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List of Acronyms

Abbreviation/acronym	Description
AB	Advisory Board
AEVs	Autonomous Electric Vehicles
ATL	Atlantic Core Network Corridor
B2A	Business to Administration
B2B	Business to Business
BRI	Belt and Road Initiative
CEF	Connecting Europe Facility
CESM	Community Earth System Models
CIMIS	Croatian Integrated Maritime Information System
CLC	China Railway Corporation
CNC	TEN-T Core Network Corridor
DCSA	Europe, or the Digital Container Shipping Association
DLT	Distributed Ledger Technology
DSS	Decision Support Systems
DTLF	Digital Transport and Logistics Forum
EC	European Commission
ECA	Extra Container Capacity Antwerp
EDB	Eurasian Development Bank
EEU	Eurasian Economic Union
eFTI	Electronic Freight Transport Information
EMSA	European Maritime Safety Agency
EMSW	European Maritime Single Window
ENMSW	Electronic Maritime Systems for Ports
ERTMS	European Rail Traffic Management System
ESPO	European Sea Ports Organisation
ETA	Estimated Time of Arrival
EU	European Union
GHG	Greenhouse Gas
HC	High Cube
HE	Horizon Europe
HHLA	Hamburger Hafen und Logistik AG
HVCC	Hamburg Vessel Coordination Center
ICT	Information and communications technology
ICTF	International Cooperation Task Force
IMO	International Maritime Organisation
IMP	Import Message Platform
IOS	Inter Organisational Systems
IoT	Internet of Things
IPCSA	International Port Community System Association
ITF	International Transport Forum
ITF	International Transport Forum
KPI	Key Performance Indicator
M2M	Machine-to-Machine
M2P	Machine-to-Person
MED	Mediterranean Core Network Corridor

MoS	Motorways of the Sea
MTO	Multimodal Transport operator
NEP	Northeast Passage
NMSW	National Maritime Single Window
NSB	North-Sea Baltic Core Network Corridor
NSMED	North-Sea Mediterranean Core Network Corridor
NSR	Northern Sea Route
NWP	Northwest Passage
P2P	Person-to-Person
PCS	Port Control System
PEP	Port Environmental Performance
PSC	Port State Control
RALP	Rhine-Alpine Core Network Corridor
RCP	Representative Concentration Pathway
RFD	Reporting Formalities Directive
RIS	River Information Services
RTG	Rubber Tyred Gantry Crane
SCAN-MED	Scandinavian-Mediterranean Core Network Corridor
SESAR	Single European Sky ATM Research
TEN-T	Trans-European Transport Network
TEU	Twenty Foot Equivalent
TPR	Transpolar Route
TRAN	Committee on Transport and Tourism
TSR	Transpolar Sea Route
UN	United Nations
UN/CEFACT	United Nations Centre for Trade Facilitation and Electronic Business
UNECE	United Nations Economic Commission for Europe
VTMIS	Vessel Traffic Management Information System
WBIF	Western Balkan Investment Framework
WCO	World Customs Organization
WTO	World Trade Organization

Executive Summary

The present deliverable focuses on identifying the main bottlenecks on the TEN-T and Global networks, particularly discussing how maritime trade and hinterland connectivity have been impacted by recent global developments such as the COVID-19 pandemic and the War in Ukraine. In addition, it encompasses the opinion from ePIcenter's International Cooperation Task Force and Advisory Board meetings, as well as including a wider analysis of the perspective of international trading partner countries. This deliverable is the final version of D1.2 on the initial challenges faced on the TEN-T and global trade routes.

Maritime trade has a considerable impact on the global economy and trade as a whole, thus heavily affected by geopolitical uncertainties, such as Brexit, the Ukraine-Russia war, COVID-19 and other events. Nonetheless, port hinterland connectivity has a considerable impact on economic growth, being essential to promote port competitiveness. The TEN-T has been crucial for ensuring a more efficient network, improving the accessibility of certain transport nodes. The development of TEN-T Core Network Corridors has also been vital for the integration of maritime connections with other modes in the network. In addition, the future European Maritime Space will boost this progress and focus on hinterland connectivity. The quality and efficiency of such connections is often measured in terms of ports' connectivity to the rail network. Nonetheless, significant progress is still required to achieve the goals for full completion of the TEN-T. This requires strong action from national governments to implement the necessary physical investments to key TEN-T infrastructure, which can only be achieved with coordination at an EU level. TEN-T policy has already been crucial to ensure such harmonisation and coordination, especially through the role of the European Coordinators at a Corridor level and the overall role of the European Commission, which are expected to be reinforced with the adoption of the new TEN-T Regulation. However, last-mile connections to ports can be made more efficient by deploying ICT solutions to simplify administrative processes, thus improving the performance of terminals in the wider logistics chain with the regard to time savings, reliability and security.

Therefore, digitalisation is key for a more efficient supply chain network. In particular, port digital maturity can be measured through the deployment of information digitalisation, the exchange of digital information and automation of information exchange and operators. Stakeholders from the logistics chain have carried out important investments in ICT infrastructure, namely the application of the EU Vessel Traffic Monitoring and Information System (VTMIS), besides the development of the European Maritime Single Window (EMSW).

The digitalisation of container operations and the diffusion of "smart containers", which enables additional information to be made available to carriers, terminal operators and cargo owners are good examples of applications of the Internet of Things (IoT). The Port of Montreal has been recognised as a frontrunner in this regard, with the development of AI activities.

The use of the KPIs preliminarily identified in ePIcenter's deliverable D5.2 can be relevant for measuring these aspects, creating a link with the project's use cases and how their impacts can bring benefits to the networks, especially regarding the efficiency and digitalisation of port hinterland connectivity. Nonetheless, other parameters should also be included to enable efficient monitoring of ePicenter's activities and more efficient connections with the TEN-T and global networks.

The broad scope of ePIcenter covers all these innovative aspects, aiming towards the optimisation and digitalisation of supply chains, such as in the China – Europe use case, focused on the development and deployment of a planning and information exchange digital platform that allows to plan every lag of cargo train journey. ePIcenter's activities cover many different innovations, including new transport technologies such as Hyperloop, Autonomous Electric Vehicles ("Pods") and modular containers ("Connectainers"); visibility and data sharing innovations and corresponding governance models; optimisation algorithms addressing synchromodal logistics and freight network configuration optimisation, as well as ship fuel minimisation, navigation in Arctic waters and reducing the impact of shipping on whales. These will be vital for achieving a more efficient and sustainable multimodal freight transport system and logistics, ensuring a seamless integration of the digital infrastructure layer through secure international information flows and digitalisation.

1 Introduction

1.1 Objectives

This document is intended to collect information from different sources, which can be used by ePIcenter partners as a useful guide for future work and progress in the project. This deliverable takes into account results from early International Cooperation Task Force meetings and a wider analysis including the perspective of international trading partner countries, concerning a review of opportunities for the TEN-T and global trade routes. This deliverable is the final version of D1.2 on the initial challenges faced on the TEN-T and global trade routes.

Therefore, the document contains many extracts from other previously published articles, which have been edited and collated, including reflecting important data of ports inserted within ePIcenter, as well as results from International Cooperation Task Force (ICTF) meetings.

This report provides an overview of initial ePIcenter deliverables, and how their findings reflect on initial TEN-T and global networks recommendations and opportunities. The report then provides an overview on issues which are relevant to highlight important recommendations, especially to reflect on KPIs that can be incorporated in the ePIcenter use cases.

During the draft phase, the report will be forwarded to other consortium partners, serving a double purpose. Firstly, it will enable the inclusion of other relevant contributions with respect to their activity. Secondly, it will enable the validation of the information already integrated in the report. This exercise culminates in the last round of contributions to finalise the report.

1.2 Review of previous ePIcenter deliverables

As previously mentioned, this deliverable is the final version of the work stemming from deliverable 1.2. In addition, it is also an extension and continuation of the work carried out in Deliverables D1.3: Arctic and New Trade Route Challenges, D5.2: Initial TEN-T & Global Networks Recommendations, as well as D6.5: Advisory Board and ICTF Report. The findings and conclusions stemming from the work developed in D1.2 are directly linked to the issues at stake in the present document, especially concerning the TEN-T network and impact of global routes on the TEN-T, and how these are linked to ePIcenter.

The following paragraphs provide a brief summary of the findings from deliverables D.1.2, D.5.2 and D.6.5, which are relevant for the present report on identifying the challenges and opportunities on the TEN-T and the global networks, especially concerning the issues at stake on the Core Network Corridors, the impact of new global routes on the TEN-T.

1.2.1 Lessons stemming from deliverable 1.2: TEN-T & Global Networks Initial Review of Challenges

The analysis carried out in deliverable 1.2 highlights the overall objective of the TEN-T Regulation of closing gaps, removing bottlenecks and technical barriers, with a focus on high-quality infrastructure. TEN-T policy also supports the deployment of innovation, new technologies and digitalisation of all transport modes. Therefore, a strong focus has to be given on digitalisation, which is a strong focus of ePIcenter. This component can be closely linked with successful initiatives from the Commission, namely the Motorways of the Sea (MoS), which is integrated within the TEN-T, and the Digital Transport and Logistics Forum (DTLF).

Despite the strong TEN-T investments (i.e. through CEF funding) on improving hinterland connections, many seaports on the network still lack high-quality hinterland connections by rail, road or inland waterway transport. Hinterland connections are recognised to play an important role in promoting port competitiveness. In this regard, intermodality also strongly influences the efficiency of these connections, contributing to the expansion

of port hinterland connectivity. Moreover, the development of TEN-T Core Network Corridors should aim towards the integration of maritime connections with other modes in the network. Although the quality and efficiency of such connections is often measured in terms of ports' connectivity to the rail network, the Staff Working Document on the revision of the TEN-T Regulation[1] already recognises that this might not be the best indicator to assess the quality of such links.

Enhancing multimodal transport can be achieved through optimal infrastructure integration and interconnection of all transport modes. Nevertheless, despite the focus on the physical layer of infrastructure, the digital layer also plays a prominent role on the network's operations. In particular, last-mile connections to ports can be made more efficient by deploying ICT solutions to simplify administrative processes, thus improving the performance of terminals in the wider logistics chain with the regard to time savings, reliability and security. The EU is supporting investments in ICT projects and including Single Windows applications to promote digitalisation. The implementation of an EU Maritime Single Window environment can facilitate data exchange in maritime transport, preventing unnecessary delays and ensuring more efficient maritime operations. In addition, the deployment of Sea Traffic Management can also improve the exchange of data and information between maritime institutions and authorities, as well as other stakeholders, with the goal of ensuring just-in-time maritime services.

Containers are being transformed by information technologies. The digitalisation of container operations and the diffusion of "smart containers", which enables additional information to be made available to carriers, terminal operators and cargo owners are good examples of applications of the Internet of Things (IoT). New technologies, digitalisation and big data have the potential to change the way cargo and traffic flows are organised and managed, as they generate business opportunities and pave the way for innovation, new services and disruptive business models. Furthermore, it enables cooperation between relevant stakeholders such as supply chain, contributing towards a better supply chain visibility, real-time management of traffic and cargo flows.

Sustainable solutions are essential for the development of both ports and surrounding urban areas. The minimisation of transportation costs is the key objective of traditional logistics models. Thus, that the layout of container terminals is a decisive player in the ports' efficiency and capacity. The ePIcenter project fits within the objective of reviewing the challenges that the multimodal containerised and large freight segment is facing, helping to identify solutions that can facilitate sustainable global trade by reducing congestion at multimodal nodes (especially at ports) and optimising operations across the TEN-T network.

Deliverable 1.2 also provides an overview on the new Global Routes and its effects on ePIcenter. For instance, findings from this analysis highlight that the Chinese Belt and Road Initiative (BRI) – the new Silk Route - has been especially relevant for the development of some Core Network Corridors, namely for the North-Sea Baltic Corridor (NSB). The NSB Coordinator has promoted various dedicated meetings on the subject, especially discussing how the Corridor's nodes and infrastructure can meet the current and future expected BRI-related traffic. In this regard, the TRAN Committee has recommended to continue the partnership with China, promoting studies concerning specific TEN-T and BRI Corridors.

1.2.2 Lessons stemming from deliverable 5.2: Initial TEN-T & Global Networks Recommendations

The findings presented in Deliverable 5.2 derived from the analysis done regarding all ports involved in ePIcenter, as well as the impacts of new Silk and Arctic Routes on the existing TEN-T Corridors and corresponding multimodal transfer zones. This document also reports on the standardisation aspects of the project as well as co-operation with standardisation bodies and policy recommendations.

Along the TEN-T, ePIcenter covers six of the nine CNCs: the Atlantic (ATL), Mediterranean (MED), North-Sea Baltic (NSB), North-Sea Mediterranean (NSMED), Scandinavian-Mediterranean (SCAN-MED) and Rhine-Alpine (RALP)

[1] Commission Staff Working Document Evaluation of the Regulation (EU) N° 1315/2013 on Union Guidelines for the development of a trans- European transport network {SWD(2021) 118 final}, Brussels, 26.5.2021 SWD(2021) 117 final

Core Network Corridors. These Corridors are represented in the project by the Ports of Antwerp (NSB, NSMED and RALP), Algeciras (ATL and MED), Hamburg (NSB, OEM, SCAN-MED) and Duisburg (NSB and RALP). In ePIcenter, these TEN-T Corridors are connected to the global networks, via the Port of Duisburg to the Silk Route (under the One Belt Road Initiative) and the Arctic Route, via the North-Sea Baltic Corridor.
Maritime and inland ports are important nodes for the TEN-T, especially as every Core Network Corridor (CNC) starts or ends in a port. Ports fulfil an important role in trade development and as gateways of a multimodal network. They are of major relevance as digital hubs, having taken significant strides for a strong digital transport infrastructure. For many seaports, the weakest link is still its hinterland connections, especially due to the lack of adequate levels of rail, road or inland connections and due to congestion on these routes.

A functioning hinterland transport network is an important determinant of economic growth. In this regard, the TEN-T aims at strengthening Europe's international competitiveness by improving the accessibility of certain regions. More specifically, the TEN-T core network aims at bridging the gaps between different national transport systems. Improved infrastructure is expected to have a significant impact on the ports' hinterland connectivity and transport efficiency. Therefore, the consolidation of ports as logistic and intermodal hubs is an essential step to take.

Stakeholders from the logistics chain have carried out important investments in ICT infrastructure. For instance, the application of the EU Vessel Traffic Monitoring and Information System (VTMIS) can be one essential step to making maritime transport smarter. Moreover, the EU Regulation on electronic freight transport information (eFTI) has already enabled more efficient multimodal logistic chain operations, ensuring the harmonisation and establishment of an EU framework for existing freight information, while also encouraging the use of electronic documents.

Information sharing offers a great potential to the maritime logistics sector, reducing costs, delivery times and present overall improvements in the overall port logistics chain. The development of the European Maritime Single Window (EMSW) has been key in this regard.

On the one hand, D5.2. shows that ports fulfil an important role in trade development and as gateways of a multimodal network. They are of major relevance as digital hubs, having taken significant strides for a strong digital transport infrastructure. On the other hand, findings show that, as a result of the Silk Route, scheduled connections between the Port of Duisburg and terminals in China have resulted in an extremely reliable option for the exchange of goods and more. Such reinforces the potential of the Arctic Route as a transoceanic maritime route, though in the long-term rather than in the near future.

The establishment of ports as logistic and intermodal hubs is paramount. Port capacity is translated into economies of scale that enable cost reductions. Moreover, maritime and land connectivity represent key aspects of competitiveness. In this regard, land connections, and especially rail connections, remain the Achilles heel of European ports. Besides, the ports of the future need to ensure more digital information and data sharing, allowing smoother and more efficient day-to-day operations, with more seamless intermodal connections to important global hubs.

In order to ensure that ePIcenter's activities take into account the impact on the TEN-T and the new global routes, D5.2 also reflected on KPIs that can be considered to measure how ports can be more efficient and digital, especially with regards to their hinterland connections.

The **Corridor Connectivity Index (CCI)**, a concept initially developed under ePIcenter's Horizon Europe (HE) sister project PLANET (Progress Towards Federated Logistics through the Integration of TEN-T into a Global Trade Network)[2] and adapted in D5.2., can be used to measure and monitor connectivity in important nodes – a CCI represents a more attractive node to transport goods via the principal entry node. Monitoring and comparing CCI values over time can be linked to new-trade routes. Its goal is to measure and monitor connectivity of principal entry nodes/inland nodes, which can be applied as a barometer of changing trade flows.

[2] PLANET Project (https://www.planetproject.eu/), Accessed in April 2022

The use of this CCI can be relevant for the activities developed under ePIcenter, which can be broadened to include other issues of interest, namely regarding the efficiency and digitalisation of port hinterland connectivity, considering how these include greener and innovative transport modes (e.g. the future deployment of the Hyperloop and autonomous vehicles for last-mile connections and their impact on overall efficiency).

It is important that other parameters are also included in order to ensure the link with the activities carried out in ePIcenter's demonstrators, enabling their monitoring and ensuring more efficient connections with the TEN-T and global networks. The CCI is defined according to the following parameters.

Table 1: Parameters from the CCI to contribute to greater efficiency of port trade flows and operations

Inland node components – inland connectivity	1. *Port capacity* 2. *Efficiency and ease of processes* 3. *Service frequency and number (road and rail) / intermodal connectivity (more sustainable transport modes)* 4. *Service quality (hinterland connections)* 5. *Digital connectivity (incorporation of SWs and/or electronic freight aspects)*
Principal Entry Node components – maritime connectivity	6. *Quality of infrastructure / intermodal platforms* 7. *Port liner shipping connectivity index*

Source: Adapted from ePIcenter's D5.2 and PLANET HE project.

The consolidation of ports as logistic and intermodal hubs is an essential step to take. Port capacity is translated into economies of scale that enable cost reductions. Besides, maritime and land connectivity represent key elements of competitiveness. Thus, it is precisely the land connections - particularly rail connections - that remain the Achilles heel of South-European ports.

It is also important to add that findings from D.5.2 highlighted that, on average, road transport represented 60% of all hinterland traffic in ePIcenter's ports in 2019 (with the highest share of 94% in the Port of Algeciras, and the lowest share of 37% in the Port of Duisburg). In turn, rail transport represented only 20% of all hinterland traffic on average, with the Port of Hamburg having the highest share (47%). Projects on last-mile connections to ports are relevant for the functioning of the transport system in the TEN-T Corridor. There are various projects in the Project Lists of the CNCs focusing on the improvements to land access and last-mile connections to ports, especially related to rail but also to road. Despite these high investments, most ports still highly depend on road traffic, with the modal split of rail traffic in the hinterland remaining low.

1.2.3 Lessons stemming from deliverable 6.5: Advisory Board and ICTF Report

D6.5. on ePIcenter's Advisory Board (AB) and International Cooperation Task Force (ICTF) Report highlighted the exchanges from meetings with the AB and ICTF, and their recommendations for the project, as well as what they considered as opportunities for the network.

In the exchanges with the AB, members highlighted that digital information has become the new normal after the COVID-19 crisis, contributing towards carbon neutrality at ports, ensuring greater fluidity of markets. New markets were amplified, such as in China, thus leading Europe towards a new pathway in learning on how to deal with the new amount of trade inflows.

Nevertheless, data sharing is still considered a major challenge. Members from the AB argued that ePIcenter might have a great possibility in accomplishing a high-quality data environment, reflecting the meaningful and complete consortium. Moreover, a significant framework to better organise the flows and the panning can be developed under the ePIcenter project, assisting ports in this new demand.

It is important to understand what bottlenecks still affect the efficiency of port hinterland connections. One other aspect that is important to be improved is the last mile Estimated Time of Arrival (ETA). The ETA's predictability is currently inefficient, preventing ports to have an appropriate preparation planning

Therefore, the AB considers that it is fundamental to have synchronised planning instruments and high-quality data to be shared between transports and countries. In addition, the lack of synchromodality is an important aspect which has been preventing vessels to arrive on time.

Artificial Intelligence can be a way forward to tackle the gap on data availability and quality, enabling a more concrete prediction of volumes, while also ensuring better planning at the port and its hinterland connection. The exchange with the Port of Montreal enabled to understand what activities the Port has been working on to deploy AI solutions in the port's operations. The port is committed to delivering AI solutions, with operators and carriers delivering the data. The tool aims to verify how many containers are onboard and which type of cargo they contain. Additionally, it is possible to know the best course of action for certain type of containers and respective cargo, if there are delays on the ship, truck or train arrival. This algorithm is developed to make the best recommendation to minimize eventual opportunistic behaviour.

2 Main bottlenecks and windows of opportunity on maritime trade routes along the TEN-T

More than 80% of world trade is carried by sea[3]. Therefore, maritime transport plays a key role in global transport and supply chains. In 2018, 11 billion tonnes of goods were transported by sea, which is also the all-time high. A clear shift has occurred in the maritime trade structure over the decades, with major bulks and containerised cargo showing the strongest expansion.

A report from INTERREG's Baltic Loop project[4] highlights that maritime trade has a considerable impact on the global economy and trade as a whole, being strongly dependant and influenced by geopolitical uncertainties (namely the US-China trade war, Brexit, the Ukraine-Russia war, COVID-19 and other events); new trade patterns (growing e-commerce, land-based infrastructure investments connecting markets, regions and countries also within the TEN-T transport network, circular economy); demand and supply (fleet size and capacity, profitability); expanding role of technology in transport systems, logistics and value chains (digitalisation, automation and electrification); high customer expectations on operational flexibility.

A study on the efficiency of maritime transport along transport networks[5] argues that maritime trade connectivity has three interdependent dimensions: 1) maritime networks, which constitute the structure and performance of shipping before the port; 2) port efficiency, which refers to the performance of the port (or group of ports sharing the same hinterland); and 3) hinterland connectivity, which encompasses multiple stakeholders responsible for economic development and exploiting maritime supply chains. Policies that work well for one dimension can have a positive impact on the others. In addition, policies that take all three dimensions into account have greater impact than policies that focus on a single dimension. The following diagram provides an overview of these dimensions.

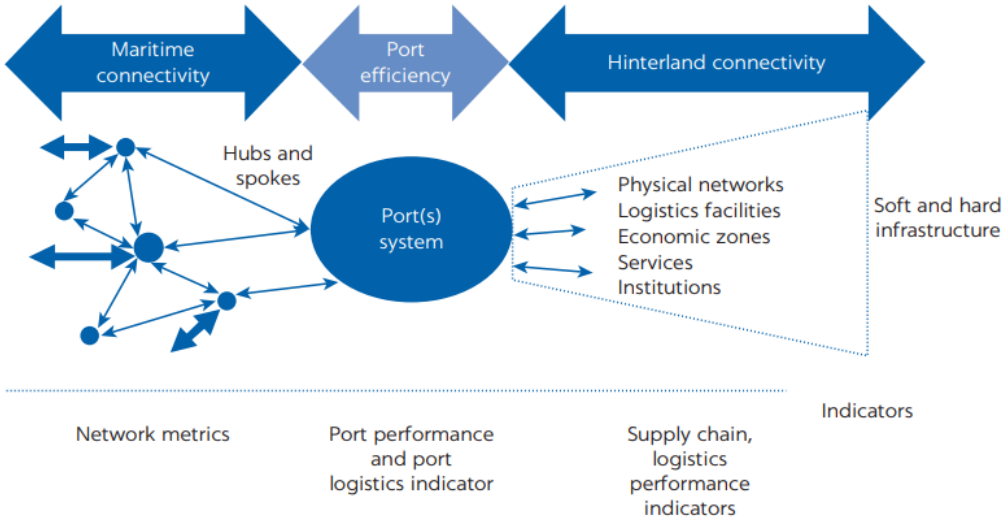

Figure 1: The three dimensions of maritime trade connectivity

Source: Jean-François Arvis, Vincent Vesin, Robin Carruthers, César Ducruet, Peter de Langen. Maritime Networks, Port Efficiency, and Hinterland Connectivity in the Mediterranean. World Bank Group.

[3] UNCTAD – Review of Maritime Transport 2019 (2020)
[4] Identification of bottlenecks and inefficiencies in transport flows in Baltic Loop East-West corridors with emphasis on maritime logistics Authors: Irina Wahlström & Yiran Chen, Åbo Akademi University Published: September, 2020
[5] Jean-François Arvis, Vincent Vesin, Robin Carruthers, César Ducruet, Peter de Langen. Maritime Networks, Port Efficiency, and Hinterland Connectivity in the Mediterranean. World Bank Group, http://hdl.handle.net/10986/30585, 2018, International Development in Focus, 978-1-4648-1274-3. ffhalshs-01933726

These three dimensions have complementary drivers of growth and efficiency. The main drivers for each dimension tend to differ, but some address more than one dimension. On maritime networks, the industry strategies by shipping lines have the greatest impact. In turn, port and terminal operators implementing new port management methods, developing public–private partnerships, and improving port logistics and trade facilitation have been the main drivers of policy interventions for port efficiency.

The main drivers of hinterland connectivity are national and regional governments, through their regional and economic strategies. Government actions include implementation of hard and soft infrastructure interventions, such as connecting infrastructure to existing economic growth poles and setting up industrial and logistics export-oriented facilities. Port authorities are also drivers of this dimension, as they promote the extension of their port's catchment area by making arrangements with and investing in the facilities of operators of inland terminals, logistics zones, and rail networks and by actively promoting their services in areas beyond their traditional hinterland. National governments are crucial to implement the necessary physical investments to key TEN-T infrastructure. To ensure such efforts from Member States, EU coordination is of paramount importance.

At an EU level, the Motorways of the Sea (MoS) is a horizontal priority and the maritime dimension of the TEN-T. MoS contributes to the development and establishment of a European Maritime Transport Space without bottlenecks, connecting Core Network Corridors (CNCs) by integrating maritime links with their hinterlands and EU Member States. It encompasses short-sea routes, ports, associated maritime infrastructures, equipment, facilities and relevant administrative formalities. MoS has been designed to remove bottlenecks in the EU transport system. Its goal is to reduce existing strains in the overcrowded European road networks, improve access to markets, and provide more efficient, commercially viable and environmentally sustainable alternatives to road-only transport. Moreover, MoS aims to introduce new intermodal, maritime-based logistics chains to bring about structural change to door-to-door, integrated transport systems. Maritime transport offers a huge potential to fortify and develop its position as the backbone mode of transport in international trade

The proposal for the revision of the TEN-T Regulation, published in December 2021[6], proposes the concept of a European Maritime Space as the new MoS, focusing on the promotion of Short-Sea Shipping for domestic port connections and connectivity with third countries. In addition, the European Maritime Space will focus on hinterland connectivity, with important leverage on modal shift, boosting the connectivity of ports with the TEN-T road and rail networks.

When ways of further promoting a more efficient hinterland connection to ports, objective data on hinterland size and access to ports and on the modal split and intermodal connectivity of that access are key. This data not only improves trade efficiency, but also helps to increase demand through lower transport costs and shorter and more-reliable access time. A port authority or port development company can expand its hinterland by increasing the attractiveness of intermodal transport. Initiatives include developing partnerships with inland ports, providing new services, and securing intermodal connections between the various terminals in a port.

The major challenge in turning better connectivity into economic benefits is to integrate the development of shipping routes and ports with logistics, free trade, and industrial zones—and more generally with hinterland connectivity. Such development requires good governance and a holistic approach to the three dimensions of connectivity. A development model in which multiple entities make decisions on the basis of their own sphere of influence is unlikely to be effective[7].

The transport industry overall has become increasingly more digital and automated. Shipping companies and ports also need to adapt to the possibilities that the change of new information and communication technologies provide in order to unlock multiple benefits and tackle the industry-specific challenges[8].

[6] Available at: https://transport.ec.europa.eu/news/efficient-and-green-mobility-2021-12-14_en, accessed in April 2022

[7] Jean-François Arvis, Vincent Vesin, Robin Carruthers, César Ducruet, Peter de Langen. Maritime Networks, Port Efficiency, and Hinterland Connectivity in the Mediterranean. World Bank Group, http://hdl.handle.net/10986/30585, 2018, International Development in Focus, 978-1-4648-1274-3. ffhalshs-01933726

[8] Identification of bottlenecks and inefficiencies in transport flows in Baltic Loop East-West corridors with emphasis on maritime logistics Authors: Irina Wahlström & Yiran Chen, Åbo Akademi University Published: September, 2020

Intelligent connected transport systems enable vessels, goods and infrastructure to communicate with each other and provide new opportunities to achieve greater sustainability, supply chain traceability, optimised operations, enhanced performance and efficiency, and safer operations throughout the (maritime) supply chain. The shipping industry, including ports, have until recently been firmly linked with the past and generally formed a discontinuation point in supply chains and supply chain efficiency due to conservative and uncoordinated communication and information transmission methods between the relevant stakeholders. Consequently, ports are faced with a number of challenges related to operational efficiency, cost minimisation, security of the port-ship interface and environmental impact.

The content and scope of smart ports solutions and strategies vary among ports. There is no "one size fits all" solution. A crucial part of developing a smart port strategy is to identify and map every port's process and specific requirements that can be improved. Nonetheless, the main objective is to manage and merge with big data, artificial intelligence and the Internet of Things (IoT) to optimise port operations sustainably and enhance communication with various actors within and outside the port in order to integrate with the entire supply chain. The digital tools and sensors can be used to forecast the assets' maintenance regime or to find solutions for alternative land-use options. Smart ports can limit their energy consumption and environmental impact by capitalising on renewable energy as sources for electricity and heating of buildings, installation of LED lighting, among other development.

Digitalisation affects all industries. The shipping sector is a traditional industry that has been slow to adapt digital tools and applications. Nevertheless, the maritime transport industry has started to undergo a profound transformation catalysed mainly by changing trade patterns, technological development and digital disruption and an expanding environmental agenda. The global trade has typically been exposed to market fluctuations and short-term cyclical factors, but the factors affecting the sector today have become more structural and existential. Environmental sustainability has become a priority on the global policy agenda, putting much-awaited pressure and scrutiny on the maritime industry and, consequently, affecting market dynamics, ports, supply chains and maritime policy governance.

A study on the hindrances of ports' digitalisation[9] highlights that the ports' ability to act as a part of digital networks and information chains is vital for its competitiveness. This requires means and prerequisites to integrate with contemporary technology platforms and system architectures. Such readiness should exist in different parallel processes taking place in organizations of port communities. Successful digitalization requires focused technology management ensuring system and data transfer interoperability.
Interoperability and stakeholder interaction is significant, particularly between the port management, municipal ownership, and business operators and vendors. In the contemporary port development, environmental regulations have an effect on the level and effectiveness of digitalization. The future development of port digitalisation will be dependent on the port capabilities to adopt and implement reliable and adoptable technologies with clear vision of the future.
According to the same study, there are several different ways to assess a ports digital maturity. Overall, the indicators of the port digitalisation consider three main aspects: (1) information digitalisation, (2) exchange of digital information; and (3) automation of information exchange and operations.

With this in mind, ePIcenter proposes the integration of the European transport network with the global network, to be achieved via the seamless (but secure and controlled) information flow across borders. The market is currently very cautious about adopting data visibility initiatives due to perceived trust and commercial difficulties. ePIcenter aims to thus remove this barrier by creating a harmonised platform that exploits the increased reliability of cyber-secure data sharing models to massively speed up processes at ports and other major nodes which link TEN-T to the Global Network. This in turn will lead to major efficiency improvements which reduce congestion and increase modal shift to greener transport options.

[9] Brunila, OP., Kunnaala-Hyrkki, V. & Inkinen, T. Hindrances in port digitalization? Identifying problems in adoption and implementation. Eur. Transp. Res. Rev. 13, 62 (2021). https://doi.org/10.1186/s12544-021-00523-0)

2.1 The impact of COVID-19

The pandemic has changed the way we live and work, having had a massive impact on transport activities, namely on trade. It encouraged individuals and organisations to look at long-established procedures and habits with new eyes and to consider alternative ways of working - from rethinking responsibilities and use of digital tools to even considering the meaning and purpose of specific jobs. It also greatly changed purchasing behaviours which resulted in new opportunities and challenges for global supply chains.

With shops and restaurants closed for months, e-commerce experienced unprecedented levels of growth globally as more and more people shopped online and as businesses that were traditionally brick-and-mortar joined the online economy. Although a lot of restrictions have since been lifted, many consumers find that their online shopping habits have solidified, and numerous new e-commerce markets are thriving.

To meet the growing demand for logistics, alleviate staff shortages and build more resiliency into supply chains, COVID-19 has greatly accelerated the digital transformation of logistics. Many roles - from customs agents to customer service representatives - suddenly faced strict occupancy limits or could no longer come into the office altogether. Organisations are having to quickly source and deploy the equipment, skills, and collaboration tools to enable remote work, as well as allow for new work schedules. Visibility tools, automation, contactless and flexible delivery technologies, and IoT sensors to track shipments are just some examples of technology acceleration as a result of COVID-19.

The effects of COVID-19 on EU's transport sector overlap with those associated with UK's departure from the EU Single Market and the Customs Union on the 1st January 2021, the most notable of which might be a reduction in freight traffic volumes on the Western Channel, likely to have resulted from a reduction in trade flows , diversion of traffic to direct ferry services between Ireland and continental Europe to avoid the landbridge across Great Britain and the uncertainty regarding traffic and charges at London Heathrow's gateway aviation hub[10]. According to the Irish Maritime Development Office[11], approximately 20% of all RoRo traffic is used via the Irish landbridge. As a response to the impact of Brexit, Ireland increased direct maritime connections with Europe, with one-third[12] of all RoRo traffic being direct (compared to 17% prior to Brexit). Both the crisis generated by the COVID-19 pandemic and Brexit led to a dynamic and adaptable response from Irish ports, which sought to increase demand by shifting capacity and frequency to other markets.

Maritime transport and port traffic was affected by the reduction in trade with China during the early phases of the pandemic, but is showing signs of recovery. According to the European Maritime Safety Agency (EMSA)[13], in 2019 there were 882,960 ship calls at EU ports, and in 2020 there were 776,964 ship calls, i.e. the number of calls decreased by 12% in comparison with 2019. The most impacted vessels are cruise ships, with a reduction in port calls in the order of -85% on a comparison between 2019 and 2020. Port calls by vehicle carriers and passenger ships have also experienced a great reduction due to the pandemic (-23% and -39% respectively). Ports such as the Port of Algeciras were quick in trying to reduce headline costs, by reducing services, cancelling ship rental contracts, which led to a great imbalance in container traffic, as discussed below.

In terms of the total gross weight of goods transported to and from principal maritime ports, data from Eurostat[14] show that those most affected in the early stages of the pandemic were in Latvia, with a reduction of 44% to their normal cargo compared to the first quarter of 2019. This was mainly due to the decrease of container imports from China[15]. This led to a further need of empty containers and the increase in the container shipping

[10] The Guardian, *British Airways owner warns it could cut Heathrow flights over higher charges* https://www.theguardian.com/business/2021/nov/22/ba-iag-uk-air-europa-uk-deal-competition *(accessed in April 2022)*
[11] Irish Maritime Development Office, https://www.imdo.ie
[12] Data as of September 2022
[13] *EMSA, January 2021 - COVID-19 Impact on Shipping Report* http://emsa.europa.eu/newsroom/covid19-impact/item/4294-january-2021-covid-19-impact-on-shipping-report.html *(accessed in April 2022)*
[14] Eurostat, *Maritime transport - goods - detailed annual and quarterly results: Gross weight of goods transported to/from main ports by direction and type of traffic (national and international) - quarterly data* https://ec.europa.eu/eurostat/databrowser/view/MAR_GO_QM/default/table *(accessed in April 2022)*
[15] PortNews, *Crisis caused by Covid-19 brought changes and highlighted new opportunities for port of Riga* https://en.portnews.ru/news/293911/ *(accessed in April 2022)*

freight fees, resulting in the reduction of the volumes. Other affected hubs are in the Netherlands, Cyprus, Croatia and France, with a reduction on volumes of 10% to 12%[16].

The EU maritime transport sector is vulnerable to impacts of situations such as the COVID-19 outbreak in Shanghai in April 2022. This outbreak led Chinese authorities to enforce restrictive lockdown measures in line with a zero-COVID policy, which then cascaded into severe delays in port operations, and will likely result in an important number of ships heading for and call at EU ports and terminals in a short time interval[17].

In the case of inland waterways, Eurostat data[18] show that 2020-Q2 container volumes did not drop much compared to the year before for countries such as the Netherlands (4%), Belgium (11%), and Germany (18%). Other countries' twenty-foot equivalent units (TEU) performances, such as Luxembourg, Austria and Romania, were less resilient in comparison. This in turn illustrates the importance of the Rhine-Alpine corridor as an economic structure to those countries, since it connects various major ports such as Duisburg, Antwerp and Rotterdam. When comparing the first two-quarters of 2019 and 2020, a reduction of 14% (Q1) and 17% (Q2) can be seen in TEU container traffic along the Rhine-Alpine corridor. One reason was the suspension of operations in certain manufacturing facilities in Europe. For example, some German vehicle manufacturers halted their production for several weeks between April and May. Hence, the demand for steel, and therefore the transport of related materials – some 25% of all volumes transported along the Rhine - declined[19].

Much of the world's passenger ferry services have been suspended due to the COVID-19 pandemic[20], but ferry services-maintained lifeline services that were critical to carry medical supplies, food, other necessities and essential workers to critical jobs. As a result of the travel limitations ferry operators saw a dramatic reduction in the number of passengers carried[21]. Given that for many islands the only route to access the island is via a ferry, many ferry operators accepted the operational losses. Ferry operators were financially compensated for keeping ferry services running with state support packages that helped the shipping industry to deal with the Coronavirus. Estonia, for example, handed out €20 million to four ferry companies in compensation for lost revenues[22].

The container crisis

Besides the pandemic's negative impacts on the global economy, such as closures of businesses and factories, shortages of raw materials and consumer goods, the health crisis also led to saturation at ports worldwide, leading to increased time in the reception time of goods. The container crisis is understood as a combination of the scarcity of transport space available to ship products and the exorbitant increases in maritime transport costs, which entails significant effects on merchants and ultimately, consumers[23].

Container shortages have been a visible consequence of the pandemic. The container crisis has been mainly a result of the contraction in the world economy due to border closures to control the spread of the virus, followed by restrictions on imports and exports, as well as temporary or permanent closures of factories and companies.

[16] Eurostat, *Maritime transport - goods - detailed annual and quarterly results: Gross weight of goods transported to/from main ports by direction and type of traffic (national and international) - quarterly data* https://ec.europa.eu/eurostat/databrowser/view/MAR_GO_QM/default/table *(accessed in April 2022)*

[17] FEPORT, *Press Release: Closure and delays in the Port of Shanghai: FEPORT calls for an urgent initiative from the EU Commission to gather all interested parties to discuss contingency plan* https://www.feport.eu/media-corner/news/news/1095-press-release-closure-and-delays-in-the-port-of-shanghai-feport-calls-for-an-urgent-initiative-from-the-eu-commission-to-gather-all-interested-parties-to-discuss-contingency-plans *(accessed in April 2022)*

[18] Eurostat, *Inland waterways transport measurement - goods - quarterly data: Container transport by nationality of vessel* https://ec.europa.eu/eurostat/databrowser/view/iww_go_qcnave/default/table?lang=en *(accessed in April 2022)*

[19] European Parliament, *EU shipping and ports facing coronavirus* https://www.europarl.europa.eu/RegData/etudes/ATAG/2020/651907/EPRS_ATA(2020)651907_EN.pdf *(accessed in April 2022)*

[20] InterFerry, COVID-19 - Guidance on reopening passenger ferry services https://interferry.com/wp-content/uploads/2020/05/INTERFERRY_GUIDANCE-ON_MITIGATING_SPREAD_OF_COVID-19.pdf

[21] Fortune Business Insights, *Global Passenger Ferries Market Size [2021-2028] | Industry Share, Growth Factors, Revenue, Competitive Landscape & Forecast* https://www.globenewswire.com/news-release/2021/12/22/2356529/0/en/Global-Passenger-Ferries-Market-Size-2021-2028-Industry-Share-Growth-Factors-Revenue-Competitive-Landscape-Forecast.html *(accessed in April 2022)*

[22] ITF, *COVID-19 Transport Brief: Lessons from Covid-19 State Support for Maritime Shipping* https://www.itf-oecd.org/sites/default/files/shipping-state-support-covid-19.pdf

[23] BPlegal: How does the container crisis affect international trade?, available at: https://www.blplegal.com/how-does-the-container-crisis-affect-international-trade/ (Accessed in April 2022)

This generated a decrease in the demand for products and the consequent drop in maritime transport, which in turn caused a lower circulation of cargo ships and containers.

However, once international economies began to grow again as a result of the global management of the virus, and the advance of vaccination, the need for maritime transport space increases dramatically. Unfortunately, the shipping transport system has been unable to meet this need due to the lack of available containers and ships, inaccessibility of routes, traffic jams at international ports, temporary closures of maritime terminals, and port delays for the entry and exit of products, all of which prevent an adequate supply chain flow. Therefore, stakeholders from the logistics chain, must keep a close eye on the container crisis to make business decisions that minimise the negative impact on operations.

In the port of Algeciras and the Port of Barcelona, as of September 2022, approximately 14% of local freight traffic is carried out with empty container units, which are damaged and expensive to repair. This leads to a heavy imbalance at inland depots, creating gridlock and hampering multimodal transfer zones in the port hinterland. Within ePIcenter, the CONNECTAINER solution developed in one of the demonstrators will seek to improve levels of optimisation in such connections, which will help to avoid reducing such imbalance not only within the port area, but also in hinterland connections and in the connection with other ports. ePIcenter's D2.5[24] points out that such solution can help to create 2-4% additional storage capacity for full containers.

2.2 The external dimension of EU transport policy and the impact of the war in Ukraine

The external dimension of EU policy

Transport connectivity within the EU and between the EU and its external partners has also been menaced by several other external factors. The EU foundation is based on an open community of European Member States and is predisposed to enlargement by its treaties (Art. 49 of the Treaty on European Union TEU[25]). However, prospects of strengthening the EU through continuous enlargements have been recently challenged by Brexit.

Other external geopolitics challenges have been shaping the debate about the strategic orientation of the EU. Article 8 of the TEU foresees a European Neighbourhood Policy (ENP), which aims to strengthen the prosperity, stability, and security of all. It is based on democracy, the rule of law and respect for human rights and is a bilateral policy between the EU and each partner country, with regional cooperation initiatives, including the Eastern Partnership (EaP). This Eastern Partnership has been undermined by the onset of the annexation of Crimea by Russia in 2014 and subsequent international crises, particularly the Russian military invasion of Ukraine in 2022, which generated shock waves to the EU connectivity and accessibility, jeopardising regional policy and putting a strain on the fulfilment of the EU transport infrastructure policy (TEN-T).

Indeed, cooperation with neighbouring and third countries in TEN-T policy is addressed in the Regulation (EU) 1315/2013, particularly in Article 8 § 4 which provides for the possibility to include indicative maps of the trans-European transport network, extended to specific neighbouring countries (presented in Annex III of the TEN-T Regulation). Furthermore, the extension of the TEN-T Network to the Eastern Neighbourhood region is included in the ´Stronger Connectivity´ priority area of the Eastern Partnership.

The network approach to Eastern Neighbourhood partners was identified and agreed with the EU in 2018. In its report on Greener Transport Connectivity for Eastern Partnership Countries (2020)[26], the World Bank presents the enhanced transport connectivity between the EU and the Eastern Neighbourhood region as highly relevant to the regional needs. The study highlights the need of the Eastern Neighbourhood region to converge with the

[24] D2.5 Modularisation potential to solve empty container repositioning imbalance, November 2022
[25] Consolidated version of the Treaty on European Union, 2012, https://eur-lex.europa.eu/resource.html?uri=cellar:2bf140bf-a3f8-4ab2-b506-fd71826e6da6.0023.02/DOC_1&format=PDF
[26] The World Bank: Greener Transport Connectivity for Eastern Partnership Countries. The World Bank and Korea Green Growth Trust Fund, 2020

EU in terms of energy efficiency, environment and climate change goals. Such goals need now to be further revised in light of current and future challenges that are likely to introduce lasting impacts on the Transport Single Transport and reshape EU policy. Consequently, follow-up measures and policy recommendations that result from our study will provide additional guidance for already coordination structures at the EU level, such as the Integrated Policy Crisis Response at the Council level (IPCR) or stakeholders at several levels, in order for them to better anticipate future changes and improve EU stakeholders' responsiveness to severe external events.

The war in Ukraine

More recently, in February 2022, Russia invaded Ukraine, wreaking havoc across the energy supply and supply chain in Eastern Europe and across the entire continent. When we look at the Triple Access Model in the light of the war in Ukraine, *Physical Mobility* and *Spatial Proximity* are the most affected dimensions. On what regards *Digital Connectivity*, Ukraine managed, so far, to keep the internet connections up-and-running in the midst of war. Even though much of Ukraine's physical infrastructure was targeted by Russia, including train stations[27], many Ukrainians were able to continue working for their employer, even if they sought refuge abroad, in result of contingency plans prepared by their companies. Ukrainian IT companies were in this way able to meet their contractual agreements with EU-based companies.

Russia and Belarus were cut off from the EU market as a result of sanctions[28]. Internet restrictions in Russia have since then in place, but the firewall only targeted specific western websites[29]. The trade between EU and Russia and Belorussia plummeted.

The EU sanctions banning Russian and Belarusian transport companies resulted in an 80km-long queue on the Poland-Belarus border, with some trucks being stuck for 33 hours[30] and experts estimating that thousands of Russian and Belarussian trucks would remain on EU territory.

Macroeconomists expect that the damage to the Ukrainian economy will be felt worldwide for a long period, since Ukraine is a major food exporter. Ukraine is the world's third-largest grain exporter, though the war has rendered most Ukrainian ports unusable. Before the war, the country transported around 90% of its grain exports by sea. In 2019, Ukraine's ports handled 55 million tonnes of grain, representing approximately one-third of total cargo volume[31]. In May 2022, Ukraine's grain exports were down 64% compared to May 2021, which can have an impact of at least 90% of the regular port turnover is affected by war-related inactivity. This plummet in grain export was mainly a result of the massive destruction in Ukrainian ports. According to the same report from ITF, as of July 2022, 18 ports were still operating, six had been blocked and nine were under Russian control. The bulk of Ukraine's grain exports was covered by four seaports: Chornomorsk, Mykolaiv, Odessa and Pivdennyi (Seaport South). Part of Ukraine's exports has shifted to ports close to the Romanian border For Ukraine, with only the three inland ports of Izmail, Reni and Ust-Dunaysk on the Danube River remaining fully operational.

As a strategy for shifting cargo to rail terminals and ports outside Ukraine, other alternatives have been sought. It is important to point out that a number of European ports have spare grain capacity that can accommodate Ukraine's deficit capacity of 15 million tonnes of grain per year. For instance, the ports of Constanţa (Romania), Muuga (Estonia) and Varna (Bulgaria) have the largest spare capacity, though additional 10 million tonnes can be made available in the medium term by adapting other dry-bulk terminals to handle grain cargo. Existing rail and road infrastructure in surrounding areas can also enable feeding these ports (15 million tonnes by rail and 10 million tonnes by road). Different rail track gauges in Ukraine and the European Union require transhipment of freight or switching wagon bogies at borders, but the capacity for either is limited. In addition, a considerable

[27] The Guardian, *Russia bombs five railway stations in central and western Ukraine* https://www.theguardian.com/world/2022/apr/25/russia-bombs-five-rail-stations-in-central-and-western-ukraine (accessed in April 2022)
[28] European Council, *EU restrictive measures against Russia over Ukraine (since 2014)* https://www.consilium.europa.eu/en/policies/sanctions/restrictive-measures-against-russia-over-ukraine/
[29] The Guardian, *Russia blocks access to Facebook and Twitter*, https://www.theguardian.com/world/2022/mar/04/russia-completely-blocks-access-to-facebook-and-twitter (accessed in April 2022)
[30] BBC News, *Ukraine war: Trucks stuck at Poland-Belarus border as EU sanctions deadline passes* https://www.bbc.com/news/world-europe-61133439 (accessed in April 2022)
[31] Dealing with the War's Impacts on Ukraine's Ports: How to Get More Grain to the World, ITF, July 2022

share of existing railway capacity runs via Belarus and Poland. The chart below outlines the opportunity that can be sought from such spare capacity.

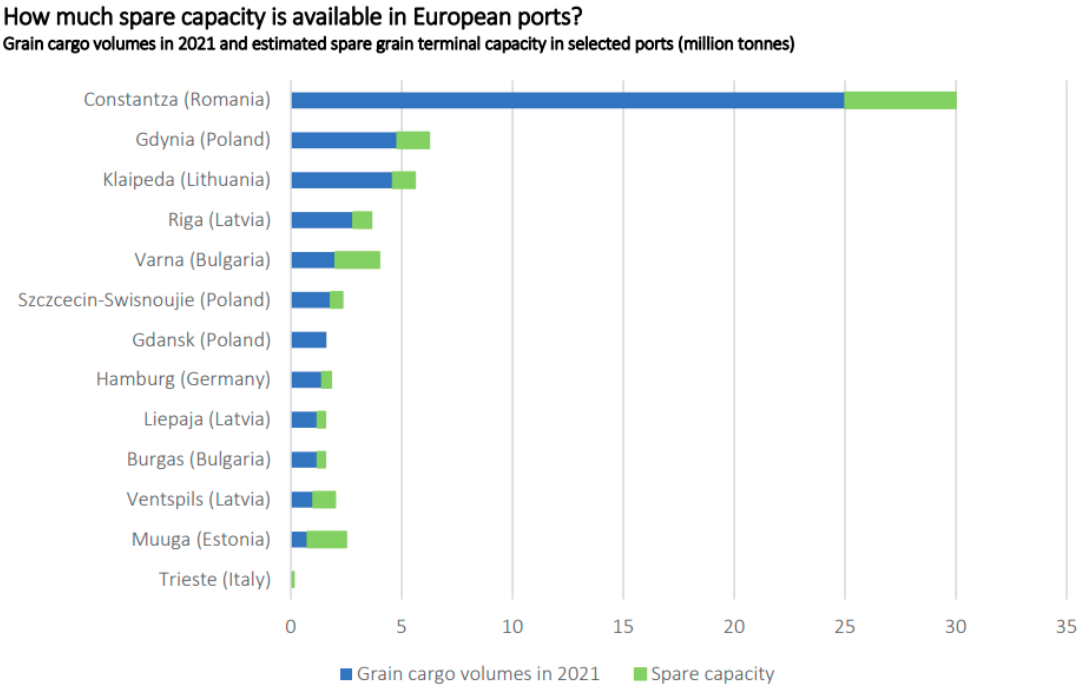

Figure 2: Spare capacity in European ports - an alternative to Ukrainian ports
Source: Dealing with the War's Impacts on Ukraine's Ports: How to Get More Grain to the World, ITF, July 2022

Nonetheless, such additional routes by either rail or road can add up to EUR120 per tonne when exporting grain out of Ukraine. In addition, different track gauges increase transshipment costs at the border between Poland and Lithuania.

The EU sanctions prohibited the access of Russian ships in EU ports, with exceptions for cargo such as oil and gas, refined petroleum products and a number of ores, pharmaceutical and medical products, agricultural and food products, and products for civil nuclear applications, as well as extending to vessels where humanitarian grounds apply. The compound effect of the sanctions with the uncertainty caused by the war affects the maritime transport sector. For instance, around 10% of the container transport in the Port of Rotterdam is linked with Russia[32].

The share of Russian and Ukrainian seafarers in the global shipping workforce (14.5%)[33] is significant and, as the EU fleets rely heavily on those workers, the European shipowners called on EU policy makers to ensure mobility and safety of seafarers[34]. Many vessels and its seafarers are in ports and waters of Ukraine, subject to shelling[35].

With commercial vessels being hit in the conflict, shipowners are avoiding the conflict area, skipping calls at Ukrainian ports, and rates spiked[36,37]. All in all, the sanctions are considered complex and evolving, and therefore

[32] Impact of Russia's invasion of Ukraine on the port of Rotterdam https://www.portofrotterdam.com/en/news-and-press-releases/impact-of-russia-ukraine-conflict-on-port-of-rotterdam (accessed in April 2022)
[33] Russian and Ukrainian seafarers make up 14.5% of global shipping workforce, according to ICS https://www.ics-shipping.org/press-release/russian-and-ukrainian-seafarers-make-up-14-5-of-global-shipping-workforce-according-to-ics/ (accessed in April 2022)
[34] ECSA urges regulators to guarantee seafarers' mobility and their rights as essential workers. https://www.ecsa.eu/index.php/news/eu-shipowners-highlight-importance-seafarers-ukraine-crisis (accessed in April 2022)
[35] Attacks on ships, seafarers in Ukraine are war crimes say HRAS https://www.seatrade-maritime.com/ship-operations/attacks-ships-seafarers-ukraine-are-war-crimes-say-hras (accessed in April 2022)
[36] Tanker rates rocket on Ukraine conflict, outlook uncertain https://www.seatrade-maritime.com/tankers/tanker-rates-rocket-ukraine-conflict-outlook-uncertain (accessed in April 2022)
[37] Widespread shipping fallout following Ukraine invasion https://www.seatrade-maritime.com/tankers/widespread-shipping-fallout-following-ukraine-invasion (accessed in April 2022)

some parties are requesting additional clarity and uniformity, as they consider that there are opportunities for "port shopping"[38].

According to Bloomberg[39], over a million containers travel more than 6,000 miles of railway linking Western Europe to Eastern China via Russia. As a result of the war, these containers are now having to find new routes by sea, adding to costs and threatening to worsen the global supply chain chaos. The conflict is adding to congestion at some of the biggest ports, putting further pressure on global supply chains that are still reeling from pandemic-induced manpower shortages.

The report highlights that a combination of sea-air solutions could help some automakers and high-tech electronics manufacturers prevent production disruptions despite a surge in costs. As of March 2022, the export volume on trains heading to Europe from the port of Dalian in China has been considerably. However, the aforementioned ITF report highlights that a corridor with Belarus would avoid transhipment costs via Poland, ensuring efficient exportation of goods via Baltic ports.

Bloomberg also argues that the rail links between China and Europe have been forged over the past decade as part of President Xi Jinping's new Silk Road project, which later morphed into the "Belt and Road" initiative. It is an ambitious mix of foreign policy and economic strategy to extend the country's influence across continents. Last year, trains moved about 1.46 million containers carrying goods valued at about 71 billion euros between China and Europe on the routes, or about 4% of total trade between the two sides, according to estimates by Bain & Co.

The rail networks stretching from China, Kazakhstan, Russia, Belarus and beyond connect Chinese commercial centres such as Yiwu in Zhejiang province, Xi'an in Shaanxi, Zhengzhou in Henan, Chengdu in Sichuan and Wuhan in Hubei to European cities including Moscow, Minsk, Hamburg, Milan, Warsaw, Munich and Madrid.

Some shipping lines have also been refusing cargo to Russia and diverting vessels into already overwhelmed European ports. Additional volume shifting from rail could slow port operations further.

[38] European ports seek clarity and uniformity in ban on Russian vessels https://lloydslist.maritimeintelligence.informa.com/LL1140511/European-ports-seek-clarity-and-uniformity-in-ban-on-Russian-vessels (accessed in April 2022)

[39] https://www.bloomberg.com/news/articles/2022-03-23/china-europe-rail-routes-become-supply-chain-s-latest-problem, accessed in April 2022

3 Lessons learned from the Advisory Board: New Opportunities for the TEN-T and Global Routes

ePIcenter's Advisory Board (AB) is comprised by EU and non-EU members, which can help not only to exchange information and lessons, but also to identify opportunities for generating greater efficiency along the TEN-T.

For ports, where digitalisation is less advanced, the ePIcenter project is seen as an advantage, as pointed out by the Port of Açú in Brazil during the exchange with ePIcenter's AB. For instance, digitalisation of the supply chain is of outmost importance and can facilitate trade, especially as Brazil is struggling with transport inefficiencies, congestion, among other aspects. Thus, the digitalisation of supply chain operations can have an extremely positive effect on administrative procedures.

In the exchange with DTLF, ePIcenter is another solution to solve data sharing issue. Looking globally, it will not solve the data sharing issue in the entire transport network, though it is very important to look at bottlenecks at a port level.

The Port of Montreal (PoM) has been recognised for its Artificial Intelligence activities ("A.I. hub"). When it comes to real time monitoring, PoM has implemented the Trucking PORTal– free web / mobile app that truckers can access and see truck turnaround time on dashboard in real time. It gives truckers not only real time congestion levels, but also machine learning predictions. Those algorithms can calculate congestion levels 24hrs in advance, enabling truck drivers to better plan their services and optimise routes with the best, non-peak hours for the port gates.

PoM is now building a similar application for rail, also with the use of artificial intelligence to dictate optimal rail movements. As a rail operator, PoM is building trains at the port and directly deliver them to rail operators on containers. The tool should be 2022 deliverable founded by national government. The Port of Montreal does not have dedicated funds for digitalisation other than ScaleAI and Ocean Supercluster innovation clusters.

PoM is using all sorts of data sources to identify containers onboard the vessel while ship sends manifest of the cargo contents 4-10 days prior the vessel arrival at the PoM. In addition, the port is also running an algorithm to identify containers containing critical cargo.

In the exchange with the Port of Açu, port representatives highlighted that the port now represents one of the largest infrastructure enterprises in Brazil: it has the third-largest iron ore terminal in Brazil, being responsible for 25% of Brazilian oil exports. Stakeholders pointed out that Radix, in collaboration with HPC Hamburg Port Consulting, the Supply Chain & Logistics Technology Program - University of Houston, and UTC Overseas, Inc., is developing a 'Smart Port' Digital Growth Masterplan for the Port of Açu (PdA), the largest private and deep-water port in Latin America and home to the world's largest offshore support base.

The goal is to develop a 5–10-year vision for the technological platform of the Port and its ecosystem, focused on the optimisation of operations, attraction of new businesses that are technologically aligned, and the establishment of a technological governance plan and systems architecture. PdA expects to generate greater efficiency, reduction in the time of shipments/landing and connection of all clusters and production steps, such as movement statistics, availability, maritime safety data, customer specifics, and engagement with all stakeholders in the ecosystem. The Digital Masterplan will include the proposal to digitise the different stages of the logistical process and attract new business to the productive port. Thus, the session was an opportunity to understand which port digitalisation programmes (such as paperless systems for vessel authorisations; e-transport declaration, etc.) have been implemented in the PdA.

4 Lessons from trading partner countries and the trade industry

According to DHL, in its maritime freight outlook for 2022-2024[40], 2021 was marked by severe capacity constraints and equipment shortages. The lack of available space on a reduce number of containerships and available containers cannot satisfy the shipping demand, as already highlighted in Chapter 2.

Maritime freight rates have thus risen to historically high levels. Some carriers have adopted opportunistic approaches. In addition, multiple disruptions have caused port congestions across the globe, e.g. in the USA. With schedule reliability at an all-time low, supply chain disruptions have multiplied.

In the US, the government has attempted to minimise congestion, such as by imposing fines for idle containers, especially as a result of the backlog of container ships at the ports of Los Angeles and Long Beach. Ports are running out of space and containers are piling up at docks because delivery is heavily delayed.

The majority of container vessels is expected to be built in China. Therefore, production is dependent on a stable production there. According to DHL, supply growth is to overtake demand growth in 2023 as recent orders start to be delivered.

Ocean Carriers put anything that can float into the Transpacific trade and the Asia to Europe trade, with 47% capacity of the Asia to Indian Sub-Continent having been shifted to the Transpacific trade, creating a giant vacuum against the demand. In addition, Port Congestion and Vessel delays are soaking up supply with more than 10%of the global fleet at anchor due to delays. DHL predicts recovery of the market by 2024, as pointed out in the following figure.

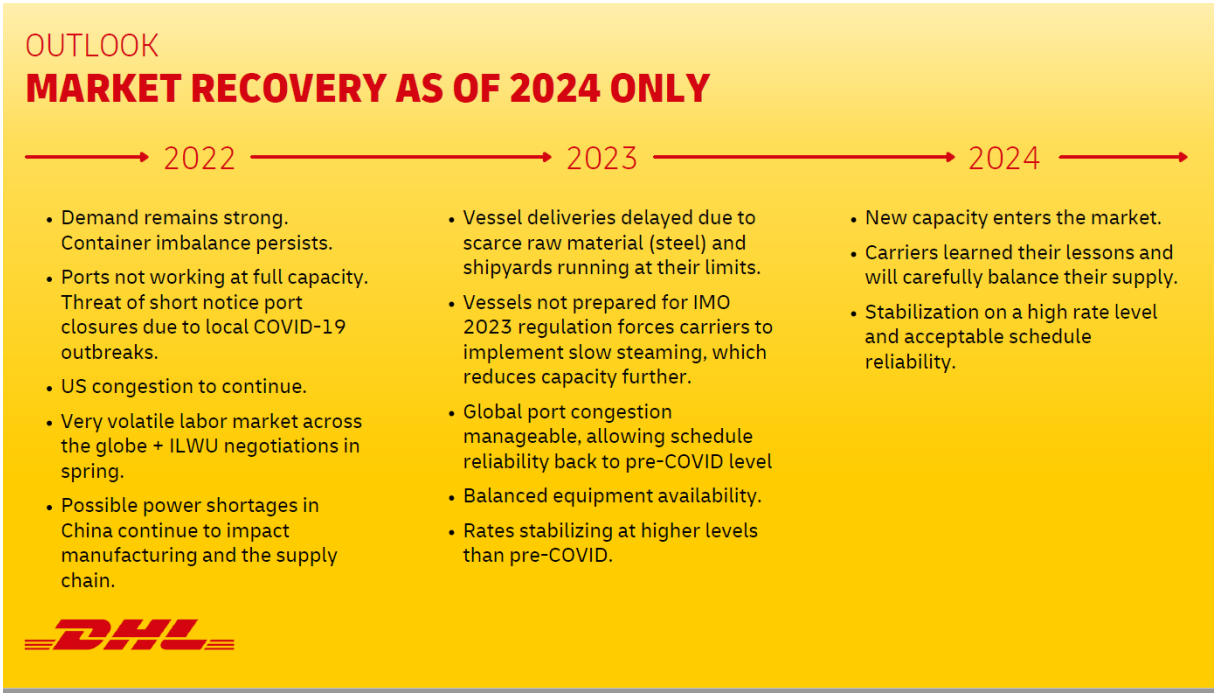

Figure 3: DHL's outlook of the maritime freight market

Source: DHL, Everything You Need to Know to Navigate a Fluid Market: Ocean Freight Market Outlook 2022-2024, April 2022

According to the same report, the main drivers of the container crisis have been the lack of capacity and adequate infrastructure at ports. Many containers are in inland depots, while others are piled up in cargo ports and are onboard vessels, especially on the transpacific trade route. The largest container shortage is in Asia due to the

[40] DHL, Everything You Need To Know To Navigate A Fluid Market: Ocean Freight Market Outlook 2022-2024, April 2022

longer turnaround time to reposition the containers due to port congestion. Europe is also having a deficit, especially in the hinterland.

In Europe, hinterland intermodal connections are relatively well-developed, particularly in northern ports. The setting of strategies such as rail shuttle, barge services contributed to expanding the hinterlands of the most efficient container ports, as pointed out in a study on port hinterland connectivity[41].

Not all types of traffic are equally sensitive to the existence of efficient alternatives to the road. The presence of high-capacity waterway connections between a port and inland region impacts flows of all types of cargo, but less on low-value cargo. This result goes against what is expected for a slow mode rather used for low value-added cargo. Inland waterways are also used to convey high value-added products to the congested metropolitan areas. It is also a mean to delay deliveries to retailers, to save warehousing costs, and having the possibility to accelerate the flow by shifting from waterway to road if needed.

HAROPA Port[42] highlighted the importance of creating alternatives at times of global crisis. According to the port representative, the main lessons learned from the COVID-19 crisis, and which can be replicated as a response to ensure efficient global trades throughout the ongoing War of aggression in Ukraine and in other crises, include ensuring greater involvement of port communities and all stakeholders along the supply chain in order to build a resilient ecosystem. In addition, efficient hinterland connectivity can only be guaranteed by providing adequate facilities to truck drivers and seafarers (namely parking with bathrooms and toilets, besides medical assistance and appropriate food distribution).

In turn, the Port of Antwerp Bruges mentioned[43] that the congestion in European ports, which has been further deteriorated by the closure of certain global routes as a consequence of the ongoing war, opens new doors of opportunity. For instance, new alternatives can be sought in Nordic ports to ensure the timely efficiency of the supply chain in Europe, solving the lack of intermodal services in certain ports.

As pointed out, as several ports shut down in Ukraine as a result of the war, many maritime ships had to be rerouted, causing congestion and further delays in cargo flows, increasingly deteriorating the global supply chain. Nonetheless, freight forwarder Informall BG[44] has sought to restore container shipping to the region by looking at implementing alternative routes via Baltic ports in Poland, Estonia and Latvia, looking at taking advantage of spare capacity in European ports. Nonetheless, existing land-transport infrastructure has created further constraints due to different rail gauges between the countries in the region, which require the transhipment of freight or switching wagon bogies at borders. In addition, a considerable share of existing railway capacity runs via Belarus and Poland, which further limits capacity due to the constraints in place[45].

[41] David Guerrero. A global analysis of hinterlands from a European perspective. In: Global Logistics Network Modelling and Policy: Quantification and Analysis for International Freight. A global analysis of hinterlands from a European perspective. In: Global Logistics Network Modelling and Policy: Quantification and Analysis for International Freight, Elsevier, 18p, 2020. ffhal-02551947f

[42] CNC Working Group on Ports, HAROPA Port's presentation on Crisis Resilience, Huelva, Spain, November 2022

[43] CNC Working Group on Ports, Port Antwerp Bruge's presentation on Crisis Resilience, Huelva, Spain, November 2022

[44] Informall BG – Restoration of direct container shipping to Ukraine is a humanitarian need, October 2022

[45] Dealing with the War's Impacts on Ukraine's Ports: How to Get More Grain to the World, ITF, July 2022

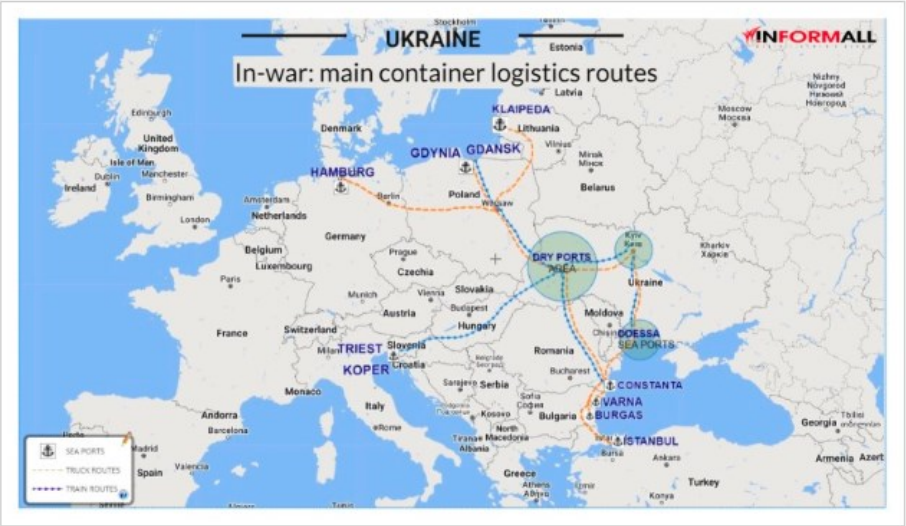

Figure 4: Main container routes in place as an alternative to the War in Ukraine. Source: Informall BG - Restoration of direct container shipping to Ukraine

Outside the EU, the study by DHL also highlights North America as the region with the most developed hinterland connections, both in terms of distance and modal share of alternative modes. Efficient railway connections are used to connect the West and East coast, creating large areas of competition between ports. Even though US railways are old, the development of intermodal services is relatively recent. When compared to other regions the world, the conditions of demand (geographically concentrated, long inter-urban distances) and supply (long double-stack trains, competition between rail companies owning their own networks) make rail particularly competitive against road. In this context, containers are often carried over long distances by rail to reach their final destinations. According to another study[46], about 25% of the rail cargo moved by rail is transferred to domestic containers.

In China, the development of intermodal connectivity at ports varies considerably across the country. Waterway transport of containers is highly developed along the Yangtze River (over more than 2000 km), with many river container terminals reaching altogether about 9 million TEU/year capacity. However, capacity and traffic remain highly concentrated on a relatively short segment, namely between Shanghai and Nanjing, the latter located 350 km from the sea. The hinterlands of ports remain, in general, limited, and very concentrated in coastal regions[47].

Nonetheless, new routes between China and Europe can help to ease the crisis in the logistics sector, especially with the closure of Ukrainian ports. Ukraine, as part of the Commission's Eastern Partnership, benefited from strong efforts to improve links with EU borders and had started to strengthen its position on the Silk Road route, ensuring the trade link between Europe and China via Ukraine[48]. Notwithstanding the crisis, several new projects have been launched to help provide some relief in the logistics sector. In July 2022, for instance, Fuzhou, in China, launched its 9,900-kilometre train journey to Europe - named the 'Mindu' freight train and expected to take 20 days less than the current sea route[49]. Another China-Europe freight train departed in July 2022, from Chongqing to Melzo, in Italy, being estimated to complete the route in approximately 22 days. The Commission's Solidarity Lanes Action Plan[50] has also ensured that alternatives other than maritime routes, via rail, road and inland

[46] Notteboom, T. E., & Rodrigue, J. P. (2005). Port regionalization: towards a new phase in port development. Maritime Policy & Management, 32(3), 297-313.
[47] Lee, S. W., Song, D. W., & Ducruet, C. (2008). A tale of Asia's world ports: the spatial evolution in global hub port cities. Geoforum, 39(1), 372-385.
[48] Russia's war on Ukraine: Implications for Transport, European Parliament, May 2022
[49] RUSSIA-UKRAINE WAR: GLOBAL IMPACT ON LOGISTICS, GEP, September 2022, available at: https://Www.Gep.Com/Blog/Mind/Russia-Ukraine-War-Logistics-Impact#:~:Text=The%20russia%2dukraine%20war%20led,The%20availability%20of%20warehousing%20space.
[50] Keeping Ukrainian goods moving: EU-Ukraine Solidarity Lanes, Available at: https://transport.ec.europa.eu/ukraine/keeping-ukrainian-goods-moving_en

waterways, are put in place to export grain from Ukraine. In addition, UN's initiative named the *Black Sea Grain Initiative*[51] has also reinforced the development of such alternatives.

In other developing regions, the integration between shipping lines and land transport remains very limited. In the context of South America, competitive hinterlands remain scarce, partly because of the lack of modal alternatives. In Africa, the degree of development of hinterland intermodality is slightly higher. The following table provides an overview on the characteristics of port hinterlands across the globe.

	North America	Western Europe	Japan	China	South America	Africa
Inland Competition	+++	++	+	+/++	---	--
Intermodalism	+++	++	-	+/++	-	+
Large Shippers	+++	++	+++	++	-	---
Large Freight Forwarders	++	+++	+	+/++	+	--/-
Low Inland Barriers	+++	+	-	-	---	--
Throughput Balance	--	+	++	++	+++	---

Figure 5: Port hinterland connectivity across the globe

Source: David Guerrero. A global analysis of hinterlands from a European perspective. In: Global Logistics Network Modelling and Policy: Quantification and Analysis for International Freight. A global analysis of hinterlands from a European perspective. In: Global Logistics Network Modelling and Policy: Quantification and Analysis for International Freight, Elsevier, 18p, 2020.
Note: +: little developed (low intermodal connections); ++ reasonably developed; +++ highly developed; - low development; -- reasonably low development; --- poorly developed.

4.1 Europe-China trade flows: bottlenecks and Opportunities

Operational bottlenecks

Despite the significant investment in rail freight on the route between China and Europe for more than a decade, rail has not yet managed to meet the outset expectations and become a viable alternative to sea freight. The rail infrastructure may have been upgraded in China and Kazakhstan thanks to the Belt and Road Initiative and as result sees impressive improvements in train transit times from China to Europe. Nevertheless, all the investments have not rendered the expected benefits due to the existing bottlenecks at the European side. It can be mainly explained by infrastructure bottlenecks on the Malaszewicze-Terespol-Brest rail segment, in particular, regarding the Malaszewicze Hub and intercountry train and container information exchange shortcomings (CN-KZ-RU-BY-PL).

The Malaszewicze-Terespol-Brest rail segment is of strategic importance for the EU, as:

- It is situated on the shortest rail route between China and Europe
- It is part of the strategic rail corridor for EU and CIS countries: Trans-European Transport Network (TEN-T; already after modernisation).
- 80% of all cargo out of China through rail is destined for DE, Benelux, FR, PL, DK, UK - on the same rail route as the fore-mentioned rail segment is positioned.

[51] Black Sea Grain Initiative by the United Nations, available at: https://www.un.org/en/black-sea-grain-initiative

- The main European Intermodal Hubs like Duisburg, Hamburg, Antwerp, Tilburg and Rotterdam are also along the same rail route.

As a result, 80% of all cargo shipments from China to Europe are passing through the Malaszewicze-Terespol-Brest rail segment and the Malaszewicze Hub. The remaining 20% of the cargo from China to Europe is transported through rail routes utilising the Kaliningrad (RU) and Chop (UA) border crossings. These rail routes cannot be seen as viable alternatives to the main route through Malaszewicze Hub due to:

- The rail border crossings are not modernised, e.g. they do not have sufficiently developed customs offices and phytosanitary service facilities. The border crossings with the existing cargo passing through are already becoming bottlenecks.
- The track infrastructure is not modernised only on the border crossings, but also along the routes in Russia, Lithuania, Ukraine and Poland.
- They are off the main Trans-European Transport Network route.

Both rail routes came into existence and are used, as they are workarounds to the existing challenge at Malaszewicze-Terespol-Brest rail segment.

One can distinguish two main root causes of inefficiencies in the Malaszewicze-Terespol-Brest rail segment:

- Outdated existing infrastructure at Malaszewicze-Terespol-Brest rail segment
- No train and container planning and information exchange systems - EU / CIS / CN

In addition, with the War in Ukraine the issue of having different track gauges in the countries has been exacerbated. In this regard, the Commission has stressed the need for improving connections with neighbouring countries more than before. Therefore, the Commission[52] proposed integrating Ukraine into the maps of the revised TEN-T Regulation, in an attempt to overcome interoperability obstacles, which can allow rail projects to ensure interoperable connectivity with Ukraine.

Opportunities to overcome the bottlenecks

The first opportunity is the development of a new border and transhipping alternative to the existing Malaszewicze Hub setup. The aim would be to create one high throughput location that will allow for high cargo volume concentration to foster optimal utilisation of shipping resources. It can also provide multimodal transportation solutions: rail, road and barge.

The hub can be the first modern, emissions-free, West-East intermodal hub in Eastern Europe, with three different transport modes:

- Rail: Rail track E20 within TEN-T
- Road: A2 motorway linking Kukuryki (PL/BY) and Swiecko (DE/PL)
- Barge transportation:
    - Port of Terespol - Black Sea (existing sailing waterways)
    - Port of Terespol - Baltic Sea (requires unblocking of sailing waterways)

Another opportunity is the design, development and deployment of a planning and information exchange digital platform that allows to plan every lag of cargo train journey. This digital platform would be utilised by CN - CIS - EU and allows to plan train journeys, develop robust schedules and ensure that each party involved contributes to the end to end planning process.

[52] Commission amends TEN-T proposal to reflect impacts on infrastructure of Russia's war of aggression against Ukraine, July 2022, https://transport.ec.europa.eu/news/commission-amends-ten-t-proposal-reflect-impacts-infrastructure-russias-war-aggression-against-2022-07-27_en

Currently this is in the scope of the China – Europe use case, which is included in the ePIcenter project. The ePI-link demonstrator plans to consider flows from Southeast Asia to Europe via the New Silk Road rail connections, carrying out a feasibility study about the possibility of applying ePIcenter data exchange and visibility solutions to rail movements such as those arriving in Poland and then moving to the port of Duisport. Nonetheless, the War in Ukraine has led to disruptions in such routes, creating delays in the results of such demonstrator. In addition, as previously pointed out, spare capacity at European ports can be used to help overcome the bottlenecks arising from the War in Ukraine. For instance, Haropa Port[53] has ensured technical cooperations with the Romanian ports of Constanţa and Galati, improving river access to the latter and rail operations within the former, within the Solidarity Lanes initiatives by the Commission. Besides, an international agreement creating safe maritime corridors in the Black Sea would best safeguard grain exports from Ukraine.

[53] CNC Working Group on Ports, HAROPA Port's presentation on Crisis Resilience, Huelva, Spain, November 2022

5 How can opportunities be reflected in day-to-day trade flows

Besides the construction of new physical infrastructure, the TEN-T policy supports the application of innovation, new technologies and digital solutions to all modes of transport. The objective is improved use of infrastructure, reduced environmental impact of transport, enhanced energy efficiency and increased safety.

In this scope, the ePIcenter project fits with the objective of reviewing the challenges that the international multimodal containerised and large freight movements faces, identifying the solutions which can facilitate sustainable global trade reducing multimodal nodes congestion and optimising the use of the TEN-T Corridors and infrastructure in an efficient way.

The technical scope of the ePIcenter project is very broad, covering many different innovations, including new transport technology such as Hyperloop, Autonomous Electric Vehicles ("Pods") and modular containers ("Connectainers"); visibility and data sharing innovations and corresponding governance models; optimisation algorithms addressing synchromodal logistics and freight network configuration optimisation, as well as ship fuel minimisation, navigation in Arctic waters and reducing the impact of shipping on whales.

As pointed out in D1.10, the main innovation areas of ePIcenter are:

- **Trusted Data Sharing Layer** (supported by Governance Models), supporting interaction modes such as a Hub-and-Spoke, Federated Network and Point-to-Point. In ePIcenter, this approach is implemented by NxtPort's 'smart data sharing' platform.
- **Visibility Solution Layer**, providing end-to-end transparency in the logistics process, consolidating multiple data-sources in a powerful data analytics engine to provide early, accurate and complete data.
- **Synchromodal Logistics Optimisation**, providing powerful new algorithms which can optimise multimodal movements through an ever-increasingly complex network of modes (including future tech such as Hyperloop, AEVs and modular containers), taking advantage of the increased availability of data such as that provided via the Trusted Data Sharing and Visibility Solution layers.
- **Freight Network Impact Configurator**, which provides new tools, methodologies, models and algorithms to enable deeper understanding the impact of new technologies, new operating procedures and new infrastructure on the freight flows. Examples in ePIcenter will focus on Hyperloop, AEVs and possibly Connectainer also, but the toolset is intended to offer capabilities in other areas as well.
- **Connectainer (Modular Containers)**, a highly innovative technology for shipping containers that addresses the significant and well-documented problem of container imbalance globally. The technology allows a 40' container to be split into 2x20' containers, and incorporates an innovative electronic ink display. In other respects Connectainer is designed to meet existing standards for conventional shipping containers, ensuring interoperability with existing handling equipment and regulations.
- **Autonomous Electric Vehicles ("Pods")**, an all-electric autonomous Pod, providing Transport as a Service as part of a fleet of vehicles that are coordinated by an intelligent Freight Mobility Platform. The removal of the driver and the driver's cab motivates the safe development of higher levels of autonomy and improves the unit economics of electrification.
- **Hyperloop**, focusing on taking a further step towards possible applications of Hyperloop as a green, low energy and fast transport mode for freight. In ePIcenter lab simulations and analysis will be undertaken to further understand the potential benefits of Hyperloop, and to develop possible business case scenarios for its use.
- **Environmentally-Friendly Ship Routing & Propulsion Algorithms**, which optimise shipping activity in terms of fuel consumption and impact on marine mammals (specifically cetaceans in Arctic waters in ePIcenter although a similar approach may be applicable to many other cases). New algorithms will be developed which optimise the route of a ship through Arctic seas, while fuel minimisation algorithms will attempt to optimise propulsion and energy usage.

These are expected to achieve ePIcenter's goals of increasing the understanding of the impact of new technologies, paradigms and new trade routes on the flow of freight in the TEN-T (and global) networks, which can be particularly achieved through ePIcenter's use cases on Synchromodal Logistics Optimisation, Freight Network Impact Configurator, AEV's, Hyperloop and Environmentally Friendly Ship Routing & Propulsion Algorithms. In addition, the Use Case on Modular Containers (Connectainer) can bring important innovation potential, which can be especially vital for improving the competitiveness of shipping and logistics chains through the deployment of more digital solutions. The Connectainer will be simulating the impact of the use of modular containers in some ports, namely in Algeciras. Algeciras is part of the Atlantic Corridor, which is a testbed for innovative solutions and a frontrunner among the CNCs.

The impacts of these ePIcenter use cases can be closely linked with the preliminary KPIs identified in Table 1, identifying how the results of simulations can bring opportunities for more efficient day-to-day operations in ports and their hinterland.

6 Conclusion

The work carried out in ePIcenter's WP1 has been focused on analysing the main challenges and opportunities in the TEN-T and Global networks. This analysis will enable to develop a deeper understanding of the current issues and potential for innovation, to be directly used in the development of ePIGEN's solutions, bringing opportunities for ensuring a seamless integration of the digital infrastructure layer through secure international information flows and digitalisation.

With this in mind, the present deliverable focuses on identifying the main bottlenecks on the TEN-T and Global networks, particularly discussing how maritime trade and hinterland connectivity have been impacted by recent global developments such as the COVID-19 pandemic and the War in Ukraine. A functioning hinterland transport network is an important determinant of economic growth, which has been given greater importance under the revision of the TEN-T Regulation, as part of the new concept of the European Maritime Space. Nevertheless, the recent crises have brought ports' hinterlands to gridlock, which, among other causes, have led to the recent container crises – further challenges and bottlenecks to the shipping and logistics chain. Coordination from the European Commission and the European Coordinators for the TEN-T Core Network Corridors is crucial to ensure that Member States meet the deadlines to implement key TEN-T infrastructure components, which will help overcome the main bottlenecks at national level and ensure greater harmonisation of European infrastructure. The future TEN-T Regulation will ensure that the roles of the European Coordinators and the Commission are further reinforced.

Such analysis enables to identify windows of opportunity for exploring a better use of digital solutions transport connections, especially port hinterland connections. Digitalisation is vital to improve the competitiveness of shipping and logistic chains. In particular, the digitalisation of supply chain operations can have an extremely positive effect on administrative procedures. Therefore, the experience from the Port of Montreal and other projects are of vital importance to explore opportunities for improving operations at ports and beyond.

Linked with this analysis, this document provides an overview of the exchanges with ePIcenter's Advisory Board and International Cooperation Task Force meetings, specifically carried out under WP5. In addition, this assessment also includes a wider perspective of international trading partner countries. This analysis is important to understand how ePIcenter's use cases can generate greater innovation on the transport networks.

7 References

- Attacks on ships, seafarers in Ukraine are war crimes say HRAS https://www.seatrade-maritime.com/ship-operations/attacks-ships-seafarers-ukraine-are-war-crimes-say-hras (Accessed in April 2022)
- BBC News, Ukraine war: Trucks stuck at Poland-Belarus border as EU sanctions deadline passes https://www.bbc.com/news/world-europe-61133439 (Accessed in April 2022)
- Black Sea Grain Initiative by the United Nations, available at: https://www.un.org/en/black-sea-grain-initiative (accessed in January 2023)
- Bloomberg: China-Europe Rail routes become supply chain's latest problems: https://www.bloomberg.com/news/articles/2022-03-23/china-europe-rail-routes-become-supply-chain-s-latest-problem, accessed in April 2022
- BPlegal: How does the container crisis affect international trade?,
- Brunila, OP., Kunnaala-Hyrkki, V. & Inkinen, T. Hindrances in port digitalization? Identifying problems in adoption and implementation. Eur. Transp. Res. Rev. 13, 62 (2021). https://doi.org/10.1186/s12544-021-00523-0)
- CNC Working Group on Ports, HAROPA Port's presentation on Crisis Resilience, Huelva, Spain, November 2022
- CNC Working Group on Ports, Port Antwerp Bruge's presentation on Crisis Resilience, Huelva, Spain, November 2022
- Commission Staff Working Document Evaluation of the Regulation (EU) N° 1315/2013 on Union Guidelines for the development of a trans- European transport network {SWD(2021) 118 final}, Brussels, 26.5.2021 SWD(2021) 117 final .
- Commission amends TEN-T proposal to reflect impacts on infrastructure of Russia's war of aggression against Ukraine, July 2022, available: https://transport.ec.europa.eu/news/commission-amends-ten-t-proposal-reflect-impacts-infrastructure-russias-war-aggression-against-2022-07-27_en (accessed in January 2023))
- David Guerrero. A global analysis of hinterlands from a European perspective. In: Global Logistics Network Modelling and Policy: Quantification and Analysis for International Freight. A global analysis of hinterlands from a European perspective. In: Global Logistics Network Modelling and Policy: Quantification and Analysis for International Freight, Elsevier, 18p, 2020. ffhal-02551947fDHL, Everything You Need To Know To Navigate A Fluid Market: Ocean Freight Market Outlook 2022-2024, April 2022
- Dealing with the War's Impacts on Ukraine's Ports: How to Get More Grain to the World, ITF, July 2022
- ECSA urges regulators to guarantee seafarers' mobility and their rights as essential workers. https://www.ecsa.eu/index.php/news/eu-shipowners-highlight-importance-seafarers-ukraine-crisis (Accessed in April 2022)
- EMSA, January 2021 - COVID-19 Impact on Shipping Report
- European Council, EU restrictive measures against Russia over Ukraine
- European ports seek clarity and uniformity in ban on Russian vessels https://lloydslist.maritimeintelligence.informa.com/LL1140511/European-ports-seek-clarity-and-uniformity-in-ban-on-Russian-vessels (accessed in April 2022)
- Eurostat, Maritime transport - goods - detailed annual and quarterly results: Gross weight of goods transported to/from main ports by direction and type of traffic (national and international) - quarterly data
- Eurostat, Inland waterways transport measurement - goods - quarterly data: Container transport by nationality of vessel
- European Parliament, EU shipping and ports facing coronavirus
- FEPORT, Press Release: Closure and delays in the Port of Shanghai: FEPORT calls for an urgent initiative from the EU Commission to gather all interested parties to discuss contingency plan
- Fortune Business Insights, Global Passenger Ferries Market Size [2021-2028] | Industry Share, Growth Factors, Revenue, Competitive Landscape & Forecast

- Identification of bottlenecks and inefficiencies in transport flows in Baltic Loop East-West corridors with emphasis on maritime logistics Authors: Irina Wahlström & Yiran Chen, Åbo Akademi University Published: September, 2020
- Irish Maritime Development Office, https://www.imdo.ie (accessed in January 2023)
- Informall BG – Restoration of direct container shipping to Ukraine is a humanitarian need, October 2022
- ITF, COVID-19 Transport Brief: Lessons from Covid-19 State Support for Maritime Shipping
- Impact of Russia's invasion of Ukraine on the port of Rotterdam
- InterFerry, COVID-19 - Guidance on reopening passenger ferry services
- Jean-François Arvis, Vincent Vesin, Robin Carruthers, César Ducruet, Peter de Langen. Maritime Networks, Port Efficiency, and Hinterland Connectivity in the Mediterranean. World Bank Group, http://hdl.handle.net/10986/30585, 2018, International Development in Focus, 978-1-4648-1274-3. ffhalshs-01933726
- Keeping Ukrainian goods moving: EU-Ukraine Solidarity Lanes, Available at: https://transport.ec.europa.eu/ukraine/keeping-ukrainian-goods-moving_en (accessed in January 2023)

- Lee, S. W., Song, D. W., & Ducruet, C. (2008). A tale of Asia's world ports: the spatial evolution in global hub port cities. Geoforum, 39(1), 372-385.
- Notteboom, T. E., & Rodrigue, J. P. (2005). Port regionalization: towards a new phase in port development. Maritime Policy & Management, 32(3), 297-313.
- PLANET Project (https://www.planetproject.eu)
- PortNews, Crisis caused by Covid-19 brought changes and highlighted new opportunities for port of Riga (Accessed in April 2022)
- Russian and Ukrainian seafarers make up 14.5% of global shipping workforce, according to ICS
- Tanker rates rocket on Ukraine conflict, outlook uncertain https://www.seatrade-maritime.com/tankers/tanker-rates-rocket-ukraine-conflict-outlook-uncertain (accessed in April 2022)
- Informall BG – Restoration of direct container shipping to Ukraine is a humanitarian need, October 2022
- The Guardian, British Airways owner warns it could cut Heathrow flights over higher charges https://www.theguardian.com/business/2021/nov/22/ba-iag-uk-air-europa-uk-deal-competition (Accessed in April 2022)
- RUSSIA-UKRAINE WAR: GLOBAL IMPACT ON LOGISTICS, GEP, September 2022, available at: https://Www.Gep.Com/Blog/Mind/Russia-Ukraine-War-Logistics-Impact#:~:Text=The%20russia%2dukraine%20war%20led,The%20availability%20of%20warehousing%20space. (accessed in January 2023)
- The Guardian, Russia bombs five railway stations in central and western Ukraine https://www.theguardian.com/world/2022/apr/25/russia-bombs-five-rail-stations-in-central-and-western-ukraine (Accessed in April 2022)
- The Guardian, Russia blocks access to Facebook and Twitter, https://www.theguardian.com/world/2022/mar/04/russia-completely-blocks-access-to-facebook-and-twitter (Accessed in April 2022)
- The World Bank: Greener Transport Connectivity for Eastern Partnership Countries. The World Bank and Korea Green Growth Trust Fund, 2020
- Thürer, M., Tomašević, I., Stevenson, M., Blome, C., Melnyk, S., Chan, H. K., & Huang, G. Q. (2020). A systematic review of China's belt and road initiative: implications for global supply chain management. International Journal of Production Research, 58(8), 2436-2453.
- UNCTAD – Review of Maritime Transport 2019 (2020)
- Widespread shipping fallout following Ukraine invasion https://www.seatrade-maritime.com/tankers/widespread-shipping-fallout-following-ukraine-invasion (accessed in April 2022)