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DBS Gateway Region

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Pilot Action

Travel Book

WP 5 – Activity 5.4

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1 Introduction

DBS Gateway Region Project aims at supporting the Danube-Black Sea region to become an attractive gateway region for maritime and inland waterway transport between Central Europe and the Black Sea, the Caspian and the Far East on a well-informed, well-prepared, well-focused and well-supported basis. The Project relies on the cooperation of public authorities, ports and their related associations as a key factor to raise the quality, reliability and efficiency of the waterway transport system. The main results of the Projects are:

- The Potential Analysis which points out the status, joint challenges and future market potentials for the waterway transport system (basis for the Joint Vision 2040).
- The Joint Vision 2040 which tells us where the DBS Gateway Region wants to go (what the region would like to achieve or accomplish in the mid-term or long-term future).
- The Roadmap which defines how we will get there (measures suitable to reach the Joint Vision 2040 and aims at turning the DBS Region into an attractive gateway region for maritime and inland waterway transport.
- The Regional Action Plans, which gives concrete steps on what needs to be done, by whom, when etc. and how much this will cost (concrete actions feasible to tackle the relevant challenges for each participating region).
- The Studies (pre-feasibility, feasibility, …) which will bring the Regional Actions Plans and the Joint Vision 2040 closer to the implementation.
- The Cooperation Platform which will support long-lasting cooperation and further actions in the region.

The Project consists of 6 work packages (WP), where WP5 intends to face the challenge that implementation often lags behind recommendations in regional Roadmaps/Action Plans. It assists the preparation of implementation of necessary projects recommended to increase the attractiveness of the waterway transport system in the DBS Gateway Region. The WP5 activities include:

- Activity 5.1 “Funding Guidelines” – elaboration of existing funding options for development projects (on EU, national and regional level) and providing guidelines on how to apply for them.
- Activity 5.2 “Project Identification” – the most important measures, for every region, chosen for further development. Additionally, selection of the adequate funding options for the identified measures, as well as matching of the selected measures with the corresponding funding option.
- Activity 5.3 “Project Development” – the projects listed in Activity 5.2 further developed in Activity 5.3 according to the provided funding guideline developed in Activity 5.1. Nine studies carried out by the relevant project partners covering important nodes within the DBS waterway transport system. Depending on the stage of project development, each

project has different starting point, e.g. pre-feasibility, feasibility study or pre-investment studies.

- Activity 5.4 “Pilot Action” – tracking and tracing of cargo flows from China to Serbia, via the Port of Constanta and the Danube River, comparison of existing available routes and development of an open access web application that determines the optimal route based on the three criteria: price, time and emissions.

Under the WP 5 – Activity 5.4 “Pilot Action” of DBS Gateway Region Project, the Pilot Action provides information on transport and forwarding processes for cargo flows from China to Serbia via the Ports of Koper, Rijeka, Bar, Piraeus and Constanta. The Pilot Action included two steps:

- Tracking and tracing of cargo from China to Serbia, via the Port of Constanta and the Danube River, with an aim of gathering all relevant transport data (marked with "I" in Figure 1), as well as collecting all relevant data from logistic service providers for other alternative routes, China to Serbia via ports: Koper, Rijeka, Bar and Piraeus (marked with "II" in Figure 1).
- Development of an open source web-application that is using the multi-criteria decision making (three criteria: price, time, emissions) in order to compare different available intermodal transport routes from an origin to a destination of cargo flows, considering different types of containers and more potential shippers, and to suggest an optimal solution for the given criteria.

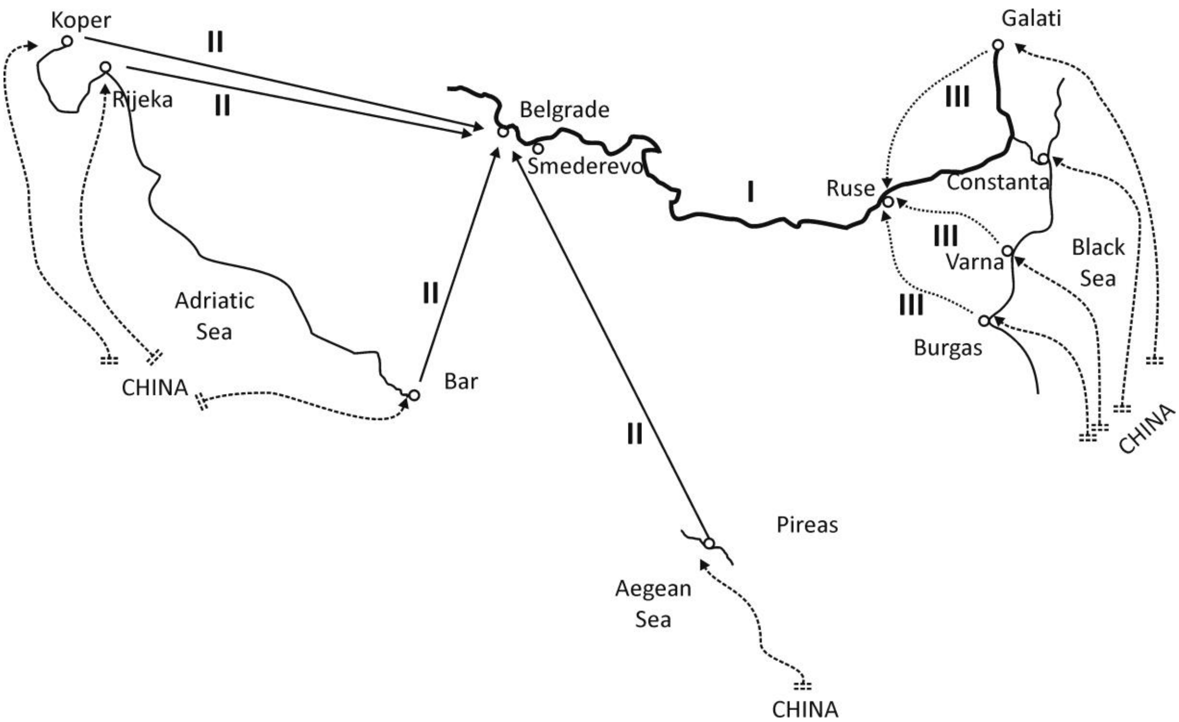


Figure 1. Graphical representation of Pilot Action

All information provided by the Pilot Action is documented in a Travel Book. Development of Travel Book aims to ensure precise and detailed information about transport and forwarding processes for the cargo flows coming to Serbia from China over the ports of Koper, Rijeka, Bar, Piraeus and Constanta. For the purpose of adequate expertise, the organization was carried out through tracking and tracing of one container from China to Serbia via the port of Constanta and bulk cargo from The Port of Constanta to Serbia port, using the inland waterway transport (IWT) on the Danube. The tracking and tracing include photos and video material, also enables detection of all existing bottlenecks. Through this research it was performed comparison of transport chain for cargo flows from China to Serbia, for every process and every segment of the transport, on selected routes (via ports of Koper, Rijeka, Bar, Piraeus and Constanta) for different scenarios, based on the three performance indicators and different heterogeneous criteria: time (minimum transit time), economical (minimum transport costs) and environmental (minimum CO2 emission).

In addition to this, the appropriate Route Inventory Survey was performed in order to investigate conditions and potential backups for the routes from other ports (such as Galati, Burgas, and Varna) which could act as an alternative Black Sea entry point for the cargo flows incoming from China to Serbia. On all of these routes, from the Port of Ruse to Belgrade, the IWT on the Danube is considered (including backup road and rail routes in the case of bad navigation conditions), while from the Black Sea ports to the Port of Ruse road and rail transport routes are analyzed (marked with "III" in Figure 1). All of these Route Inventory Survey (given as Annexes 1 to 6) represents supplement to the Travel Book in providing precise and detailed information about transport and forwarding processes related to cargo flows incoming from China to DBS region.

1.1 Background

Analysis of the current container flows and container transport routes in general

Maritime transport is the backbone of globalization and lies at the heart of cross-border transport networks that support supply chains and enable international trade. An economic sector in its own right that generates employment, income and revenue, transport, including maritime transport, is cross-cutting and permeates other sectors and activities. Maritime transport enables industrial development by supporting manufacturing growth; bringing together consumers and intermediate and capital goods industries; and promoting regional economic and trade integration.

Container transport today plays a very important role in the transport of goods with a constant tendency of growth in the context of global economic globalization. The advantages of container transport have been recognized since the 1980s, and they relate to the whole economy and even society as a whole. Increased number of business entities involved in the process, improved coordination and transport management, enabled the achievement of economies of scale in door-to-door modality, all of which led to cost savings and profit increases. World seaborne trade gathered momentum in 2017 (Figure 2), with volumes expanding at 4 percent, the fastest growth in five years. Supported by the world economic recovery and the improved global merchandise trade, world seaborne trade was estimated at 10.7 billion tons, with dry bulk commodities powering nearly half of the volume increase.

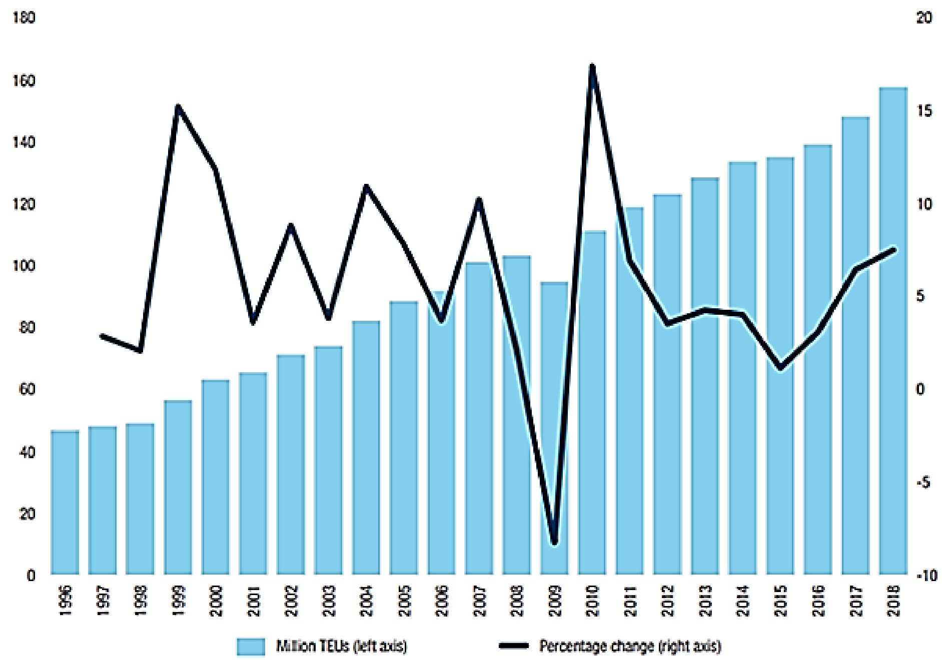
Figure 2. World seaborne trade in 2017 (source: *Review of Maritime Transport, 2018*)

Bearing in mind the low base effect, the recovery benefited all market segments; containerized trade and dry bulk commodities recorded the fastest expansion. Following the weak performances of the two previous years, containerized trade increased by 6.4 percent in 2017. Meanwhile, dry bulk commodities trade increased by 4.0 percent, up from 1.7 percent in 2016. Crude oil shipments rose by 2.4 percent, down from 4 percent in 2016, while, together, refined petroleum products and gas increased by an estimated 3.9 percent (*Review of Maritime Transport, 2018*).

Global containerized volumes reached 148 million TEUs (Figure 3), supported by various positive trends. The modest global recovery was crucial to the rise in containerized volumes. In addition, factors such as a recession in Brazil and the Russian Federation, increased consumption requirements in the United States, improved commodity prices, strong import demand from China and the rapid growth of intra-Asian trade reflecting the effect of regional integration and participation in global value chains, contributed to the recovery.

Trade growth strengthened on the major East–West trade lanes, namely Asia–Europe, the Trans-Pacific and Trans-Atlantic routes (Table 1 and Figure 4). Volumes on the Trans-Pacific route (eastbound and westbound) increased by 4.7 percent, while volumes on the East Asia–North America route (eastbound and westbound) increased by 7.1 percent. Overall, the Trans-Pacific trade lane remained the busiest, with total volumes reaching 27.6 million TEUs, followed by 24.8 million TEUs on the Asia–Europe route and 8.1 million TEUs on the transatlantic route. Growth accelerated across non-mainline routes (Table 2). Robust growth (6.5 percent) on the North–South trade route reflected improvements in the commodity price environment and the higher import demand of oil- and commodity-exporting countries. Supported by positive economic trends in

China, economic growth in emerging Asian economies, as well as regional integration and global value chains, volumes on the intra-Asian routes picked up, expanding by 6.7 percent. Containerized trade on the non-mainline East–West routes grew by an estimated 4.0 percent, with varied performances across individual routes; key factors were faster growth on routes within and outside the Indian subcontinent and slower growth on routes within and outside Western Asia(*Review of Maritime Transport, 2018*).



Source: UNCTAD secretariat calculations, based on data from MDS Transmodal, 2018.

Figure 3. Global containerized trade, 1996-2018

Table 1. Containerized trade on major East-West trade routes 2014-2018 (Million 20-foot equivalents and percentage annual change)

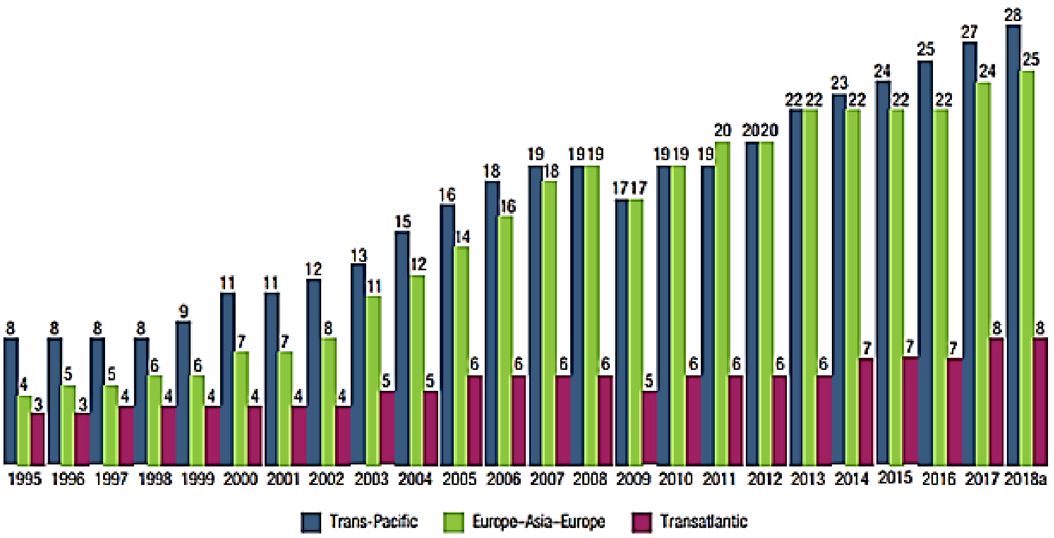
	Trans-Pacific		Asia–Europe		Transatlantic	
	Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound
	East Asia–North America	North America–East Asia	Northern Europe and Mediterranean to East Asia	East Asia to Northern Europe and Mediterranean	North America to Northern Europe and Mediterranean	Northern Europe and Mediterranean to North America
2014	15.8	7.4	6.8	15.2	2.8	3.9
2015	16.8	7.2	6.8	14.9	2.7	4.1
2016	17.7	7.7	7.1	15.3	2.7	4.2
2017	18.7	7.9	7.6	16.4	3.0	4.6
2018ª	19.5	8.1	7.8	16.9	3.2	4.9
Percentage annual change						
2014–2015	6.6	-2.9	0.2	-2.3	-2.4	5.6
2015–2016	5.4	7.3	3.8	2.7	0.5	2.8
2016–2017	5.6	2.1	6.9	7.1	8.0	8.3
2017–2018ª	4.1	3.0	3.2	3.3	7.3	7.1

Source: UNCTAD secretariat calculations, based on MDS Transmodal, 2018.

Table 2. Containerized trade on non-mainline routes 2016-2018

Intraregional		Intra-Asian	Non-mainlane East–West	North–South
Percentage annual change				
2016	5.0	5.6	4.9	1.9
2017	6.3	6.7	4.0	6.5
2018ª	6.1	6.8	5.2	6.4

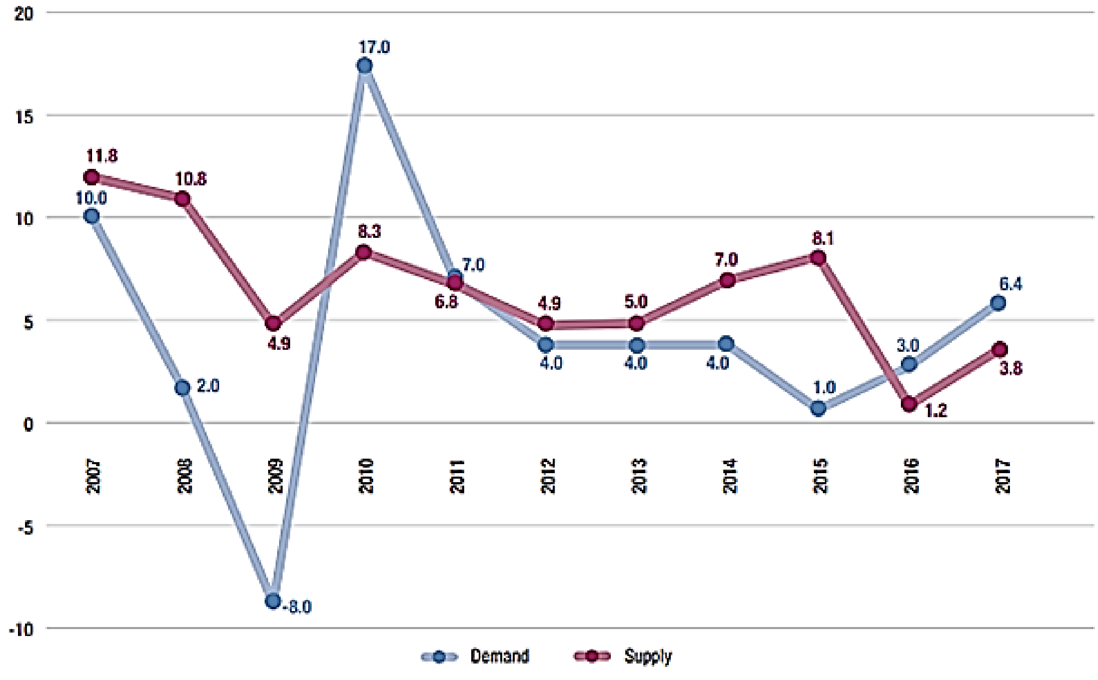
Source: UNCTAD secretariat calculations, based on data from Clarksons Research, 2018e.



Source: UNCTAD secretariat calculations, based on Economic Commission for Latin America and the Caribbean, 2010. Figures from 2009 onward are derived from data provided by MDS Transmodal and Clarksons Research.

Figure 4. Estimated containerized cargo flows on major East-West container trade routes, 1995-2018, (Million 20-foot equivalents units)

Global supply of container ship-carrying capacity grew at an estimate of 2.8 percent, bringing the total global capacity to 256 million dwt. Although supply growth was relatively moderate, the container market continued, nevertheless, to struggle with the delivery of mega container ships and surplus capacity among the larger vessels (exceeding 14,000 TEUs). World fleet capacity is projected to rise by 3 percent in 2018. Even though the supply of global container ship capacity continued in 2017, freight rates made a remarkable recovery from the lows recorded in 2016. This performance was supported by the upturn in the global demand for container transport services in 2017 across all trade lanes. As shown in Table 2, freight rates on the mainline trade routes went up, although they remained unpredictable, with a drop in the second half due to low demand growth. The surge was driven mainly by positive market trends in the developed regions. During the year, the United States and the European Union recorded economic growth and higher import demand. Average Trans-Pacific spot freight rates increased by 16.7 percent, with the Shanghai–United States West Coast routes averaging $1,485 per 40-foot equivalent unit (FEU). Rates on the Shanghai–United States East Coast route increased by 17.3 per cent over 2016 and averaged $2,457 per FEU. On the Shanghai–Northern Europe route, average rates stood at $876 per TEU, up by 27 percent, whereas Shanghai–Mediterranean rates averaged $817 per TEU, an increase of 19.4 per cent over the previous year.



Source: UNCTAD secretariat calculations, based on data from chapter 1, figure 1.5 for demand and Clarksons Research, *Container Intelligence Monthly*, various issues, for supply.

Figure 5. Grow of demand and supply in container shipping 2007-2017

On the non-mainline routes, robust growth in all trade clusters supported the positive development of freight rates, which rose sharply in 2017, outperforming those on the mainline trade routes. Among the North–South routes, the Shanghai–South Africa (Durban) freight rates averaged $1,155 per TEU, an increase of almost 98 percent compared with 2016. The Shanghai–South America (Santos) annual freight rates reached an average of $2,679 per TEU, an increase of 62.7 per cent over the 2016 average. These surges were mainly driven by large growth in demand from oil and commodity-exporting countries following the 2017 improvements in the commodity price environment. With regard to the intra-Asian routes, the Shanghai–Singapore route averaged $148 per TEU, compared with $70 per TEU in 2016, a 111.4 percent increase. These rates were supported by continued positive trends in the Chinese economy, as well as in other emerging economies in the region (*Review of Maritime Transport, 2018*).

Container flows are quite representative of global trade imbalances, which have steadily been growing since the mid-1990s. For instance, there are 2.2 times as many containers moving from Asia to the United States (17.9 million TEUs in 2017) than vice-versa, meaning that the equivalent of 9.7 million TEUs had to be repositioned across the Pacific. More than half the slots of containerships leaving the United States are for empties, particularly for major container ports such as Los Angeles. The Asia-Europe trade route is facing a similar imbalance. It is not uncommon to see whole containerships being chartered solely to reposition empty containers. Thus, production and trade imbalances in the global economy are clearly reflected in imbalances in the physical flows of containers and transport rates. Repositioning empties can account between 15 and 20 percent of the operating costs of a shipping line.

Freight market	2010	2011	2012	2013	2014	2015	2016	2017
Trans-Pacific	(Dollars per 40-foot equivalent unit)							
Shanghai–United States West Coast	2 308	1 667	2 287	2 033	1 970	1 506	1 272	1 485
Percentage change	68.2	-27.8	37.2	-11.1	-3.1	-23.6	-15.5	16.7
Shanghai– United States East Coast	3 499	3 008	3 416	3 290	3 720	3 182	2 094	2 457
Percentage change	47.8	-14.0	13.56	-3.7	13.07	-14.5	-34.2	17.3
Far East–Europe	(Dollars per 20-foot equivalent unit)							
Shanghai–Northern Europe	1 789	881	1 353	1 084	1 161	629	690	876
Percentage change	28.2	-50.8	53.6	-19.9	7.10	-45.8	9.7	27.0
Shanghai–Mediterranean	1 739	973	1 336	1 151	1 253	739	684	817
Percentage change	24.5	-44.1	37.3	-13.9	8.9	-41.0	-7.4	19.4
North–South	(Dollars per 20-foot equivalent unit)							
Shanghai–South America (Santos)	2 236	1 483	1 771	1 380	1 103	455	1 647	2 679
Percentage change	-8.0	-33.7	19.4	-22.1	-20.1	-58.7	262.0	62.7
Shanghai–Australia/ New Zealand (Melbourne)	1 189	772	925	818	678	492	526	677
Percentage change	-20.7	-35.1	19.8	-11.6	-17.1	-27.4	6.9	28.7
Shanghai–West Africa (Lagos)	2 305	1 908	2 092	1 927	1 838	1 449	1 181	1 770
Percentage change	2.6	-17.2	9.64	-7.9	-4.6	-21.2	-18.5	49.9
Shanghai–South Africa (Durban)	1 481	991	1 047	805	760	693	584	1 155
Percentage change	-0.96	-33.1	5.7	-23.1	-5.6	-8.8	-15.7	97.8

Intra-Asian	(Dollars per 20-foot equivalent unit)							
Shanghai–South-East Asia (Singapore)	318	210	256	231	233	187	70	148
Percentage change		-34.0	21.8	-9.7	0.9	-19.7	-62.6	111.4
Shanghai–East Japan	316	337	345	346	273	146	185	215
Percentage change		6.7	2.4	0.3	-21.1	-46.5	26.7	16.2
Shanghai–Republic of Korea	193	198	183	197	187	160	104	141
Percentage change		2.6	-7.6	7.7	-5.1	-14.4	-35.0	35.6
Shanghai–Hong Kong SAR	116	155	131	85	65	56	55	—
Percentage change		33.6	-15.5	-35.1	-23.5	-13.8	-1.8	—
Shanghai–Persian Gulf/ Red Sea	922	838	981	771	820	525	399	618
Percentage change		-9.1	17.1	-21.4	6.4	-36.0	-24.0	54.9

Source: Clarksons Research, *Container Intelligence Monthly*, various issues.
Note: Data based on yearly averages.
Abbreviation: SAR, Special Administrative Region

Figure 6. Freight rates 2010-2017, main container trade routes

For trans-Pacific trade, it costs more per TEU for eastbound flows than for westbound flows, making freight planning a complex task for container shipping companies. For Asia-Europe flows, westbound rates are higher than eastbound rates. Thus, production and trade imbalances in the global economy result in imbalances in physical flows and transport rates. Even if eastbound trans-Pacific rates are lower than westbound trans-Pacific rates, in theory conferring an advantage to American exports, costs differences are so in favor of Asia (China) that the American economy does not take much advantage of this benefit.

The issue of imbalanced container flows does not show evidence of receding, although its share of total container flows, at 20 percent, has stabilized. However, as global container volumes increase, the absolute number of empty containers requiring to be repositioned increases as well. This requires additional physical capabilities in terms of terminal storage space and container shipping slots. Trade between an origin group of countries and a destination group of countries is referred to as a trade route. Figure 7 presents top trade routes (TEU shipped) in 2017. There are about 500 liner shipping services providing regularly scheduled service (usually weekly) that enable goods to move between ports along the many trade routes of the world (Figure 8).

Route	West Bound	East Bound	North Bound	South Bound	Total
Asia-North America	7,490,000	19,482,000			26,572,000
Asia-North Europe	9,924,000	5,139,000			15,063,000
Asia-Mediterranean	5,504,000	2,409,000			7,913,000
Asia-Middle East	3,340,000	1,400,000			
North Europe-North America	3,284,000	2,120,000			5,404,000
Asia-East Coast South America			730,000	1,344,000	2,074,000
North Europe/Mediterranean-East Coast South America			830,000	850,000	1,680,000
North America-East Coast South America			794,000	474,000	1,268,000

Figure 7. Top trade routes in TEU for 2017 (source: World Shipping Council)

ROUTE	SERVICES
Asia-East Coast North America	19
Asia-West Coast North America	54
Asia-North Europe	20
Asia-Mediterranean	29
North Europe-North America	32
Mediterranean-North America	17
Asia-Middle East	43
Asia-South Asia	53
North America-Mid-East/South Asia	10
South Asia-Europe	20
Middle East-Eastern Europe	36
Oceania	46
East Coast South America	14
West Coast South America	31
South Africa	19
West Africa	46
Total	**487**

Notes: Services may be counted on more than one route.

Figure 8. Liner shipping services 2017 (source: Drewry Container Forecaster Q1&Q2 2018)

Proposal of the container transport route using IWT on the Danube

The possibilities for container transport on the Danube are always considered when one wants to emphasize the advantages of this powerful river and when plans are being developed for the development of numerous potential activities in and around the Danube region. Justified or not, but the very realization of the transport of containers on the middle and lower Danube and the surrounding inland waterways ends with sporadic attempts and theoretical discussions, hoping that the circumstances will change and that on these waterways in the future we have many more containers.

In the past there were attempts to transport certain container lots for dedicated jobs. Only in 2005 a relatively regular container line Constanta-Belgrade-Constanta was established, and a year later the line Constanta-Budapest-Constanta. The first service experienced its peak in 2008 when more than 2,800 TEUs were transported, but the global economic crisis and the overall reduced volume of economic activities resulted in a reduction in the number of transported containers, the irregularity of the service itself, and the prolongation of transit times. The service was not exclusive, but it took place with the additional vessels in the convoy, which significantly reduced the quality of the service itself and which affected the loss of confidence of liner shipping container shippers and the owners of goods.

The service from Budapest to Constanta was subsidized by the EU through the Marko Polo project. Its main disadvantage was the upstream overcrowding of empty container equipment for the needs of Hungarian exports, which was again backward by the railroad on the Budapest-Koper route, and its duration was limited by the period of the subsidy. Both services are not active at the moment, and in the lower Danube it is not possible to talk about a more serious service, but about dedicated services, without the features of a regular liner service. A logical question arises as to why there was no serious development of container transport on the Danube, Sava and other inland waterways in the region. The theory lists two basic factors for the success of a containerized inland service:

- Passable waterway of certain category;
- Modern terminals on the waterway.

Also, for the transport of containers by river, the following parameters are important: the price of transport in relation to alternative routes and modes of transport, the speed of transport, the distance of the final destination from the ports, the regularity of the service, the economic activity of the region, the distance of commercial centers from waterways and ports therefore, the number of transported or potential container units, the balance in imports and exports in the region, the state of the infrastructure, the habits of the service users, the administrative formalities in transport, the possible risks, the different interests of freight forwarding companies, and more. Individual analysis of these factors would give many answers to the above question, but complex analysis requires much more time, and this is the intention to point out only some reasons that affect this state of container transport on the middle and lower Danube and other inland routes areas.

The price of the container transport should be considered as a unique price to the end user, and not only as the cost of transporting containers on inland waterways. The key part of the total price is ocean freight to and from the port of Constanta to or from the extreme destinations, all compared with those prices to competitive ports in the surrounding area such as the Adriatic ports of Rijeka, Koper and Bar, as well as the port of Thessaloniki and Piraeus in Aegean. These prices are variable monthly, even more often, so if prices across the Black Sea ports, especially the Constanta, were more favorable by the middle of the past decade, this situation has changed over the past five to seven years, precisely because of the increased economic activity in this region.

With similar prices of ocean freight to competitive ports as the carrier of transport routes, a comparative analysis of the quality and price of the services on the Danube to the final destination is reflected. This is one of the key factors of the competitiveness of the container service on the Danube in relation to other directions, and not on other modes of transport in the same direction. The distance from Constanta to Belgrade by waterway is about 940 km, and the road and rail competitor routes to Rijeka and Bar are from 500 to 550 km (the distance of sea ports from Belgrade). At present, the river line transport of the container does not manage to be competitive in relation to road and rail transport from the Adriatic ports in terms of transit time, the quality of the complete infrastructure, and also the prices in this part of the transport from and to the listed seaports.

The cost and fees of this transport are also affected by the number of containers in individual transports, as well as the time of the ship's rotation, and again the number of transport containers depends on the price and the transit time, and so on. The minimum barge occupancy of 75% which allows shipping companies the cost-effective transportation of containers on inland waterways at this time is simply not achievable without jeopardizing the acceptable turnover of the ship. Based on the experience, and in order to maintain an acceptable transit time anddiscuss the possibilityfor regular liner service, the optimal number of departures would be three times a week, and at least two in both directions, upstream and downstream.

The regularity of the liner service depends on the frequency of difficult navigation on waterways, and we are well aware of the problems with the low water level of the Danube on critical sections (there are over 35 bottlenecks on the middle and lower Danube), the appearance of ice, al and the prohibition of navigation due to high water levels of this river. Alternative solutions in this direction by rail and road transport are not cost-competitive and increase the risk of serious financial losses.

Provided there are two basic elements for a regular liner container service on inland waterways, which are a passageway and modern terminals on waterways, the category of transport volumes as a factor should be introduced immediately, with the increase automatically increasing all the comparative advantages of liner container transport on inland waterways, in relation to road and rail transport on comparable destinations. SWOT analysis are given in Table 3.

The transport managers and the liner shipping container themselves have a major role in determining the routes to which the containerized goods will move. They can influence the change of transport routes, but only under the condition of full competitiveness. The logistics and transport routes are difficult to change, except in cases where they offer significantly more favorable transport conditions. Many freight forwarders use their own road vehicles with platforms for the transport of containers, which puts container transport in inland waterway in an inferior position.

The regional organization of maritime container ships is also unfavorable for goods for the Republic of Serbia market. The Serbian market is under the control of regional centers located in Genoa, Rijeka, Koper or Ljubljana, so that goods for and from Serbia are systematically installed over the Adriatic ports, and there is often a certain lack of binding of these regional centers with regional centers in Constanta, who are in charge of the markets of Romania and Bulgaria. On the other hand, river shipping is interested in the transport of containers, but on condition that they can provide 75% of the ship's capacity, which risk transfers to transport organizers or organizers of the service itself.

Table 3. SWOT analysis of the container transport route using IWT on the Danube

STRENGHTS: Lower costs in the part of river transport from / to Constanta in relation to road and rail transport to seaports in the environment. Less congestion of the infrastructure. Possibility of transporting large container lots through individual and frequent transportation. Possibility of transporting "heavy containers" over the allowed road transport limits. Possibility of easier transportation of special containers. Possibility of faster and cheaper delivery of empty container equipment for bigger jobs and cheaper relocation of equipment according to needs and seasonal peaks. Increased competitiveness for certain markets in the Black Sea region. Great benefits from an environmental aspect.	WEAKNESSES: Long transit time. Lack of modern three-way edge terminals. Lack of conditions for the transport of all types of containers (frigo). Poor infrastructure on the waterway. The need for further transportation by road to the final destination. Insufficient schedule of economic centers in the lower Danube.
OPORTUNITIES: Shortening the transit time by a stand-alone service with a lone body of about 1,000 tons of capacity and a smaller gauze and frigo container equipment. Fast and high-quality regulation of waterways, especially on critical sections. Construction of modern commodity terminals along the waterways. Suitable for the development of grain transport in containers, which would significantly increase the amount of transported containers.	THREATS: Increased risk of irregular service due to prohibition and difficult navigation. Non-competitiveness of alternative modes of transport in case of difficult navigation on the Danube. Poor infrastructure. Increase in shipping costs to the port of Constanta due to increased demand or reduction in the number of services.

Increasing the economic activity of the regions that gravitate to the Danube and the Sava River Basin, as well as other inland waterways. Increase in the share of containerized goods in the total transport of goods. Training of as large a network of inland waterways (channel network, Sava, Tisa and other rivers). Significant increase in the quality of the complete infrastructure. Animation of as many liner shipping containers as possible for the development of the Danube route as regular services. Using the transport of goods with their own containers on inland waterways, as a substitute for road transport.	

In order to accelerate the development of container transport on the Danube and other inland waterways it is necessary to provide the following:

- A passable fairway of adequate category;
- Modern trimodal logistic terminals on waterways;
- Regular service 2 to 3 times a week in both directions;
- Short transit time and fast-turning boats;
- To achieve a competitive price in relation to rail and road transport from the seaports;
- Provide short retention due to administrative formalities in ports and border crossings;
- To equip ports with modern equipment for unloading and support of all types of container equipment;
- Organize fast and economical shipping of goods from the port and warehouse to the final destinations;
- More aggressively, the advantages of the container service on waterways;
- Planned and earmarked funds from EU development funds and budgets for developing these projects.

In Northern and Western Europe, container transport on inland waterways functions at a high level with high frequency. The reasons for this situation are numerous: regulated waterways, modern terminals and warehouses, regular services and high frequency, fast turnover of ships, grouping of containers on certain lines, developed economic activity, branched channel network along water flows, optimal the availability of ships that affects the economy of this transport per unit, developed infrastructure in ports, fast ship movements and reduced administration.

Container transport on inland waterways, on the Danube, Sava, Tisa and channel networks, has a certain prospect. How much longer we will wait for it to develop will depend in many ways on ourselves.In order to organize a quality and sustainable service it is necessary to change a lot, not only because of the container service, but also because of the development of river traffic on the Danube, Sava and all inland waterways. Serbia has only on the Danube 599 km of the Danube waterway, 178 km of the Sava waterway, and this sum can be significantly increased if the potentials of the Tisa and the canal network are added. How much would it cost us to build roads or railways of that length? We get this road for free, it is a gift of nature.Thus, this waterway must be connected to the lower and upper Danube streams. It is necessary to quickly solve evident problems together with other countries in the region in order to get quality, economical and above all functional container transport on inland waterways in the region.

1.2 Scope and objective of the research

Transportation costs and transit time are the two most commonly considered problems in container transport. Also, carbon dioxide emissions can no longer be ignored: on the one hand, companies have a moral obligation to operate in a sustainable way, and on the other hand, as customers become more and more aware of the enormous impacts on the environment. The one of the main goals of this project research is the concept of multimodalism and the creation of a new generic knowledge for making the optimal decision in terms of more adopted heterogeneous criteria: transport costs, transit time, carbon dioxide emissions. The advantage of this research is that it can be applied to different nodes and container merchandise flows in intermodal networks, taking into account concept of multimodalism by itself. In the practical domain, the expected results provide companies with the ability to make decisions about transport routes, taking into consideration all three optimized criteria, leaving the possibility of decision depending on the weight coefficients that are considered at the moment as the most significant ones.

The main outputs of this project activity would be some kind of information and data support for developing appropriate open source web-application which should help in intermodal transport routes decision making process. All information collected and provided by the Pilot Action is documented in a Travel Book. Therefore, a Travel Book represents collected and gathered transport data from two kinds of sources. First, the data collection was carried out through tracking and tracing of one container from China to Serbia via the port of Constanta and bulk cargo from The Port of Constanta to Serbia port, using the inland waterway transport (IWT) on the Danube. On that way, precise and detailed information about transport and forwarding processes for the cargo flows coming to Serbia from China over the ports of Constanta was collected. In addition to this way of data collection, the appropriate Route Inventory Survey was performed in order to prove ability of other Black Sea ports (such as Galati, Burgas, and Varna) to act as an alternative Black Sea gateways for cargo flows incoming from China to Serbia. Second, the relevant data was collected from logistic service providers for other alternative routes China to Serbia via ports: Koper, Rijeka, Bar and Piraeus. Based on the data gathered through the tracking of cargo and collected from inquiries, a database was created. It was used for the creation and testing of the open source web-application that is using the multi-criteria decision-making for comparison of the defined intermodal transport routes from China to Serbia, considering different types of containers and more potential shippers.

The developed application enables multi-criteria analysis of potential routes. It is very important due to reason that a small number of researchers related to container transport are dealing at the same time taking with several criteria. In most cases, models are based on the minimization of just one parameter, where the transportation cost is the main subject of decision making. However, an adequate way to make the best decision in the context of the existence of multiple heterogeneous criteria, which are often mutually opposed, is to use multi-criteria decision-making methods. Therefore, within the framework of this investigation, the search for the best solution is sought from a number of acceptable solutions in terms of more adopted criteria: minimum transit times, lowest transport costs and minimum emissions during the transport of containers, in view of the maritime and inland transport network.

The knowledge in decision making with multi-criteria evolutionary algorithms is a convenient approach that can help companies in decision-making and business improvements by continuously monitoring market changes in a reliable way, in order to compare existing differences. The essence is to build an appropriate mathematical model that will provide accurate information when transporting containers between logistics nodes. Basically, the model would provide the following information:

- The efficiency of analyzing a number of permissible solutions in terms of more widely adopted heterogeneous criteria taking into account the maritime and inland transport network, analyzing at the same time different types of transport and different types of containers.
- Simple selection of weight coefficients whose change is defined and evaluated by the desired criteria.
- Quick information, short execution time of programs in the absence of existing software packages.
- Generate a whole set of potential solutions at the same time.

Hence, the final result of the Pilot Action is open source web-application which is based on a new generic knowledge for making the best decision in terms of more adopted heterogeneous criteria.

1.3 Structure of the research

The structure of this research is organized as follows:

Section 2 reports on the tracking and tracing of one container and bulk cargo transportation from China to Serbia via the port of Constanta, using the IWT on the Danube.

Section 3 reports on the relevant data gathered from the logistic service providers for other alternative routes between China to Serbia via ports: Koper, Rijeka, Bar and Piraeus.

Section 4 presents the definition of the criteria for multi-attributive decision making, and make comparison of the transport chain for cargo flows from China to Serbia on selected routes for different scenarios.

Finally, Section 5 is devoted to conclusions and recommendations.

2 Tracking and tracing of the container flows from China to Serbia via port of Constanta using IWT on the Danube

2.1 Detailed description of the transport chain

For the purpose of adequate expertise, the organization was carried out through tracking and tracing of one container from China to Serbia via the port of Constanta and bulk cargo from The Port of Constanta to Serbia port, using the IWT on the Danube. During this research we choose *Hapag Lloyd Equipment* because of longest demurrage and detention free time in POD–The Port of Constanta and CFS - Belgrade. Transport route of the subject container is:

- Origin: Port of Shanghai, China
- Port of transhipment: Port of Constanta, Romania
- Port of discharge: Port of Smederevo, Serbia
- Final place of delivery: Belgrade, Serbia

Client who participates in this project is Strukturcom d.o.o importing Led panels from China. Container number/seal number: HLBU1731637/HLB5176091-20db. Other basic data are provided in Table 4. Transport plan in this project consists of 5 phases:

- Picking up an empty container from the port yard and stuffing it at shippers warehouse;
- Returning the subject container to the port yard;
- Transport of the subject container from the Port of Shanghai to the Port of Constanta;
- Transport of subject container from the Port of Constanta to the Port of Smederevo;
- Transport of subject container from the Port of Smederevo to the Belgrade customs office and delivery/ unloading to client warehouse.

Table 4. Basic data of transport route

Client	**Strukturcom doo**
Container	HLBU1731637
Container seal number	HLB5176091
Container type	20db
Vessel	Mackinac Bridge
Voyage	V.017W
Port of Loading (POL)	Shanghai
Port of Discharge (POD)	Constanta
ATD-Actual time of departure	23.11.2018.
ATA-Actual time of arrival	31.12.2018.
Final Destination	Belgrade via Smederevo
Cargo details	Led panels/5820kg/26cbm

For tracking position of subject container, we used GPS tracking device ZT 20, positioned inside container sending us real time position of container. Tracking device ZT 20 are shown on Figure 9 and Figure 10, also technical data about device are shown in Figure 11.

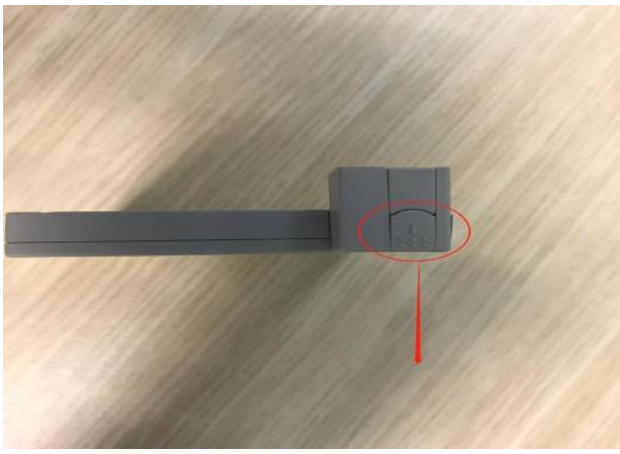


Figure 9. ZT 20 Tracking device

Figure 10. ZT 20 tracking device

ZT-20 Data Acquiring Speed and Battery Life

	ZT-20	
Data Acquiring Speed	30 seconds	79.67%
	60 seconds	80.33%
	2 minutes	81.33%
	5 minutes	96.33%
Battery Life	Total Reporting Period:	30 Days
	Total Reporting Times:	718 Times
	Average Reporting Frequency:	1 Hours 12 Minutes

Figure 11. Technical data of tracking device ZT 20, used in project

Phase 1- Picking up empty container from the port yard

Empty container (HLBU1731637) where picked up on 14.11.2018, positioned on shippers warehouse for stuffing on 15.11.2019. Figure 12 shows stuffing the cargo into the container. Also, Figure 13 below shows position from ZT 20 tracking device.


Hapag-Lloyd







Figure 12. Stuffing cargo in container at shippers warehouse

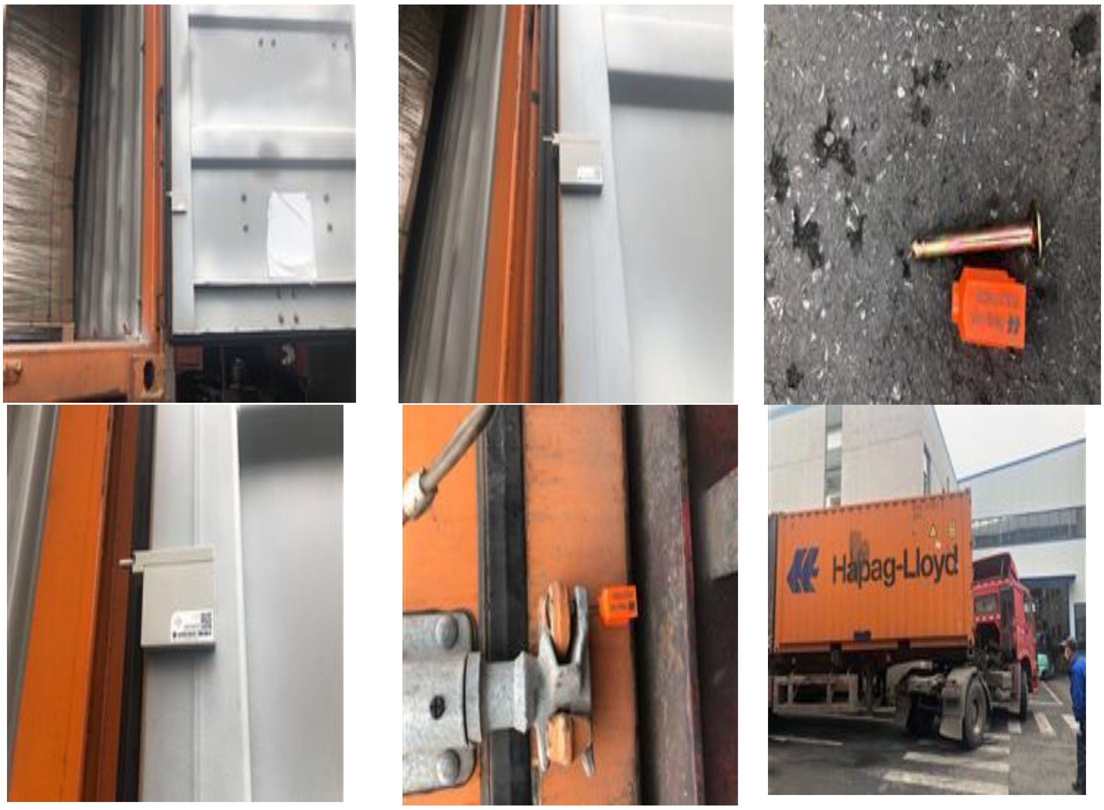


Figure 12. (Continued)

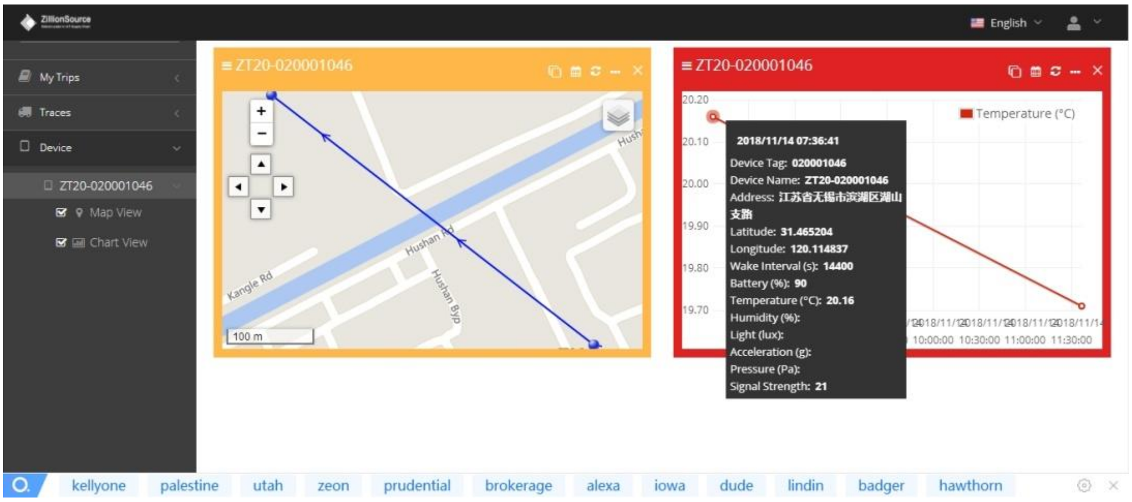


Figure 13. Shows position of cargo, at shippers warehouse

After container where stuffed and export customs clearance procedure where completed, container where transported to the port yard of Shanghai.

Phase 2- Bringing of the subject container back to the port yard

Container where unloaded from truck at port yard of the Port of Shanghai on same day -15.11.2018. and left on the yard, waiting for mother vessel to pick it up and transport to the Port of Constanta. Below, Figures 14 are showing container being unloaded from the truck at the Port of Shanghai.

Figure 14. Container is unloaded at the Port of Shanghai

After container are drooped in port yard, transport document are being created. House bill of Lading are shown on Figure 15.

Shipper
SUPTEC ELECTRONIC CO., LTD

B/L No.
XYSH18011214
HLCUSHA1811HYTE6

OCEAN BRIGHT LOGISTICS LIMITED
BILL OF LADING
NVOCC NO.: SMTC-NV00496

Received from the shipper in apparent good order and condition unless otherwise indicated herein the Goods or the container(s) or package(s) said to contain the cargo herein mentioned, to be carried subject to all the terms and conditions appearing on the face and back of this Bill of Lading by the vessel named herein or any substitute at the Carrier's option and/or other means of transport, from the place of receipt or the port of loading to the port of discharge or the place of delivery shown herein and there to be delivered unto order or assigns. If required by the Carrier, this Bill of Lading duly endorsed must be surrendered in exchange for the Goods or delivery order.
In accepting this Bill of lading, the Merchant agrees to be bound by all the stipulations exceptions, terms and conditions on the face and back hereof, whether written, typed, stamped or printed, as fully as if signed by the Merchant, any local custom or privilege to the contrary notwithstanding, and agrees that all agreements or freight engagements for and in connection with the carriage of the Goods are superseded by this Bill of Lading.
In witness whereof, the undersigned, on behalf of the Master and the owner of the Vessel, has signed the number of Bill(s) Lading stated below all of this tenor and date one of which being accomplished, the other to stand void.

Consignee
COMPANY NAME: STRUKTURCOM DOO
ADDRESS: BUL. ARSENIJA CARNOJEVICA 73, 11070
BELGRADE, SERBIA

Notify Party
SAME AS CONSIGNEE

For delivery of goods please apply to:
WORLD TRANSPORT OVERSEAS SERBIA
VILINE VODE BB L14-6, 11000 BEOGRAD
TELEPHONE: +(381 11) 7850 254/5/6/7/8

Pre-Carriage by	Place of receipt
Ocean vessel / Voy. No.: MACKINAC BRIDGE V. 017W	Port of loading: SHANGHAI
Port of discharge: CONSTANTA	Place of delivery: CONSTANTA

Final destination for the Merchant's reference

Container No.	Seal No. Marks and Numbers	No. of Containers or pkgs.	Kind of Packages: description of goods	Gross weight	Measurement
	N/M	250CARTONS	SHIPPER'S LOAD, COUNT AND SEAL SOLAR MODULE	6390KGS	26CBM

Particulars furnished by shipper

ORIGINAL

HLBU1731637 HLB5176091

SHIPPED ON BOARD
23 NOV 2018

CY TO CY 1X20'GP
FREIGHT COLLECT

*Total number of Containers or other Packages or units received by the Carrier (in words): SAY TWO HUNDRED AND FIFTY CARTONS ONLY.

Freight and charges	Revenue tons	Rate	Per	Prepaid at	Collect

Exchange rate	Prepaid	Payable at	Place and date of issue: SHANGHAI 2018-11-23
	Total prepaid in national currency	No. of original B(s)/L: THREE	OCEAN BRIGHT LOGISTICS LIMITED

Date
SHIPPED ON BOARD THE MESSRS VESSEL

For and on behalf of OCEAN BRIGHT LOGISTICS LIMITED
As Carrier
Authorized Signature As Carrier

0945236

Figure 15. House bill of Lading

Phase 3-Transport of subject container from the Port of Shanghai to the Port of Constanta

Subject container where loaded on vessel on 23.11.2018. and vessel sailed on same day-23.11.2018. Transit time to the Port of Constanta where 35 days planned and container arrived in the Port of Constanta on 31.12.2018. – actual time of arrival. Container was unloaded from vessel on same day. Figure 16. shows the signal from GPS ZT 20 device, showing that the container arrived in the Port of Constanta.

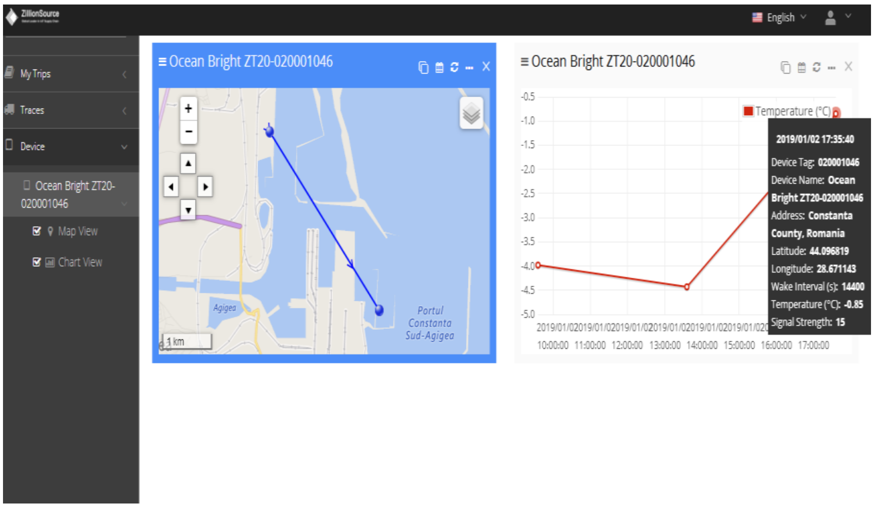


Figure 16. Container arrived at The Port of Constanta

Phase 4 - Transport of the subject container from the Port of Constanta to the Port of Smederevo

As already has been mentioned, mother vessel Mackinac Bridge left the port of Shanghai on 23.11.2018. and arrived on the Port of Constanta on 31.12.2018. Transit time where 38 days, even if planned transit time where 35 days. Mother vessel arrived and container unloaded from vessel on 02.01.2019. Unloading took 2 days because of the New Year's holiday. After container finally touch the ground at the Port of Constanta, our transport planners begin process of planning 4 phase of this project. All transit documents are shown in Figures 17a to 17f.

M/S EMMA
PORT: CONSTANTA / ROMANIA
DATE: 15.01.2019

MASTER'S RECEIPT OF DOCUMENTS
FOR RECEIVERS

THIS IS TO CERTIFY THAT I, REPRESENTATIVE OF M/S EMMA CONFIRM THAT I HAVE RECEIVED ON BOARD FROM "PHOENIX RIVER TRANS SRL" THE FOLLOWING CARGO DOCUMENTS:

BARGE DE 16133

1) 3/3 ORIGINAL BILL OF LADING 28 / 15.01.2019
2) 4 NON NEGOTIABLE COPY BILL OF LADING 28 / 15.01.2019
3) 5 ORIGINAL CARGO MANIFEST 28 / 15.01.2019
4) T1 ORIGINAL
5) MASTER'S RECEIPT
6) 1 TRANSIT DECLARATION CONFIRMATION

MASTER OF
M/S EMMA

M/S EMMA
TOMI KARGO BN D.O.O.
J. Zm... 4
B R C K O

Figure 17a. Transit documents for transport from Constanta to Smederevo

1. Expeditorul si adresa Shippers and their address **SUPTEC ELECTRONIC CO. , LTD**	7. Scrisoare de trasura nr. Bill of Lading No. **28** **S.C. PHOENIX RIVER TRANS S.R.L.**
2. Destinatarul si adresa Consignees and their address **WORLD TRANSPORT OVERSEAS SERBIA VILINE VODE BB L14-6, 11000 BEOGRAD ON BEHALF OF STRUKTURCOM DOO ARSENIJA CARNOJEVICA 73 , 11070 BELGRADE , SERBIA**	8. Numar de originale Number of originals **3/3**
3. Adresa avizatului Notify and address **STRUKTURCOM DOO ARSENIJA CARNOJEVICA 73 , 11070 BELGRADE , SERBIA**	9. Transportator Carrier **"TOMI Kargo BN" d.o.o.**
4. Nava / Armator Vessel / Ship owner **DE 16133** 5. Portul de incarcare Port of loading **CONSTANTA, ROMANIA** 6. Portul de descarcare Port of discharge **SMEDEREVO , SERBIA**	10. Transportul marfurilor se efectueaza in baza prevederilor valabile ale "CMNI" The shipment/transportation of the goods is subject to terms of the "CMNI" COPY NON NEGOTIABLE

11. Marci si numere Marks and numbers	12. Felul ambalajului si denumirea marfi Kind of packages and description of goods	13. Numarul de bucati Number of pieces	14. Greutate Weight
HLBU 1731637 **HLB 5176091**	**250 CARTONS SOLAR MODULE**	**1X20` GP**	**CARGO WEIGHT - 6390 KGS** **GROSS WEIGHT INCL TARE – 8640 KGS**

15. Navlu
Freight and charges

"FREIGHT COLLECT"

16. Pescaj Draft	18. Instructiuni de plata Payment instructions	20. Locul si data intocmirii, semnatura si stampila Place and date of issue, signature, stamp **CONSTANTA, ROMANIA 15.01.2019** **MASTER OF M/S EMMA** M/S EMMA TOMI KARGO BN D.O.O. J. Zmaja 4 BRČKO
17. Greutate conform pescaj Weight as per draft	19. Anexe si sigilii Enclosure and seals	

Figure 17b. Transit documents for transport from Constanta to Smederevo

S.C. PHOENIX RIVER TRANS S.R.L.

CARGO MANIFEST

Vessel	Port of loading	Port of discharging
DE 16133	CONSTANTA, ROMANIA	SMEDEREVO , SERBIA

B/L No.	Shipper / Consignee / Notify	Goods: Packages	Goods: Contents	Weight	Remarks
28	Shipper SUPTEC ELECTRONIC CO. , LTD Consignee WORLD TRANSPORT OVERSEAS SERBIA VILINE VODE BB L14-6, 11000 BEOGRAD ON BEHALF OF STRUKTURCOM DOO ARSENIJA CARNOJEVICA 73 , 11070 BELGRADE , SERBIA Notify STRUKTURCOM DOO ARSENIJA CARNOJEVICA 73 , 11070 BELGRADE , SERBIA	HLBU 1737637 1X20` GP HLB 5176091	250 CARTONS SOLAR MODULE	CARGO WEIGHT - 6390 KGS GROSS WEIGHT INCL TARE - 8640 KGS	"FREIGHT COLLECT"

CONSTANTA, ROMANIA / 15.01.2019
AS AGENTS ONLY

SC PHOENIX RIVER TRANS SRL ROMANIA

MASTER OF M/S EMMA

M/S EMMA
TOMI KARGO BN D.O.O.
J.Zmaja
BRČKO

Figure 17c. Transit documents for transport from Constanta to Smederevo

COMUNITATEA EUROPEANĂ

TIPUL DECLARAȚIEI(1) T1 — MRN 19ROCT190000026820

Formulare(3) 001 — Declarat(200) S

Articole(5) 1 — Total Coldete(6) 250 — Greutate Brut (kg)(35) 6390

A — TSAD

2 Expeditor/Exportator Nr.
SHENZHEN SUPTEC ELECTRONIC CO LTD
SHANGHAI
CHINA
N/A CN

8 Destinatar Nr.
WORLD TRANSPORT OVERSEAS SERBIA
VILINE VODE BB, BELGRADE
11000
N/A RS

Numere de Referință(7) 19PO598/VPLS

Exemplarul de retur se remite Biroului ROANV002 DGV - Serviciul Tranzit
Alexandru Ivasiuc nr.34-40,
Sector 6, Bucuresti ROMANIA RO

Data și ora sosirii la primul loc de sosire pe teritoriul vamal (S12)

Cod modalitate de plata cheltuieli de transport (S29)

Cod țară exped./exp(15) China — Cod țară dest(17) Serbia

Identitatea și naționalitatea mijlocului de transport la plecare (18) BARJA;DE16133 RO

Identitatea și naț. Mijloc transport activ care trece frontiera(21) BARJA;DE16133 RO

Mod de transport la frontieră (25) 80 — Localizarea mărfurilor (30)

56 Alte incidente în cursul transportului — Relatarea faptelor și măsurilor luate

G VIZA AUTORITĂȚILOR COMPETENTE

Locul de încărcare (S17) CONSTANTA SUD — Locul de descărcare (S18) SMEDEREVO

A — Număr de referință al transportului(S10)

Codul țării(țărilor) de pe itinerary (S13)
CN RO RS

Destinatar (securitate) S06 Nr.
WORLD TRANSPORT OVERSEAS SERBIA
VILINE VODE BB, BELGRADE
11000
N/A RS

Expeditor (securitate) S04 Nr.
SHENZHEN SUPTEC ELECTRONIC CO LTD
SHANGHAI
CHINA
N/A CN

Transportator S07 Nr. RO14726357
PHOENIX SHIPPING SRL
SARMISEGETUZA 52
CONSTANTA
900696 RO

Număr Sigiliu(S28)

Transbordări(55)
Locul și țara: — Locul și țara:
Identitatea și naționalitatea noului mijloc de transport: — Identitatea și naționalitatea noului mijloc de transport:
Ctr. (1) Identitatea noului container — Ctr. (1) Naționalitatea noului container:

VIZA AUTORITĂȚILOR COMPETENTE (F)
Noile sigilii: Număr: mărci: — Noile sigilii: Număr: mărci:
Semnătura: Ștampila: — Semnătura: Ștampila:
Date deja înregistrate în sistem — Date deja înregistrate în sistem

Principalul obligat/titularul TIR(50) Nr. RO16662942
BETA INTERTRANS SRL
PORTUL CONSTANTA BAZA MOL 4
CONSTANTA 900900 RO

BIROU DE PLECARE(C) ROCT1900
CONSTANTA SUD AGIGEA
CLAD.APMC MOL 1S,INCINT.PORT AGIGEA
907015
AGIGEA, JUD. CONSTANTA
Data acceptării: 2019-01-15

Birouri de trecere prevăzute (și țări) (51)

52 Garanție nevalabilă pentru — Cod 6 — Birou de destinație (și țara) (53) CALAFAT

CONTROLAT LA BIROUL DE PLECARE (D)
Rezultat: A1 Satisfacator
Sigilii aplicate: Număr: 1
mărci: 0353576
Termen (data limită): 2019-02-15

CONTROLAT LA BIROUL DE DESTINAȚIE (I)
Data sosirii:
Controlul sigiliilor:
Observații:

Exemplarul de retur trimis la data de după înregistrarea sub nr.
Semnătura Ștampila

Figure 17d. Transit documents for transport from Constanta to Smederevo

B Plecare: ROCT1900

Data: 2019-01-15

19ROCT190000026820

LISTĂ ARTICOLE TRANZIT/SECURITATE	Formular(3) 2						
Art. nr.(32)	Nr. și natura coletelor/buc. mărci și nr. colete(31/1)			Descrierea mărfurilor(31/2)			
Expeditor/Exportator(2)				Destinatar(8)			
Expeditor(securitate)(S04)				Destinatar(Securitate)(S06)			
Documente prezentate/certificate(44/1)				Declarație Sumară/Document Precedent(40)			
				Mențiuni Speciale(44/2)			
Identitatea și naț. Mijloc transport la plecare(18)				Număr de identificare unic pt. loturi(7)			
Identitatea și naț. Mijloc transport activ care trece frontiera(21)				Nr. Containerelor(31/3)			Numărul sigiliului(S28)
Locul de descărcare(S18)				Codul mărfurilor(33)			Greutate Brută(kg)(35)
UN/DG(44/4)	Cant. sen.(31/5)	Cod sen.(31/4)	Cod mod plă. cheltuieli(S29)	Tipul Decl(1)	Cod ț. exped/exp (15)	Cod ț. destin(17)	Greutate netă(kg)(38)
1	250 FARA MARCA/ 530 BUCATI			PANOURI SOLARE - 530 BUCATI			
380 STS18111501 22096 USD/ 1170.50 USD							
BARJA;DE16133							
BARJA;DE16133				HLBU1731637			
CONSTANTA SUD							6390
							5820

Figure 17e. Transit documents for transport from Constanta to Smederevo

Constanta, 15.01.2019

Transit closure receipt/confirmation

Undersigned MILOS SKANKOVIC , as master of vessel/convoy M/S EMMA for barge DE 16133 and on behalf of owners hereby confirm that I have received from agent the transit document/s under MRN : 19ROCT19000026820 which I declare to present for closure at custom exit point CALAFAT.

In case that by any reason I/we shall fail to present said document/s for closure, myself and owners will bear the legal consequences which will rise from this fact.

Master of m/s EMMA

M/S EMMA
TOMI KARGO
J.Z m
B R

Figure 17f. Transit documents for transport from Constanta to Smederevo

After container was unloaded from mother vessel, it is loaded on barge and transported to the Port of Smederevo. Container loaded on barge 15.01.2019. Transit time of barge, transporting container on route Constanta-Smederevo is planned for 3 days. Figure 18 below showing loading on barge in the Port of Constanta.

Figure 18. Loading container on transport barge in the Port of Constanta

Phase 5 - Transport of the subject container from the Port of Smederevo to the Belgrade customs office and delivery/unloading to the client warehouse

Finally, barge arrived at Smederevo port on 27.01.2019. Container where unloaded from the barge on the same day. Figure 19 shows loading container on a truck at the Smederevo port. On the same day, the truck arrived at client's warehouse and finished import customs clearance and unloading at the clients warehouse. Figure 20 presents the unloading of the container.

Figure 19. Shows loading subject container on truck in Smederevo port

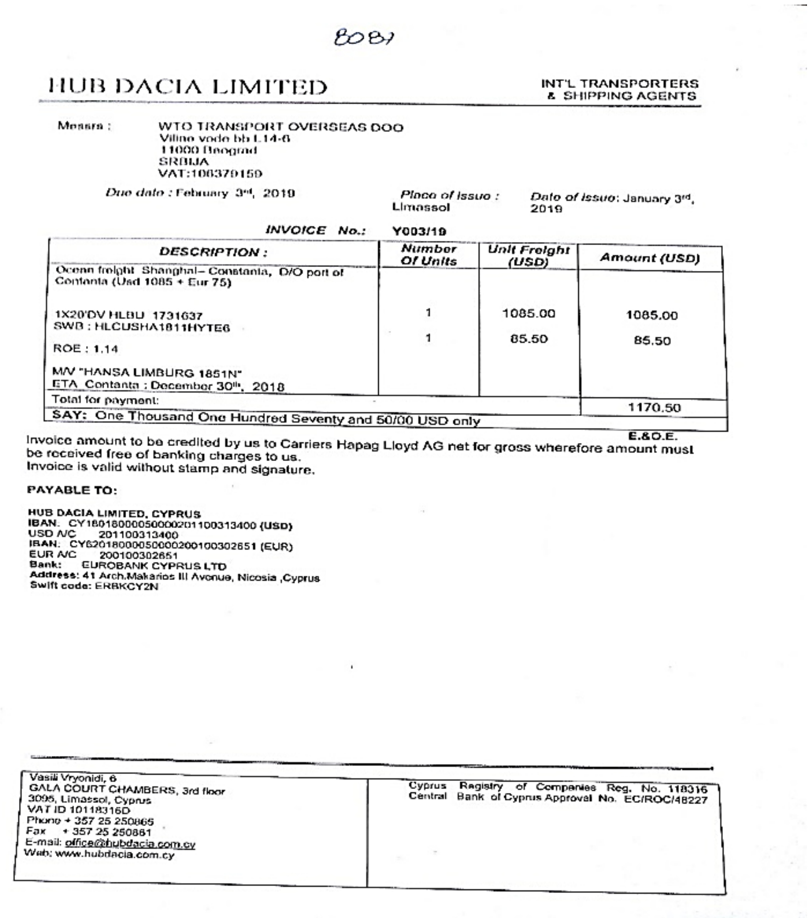
Figure 20. Subject container are being unstuffed at clients warehouse

In this transport option and this transport route costs are calculated on the FOB incoterms term. Firstly, this was the main term of agreement between shipper and consignee, second, in the calculation we used in the Mathematical criteria, costs are also considered as FOB terms. As FOB terms are implied, all costs from the dock of the vessel are consignee obligations and other costs (from shippers factory to dock of the vessel are) are on shippers account. So, in this particular case, cost we consider are:

- Transport costs from FOB Shenzhen to the Port of Constanta;
- Costs for carrier local charges and transport customs formalities in the Port of Constanta;
- Costs for transport from the Port of Constanta to the Port of Smederevo;
- Costs for inland trucking from Smederevo to consignee warehouse;
- Other costs (insurance, demurrage, detention, possible damage…).

Transport costs from FOB Port of Shenzhen to the Port of Constanta

As already mentioned in headline, this cost is ocean freight for vessel transporting subject container from FOB Shenzhen port in China to the Port of Constanta in Romania (Figure 21). Ocean freight costs are changing mostly once per month, as carrier need to update his ocean freight rates according to oil level rates in the world.



8081

HUB DACIA LIMITED — INT'L TRANSPORTERS & SHIPPING AGENTS

Messrs : WTO TRANSPORT OVERSEAS DOO
Viline vode bb L14-6
11000 Beograd
SRBIJA
VAT:106370159

Due date : February 3rd, 2019 — Place of issue : Limassol — Date of issue: January 3rd, 2019

INVOICE No.: Y003/19

DESCRIPTION :	Number Of Units	Unit Freight (USD)	Amount (USD)
Ocean freight Shanghai– Constanta, D/O port of Contanta (Usd 1085 + Eur 75)			
1X20'DV HLBU 1731637 SWB : HLCUSHA1811HYTE6	1	1085.00	1085.00
ROE : 1.14	1	85.50	85.50
M/V "HANSA LIMBURG 1851N" ETA Contanta : December 30th, 2018			
Total for payment:			1170.50
SAY: One Thousand One Hundred Seventy and 50/00 USD only			

E.&O.E.

Invoice amount to be credited by us to Carriers Hapag Lloyd AG net for gross wherefore amount must be received free of banking charges to us.
Invoice is valid without stamp and signature.

PAYABLE TO:

HUB DACIA LIMITED, CYPRUS
IBAN. CY180180000050000201100313400 (USD)
USD A/C 201100313400
IBAN: CY620180000050000200100302651 (EUR)
EUR A/C 200100302651
Bank: EUROBANK CYPRUS LTD
Address: 41 Arch.Makarios III Avenue, Nicosia ,Cyprus
Swift code: ERBKCY2N

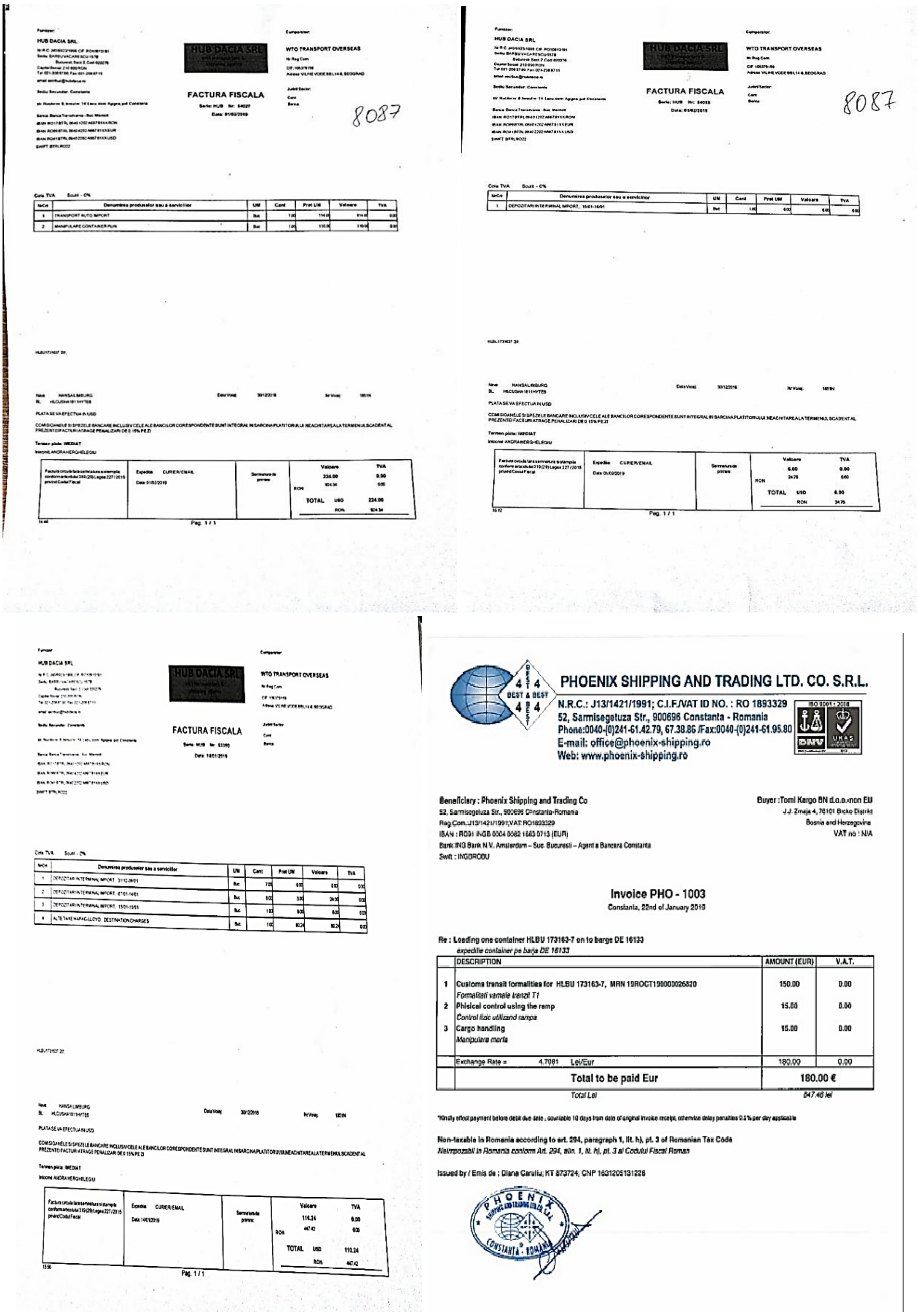
Vasili Vryonidi, 6
GALA COURT CHAMBERS, 3rd floor
3095, Limassol, Cyprus
VAT ID 10118316D
Phone + 357 25 250865
Fax + 357 25 250861
E-mail: office@hubdacia.com.cy
Web: www.hubdacia.com.cy

Cyprus Registry of Companies Reg. No. 118316
Central Bank of Cyprus Approval No. EC/ROC/48227

Figure 21. Ocean freight FOB Shenzhen-Constanta

Costs for carrier local charges in port Constanta

These costs are referring to cost occurred in the Port of Constanta and this costs are usually not changing. In this type of costs falls in: THC-terminal handling charge cost, local forwarder activities, local customs formalities, possible customs inspections, etc. Figures 22 below showing costs occurred in the Port of Constanta for the subject transport.



FACTURA FISCALA

8087

FACTURA FISCALA

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FACTURA FISCALA

PHOENIX SHIPPING AND TRADING LTD. CO. S.R.L.
N.R.C.: J13/1421/1991; C.I.F./VAT ID NO. : RO 1893329
52, Sarmisegetuza Str., 900696 Constanta - Romania
Phone:0040-(0)241-61.42.79, 67.38.86 /Fax:0040-(0)241-61.95.80
E-mail: office@phoenix-shipping.ro
Web: www.phoenix-shipping.ro

Beneficiary : Phoenix Shipping and Trading Co
52, Sarmisegetuza Str., 900696 Constanta-Romania
Reg.Com.:J13/1421/1991;VAT:RO1893329
IBAN : RO91 INGB 0004 0082 1583 0713 (EUR)
Bank: ING Bank N.V. Amsterdam – Suc. Bucuresti – Agentia Bancara Constanta
Swift : INGBROBU

Buyer :Tomi Kargo BN d.o.o.-non EU
J.J. Zmaja 4, 76101 Brcko District
Bosnia and Herzegovina
VAT no : N/A

Invoice PHO - 1003
Constanta, 22nd of January 2019

Re : Loading one container HLBU 173163-7 on to barge DE 16133
expeditie container pe barja DE 16133

	DESCRIPTION	AMOUNT (EUR)	V.A.T.
1	Customs transit formalities for HLBU 173163-7, MRN 19ROCT190000026820 *Formalitati vamale tranzit T1*	150.00	0.00
2	Phisical control using the ramp *Control fizic utilizand rampa*	15.00	0.00
3	Cargo handling *Manipulare marfa*	15.00	0.00
	Exchange Rate = 4.7081 Lei/Eur	180.00	0.00
	Total to be paid Eur	180.00 €	
	Total Lei	*847.46 lei*	

*Kindly effect payment before debit due date , countable 10 days from date of original invoice receipt, otherwise delay penalties 0.5% per day applicable

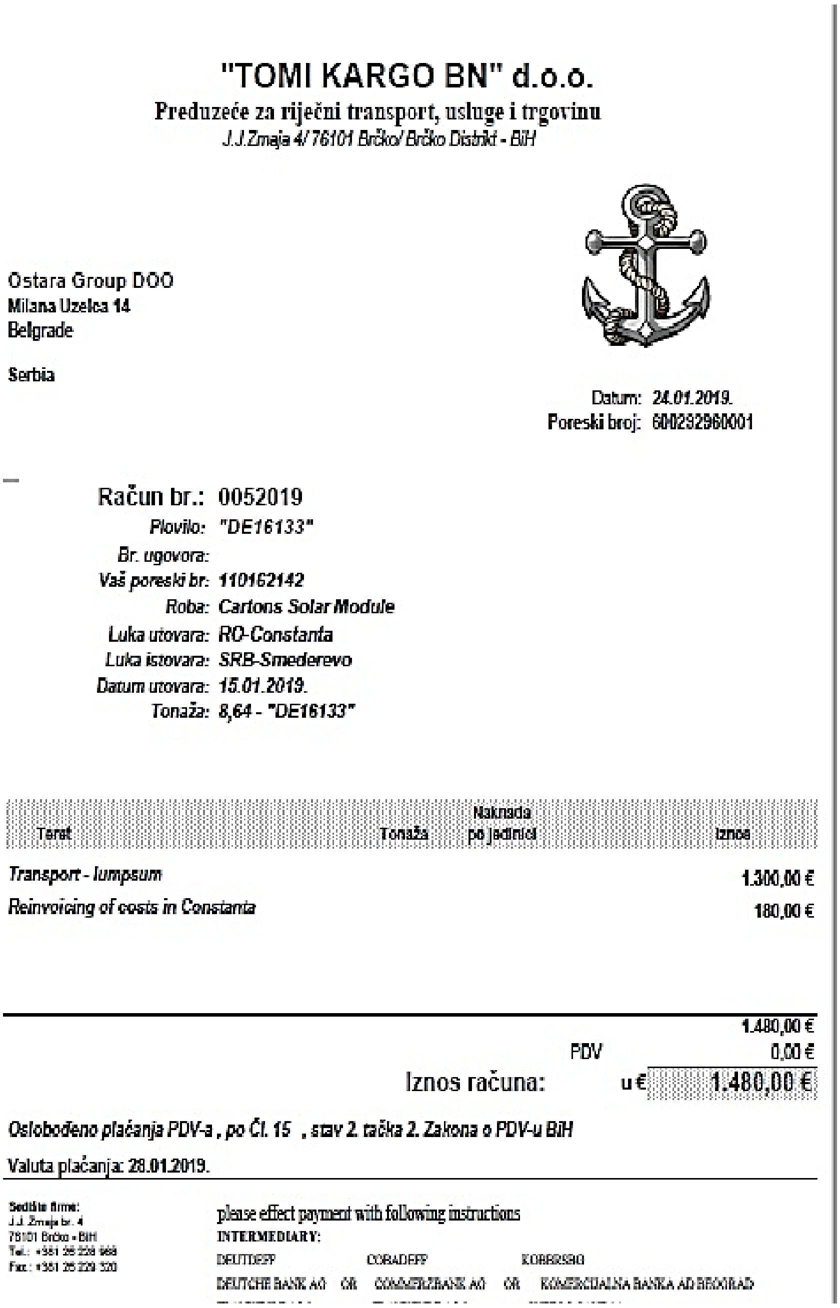
Non-taxable in Romania according to art. 294, paragraph 1, lit. h), pt. 3 of Romanian Tax Code
Neimpozabil in Romania conform Art. 294, alin. 1, lit. h), pt. 3 al Codului Fiscal Roman

Issued by / Emis de : Diana Carulia; KT 873724; CNP 1631205131228

Figure 22. Local costs in the Port of Constanta

Costs for transport from the Port of Constanta to the Port of Smederevo

This cost representing transport costs from the Port of Constanta (Romania) to the Port of Smederevo in Serbia via river barge. In this transport section, it must be said, these costs are very effective and very competitive for lots of 10 containers and above. Comparing to other transport routes this can be very cost-effective. Figure 23 below, shows transport cost of the river barge for the subject container.



"TOMI KARGO BN" d.o.o.
Preduzeće za riječni transport, usluge i trgovinu
J.J.Zmaja 4/ 76101 Brčko/ Brčko Distrikt - BiH

Ostara Group DOO
Milana Uzelca 14
Belgrade

Serbia

Datum: 24.01.2019.
Poreski broj: 600232960001

Račun br.: 0052019
Plovilo: *"DE16133"*
Br. ugovora:
Vaš poreski br: *110162142*
Roba: *Cartons Solar Module*
Luka utovara: *RO-Constanta*
Luka istovara: *SRB-Smederevo*
Datum utovara: *15.01.2019.*
Tonaža: *8,64 - "DE16133"*

Teret	Tonaža	Naknada po jedinici	Iznos
Transport - lumpsum			1.300,00 €
Reinvoicing of costs in Constanta			180,00 €
			1.480,00 €
		PDV	0,00 €
		Iznos računa: u €	1.480,00 €

Oslobođeno plaćanja PDV-a , po Čl. 15 , stav 2. tačka 2. Zakona o PDV-u BiH

Valuta plaćanja: 28.01.2019.

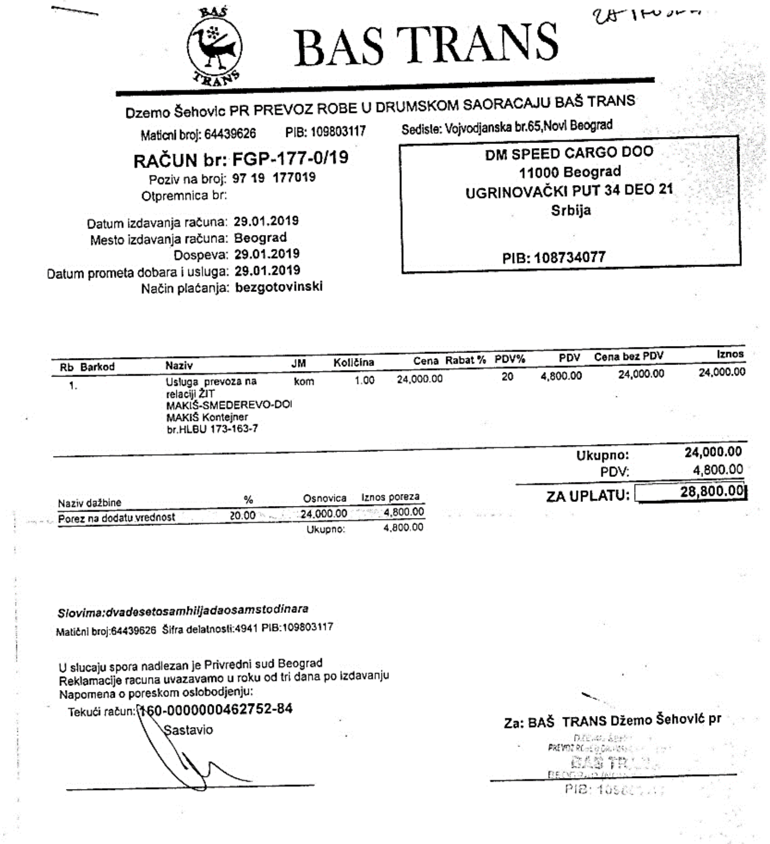
Sedište firme:
J.J. Zmaja br. 4
76101 Brčko - BiH
Tel.: +381 26 228 968
Fax.: +381 26 229 320

please effect payment with following instructions
INTERMEDIARY:
DEUTDEFF — CORADEFF — KOBBRSBG
DEUTCHE BANK AG OR COMMERZBANK AG OR KOMERCIJALNA BANKA AD BEOGRAD

Figure 23. Transport cost Constanta-Smederevo via river barge

Costs for inland trucking from the Port of Smederevo to consignee warehouse

This transport cost refers to inland trucking from the Smederevo port to the consignee warehouse, which is detailed explained in this project. Figure 24 below shows transport cost in this part of transport route.



BAS TRANS

Dzemo Šehovic PR PREVOZ ROBE U DRUMSKOM SAORACAJU BAŠ TRANS

Maticni broj: 64439626 PIB: 109803117 Sediste: Vojvodjanska br.65,Novi Beograd

RAČUN br: FGP-177-0/19
Poziv na broj: 97 19 177019
Otpremnica br:

DM SPEED CARGO DOO
11000 Beograd
UGRINOVAČKI PUT 34 DEO 21
Srbija

PIB: 108734077

Datum izdavanja računa: 29.01.2019
Mesto izdavanja računa: Beograd
Dospeva: 29.01.2019
Datum prometa dobara i usluga: 29.01.2019
Način plaćanja: bezgotovinski

Rb	Barkod	Naziv	JM	Količina	Cena	Rabat %	PDV%	PDV	Cena bez PDV	Iznos
1.		Usluga prevoza na relaciji ŽIT MAKIŠ-SMEDEREVO-DOI MAKIŠ Kontejner br.HLBU 173-163-7	kom	1.00	24,000.00		20	4,800.00	24,000.00	24,000.00

Ukupno: 24,000.00
PDV: 4,800.00
ZA UPLATU: 28,800.00

Naziv dažbine	%	Osnovica	Iznos poreza
Porez na dodatu vrednost	20.00	24,000.00	4,800.00
		Ukupno:	4,800.00

Slovima:dvadesetosamhiljadaosamstodinara
Matični broj:64439626 Šifra delatnosti:4941 PIB:109803117

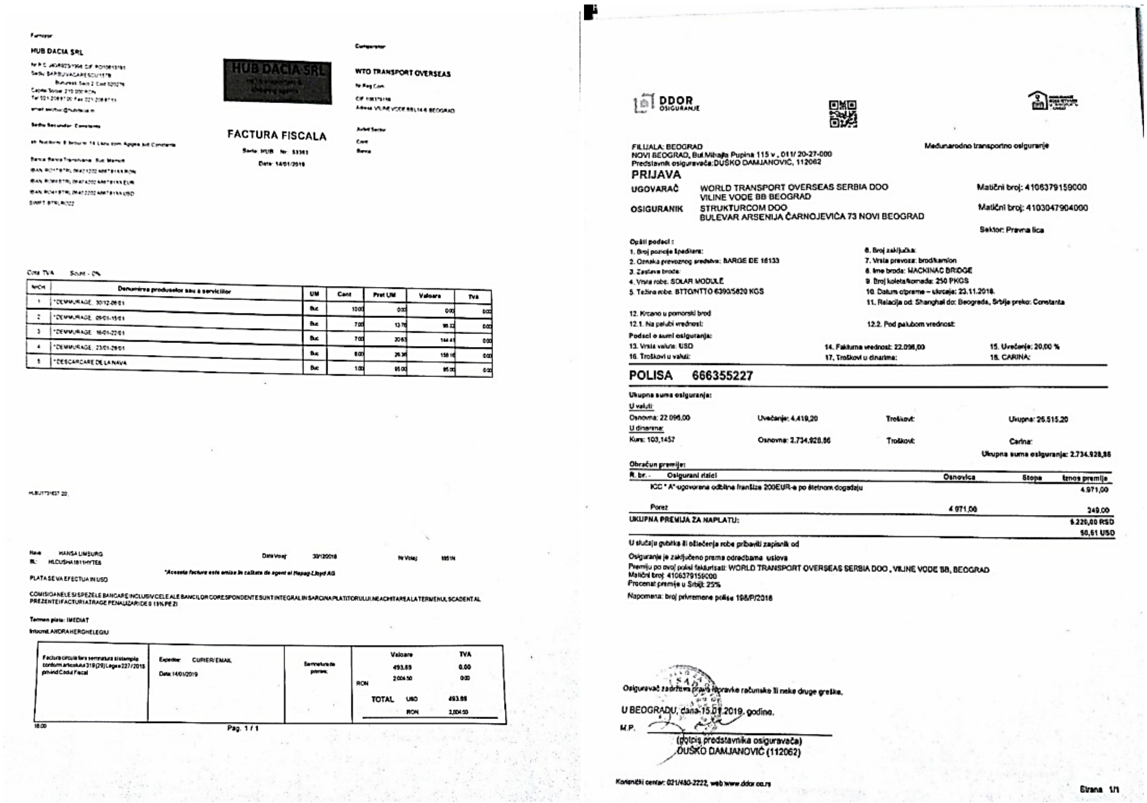
U slucaju spora nadlezan je Privredni sud Beograd
Reklamacije racuna uvazavamo u roku od tri dana po izdavanju
Napomena o poreskom oslobodjenju:
Tekući račun: 160-0000000462752-84
Sastavio

Za: BAŠ TRANS Džemo Šehović pr

Figure 24. Transport cost of truck from the Port of Smerderevo to consignee warehouse

Other costs

In this part of costs, we named all costs which can be occurred in transport route but they are not directly transport cost. In this cost are calculated costs of insurance policy, demurrage and detention costs, possible damage of cargo costs, etc. In this subject transport, the demurrage occurred; as cargo arrived exactly on 31.12.2018, time of holidays. Other way, it could be definitely said, this cost should not happen. Figure 25 below shows transport insurance costs and demurrage cost. Finally, total lump sum of FOB Port of Shenzhen-Shippers warehouse is 3915 EUR.


FACTURA FISCALA
HUB DACIA SRL
WTO TRANSPORT OVERSEAS

DDOR OSIGURANJE
FILIJALA: BEOGRAD
PRIJAVA
UGOVARAČ WORLD TRANSPORT OVERSEAS SERBIA DOO
OSIGURANIK STRUKTURCOM DOO
BULEVAR ARSENIJA ČARNOJEVIĆA 73 NOVI BEOGRAD
POLISA 666355227
UKUPNA PREMIJA ZA NAPLATU:
U BEOGRADU, dana 15.01.2019. godine.
DUŠKO DAMJANOVIĆ (112062)

Figure 25. Other costs

2.2 Bulk Cargo

With 10 riparian states and 2,414 navigable river-km, the Danube is not only the most international river in the world but also shows a large variety in nautical, hydrological and hydro-morphological characteristics. Some parts are compounded stretches and large parts of the Danube are free-flowing. These circumstances have far-reaching impacts on the maintenance activities required by the Danube's different region countries.

General characteristics of the Danube

According to the Danube Commission, the Danube can broadly be divided into three main sections (Upper, Central and Lower Danube) with different nautical characteristics (Figure 26). The hydrological and hydro-morphological characteristics of the Danube, together with river engineering interventions, determine the nautical situation on the waterway. Figure 27 depicts the maximum possible dimensions of vessels and convoys on the Danube waterway from Kelheim in Germany to the Black Sea related to waterway classes as defined by the UNECE.

	Upper Danube Kelheim – Gönyű	Central Danube Gönyű – Turnu-Severin	Lower Danube Turnu-Severin – Sulina
Length of section	624 km	860 km	931 km
River-km	2,414.72–1,791.33	1,791.33–931.00	931.00–0.00
Ø gradient per km	~ 37 cm	~ 8 cm	~ 4 cm
Height of fall	~ 232 m	~ 68 m	~ 39 m
Upstream travel speed of vessels	9–13 km/h	9–13 km/h	11–15 km/h
Downstream travel speed of vessels	16–18 km/h	18–20 km/h	18–20 km/h

Source: via donau, Danube Commission

Figure 26. Nautical characteristics of the different Danube sections (Source: Viadonau, Danube Commision)

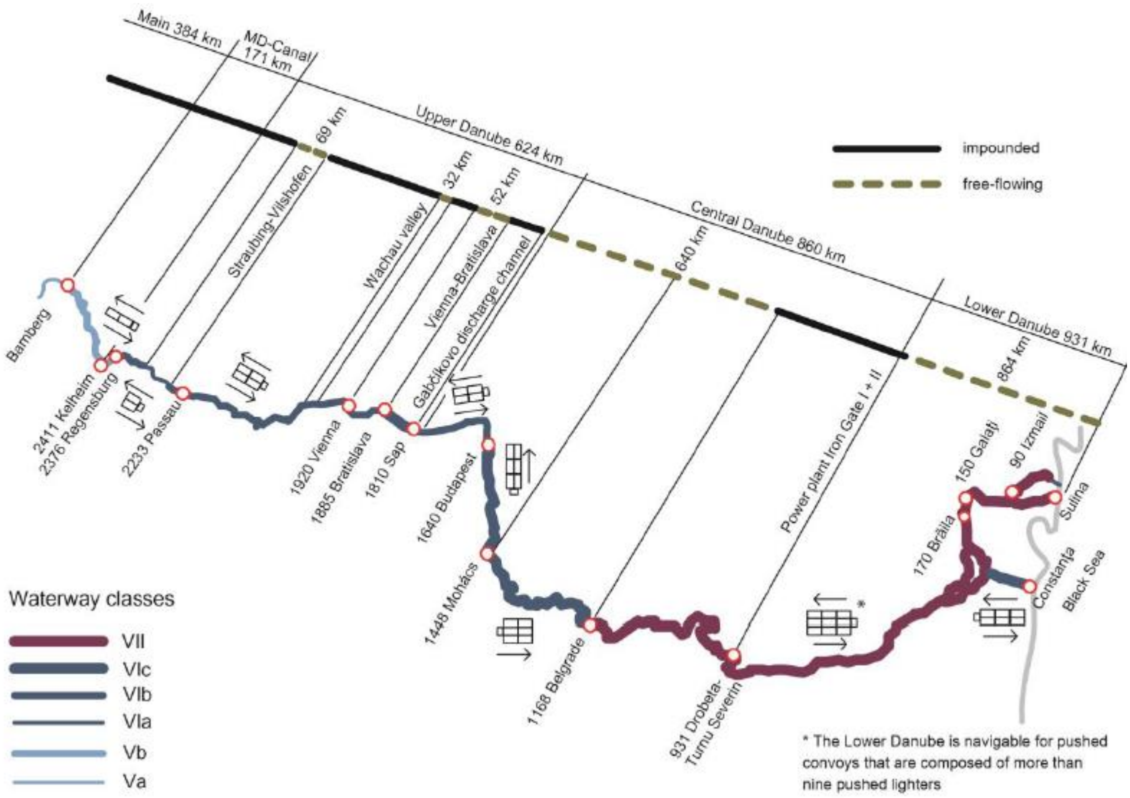


Figure 27. Maximum possible dimensions of convoys on the Danube waterway according to UNECE waterway classes (Source: Viadonau)

The length of the Danube River in Serbia is 588 km, out of which 137 km are a joint stretch with Croatia; 229 km are a joint stretch with Romania, while 222 km are a national stretch. Part of the Danube River between Bezdan and Belgrade is a free-flowing section, while the Danube downstream of Belgrade is under the influence of the Iron Gate reservoir. The river bed consists of mostly sand. The two hydropower plants, Iron Gate I (km 943) and Iron Gate II (km 863), form a reservoir, which is among the largest in Europe and helps to provide favourable navigation conditions downstream of Belgrade. The reservoir of the Iron Gate I dam extends to Belgrade (km

1,170) during high and average waters and to Novi Sad (km 1,255) during low waters. Low water periods are not affecting navigation in the reservoir; during extreme water periods, the reservoir needs to be partly emptied, which in most cases does not cause any obstacles to navigation.

Monitoring of the fairway on the Danube in Serbia is performed by the Directorate for Inland Waterways Plovput, who holds a survey database of the last 50 years. Single-beam and multi-beam equipment is available. Hydrographic surveys of the free-flowing sections are performed each year in spring/summer with single-beam. The border section is monitored by Croatia and Serbia, taking turns. Critical sections may be surveyed more than once a year, if necessary. The joint section of the Danube River between Serbia and Romania, which is under the direct influence of the regime of work of Iron Gate I and Iron Gate II, is currently monitored once in four years.

Monitoring of sections without regulated fairways is performed twice a year. Additional monitoring of the riverbed is performed by marking vessels (echo-sounder). Water levels are monitored using automatic gauging stations, available on the free-flowing stretch. A higher density would be required to provide sufficient quality of measurements. The marking of the fairway is monitored twice per month. There are no major issues related to monitoring of fairway.

Summary of current ecological status and environmental impacts - Serbia

The following map (Figure 28) displays the ecological status and ecological potential of the Serbian Danube, according to the Danube River Basin Management Plan/Update 2017against the background of the critical navigation locations in Serbia.

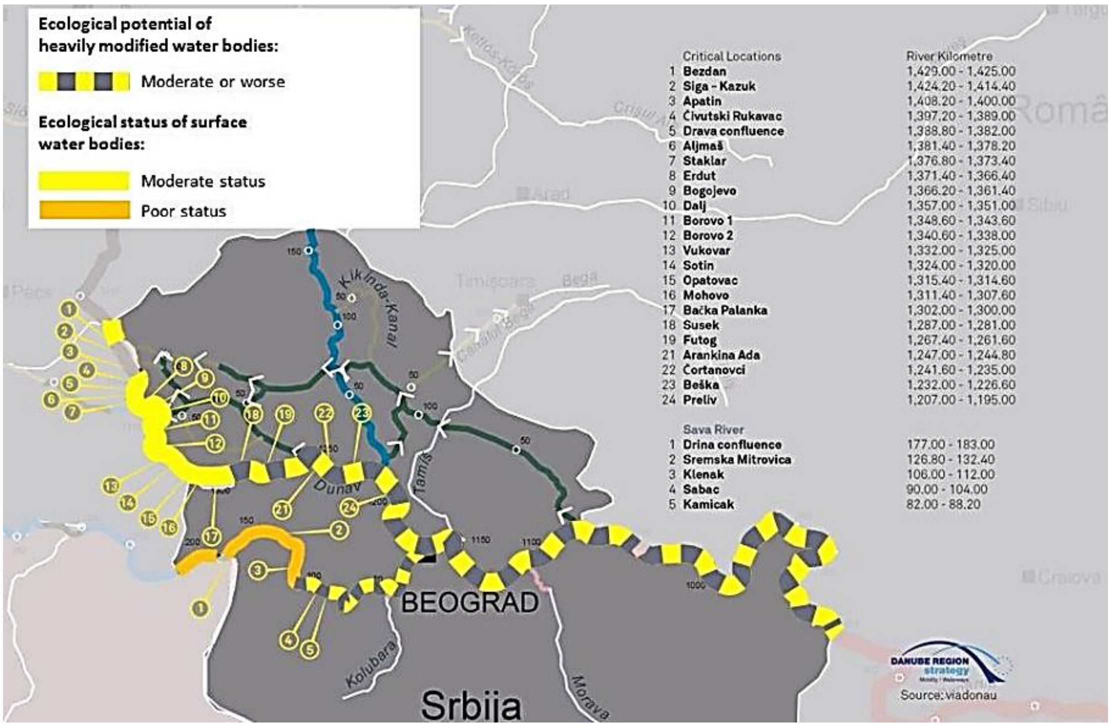


Figure 28. Ecological status and ecological potential of surface water bodies (source: DRBM Plan – Update 2017)

Location / Length (km)			right bank / left bank	Name of sector / location
River-km (from / to)		Length		
1,429.00	1,425.00	4.00	HR / RS	Bezdan
1,424.20	1,414.40	9.80	HR / RS	Siga - Kazuk
1,408.20	1,400.00	8.20	HR / RS	Apatin
1,397.20	1,389.00	8.20	HR / RS	Čivutski Rukavac
1,388.80	1,382.00	6.80	HR / RS	Drava confluence
1,381.40	1,378.20	3.20	HR / RS	Aljmaš
1,376.80	1,373.40	3.40	HR / RS	Staklar
1,371.40	1,366.40	5.00	HR / RS	Erdut
1,366.20	1,361.40	4.80	HR / RS	Bogojevo
1,357.00	1,351.00	6.00	HR / RS	Dalj
1,348.60	1,343.60	5.00	HR / RS	Borovo 1
1,340.60	1,338.00	2.60	HR / RS	Borovo 2
1,332.00	1,325.00	7.00	HR / RS	Vukovar
1,324.00	1,320.00	4.00	HR / RS	Sotin
1,315.40	1,314.60	0.80	HR / RS	Opatovac
1,311.40	1,307.60	3.80	HR / RS	Mohovo
1,302.00	1,300.00	2.00	HR / RS	Bačka Palanka
1,287.00	1,281.00	6.00	RS / RS	Susek
1,267.40	1,261.60	5.80	RS / RS	Futog
1,247.00	1,244.80	2.20	RS / RS	Arankina Ada
1,241.60	1,235.00	6.60	RS / RS	Čortanovci
1,232.00	1,226.60	5.40	RS / RS	Beška
1,207.00	1,195.00	12.00	RS / RS	Preliv

Figure 28. (Continued)

The ecological status of the Danube water-body in the Republic of Serbia is identified within the DRBMP as moderate in the upper stretch to moderate to worse in the middle and lower stretch. Having in in mind a long term absence of river training and dredging works for the purpose of fairway maintenance, no major impact to the existing quality of the water-body was identified. No specific activities are being performed by the authority responsible for waterway maintenance. Due to the absence of budget for maintenance dredging activities, fairway maintenance activities are limited to hydrographic surveying activities and waterway marking activities, with no effect to the environment.

In 2017, an EU-funded project of river training and dredging works on critical sectors on the Danube River in Serbia has started, including an independent environmental monitoring component as a part of the Supervision contract. The environmental monitoring will be performed before, during and after river training and dredging works, in order to properly identify and evaluate effects of the works to environmental components, in terms of hydro-morphology, sediment and water quality and biology.

Summary of current ecological status and environmental impacts – Romania

The Danube River is the main navigable route from Romania. On Romanian territory, the waterway is divided into riverine Danube, from entering the country to Galati and maritime Danube from

Galati until it flows into the Black Sea. Also, the Danube - Black Sea channel (CDMN) and Poarta Alba - Midia - Năvodari channel (CPAMN) provides the connection with the Black Sea.The following map displays (Figure 29) the ecological status and ecological potential of the Romanian Danube, according to the Danube River Basin Management Plan/Update 2017 against the background of the critical navigation locations in Romania.

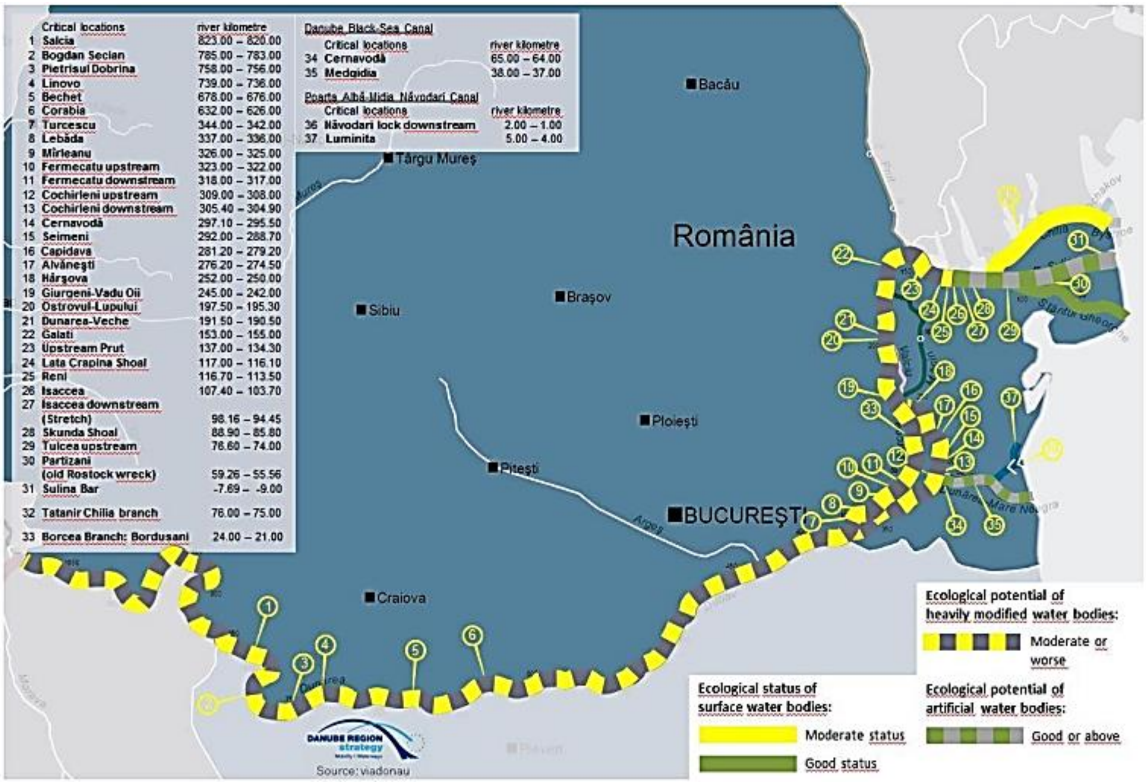


Figure 29. Ecological status and ecological potential of surface water bodies (source: DRBM Plan – Update 2017)

During this research, beside the trucking and tracing of container from Constanta to Belgrade, it was also organized transport of bulk cargo in IWT, from the Port of Constanta to the Port of Prahovo. Specification and report as below (Table 5).

Table 5. Report

Number: 20 0309/19	Our ref.: BO 2000786 Belgrade, 11.03.2019.
Commodity declared as: Monocalcium phosphate	
Packing: big bags 1000kg, bags 25kg	
Principal: Phosphea Danube d.o.o.	
Number of bags: (2000 pcs 25/1, 569 pcs 1000/1)	
Vessel/barge: DISCOVER	
Date of sampling: 10-11.03.2019.	
Place of loading: port of Constanta	

After instructions and nomination received from the company Phosphea Danube d.o.o., Beograd, organization of transport has started as follows:

SAMPLING:

Sampling was performed according to standards SRPS EN 1482-1:2010 and SRPS EN 1482-2:2010, during loading of a/m commodity into the barge DISCOVER. The increments were collected and the bulk sample was shortened and 3 representative samples of commodity were formed. Distribution of samples:

MCP 25/1 kg:

- Phosphea Danube d.o.o., SGS seal no. P8756228
- SGS R1 SGS seal no. P8756229
- SGS R2 SGS seal no. P8756230
- SGS R3 SGS seal no. P8756231

MCP 1000/1 kg:

- Phosphea Danube d.o.o., SGS seal no. P8756232
- SGS R1 SGS seal no. P8756233
- SGS R2 SGS seal no. P8756234
- SGS R3 SGS seal no. P8756235

TALLY OF BAGS

From 10th to 11th March, 2019, was performed the inspection of loading and marking bags of the commodity into the barge and tallying of bags. The following was ascertained:

MCP 25/1kg:

Date	Damaged during loading, pcs	Damaged in the barge, pcs	Loaded undamaged bags pcs	Total number of loaded bags, pcs
10.03.2019.	-	-	2000	2000
TOTAL	-	-	**2000**	**2000**

MCP 1000/1kg:

Date	Damaged during loading, pcs	Damaged in the barge, pcs	Loaded undamaged bags pcs	Total number of loaded bags, pcs
10.03.2019.	-	-	569	569
TOTAL	-	-	**569**	**569**

SEALS:

After loading a/m commodity the barge DISCOVER was sealed with SGS seals marked asC03002300, C03002292.

Accourding to detailes of tracking and tracing of bulk cargo below Figures 30-32 present the 3 phase (1 - Port of Constanta, 2 - transport Constanta – Prahovo, 3 – Port of Prahovo) monitoring of transport of bulk cargo on IWT from the Port of Constanta to the Port of Prahovo, Serbia.

Figure 30. Phase 1 – bulk cargo transportation

Figure 31. Phase 2 – bulk cargo transportation

Figure 32. Phase 3 – bulk cargo transportation

3 Selected transport chains from China to Serbia from the logistic service providers perspective

The intercontinental container transport chainconsists of an ocean part where the containers are transported through the world's largest ocean carriers and the land section where the containers are transported using different modes of land transport. Hence, the selected transport chains from China to Serbia (shown in Figure 33), consists of three categories of nodes: port of loading, unloading port and end point of delivery of containers and two types of branches connecting those nodes.

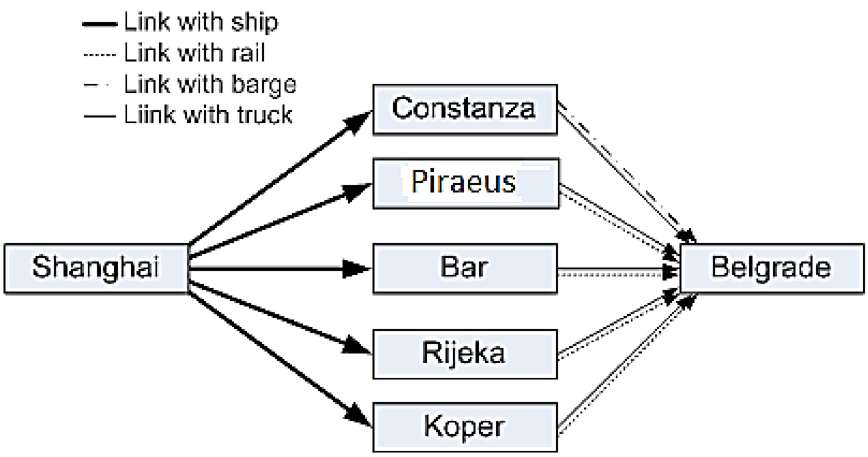


Figure 33. Selected intermodal container transport chains

Loading port

The Port of Shanghai is the world's busiest port in the world, and is located in the heart of the Yangtze River Delta. The aim of Shanghai is to be an international and forwarding center in the near future. Since 2005, Shanghai has the largest seaport in the world, and since 2010 it has been the world's largest container port. During 2016, Shanghai had a turnover of 37.13 million TEU. Only during 2016, container traffic increased 1.6% compared to 2015.

Port of unloading

The main hubs for importing containers to Serbia are the ports: Rijeka, Bar, Koper, Constanta and Piraeus.

Place of delivery

Serbia is a continental state, while the Belgrade region represents the largest percentage of total imports of goods to Serbia (Republic Institute for Statistics, 2016). With unloading ports it is connected by direct connections, and containers can be transported by different modes of transport (rail, road, river). Also, each branch has its own special characteristic: sea connections, land connections.

Sea connections

Containers are transported by sea from the port of loading to the port of unloading by different container ocean carriers. This research deals with container owned by the six largest shipping companies (Maersk Line - MSK, Mediterranean Shipping Company - MSC, CMA CGM, Evergreen Line-EMC, China Ocean Shipping Company-COSCO and Hapag-Lioyd). Each of the abovementioned carrierstransport containers from the port of Shanghai to the nominated ports in the Mediterranean via the various services (Table 6).

Table 6. List of shipping services from Shanghai to nominated ports

SHANGHAI-	*CONSTANTA*	*PIRAEUS*	*BAR*	*RIJEKA*	*KOPER*
MAERSK	AE3	AE20 + L51	/	AE12	AE12
MSC	Tiger Service + Black Sea	Tiger Service + East Mediterranean	Dragon Service + West Mediterranean	Dragon Service + West Mediterranean	Dragon Service + West Mediterranean
CMA - CGM	BEX	MEX + FEMEX 1 / BEX + FEMEX 1	MEX + FEEDNAP / NEWMEX2S + FEEDNAP	BEX2	BEX2
COSCO	CESS + AFS / MD1 +AFS / ABX + AFS	CESS / MD1 / ABX	/	CESS + AFS / MD1 +AFS / ABX + AFS	ABX
EVERGREEN	UAM	UAM	/	UAM + GTS / CES + GCY / MD1 + GCY	CES + BSF / MD1 + BSF
HAPAG LIOYD	EUM + ADX / LOOP 4 + ADX	EUM + ADX / LOOP 4 + ADX	/	LOOP 4 / EUM	EUM + BSF / LOOP 4 + BSF

Land connections

By land connections, containers are delivered from unloading ports to the final destination in Belgrade. Land connections between the ports of delivery (unloading ports) and the final place of delivery use different modes of transport are shown in Table 7.

Table 7. Connection of the port of delivery with Belgrade through various modes of transport

Port / Type of transport	Road	Rail	IWT
Koper	x	x	
Rijeka	x	x	
Bar	x	x	
Piraeus	x	x	
Constanta	x		x

The total transport costs of the most commonly used types of containers (20 ft, 40 ft and 40 ft hc) from the port of Shanghai to Belgrade in this research represent the sum of all transportation costs, including ocean freight costs on first leg, from The Port of Shanghai to the ports in Europe (Constanta, Piraeus, Bar, Rijeka and Koper), port charges, manipulation costs and customs formalities at unloading ports and transport costs from nominated ports to the terminal in Belgrade using different modes of transport. The transport of containers by rail and barges also includes the costs of manipulating the containers at the terminals in Belgrade and local transportation by truck to the consignees (last mile delivery). Tables 8-10 presentocean freight of selected shipping companies (MSK, MSC, CMA-CGM, Hapag Lioyd, COSCO, EMC) from Shanghai to unloading ports. The value of ocean freight for different types of containers is calculated for the period January - December 2018.

Table 8. Ocean freight from Shanghai to nominated unloading ports (20 ft)

20 FT	CONSTANTA	PIRAEUS	BAR	RIJEKA	KOPER
MAERSK	1300 $	1175 $	/	1283 $	1283 $
MSC	1183 $	1267 $	1267 $	1133 $	1133 $
CMA – CGM	1188 $	1367 $	1650 $	1250 $	1250 $
HAPAG LIOYD	1299 $	1711 $	1931 $	1310 $	1310 $
EVERGREEN	1650 $	1283 $	/	1196 $	1196 $
COSCO	1185 $	1379 $	/	1200 $	1200 $

Table 9. Ocean freight from Shanghai to nominated unloading ports (40 ft)

40 FT	CONSTANTA	PIRAEUS	BAR	RIJEKA	KOPER
MAERSK	2400 $	2350 $	/	2383 $	2383 $
MSC	2308 $	2458 $	2517 $	2250 $	2250 $
CMA – CGM	2233 $	2542 $	3200 $	2400 $	2408 $
HAPAG LIOYD	2547 $	3368 $	3862 $	2621 $	2621 $
EVERGREEN	3017 $	2367 $	/	2267 $	2267 $
COSCO	2270 $	2633 $	/	2300 $	2300 $

Table 10. Ocean freight from Shanghai to nominated unloading ports (40 ft hc)

40 FT HQ	CONSTANTA	PIRAEUS	BAR	RIJEKA	KOPER
MAERSK	2400 $	2350 $	/	2433 $	2433 $
MSC	2308 $	2458 $	2567 $	2300 $	2300 $
CMA - CGM	2250 $	2567 $	3300 $	2450 $	2458 $
HAPAG LIOYD	2647 $	3468 $	3962 $	2721 $	2721 $
EVERGREEN	3108 $	2408 $	/	2333 $	2325 $
COSCO	2330 $	2683 $	/	2367 $	2367 $

Tables 11-13 present the port cost values for the selected container types, depending on the name of the ocean carrier and the unloading port. The value of port charges was calculated for the period January - December 2018.

Table 11. Port costs (20 ft)

20 FT	CONSTANTA	PIRAEUS	BAR	RIJEKA	KOPER
MAERSK	250€	240 €	/	200 €	200 €
MSC	250€	240 €	280 €	227 €	227 €
CMA - CGM	250€	240 €	210 €	210 €	210 €
HAPAG LIOYD	250€	240 €	250 €	200 €	200 €
EVERGREEN	250€	240 €	/	196 €	196 €
COSCO	250€	240 €	/	195 €	195 €

Table 12. Port costs (40 ft)

40 FT	CONSTANTA	PIRAEUS	BAR	RIJEKA	KOPER
MAERSK	250€	340 €	/	200 €	200 €
MSC	250€	340 €	290 €	227 €	227 €
CMA - CGM	250€	340 €	210 €	210 €	210 €
HAPAG LIOYD	250€	340 €	250 €	200 €	200 €
EVERGREEN	250€	340 €	/	236 €	236 €
COSCO	250€	340 €	/	195 €	195 €

Table 13. Port costs (40 ft hc)

40 FT	CONSTANTA	PIRAEUS	BAR	RIJEKA	KOPER
MAERSK	250€	340 €	/	200 €	200 €
MSC	250€	340 €	290 €	227 €	227 €
CMA - CGM	250€	340 €	210 €	210 €	210 €
HAPAG LIOYD	250€	340 €	250 €	200 €	200 €
EVERGREEN	250€	340 €	/	236 €	236 €
COSCO	250€	340 €	/	195 €	195 €

Tables 14-16 present the transport costs (road, rail, IWT) from the port of unloading to Belgrade (final place of delivery). The total costs represent the sum of transport costs from the unloading port to Belgrade, the cost from customs forwarder (making transit papers), manipulation (transshipment) from one transport mode to another to the final consignee (from the port of Belgrade or the railway terminal –last mile delivery). The price of river transport was taken from the period of 2010, when the last route was developed on the route Constanta - Belgrade. The value of rail and road cost of expenses is calculated for the period January - December 2018.

Table 14. Land transport costs up to CFS Belgrade (20 ft)

20 FT	CONSTANTA	PIRAEUS	BAR	RIJEKA	KOPER
ROAD	1750€	1930 €	590 €	690 €	790 €
RAIL	/	800 €	605 €	575 €	740 €
IWT	470€	/	/	/	/

Table 15. Land transport costs up to CFS Belgrade (40 ft)

40 FT	CONSTANTA	PIRAEUS	BAR	RIJEKA	KOPER
ROAD	1750€	1930 €	590 €	690 €	790 €
RAIL	/	950 €	705 €	660 €	920 €
IWT	570€	/	/	/	/

Table 16. Land transport costs up to CFS Belgrade (40 ft hc)

40 FT HQ	CONSTANTA	PIRAEUS	BAR	RIJEKA	KOPER
ROAD	1750€	1930 €	590 €	690 €	790 €
RAIL	/	950 €	705 €	660 €	920 €
IWT	570€	/	/	/	/

The total transit time is the time from the moment of departure of the container ship from the port of loading until the moment of arrival of the container to the appropriate destination in Belgrade. It includes the time of shipping of containers at sea, which varies depending on the ship services of different shipping companies (one shipper can arrive at the unloading port in up to 3 ways), waiting time in the unloading port and the time of transport of the container from the unloading port to the end point in Belgrade. Table 17 presents the shipping time at sea, while Table 18 shows the time of land transport.

Table 17. Transit time at sea (days)

SHANGHAI-	RIJEKA	KOPER	BAR	PIRAEUS	CONSTANTA
MAERSK	32	30	/	32	29
MSC	31	34	33	31	38
CMA - CGM	32	30	34 / 37	34 / 35	29
COSCO	29 / 27 / 31	30 / 28 / 32	/	31 / 29 / 26	30
EVERGREEN	35	33	/	45 / 26 / 31	31 / 36
HAPAG LIOYD	31 / 33	32 / 34	/	29 / 34	34 / 36

Table 18. Transit time on land up to CFS Belgrade

20 DV/40 DV/40 HQ	CONSTANTA	PIRAEUS	BAR	RIJEKA	KOPER
ROAD	3 days	2 days	2 days	2 days	2 days
RAIL	/	7 days	5days	4 days	5 days
IWT	12 days	/	/	/	/

Total carbon dioxide emissions are the sum of emissions at sea and emissions on land. The emission of gases during manipulation in the unloading port is negligible. Table 19 shows the emission factor for each of the transport types. Tables 20 and 21 present the distances at first leg and distances on second leg.

$$CO_2 \text{ emission} = \text{distance x emission factor}$$

$$g\ CO_2 / TEU = km \times [g \text{ of } CO_2 / (TEU \times km)]$$

Table 19. Emission factors depending on the mode of transport (source: Greenhouse Gas Protocol - Distance-based methodology for calculation of CO2 emissions-Maersk Line 2012)

TYPE OF TRANSPORT	*kg CO_2 / TEU*
ROAD	0,72
RAIL	0,205
IWT	0,084
CONTAINER OCEAN SHIP	0,084

Table 20. Distance on the first leg

SHANGHAI-	CONSTANTA	PIRAEUS	BAR	RIJEKA	KOPAR
MAERSK	15847 km	15330 km	/	18251 km	18089 km
MSC	16396 km	15848 km	17178 km	16543 km	17012 km
CMA - CGM	15847 km	18162 km / 17852 km	16780 km / 16715 km	18251 km	18089 km
HAPAG LIOYD	16952 km / 17131 km / 16830 km	18250 km / 18356 km / 17892 km	/	18325 km / 18460 km / 18290 km	18089 km
EVERGREEN	17403 km	17415 km	/	15344 km / 15356 km / 19431 km	17852 km / 17689 km
COSCO	16374 km / 15344 km	15356 km / 16856 km	/	16406 km / 16417 km	17917 km / 16580 km

Table 21. Distance on the second leg

TO BELGRADE	CONSTANTA	PIRAEUS	BAR	RIJEKA	KOPAR
ROAD	800 km	1100 km	450 km	550 km	600 km
RAIL	/	1290 km	500 km	666 km	700 km
IWT	890 km	/	/	/	/

4 Analysis of the selected transport chains from China to Serbia

4.1 Mathematical considerations and model

Definition for weighting decision criteria

Real problems usually do not have criteria of the same degree of significance and it is necessary that the decision maker defines factors of significance of particular criteria using the appropriate weight coefficients (weights) or so-called potters for criteria (if their sum is 1, these are normalized weights). Given the nature of the criteria, the values of the criteria by alternatives, x_{ij}, are either numbers of the most diverse type, or linguistic statements, e.g. from the set of statements: large, medium, small, or binary statements: “yes, no”.Not all criteria are equally important, so their "importance" is the weight of the criteria. In this part of the multi-criteria analysis (determining the weight of the criteria), subjectivism is expressed - individual or group. The essence is to introduce subjectivism analysis in a very orderly way. In other words, subjectivism in multi-criteria analysis is inevitability, but it can be controlled and rigorously treated.

Defining the weight of the criteria is not always easy and in essence every decision maker subjectively defines the weight coefficients. Weighting coefficients in some methods have a decisive influence on the solution. It can happen that the introduced values for weights do not require a "good solution" and it is necessary to analyze how the solution behaves depending on the possible real variants for the weight of the criteria. The problem is simpler if there are absolute priorities among the criteria. The severity of the criteria can be defined using the Delphi method, especially in situations that are not generally known, but are known only to experts.The resulting criterion function in compromise programming when the decision-maker can set or change when solving the multi-objective weight of certain, criteria has the following form:

$$R(F(x), p, \omega) = \left\{ \sum_{i=1}^{n} \omega_i^p \, [f_i^* - f(x)]^p \right\}^{\frac{1}{p}}$$

where ω_i represents the weight coefficient for the criterion function f_i (x), in order to emphasize the dependence on the parameter p.

Weight coefficients are subjective measures of significance of particular criteria that the decision maker defines on the basis of their estimates. The use of entropy is proposed for the determination of criteria of significance of criteria:

$$e(f_i) = \frac{1}{ln} J \sum_{j=1}^{n} \left(\frac{d_{ij}}{S_i}\right) ln\left(\frac{d_{ij}}{S_i}\right), i = 1, \dots, n$$

$$d_{ij} = \frac{(f_i^* - f_{ij})}{D_i}$$

where are:

$d_{ij} - j -$ discrete value $(j = l, \ldots, J)$ $i -$ deviation functions,

D_i –the length of the range (if no transformation is needed then it is $D_i = 1$),

$f_{ij} - j - \text{discrete value}, i -$ criteria functions,

$S_i -$ denotes a sum of values $S_i = \sum jd_{ij}$

The use of weight coefficients is most appropriate within the iterative process.

Definition of the criteria for multi-attributive decision making

Transport costs take up to 20%of the total price of the product. Different types of transport also have different connections with the space. What kind of transportation will be chosen to transport cargo from one place to another depends on a number of factors, such as the type of goods, the available infrastructure, the place of departure and arrival, the technology, and the particular distances to be crossed. Numerous factors together define transport costs. From the relationship that exists between the transport costs, the distance and the type of transport used, it is possible to roughly approximate the distances for which different types of freight transport are suitable. Road transport is convenient on shorter routes (distances up to 500 km - 750 km), rail transport on medium-sized routes (up to 1,500 km), and inland waterway transport on long distances (over 1,500 km).From the aspect of capacity (in TEU units) the benefits of certain modes of transport are:

- Truck: 1-4 TEU
- Train composition: about 80 TEU
- Ocean:> 6000 TEU

Depending on the geographical characteristics, the mode of transport is chosen, and considering the fact that a network of road roads has been developed and that this type of transport is at least dependent on geographical characteristics, its use is used and even on long distances. What kind of transport will be used depends on the state policy. In Europe, the intension is to redirect goods flows from road to another mode of transport (for example, in Switzerland, all cargo, which passes through the country, must be transported by rail to reduce air pollution in the alpine valleys). The European Union is trying to improve transport alternatives by investing in the railways and its infrastructure, at the same time increasing the fee for the use of road transport routes. Competition between different modes of transport has brought about significant changes in the length of cargo transportation. The costs of the transport system include several types of transport costs that occur when shipping cargo from departure to arrival, depending on the type of transport used, transhipment from one mode of transport to another and storage activities

As already stressed, the use of container creates savings in maritime and land transport, but also in overloading. The use of bigger ships (the more capacity they have), owned by shipping companies for the transport of containers, decrease the costs of TEUs. Although there is a trend of increasing the size of ships to reduce costs per TEU, this increase can lead to an increase in costs in other components of container transport (larger ships require larger ports, higher demand for containers and adequate unloading equipment, etc.).

Numerous technical improvements in the area of river / maritime transport and better integration between road and rail have led to a reduction in transhipment costs, but by the time of containerization, the highest achievements have been recorded so far. Total shipping and shipping costs, in addition to transport costs, include freight transhipment costs. While shipping companies engaged in container shipping require larger ships, transhipment and land distribution systems are trying to cope with the increased volume of containers. Technological achievements and infrastructure improvements significantly influence the realization of the transport chain between the starting point and the destination.

Transport of goods, both in connection with the supply of raw materials and the import of finished products, is the bloodstream of every economy. Being able to procure raw materials in time and deliver finished products to end users is one of the most important operational goals of each company. Unfortunately, in order to meet the essential delivery deadlines, transport users themselves have been designated for faster transport and thus often generate higher transport costs in order to avoid additional costs for end-users of the product. Large importers often define strict deadlines when generating tenders.

Establishing a sustainable transport, implementing an energy and transport policy that provides greater energy efficiency, is one of the main ways to reduce carbon dioxide emissions, and thus improve the quality of the citizens' life. The transport sector is one of the largest carbon dioxide emitters and therefore the largest environmental pollutant with an annual emission of 15% of the total carbon dioxide emissions. Transport has a key impact on the quality of life and the economic growth and development of society, but it is also one of the largest energy users with extremely low energy efficiency and high emissions

Mathematical model

Developed mathematical model used for comparison of the different container transport chain from Shangai to Belgrad (shown in Figure 33) is presented below.

Nodes	Description
N	set of nodes, N = OUGUP, where the "O" presents port of loading, "G" port of discharge and "P" finale place of delivery
A	set of branches connecting the port of loading with the final destination, where A = FL ∪ SL, while FL represents ocean connection (first leg), and SL connections on the land (second leg)

Variable	Description

cf_{ij}^{t}	binary cost variable, represents the container flow on the first leg by connecting the corresponding container ocean carrier "i" with the corresponding unloading port "j", taking into account the different types of container "t",$cf_{ij}^{t} \in \{0,1\}$
cs_{jk}^{t}	binary cost variable, represents the container flow on the second leg connecting the corresponding unloading port "j" and declaring the appropriate mode of transport "k" to the final destination, taking into account the different types of container "t", $cs_{jk}^{t} \in \{0,1\}$
tf_{ij}^{s}	binary time variable, represents the container flow on the first leg connecting the corresponding container ocean carrier "i" with the corresponding unloading port "j", taking into account different transport routes - services "s" on the first leg ,$tf_{ij}^{s} \in \{0,1\}$
ts_{jk}	binary time variable, represents the container flow on the second leg connecting the corresponding unloading port "j" and declaring the appropriate mode of transport "k" to the final destination,$ts_{jk} \in \{0,1\}$
df_{ij}^{s}	binary variable of carbon dioxide emissions, represents a container flow on the first leg by connecting the corresponding container ocean carrier "i" with the corresponding unloading port "j", taking into account different services "s" first leg,$df_{ij}^{s} \in \{0,1\}$
ds_{jk}	binary variable of carbon dioxide emissions, represents the container flow on the second leg connecting the corresponding unloading port "j" and declaring the appropriate mode of transport "k" to the final destination, $ds_{jk} \in \{0,1\}$

Parameters	Description
n_i	number of container ocean carriers
n_j	number of transshipment ports
n_k	modes of transport on the land
n_s	transport routes – services on the first leg
n_t	container types
CFL_{ij}^{t}	costs on the first leg (USD)
CSL_{jk}^{t}	costs on the second leg (EUR)
CG_{ij}^{t}	port costs (EUR)
EM	carbon dioxide emission coefficient at first leg
EM_k	carbon dioxide emission coefficient at second leg
DFL_{ij}^{s}	distance on the first leg (from the loading port to the discharge port) (km)
DSL_{jk}	distance on the second leg (from the unloading port to the final point) (km)
TFL_{ij}^{s}	transit time on first leg (days)
TSL_{jk}	transit time on second leg (days)
EX	coefficient of currencies (EUR / USD)

$$(i,j) \in FL, 1 \leq i \leq n_i , 1 \leq j \leq n_j$$

$$(j,k) \in SL, 1 \leq j \leq n_j , 1 \leq k \leq n_k$$

Objective functions:

Minimization of transport costs (Z_1):

$$Z_1 = \min \left[\sum_{(i,j) \in FL} \sum_{t=1}^{n_t} (CFL_{ij}^t + CG_{ij}^t) * cf_{ij}^t + \sum_{(j,k) \in SL} \sum_{t=1}^{n_t} CSL_{jk}^t * cs_{jk}^t \right] (1)$$

Minimization of transit time (Z_2):

$$Z_2 = \min \left[\sum_{(i,j) \in FL} \sum_{s=1}^{n_s} TFL_{ij}^s * tf_{ij}^s + \sum_{(j,k) \in SL} TSL_{jk} * ts_{jk} \right] (2)$$

Minimization of carbon dioxide emissions (Z_3):

$$Z_3 = \min \left[\sum_{(i,j) \in FL} \sum_{s=1}^{n_s} (DFL_{ij}^s * EM) * df_{ij}^s + \sum_{(j,k) \in SL} (DSL_{jk} * EM_k) * ds_{jk} \right] (3)$$

Constraints:

$$\sum_{i=1}^{n_i} cf_{ij}^t = \sum_{k=1}^{n_k} cs_{jk}^t , 1 \leq j \leq n_j, 1 \leq t \leq n_t (4)$$

$$\sum_{(i,j) \in FL} cf_{ij}^t = n_l^t, 1 \leq t \leq n_t (5)$$

$$\sum_{(j,k) \in SL} cs_{jk}^t = n_l^t, 1 \leq t \leq n_t (6)$$

$$\sum_{(i,j) \in FL} cf_{\mathrm{ij}} = 1 \quad (7)$$

$$\sum_{(j,k) \in SL} cs_{\mathrm{jk}} = 1 \quad (8)$$

$$\sum_{(\mathrm{i,j}) \in \mathrm{FL}} cf_{\mathrm{ij}} = \sum_{(\mathrm{j,k}) \in \mathrm{SL}} cs_{\mathrm{jk}} , \ \forall \mathrm{j} \quad (9)$$

$$\sum_{(\mathrm{i,j})\in \mathrm{FL}} \sum_{\mathrm{s}} tf_{ij}^{s} = 1 \tag{10}$$

$$\sum_{(j,k)\in SL} ts_{\mathrm{jk}} = 1 \tag{11}$$

$$\sum_{i=1}^{n_i} \sum_{s=1}^{n_s} tf_{ij}^{s} = \sum_{k=1}^{n_k} ts_{jk}\,, \forall\ \mathrm{j} \tag{12}$$

$$\sum_{(\mathrm{i,j})\in \mathrm{FL}} \sum_{\mathrm{s}} df_{ij}^{s} = 1 \tag{13}$$

$$\sum_{(j,k)\in SL} ds_{jk} = 1 \tag{14}$$

$$\sum_{i=1}^{n_i} \sum_{s=1}^{n_s} df_{ij}^{s} = \sum_{k=1}^{n_k} ds_{jk}\,, \forall\ \mathrm{j} \tag{15}$$

Corresponding explanations of the model

The function (1) minimizes the total transport costs in the observed transport network, when importing different types of containers. They represent the sum of all costs in the first leg, port charges in the observed Mediterranean ports and transport costs of trucks, railways and barges that are engaged for the transportation of containers on the land. The function (2) minimizes the total transit time required to deliver the container from the shipping port to the final delivery point, taking into account different types of service at first leg. Its suspicion is the sum of transit times at first leg, looking at different services, different container ocean carriers at first leg and transit time on second leg, which includes waiting time at the port of discharge depending on the mode type of transportation on second leg. The function (3) minimizes the total carbon dioxide emissions. They represent the sum of total carbon dioxide emission at first leg according to different distances by container ocean carrier service types and total carbon dioxide emissions on second leg, taking into account different emission coefficients depending on the mode type of transportation on second leg. The constraint (4) shows that the total number of containers that arrive at the port equals the number of containers leaving the same port. The constraints (5) and (6) equalize the total number of containers of different types with the total number of containers from the previously defined set, for each of the defined routes, either at first leg or on second leg. Constraints (7) and (8) define a uniquely best solution by looking at a group of possible pairs of solutions in terms of transport costs at first leg and second leg. The constraint (9) selects and connects the first leg and second leg from the aspect of transport costs. The constraints (10) and (11) define a unique best solution by looking at a group of possible pairs of solutions in terms of transit times at first leg and second leg. The constraint (12) selects and connects the first leg and the second leg from the aspect of transit time. Constraints (13) and (14) define a unique best solution by looking at a group of possible pairs of solutions in terms of carbon dioxide emissions at first leg and second leg. The constraint (15) selects and connects the first leg and second leg from the aspect of carbon dioxide emissions.

4.2 Comparison of the selected container transport chain from China to Serbia for different scenarios

The conducted analysis is based on seven different scenarios considering three selected criteria i.e. transit time, carbon dioxide emissions and transport costs transporting three different types of containers (20ft, 40ft and 40ft hc) from the Far East to Serbia:

- Starting point in China: Port of Shanghai;
- Transhipment points in Europe: Ports of Rijeka, Bar, Koper, Piraeus, and Constanta
- Ending point in Serbia: city of Belgrade

Scenario 1 – Optimization of transportation cost

In this scenario we analyze one objective optimization ("min cost") where the optimal transportation cost between Shanghai and Belgrade per each container (20ft, 40ft, 40ft hc) are respectively 1594 EUR, 2470 EUR, 2483 EUR, while the nominated carriers are MSC, CMA-CGM, CMA-CGM using see and land legs together. In all 3 cases port of discharge was The Port of Constanta and mode of transport from Constanta to Belgrade was by barge (inland waterway transport). The first valid data regarding minimum price for transport between Shanghai and Belgrade base on freight on board (FOB) term per each type of container are given in Figure 34.

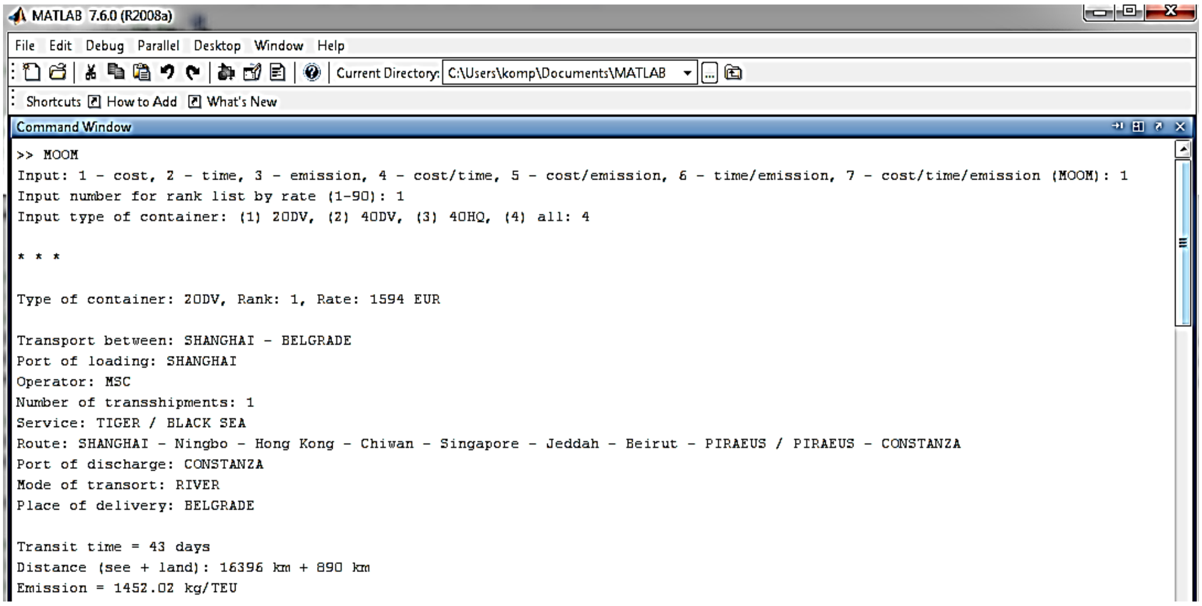


Figure 34. Simulation results – transport costs minimization

```
* * *

Type of container: 40DV, Rank: 1, Rate: 2470 EUR

Transport between: SHANGHAI - BELGRADE
Port of loading: SHANGHAI
Operator: CMA-CGM
Number of transshipments: 1
Service: BEX / FEMEX1
Route: SHANGHAI - Ningbo - Chiwan - Yantian - Tanjung Pelepas - Izmit - Istanbul Ambarili - CONSTANZA
Port of discharge: CONSTANZA
Mode of transort: RIVER
Place of delivery: BELGRADE

Transit time = 41 days
Distance (see + land): 15847 km + 890 km
Emission = 1405.91 kg/TEU
```

```
* * *

Type of container: 40HQ, Rank: 1, Rate: 2483 EUR

Transport between: SHANGHAI - BELGRADE
Port of loading: SHANGHAI
Operator: CMA-CGM
Number of transshipments: 1
Service: BEX / FEMEX1
Route: SHANGHAI - Ningbo - Chiwan - Yantian - Tanjung Pelepas - Izmit - Istanbul Ambarili - CONSTANZA
Port of discharge: CONSTANZA
Mode of transort: RIVER
Place of delivery: BELGRADE

Transit time = 41 days
Distance (see + land): 15847 km + 890 km
Emission = 1405.91 kg/TEU
```

Figure 34. (Continued)

Scenario 2 – Optimization of transit time

The optimal transit time between Shanghai and Belgrade is 29 days using ocean and inland freight together (Table 22). The operator COSCO use Far East Black Sea Express Service - ABX (Figure 35) from Shanghai to Piraeus and Adriatic Feeder Service - AFS from Piraeus to Rijeka (Figure 36), then continues with truck to the final destination Belgrade.

Table 22. Optimal transit time

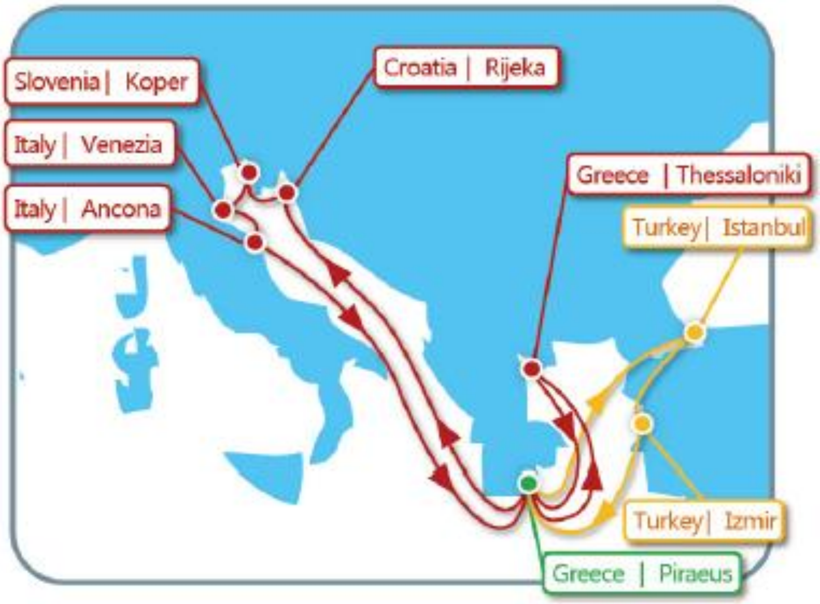
Port of loading	Shanghai
Carrier	COSCO
Number of T/S	1
Service	ABX / AFS
Route	Shanghai-Ningbo-Shekou-Singapore-PortKelang-Pireaus/Pireaus-Rijeka

Port of discharge	Rijeka
Mode of transport	Truck
Place of delivery	Belgrade
Opt. transit time	29 days
Rate 20 dv	2189 EUR
Rate 40 dv	3216 EUR
Rate 40 hc	3253 EUR
Distance	17.498 km

Transit Time (Day)

From / To	Piraeus	Kumport	Constantza	Ilyichevsk
Shanghai	22	24	26	29
Ningbo	21	23	25	28
Shekou	18	20	22	25
Singapore	14	16	18	21
Port Kelang	13	15	17	20

Figure 35. Far East Black Sea Express Service



Adriatic Feeder (AFS)

Port	Time
Piraeus	0
Thessaloniki	2
Piraeus	5
Rijeka	8
Koper	9
Venezia	11
Ancona	12
Piraeus	14

Figure 36. Adriatic Feeder Service

Total transit time between Shanghai and Belgrade includes:

- transit time between Shanghai and Pireaus - 22 days
- waiting time (for feeder to Rijeka) in Pireaus - 2 days
- transit time from Pireaus to Rijeka - 3 days
- waiting time in Rijeka port - 1 day
- transit time from Rijeka to Belgrade by truck - 1 day

Scenario 3–Optimization of CO_2 emissions

The results that analyze minimization according to the criteria ("minimum carbon dioxide emission") are shown in Figure 37. It is noticed that the minimum approximation of carbon dioxide emissions from Shanghai to Belgrade is 1405.91 kgCO2 / TEU using MAERSK LINE carrier through the AE3 ocean service to the port of Constanta, using barge transport to Belgrade port.

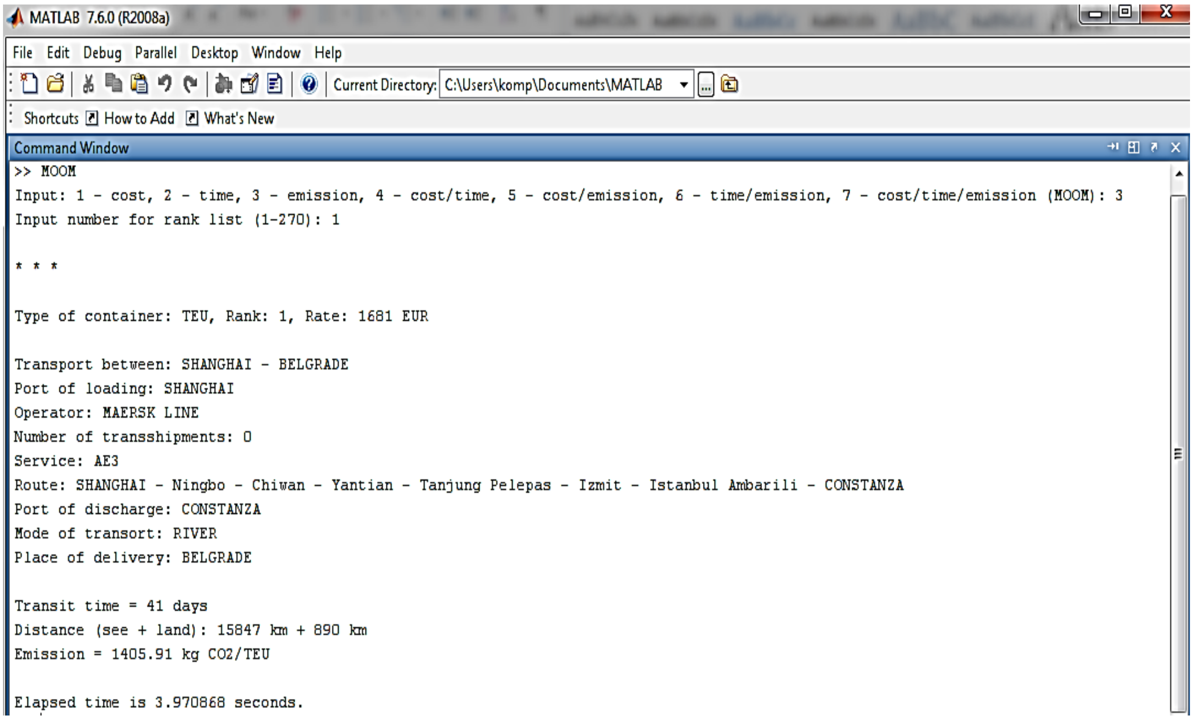


Figure 37. Simulation results – carbon dioxide emmision minimization

Scenario 4 – Optimization of transportation costs and time

The results that observe two criteria at the same time (transport costs and transit time) are shown in Figure 38. In the first iteration, the best solution was selected, in the other to display the 40fthc containers, while unequal weighting of the criteria was performed. The best solution is the COSCO ocean carrier. Using the ABX service to Piraeus, then AFS from Piraeus to Rijeka as well as truck transport from Rijeka to Belgrade, the best transit time was obtained for 29 days. The transport cost was € 2634.

```
Command Window
>> MOOM
Input: 1 - cost, 2 - time, 3 - emission, 4 - cost/time, 5 - cost/emission, 6 - time/emission, 7 - cost/time/emission (MOOM): 4
Input number for rank list (1-90): 1
Input type of container: (1) 20DV, (2) 40DV, (3) 40HQ, (4) all: 3
Input scalar for cost: 1
Input scalar for time: 1

* * *

Type of container: 40HQ, Rank: 1, Rate: 2634 EUR, Transit time = 29 days

Transport between: SHANGHAI - BELGRADE
Port of loading: SHANGHAI
Operator: COSCO
Number of transshipments: 1
Service: ABX / AFS
Route: SHANGHAI - Ningbo - Yantian - Hong Kong - Nansha - Singapore - Suez - PIREAUS / PIREAUS - Thessaloniki - Pireaus - RIJEKA
Port of discharge: RIJEKA
Mode of transort: TRUCK
Place of delivery: BELGRADE

Distance (see + land): 16417 km + 550 km
Emission = 1638.63 kg/TEU
```

Figure 38. Simulation results – transportation cost and transit time minimization

Scenario 5 – Optimization of transportation costs and CO_2 emissions

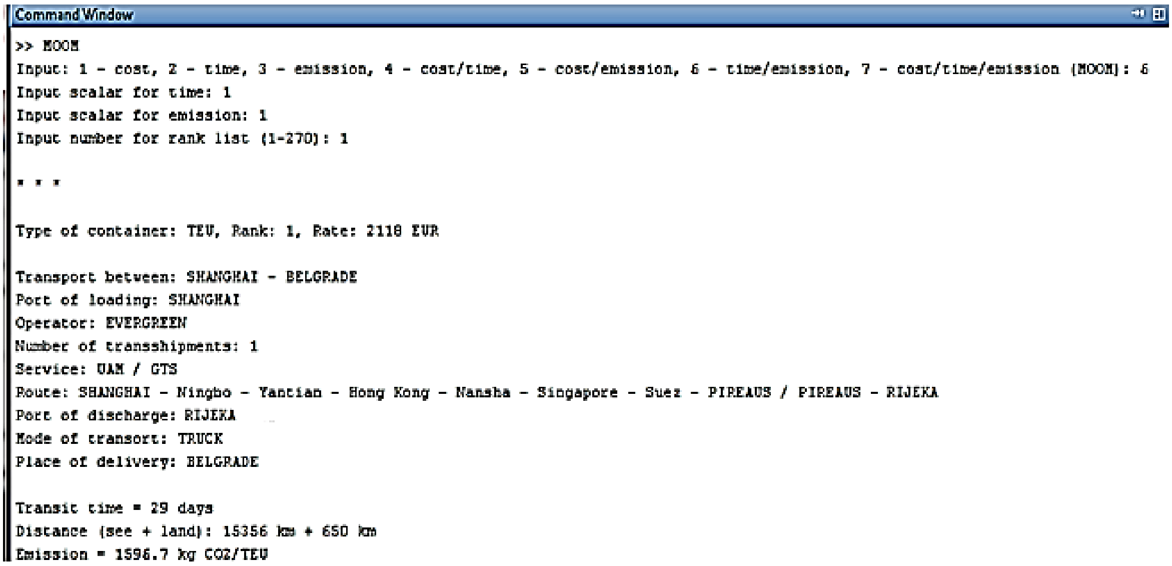
The results that observed the two criteria at the same time (transport costs and carbon dioxide emissions) are shown in Figure 39. In the first iteration, an equal weighting of the criteria was made, while in the second, the best solution was selected. The best solution was the CMA – CGM carrier. The obtained transport route Shanghai-Constanta-Belgrade provides a view of the required output data: 1590 € and 1405.91 kgCO2 / TEU.

```
Command Window
>> MOOM
Input: 1 - cost, 2 - time, 3 - emission, 4 - cost/time, 5 - cost/emission, 6 - time/emission, 7 - cost/time/emission (MOOM): 5
Input scalar for cost: 1
Input scalar for emission: 1
Input number for rank list (1-270): 1

* * *

Type of container: TEU, Rank: 1, Rate: 1598 EUR

Transport between: SHANGHAI - BELGRADE
Port of loading: SHANGHAI
Operator: CMA-CGM
Number of transshipments: 1
Service: BEX / FEMEX1
Route: SHANGHAI - Ningbo - Chiwan - Yantian - Tanjung Pelepas - Izmit - Istanbul Ambarili - CONSTANZA
Port of discharge: CONSTANZA
Mode of transort: RIVER
Place of delivery: BELGRADE

Transit time = 41 days
Distance (see + land): 15847 km + 890 km
Emission = 1405.91 kg CO2/TEU
```

Figure 39. Simulation results – transportation cost and CO_2minimization

Scenario 6 – Optimization of transportation time and CO_2 emissions

The results that observed the two criteria at the same time (transit time and carbon dioxide emissions) are shown in Figure 40. In the first iteration, unequal weighting of the criteria was carried out, while the second one was selected as the best solution. The best solution was the EVERGREEN carrier. The obtained transport route Shanghai-Piraeus-Rijeka-Belgrade also provides the required output data: 29 days and 1596.7 kgCO2 / TEU.



```
Command Window
>> MOOM
Input: 1 - cost, 2 - time, 3 - emission, 4 - cost/time, 5 - cost/emission, 6 - time/emission, 7 - cost/time/emission (MOOM): 6
Input scalar for time: 1
Input scalar for emission: 1
Input number for rank list (1-270): 1

* * *

Type of container: TEU, Rank: 1, Rate: 2118 EUR

Transport between: SHANGHAI - BELGRADE
Port of loading: SHANGHAI
Operator: EVERGREEN
Number of transshipments: 1
Service: UAM / GTS
Route: SHANGHAI - Ningbo - Yantian - Hong Kong - Nansha - Singapore - Suez - PIREAUS / PIREAUS - RIJEKA
Port of discharge: RIJEKA
Mode of transort: TRUCK
Place of delivery: BELGRADE

Transit time = 29 days
Distance (see + land): 15356 km + 650 km
Emission = 1596.7 kg CO2/TEU
```

Figure 40. Simulation results – transit time and carbon dioxide emission minimization

Scenario 7 – Optimization of transportation costs, time and CO_2 emissions

The results that observe all three criteria simultaneously (transport costs, transit times of carbon dioxide emissions) are shown in Figure 41. In the first iteration, an equal weighting of criteria was made, while in the second it was selected the best solution. The best solution is the COSCO carrier. Using the ABX / AFS shipping services via Piraeus, the container was being loaded in Rijeka on the train. The obtained transport route Shanghai-Piraeus-Rijeka-Belgrade also provides the required output data: € 1657, 31 day and 1515.56 kgCO2 / TEU.

```
Command Window
>> MOOM
Input: 1 - cost, 2 - time, 3 - emission, 4 - cost/time, 5 - cost/emission, 6 - time/emission, 7 - cost/time/emission (MOOM): 7
Input scalar for cost: 1
Input scalar for time: 1
Input scalar for emission: 1
Input number for rank list (1-270): 1

* * *

Type of container: TEU, Rank: 1, Rate: 1657 EUR

Transport between: SHANGHAI - BELGRADE
Port of loading: SHANGHAI
Operator: COSCO
Number of transshipments: 1
Service: ABX / AFS
Route: SHANGHAI - Ningbo - Yantian - Hong Kong - Nansha - Singapore - Suez - PIREAUS / PIREAUS - Thessaloniki - Pireaus - RIJEKA
Port of discharge: RIJEKA
Mode of transort: RAIL
Place of delivery: BELGRADE

Transit time = 31 days
Distance (see + land): 16417 km + 666 km
Emission = 1515.56 kg CO2/TEU
```

Figure 41. Simulation results – transit time, transportation cost, carbon dioxide emission minimization

5 Conclusions

This Pilot Action analyzes the container transport with primary focus on import of containers from China to Serbia through Mediterranean and Black Sea ports. The complete project is divided into two parts, where the first part of the analysis assumed the collecting of relevant information presented in the form of Travel Book. The second part of the project has aim to develop an mathematical model which is then used for comparison of different container routes from an origin to a destination of cargo flows. The final aim of the project is development of an open source web-application based on multi-criteria decision making. The open source nature of the application will enable it to faster data filling and wider availability.

Possibilities for container transport on the middle and lower Danube are always considered emphasizing the advantages of river transport: lower costs in the part of river transport from / to Black Sea ports in relation to road and rail transport to seaports in the environment, less congestion of the infrastructure, possibility of transporting large container lots through individual and frequent transportation, possibility of transporting "heavy containers" over the allowed road transport limits, possibility of easier transportation of special containers, possibility of faster and cheaper delivery of empty container equipment for bigger jobs and cheaper relocation of equipment according to needs and seasonal peaks and benefits from an environmental aspect.

Justified or not, but the realization of the transport of containers on the middle and lower Danube and the surrounding inland waterways ends with sporadic attempts and theoretical discussions. However, for the transport of containers on inland waterway, various parameters are important, such as: price in relation to alternative routes and modes, speed, distance from port/terminal to final destination, regularity of the service, economic activity of the region, distance of commercial centres to waterway/ports, state of the infrastructure, administrative procedures, etc. Individual analysis of these factors would provide many answers, but requires time.

The collected, reviewed and summarized information presented in Travel Book served in making an unbiased comparison and assessment of the competing container transport routes between China and Europe. In the transportation process of containers from China to Serbia via The Port of Constanta using IWT we can influence the improvement of both transit time and optimization of transport costs through several phases:

- selection of carriers with direct service from China Main Ports (CMP) to the Port of Constanta – without container transhipment;
- selection of carriers with similar ocean freight rates from CMP up to the Port of Constanta comparing to competitive ports (Rijeka and Piraeus);
- dispatch a large lot of containers at the same time - there is a significant advantage in reducing transport costs per transport unit;
- engagement of 2 captains during transport on IWT.

Therefore, the basic conclusion is that the development of line service in the Danube will certainly result in healthy competitiveness with the currently two most loaded routes during container transport from China to Serbia (route 1: China - Rijeka - Railway to Belgrade, and route 2: China - Piraeus - Railway to Belgrade). In addition, the following could be concluded and recommended:

- In addition to Constanta, and other Black Sea ports (Burgas, Varna, Galati) have potential to participate actively in the implementation of the transport communication between China and Serbia (and the rest of the region and Europe);
- The development of container transport in the Danube could provide to Black Sea ports easier access to the hinterland and rise their competitiveness. Also, the economy and the international trade of the hinterland can be improved by the better connection with the ports which is in compliance with the goals of the project DBS Gateway Region;
- Apart further development of IWT infrastructure, the development of efficient and safe rail and road infrastructure is also prerequisite for increasing competitiveness of the Black Sea ports, mainly within the context of creating efficient backup routes in the case of unfavorable navigation conditions).