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DBS Gateway Region

Project co-funded by the European Union funds (ERDF, IPA)

Pilot Action

WP 5 – Activity 5.4

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Contents

1 Introduction

1.1 Background

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.

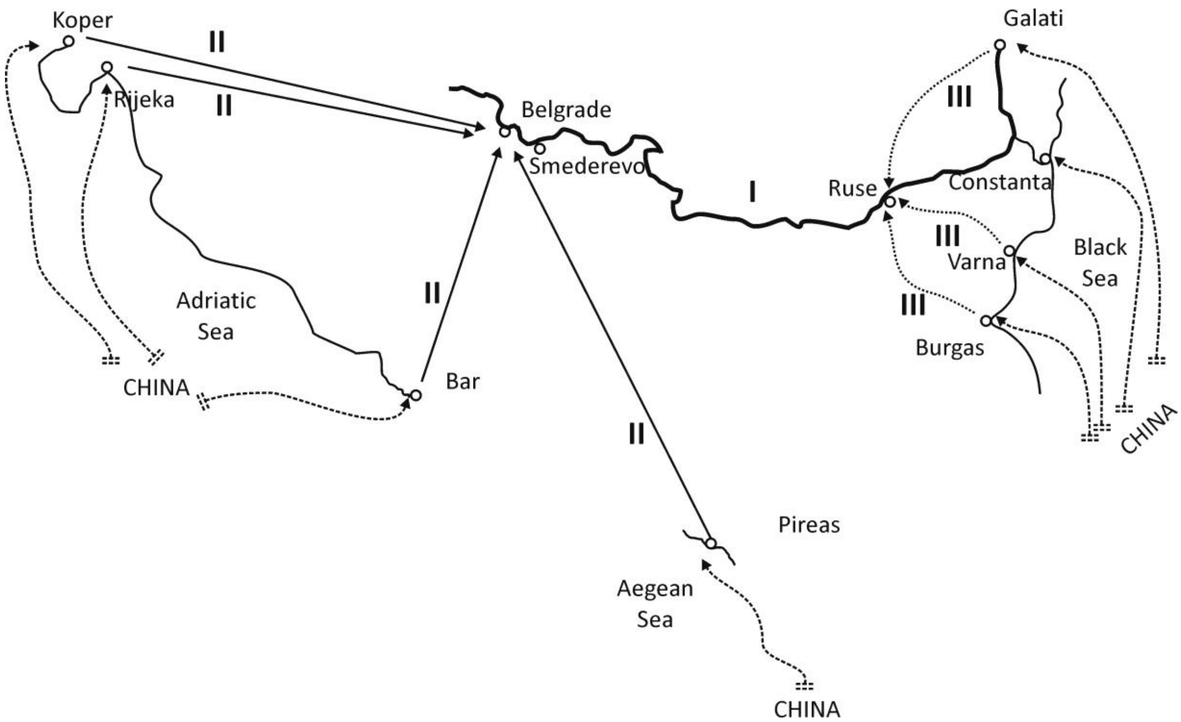

Figure 1 Graphical representation of Pilot Action

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 was performed in order to enable detection of all existing bottlenecks.

Based on the Travel Book, the Evaluation Report is created. The Evaluation Report includes the comparison between the considered intermodal transport routes, lessons learned from the pilot action and resultant recommendations.

The data collected from the logistic service providers and from the tracking and tracing of cargo from China to Serbia, via the Port of Constanta and the Danube River, the data base was created. The data base is integrated in the 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.

The application is set on the DBS online Platform.

1.2 Objective

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.

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 opposite, 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.

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

In the past, there were attempts to transport certain container lots for dedicated jobs via the Constanta port and the Danube River. 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. However, the global economic crisis and the overall reduced volume of economic activities resulted in a reduction in the number of transported containers, as well as in 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: (1) good navigational conditions and (2) 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, etc. 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.

2.1 Detailed description of the tracking and tracing of one container from China to Serbia via the Port of Constanta

In order to provide relevant information on transport and forwarding processes for cargo flows from China to Serbia and further to the Central Europe via the Port of Constanta, the first part of Pilot Action assumed gathering relevant data through tracking and tracing of one container from China to Serbia via the Port of Constanta using the IWT on the Danube. The company chosen for container transport realization was *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 was:

- 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 was Strukturcom d.o.o importing Led panels from China. Container number/seal number: HLBU1731637/HLB5176091-20db. Other basic data are provided in Table 1. Transport plan in this project consisted 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 1 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, GPS tracking device ZT 20 was used, positioned inside container sending real time position of container. Tracking device ZT 20 are shown on Figure 2, while technical data about given device are shown in Figure 3.

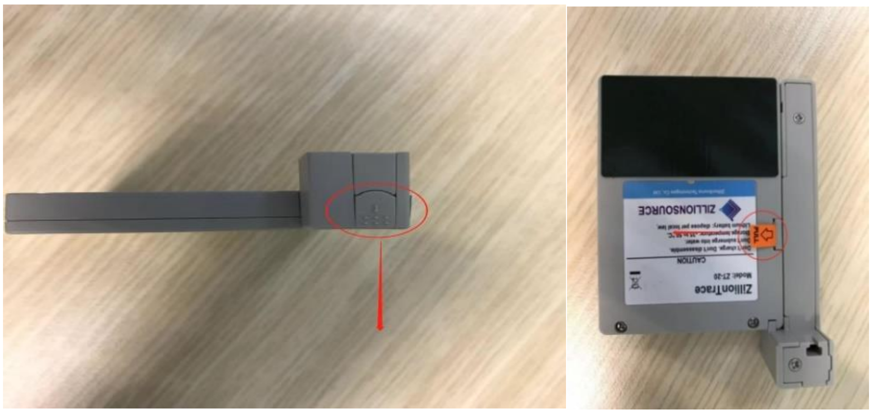

Figure 2 ZT 20 Tracking device

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 3 Technical data of tracking device ZT 20, used in project

Empty container (HLBU1731637) where picked up on 14.11.2018, positioned on shippers warehouse for stuffing on 15.11.2019.

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

Container where unloaded from the 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.

After container is drooped in the port yard, transport document are created.

The subject container was loaded on vessel on 23.11.2018. and vessel sailed on same day- 23.11.2018. Transit time was 38 days, even do planned transit time was 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 was unloaded from mother vessel, it is loaded on barge and transported to the Port of Smederevo. Container was loaded on barge 15.01.2019.

Finally, barge arrived at Smederevo port on 27.01.2019. Container where unloaded from the barge on the same day. On the same day, the truck arrived at client's warehouse and finished import customs clearance, after which it was unloaded at the client's warehouse.

In this transport option and this transport route costs are calculated on the FOB incoterms term. 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. Hence, in this particular case, cost we consider are:

- Transport costs from FOB the Port of Shanghai 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 the Port of Smederevo to consignee warehouse;
- Other costs (insurance, demurrage, detention, possible damage…).

According to the all gathered data it can be concluded that under FOB agreement, total costs from the Port of Shanghai to customer's warehouse was 3915 EUR whit total transport time of 65 days. Some of the main reasons of such unsatisfying transport time and transport costs are:

- Not competitive ocean freight costs to the Port of Constanta;
- Not competitive port costs;
- Nonexistence of the line service;
- Longer transport times;
- Inadequate container lot size - organization of transport of just one container;
- Engagement of one captain during transport on IWT.

2.2 Bulk Cargo

Beside the trucking and tracing of one container from the Port of Constanta to Belgrade, the second part of gathering relevant data of using IWT on the Danube assumed organizing tracking and tracing of bulk cargo from the Port of Constanta to the Port of Prahovo. Specification of organized transport is given in Table 2.

Table 2 Report of organized bulk cargo transportation

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: the Port of Constanta	

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

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 three representative samples of commodity were formed.

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

After loading a/m commodity the barge DISCOVER was sealed with SGS seals marked asC03002300, C03002292. According to the detailes of tracking and tracing of bulk cargo monitoring of transport of bulk cargo on IWT from the Port of Constanta to the Port of Prahovo, Serbia was performed.

The total transport time was 7 days with the costs of 10EUR/MT.

2.3 Proposal for improving the container transport route using IWT on the Central and Lower Danube

There are two basic elements for a regular liner container service on inland waterways: a passable waterway and modern terminals. Apart those factors, also very important factors are the speed of transport, the regularity of the service, the economic activity of the region, the number of transported container units, the balance of imports and exports, etc. None of these factors is applicable in our case study. Even more, our case study represents the worst-case scenario in order to identify all types of bottlenecks in the realization of such a container transport route using IWT. The detailed SWOT analysis of liner container transport on the Danube River is given in Table 3.

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

STRENGHTS:	WEAKNESSES:
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.	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.

Great benefits from an environmental aspect.	
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. 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.	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.

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.

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 three-modal 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.

3 Route Optimization

3.1 The Route Optimization Application

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 oppose, 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.

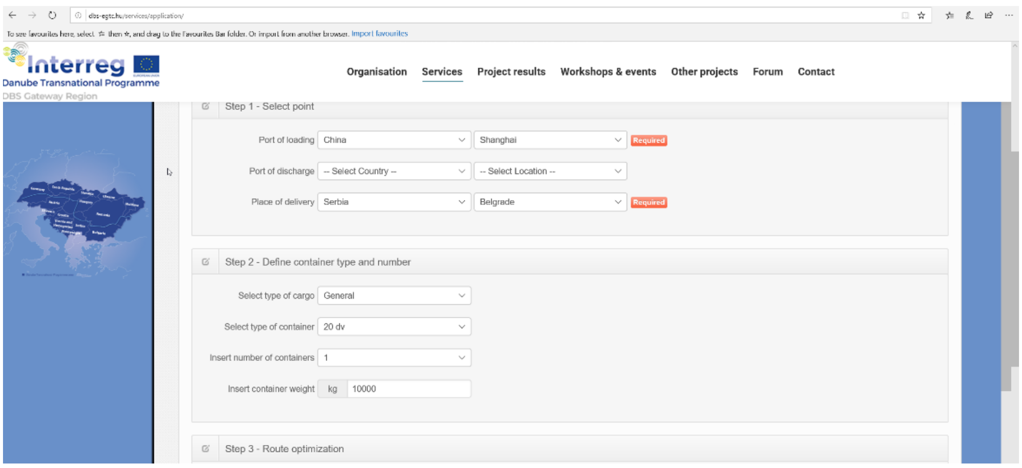

Figure 4 The DBS route optimization open source application

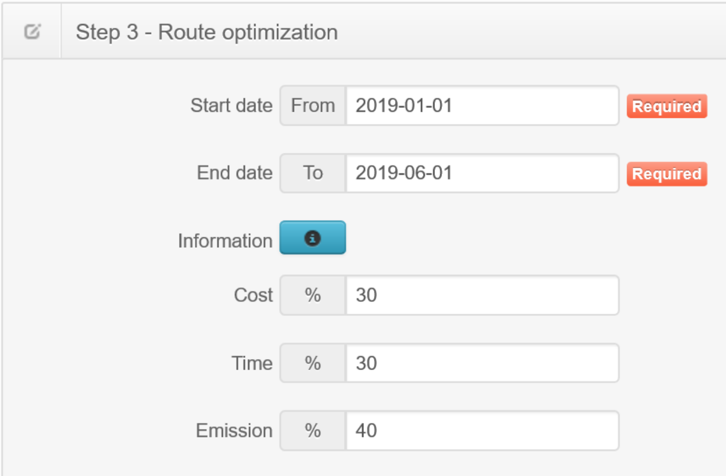

Figure 5 Route optimization weight criteria in the application

3.2 Selected transport routes from China to Serbia from the logistic service providers perspective

The intercontinental container transport chain consists of the main transport route section via ocean, where the containers are transported by the world's largest ocean carriers, and the last mile transport route section using different modes of transport (road, rail or inland waterway transport - IWT). The selected transport routes from China to Serbia (shown in Figure 6), consist 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.

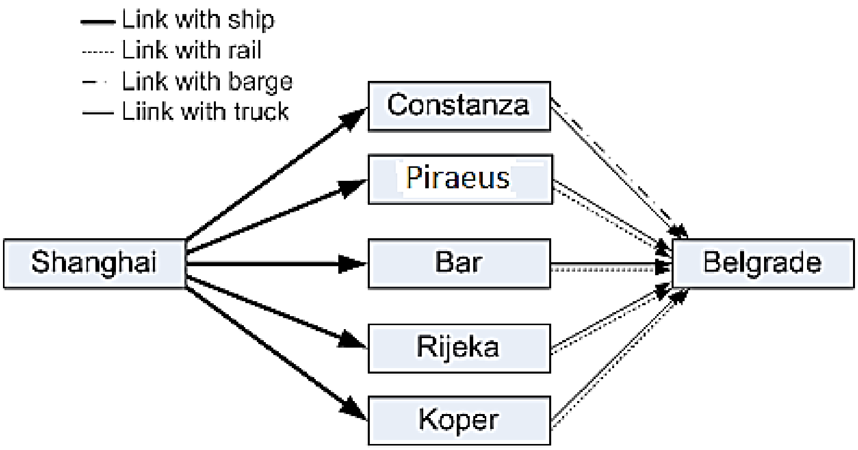

Figure 6 Potential intermodal transport routes from China to Serbia

The Port of Shanghai is the world's busiest port and since 2010 the world's largest container port. 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 carriers transport containers from the port of Shanghai to the nominated ports.

Serbia is a landlocked country, so the main hubs for importing containers to Serbia are the ports: Rijeka, Bar, Koper, Constanta and Piraeus.

Belgrade is the capital city of Serbia and main center of buissines activities attrackting over 30% of total imports of goods to Serbia (Republic Institute for Statistics, 2016). With all considered ports it is connected by direct connections, and containers can be transported by different modes of transport (rail, road, IWT).

The total transport costs 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).

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.

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.

Based on the data gathered through the tracking of cargo from China to Serbia and collected from inquiries sent to the great number of logistic service providers, the database for the Danube Black Sea region was created. The database was used for the creation and testing of the open source web-application that is using the multi-criteria decision making (three criteria: price, time, emissions) for comparison of the defined intermodal transport routes from China to Serbia (via ports Constanta, Koper, Rijeka, Bar and Piraeus), considering different types of containers and more potential shippers.

3.3 Route optimization results for the selected case study

The route optimization was performed (tested) for six different scenarios for transporting containers from the Far East to Serbia:

- One general cargo TEU, with gross weight 10,000 kg;
- Starting point in China: the Port of Shanghai;
- Potential transshipment ports in Europe: Rijeka, Bar, Koper, Piraeus, and Constanta;
- Ending point in Serbia: city of Belgrade;
- Different weights of the optimization criteria.

All values of transportation costs and times (ocean freight costs, terminal costs, etc.) used for calculation in the following scenarios represent an average values gathered for the year 2018.

Table 4. Route optimization results

Scenario	Criteria	Weight [%]	Total costs [EUR]	Total time [days]	Total emissions of CO_2 [kg/TEU]	Operator	Through the port	Mode of transport - delivery
I	Costs	100	1909	43	1452.024	Hapag - Lloyd	Constanta	IWT
	Time	0						
	Emissions	0						
II	Costs	0	2488	30	3167.5	Hapag - Lloyd	Koper	Rail
	Time	100						
	Emissions	0						
III	Costs	0	1920	48	1405.908	MSC	Constanta	IWT
	Time	0						
	Emissions	100						
IV	Costs	50	2229	31	3160.53	COSCO	Rijeka	Rail
	Time	50						
	Emissions	0						
V	Costs	30	2119	33	1515.558	COSCO	Rijeka	Rail
	Time	30						
	Emissions	40						
VI	Costs	60	1909	43	1452.024	Hapag - Lloyd	Constanta	IWT
	Time	20						
	Emissions	20						

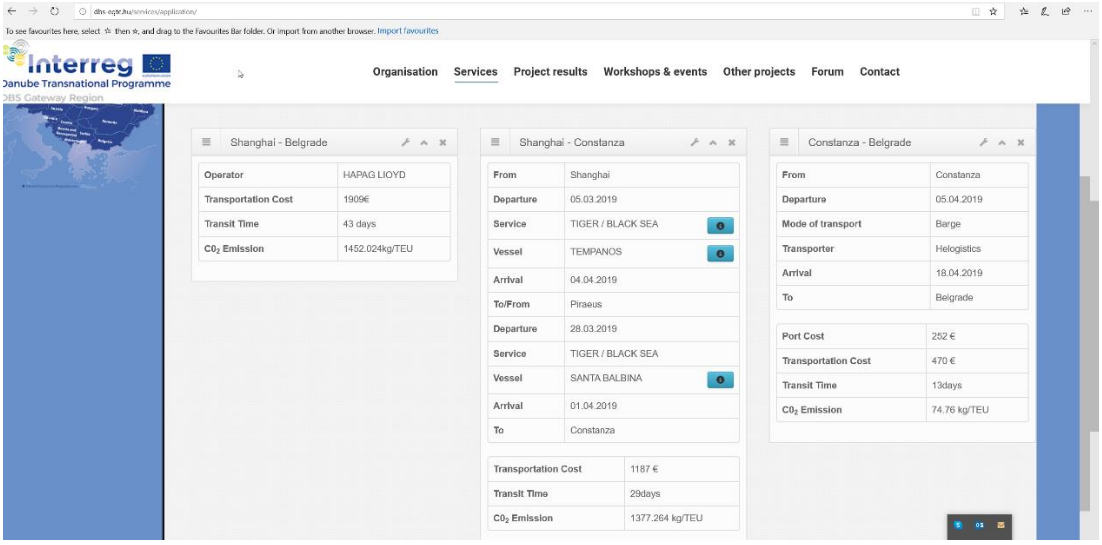

Figure 7 Presentation of the optimization results

4 Conclusions

Level of container transport on the inland waterways in Northern and Western Europe is at much higher level in comparison to the container transport on the Danube. This is due to the significantly better navigational conditions, modern terminals and warehouses, regular services, developed economic activity, branched channel network along water flows, fast ship movements and reduced administration.

Container transport on the middle and lower Danube was always considered as an unused potential due to the following advantages: lower transport costs of the water transport, 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.

However, despite the obvious potential, the realization of the container transport on the middle and lower Danube did not get further than sporadic attempts and theoretical discussions.

Within the DBS Gateway Region project, the Pilot Action was performed in order to analyze and detect the existing obstacles for the transport of containers on the Danube and to provide recommendations for the removal of the obstacles.

The analysis of the container transport had primary focus on import of containers from China to Serbia through Mediterranean and Black Sea ports. The action was realized in two steps. The first step of the analysis included collection of relevant data gathered in the form of a Travel Book. The second step had an aim to develop a mathematical model that will be used for comparison of different container routes from an origin to a destination of cargo flows.

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, both transport costs and transport time were not competitive to the ones on the alternative routes. However, it was concluded that the improvement of both transit time and optimization of transport costs is possible in order to make the route competitive. The competitiveness of the route via Black Sea ports could be achieved through:

- Improving the navigational conditions, and modern trimodal logistics terminal on waterways (with modern handling equipment);
- 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);
- Dispatching a large lot of containers at the same time (there is a significant advantage in reducing transport costs per transport unit), through regular container service 2 to 3 times a week in both directions;
- Providing short transit time and fast-turning boats, with engagement of 2 captains during transport on IWT;
- Providing short retention due to administrative formalities in ports and border crossings;
- Achieving a competitive price in relation to rail and road transport from the seaports;
- Providing access to the earmarked funds from EU development funds and budgets for developing these projects.

Based on the data gathered in the first step, a data base was created, which is then used as support for developing and testing of the appropriate open source web-application, for comparison of the selected intermodal transport routes and the decision making process about the optimal route. The developed application (with working name "*Route optimization*") is based on multi-criteria decision making. The application was tested for the six scenarios in the case study of the container transport route optimization between China and Serbia, considering the potential transshipment ports: Rijeka, Bar, Koper, Piraeus, and Constanta. Testing of the application proved the multi criteria approach as well as the application usefulness and effectiveness. The open source nature of the application will enable faster update of the data base and utilization of the application by greater number of stakeholders in the DBS Gateway Region. The future research should primarily consider update and extension of the database, so that the application can be further tested for the other geographical regions.

The basic conclusion of the Pilot Action 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 Seaports (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).