Interreg

EUROPEAN UNION

Danube Transnational Programme

DIONYSUS

Integrating Danube Region into Smart & Sustainable Multi-modal & Intermodal Transport Chains

Policy recommendations for Container Liner Service on the Danube River

Output T1.5

Version: 3.0

Date: 20/10/2022]

[Status: final]

Project co-funded by European Union Funds (ERDF, IPA, ENI)

Document History

Version	**Date**	**Authorised**
1.0	18.05.2022	EHOO
2.0	07.09.2022	EHOO
3.0	20.10.2022	EHOO

Main & Contributing Authors

Name	**Organisation**	**Email**
Karin Voglsam	EHOO	k.voglsam@ennshafen.at
Christian Stark	PDM	stark@prodanube.eu
Igor Barna	VPAS	igor.barna@vpas.sk
Silviu Meterna	PDR	pdr.office.2020@gmail.com
PP experts (assigned Communication experts)	All DIONYSUS partners	

Table of Contents

Table of Figures 3

Table of Tables 3

Abbreviations 4

1 Introduction 5

2 Scope of the report 7

2.1 Objectives of Output T.1.5 Policy recommendations for Container Liner Service on the Danube River 8

3 Findings of the Workshops on Container Liner Services 9

3.1 Conclusions 1st Workshop 10.12.2020 (online) 9

3.2 Conclusions 2nd Workshop 07.12.2021 (online) 10

3.3 Conclusions 3rd Workshop 14.04.2022 (online) 13

4 Overview and analysis of previous failed liner services on the Danube 18

4.1 BRP / JUGOAGENT / ZIM / Nord Marine 18

4.2 MAINROMLINE 18

4.3 HELOGISTICS (DDSG) – HELO 1 19

4.4 Danube Logistics: Constanta – Giurgiulesti 20

5 Conclusions of past Container Liner Services 21

6 Assessment / Architecture of new routes & services – outlook 23

6.1 Favorable conditions 23

6.2 Unfavorable conditions 24

6.3 Recommendations for the modelling and establishing container liner services on the Danube 25

6.4 Containerized IWT potentials 26

6.5 News from the Container World 4Fold Container 27

6.6 Existing situation and further development steps 30

6.7 Description of the container barge liner service modelling logic 32

6.8 Conclusion of Concept for Container Liner Services 33

7 Framework condition analysis on Container Liner Service 35

8 Initiatives for supporting Container Liner Service 42

8.1 NAIADES-III & Green Deal 42
8.2 Initiative "Intermodal & rolling cargo by barge" viadonau (2021-2022) 43
9 Financing and funding opportunities 45
10 Conclusions & Policy Recommendations 48
11 References 56

Table of Figures

Figure 1 4Fold Container 28
Figure 2 4Fold Container 29
Figure 3 Port of Constanta container traffic 37

Table of Tables

Table 1 Number of annually transported containers on the Constanta-Giurgiulesti service 20
Table 3 Action plan for the development of container barge service on the Danube 31
Table 4 Necessary conditions for the development of inland waterway transport 36

Abbreviations

Abbreviation	Explanation
DR	Danube Region
TEN-T	Trans-European Transport Network
IWT	Inland Waterway Transport
PPs	Project partners
ASPs	Associated Strategic partners
EHOO	Ennshafen Port
WP	Work package
CLS	Container Liner Service

1 Introduction

The project's overarching goal is to facilitate DR's integration into multimodal and intermodal freight and passenger transport systems. In this context, Danube ports must be seen as key elements of the extensive DR transport system (which consists of a range of corridors, each with specific characteristics in terms of scale, trade, transport modes used, price and service quality), which are essential to help achieve this overarching goal.

WPT1 aims to provide a substantial knowledge basis regarding ongoing and future transport corridor developments in the Danube region as well as regarding their potential connections to transport corridors and networks in the Black Sea region. The analyses and assessments carried out in this work package shall identify gaps in corridor planning and transport infrastructure of the DR.

To achieve this, four activities have been planned. Activity A.T1.1 will identify and label gaps that are relevant for a better functioning transport system and for a higher share of waterborne transport considering the enabling role of ports. It will include:

- the assessment of the TEN-T Core as well as Comprehensive network sections and nodes (T.T1.1.1),
- a status quo analysis of the DR infrastructure (T.T1.1.2),
- an analysis of on-going and planned corridor projects for selected sections and nodes (T.T1.1.3),
- traffic flows analysis at DR transport corridor level involving all transport modes (T.T1.1.4).

Activity A.T1.2 investigates the current market situation and identifies alternative cargo volumes in growing markets. It will encompass:

- definition of trade flows and economic development scenarios (T.T1.2.1),
- analysis and forecasts of the main cargo flows for all modes of transport (T.T1.2.2),
- identification and quantification of the cargo flows that represent a potential for IWT (T.T1.2.3),
- evaluation of the high impact of available fairway depth on transport efficiency and competitiveness (T.T1.2.4)
- analysis of the prospects of containerized cargo development on the Danube (T.T1.2.5)
- investigation of the development of transport of passengers on the Danube waterway with a special focus on river cruise passengers (T.T1.2.6).

Activity A.T1.3 will investigate new cargo opportunities for Danube IWT that the transport of containers may offer. It will be done through the following tasks:

- analysis of the market framework conditions, as well as failed past operations (T.T1.3.1),
- studying potential routes and modelling of the potential services (T.T1.3.2),

- organization of the three stakeholder meetings that will identify potential partners for such a service as well as to inquire into the necessary market and regulatory pre-conditions (T.T1.3.4),
- based on the market analysis and the stakeholder feedback, elaboration of the recommendations for the conditions to set-up a successful service (T.T1.3.4)

Activity A.T1.4 will analyze potential new cargo flows due to connections of the Danube waterway with transport corridors in the adjoining Black Sea region. It is especially related to the Middle Corridor comprising Georgia, Azerbaijan, Kazakhstan and reaching out to western provinces in China, as well as Connections via the Black Sea linking the Danube seaports with destinations in the Russian Federation as well as in Turkey. This will be achieved through:

- analysis of these socio-economic benefits and costs of increased cargo flows on the Danube waterway (T.T1.4.1),
- elaboration of the strategic concept for the promotion of Danube waterway transport in the European transport policy framework and towards the transport & logistics markets (T.T1.4.2),
- development of an Action plan detailing the measures to connect the Danube corridor with EU Eastern Partnership (EaP) corridors, the Russian Federation and Turkey (T.T1.4.4).

2 Scope of the report

Currently, there is only a very small number of containers being transported on the Danube which belong by the majority to empty container return market operations. In the past, several companies tried to implement container services e.g., on the relation Giurgiu – Constanta, Belgrade-Constanta as well as Budapest-Constanta. These services did not prove to be economically successful and terminated after some period of operations. The same fate happened to a service introduced in the early 2000 years which established operations between Deggendorf – Enns – Budapest with dedicated 45 feet open-sided containers. Despite these failures, the transport of containers offers significant new cargo opportunities for Danube IWT and therefore shall be investigated and prepared in A.T1.3.

First, the market framework conditions, as well as failed past operations, will be analysed (T.T1.3.1).

Secondly, potential routes will be studied and potential services modelled (T.T1.3.2). Three stakeholder meetings shall identify potential partners for such a service as well as to inquire into the necessary market and regulatory pre-conditions (T.T1.3.4). Based on the market analysis and the stakeholder feedback, recommendations for the conditions to set-up a successful service will be elaborated (T.T1.3.4).

In total three Workshops on Container Liner Services will be designed and executed, one workshop each by MPAC in Constanta (Online), one by FTTE in Belgrade (Online), and one by MPAC in Constanta.

These workshops will constitute O.T1.4. The workshops will reunite PPs, ASPs, and external stakeholders and will be organized with the purpose to identify interested companies to revive and develop the Container Liner Services on the Danube River.

With this occasion the reports of the previous stakeholder meetings and the draft of Output T1.5. – Policy recommendations for Container Liner Services on the Danube River (report) will be presented and further discussed. The target audience will be stakeholders interested in further elaborate Business Cases which will bring together specialized concepts and policy recommendations, highlighting the necessary activities in order to initiate and support the development of container liner services. Besides the specialized project partners who will bring in their expertise in IWT activities (port authorities, ship owners, port operators, consultancy companies), researchers (maritime and transport universities), representatives of business support organizations (chambers of commerce & industry) and policy decision-makers (transport ministries) will also contribute. On these occasions, the Stakeholders Reference Group will be initiated and expanded.

2.1 Objectives of Output T.1.5 Policy recommendations for Container Liner Service on the Danube River

The PPs under the coordination of EHOO will elaborate policy recommendations which shall create a favourable framework for a successful implementation of a container liner service on the Danube. The recommendations will include measures for the improved regulations and handling of border and customs control, preferential tariffs for ports and canals, priority rules at locks, financing and funding opportunities and any other supportive measure which might be identified in the stakeholder meetings. The Policy Recommendations will be drafted by EHOO with support of the PPs as presented in the activity description. The findings of the WP 3 Workshops on Container Liner Services will be reflected in the Policy Recommendations on Container Liner Services.

The PPs involved will filter the information received, share it at the consortium level and jointly develop harmonized solutions in the form of Recommendations for positive regulatory framework & Service implementation. But for the elaboration of this tool, the previous failed transport experiences of containerized cargo will be analysed, the assessment of new routes & services will be executed and the architecture of new container liner services will be established.

Based also on all information gathered following the meetings organized with the key stakeholders, the Recommendations for Container Liner Service on the Danube River will increase the successful chances of such initiative.

3 Findings of the Workshops on Container Liner Services

3.1 Conclusions 1st Workshop 10.12.2020 (online)

The 74 participants represent important organizations (public institutions, authorities, private companies, associations, universities, research organizations, etc.), providing useful information based on their various areas of expertise.

This first event was an important step towards the revival of Danube container transport. The purpose of Dionysus is to reunite relevant decision-makers who influence inland waterway transportation and to build the foundation of a stakeholder reference group, where people from EU organizations, private companies or all those involved in the academic fields can discuss the problems they identify in practice but most importantly, to provide solutions. While designing plans for the future, previous experiences and mistakes should be used as lessons. Moreover, the fast evolution of digitalization, the increasing trend of using clean transport ways and availability of EU funding schemes must be used as engines for keeping Danube a desirable transport alternative.

It was stated that the most important output of the project will consist in the elaboration of a large number of port development plans, which will consequently be used by project partners for preparing quality investment projects in order to obtain EU funding. These investment projects will have a significant impact on the regional economic development of the port hinterland, making Dionysus a key instrument for reaching the EU's strategy regarding the Danube River.

Mrs. Desiree Oen, senior expert in DG MOVE and adviser to Karla Peijs, European coordinator of the Rhine-Danube TEN-T Corridor, was emphasizing the importance of well-developed ports as modal points of intermodal logistic chains, playing a key role in facilitating a sustainable transport growth in the Danube Region.

Port developments plans are highly awaited and they will stand as an important corner stone in the development of sustainable logistic chains in the Danube Region and further in Europe.

"We need to create a real dialogue and not a competition", highlighting the European Commission's constant efforts to support transport on the Danube, a priority being the fairway maintenance works on the inland waterway, customs formalities and digitalisation. Furthermore, there is a need besides the port infrastructure namely an adequate fleet, which can be achieved by using dedicated financing instruments in the next period for the development of this waterway. All these measures being a support for the transport of containers.

A very small number of containers are transported on the Danube and most of these containers belong to empty container return market operations.

The main barriers in today's Danube traffic are Danube's infrastructure (water levels and navigability) and Danube ports (quays, equipment, connections to hinterland). Therefor necessary investments for the majority of ports in the lower Danube are such as: quays platforms and supra-structural works; dredging works in the ports; specialized equipment for container operations, road and rail connection.

Certain objective and subjective aspects make the development of traffic management very difficult was stated by stakeholders e.g., Unpredictability of Danube water level and a big number of points with very low water level. The efforts will be continued in promoting Danube as a viable option in the multimodal transport practice and will be part of a real container Liner Service.

Another stakeholder stated that they will never give up in developing container transport on the Danube, by using big capacity and low draft vessels. Some investments have already been done and such vessels will be brought in Romanian ports from 2022. Also, free floating cranes will be made available in 2022, standing as an alternative for operators who refuse using barges.

Improved communication with shipping companies is essential for the development of container transport.

Regarding a long-term strategy a 5 points plan was presented, including **investment programs in new river vessels** with low drafts, **investments in port infrastructure**, **supra-structure** and **equipment** and **market analysis** – proximity to market and efficiency.

3.2 Conclusions 2nd Workshop 07.12.2021 (online)

The 82 participants representing important organisations (public institutions, authorities, private companies, associations, universities, research organisations, etc.) took part to the Workshop and provided useful information based on their various areas of expertise.

Thus, representatives of shipping companies, ports, agencies, state authorities, and the academic community need to take them into account and to find ways to overcome them, if the container traffic on the Danube is to be further increased.

The obstacles defined in the 1st workshop are now already widely recognized by all stakeholders. In the second workshop **innovative barge technologies were highlighted** and presented to contribute largely to launching and improving container liner services on the Danube River. Also, the large number of port development plans should contribute to reduce the obstacles with regard to port infra- and superstructure as well as hinterland connections.

DP World in the Port of Constanta in Romania has two mainline and six feeder services calling at the container terminal in the Port of Constanta. Nevertheless, the liner services which exist in the maritime legs and calling their terminal in the Constanta Port have not been replicated, in any measure, at the river legs.

Customer expectations from the Danube transportation:

- reliability
- transparency
- visibility
- efficiency

Today, contrary to other transport modes, Danube container transport can offer to the customers uncertainty, lack of transparency and long transit times.

First condition for liner service to work is PREDICTABILITY – the foundation the concept of liner services has been built.

Predictability issues have been related to the improper infrastructure maintenance on the Danube as well as the capability of Danube ports to provide first and last mile services. These attributes would make inland waterway transport competitive for most cargos even with long transit times.

Concept for CLS:

The work was based on two perspectives:

- consultations with important stakeholders form the DR
- consultation from the available literature related to these aspects

The main tasks were to assess potential routes and services and present a model of the CLS's according to vessel concepts and market requirements.

The concepts shall provide a knowledge basis for companies that are interested in container transport.

Shipping routes design process has been based on:

- the optimal turnaround times
- the optimal choice of the final port of call in the outbound direction, and empty container balancing and repositioning

Online tool:

- for the definitions of concepts for CLS on the Danube River
- as a prerequisite: registration for using the tool
- determination of ports to be called in the upstream and downstream direction
- number of full containers to be shipped between called ports
- number of empty containers to be shipped between called ports
- number of empty containers to be stored at each port
- number of empty containers to be leased at each port
- turnaround time and calculation of container transport costs between called ports

Conclusions of previous studies with regard to CLS:

- bundling of transports
- fewer empty runs
- reduced costs
- agreements with shipping companies to establish continuous, closed combined offer on the Danube
- creation of Transport policy framework by policy recommendations to have a successful implementation of a container liner service on the Danube

Barge innovations:

- double-hull barges
- ICT
- Fuel cell
- Electric barge motor
- Catalyst
- Filter systems
- Z-drive
- Advising
- Air lubricated barges fast barges….

Most promising innovations for a successful broad-based market introduction:

- Catalyst and filter systems
- Z-drive
- Tempo Maat
- Air-lubricated barges
- Model shift scans
- Dedicated barges
- Sea-river transport
- Create new markets a new product to stay competitive with road transport

Future aspects:

- Specific design of future inland container vessels
- Such vessels should operate in low water periods

Design results of new vessels - 4 container RoRo vessels

- NOVIMAR Class Va inland container RoRo vessel / regular draught

- NOVIMAR Class Va inland container RoRo vessel / shallow draught (sterb access version, double-end access version)
- NOVIMAR Class III inland container RoRo vessel
- NOVIMAR sea-river container RoRo vessel

Project NOVIMOVE (novel inland waterway transport concepts for moving freight effectively:

IWT is a major key-holder for unlocking congestion in seaports, terminals, road networks, and access to urban areas besides being a main factor in reducing CO2 emissions in transport.

Key results NOVIMOVE:

- Enhanced IWT freight throughput performance with respect to 2010 for the Rhine-Alpine route
- Innovative vessel concepts and operations
- A dynamic scheduling system for bridges and locks will be in use by 2026
- Stakeholder groups coming more and more important

3.3 Conclusions 3rd Workshop 14.04.2022 (online)

The 50 participants who attended the 3rd Workshop on Container Liner Services represented important organisations (public institutions, authorities, private companies, associations, universities, research organisations, etc.), providing useful information based on their various areas of expertise.

The purpose was that actors to the same table would succeed to emphasise the main problems that each part of the container transport on Danube mechanism is dealing with.

The representative of maritime port administration of Constanta stressed out that the present climate of great uncertainty has huge implications, the economic consequences will be felt mainly as a rise in commodity prices, which will fuel the already existing inflationary pressures; net importers of energy & food products will be particularly affected, with the spectre of major supply disruptions in the event of an even greater escalation of the conflict. The drop in demand from Europe will also hamper global trade, and consequently the transport on the Danube.

Regarding the Danube transport development, this situation may be an opportunity, unfortunately without having an estimation yet to what extent; Constanta Port is already attracting a consistent share of goods to be transported to the rest of Europe, being preferred within the Black Sea area. The tremendous increase of traffic in Constanta, due to the geopolitical circumstances, could give a push also to the other modes of transport, even if we are talking about rail, roads and inland transportation. Inland and rail are already first priorities for the investments, in the context of the European Green policy.

The stakeholders should pledge to transform the Danube River in a successful Green Corridor.

The shipping industry emits an estimated 1 billion metric tons of carbon dioxide each year. On its current trajectory, maritime trade is projected to grow by as much as 130% by 2050 over today's trade volume. The world cannot stop the climate crisis without urgent action to decarbonize international shipping this decade. By building out zero-emission maritime "corridors," major trade partners can catalyse land-side investments needed in clean energy and zero-emission electro-fuel infrastructure at ports.

The current lack of fairway maintenance on the Danube resulting in unreliable and unpredictable navigation is a pressing issue for the inland waterway sector and the industry using it. The failure of some countries to honour their commitment to maintain the Danube threatens the safe and cost-efficient navigability of the river with disastrous consequences for the sector and affected industry. The containerized transport on Danube is affected by this reality, but these times of change could be the urge that Danube transportation needs.

Containers represent a major market on Rhine Corridor, but in the Danube region it is almost inexistent.

There is the need to stimulate the transport of containers on the Danube!

The development of container transport on the Danube would produce positive, long-term effects.

Actions needed:

- Investments in fairway improvement
- Port infrastructure to handle the demand
- Improve rail connections
- Support business model development

Regarding logistics, one considered necessary to increase the competitiveness of inland navigation in logistic network.

Some initiatives needed:

- Evaluating the potential for promising cargo types
- Enhancing cooperation between the relevant market actors
- Organizing expert working groups focusing on dedicated product groups on national level

Priority objectives of the programming period 2021-2027 DTP:

- A smarter Danube Region, by enhancing innovation and technologies transfer in Danube region; development of skills for advancing smart specialization strategies, industrial transformation and transition towards industry 4.0 including cross sectorial collaborations.
- A greener, low carbon Danube Region, by enhancing the integration of renewable energy sources; promoting climate change adaptation capacities in

the Danube Region and disaster management on transnational level in relation to environmental risks; sustainable, integrated, transnational water and sediment management in the Danube River Basin ensuring good quality and quantity of waters and sediment balance;

- A more social Danube Region, promoting accessible, inclusive and effective labour markets, quality services in education, training and lifelong learning; socio-economic development through heritage, culture and tourism;
- A better cooperation governance in the Danube Region, by increasing institutional capacities for territorial and macro-regional governance.

Obstacles that limit development of container barge transport on the Danube:

- Lack of transparency and long transit times
- Lack of service consistency which enables reliability and capacity to provide lower costs

Barge transport needs to create new markets and new products to stay competitive, in relation with road and rail transport, offering innovative barge technologies.

Several companies tried to implement container services on the relation Giurgiu-Constanta, Belgrade-Constanta, as well as Budapest-Belgrade-Constanta, but these services did not prove to be economically successful and were ceased.

Fairway maintenance impact calculation tool:

- To conduct an impact analysis on fairway maintenance, based on the situations encountered and reported, illustrating economic losses impacting the barge operators (limitations of transport capacity, days of delay)
- To identify and analyze the critical areas and depths, based on the existent history, negatively impacting the costs (ships berthing, not loading at full capacity)

Variables should be taken into account when performing the calculation:

- Ships/barges/composition of the convoy
- Penalties for delays specified in the contract documents
- Daily expenses associated with the ship/barge (euro/hour)

Few aspects that should be implemented:

- Becoming a part of the national transport strategy and waterborne transport strategy
- Necessary clear measures from port authorities, canal administrations, service providers
- To be included into development strategies of key players

Possible solutions to increase container services on the Danube into transport logistic chain:

- Defining of cargo flows (main actors, cargo type, ports)
- Defining route connections (role of Constanta Port)
- Coordination of existing lines (JIT)
- Regularity and predictability
- Flows of full/empty containers
- Model for ships/vessels to be used
- Necessity of synergies
- New projects on inland water container transport
- Boost of dedicated political decisions
- Relevant answer from logistic chain actors
- New initiatives, as predefined routes are determined where initiatives can be launched
- Case studies to actualize the action plan
- Cooperation across stakeholders is the key (national governments, port authorities, shippers, vessel owners)

Feedback by private companies:

MAHART Container Centre Ltd.

- Infrastructure problems – sufficient water level
- Missing proper port equipment for loading/unloading containers by reliable way
- Lack of proper vessel – self-ongoing standard Rhine-type vessels or KVBs. Barge service is not a reliable option
- Old, outdated regulations for container transport on Danube
- TEN corridor provided by Danube is not matching with maritime container flows
- "Container Line Service" should focus not only containers, but other intermodal units also

Luka Dunav AD – Dunav Pancevo (a fully utilized intermodal terminal for containers)

- Pancevo facilitates easier access for goods from EU, China and other markets
- Current ports for receiving containers from Constanta, Rijeka and Koper
- Existing direct connection of port's berths with rail and road provides full intermodal services
- 2020 over 1 million tons of various goods were transshipped/handled in the port of "Danube" Pancevo

IHORKS Shipping and Trading

- Daily evolution of water level allows loading of bigger weight only for short period of time
- The containers remained empties must be transported back to ROCND, because an empty container once taken from shipping line incurred a lot of costs
- Still continued effort in developing of several other container services
- Focus to implement a general container line service like Enns – Budapest – Serbian port – ROCND

4 Overview and analysis of previous failed liner services on the Danube

There have been several attempts to establish container liner services on the Danube, especially in the period from 2005 to 2017. However, all these services have proven to be economically unprofitable. One of the biggest problems relates to the custom clearance in Serbia and Hungary. These procedures take up to three days. The fixed costs of the ship due to the delay of three days greatly burden the costs of transporting full containers on the routes on the Danube River.

Currently, there is only a very small number of containers being transported on the Danube that belong, by the majority, to empty container return market operations. In the past, several companies tried to implement container services e.g., on the relation Giurgiu – Constanta, Belgrade-Constanta as well as Budapest-Constanta. In 2011, five different regular services operated on the Danube, three regular container services (one of them was discontinued in March 2012) and two regular RoRo services.

- MainRom Line Logistics Ltd. (Constanta – Giurgiu)
- BRP Bulgarian River Shipping (Constanta – Belgrade)
- HELOGISTICS: HELO 1 (Constanta – Budapest, service now discontinued)

HELO 1 service was economically successful and terminated after some period of operations. The same fate happened to a service introduced in the early 2000 years, which established operations between Deggendorf – Enns – Budapest with dedicated 45 feet open-sided containers. Danube Star is actual the only service between Passau (Austria) – Ruse (Bulgaria) that is running on the Danube with RoRo services and empty container transportation. Despite these failures, the transport of containers offers significant new cargo opportunities for Danube IWT and therefore shall be investigated and prepared in A.T1.3. Following subchapters will give characteristics of the previous attempts to establish container barge service on the Danube River.

4.1 BRP / JUGOAGENT / ZIM / Nord Marine

This service was active in the period from 2005-2010. It was a joint service of BRP, JUGOAGENT, ZIM and Nord Marine between Belgrade and Constanța that started in 2005. The service survived until the Helogistics' line commenced in 2010. The frequency of service varied during the period of operation. It went from weekly to 2-weekly or even monthly/occasionally (Martin, 2015).

The service is usually regarded as not very successful. There are several reasons for such evaluation. The most important were, as always, non-favourable hydro-meteorological conditions, with emphasis on low water level, as well as the behaviour of freight forwarders on IWT, which did not favour the development of container barge transport on the Danube (Martin, 2015). Some attempts to restart the service were seen after the end of the Helogistics service.

4.2 MAINROMLINE

One of the first attempts to establish container barge transport on the Danube was recorded in the second half of 2005. During that period, the shipping company MainRom Line was founded, which among others aimed to establish container barge services on the Danube. The company procured two specialized container push barges

and a high lifting capability pusher with the hydraulic bridge. At the same time, the terminal in the Port of Giurgiu was made capable of handling containers.

The service itself was organized as a regular domestic Romanian container line between Constanța and Giurgiu (60 km from Bucharest), through which both empty and full containers were transported. It was operational in the period from 2006 to 2012. Occasional services to Zimnicea (RO) and Svistov (BG) were provided. Frequency of the service was typically one to two round trips per week (Martin, 2015).

Company MAINROMELINE had a dedicated berth and stacking area within Giurgiu Free Zone. The company has also commenced transport of grain and scrap metal cargoes with some success. The service was ceased following multiple reported changes of ownership. In addition, the relatively short distance between these ports, as well as the presence of extremely strong competition, in the form of road transport are most often taken as the main reasons that caused this service to become unprofitable.

4.3 HELOGISTICS (DDSG) – HELO 1

A HELO1, a weekly container service between Budapest-Belgrade-Constanța, was introduced in August 2010. It was a new and innovative container service on the Danube. Calling at Port of Smederevo was added in July 2011, while there were also occasional calling at Bulgarian ports. The service was organized by Helogistics Holding Gmbh and included river shipping companies such as EDDSG Gmbh and MAHART Duna Cargo Kft. It had a strict weekly schedule, so the service was operated whatever were the circumstances.

This service intended to link the traditional ways of transporting cargo on the Danube, i.e., the transport of bulk and liquid cargo, with container transportation. It used the combined pushed convoys, which consisted of six standard push barges for the transport of bulk and liquid cargo and one push barge for the transport of containers.

The use of such a combined pushed convoys has led to good business results. During the first year of operating the service, a total of around 6000 TEU was transported, i.e., 57 per round trip in average. Company claimed that the utilisation of ship capacity of 70 % was achieved (Martin, 2015). Industry feedback, from customers and port operators, was very positive, with emphasis on the reliability of the service.

However, managing the service itself meant overcoming a number of difficulties and obstacles. Frequent occurrences of low water on the Danube led to the need to dismantle the convoy and moving the container barges by employing additional pushers. Further, the congestion in sectors with low water, due to huge number of ships and convoys waiting to cross the low-water sector, significantly affected the ability of push convoys to follow the scheduled calling at ports on the route.

In particular, 2011 and 2012 were marked by a very large number of days when low water levels were recorded on the Danube. This caused the occurrence of the most of explained difficulties in keeping the schedule of the service, which directly affected the cost-effectiveness of transporting containers on Danube. For that reason, a decision was made to suspend this container on barge service. Service was halted following also the end of EC “Marco Polo” assistance in March 2012, and concurrent management change at HELOGISTICS (Martin, 2015).

However, a number of shippers, who used the HELO1 line, requested that the transport of containers on the Danube be continued. For that reason, MainRom Line and MAHART Duna Cargo Kft have introduced the so-called "Relocation program" for empty containers. This program is based on the transport of containers from Constanta to Budapest, upstream, or from Budapest to Belgrade or Constanta, in the downstream direction. Even though it is not a standard liner service, there is sufficient carrying capacity of engaged vessels to meet the existing demand for empty containers transportation. The service is organized as a monthly or biweekly, while, in certain parts of the year, the weekly frequency is achieved. The main problem, recognized by the operators, which appears as an obstacle to further improvement of this service, is the need to integrate all stakeholders in order to increase the attractiveness and competitiveness of container barge transport on the Danube. In that way, preconditions would be fulfilled for the transport of full containers on this, but also other similar possible container shipping liner services on the Danube River.

4.4 Danube Logistics: Constanta – Giurgiulesti

Service Constanța-Giurgiulesti was initiated as a sea-going service (via Sulina Channel and Black Sea) but on a few occasions did employ a barge service (via the Danube and Danube-Black Sea Canal). It was further established as a maritime service only. The service is operated by the Danube Logistics SRL, a private owner and operator of Giurgiulești International Free Port. Operator of the service has signed agreements signed with several major container lines, including MSC and China Shipping Container Lines The frequency of the service is one sailing per week in each direction (Martin, 2015). Number of annually transported containers is given in Table 1 Number of annually transported containers on the Constanta-Giurgiulesti serviceTable 1.

Year	Number of transported containers (TEU)
2012	1,620
2013	6,481
2014	11,076

Table 1 Number of annually transported containers on the Constanta-Giurgiulesti service

5 Conclusions of past Container Liner Services

Obstacles that, to a greater or lesser extent, limit the development of container barge transport on the Danube are today widely recognized by all stakeholders. Thus, representatives of shipping companies, ports, agencies, state authorities, and the academic community clearly point to numerous barriers, which occur at all management levels (strategic, tactical and operational) and which prevent a significant increase in container traffic on the Danube. Therefore, there are numerous obstacles, which need to be taken into account and for which it is necessary to find ways to overcome them, if this container traffic on the Danube is to be further increased.

Based on the previous experiences, it can be seen that the development of container barge transport has been really stimulated by the introduction of container terminals in the hinterland. Many of inland barge terminals are, more or less, identical in terms of type of equipment, lay out and working methods. Differences in type of equipment may be the result of differences in development phase and, related to that, the size of the terminal. The starting point for establishing a new inland terminal and barge service is usually the presence of one or a few launching customers, which guarantee a minimum (threshold) transport volume to start operations and hence limit exploitation risks. In that initial phase, where volumes are still small, simple and rather inexpensive terminal equipment may be chosen, for instance a reach stacker (possibly second-hand) or a general-purpose crane that is mixed used for both container and general cargo transhipment (Konings, 2009).

No obstacles should lead us to think about rejecting the idea of introducing container shipping liner services on the Danube. The establishment of such services implies cooperation and joint action of shipping companies, port operators, but also decision makers, i.e., government officials. In order to overcome obstacles, one of the possible directions of action is the necessity of investing in ships with low draft, in order to reduce the impact of low water levels. Such investment programs would have to be subsidized by the European commission, as well as Danube countries. It is also necessary to explore the possibilities of developing ships that would be harmonized with the concepts of so-called green ships. Subsidy programs from EU funds could be very important for enabling such a development.

The next course of action relays on the goals of the Danube Strategy, which, among others, requires reaching a depth of 250 cm on the Danube, throughout the year. Achieving this goal is very important, because the navigation of container ships takes place on the same waterway, on which bulk and liquid cargo ships and convoys navigate. Therefore, if, due to the low water level, the navigation of other ships, with greater draft, is not possible, it can directly and negatively affect keeping the schedule of container ships and push convoys.

Investments in port infrastructure and superstructure is another and very important step in fulfilling the conditions for the development of container barge transport on the Danube. However, such investments would also have to be subsidized. Namely, the development of port container terminals on the Danube would require investments expressed in millions of euros. It is obvious that the EU or national governments should support private shipping and port operators if container traffic on the Danube is to be increased.

Increasing container traffic on the Danube would also require improving the hinterland connection of ports with the most important trade centers in the Danube region. This refers to the improvement of both road and railway traffic networks.

It is also necessary to do a market analysis of potential demands for container barge transport on Danube. This refers to the research that would aim to answer the question of whether the establishment of liner container services on the Danube can be performed in an efficient manner, which would enable shipping companies to make a profit. Such research should put particular attention to the analysis of the competitive freights as well as transit times in comparison to road and railway system, as main barge transport competitors.

Establishing regular container transport services on the Danube presents a challenge for all parties involved in this process. Therefore, it is a business activity requiring full engagement and investments of funds and efforts of shipowners and ports, as well as government representatives, customers, or potential users.

6 Assessment / Architecture of new routes & services – outlook

Liner Shipping companies, including barge operators, make decisions at the strategic, tactical, and operational planning levels. Strategic decisions mostly relate to the adoption of general policies and business directions and represent a framework for decision-making at the tactical and operational planning levels.

The available carrying capacities of inland waterway ships on different barge container liner services depend on decisions made at the tactical level, which, also sets limitations that need to be taken into account in decision-making processes at the operational level.

D.T1.3.1 presents a theoretical and practical analysis of the causes and conditions of the development of container barge networks. In this research, we particularly emphasize the possibilities of establishing container transportation on the Danube River. Main findings, in terms of favorable and unfavorable conditions, as well as recommendations for the modelling and launching container liner service on the Danube River are given below.

6.1 Favorable conditions

- **the Danube River enables the connection of economic potentials in the hinterland of a number of capitals and other strongest industrial regions in the Southeast Europe** (Belgrade, Budapest, Bratislava and Vienna; City of Bucharest is in the immediate vicinity, i.e. 60 km away from the Port of Giurgiu; Ennshafen Port is situated in Austria's strongest industrial region (the Container Terminal has a capacity with 450,000 TEU's; 2 industrial parks with more than 60 companies settled there; directly in the port area over 2.500 employees));
- **the Danube River provides good enough conditions for the development of container barge transport from the connection with other river basins point of view** (Rhine River, through the Main-Danube Canal and the Main River; Sava River, Tisza River, etc.);
- **annual container traffic in the Port of Constanta clearly indicates a significant, but untapped potential for the establishment of regular container barge lines on the Danube;**
- **from the distance of transport perspective,** as one of the factors of competitiveness**, the Danube River offers favorable conditions for development of container barge transport;**
- **the most important economic regions in Serbia** are the areas near the cities of Belgrade and Novi Sad – **proximity of the Danube River**; **container handling equipment is available in the ports of Belgrade and Pančevo**;
- **location of the port of Belgrade** at the mouth of the Sava River, or near the mouth of the Tisza River, as well as between the ports of Smederevo and Novi Sad, **is an extremely strong argument for choosing this port as a hub port, in the possible future establishment of "hub-and-spoke" system on the Danube;**

- there is possible **connection between Zagreb**, as the most important economic center in Croatia, **and the Danube River**;
- **port of Budapest is capable to handle container ships** (in most cases, the equipment is used to transship empty containers).

6.2 Unfavorable conditions

- **container transit times,** between the **Port of Constanta** and the **ports in e.g., Serbia or Hungary** are significantly higher **than** containers delivery times **from the ports of Rijeka, Koper or Bar,** using **road or rail transport** (7 to 11 days, or 4 to 8 days compared to 1 day);
- the level of development and suitability of **available infrastructure** in the most ports on the Danube River to the needs of transshipment and transport of containers on the Danube is **another significant group of obstacles** to the development of this type of transport;
- **the structure of the cargo** that is currently most often **transported on the Danube** cannot be considered favorable for the development of container barge transport;
- **current level of economic activity in the hinterland area** on Danube is an obstacle for generation of sufficient volumes of container flows which would justify the establishment of container liner services;
- potential shippers are most **often insufficiently informed about the advantages of inland waterway transport** and they have **preferences toward road and rail transport**;
- possibilities of shipping containers from **The Port of Constanta to Bucharest**, using barge transport (via Giurgiu Port or Oltenita) has very **strong competition of road transport** (Bucharest and Constanta are connected with a 200 km highway);
- in Bulgaria, the most developed economic areas are the capital city of Sofia **with its surroundings, as well as the city of Ruse**; freight flows to Sofia, both in export and import direction, go through the ports of **Burgas and Varna**;
- concerning Serbia, the import and export of containers is mainly done through the **port of Rijeka, but also through the ports of Koper and Bar**;
- import and export activities **in Croatia** are mainly realized **through the Port of Rijeka**;
- most **import-export processes to or from Hungary** takes place through the **ports of Hamburg, Rotterdam and Antwerp**;
- **non-favorable hydro-meteorological conditions**, with emphasis on **low water level**, are usually taken as the main reason for non-successful attempts to establish container liner services on Danube;
- **low water levels** increase barge **freight rates** and undermine **service reliability**, two major factors shaping competition with other transport modes;

- **low water level**, on a certain part of the waterway, can lead to the need to move **barges one by one** (to dismantle the pushed convoys in order to enable the passage through a given section and formation, after the passage of the sector, of pushed tows) – transit time, of any type of cargo, may increase significantly;
- lower **water level** may lead to increased shipping traffic, as barges have to reduce the cargo load per sailing to reduce vessel draft and thus **make more roundtrips** to carry the same amount of freight
- **Danube flows through both the EU and non-EU countries** – this may cause **administrative and political obstacles**, which can, significantly, reduce the competitiveness of container barge transport compared to its rail and road alternative;
- **custom clearance procedure** in Serbia and Hungary may take up to three days - the fixed costs of the ship due to the delay of three days greatly burden the costs of transporting full containers on the routes on the Danube River;

6.3 Recommendations for the modelling and establishing container liner services on the Danube

- **Port of Constanta**, should be a starting and ending port of call on all potential container liner services;
- Some of the **ports of call of the container liner service** (based on the previous experiences) should be Giurgiu, Ruse, Svistov, Smederevo, Belgrade, Novi Sad, Budapest, Port of Bratislava, Ennshafen port, Deggendorf, Passau;
- **the analysis of the potential demand** for container barge transport on the Danube should incorporate the **cargo flows of the Danube countries in the import and export direction** and **selection of those that could be transferred from other transport modes to river transport**;
- the starting point for establishing a new barge service is usually the presence of **one or a few launching customers**, which guarantee a minimum (threshold) transport volume to start operations and hence limit exploitation risk;
- the establishment of container liner services, with a **high frequency (frequency of the service** should typically be **one to two round trips per week**), would be a necessary step towards the transfer of existing container flows in the Danube region, to a certain extent, to the Danube;
- container demand should relate to the container **transport over long, but also short distances** (experience on the Rhine indicate that containers are transported from the port of Rotterdam or Antwerp, by IWT, to locations in the hinterland, which are only about 50 km away);
- development of container barge transport is stimulated by **building up container terminals** in the hinterland;
- In that initial phase, where volumes are still small, **simple and rather inexpensive terminal equipment** may be chosen, for instance a reach stacker

(possibly second-hand) or a general-purpose crane that is mixed used for both container and general cargo transshipment;

- use of the **combined pushed convoys**, consisting of standard push barges for the transport of bulk or liquid cargo and push barge for the transport of containers, may lead to good business results;
- one of the possible directions of action is the necessity of investing in **green ships with low draft**, in order to reduce the impact of low water levels - **subsidy programs from EU funds** could be very important for enabling such a development;
- process of establishing inland waterway container services must also take into account the possibility of **interruptions or limitations in navigation** (due to unfavorable hydro-meteorological conditions, i.e., low or high-water level, fog, ice level, ice drift, wind, etc.) and provide for appropriate solutions;
- development of container transport networks on inland waterways should be based on the establishment of some types of the **"hub-and-spoke" concept**
- the processes of **transporting empty containers by barge ships** should be particularly emphasized;
- container liner service operator should **sign collaborative agreements with major shipping container lines** (like MSC and China Shipping Container Lines) in order to increase the attractiveness and competitiveness of container barge transport on the Danube;
- **integration of river and maritime shipping companies, terminal operators, road or rail carriers, freight forwarders** are a basic precondition for a more significant development of inland waterway transport, and especially container barge transport;
- establishment of container liner service services implies **cooperation and joint action of market players and decision makers**;
- in the initial stages, **transport and port authorities** should be in charge of the integration of all participants.

6.4 Containerized IWT potentials

Within DIONYSUS output O.T.1.3 IWT Market observatory the containerized IWT potentials were analyzed. Global and Danube Region trends were reviewed and technology that can contribute to the future expansion of the container market on the Danube was introduced.

New technologies, such as container liner bags **can divert new type of goods** to be carried in a standard shipping container.

Liner bags are a clean, safe and effective packaging solution that transforms containers into reliable and cost-effective alternatives to tank containers, ensuring the lowest logistical costs and reducing environmental impact:

• Protect goods from external agents and contaminations

• Reduce total handling costs: easy and fast to install – load – discharge – dispose

• Maximize container payload • 100% waterproof

• 100% recyclable

Fields of application

Food and Feed: Barley, cocoa, corn, fishmeal, flour, ground nuts, lentils, milk powder, nuts, peas, rice, salt, seeds, soya beans, starch, sugar, tea leaf, wheat, grain, flour, cattle feed, mixed grain feed, etc.

Chemicals: ABS resin, aluminium, certain fertilizers, glass beads, nylon polymer chip, polyester granules, PE granules, PP granules, PVC powder, PTA powder, soda, catalysts, pigments, zinc powder, detergents, carbon black.

Minerals: Anhydrite binder, bentonite clay, gypsum, silica, talcum powder, tri-poly phosphate, vanadium slag, Aluminium fluoride, bleaching earth, titanium dioxide, zeolite, cement, lime, chalk.

Wastes: organic waste, residue sludge and ashes from industrial and organic processes.

6.5 News from the Container World 4Fold Container

The disposition of empty container is a complex issue in global distribution of goods. About a third of all transported containers are empty. The need of empty equipment is rare balanced and brings supply chains in times of crisis to stagnation, causes costs and emissions.

This is because the same number of resources are needed in the logistics chain to transport loaded and empty containers. "We can solve part of this imbalance, or at least the inefficiency of "air transport," claims Hans Broekhuis, CEO of Holland Container Innovations, also known as 4Fold.

Figure 1 4Fold Container

The Dutch company was already able to have the first foldable containers certified by the Container Safety Convention and the International Organization for Standardization in 2013. The 4Fold container can be reduced by three quarters of its volume from top to bottom using a specific folding technique. Four folded containers can thus be made into one unit.

This saves space, costs and emissions during transport.

Solutions like these are very interesting, especially from an environmental point of view, and could fundamentally change the container market. Nevertheless, the market is initially reacting hesitantly. Higher up-front costs and a rather conservative attitude of

the transport sector are probably the reasons. For 4Fold, however, the road continues. "4FOLD is actively looking for cooperations within the supply chain with forwarders, shippers, ports, terminals and depots. Hamburg stands as an important hub for the Europe - USA Green Corridor high on the list," says Broekhuis.

The next step for the company is to coordinate all operational issues and processes around folding/unfolding and equipment maintenance with depots. Broekhuis is positive about the future: "Shippers will benefit from the emissions savings, and carriers, ports and terminals will enjoy the efficiency and flexibility of moving the 4FOLD folding containers faster and in less space than normal containers."

Figure 2 4Fold Container

LIKE AN ACCORDION

The U.S. supplier Staxxon is also convinced by the idea and is launching its own foldable model, which is already being tested by shipping companies this year (2022). Staxxon also particularly sees the benefits for the environment and climate. "About 25 percent of global emissions come from the transportation sector," explains Santtu Seppälä, Staxxon CSO. The Staxxon containers can be folded in different stages like an accordion. Thus, two, three, four and five containers can be combined in such a way that they always replace one regular container.

This "bundle" is already certified and can be used, loaded and secured in exactly the same way as a normal standard container. Due to the high flexibility of the bundling options, Staxxon containers can be seamlessly introduced into already existing logistics processes. Folding itself should not be a bottleneck, that is important to the company. An automated process allows folding in under three minutes. Manual folding is also possible, with a trained two-man team needing just ten minutes per container. The model is scheduled to go on the market as early as next year. Seppälä believes that the current crisis situation will lead to more investment in modern, environmentally friendly container solutions. "Our solution would not only help to alleviate the current crisis, but also to prevent a similar crisis in the future."

(Source:https://www.hafen-hamburg.de/de/port-of-hamburg-magazine/container-welten/neues-aus-der-containerwelt/)

6.6 Existing situation and further development steps

It is possible to distinguish several phases in the historical growth pattern of the European container barge network. These phases are the following (Notteboom and Konings, 2004; Notteboom, 2006; Frémont et al, 2009; Notteboom et. al.,2020):

- First phase (the pioneering phase mid-1968 till early 1970s);
- Second phase (mid 1970s till mid 1980s);
- Third phase (mid 1980s till mid 1990s);
- Fourth phase (from mid 1990s till 2007);
- Fifth phase (from 2007).

Each of the phases has its distinctive characteristics related to:

- terminal development;
- barge service design;
- container volumes;
- market organization.

This section describes the existing situation on the Danube based on the characteristics of the growth pattern phases of the European container barge network. In addition, we indicate possible directions for the development of container barge transport, i.e., what should be done to move to the next development phase of container transport on the Danube.

After analysing the phases in the historical growth pattern of the European container barge network, described in D.T1.3.1, we can see that existing situation on the Danube mostly corresponds to the first phase characteristics, given below:

- terminals:
  - establishment of first container terminals;
  - development of specialized terminals;
- services:
  - transport at irregular intervals;
  - usage of conventional barges;
  - primarily transport of grouped empty containers (in the immediate vicinity of the users);
  - barge transport unattractive to deep-sea carriers and shippers;
  - service offered by barge operators do not include transshipment and pre- and end-hauls by trucks;
- Container volumes:
  - low volumes;
- Market organization:
  - features only few pioneering barge operators in the market.

It can be noticed that even the characteristics of the first phase have not yet been fully achieved on the Danube. However, in order to accelerate the development of barge container transport on the Danube, the next steps in this process should be aimed at achieving the characteristics related to both the second and the third phase of this

growth pattern. These characteristics, which can be also taken as an action plan for the development of container liner services on the Danube, are given in Table 2.

Network elements	Distinctive characteristics	Comment
Terminals	new terminals to be set up within the perimeter of existing ports, or at new locations along the main navigation route initiative for setting up inland waterway terminals should also come from the Danube carriers	
Services	scheduled container liner services by barge to be developed gradually Jointly operated and frequent liner services to each of the three navigation areas on the Danube complemented by a limited number of direct point-to-point shuttles to achieve guaranteed punctuality - barge transport will gain in competitiveness	operators may divide the Danube into three navigation stretches, namely the Lower Danube, the Middle Danube and the Upper Danube line-bundling services with typically five inland ports of call per loop barge services are threatened by rail services; as a response, more and more waterway services are to be established; such services should consist of point-to-point services between the port and the largest urban area in the hinterland; it lowers costs and improves the reliability, frequency and transit time of services Once punctuality could be guaranteed by fixed departure schedules for each navigation area, with exceptions only occurring in case of problems with water levels, barge transport will quickly gain in competitiveness
Container volumes	annual transport volume on the Rhine to grow	
Market organization	the market is expected to be dominated by a few carriers / alliances operational collaboration agreements - raise the level of service and prevent destructive competition partners to streamline their sailing schedules participating parties to maintain its own commercial identity and freedom limited degree of central planning	existing barge carriers to initiate joint liner services on the different navigation areas of the Danube so as to offer a high frequency of departures from the seaports to the lower Rhine

Table 2 Action plan for the development of container barge service on the Danube

6.7 Description of the container barge liner service modelling logic

The problem considered in this paper consists of finding the route for a given barge container ship as to maximize the profit of the shipping company. The solution of this problem defines upstream and downstream calling sequence and number of loaded and empty containers transported between any two ports while achieving maximum profit of the shipping company. The first port (a sea port, located at a river mouth) is always included in a solution, while the remaining n−1 ports in either direction (upstream or downstream) may or may not appear in the optimal (and even any feasible) solution.

Our approach is based on the perspective that a barge shipping company on Danube would like to design a liner service, i.e., sequence of calling ports with a given schedule. Such service has to be defined under the following assumptions, which are typically considered in the barge container ship routing:

- a predetermined ordering of ports for the outbound-inbound trips is given;
- the port calling sequence must start at and return to the first port, i.e., sea port located at a river mouth (usually, the Port of Constanta in case of Danube River);
- at the last visited port (furthest called port upstream), the ship changes sailing direction. In our case, this port is not known in advance and it is up to the model to make recommendation in terms of the last visited port in the upstream direction;
- the ship does not have to visit the same ports in upstream and downstream directions;
- the model assumes a weekly known cargo demand for all port pairs;
- all the container demand emanating from a port may not be selected for transport even if that port is included in the route or service;
- repositioning of empty containers between the ports in allowed.

We have analysed a number of mathematical programming models, which can be found in the literature, and which relate to barge container shipping. Some of these models are contained in the following papers:

1. Maraš, V., (2008), “Determining Optimal Transport Routes of Inland Waterway Container Ships”, in Transportation Research Record, No. 2062, Transportation Research Board of the National Academies, Washington, D.C., pp. 50-58.
2. Maraš, V., “Routing of container ships on inland waterways”, Faculty of Transport and Traffic Engineering, University of Belgrade, February 07, 2012.
3. Maraš, V., Lazić, J., Davidović, T., Mladenović, N. (2013). “Routing of barge container ships by mixed-integer programming heuristics”, Applied Soft Computing, Vol. 13, Number 8, pp. 3515-3528.
4. Alfandari, L., Davidović, T., Furini, F., Ljubić, I., Maraš, V., Martin, S. (2019). Tighter MIP Models for Barge Container Ship Routing, OMEGA: International journal of management science, Vol. 82, pp. 38-54.

However, a model proposed in the Alfandari et. al., 2019 significantly outperforms all other existing approaches available in the literature. It is particularly related to the computational time. In addition, it is also the first approach for the barge container shipping that simultaneously searches for the optimal route, while taking into account empty container balancing and repositioning, optimizing the turnaround time and therefore the size of the fleet and search for the final port of call in the upstream direction. Therefore, in the next section, we will introduce the model given in the Alfandari et. al., 2019.

Adopted model

The selected model is intended to determine:

- The turnaround time of the route, expressed in weeks (which also represents the size of the fleet);
- The last port of call of the route in the upstream direction;
- The sequence of ports to be called in the upstream direction;
- The sequence of ports to be called in the downstream direction;
- The numbers of full and empty containers to be shipped between any two ports;
- The numbers of empty containers leased or stored at any port on the route.

The model asks to maximise the profit, which is calculated as the difference between the revenue for shipping full containers and the port call costs, cargo-handling costs, bunker and capital costs. In order to be able to give realistic results, the model is structured to respect the following constraints:

- The route must start at Port 1 (Port of Constanta in our case);
- The total turnaround time (which includes travelling and handling time in ports) must be between pre-defined min and max numbers of weeks;
- At each port in the route, if the total inflow of full and empty containers (counting the flow both in upstream and downstream direction) is not equal to the total outflow, the difference should be balanced by either leasing or storing containers at that port;
- Empty containers can be transported on the ships;
- Full containers can be transported either in the upstream or downstream direction.

6.8 Conclusion of Concept for Container Liner Services

The report D.T.1.3.2 assesses potential routes and services and introduces a tool for modelling of the container liner services on inland waterways. The outcome of this research enables us to identify opportunities and potential threats for container liner services, which are considered as a pre-condition to develop container transport on the Danube River.

We particularly emphasise favourable and unfavourable conditions, as well as recommendations for the modelling and launching container liner service on the Danube River. We describe the existing situation on the Danube based on the characteristics of the historical growth pattern phases of the European container barge network. After analysing these phases, it can be seen that existing situation on the

Danube mostly corresponds to the first phase characteristics. Even more, it is easily noticed that the characteristics of the first phase have not yet been fully achieved on the Danube River. As one of the main findings, the next steps in the process of development of barge container transport on the Danube should be aimed at achieving the characteristics related to both the second and the third phase of this growth pattern. These characteristics should be taken as an action plan for the further development of container liner services on the Danube.

We have developed an online tool for optimal routing of a barge container ship on an inland waterway. It is based on the MILP model and aims to maximize the profit of the shipping company, while, at the same time, defines upstream and downstream calling sequence and number of loaded and empty containers transported between any two ports. Therefore, our model and the tool aim to facilitate decision-making processes at the strategic planning level, which relate to the establishment of a container barge network on the Danube River.

Our approach is based on the development of a mathematical programming model that can be applied to give recommendations about establishing a container liner service on any inland waterway. We specifically analyze the possibilities of applying this model in an attempt to facilitate decision-making processes related to the establishment of this service on the Danube.

The aim of the proposed model is to enable each user to receive recommendations on the possibility of establishing a container liner service on the Danube River. Each user has the option of selecting the ports to consider, providing the appropriate time and cost-related data about selected ports, defining the basic characteristics of the ship that would be employed in container liner service, setting the expected demands and freight rates between ports, determining values of preferred turnaround times, as well as values of fuel and lubricant prices.

Thus, by simply changing the values of these parameters, the user can get an indication of the cost-effectiveness of introducing or maintaining a container liner service on the Danube under various scenarios. In other words, the user can increase or decrease the values of each of these parameters and thus analyse the impact of such changes on the justification of the introduction or maintaining such services.

7 Framework condition analysis on Container Liner Service

This chapter presents a theoretical and practical analysis of the causes and conditions of the development of container barge networks. Emphasis in this research is given to the possibility of establishing such processes of container transportation on the Danube River.

In order to understand the situation on the Danube River in this regard, it is necessary to take into account and investigate the development of the container barge network on other inland waterways, especially in Europe. Therefore, it is not enough to rely only on the aspects or development factors that characterize the Danube River.

Important conclusions and recommendations for the future development of container barge transport can be obtained by considering the conditions and characteristics of different phases in the development of container services on the e.g., Rhine, Yangtze or the inland waterways of France.

At the same time, special attention should be paid to the competition between the two largest European ports, Rotterdam and Antwerp, with emphasis on their connection with the hinterland. Further, ports like Hamburg, Bremerhaven and Wilhelmshaven are destinations served by CTE (Container Terminal Enns) weekly by railway. Therefore, these connections represent very strong competition to establishment of container services on Danube, linking several Danube ports with the Port of Constanta.

The use of inland waterways for the transport of containers from the seller to the end customer usually implies the organization of road transport of the same containers on the routes from the location of the seller to the port of loading (pre-haulage) and from the port of unloading to the end customer (end-haulage).

The price of transport per km on such usually shorter routes is higher compared to the price of container transport, also per km, over longer distances. Therefore, it is necessary that transport chains, which include container barge transport, are competitive comparing to road only or railway/road transport of containers, in order to increase the share of inland water transport in the total volume of container transportation in a given market.

The price, costs and quality of door-to-door transport services play a crucial role in achieving competitive advantages and increasing market share of transport chains that include inland waterway transport.

Frémont et al., 2007 defined the necessary conditions for the development of container barge transport). These conditions are based on factors that crucially affect the competitiveness of container transport on inland waterways.

Competitiveness Conditions factors	
Infrastructure	The existence of an inland waterway network which permits services to the hinterland, particularly the largest cities. The greater that network's density and interconnectivity with other basins, the greater the possibilities of serving a large hinterland (Konings, 2002).
The characteristics of the market	The greater the volumes at the seaport or the final destination, the more advantageous it becomes to use inland waterway services (Notteboom, 2002). In addition, the more distant the markets from the port the greater the opportunities to exploit waterway transport.
The services and the terminals	It is necessary for inland waterway services to be reliable and frequent and offer a transit time that is acceptable in comparison with road and rail. There must be a network of inland waterway terminals or inland hubs, where traffic flows are concentrated and broken up in order to be routed to their final destinations (Konings, 2006). It is essential for these to be well located with respect to the market.
End-haul Road transport	Terminal handling costs in the barge terminal should not be too great to threaten the competitiveness of the combined waterway-rail/road services in compared to all-road or rail/road transport.
The organization of the market	There is a need to provide the shipper with an integrated end-to-end service between the maritime terminal and the final destination (Panayides and Cullinane 2002). This requires actors that are able to coordinate the inland chain (Van der Horst and De Langen, 2008). In particular, combined transport operators are needed to setup an end-to-end service with a different form of coordination (Langen and Chouly, 2004).

Table 3 Necessary conditions for the development of inland waterway transport

(Source: Frémont et al., 2007)

Discussion about Danube situation

Infrastructure

The Danube River flows through several large and capital cities. These are Belgrade, Budapest, Bratislava and Vienna. In addition, City of Bucharest is in the immediate vicinity, i.e., 60 km away from the Port of Giurgiu. Thus, the Danube River enables the connection of economic potentials in the hinterland of a number of capitals in Southeast Europe. It can be concluded that, in this regard, there are favorable conditions for the development of container barge transport on the Danube.

The Danube River, through the Main-Danube Canal and the Main River, connects with the Rhine River, i.e., with the most important European waterway. Then, the Sava River Basin, as well as the Tisza River, i.e., their hinterland, also represent potential markets that could be served by established container barge lines on the Danube. It can be

concluded that, from the connection with other river basins point of view, the Danube River provides good enough conditions for the development of container barge transport.

If, from the infrastructural point of view, only the inland waterway and its overall connectivity are taken into account, it can be clearly seen that the Danube River has favorable conditions for the establishment of regular container shipping lines. The term overall connectivity implies the possibility of connecting large and economically developed cities, as well as the possibility of serving the hinterland of other river basins.

The characteristics of the market

Container barge lines, which would be established on the Danube River, should have the Port of Constanta as the starting or final port of call. The container traffic of the Port of Constanta is given in Figure 1. Such traffic in the Port of Constanta clearly indicates a significant, but untapped potential for the establishment of regular container barge lines on the Danube.

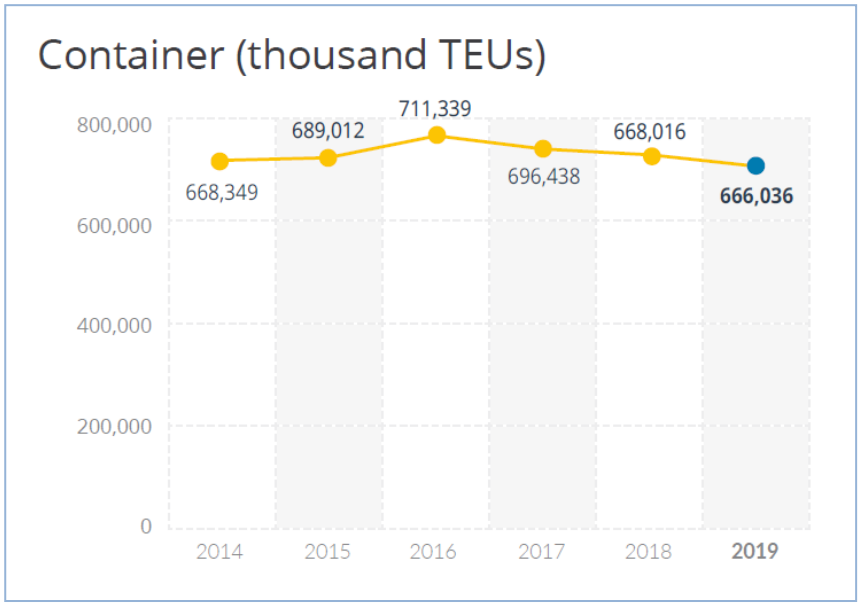

Figure 3 Port of Constanta container traffic

(Source: Port of Constanta, Annual report, 2019)

Servicing large centres, such as Belgrade, Budapest, Bratislava or Vienna, should be one of the basic goals in the development of container barge transport on the Danube. The distances from the Port of Constanta to these centres are significantly greater than the distances over which containers are transported on the Rhine. So, if we take into account the distance of transport, as one of the factors of competitiveness, as well as the fact that with longer transport distances, the competitive advantages of inland water transport come to the fore, it can be concluded that the Danube River, from this point of view, offers favourable conditions for development of container barge transport.

The services and the terminals

The container transit times, between the Port of Constanta and the ports in e.g. Serbia or Hungary, in upstream navigation, can be from 7 to 11 days, or 4 to 8 days, in downstream navigation. On the other hand, the containers delivery times from the ports of Rijeka, Koper or Bar, using road or rail transport, on the same routes, is about one day. Thus, it is obvious that inland navigation, in this respect, has no comparative advantage over their competing modes of transport. For that reason, the establishment of container liner services, with a high frequency, would be a necessary step towards the transfer of existing container flows in the Danube region, to a certain extent, to the Danube. Without such an approach, in the long run, we will not be able to overcome a situation where users are not interested in barge container transport, with the justification that there are no liner services, while the shipowners themselves will not establish such services with the argument that demand is not high enough.

Based on previous experience in the development of container transport networks on inland waterways, the development of this type of transport should be based on the establishment of some forms of "hub-and-spoke" concept. The application of the “hub-and-spoke” services on inland waterways is based on the organization of main container barge lines between hub ports. Further, a feeder service would be established for transporting containers to and from ports characterized by smaller traffic or located along tributaries. It can be concluded that determining the required number of hub ports on the inland waterway would be very important for achieving positive financial effects when establishing "hub-and-spoke" networks. The choice of ports that would have the role of hub ports depends on the available transshipment and transport equipment at the container terminal, as well as on the location of each port, i.e., on its distance from the most important markets. As an example, we can take into account the Port of Belgrade. The location of the port at the mouth of the Sava River, or near the mouth of the Tisza River, as well as between the ports of Smederevo and Novi Sad, is an extremely strong argument for choosing this port as a hub port, in the possible future establishment of "hub-and-spoke" system on the Danube.

End-haul Road transport

The quality and price of transhipment processes in inland ports greatly affect the competitiveness of barge container transport. Transit times on inland waterways is usually longer compared to its competing modes of transport. For that reason, and especially because the terminals in the ports are places where inland waterway and road transport are connected, it is necessary to minimize any unnecessary delays in the container terminals themselves. The hinterland, about 15 km in diameter from the terminal, is a region where combined inland waterway-road transport, can offer price-competitive services compared to the road “door-to-door” transport (Konings, 2009). At longer distances, the total cost of combined inland waterway-road transport becomes significantly higher. On the other hand, the container handling charges in ports can be very high and have a significant share in the total cost of container transport. Depending on the distance, on the entire transport route, this share can amount to up to 30% of the total transport costs (Macharis and Verbeke, 2004). Therefore, the costs of container handling charges in ports are very significant for increasing the competitive advantages of transport chains that include inland waterway transport. Of course, the

shorter the distances of container transport, both on the inland waterway and road legs, it is necessary to pay more attention to the container handling charges in an effort to increase market share of combined waterway-road chains.

As an example, on the Danube, we can take the situation in Romania, where we have the Port of Constanta, as a starting and ending port of call on all potential container liner services. In addition, the most important area, in the economic sense (economic hub), in Romania is certainly the city of Bucharest and its surroundings. A 200 km long highway connects Bucharest and Constanta. Therefore, the competition of road transport with the possibilities of transporting containers from the Port of Constanta to Bucharest, using inland waterway transport (via the Port of Giurgiu or Oltenita), is an obstacle that is not easy to overcome. However, the experience from the Rhine, where containers are transported from the port of Rotterdam or Antwerp to locations in the hinterland, which are only about 50 km away, indicates that this market should not be neglected, despite the extremely strong competitive advantages of road “door-to-door” transport.

The organization of the market

The quality of container transport services provided on inland waterways, in terminals or road transport, from the origin to the port of loading, or from the port of unloading to the end user, primarily depends on the business modes of river shipping, terminal operators and road carriers. In most cases, they all act independently of each other. This, at the same time, represents one of the most significant obstacles to the development of competitive container liner services in inland waterway transport. It can be concluded that the integration of these operators is a basic precondition for a more significant development of inland waterway transport, and especially container barge transport (Frémont et al., 2007).

Maritime shipping companies and freight forwarders may also be interested in organizing container barge transport. There are many advantages and benefits that can be achieved by shipping companies if they integrate all participants, i.e., operators on transport routes from seaports to final destinations in the hinterland and vice versa. These benefits are primarily related to gaining the ability to provide "end-to-end" services to their customers. Thus, maritime shipping companies take control of the hinterland transport routes. In this way, they gain the opportunity to manage costs, i.e., to achieve comparative advantages compared to their main competitors through potential cost reductions.

River shipping carriers, as well as operators of large terminals, can also significantly influence the success in the further development of their activities, if they are directed towards integration, i.e., unification of all participants in the process of container transport on the routes from the seaport to the hinterland locations. Terminal operators in seaports, which are located at the mouth of rivers, through the organization of barge liner services, can offer maritime shipping companies the ability to return their containers back to the seaports, after unloading or loading cargo in the hinterland. Such a service could be especially important in the processes of transporting empty containers. Likewise, the operators themselves would be able to provide smooth passage of containers through the port.

If these operator or participants (maritime and river shipping companies, port terminal operators, road carriers, freight forwarders) are not successful in integrating transport operators, this task can be taken over by the port authorities. The activities of port authorities, in this regard, can be particularly important in the initial stages of integration, so as not to lose the advantages of inland waterway transport compared to its main competitors.

Different nautical conditions

The port of Duisburg is the most important port of call for large barges coming from Antwerp and Rotterdam. The middle and upper Rhine sections have increasingly been confronted with low water level conditions caused by draught. The lower water level actually led to increased shipping traffic, as barges had to reduce the cargo load per sailing to reduce vessel draft and thus make more roundtrips to carry the same amount of freight. Low water levels increase barge freight rates and undermine service reliability, two major factors shaping competition with other transport modes.

Level of development and suitability of available infrastructure

The level of development and suitability of available infrastructure to the needs of transhipment and transport of containers on the Danube is another significant group of obstacles to the development of this type of transport. As far as the waterway is concerned, there are problems related to water levels and navigational conditions. Navigational difficulties that occur because of unfavorable hydro-meteorological conditions, i.e., low or high-water level, fog, ice level, ice drift, wind, etc., stand out as particularly significant. Such events significantly affect the accuracy and regularity, i.e., reliability in maintaining the established shipping lines. Therefore, hydro-meteorological conditions to a great extent impact the navigation and calling at ports according to scheduled arrivals on the inland shipping lines of container ships.

If, due to any of these reasons, the navigation processes are interrupted or restricted, the timely (just-in-time) delivery of containers to end users will be jeopardized, which may cause the payment of appropriate penalties by shipping companies. Therefore, the process of establishing inland waterway container services must also take into account the possibility of interruptions or limitations in navigation and provide for appropriate solutions. Such solutions should be defined in a way as to prevent delays in the delivery of containers to unloading ports or end users.

These solutions may relate to the establishment of road or rail services, which would be activated in cases of adverse hydro-meteorological conditions for the inland waterway transport of containers. The freight rates paid for these alternative transport services, in described situations, should be equal to the freight rates paid for the container barge transport.

Low water level on a certain part of the waterway can lead to the need to move barges one by one, i.e., to dismantle the pushed convoys in order to enable the passage through a given section. So, in such a situation, the pushed convoys with four barges, in upstream navigation, would have to cross this sector seven times (four times with one barge, upstream, and three times separately, in downstream navigation). Such processes, together with the dismantling and formation (after the passage of the sector) of pushed tows, clearly indicate that the transit time, of any type of cargo, will increase significantly.

As the volume of ship flows increases on a given inland waterway, such situations can lead to long waiting times for ships to cross the sectors with low water levels.

In order to overcome the obstacles that arise as a result of low waters, the concepts of container ships, which are characterized by significantly less draft compared to the existing fleet, are increasingly being considered. However, as already pointed out, the increase in the volume of ship flows can also lead to the significant queues for crossing the low-water sector.

Thus, modern low-draft container ships could face a situation where the waterway is blocked with ships or pushed convoys carrying other types of cargo and which are characterized by significantly higher draft. Container ships, in such a situation, would not be able to cross the low-water sector due to long queues.

In that way, container ships would not be able to follow the scheduled arrivals at ports on the route, although their dimensions enable passage through the sector with low water levels. It is clear that such circumstances would significantly affect the sustainability and cost-effectiveness of container liner services on the Danube, or, in general, on any inland waterway.

8 Initiatives for supporting Container Liner Service

8.1 NAIADES-III & Green Deal

NAIADES is an action program of the European Commission to promote European inland navigation. In the new program NAIADES-III (24.6.2021 / COM (2021) 324 final) with the title "Boosting future-proof European inland waterway transport" the **Inland Waterway Transport Action Plan for 2021 – 2027** focuses on two core objectives:

1. **Shifting more freight transport to inland waterways**
2. Setting the sector on an irreversible path to zero-emission underpinned by a paradigm shift towards further digitalization as well as accompanying measures to support the current and future workforce.

Shifting more freight transport to inland waterways - Flagships

Flagship 1: Helping waterway managers to ensure a high level of service (GNS – Good Navigation Status) along EU inland waterway corridors by 31.12.2030

Flagship 2: Updating the EU's legal framework for intermodal transport to stimulate IWT

Transitioning to zero-emission inland waterway transport

Flagship 3: Speeding up certification procedures for innovative and low-emission vessels

Flagship 4: Guaranteeing IWT investments take into account climate and environmental objectives

Flagship 5: Developing inland ports as multimodal alternative fuels infrastructure hubs

Flagship 6: A roadmap for digitalisation and automation of IWT

Flagship 7: Smart and flexible EU crewing rules

Flagship 8: Supporting the sector and Member States in the transition to zero-emission vessels

ACTION PLAN of NAIADES III contains 35 actions that will drive the IWT sector to growth and an expanded role in the European transport sector. A strong role is identified for inland ports and initiatives that support ports in achieving the European Green Deal.

NAIADES III set out the initiatives and actions that the EU will take over the coming years to ensure that the IWT sector improves and grows in a future-proof manner.

There are 8 flagship projects:

1. Helping waterway managers to ensure a high level of service (GNS – Good Navigation Status) along EU inland waterway corridors by 31.12.2030
2. Updating the EU's legal framework for intermodal transport to stimulate IWT
3. Speeding up certification procedures for innovative and low-emission vessels

4. Guaranteeing that IWT investments take into account climate and neutral and environmental objectives
5. Developing inland ports as multimodal alternatives infrastructure hubs
6. A roadmap for digitalization and automation in IWT
7. Smart and flexible EU crewing rules
8. Supporting the sector and Member States in the transition to zero-emission vessels.

The European Green Deal [COM (2019)640 final] is also underlying these initiatives:

- Sustainable and Smart Mobility Strategy [COM (2020)789 final], adopted on 9.12.2020 "inland waterway transport should increase by 25% by 2030 and by 50% by 2050"
- Zero Emission Mobility is the major objective of the Zero Pollution Action Plan [COM (2021)400 final], adopted on 12.5.2021

8.2 Initiative "Intermodal & rolling cargo by barge" viadonau (2021-2022)

This initiative of viadonau highlighted the advantages and potentials for an environmentally-friendly transport via barge of this type of cargo. Service providers for Danube navigation discussed the opportunities with freight forwarders, sea carriers and cargo owners during different expert workshops. This should enhance an information and knowledge exchange with the aim to initiate new transports of container and rolling cargo on the Danube and strengthen this sustainable mode of transport.

Stakeholder expert workshop as a hybrid stage for "container transports on the Danube" held on 21st September 2021.

In international freight transport, nothing goes without the container. On the Danube, however, they are rarely seen. Although empty container transports have been running steadily for several years. Not to forget, there are large volumes of continental transports in swap bodies and semi-trailers, which could also be transported in an environmentally friendly way by barge. How the volume of intermodal units on the Danube can be increased was discussed at the first hybrid expert workshop with a total of almost 50 guests. Some of them were connected online and some were present on site.

How exactly container transports by inland vessel can work on the Danube was discussed at an expert workshop, which was held at Tech Gate Vienna on September 29, 2021. But not all participants were attending physically in the room, because for the first time, the audience could choose to participate in person or virtually. Special attention was paid to the constant exchange between the digital and the in-person audience during the workshop via webcam & co.

First Hans-Peter Hasenbichler, Managing Director of viadonau, highlighted the advantages of Danube navigation and its good environmental performance, as well as the development of initiatives in the field of Danube logistics at viadonau. Afterwards, Bettina Matzner gave a short overview of the special field of container transport via Danube and current challenges and potentials. The Austrian Federal

Ministry for Climate Protection also attaches great importance to the topic of "combined transport" within the Austrian transport policy. Julia Elsinger presented national strategies and funding in this area.

Digitally connected from Salzburg, Otto Hawlicek from Container Terminal Enns gave an insight into the multimodal terminal on the Danube in the Ennshafen. Efficient handling of containers by gantry cranes, which span the depots as well as railway tracks and quay, enables the optimal transhipment of containers with increasing quantities every year between the three modes. Currently, about a quarter of the empty containers are delivered to the Ennshafen by barge. In addition to these transports, Mr. Hawlicek also sees potential for continental volumes in swap bodies and semi-trailers by barge.

Not far away, intermodal transports are also moving into the spotlight in Bavaria. Andreas Plank of Bayernhafen reported on the planned expansion in Regensburg and the implementing of the new container terminal in Passau in cooperation with various partners.

Multinaut Donaulogistik has also gained experience with container transports by barge in the past. Chartering a total of 20 vessels, numerous products are transported along the Rhine-Main-Danube corridor. As Valdet Farizi highlighted, suitable vessels and necessary experience are already available. In order to ensure reliability despite lock closures in the westbound direction, currently potentials for cooperation with railways are worked out.

At Nothegger Transport Logistik, on the other hand, the focus is not on ISO containers but on continental volumes. With numerous block train connections through Western Europe, Karl Nothegger Senior has already been able to establish many intermodal transports. Currently, the possibility of inland waterway transports to the east is being investigated in a joint project with various partners; the conception of an optimized vessel is also part of this project.

The following discussion showed that in principle there is enough volume available for the transport of full containers. What container transports on the Danube still need for a big push is **cooperation**: only together can **carriers**, **forwarders**, **ports** and **shipping companies** get such concepts off the ground. Last but not least, **cooperation with rail operators** would open up special opportunities to **maximise the strengths of both modes of transport and increase resilience.**

(Source: https://www.viadonau.org/en/newsroom/news/detail/expert-workshop-as-a-hybrid-stage-for-container-transports-on-the-danube?)

9 Financing and funding opportunities

1. Danube Transnational Programme (programming period 2021 – 2027)

Priority objectives and specific objectives of DTP 2021-2027

Priority 1: A smarter Danube Region

Specific Objectives:

1.1. Enhancing innovation and technology transfer in Danube region

1.2. Development of skills for advancing smart specialization strategies, industrial transformation and transition towards industry 4.0, including cross-sectoral collaborations.

Priority 2: A greener, low-carbon Danube Region

Specific Objectives:

2.1 Support greening the energy and transport sectors in the Danube Region by enhancing the integration of renewable energy sources.

2.2 Promoting climate change adaptation capacities in the Danube Region and disaster management on transnational level in relation to environmental risks (taking into account ecosystem-based approaches).

2.3 Sustainable, integrated, transnational water and sediment management in the Danube River Basin ensuring good quality and quantity of waters and sediment balance.

2.4 Protecting and preserving the biodiversity in ecological corridors and eco-regions of transnational relevance in the Danube Region.

Priority 3: A more social Danube Region

Priority 4: A better cooperation governance in the Danube Region

(Source: https://www.interreg-danube.eu/about-dtp/new-funding-2021-2027)

2. National Programs & Fundings

The deliverable D.T3.1.2 - Analysis of European & National Transport Policies, Strategies & Programs with regard to the Danube Ports, Summary Report - is focused on an analysis of European and national transport policies, strategies and programs regarding the Danube ports. The analysis contains an in-depth insight of national transport strategies and is based on national reports delivered by project partners.

Austria:

Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology is the Austrian ministry responsible for transport policy in Austria. Key documents for future transport development are: Austria's 2030 Mobility Master Plan, RTI Strategy (RTI -Research, Technology and Innovation Strategy Mobility) and the Action Programme for the Austrian Danube until 2022, published in 2015) - an

integrative strategy for a well-balance development of the Danube, that reconciles objectives for navigation, ecology and flood protection.

Slovakia:

A "Strategic plan for the development of transport in the Slovak Republic until 2030 (2016)" replaced all the previous strategic documents focused on modes separately. Along with abovementioned document, a specific document - "Water transport development concept of the Slovak Republic" is in force since 2000 (updated in 2004) for water transport. Since the concept for water transport was not designed to target the specific year, it stays valid.

Hungary:

The main national transport strategies, completed by or with an assignment from ministries and/or governmental bodies, mentioning ports, are: the National Port Development Master Plan, the National Transport Infrastructure Development Strategy, the National Danube Water Transport Strategic Plan, the National Shipping Strategy. National Port Development Master Plan (2019) is a Master Plan on strengthening Danube transport through the infrastructural development of TEN-T ports. The National Transport Infrastructure Development Strategy was prepared under the leadership of the Ministry of National Development and the Transport Development Coordination Centre and covers the period 2014-2050. National Danube Water Transport Strategic Plan (2013) is an outcome of the ProDuna project supporting Hungarian inland navigation, financed with EU co-fund. The document is a base to define the organizational and legal framework of inland navigation, its infrastructure and facilities, its 7 Project co-funded by European Union Funds (ERDF, IPA, ENI) Work package T3 DIONYSUS – Integrating Danube Region into Smart & Sustainable Multi-modal & Intermodal Transport Chains public freight transport segment, education and R&D, eventually to improve the competitiveness of the industry.

Croatia:

Government Program 2020-2024 is a short-term act which is of national significance. It defines priorities of the Government during its mandate. Transport infrastructure is one of the priorities of the Government Program. One of the statements is development of inland ports (Osijek, Vukovar, Slavonski Brod, Sisak) and inland waterways transport (Drava, Danube, Sava). Transport Development Strategy for the period 2017-2030 is an overall transport strategic document. Based on it Croatian Government adopt River Transport Development Strategy which contains basic specific goals that are relevant for inland navigation and ports. Ministry of Sea, Transport and Infrastructure Strategic Plan 2020-2022 gives the vision of the highly developed, efficient, secure, environmentally friendly and modern transport and communication system which should be integrated in international transport network and which should maximize utilization of the transport and geographic position of Republic of Croatia and meet the needs of the cargo and passenger freight.

Serbia:

Transport policy in the Republic of Serbia is characterised by developing infrastructure network especially for road transport and intensively developing inland ports infrastructure in the last few years. The selected strategies which were analysed are: Strategy of railway, road, inland waterway, air and intermodal transport development

in the Republic of Serbia 2008-2015, Strategy on waterborne transport development of the Republic of Serbia, 2015-2025, National Program for the Development of Railway Infrastructure 2017-2021.

Bulgaria:

The Ministry of Transport, Information Technology and Communications, and its affiliated institutions are the main state entities responsible for the government's policies in the field of transport. The most important transport strategies with relevance to the upcoming programming period are the Integrated Transport Strategy for the period until 2030 and the Transport Connectivity programme 2021 – 2027. Some other documents with focus on the subject are the Strategy for the Development of Road Infrastructure 2016 – 2022, the National Strategy for Road Safety 2021 – 2030, the Programme for the Development and Exploitation of Railway Infrastructure 2019 - 2023, the Strategy for Maritime Safety and Protection of the Environment from Ship-source Pollution, and the Maritime Spatial Plan of the Republic of Bulgaria 2021 – 2035.

Romania:

In Romania the national transport policies, strategies & programs with regard to the Danube ports are established by the central authority – the Ministry of Transport and Infrastructure. The main strategic document for transport infrastructure is the General Transport Master Plan (modified at the end of 2021). For ports, the document will be supplemented with a Naval Transport Strategy. The Government Program 2021 – 2024 is a short-term strategy of national significance which defines the priorities of the Government during its mandate.

European Union:

EU transport policy helps keep the European economy moving by developing a modern infrastructure network allowing the transport of people and goods to be quicker and safer, while at the same time promoting sustainable and digital solutions. Transport policy of the EU is largely based on a 2011 White Paper, comprising 40 initiatives designed to generate growth, jobs, reduce dependence on imported oil, and cut the sector's carbon emissions by 60% by 2050. The selected EU transport policies are: 2011 White Paper: Roadmap to a single European transport area, Trans-European Transport Network Policy (TEN-T Guidelines, Regulation 1315/2016 with the proposal for the revision of the TEN-T Guidelines - COM(2021) 812 final), Sustainable and Smart Mobility Strategy, NAIADES III Action plan and the European Rail Network for Competitive Freight (Regulation EU 913/2010)

10 Conclusions & Policy Recommendations

The implementing project partners under the coordination of MPAC executed various activities such as stakeholder meetings, coordination meetings with involved public authorities, shippers which are interested to use container liner services, maritime vessel operators, port and terminal operators to initiate and to support the establishment of container liner services as well as activities to facilitate collaboration of actor in a container transport chain. These activities are included and summarized in deliverable D.T.1.3.4 which came to following conclusions and recommendations.

Updated Market Analysis regarding the perspectives of development for Container Liner Services on the Danube

Strengths	Weaknesses
• Dense network of ports and transport infrastructure – ports, roads, railways in the region; • Connections with the maritime transport • Shipping costs and low level of emissions related to the volume of cargo transported • Experienced and flexible Port Operators and logistic competence • Good competition level; • Multimodality. The majority of ports are trimodal • Proactive management for promoting the development projects and applying the principle of partnership at the Port Community level • Experience in demand driven development • Good planning of inland ports development • The availability of a wide range of ship and freight services • Experience for development of projects and ongoing measures for ports development • Qualified personnel • Consolidated port management models (includes: Port management model; The use of corporatized port management model, which allows for development in accordance with market requirements) • Member in international and European organizations • Waterway administration established and in charge for ensuring good navigation conditions.	• Low-capacity utilization of available facilities in ports • Public economic situation • Old infrastructure and superstructure in many ports; old handling equipment and many ports do not have equipment for container handling • Needs for investments in the rail and road connections Lack of inventory of realistic development needs and plans • Lack of long-term port policies and port development strategies • Unsatisfactory coordination between different modes of transport and lack of integrated transport systems; • Lack of Port Community Systems (PCS) • Slow business development • Intermodal transport not developed enough • Insufficient lobbying for ports and IWT • Long transport times • Too strong competition from road and rail links to/from nearby ports for container transports, in terms of distances, prices and regular services. • Lack of resources for maintenance and repair. • Insufficient investment in port infrastructure and new handling technologies.

Opportunities	**Threats**
• Introduction of businesses/industries into ports • Existence of European funds available for the development of transport infrastructure • Taking advantage of free capacity • Modal split shift • New industrial clusters / Development of clusters to boost competitiveness • Support of the European Union for the development of water transport • Alternative fuels / Eco-footprint philosophy /Decarbonizing strategy • Regional European policies regarding the Danube and Black Sea • "One belt one road" – new transport routes to/from Far East • New markets (biomass, LNG, high & heavy, Ro-Ro, containers, etc.) • Improving shipping conditions (Danube waterway, CEF projects) • Training of port professionals, training of labor force suitable for any port • Research and design of modern equipment for handling in ports and for container traffic • Modern standards and technology for transshipment in Austria and Hungary as an opportunity for know-how transfer to other countries. • Cooperation between ports	• Problems with Danube navigability / hydrological conditions • Occurrence of bottlenecks on the fairway (insufficient depths) or in the road / railway connections • The direct competition of rail transport, as well as of the road transport • Competition between ports • Unstable market and demand for port services • Low predictability for traffic demand and economic framework • Bureaucracy • Dislocation of heavy industry • Emigration of industry / Decline in industrial production on the region • Economic situation in the Eastern Europe and global economy • Economic situation of the port operators and service providers • Stricter environmental regulations for ports / Potential new cost of implementation environmental legislation • Insufficient investment in port infrastructure and new handling technologies • Lack of labor supply • Risk of delay in the implementation of large infrastructure projects • Small market sector

Unfortunately, apart from the above-mentioned strengths and opportunities, Danube ports have a number of weaknesses which will need to be neutralized, minimized or completely eliminated when and if possible. Most notable weaknesses focus around the excess capacity or low utilization of the available capacities, as well as lack of resources for provision and improvement of high-quality road and rail connections of ports with the rest of the network.

Insufficient lobbying for interests of ports is also seen as one of the common weaknesses of the entire Danube port industry. Many ports are in need of heavy upgrade of their old infrastructure and supra-structure, while the funds for maintenance of infrastructure are very limited and are not provided from European funds.

Moreover, last, but not least, port industry in the Danube area is faced with a number of threats which are external to ports themselves, but which call for measures to mitigate or remedy such threats. Most important threats for the Danube area port industry are still persisting 191 navigation hindrances along the Danube, overall economic situation in Southeast Europe, fierce competition of road and rail sectors feeding the industrial and commercial sectors along the Danube directly from nearby seaports of Koper, Rijeka, Trieste and even from the farther ports in the Northwest Europe, like Rotterdam, Amsterdam, Antwerp, Hamburg and others. Volatility of the market also represents a serious threat which will be very difficult to mitigate. Even though an increasing number of young professionals take interest in port business, a constant supply of skilled labour, both on operational and managerial level, is still a threat, especially on the long-term run.

It is unlikely that a waterway offers on the Danube created on regular services will be marketable as long as there is no equivalence of the waterway system with the railway system in the area of aid.

Under the precondition of marketability, a container liner service offer would provide a location advantage for the participating ports. In addition to the "new Silk Road", such a liner services offer in combination with railway could significantly increase the attractiveness of the location.

Currently, however, almost all providers and terminals in their infrastructure and in their organization are geared to the railway system and would have to adapt their internal structures only to the new system. As long as there are no bottlenecks on the railways, it is unlikely that such system adjustments will be made, not least because of the rail's extensive network effect, as it limits the flexibility of relational choice. However, it should also be noted here that for such possible strategy changes, an isolated consideration of the container sector alone is not constructive.

There is currently an opportunity in the Danube region to develop and establish full container liner services in those areas where there is a need for container transport (industry / seaports) and where there is currently insufficient rail capacity. In particular, there is potential in the Danube region downstream from Budapest to Constanta. Here the window of opportunity should be used and with relevant companies, these container line services should be built up before sufficient railway capacities are built up. As soon as rail capacity is built up, it is very difficult to be competitive with block train solutions in terms of market price and handling time.

Compared to the Rhine, the shipping companies for the Danube have not yet developed a sufficient commitment to establish a continuous, closed combined offer on the Danube (combined price from sea transhipment and IWW route transport). Only through such a combination product you can get in the direction of a competitive market price, otherwise the costs for the broken transport routes result in high costs

(individual processes and individual prices result in non-competitive sums compared to offer from a single source). This topic should be addressed by individual shipping companies and initial pilot projects should be developed.

Presently we do not hold much information regarding the new business models concerning the transport of containers on the Danube. The shipping industry has the potential to become genuinely competitive in the future thanks to the new type of vessels powered by electricity or liquid natural gas, and tailored to the demands of today's goods transport, but European countries must abide by the existing agreements and ensure that their waterways meet the agreed standards. Even if the best vessel and the best logistics system exist, they are of no use if the general conditions on the Danube are not met (for example in relation to water depth, bridge height or the technical specifications of locks) and they have not been implemented everywhere. We are currently witnessing the tendency of containerization of cereals in maritime traffic, which can also be translated on river transport on the Danube, as future trend on this sector.

The war in the Ukraine is stifling trade and logistics of Ukraine and the Black Sea region. The search for alternate trade routes for Ukrainian goods has rapidly increased the demands on land and maritime transport infrastructure and services. For Ukraine's trading partners, many commodities now have to be sourced from further away. This has increased global vessel demand and the cost of shipping around the world.

Higher energy costs have led to higher marine bunker prices, increasing shipping costs for all sectors. By the end of May 2022, the global average price for very low sulphur fuel oil (VLSFO) had increased by 64 per cent with respect to the start of the year. Taken altogether, these increased costs imply higher prices for consumers and threaten to widen the poverty gap.

Disrupted regional logistics, the halting of port operations in Ukraine, the destruction of important infrastructure, trade restrictions, increased insurance costs, and higher fuel prices, have all contributed to the logistical hurdles arising in the Black Sea region. They have also contributed to a more costly and unpredictable global trading and shipping environment. Many countries have had to look further afield for suppliers of oil, gas and grain.

Consequently, shipping distances increased, along with transit times and costs. It is not possible to associate all developments in global shipping with a specific cause. The war in Ukraine is one of several major issues currently affecting international maritime transport, compounding other challenges such as the COVID-19 pandemic, port congestion, the need to switch to low carbon fuels, to name but a few.

Nevertheless, it is clear that the disruptions and the higher ton-mile demand caused by the war in Ukraine contribute strongly to higher shipping costs.

Although the Russian Federation and Ukraine are not deeply integrated into global container shipping and value chain networks, the conflict and trade restrictions have also affected this shipping segment. Container carriers cut ship carrying capacity assigned to the Russian Federation, and suspended operations at Ukrainian seaports. Several neighbouring countries saw ship capacity deployed in their ports increase slightly.

As ports closed and carriers discontinued shipping services to the Russian Federation and Ukraine, ships and containers had to re-route. Cargo designated for the Russian Federation and Ukraine is now piling up at ports, including Hamburg, Germany; Rotterdam, Netherlands; Constanta, Romania; and Istanbul, Turkey. Shippers are facing delays and can be expected to see an increase in detention and demurrage charges at ports.

Russian Federation cargo is also being stranded at ports e.g., in Europe. This adds pressure on warehousing and storage capacity and drives costs upward. Freight rates had surged since the pandemic and the need to reposition ships and containers during the war adds to upward pressures on freight rates.

The COVID-19 pandemic led to a sudden dip in international seaborne trade. But by late 2020 there had been a swift rebound mainly in container and dry bulk shipping. The asymmetric maritime trade recovery, mainly on East–West containerized trade lanes, increased pressure on supply chains, ports, shipping and trade. The surge in e-commerce, capacity constraints, equipment shortages and renewed virus infections in some parts of the world put supply chains under pressure in 2021. Pressure continued in 2022 so far still exhibiting high port congestion and constrained logistics and transport networks. Median waiting time in ports for container ships increased by almost 20 per cent between pandemic times and the end of 2021.

Freight rates surged, surcharges proliferated and service reliability declined while delays and dwell times went up. By the end of 2020, container rates were over five times higher than their 2019 levels; although declining, they remain elevated. New disruptions such as the closing of manufacturing activities and ports in China in the first half of 2022 due to new cases of COVID-19 infections have further disrupted the system. Increased costs are a challenge for all traders and supply chains, particularly smaller shippers who are less able to absorb the additional expense and disadvantaged when they are negotiating rates and booking space on ships.

Obstacles:

- high and low water seasons – unstable navigable conditions

- no reliable liner services
- lock maintenance and natural disasters
- engagement and financial power of the property owners and shipping companies
- much shorter transit times for railway and road delivery
- lack of financial support (funds) for waterway - compared with road/railway system

Potentials:

- increasing of global container transportation
- shift of bulk/mass goods into containers
- barges/RoRo vessels are used already for container transportation on the Danube
- investments in the development of Danube navigation
- innovations for combined cargo transshipment
- decarbonizing strategy in Europe
- overloaded railway infrastructure in the long run
- trimodal hubs connected to the project "New Silk Road" (OBOR).

Conclusions and recommendations for the conditions of setup a successful Container Liner Services development on the Danube

The recommendations and conclusions for the conditions of setup a successful Container Liner Services development on the Danube, drawn by the participants of the 3 workshops, are presented as follows:

- maintaining a realistic approach is compulsory for obtaining an improvement of the container transport situation on the Danube;
- the fast evolution of digitalization, the increasing trend of using clean transport ways and availability of EU funding schemes must be used as engines for keeping Danube a desirable transport alternative;
- the elaboration of a large number of port development plans, which will consequently be used by project partners for preparing quality investment projects in order to obtain EU funding;
- ports must not be approached individually but as a network;
- an efficient infrastructure planning for ports and their connections with the hinterland is in line with the first two thematic areas included in the Action Plan;
- understanding the characteristics of that phase defining requirements and constraints to be included in the modelling; figuring out what should be done to move to the next phase of development of container transport on the Danube;
- containerization potential on Danube is to elaborate IWT market potential in the Danube region and the determination of cargo flows with a potential to contribute to the development of intermodal services in this region;
- necessary investments for the majority of ports in the lower Danube, such as: quays, platforms and supra-structural works; dredging works in the ports; specialized equipment for container operations; road and rail connection; including investment programs in new river vessels with low drafts, investments in port infrastructure, supra-structure and equipment and market analysis – proximity to market and efficiency;
- to provide a chance to stakeholders from the Danube region to familiarize themselves with the experiences of other regions in the COB development;

- the innovative barge technologies should contribute largely to launching and improving container liner services on the Danube River;
- to build a stakeholder's reference group which is a data base organized by type of entities starting from the international organization, infrastructure and service provider, SME, business support organization, National Public Authority;
- to assess potential routes and services and present a model of the container liner services according to vessel concepts and market requirements; that concepts shall provide a knowledge basis for companies that are interested in container transport; shipping routes design process has been based on the optimal turnaround time, the optimal choice of the final port of call in the outbound direction, and empty container balancing and repositioning; the number of full containers to be shipped between called ports, the number of empty containers to be shipped between called ports, the number of empty containers to be stored at each port, the number of empty containers to be leased at each port, turnaround time and calculation of container transport costs between called ports as well;
- cost competitiveness of intermodal barge transport in single trips for sailing, handling, and haulage; cost competitiveness of intermodal barge transport in roundtrips, and impact of terminal size on the cost competitiveness of intermodal barge transport where the one of several important conclusions is motivation to promote intermodal transport;
- the development of container transport on the Danube would produce positive, long-term effects; to take into account some actions needed, which could be implemented to increase the level of container transport on the Danube, such as: investments in fairway improvement, the existence of adequate port infrastructure so as to handle the demand, improving rail connections, providing a proper business model development;

Priority objectives identified:

- a smarter Danube Region, by enhancing innovation and technologies transfer in Danube region; development of scills for advancing smart specialisation strategies, industrial transformation and transition towards industry 4.0 including cross sectorial collaborations;
- a greener, low carbon Danube Region, by enhancing the integration of renewable energy sources; promoting climate change adaptation capacities in the Danube Region and disaster management on transnational level in relation to environmental risks; sustainable, integrated, transnational water and sediment management in the Danube River Basin ensuring good quality and quantity of waters and sediment balance;
- a more social Danube Region, promoting accessible, inclusive and effective labour markets, quality services in education, training and lifelong learning; socio-economic development through heritage, culture and tourism;
- a better cooperation governance in the Danube Region, by increasing institutional capacities for territorial and macro-regional governance;
- measures for the improved regulations and handling of border and customs control;

- preferential tariffs for ports and canals; priority rules at locks; financing and funding opportunities; other supportive measure which might be identified in stakeholder meetings; findings of WP T1 Workshops on container liner services will be reflected; analyses of previous failed transport experiences of containerized cargo; harmonized solutions in the form of Recommendations for positive regulatory framework & service implementation; assessment of new routes & services; architecture of new container liner services.

11 References

Inputs from other deliverables/reports

- DIONYSUS deliverable D.T.1.3.1 Framework condition analysis on container liner services
- DIONYSUS D.T.1.3.2 Concept for Container Liner Services
- DIONYSUS D.T.1.3.4 Report on activities to initiate and support Container Liner Services
- DIONYSUS output O.T.1.4 Workshops on Container Liner Services
- DIONYSUS deliverable D.T.3.1.2 Analysis of European & National Transport Policies, Strategies & Programs with regard to the Danube Ports – Summary
- DIONYSUS output O.T.1.3. IWT Market Observatory

Internet Research

https://www.hafen-hamburg.de/de/port-of-hamburg-magazine/container-welten/neues-aus-der-containerwelt/

https://www.viadonau.org/en/newsroom/news/detail/expert-workshop-as-a-hybrid-stage-for-container-transports-on-the-danube?

https://www.interreg-danube.eu/about-dtp/new-funding-2021-2027