Multidisciplinary
SCIENTIFIC JOURNAL
OF MARITIME RESEARCH

University of Rijeka
FACULTY OF MARITIME STUDIES

Multidisciplinarni
znanstveni časopis
POMORSTVO

https://doi.org/10.31217/p.34.1.15

Simulation Analysis of Seaport Rijeka Operations with Established Dry Port

Ivica Lovrić[1], Dajana Bartulović[2], Maša Viduka[3], Sanja Steiner[4]

[1] City of Zagreb, Trg Stjepana Radića 1, 10000 Zagreb, Croatia, e-mail: ivica.lovric@zagreb.hr
[2] Institute of Traffic and Communications, Kušlanova 2, 10000 Zagreb, Croatia, e-mail: ipv@ipv-zg.hr
[3] Ministry of the Sea, Transport and Infrastructure, Prisavlje 14, 10000 Zagreb, Croatia, e-mail: masa.viduka@mmpi.hr
[4] Croatian Academy of Sciences and Arts, Traffic Institute, Kušlanova 2, 10000 Zagreb, Croatia, e-mail: ssteiner@hazu.hr

ABSTRACT

Seaport Rijeka is the largest seaport in Croatia. It specializes in transport of cargo, with the primary activities of loading, unloading, storage and transport of general cargo, timber, bulk cargo, livestock, containers, and other cargo at five specialized terminals. It is focused on increasing the quality of services and the competitiveness of the transport routes in Croatia. Due to its favourable position on the TEN-T network, Seaport Rijeka provides the shortest maritime connection between the countries of Central and Eastern Europe as well as the overseas countries. In the past 20 years Seaport Rijeka keeps record of continuous growth in container traffic. Due to increasing demand in container traffic, it seeks for the solutions to expand. One of the possible solutions that would satisfy the increasing demand in container traffic is establishing a dry port. Dry port is an inland intermodal terminal which has direct connection to the seaport by road or rail and its main purpose is to provide logistic activities and transport to inland destinations. Dry ports have many advantages, faster transport of cargo from seaports, use of more efficient modes of transport, providing facilities for the storage and consolidation of goods, the maintenance of road or rail freight carriers, customs services, etc. In the case of container transport, dry ports can be used to outsource the logistic activities of transport process, away from congested area of seaports. Due to the fact that Seaport Rijeka is reaching the limits of its capacity, one of possible solutions of its expansion is establishing a dry port. The focus of this paper is to prove that establishing a dry port would speed up the transport process of containers between Seaport Rijeka and its destinations. Due to this hypothesis, four simulations were made. First simulation shows the transport process in the existing set-up of the Seaport Rijeka. Second, third and fourth simulation shows the transport process in the future possible set-up of the Seaport Rijeka with established dry port in Miklavlje, Zagreb or Vinkovci.

ARTICLE INFO

Review article
Received 2 May 2020
Accepted 25 May 2020

Key words:
Seaport operations
Seaport Rijeka
Dry port
Establishment
Simulation analysis

1 Introduction

Seaport Rijeka is located on the strategic EU TEN-T Mediterranean Corridor and is also connected to the Baltic-Adriatic Corridor. [11] Due to its favourable position, Seaport Rijeka provides the shortest maritime connection between the countries of Central and Eastern Europe as well as the overseas countries.

The EU and Croatia are strategically and operationally supporting investments in port and railway infrastructure that raise the traffic capacity of this traffic route and eliminate bottlenecks.

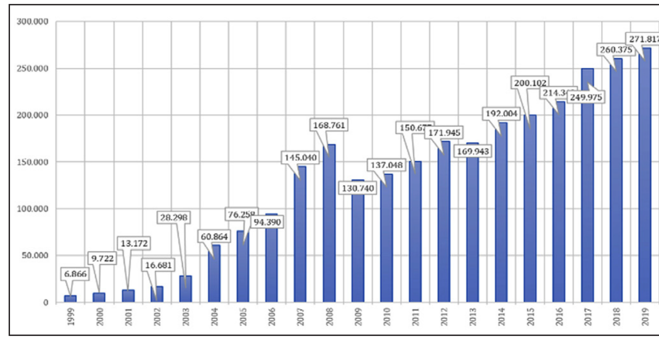
Figure 1 shows the position of Seaport Rijeka in EU TEN-T and potential strategic transport directions.

Seaport Rijeka specializes in transhipment of cargo, with the primary activities of loading, unloading, storage and transport of general cargo, timber, bulk cargo, livestock, tropical and other cargo. Port of Rijeka j.s.c. with a share of 49 % also manages Adriatic Gate Container Terminal, a container terminal with a concession agreement until 2041. The annual capacity of the AGCT is currently 450,000 TEUs, with a plan to expand to 600,000 TEUs. [23]

Seaport Rijeka keeps the record of continuous growth in container traffic from 1999 to 2019, although there were certain periods when several factors such as the global crisis, declining purchasing power of users, exceptional growth of competing ports or systematic neglect of

Figure 1 Position of Seaport Rijeka in TEN-T and Strategic Transport Directions

Source: Authors



Graph 1 Container Traffic of Seaport Rijeka from 1999 to 2019

Source: Authors according to annual reports of Seaport Rijeka container traffic [23]

transport and logistics strategy of the Republic of Croatia caused a drop in container traffic of the Seaport Rijeka. [23] Table 1 and Graph 1 show the increase in Seaport Rijeka container traffic.

Table 1 Increase in Container Traffic of Seaport Rijeka from 1999 to 2019

Year	Total Number of TEU Units	Increase/Decrease in Percentage (%)
1999	6.866	/
2000	9.722	42
2001	13.172	35
2002	16.681	27
2003	28.298	70
2004	60.864	115
2005	76.258	25
2006	94.390	24
2007	145.040	54
2008	168.761	16
2009	130.740	-23
2010	137.048	5
2011	150.677	10
2012	171.945	14
2013	169.943	-1
2014	192.004	13
2015	200.102	4
2016	214.348	7
2017	249.975	17
2018	260.375	4
2019	271.817	4

Source: Authors according to annual reports of Seaport Rijeka container traffic [23]

For the Rijeka Seaport to increase its capacity, which will be necessary due to the increase of container traffic in past 20 years [23], and without large investments, one of the possible solutions is the construction of a dry port terminal.

Dry port is an inland intermodal terminal which has direct connection to the seaport by road or rail and its main purpose is to provide logistic activities and transport to inland destinations. [1, 3, 17, 19, 20, 21]

A well-designed dry port concept can shift cargo from the road to more energy efficient modes of transport that are less harmful to the environment, reduce congestion in cities, make handling of goods in seaports more efficient and make it easier for carriers to improve logistics solutions in seaport hinterland. [2, 6, 22, 24, 26, 27, 28]

In addition to their role in cargo transhipment, dry ports may also contain facilities for the storage and consolidation of goods, the maintenance of road or rail freight carriers and customs services. The location of these facilities on a dry port frees up storage and customs space on the seaport itself. [4, 8, 12, 18]

A dry port can speed up the flow of cargo between ships and major transport networks, creating a central distribution point. Dry ports can improve the movement of cargo, in this case containers, by moving sorting and processing of containers to dry port facilities, far away from congested seaports. [5, 7, 9, 10, 14]

Zagreb, Miklavlje and Vinkovci were chosen as possible locations, because of their geographical positions and existing infrastructure features. [13, 15, 25] Simulations were made for all three possible solutions to find the optimal solution and to see if it would speed up the transport process of cargo, specifically containers, and consequently increase the capacity of the Rijeka Seaport and eliminate bottlenecks and congestion at the Seaport Rijeka.

Four simulations of the operation of Rijeka Seaport were made. One simulation shows the operations of Rijeka Seaport in the existing set-up without established dry port and three simulations show the operations of Rijeka Seaport with the established dry port in Miklavlje, Zagreb and Vinkovci. Simulations are made using Arena Simulation Software. Analysis of simulation results is conducted using Microsoft Excel.

Given the limitations of the simulation software, and with the purpose to obtain the most accurate results, the arrival of one ship with 130 TEU was simulated for each seaport set-up, and the simulation was repeated 30 times. For simplicity, it is assumed that each container is equal to 1 TEU. The input parameters are set up based on triangular distribution, i.e. three values: minimum, most likely, and maximum. The input parameters values are estimated for each required activity of the process based on real-life time frames, e.g. input parameters for road transport to Zagreb are 2.5, 4.5, 5 hours respectively, to Vienna are 5.5, 6.5, 8 hours, to Budapest are 5.5, 6, 7.5 hours; time spent in Temporary Storage are 6, 10, 12 days, time spent in Storage 1 are 3, 5, 9 days, in Storage 2 are 2, 3, 6 days, in Open Depot 0, 2, 2.5 days, in Closed Depot are 1, 2, 3 days, etc. The simulation uses input parameters to calculate output parameters. The simulation diagram of each Seaport Rijeka operations set-up (simulation model) is shown in following figures. Relevant output parameters of the transport process such as time and number of units as well as transport time required to destination by road or rail are shown in the following tables for each model. As 30 simulations of each model were made, the minimum and maximum time averages within these simulations are shown as well.

2 Simulation Analysis of Seaport Rijeka Operations

The simulation diagram of Seaport Rijeka operations in the existing set-up (AS-IS simulation model) is shown in Figure 2.

Table 2 shows the results of the AS-IS simulation model. As it is shown in the table, the number of containers that entered and exited the system is equal to 130 containers. The average time the container spent in the system from

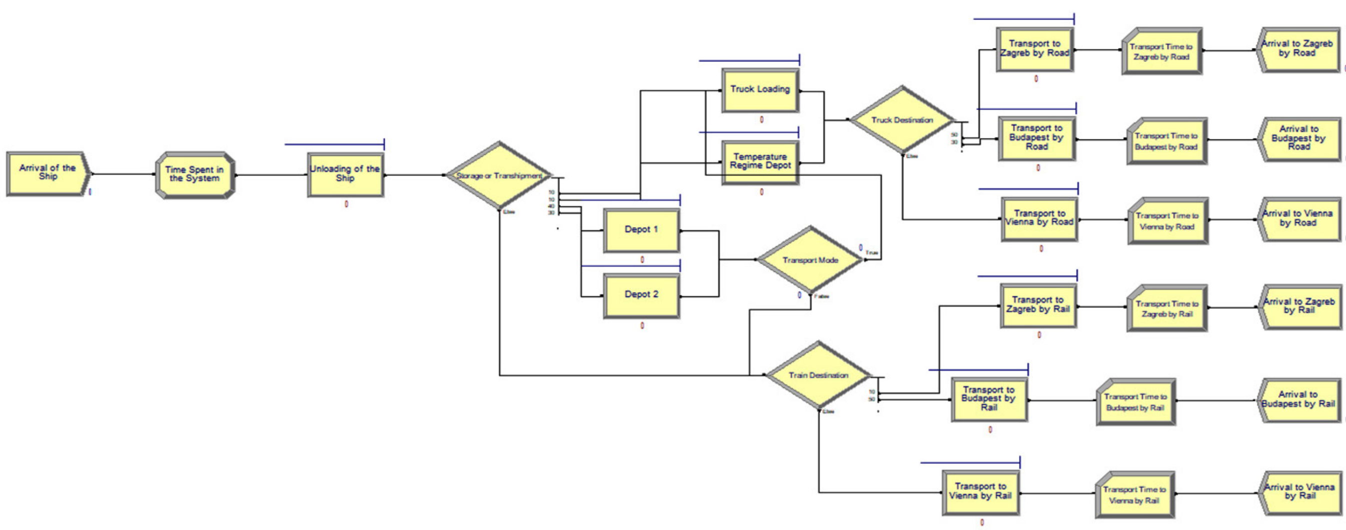


Figure 2 Simulation of the Operation of the Seaport Rijeka (Existing Set-up – AS-IS Model)

Source: Authors

Table 2 Relevant Parameters of the Transport Process

Time/Number of units (hrs/TEU)	Average (hrs)	Tolerances	Minimum Average (hrs)	Maximum Average (hrs)	Minimum Value (hrs)	Maximum Value (hrs)
Value Added Time	121.53	2.12	107.64	130.91	2.7577	289.86
Wait Time	0.1043	0.05	0.02085917	0.7285	0.00	13.1624
Total Time	121.64	2.12	107.78	130.94	2.9804	289.86
Number In (TEU)	130.00	0.00	130.00	130.00	/	/
Number Out (TEU)	130.00	0.00	130.00	130.00	/	/
Number TEU in Process	58.2106	1.09	52.1870	62.1383	0.00	130.00

Source: Authors

Table 3 Transport Time Required to Destination by Road/Rail

AS-IS model – Seaport Rijeka	Average (hrs)	Tolerances	Minimum Average (hrs)	Maximum Average (hrs)	Minimum Value (hrs)	Maximum Value (hrs)
Transport Time to Vienna by Road	119.17	14.70	63.222	212.66	5.9484	285.36
Transport Time to Budapest by Road	125.69	11.31	55.2889	207.86	5.8647	289.86
Transport Time to Zagreb by Road	110.87	6.65	73.443	147.49	2.9804	282.49
Transport Time to Vienna by Rail	127.11	3.67	106.09	142.83	25.7914	236.13
Transport Time to Budapest by Rail	125.26	3.72	108.11	144.65	16.5369	234
Transport Time to Zagreb by Rail	102.38	6.44	56.7486	133.04	6.8994	211.15

Source: Authors

unloading from the ship to arriving at the final destination is 121.46 hours. The longest time container spent in the system is 289.86 hours, while the least time container spent in the system is 2.9804 hours. Total time spent in the system is divided between the time the container spent in the process, and the time it spent waiting for the process to take place, i.e. in line. Average number of containers is 58.2106 containers, while the minimum average number of containers in the system is 52.1870 and the maximum average number of containers is 62.1383.

Table 3 shows the times required for one container to be transported from Rijeka to its destination, depending on whether it is transported by road or rail. In addition to the average times, the maximum and minimum values are also displayed. Minimum average values are slightly larger due to larger number of TEU units (a number arbitrarily chosen by simulation) that were directed to Zagreb by road and longer time required to process them in the depot.

Table 3 clearly shows that according to the existing setup, road transport is the fastest mode, and if rail transport is not set as a competitive mode of transport, freight will continue to be transported by road, which is not in line with EU guidelines, which encourages the development of rail transport as the "backbone" of freight transport within the European Union.

3 Simulation Analysis of Seaport Rijeka Operations with Established Dry Port in Miklavlje

Miklavlje is one of the three possible solutions for the location of the dry port terminal. Miklavlje was chosen because of its location near the Rijeka Seaport. The idea is to connect the Rijeka Seaport by rail with the dry port. The Miklavlje Logistics Centre is located in the Municipality of Matulji, about 17 km west of the city of Rijeka, next to the Rijeka-Rupa motorway (on the Croatian-Slovenian border), the state road in the same direction and along the Rijeka-Ljubljana railway. The development of the logistics centre is planned on an area of 158.5 hectares, with the possibility of further expansion, depending on future requirements. [15] Thanks to this position, spatial potential and direct connection to European transport routes, the logistics centre provides the opportunity to develop various entrepreneurial projects (logistics and distribution centres, production facilities, business, services, transport, etc.) to a wide range of investors, especially those coming from areas of southern Germany, Austria, Switzerland, Italy, Czech Republic, Slovakia, Hungary, Slovenia, Serbia, Bosnia and Herzegovina, which gravitate around Rijeka Seaport and use the Rijeka traffic route.

The simulation diagram of Seaport Rijeka operations with dry port established in Miklavlje (TO-BE Miklavlje simulation model) is shown in Figure 3.

Table 4 shows the results of the TO-BE simulation model with a dry port in the immediate vicinity of Rijeka Seaport, in Miklavlje. As in the AS-IS model, the number of containers that entered and exited the system is equal to 130 containers and the simulation was run 30 times. The average time the container spent in the system from unloading from the ship to arriving at the final destination is 80.3701 hours. The longest time container spent in the system is 289.29 hours, while the least time container spent in the system is 2.9224 hours. Total time spent in the system is divided between the time the container spent in the process, and the time it spent waiting for the process to take place, i.e. in line. Average number of containers is 39.6245 containers, while the minimum average number of containers in the system is 33.8458 and the maximum average number of containers is 46.1689.

Table 5 shows the times required for one container to be transported from Rijeka to its destination, depending on whether it is transported by road or rail if a dry port is to be established in the Miklavlje area. In addition to the average times, the maximum and minimum values are also displayed. Minimum average values are slightly larger due to larger number of TEU units (a number arbitrarily chosen by simulation) that were directed to Zagreb by road and longer time required to process them in the depot.

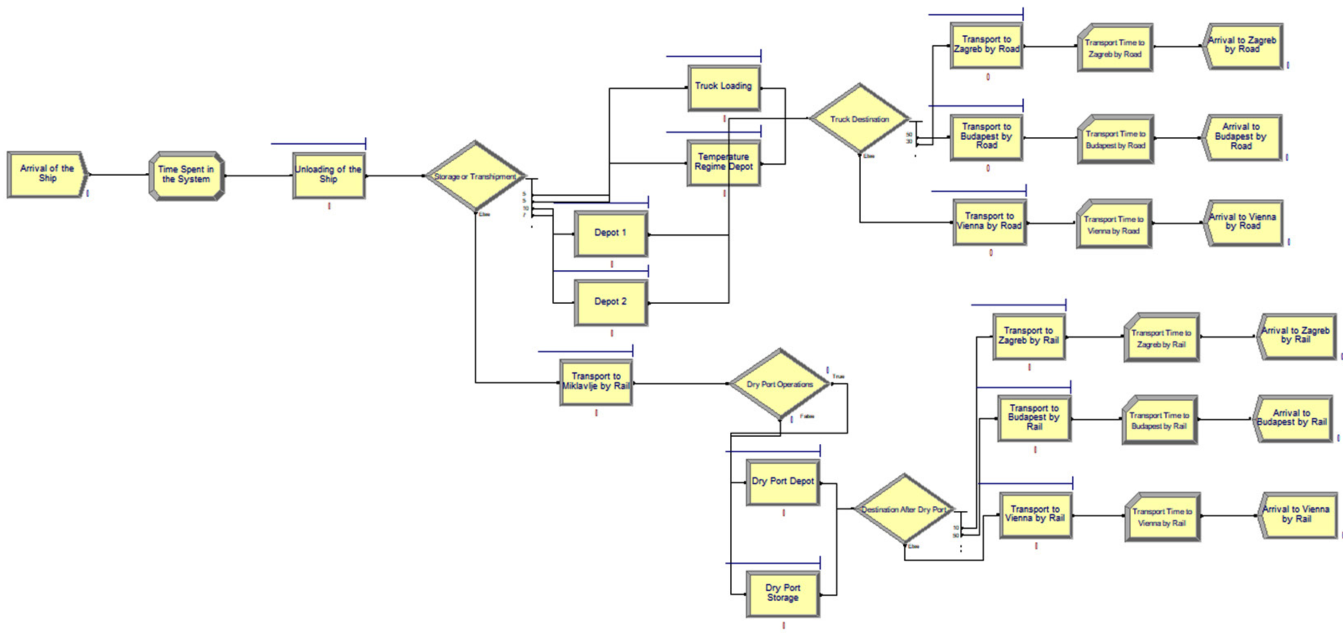


Figure 3 Simulation of Seaport Rijeka with Established Dry Port (TO-BE Model – Miklavlje)

Source: Authors

Table 4 Relevant Parameters of the Transport Process

Time/Number of units (hrs/TEU)	Average (hrs)	Tolerances	Minimum Average (hrs)	Maximum Average (hrs)	Minimum Value (hrs)	Maximum Value (hrs)
Value Added Time	77.1141	1.45	71.7396	84.8720	2.8502	289.29
Wait Time	3.2560	0.57	0.7569	6.2510	0.00	43.1403
Total Time	80.3701	1.54	73.7924	88.7974	2.9224	289.29
Number In (TEU)	130.00	0.00	130.00	130.00	/	/
Number Out (TEU)	130.00	0.00	130.00	130.00	/	/
Number TEU in Process	39.6245	1.16	33.8458	46.1689	0.00	130.00

Source: Authors

Table 5 Transport Time Required to Destination by Road/Rail

TO-BE model – Miklavlje	Average (hrs)	Tolerances	Minimum Average (hrs)	Maximum Average (hrs)	Minimum Value (hrs)	Maximum Value (hrs)
Transport Time to Vienna by Road	125.63	11.94	66.8306	203.54	6.0756	283.43
Transport Time to Budapest by Road	121.24	10.79	59.6551	171.79	5.8436	279.37
Transport Time to Zagreb by Road	113.44	6.00	80.4975	155.03	2.9224	289.29
Transport Time to Vienna by Rail	77.9494	1.71	69.8824	86.7704	30.5267	131.05
Transport Time to Budapest by Rail	61.2347	0.77	56.9419	65.5463	22.6463	92.4907
Transport Time to Zagreb by Rail	47.3934	1.90	36.3356	58.0630	9.1995	72.0059

Source: Authors

4 Simulation Analysis of Seaport Rijeka Operations with Established Dry Port in Zagreb

One of the possible locations for the construction of a dry port terminal is in Zagreb. The advantage of Zagreb is definitely its geostrategic position and the fact that it is located on two rail freight corridors, the Mediterranean and the Alpine-Western Balkan. [16, 25] Most of the cargo that has a destination in the countries of the European Union and is brought to the Rijeka Seaport by ship, passes through Zagreb on its way.

The role of the dry port is to avoid unnecessary storage of containers on the seaport itself. The containers are loaded directly on the train, transported to Zagreb, and are furtherly handled/processed at the dry port. Since operations in a dry port are performed much faster than on the seaport itself, the cargo is kept at the dry port much shorter and it reaches the destination much faster, which can be seen from the simulation results shown in the tables below.

The simulation diagram of Seaport Rijeka operations with dry port established in Zagreb (TO-BE Zagreb simulation model) is shown in Figure 4.

Table 6 shows the results of the TO-BE simulation model with a dry port in the vicinity of City of Zagreb, possibly in Velika Gorica. As in the AS-IS model, the number of containers that entered and exited the system is equal to 130 containers and the simulation was run 30 times. The average time the container spent in the system from unloading from the ship to arriving at the final destination is 72.3399 hours. The longest time container spent in the system is 289.47 hours, while the least time

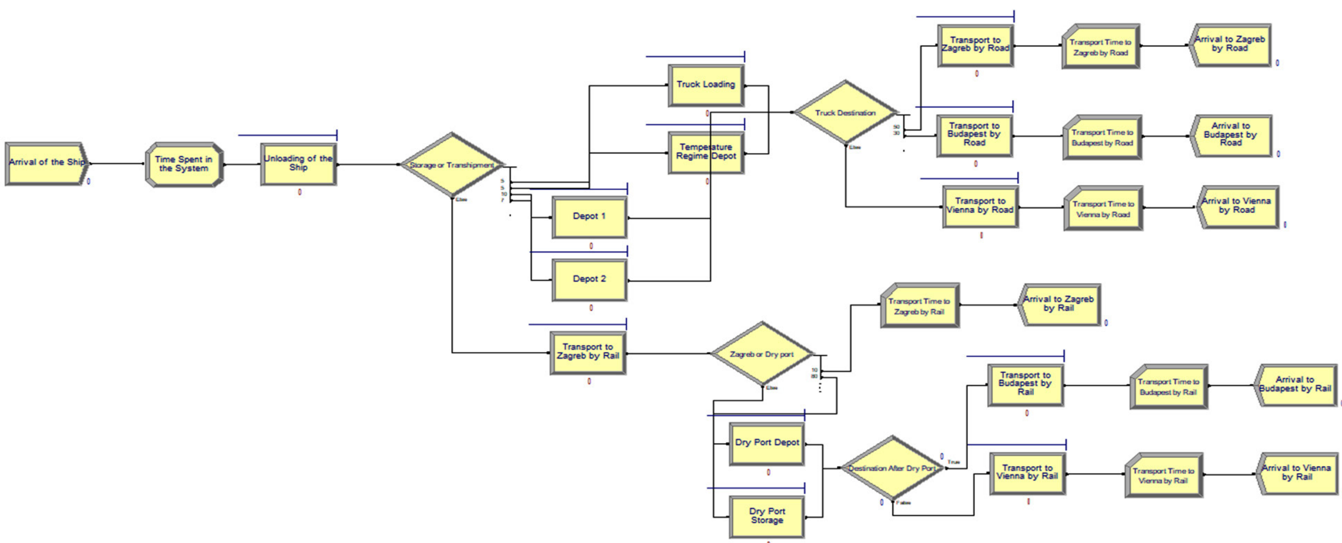


Figure 4 Simulation of Seaport Rijeka with Established Dry Port (TO-BE Model – Zagreb)

Source: Authors

Table 6 Relevant Parameters of the Transport Process

Time/Number of units (hrs/TEU)	Average (hrs)	Tolerances	Minimum Average (hrs)	Maximum Average (hrs)	Minimum Value (hrs)	Maximum Value (hrs)
Value Added Time	70.7244	1.66	61.8250	78.3930	2.7556	289.47
Wait Time	1.6155	0.14	0.7748	2.2947	0.00	12.8458
Total Time	72.3399	1.61	64.1197	79.8556	2.9224	289.47
Number In (TEU)	130.00	0.00	130.00	130.00	/	/
Number Out (TEU)	130.00	0.00	130.00	130.00	/	/
Number TEU in Process	35.6631	0.91	31.4582	42.5818	0.00	130.00

Source: Authors

Table 7 Transport Time Required to Destination by Road/Rail

TO-BE model – Zagreb	Average (hrs)	Tolerances	Minimum Average (hrs)	Maximum Average (hrs)	Minimum Value (hrs)	Maximum Value (hrs)
Transport Time to Vienna by Road	122.25	12.08	75.7028	202.24	6.1454	280.11
Transport Time to Budapest by Road	124.14	9.03	88.8765	186.27	5.8435	287.16
Transport Time to Zagreb by Road	113.47	6.71	63.5515	140.15	2.9224	289.47
Transport Time to Vienna by Rail	65.2477	1.02	60.3022	72.613	20.3167	100.19
Transport Time to Budapest by Rail	59.1304	0.56	54.8758	62.01	20.7279	92.5141
Transport Time to Zagreb by Rail	11.9081	0.50	9.5746	15.102	5.2669	23.3067

Source: Authors

container spent in the system is 2.9224 hours. Total time spent in the system is divided between the time the container spent in the process, and the time it spent waiting for the process to take place, i.e. in line. Average number of containers is 35.6632 containers, while the minimum average number of containers in the system is 31.4582 and the maximum average number of containers is 42.5818.

Table 7 shows the times required for one container to be transported from Rijeka to its destination, depending on whether it is transported by road or rail if a dry port is to be established in the Zagreb area. In addition to the average times, the maximum and minimum values are also displayed. Minimum average values are slightly larger due to larger number of TEU units (a number arbitrarily chosen by simulation) that were directed to Budapest by road and longer time required to process them in the depot.

5 Simulation Analysis of Seaport Rijeka Operations with Established Dry Port in Vinkovci

As a third possible solution, a dry port was proposed to be located in Vinkovci. The position of the city of Vinkovci which is in the zone between significant transport corridors of European and national importance also influenced the formation of the transport system of the city itself. The former X Pan-European Railway Corridor, today's Alpine-Western Balkan Rail Freight Corridor, runs through the city. The proximity of the Danube (TEN-T corridor Rhine-Danube) and the route of the state road D2 along with it, and the highway Zagreb-Lipovac (former X pan-European corridor) influenced the formation of a significant transversal road connection that passes through the city of Vinkovci. [11, 16]

One of the largest railway hubs on the Croatian railways network is located in Vinkovci. The railway hub consists of a passenger and a freight terminal. The freight terminal consists of 50 tracks classified into four groups. Nowadays, traffic through the freight terminal has been significantly reduced, and its future depends on the development of the multi-purpose canal project, where part of the existing freight terminal capacity could be used for new dry port.

The advantage of the city of Vinkovci is that its traffic routes, unlike Zagreb and Miklavlje, are not oriented to the directions of Western Europe, but also to the directions of Eastern and South-Eastern Europe, which are also used to transport goods unloaded in the Rijeka Seaport, primarily direction of Orient – East Med Corridor via Vukovar and RFC 10 to Thessaloniki. [13]

The simulation diagram of Seaport Rijeka operations with dry port established in Vinkovci (TO-BE Vinkovci simulation model) is shown in Figure 5.

Table 8 shows the results of the TO-BE simulation model with a dry port in the railway hub of city of Vinkovci. As in the AS-IS model, the number of containers that entered and exited the system is equal to 130 containers and the simulation was run 30 times. The average time the container spent in the system from unloading from the ship to arriving at the final destination is 844.02 hours. The longest time container spent in the system is 2420.74 hours, while the least time container spent in the system is 3.1756 hours. Total time spent in the system is divided between the time the container spent in the process, and the time it spent waiting for the process to take place, i.e. in line. Average number of containers is 51.3340 containers, while the minimum average number of containers in the system is 45.5522 and the maximum average number of containers is 56.7295.

Table 9 shows the times required for one container to be transported from Rijeka to its destination, depending on whether it is transported by road or rail if a dry port is to be established in the area of city of Vinkovci. In addition to the average times, the maximum and minimum values are also displayed. Minimum average values are slightly larger due to larger number of TEU units (a number arbitrarily chosen by simulation) that were directed to Zagreb by road and longer time required to process them in the depot.

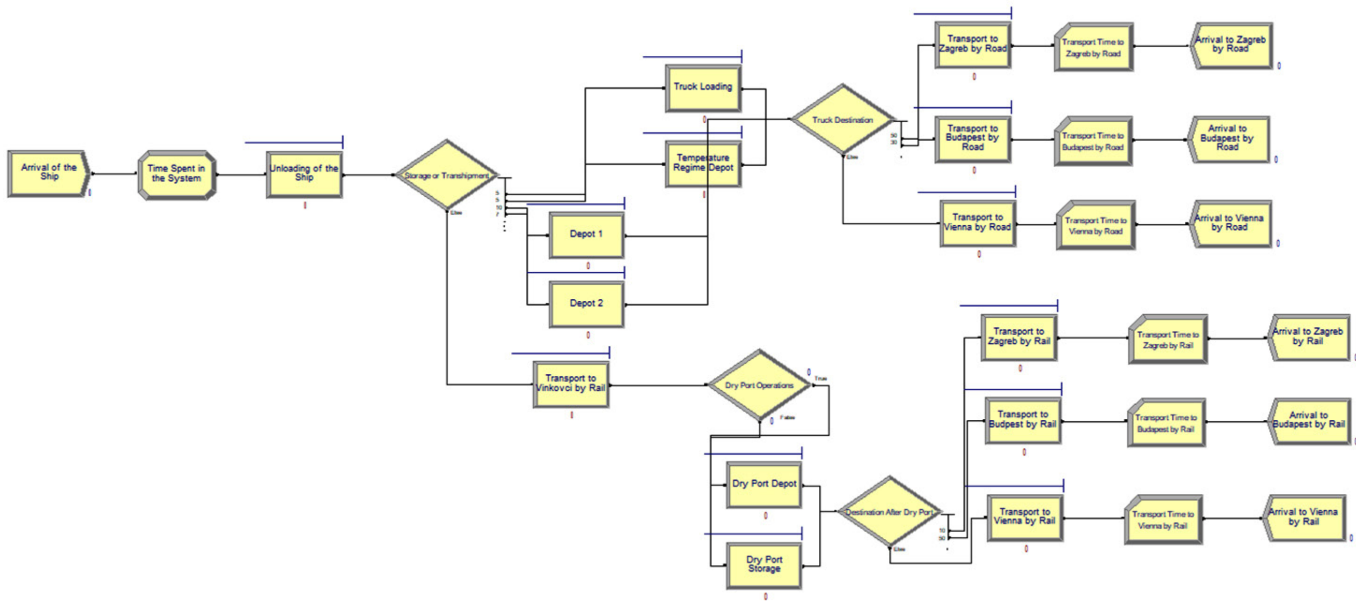


Figure 5 Simulation of Seaport Rijeka with Established Dry Port (TO-BE Model – Vinkovci)

Source: Authors

Table 8 Relevant Parameters of the Transport Process

Time/Number of units (hrs/TEU)	Average (hrs)	Tolerances	Minimum Average (hrs)	Maximum Average (hrs)	Minimum Value (hrs)	Maximum Value (hrs)
Value Added Time	93.3898	1.42	88.1777	103.18	2.7814	282.90
Wait Time	750.63	38.48	541.45	956.69	0.00	2336.86
Total Time	844.02	38.04	639.40	1045.50	3.1756	2420.74
Number In (TEU)	130.00	0.00	130.00	130.00	/	/
Number Out (TEU)	130.00	0.00	130.00	130.00	/	/
Number TEU in Process	51.3340	1.01	45.5522	56.7295	0.00	130.00

Source: Authors

Table 9 Transport Time Required to Destination by Road/Rail

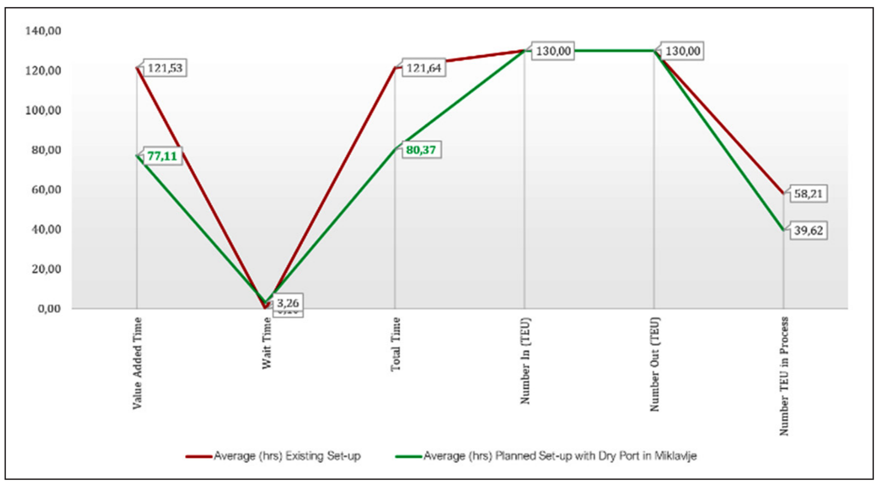
TO-BE model – Vinkovci	Average (hrs)	Tolerances	Minimum Average (hrs)	Maximum Average (hrs)	Minimum Value (hrs)	Maximum Value (hrs)
Transport Time to Vienna by Road	120.02	11.19	53.1790	182.28	6.2756	282.90
Transport Time to Budapest by Road	119.72	9.21	67.2319	167.12	5.8951	273.98
Transport Time to Zagreb by Road	120.57	6.30	78.6195	156.13	3.1756	281.99
Transport Time to Vienna by Rail	1121.48	46.50	876.19	1313.47	70.2195	2420.74
Transport Time to Budapest by Rail	1099.72	31.94	973.06	1306.12	53.6797	2380.55
Transport Time to Zagreb by Rail	1072.16	81.69	706.94	1582.46	43.7273	2319.69

Source: Authors

6 Analysis of simulation results and discussion

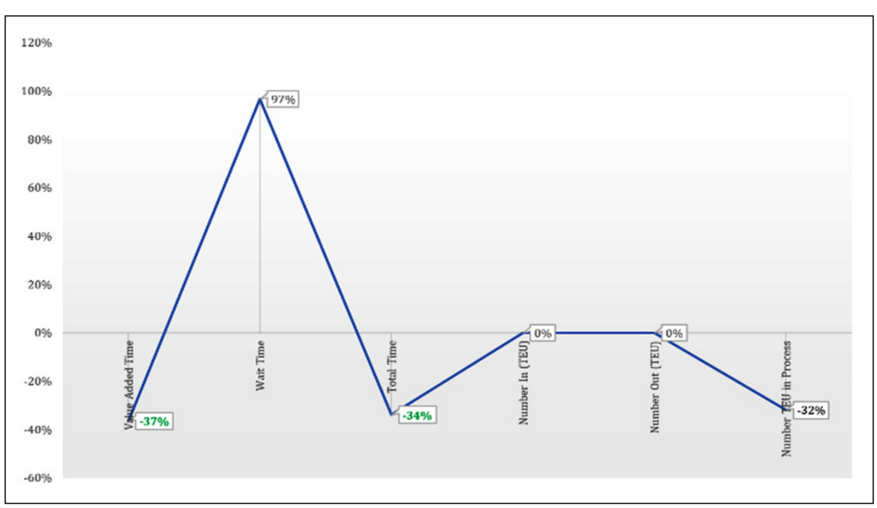
By comparing the obtained results, simulations of possible locations of the dry port terminal, the best solution for dry port location is in the area of City of Zagreb. As stated, Zagreb has the most favourable geostrategic position and the best connection with the cities of Central and Western Europe. Further research and analyses are needed to determine the optimal location for the construction of the dry port terminal. Also, the other two proposed locations should not be rejected, as each of them has its own advantages, which in more detailed analysis, can prove to be crucial for the construction of a dry port.

The conclusions of the results obtained by simulations are presented in graphs below. Two parameters are presented in the following graphs: *Average Total Time and Number of Units Operated at the Existing Seaport Set-up and Seaport with Established Dry Port* and *Average Time Required to Destination by Road/Rail at the Existing Seaport Set-up and Seaport with Established Dry Port* for each selected location (Miklavlje, Zagreb, Vinkovci).



Graph 2 Comparison of Average Total Time and Number of Units Operated at the Existing Seaport Set-up and Seaport with Dry Port Established in Miklavlje

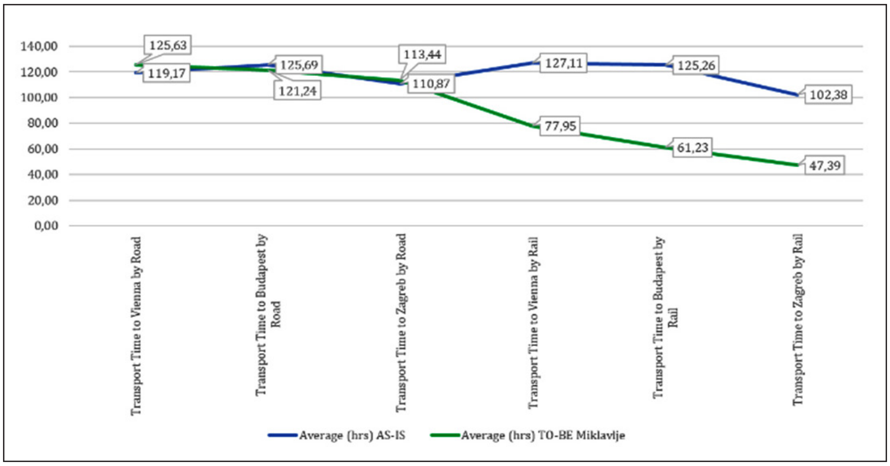
Source: Authors



Graph 3 Decrease/Increase in Average Total Time and Number of Units Operated – AS-IS/TO-BE Miklavlje, Expressed as a Percentage

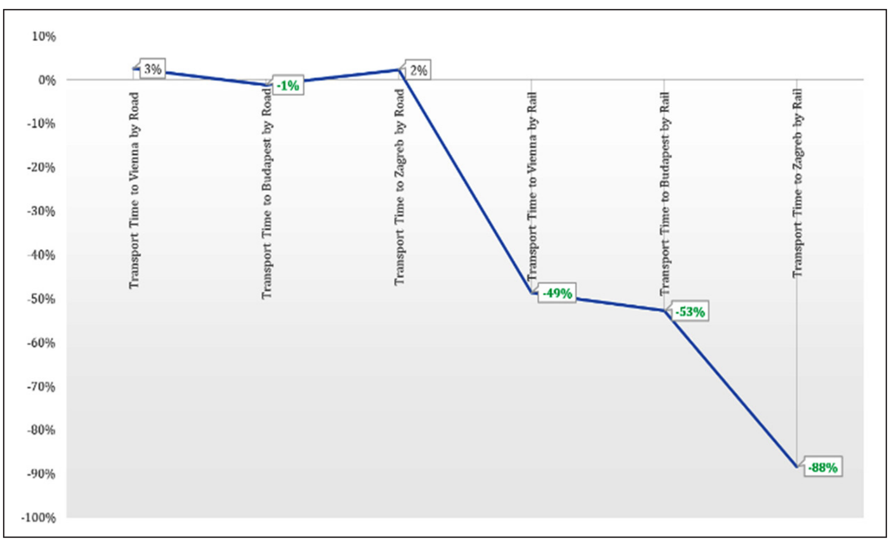
Source: Authors

Conclusion of graphs 2 and 3: The average total time in the process with the established dry port in Miklavlje would decrease compared to the existing set-up without a dry port by 37 %, the waiting time would increase, while the total time would decrease by 34 %.



Graph 4 Comparison of Average Time Required to Destination by Road/Rail at the Existing Seaport Set-up and Seaport with Dry Port Established in Miklavlje

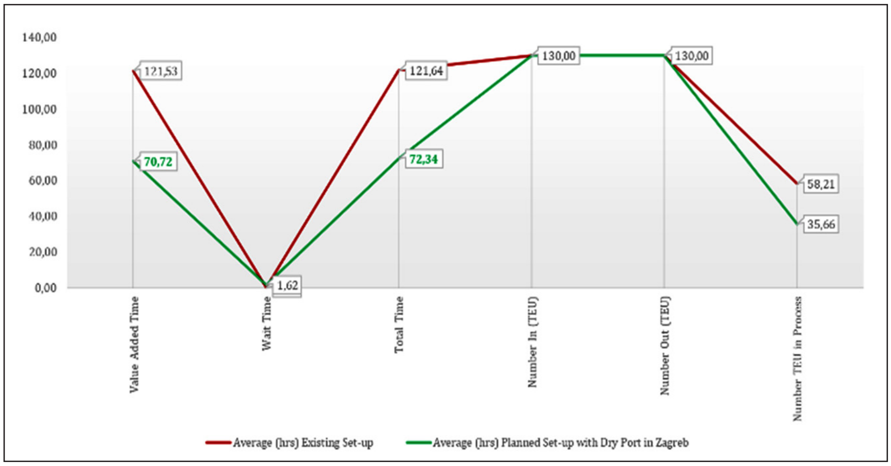
Source: Authors



Graph 5 Decrease/Increase in Average Time Required to Destination by Road/Rail – AS-IS/TO-BE Miklavlje, Expressed as a Percentage

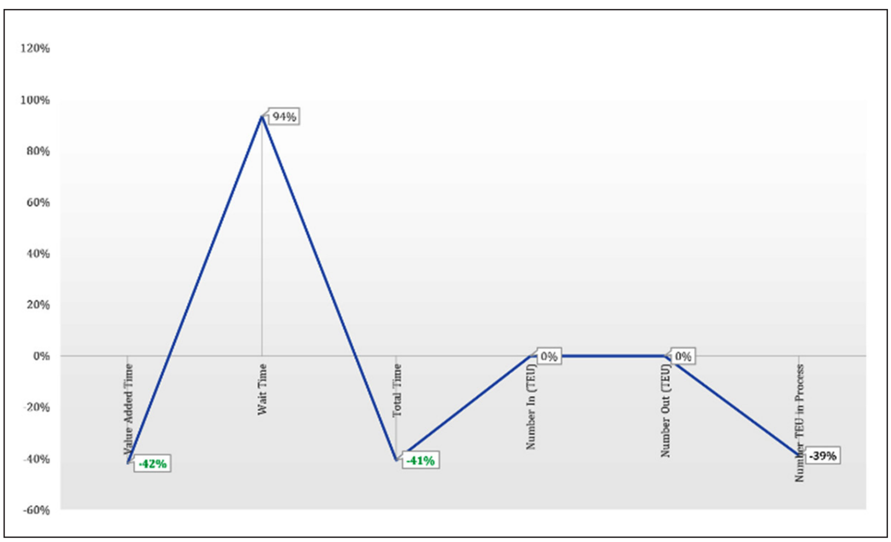
Source: Authors

Conclusion of graphs 4 and 5: The average time required by road/rail with an established dry port in Miklavlje would be significantly reduced due to railway use, while in the terms of road transport, it would remain approximately the same, compared to the existing set-up without a dry port. Graphs 4 and 5 show the significant impact of the establishment of a dry port and significant time savings due to rail transport, compared to the existing set-up without a dry port.



Graph 6 Comparison of Average Total Time and Number of Units Operated at the Existing Seaport Set-up and Seaport with Dry Port Established in Zagreb

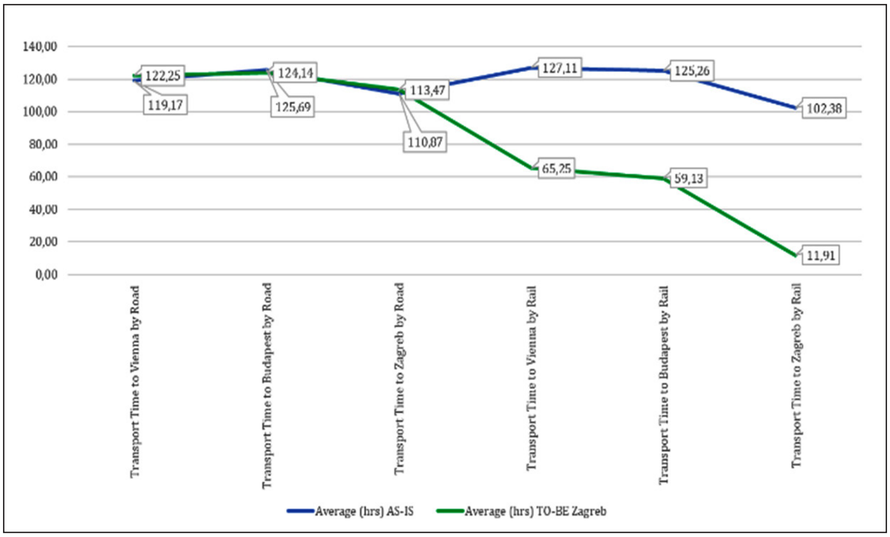
Source: Authors



Graph 7 Decrease/Increase in Average Total Time and Number of Units Operated – AS-IS/TO-BE Zagreb, Expressed as a Percentage

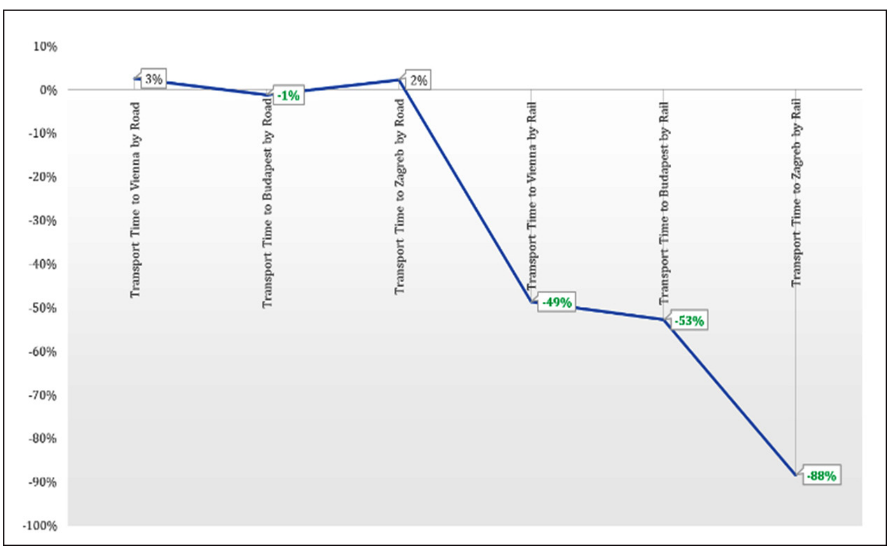
Source: Authors

Conclusion of graphs 6 and 7: The average total time in the process with an established dry port in Zagreb would decrease compared to the existing set-up without a dry port by 42 %, the waiting time would increase, while the total time would decrease by 41 % .



Graph 8 Comparison of Average Time Required to Destination by Road/Rail at the Existing Seaport Set-up and Seaport with Dry Port Established in Zagreb

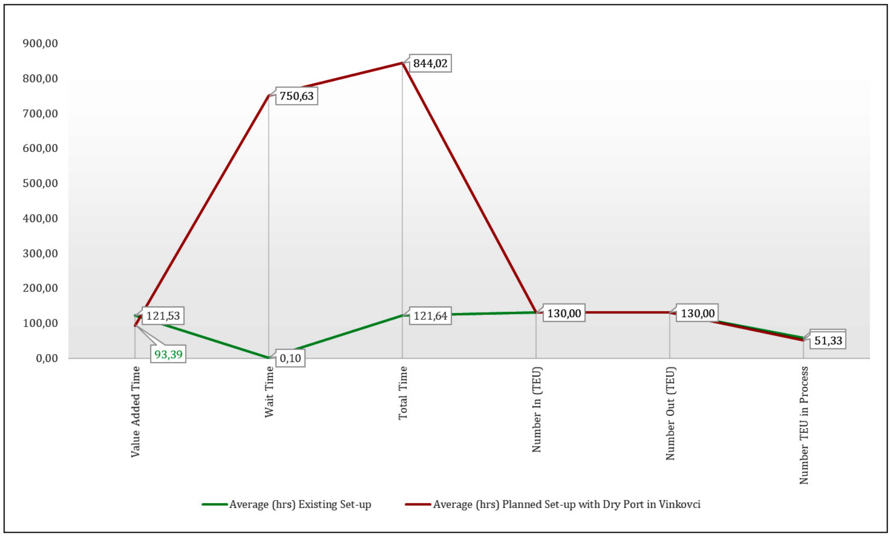
Source: Authors



Graph 9 Decrease/Increase in Average Time Required to Destination by Road/Rail – AS-IS/TO-BE Zagreb, Expressed as a Percentage

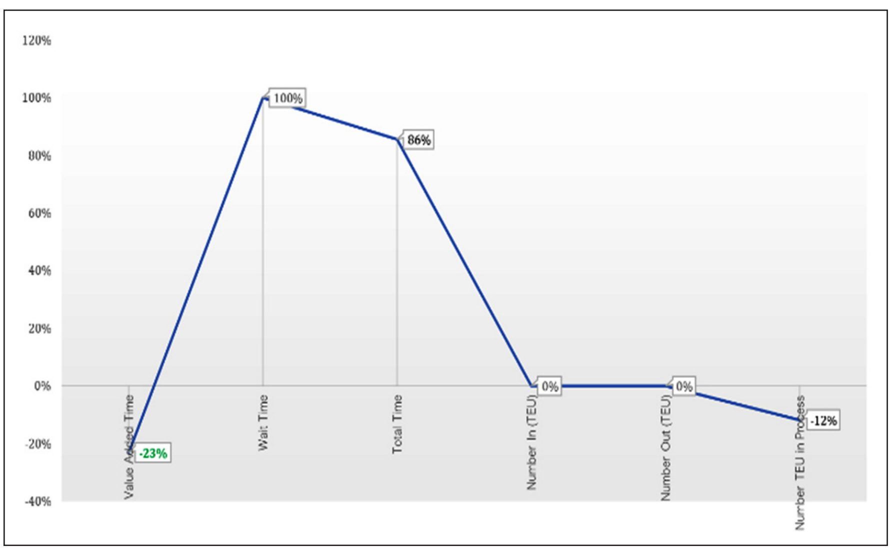
Source: Authors

Conclusion of graphs 8 and 9: The average time required by road/rail with an established dry port in Zagreb would be significantly reduced due to railway use, while in the terms of road transport, it would remain approximately the same, compared to the existing situation without a dry port. Graphs 8 and 9 show the significant impact of the establishment of a dry port and significant time savings due to rail transport, compared to the existing set-up without a dry port.



Graph 10 Comparison of Average Total Time and Number of Units Operated at the Existing Seaport Set-up and Seaport with Dry Port Established in Vinkovci

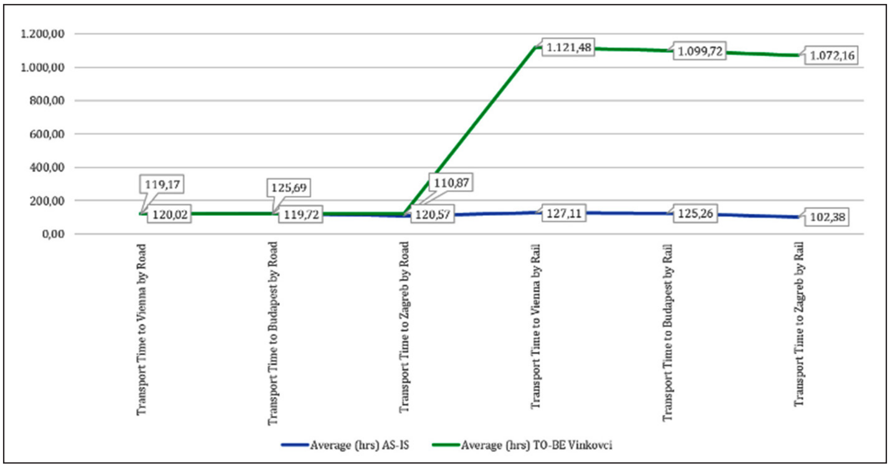
Source: Authors



Graph 11 Decrease/Increase in Average Total Time and Number of Units Operated – AS-IS/TO-BE Vinkovci, Expressed as a Percentage

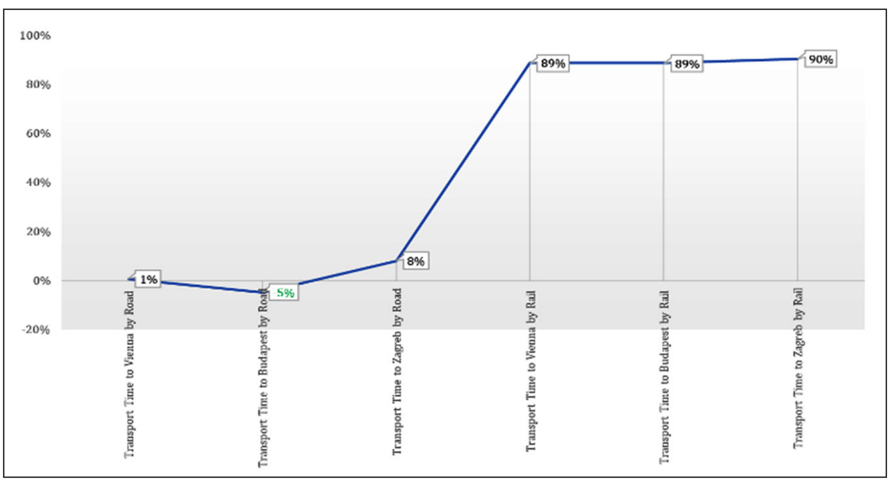
Source: Authors

Conclusion of graphs 10, and 11: The average total time in the process with the established dry port in Vinkovci would decrease compared to the existing set-up without a dry port by 23 %, while the waiting time and total time would increase.



Graph 12 Comparison of Average Time Required to Destination by Road/Rail at the Existing Seaport Set-up and Seaport with Dry Port Established in Vinkovci

Source: Authors



Graph 13 Decrease/Increase in Average Time Required to Destination by Road/Rail – AS-IS/TO-BE Vinkovci, Expressed as a Percentage

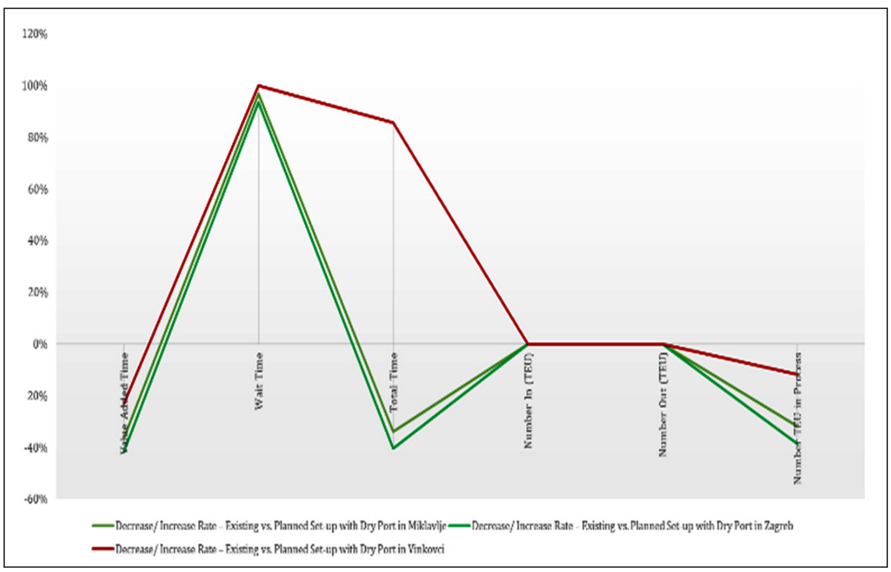
Source: Authors

Conclusion of graphs 12, 13: The average time required by road/rail with an established dry port in Vinkovci would increase significantly in terms of railway use, while the road would remain approximately the same, compared to the existing set-up without a dry port. Graphs 12 and 13 show the increase in transport time due to the fact that the simulation uses Vienna and Budapest as destinations, where transport via Vinkovci would not be efficient, compared to the existing set-up without a dry port, but perhaps for some other destinations such as Thessaloniki, it would be very useful.

Table 10 Decrease/Increase Rate (%) of the Average Total Time and Number of Units Operated at Three Locations of Dry Port Establishment – Miklavlje, Zagreb, Vinkovci

Average Time/Number of Units (TEU)	Decrease/Increase Rate – Existing vs. Planned Set-up (Miklavlje)	Decrease/Increase Rate – Existing vs. Planned Set-up (Zagreb)	Decrease/Increase Rate – Existing vs. Planned Set-up (Vinkovci)
Value Added Time	-37 %	-42 %	-23 %
Wait Time	97 %	94 %	100 %
Total Time	-34 %	-41 %	86 %
Number In (TEU)	0 %	0 %	0 %
Number Out (TEU)	0 %	0 %	0 %
Number TEU in Process	-32 %	-39 %	-12 %

Source: Authors



Graph 14 Comparison of Decrease/Increase Rate (%) of the Average Total Time and Number of Units Operated – AS-IS/TO-BE Miklavlje, Zagreb, Vinkovci

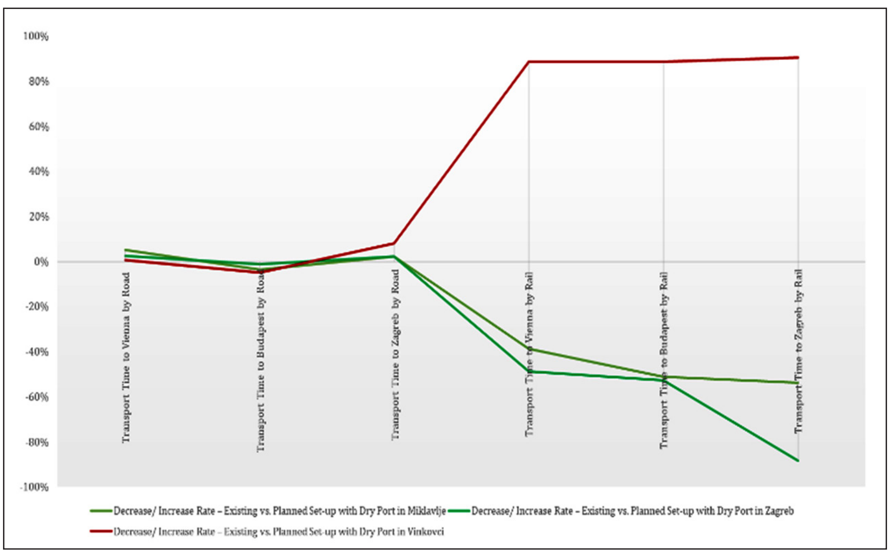
Source: Authors

Conclusion of Table 10 and Graph 14: The average total time with an established dry port in three locations – Miklavlje, Zagreb and Vinkovci shows a decrease, compared to the existing set-up without a dry port. The best result can be seen with the establishment of a dry port in the Zagreb area.

Table 11 Decrease/Increase Rate (%) of the Average Time Required to Destination by Road/Rail to Destination at Three Locations of Dry Port Establishment – Miklavlje, Zagreb, Vinkovci

Average Time Required by Road/Rail	Decrease/Increase Rate – Existing vs. Planned Set-up (Miklavlje)	Decrease/Increase Rate – Existing vs. Planned Set-up (Zagreb)	Decrease/Increase Rate – Existing vs. Planned Set-up (Vinkovci)
Transport Time to Vienna by Road	5 %	3 %	1 %
Transport Time to Budapest by Road	-4 %	-1 %	-5 %
Transport Time to Zagreb by Road	2 %	2 %	8 %
Transport Time to Vienna by Rail	-39 %	-49 %	89 %
Transport Time to Budapest by Rail	-51 %	-53 %	89 %
Transport Time to Zagreb by Rail	-54 %	-88 %	90 %

Source: Authors



Graph 15 Comparison of Decrease/Increase Rate (%) of the Average Time Required to Destination by Road/Rail – AS-IS/TO-BE Miklavlje, Zagreb, Vinkovci

Source: Authors

Conclusion of Table 11 and Graph 15: Average time required by road/rail with established dry port in three locations – Miklavlje, Zagreb and Vinkovci shows a significant decrease in two locations, compared to the existing set-up without dry port. The best result can be seen with the establishment of a dry port in Zagreb.

7 Conclusion

Due to the fact that Seaport Rijeka is reaching the limits of its capacity, one of possible solutions of its expansion is establishing a dry port. The focus of this paper is to prove that establishing a dry port would speed up the transport of containers between Seaport Rijeka and its destinations. Three locations of dry port were chosen to show the transport process, due to time required to transport containers from seaport to its destinations. Chosen destinations are set up to be city of Vienna and city of Budapest, as those were already destinations Seaport Rijeka uses in existing set-up to transport containers. Dry port locations are chosen to be in Miklavlje, Zagreb and Vinkovci because of their geographical locations that are already placed on the significant routes of European TEN-T network, and some already have existing necessary infrastructure, as well as they fit in the concept of building dry ports, i.e. distant, mid-range and close dry ports. Miklavlje is chosen to be close dry port, Zagreb mid-range, and Vinkovci distant dry port. Due to this hypothesis, four simulations were made. First simulation shows the transport process in the existing set-up of the Seaport Rijeka. Second, third and fourth simulation shows the transport process in the future possible set-up of the Seaport Rijeka with established dry port in Miklavlje, Zagreb or Vinkovci. Simulations were made using Arena Simulation Software. Analysis of simulation results was conducted using Microsoft Excel. Comparing the results of simulations made with established dry port serving seaport against the simulation made to present existing transport operations without dry port, showed that transport process is improved, in the terms of reduced time required to reach the allocated destination by implementing rail transport and outsourcing logistic activities of seaport to its dry port. The simulations also showed that the best location for establishing dry port is in the area of Zagreb. Due to the results of this research, which shows that the transport process will be improved by establishing dry port to serve the Seaport Rijeka, the further analysis of other factors can be made in the future research.

References

[1] Ballis, A. and Golias, J. (2002). Comparative evaluation of existing and innovative rail–road freight transport terminals. *Transportation Research Part A: Policy and Practice*, 36(7), 593–611.

[2] Bask, A., Roso, V., Andersson, D. and Hämäläinen, E. (2014). Development of seaport-dry port dyads: two cases from Northern Europe. *Journal of Transport Geography*, 39, 85–95.

[3] Bergqvist, R., Falkemark, G., Woxenius, J. (2010). Establishing intermodal terminals. *World Review of Intermodal Transportation Research*, 3(3), 285–302.

[4] Black, J., Roso, V., Marušić, E., Brnjac, N. (2018). Issues in Dry Port Location and Implementation in Metropolitan Areas: The Case of Sydney, Australia. *Transactions on Maritime Science*, 7(1), 41–50.

[5] Cezar-Gabriel, C. (2010). Performance assessment in Operating Dry Ports. *Annals of the University of Oradea, Economic Science Series*, 19(2), 934–938.

[6] Chen, J., Fei, Y., Zhang, F., Jing, C. (2018). Evaluating Correlations between a Seaport and Its Dry Ports: Case Study of Xiamen Port in China. *Discrete Dynamics in Nature and Society*, 2018, 1–15.

[7] Crainic, T.G., Dell'Olmo, P., Ricciardi, N. and Sgalambro, A. (2015). Modeling dry-port-based freight distribution planning. *Transportation Research Part C: Emerging Technologies*, 55, 518–534.

[8] Cullinane, K. and Wilmsmeier, G. (2011). The contribution of the dry port concept to the extension of port life cycles. *Handbook of Terminal Planning, Operations Research Computer Science Interfaces Series*, Springer, 49, 359–380.

[9] Dragović, B., Tzannatos, E., Park, N.K. (2017). Simulation modelling in ports and container terminals: literature overview and analysis by research field, application area and tool. *Flexible Services and Manufacturing Journal*, 29, 4–34.

[10] Dundović, Č., Hess, S., Šantić, L. (2006). Proračun opterećenja i kapaciteta kontejnerskog terminala luke Ploče. *Journal of Maritime Research*, 20(2), 79–95.

[11] EU TEN-T Network, http://ec.europa.eu/transport/themes/infrastructure/index_en.htm, accessed: 02/05/2020.

[12] Hanaoka, S. and Regmi, M.B. (2011). Promoting intermodal freight transport through the development of dry ports in Asia: An environmental perspective. *IATSS Research*, 35, 16–23.

[13] Master plan grada Vinkovaca za promet. (2016). http://via-vinkovci.hr/wp-content/uploads/2019/11/Master-plan-Grada-Vinkovaca-za-promet.pdf, accessed: 02/05/2020.

[14] Mlinaric, T.J., Rogić, K. and Rožić, T. (2011). Methodology for Determining Dry Port System Transport Network – Case Study Port of Rijeka. *DAAAM International Scientific Book*, 10, 133–146.

[15] Prostorni plan uređenja Općine Matulji. (2017) http://matulji.hr/pocetna/prostorni-planovi/, accessed: 02/05/2020.

[16] Rail Freight Corridors (RFCs) map. (2018). http://rne.eu/wp-content/uploads/RFC-MAP-2017.pdf, accessed: 02/05/2020.

[17] Rodrigue, J.P. and Nottebom, T. (2012). Dry ports in European and North American intermodal rail systems: two of a kind? *Research in Transportation Business & Management*, 5, 4–15.

[18] Rogić, K.; Rožić, T. & Kolarić, G. (2013). Functionality of logistics distribution centers as an inland port terminal (dry port terminals) – case study city of Zagreb. *Conference of Planning and development of sustainable transport system*, Zagreb, 16 April, 83–95.

[19] Roso, V. (2010). Emergence and significance of dry ports. *Baltic Transport Journal*, 6, 44–45.

[20] Roso, V. (2013). Sustainable intermodal transport via dry ports – importance of directional development. *World Review of Intermodal Transportation Research*, 4(2/3), 140–156.

[21] Roso, V. and Lumsden K. (2010). Review of dry ports. *Maritime Economics and Logistics*, 12(2), 196–213.

[22] Roso, V., Woxenius, J., Lumsden, K. (2009). The dry port concept: connecting container seaports with the hinterland. *Journal of Transport Geography*, 5, 338–345.

[23] Seaport Rijeka Annual Reports from 1999 to 2019, https://lukarijeka.hr/, accessed: 02/05/2020.

[24] Shi, X. and Li, H. (2016). Developing the port hinterland: different perspectives and their application to Shenzhen Port, China. *Research in Transportation Business & Management*, 19, 42–50.

[25] Strategija prometnog razvoja Republike Hrvatske (2017-2030). (2017). https://vlada.gov.hr/UserDocsImages/ZPPI/Strategije/MMPI %202017-2030 %20STRAT %20PROM %20RZV %20RH %2025-8_17.pdf, accessed: 02/05/2020.

[26] Wang, G.W., Zeng, Q., Li, K. and Yang, J. (2016). Port connectivity in a logistic network: the case of Bohai Bay, China. *Transportation Research Part E: Logistics and Transportation Review*, 95, 341–354.

[27] Wilmsmeier, G., Monios, J. and Lambert, B. (2011). The directional development of intermodal freight corridors in relation to inland terminals. *Journal of Transport Geography*, 19(6), 1379–1386.

[28] Woxenius, J. and Bergqvist, R. (2009). Hinterland transport by rail – comparing the Scandinavian conditions for maritime containers and semi-trailers. *The International Association of Maritime Economists Conference (IAME)*, Copenhagen, 24-26 June, 1–15.