%, while the average deviation from the arithmetic mean in the number of vehicles is 205,834 vehicles or 6.3%.

The Port of Zadar – Gaženica and the Port of Split are the biggest Croatian RO-RO passenger ports due to their geographical position. The infrastructure and superstructure in the observed ports offer satisfying support and a response to the momentary demand for the RO-RO passenger transport. The number of passengers for the Port of Gaženica and the Port of Split in the domestic and international liner coastal transport are shown by the graph in Figure 3.

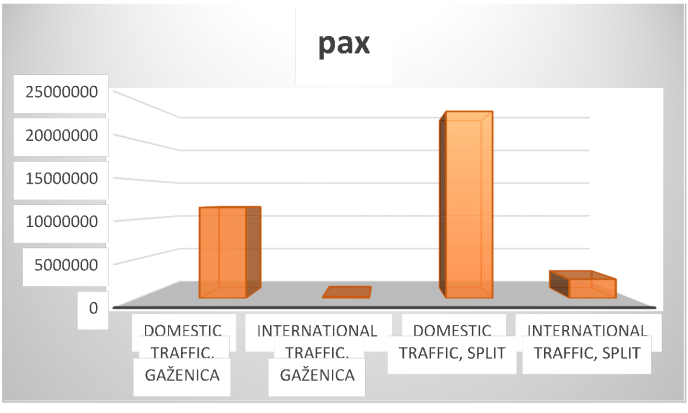

Figure 3: Number of passengers for the Port of Gaženica and Port of Split in the domestic and international coastal liner traffic
Source: Authors according to [11,12]

In the period from 2015 to 2019, the total generated passenger traffic in the domestic liner traffic for the Port of Gaženica was 11,485,412 passengers, while the Port of Split generated the passenger traffic of 23,664,547 passengers, in the same period. On average, that were 2,297,082 passengers annually (arithmetic mean) for the Port of Gaženica, and 4,732,909 for the Port of Split. The average deviation from the arithmetic mean in the number of passengers in the Port of Gaženica is 86,685 passengers or 3.8%, while the indicator considered was 6.1% or 289,210 for the Port of Split.

International passenger traffic for the period in question in the Port of Gaženica and Split was in terms of intensity considerably lighter so that the total generated passenger traffic in the international liner traffic was 179,351 passengers for the Port of Gaženica. The passenger Port of Split had 2,402,451 in the same period. On average, annually (arithmetic mean) that were 35,870 passengers for the Port of Gaženica and 480,490 for the Port of Split. The average deviation from the arithmetic mean in the number of passengers in the Port of Gaženica was 3,323 passengers or 9% and 50,063 or 10.4% for the indicator considered for the Port of Split. The fluctuation percentages

for both ports are evidently similar although the actual passenger traffic in the Port of Split was far greater.

The trend of the number of vehicles in the domestic and international traffic for the period considered roughly follows the number of passengers. The number of vehicles in this period for the Port of Gaženica and the Port of Split in the domestic and international coastal liner traffic is shown by the graph in Figure 4.

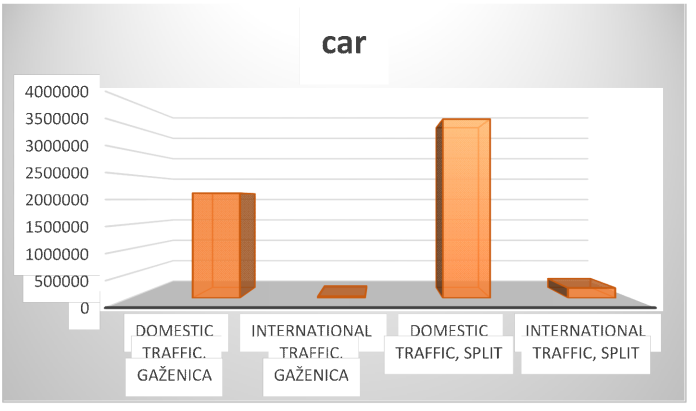

Figure 4: Number of vehicles for the Port of Gaženica and the Port of Split in the domestic and international coastal liner traffic
Source: Authors according to [11,12]

In the considered period the total generated vehicle traffic in the domestic liner traffic for the Port of Gaženica was 2,129,220 vehicles, while the passenger port of Split had 3,631,823 vehicles in the same period. On average, annually (arithmetic mean) that was 425,844 vehicles for the Port of Gaženica, while it was 726,365 for the Port of Split. There is an average deviation from the arithmetic mean in the number of vehicles in the Port of Gaženica of 43,641 or 10.2% and the indicator considered is 51,111 for the Port of Split or 7%.

International vehicle traffic in the period considered in the Port of Gaženica and Split was in terms of intensity considerably lighter so that the total generated vehicle traffic in the international liner traffic for the Port of Gaženica was 34,673 and 203,699 for the Port of Split for the same period. On average, annually (arithmetic mean) that was 6,935 vehicles for the Port of Gaženica and 40,740 vehicles for the Port of Split. The average deviation from the arithmetic mean in the number of passengers in the Port of Gaženica was 1,187 vehicles or 17.1%, while the indicator considered was 2,660 or 6.5% for the Port of Split. The number of vehicles in these ports in the domestic traffic has been constantly increasing, while the international traffic shows certain variations on the annual levels. Deviations in the number of vehicles from the average (arithmetic mean) are relatively bigger for the Port of Gaženica than the Port

of Split. However, the real indicators are in reality bigger for the Port of Split, which also records far greater vehicle traffic.

6. Conclusion

For a large number of the inhabited islands, as well as their attractiveness of tourist offer, liner passenger shipping is particularly significant. Without a constant and regular connection between islands and the mainland, the development of islands would be in jeopardy. Therefore, RO-RO passenger shipping is one of the key factors of the development of the Croatian islands.

In the last few years, the number of RO-RO passenger ports in the Croatian waters has almost been balanced. The number of passengers and vehicles on these lines has been rising year by year.

A clear analysis of the available data shows a positive trend in terms of the transport of passengers and vehicles in the most significant Croatian ports. The Port of Rijeka is an exception, where there is no RO-RO passenger traffic. The Port of Split is by far the most significant RO-RO passenger intersection on the territory of the Republic of Croatia. In the last few years, it has been experiencing continuous growth in passenger traffic, both domestic and international. It is followed by the Port of Gaženica. The Port of Ploče has experienced continuous growth of passengers and vehicles in the last few years, while the RO-RO passenger traffic for the Port of Dubrovnik and Šibenik is negligible when compared to the total traffic in these ports.

All things considered, it can be concluded that the RO-RO passenger connections are a highly important factor for the development of islands. Its importance is evident not only for the quality of life of the island population but also for the more significant positioning in tourism. Therefore, the need to strengthen the role of RO - RO passenger shipping as an important part of the maritime sector in the development and competitiveness of the Republic of Croatia. This is achieved by initiatives for sustainable growth of economic activities on islands and in the coastal area. The RORO passengers traffic system simulations are suggested by authors. It would result in better insight into the possibilities for a more flexible connection of islands and mainland.

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