COMBINED TERMINAL STRATEGY

- A strategy to push forward interregional CT development

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WP 3, Activity 3.3, Final Version

2021 June, 11

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CONTENT

ABSTRACT

ENGLISH – The COMBINE project aims to improve combined transport (CT) in the Baltic Sea Region (BSR) and to make freight transport more efficient and environmentally friendly. This paper gives an initial overview of the CT with a focus on the terminals and intends to develop policy measures at the level of the EU and the Baltic Sea. A policy workshop was held as part of the project, the results of which were incorporated into the analysis. The measures are seen as strategic for further development to ensure the positioning of a sustainable and efficient CT landscape.

Keywords: Combined transport, terminal strategy, Baltic Sea region

JEL: O1, R4, R41

DEUTSCH – Das Projekt COMBINE zielt darauf ab, den kombinierten Verkehr (CT) im Ostseeraum (BSR) zu verbessern und den Güterverkehr effizienter und umweltfreundlicher zu gestalten. Das vorliegende Papier gibt einen ersten Überblick zum CT mit Fokus auf den Terminals und versucht im Folgenden, Politikmaßnahmen auf Ebene der EU und der Ostsee zu entwickeln. Im Rahmen des Projektes wurde auch ein Policy-Workshop durchgeführt, dessen Ergebnisse in die Analyse eingeflossen sind. Die Maßnahmen werden als strategisch für die weitere Entwicklung gesehen, um die Positionierung einer nachhaltigen und effizienten CT-Landschaft zu gewähren.

Schlüsselwörter: Kombinierter Verkehr, Terminalstrategie, Ostseeregion

JEL: O1, R4, R41

ACKNOWLEDGEMENTS AND CONTRIBUTIONS

The authors would like to thank Ernest Czermański and Jakub Jankiewicz (both University of Gdansk, UG), Normunds Krumins and Egons Mudulis (both Latvian Logistics Association), Clemens Bochynek, Can Dincer and Vivin Kumar Sudhakar (all German Research Association for Combined Transport – SGKV) and Anna Kristiansson and Thomas Asp (both CLOSER) for providing information, data about the projects, and participating in the discussion of the results.

1 Introduction

The project COMBINE aims at enhancing the combined transport (CT) in the Baltic Sea region (BSR) and at making freight transport more efficient and environmentally friendly.

The optimization of the movement of freight goods is essential, not only in terms of productivity but increasingly also in terms of environmental sustainability (Bochynek, et al. 2020). The need to lower external and environmental costs in freight transportation challenges to re-think the way goods are transported. An approach to reduce transportation-related costs is the combined freight transport. While optimizing economic costs has always been a common approach, environmental concerns regarding the use of certain transport mode have become more relevant over the last decades. In its strategy for low-emission mobility, the EU commission demands a reduction in Greenhouse Gas (GHG) emissions from transport by at least 60 % by mid-century compared to 1990 (EC, 2016). An option that is often overlooked to reduce both economic and environmental costs is the application of combined freight transportation (Jahn et al., 2020). In view of growth-induced increases in trade volumes and transport demand, the future of European freight transportation has to be revised. Rail and waterborne transportation should be strongly intensified to reduce the public and environmental costs. CT offers a great chance to develop a transportation system that combines rail (and inland waterways) transport capacity with road transport flexibility in the best way possible and with the lowest external effects (Bielenia et al., 2020).

CT is a form of intermodal transport where the goods never change the transportation unit during the entire transportation process, even though the freight successively changes between at least two different modes of transport. Combined freight transportation is thereby characterized by the integration of several transport modes into the freight transportation chain while using the same carriage unit for the whole transport journey. It aims at keeping the lengths of the initial and final road leg of the transportation route as short as possible while carrying out its major part by other transportation modes like rail, inland waterway, or sea (UNECE, 2001). Terminals are an integral part of CT and represent physical nodes where freight either originates, ends, or is handled in the freight transport process. Terminals are also nodes of transfer between modes (Rodrigue et al. 2017).

Achieving these ambitious goals – which are guided by the EU-Combine flagship project[1] – requires various forms of action regarding, for example, transport organization, the legal framework, technological and innovation development, and cargo unit carriages. The whole process of combined transport engages many different players including shippers, forwarders, terminal operators, infrastructure managers, or the government (Bielenia et al., 2020). As terminals play a key role in the processes of CT, one major requirement for the effective and successful implementation and interregional application of CT in the BSR is a sophisticated and well-coordinated terminal infrastructure

[1] The EU-flagship projects are visionary, science-driven, and larger-scale research activities intended to address scientific and technological challenges. They bring together excellent research and multidisciplinary teams and turn research activities into innovation and growth opportunities (EC, 2021).

that is adapted to the local requirements. Therefore, this report will be particularly dedicated to the development of an BSR-related terminal strategy.

Aim of this report

The aim of the report is to address a comprehensive combined terminal strategy for the BSR. The paper will give an overview about the existing CT market and infrastructure in the BSR, necessary measures in terminals to strengthen CT, and recommendations. Terminals and terminal expansions are mainly planned based on the regional competitive situation and the demand for terminal services, partly also from a national perspective. The advantage of the COMBINE project (and its output) is that it adopts an interregional perspective and looks at the terminal structure of combined transport in a pan-European context – in this case the Baltic Sea region.

Structure of the report

In the following, this report is primarily intended to summarize the main results of the project-internal reports "Overview of the combined transport market in the BSR" (Bochynek et al., 2020) and "Combined Transport Terminal Benchmark Analysis" (Bielenia et al., 2020).[2] Moreover, some CT-related pilot activities and efficiency optimizations such as last mile solutions are integrated in this report (Work Package 4, Activity 4.1).

The structure is as follows: Chapter 2 summarizes the essential core results of the two above-mentioned reports. Chapter 3 aims at developing a combined terminal strategy for the Baltic Sea Region, also including a discussion of the main results of a workshop with relevant regional and national stakeholders as well as terminal and umbrella organizations that took place in April 2021. Finally, the paper closes with a conclusion (Chapter 4).

[2] EU-INTERREG Combine project work package 2, Activity, 2.1 and work package 3, Activity 3.1.

2 Combined transport market in the BSR

The following chapter will put a special focus on the Combined Transport market in the BSR. To get a comprehensive picture of the CT market situation, this chapter will separately deal with and present the key information about the CT market in general, and more specifically, about CT terminals and CT related technologies. The presented content regarding the CT market, terminals and technologies is mainly based on the two COMBINE-internal outputs "Overview of the combined transport market in the BSR" and "Combined Transport Terminal Benchmark Analysis".

2.1 Combined transport market

CT is an intermodal transport mode where, even though the freight successively changes between at least two different modes of transport, the goods never change the transportation unit during the entire transportation process. Furthermore, in CT, major part of the freight transport is carried out by rail, inland waterway, or sea, while the road legs in the beginning (First Mile) and at the end of the transport chain (Last Mile) should be kept as short as possible (EC, 2019; UNECE, 2001).

Economic potential of CT

The freight transport plays an enormous role for Europe's economic success and wealth as well as for Western society in general. Transportation is undoubtedly an indispensable part of modern economy. Nevertheless, increasing environmental pressure and the undeniable fact of the large environmental impact of transportation, e.g., as a contributor to GHG emissions, require a fast and effective reorganization of freight transportation (Bochynek et al., 2020). Contrary to the EU's general decreasing emissions trend, the GHG emissions from the EU's transport sector continued to increase during the last years and made up roughly 30% of the total EU-28 GHG emissions in 2017, whereby road transport is by far the highest contributor to transport emissions (EEA, 2019; EEA, 2020). In this respect, CT represents a potential to reduce emissions and raise the efficiency and productivity or capacity of transportation processes, as it combines the different modes of transport in a way that aims at simultaneously encouraging the specific advantages – i.e., high flexibility for road and high capacities for rail transportation – and reducing the drawbacks – like high emissions for road and low flexibility for rail transportation – of each transportation mode (UIC, 2020).

In an archetypical Combined Transport Chain, an intermodal loading unit (ILU) is initially transported by a forwarding agent or carrier by truck to a terminal. It is then transferred to another mode of transport, such as rail or inland waterway, for the leg to the next transshipment node. At the destination, the loading unit is transshipped to a truck for the final leg to the ultimate destination (Bochynek et al., 2020). Even though this is only a simple example of a possible CT chain, it already highlights the central issues that make up the complexity of CT: successive process steps, many involved actors as well as equipment and infrastructural requirements. These issues shall now be briefly discussed.

As all necessary transport services, for example, organization and planning of transport chains, carriage and handling of goods or infrastructure development, are usually not organized by one single actor, the nature of CT necessitates the involvement of several stakeholders. Moreover, every CT chain unavoidably consists of several successive process steps in the following order: stuffing and loading, pre-haulage (first leg/first mile), transshipment to non-road transport, main leg transportation, transshipment to last mile transportation, post-haulage (last mile), unloading and stripping, where every process step depends on the accurate realization of the prior step (Bochynek et al., 2020). As a result, a CT chain includes many potential bottlenecks. All in all, these two aspects clearly show that two key requirements for the efficient application of interregional CT in the BSR are a well-developed transport infrastructure and a well-coordinated stakeholder network.

Terminals as nodes for transportation

One of the most important infrastructural requirements for CT are terminals (which are defined as places equipped for the transshipment of ILUs between at least two different transport modes or two different rail systems and their temporary storage) (EP, 2013; UNECE, 2001). Subsection 2.2 and section 3 of this report will put a more detailed focus on the terminal situation within the BSR and the development of a CT terminal strategy, respectively. In terms of the required equipment for the implementation of CT, the widespread use of ILUs plays a decisive role. ILUs are generally defined as transportation units that are suitable for intermodal transport, meaning that they can be transshipped between different transportation modes without handling the goods themselves, including containers (ISO and standardized non-ISO), swap bodies, semi-trailers, and loaded road vehicles (EC, 2019; UNECE, 2001).

Identification of relevant cargo flows and export-trade relations

In the following, attention will be drawn to the current CT market in the BSR and the associated cargo flows. At first, it has to be said that due to multiple reasons transport in the BSR, so far, has been mainly and traditionally carried out by road transport (e.g., trucks and semi-trailers). The primarily rural character of the region, connected with a low population density,[3] and comparatively low and spatially scattered transport volumes are leading to transport routes characterized by comparatively long last mile distances.

To strengthen CT in the BSR, it is therefore essential to capture all relevant regional and supra-regional cargo flows and thus the related transportation needs to further apply suitable measures and to shift the modal split within the BSR towards rail, inland-waterway and short-sea shipping (Bochynek et al., 2020).[4] A cargo flow analysis shows that road transportation makes up by far the largest share of total cargo volume within the trade relations of the BSR countries. This heavy reliance on and dominance of

[3] For a compact overview of the socio-economic development, see Stiller/Wedemeier (2011).
[4] An analysis of the cargo flows within the BSR and beyond has been conducted within the scope of output 2.1 of the COMBINE project by members of SGKV and UIRR. It is based on Eurostat data and further information provided by the industry association International Union for Road-Rail Combined Transport (UIC / UIRR). To present the cargo flow analysis in an appealing way, an interactive tool for the visualization of transported goods is additionally presented on the COMBINE website (https://www.combine-project.com/en/node/79793) (Combine, 2021).

road transport within the BSR is further emphasized by its remarkable increase of almost 100% between 2007 and 2018 (Bochynek et al., 2020). Regarding the 15 most important export trade relations of BSR countries in terms of total cargo volume (in 2018), a significant role of the other transportation modes – meaning that within a trade relation, a comparable or at least a notable amount of cargo is transported with a transportation mode other than road transport – can only be observed in sporadic cases. For maritime waterway transportation, these are the relations Denmark-Sweden, Denmark-Germany and Sweden-Germany. The trade relations between the Netherlands, Germany and Belgium show a notable share of inland waterway transportation, while rail transportation only plays a significant role in the trade relation between Sweden and Norway. However, most of these cases still show a strong imprint of road transportation (see Table 1).

Firstly, the cargo flow analysis has demonstrated that significant road traffic exists between the BSR countries but also externally with other European countries. Regarding the 15 trade relations mentioned in Table 1, 76.3% of the exchanged cargo volume was transported by road. It proves that Combined Transport could play an essential role in the greening of transport, as expected at the European level (with the newly adopted Green Deal) but also at the national level (with the publication of national plans on logistics and transportation).[5]

Secondly, the cargo flow analysis based on UIC/UIRR data has shown that CT has an enormous growth potential, especially within the BSR. The internal BSR CT traffic (in this case with focus on unaccompanied CT) is estimated at around 440.000 TEU (with 99% involving Germany), which represents less than 5% of the total European cross-border unaccompanied CT. Without the trade relations involving Germany, the internal BSR CT traffic is almost equal to zero. The external BSR CT traffic is evaluated at about 680.000 TEU which is around 7% of the current total European cross-border unaccompanied CT (Bochynek et al., 2020). As the widespread application of CT and its share in the overall freight transportation do not solely depend on the regional willingness to apply CT, but also on the infrastructural feasibility, the following subsection will go more into detail about the potentially most important infrastructural module regarding the application and promotion of CT: the CT terminal. Innovative technologies including ILUs and handling technologies that can improve the terminal processes and by that promote CT shall also be explored in this context.

[5] The basis of the statistics are the handled goods in thousands of metric tons that have been transported. The statistically optimal measure, however, is ton-kilometers (tkm). In freight transport, tkm is a measure of the transport performance of freight goods. It is measured by the product of the transported mass in metric tons (t) and the distance transported in kilometers (km) (EC, 2003).

Table 1: 15 Most Important Export Trade Relations of BSR Countries in Terms of Total Cargo Volume (in Thousand Tons), 2018

Trade relation	Total cargo volume	Inland waterway	Maritime waterway	Rail	Road
Germany with Netherlands	288,112	53,746	6,891	4,503	222,972
Belgium with Netherlands	211,219	73,531	3,336	21	133,531
Belgium with France	161,097	10,971	6,592	3,448	140,086
Germany with Belgium	147,318	45,272	6,760	3,156	92,130
Belgium with Germany	145,867	43,547	4,339	3,659	94,322
Poland with Germany	141,959	651	9,571	5,753	125,984
Germany with Poland	129,707	361	6,700	4,628	118,018
Germany with France	128,733	5,497	2,805	2,955	117,476
Germany with Austria	109,486	584	0	9,626	99,276
Germany with Italy	62,769	0	1,694	15,231	45,844
Germany with Switzerland	60,733	1,139	0	4,851	54,743
Germany with Denmark	47,579	1	20,150	622	26,806
Germany with Czech Republic	46,422	16	0	10,731	35,675
Denmark with Germany	45,386	2	19,307	102	25,975
Sweden with Norway	44,508	0	5,872	20,632	18,004
Total	**1,770,895**	**235,318**	**94,017**	**90,718**	**1,350,842**
Modal Share (in %)	**/**	**13.3**	**5.3**	**5.1**	**76.3**

Source: Combine (2021), own elaboration.

2.2 Combined transport terminals and innovative technologies

As places where cargo can be transshipped between different transport modes as well as temporarily stored, terminals play a crucial role within the processes of CT. By definition, a CT transport chain is characterized by the use of at least two different modes of transport, therefore transshipment processes and thus CT terminals are an integral part of CT (Bochynek et al., 2020). Consequently, CT terminals are worth to be examined more closely. In the following, we will therefore discuss several terminal-related aspects from both a general and a BSR-oriented perspective including terminal services and processes, potential bottlenecks, promising technologies, and the current terminal situation within the BSR.[6]

As previously discussed, the CT transport chain is composed of several successive process steps, where the transshipment process in CT terminals is one of them. For the improvement and promotion of CT, it is crucial that processes are further developed and improved at every stage of the transport chain as the overall efficiency of CT depends on each of them. Efficiency improvements are particularly important regarding CT terminals, as they might be the weakest link in a CT transport chain. Therefore, it is extremely important to foster the development of efficiently operating CT terminals and a well-functioning CT terminal network within the BSR and beyond (Bielenia et al., 2020). This may require investments in the infrastructure and equipment of CT terminals and the utilization of innovative and effective (handling) technologies.

Performance indicators of a CT terminal

A set of indicators can be used to describe the performance of a CT terminal. One of the most important performance indicators is the maximum turnover capacity which is defined as the lowest value among the throughput of the terminal entrance gate, the throughput of the storage yard and the transshipment capacity of the terminal's handling equipment (Bielenia et al., 2020). These parameters in turn depend on other terminal-related infrastructure parameters (e.g., gate equipment and quantity, terminal and storage area, type and number of handling equipment, number and length of rail tracks, degree of digitalization/automatization of terminal processes, and legal aspects like weight limits for cargo units).

The throughput of the terminal entrance gate describes the number of ILUs that can be checked at the entrance gate of the terminal in one year. The gate capacity is mainly determined by the terminal opening days per year, the number of gate lanes, the average time at gate per vehicle and the degree of process automation. A comparison of three different BSR CT terminals within the benchmark analysis shows that semi- and especially fully automatic gates can considerably increase the terminals' gate throughput capacity. In practice, the gate throughput should always be higher than the other throughput parameters to adapt to fluctuations of first and last mile operations during daytime (Bielenia et al., 2020).

The throughput of the storage yard specifies the number of ILUs that can be stored on the terminal's storage yard during the year. It is mainly depending on the size of the storage area and indirectly on the used handling equipment which influences the way the cargo can be stored and therefore the storage capacity for a given area. While gantry cranes (RMGs/RTGs) allow a tight block storage, this is not possible when using reach stackers (RS which would not have access to second and subsequent rows without restacking containers. Furthermore, the annual storage throughput can be controlled by individual storage fees, which affect the storage period and thus the storage throughput. Terminals in

[6] To a large extent, the following contents will be based on Output 3.1 and additionally Output 2.1 of the COMBINE project. Due to the limitation of this report, it is not possible to cover all the infrastructural components that affect the turnover capacity of a CT terminal; nevertheless, an attempt was made to discuss the most important ones.

Germany and Denmark, for example, increase their storage efficiency by shortening free storage time (Bielenia et al., 2020).

The transshipment capacity of the terminals' handling equipment, as the last of the three performance determining parameters, corresponds to the number of ILUs that can annually be transshipped by the terminal's primary handling equipment, which includes gantry cranes and reach stackers. Determinant and controllable factors for the transshipment capacity of the handling equipment of a terminal are the number and the types of handling devices/facilities as well as their daily operating hours. Different types of handling equipment differ in their productivity: while gantry cranes can handle up to 20 to 30 ILUs per hour, reach stackers can only handle 12 ILUs within one hour. Despite this significant productivity advantage of gantry cranes over stackers, the benchmark analysis shows that most of the terminals considered are using reach stackers, mainly due to its good availability as well as the relatively low investment costs and requirements to the infrastructure (Bielenia et al., 2020).

If one of these three parameters is significantly lower, it must be considered a bottleneck for the terminal and its efficiency. It may necessitate further investments in the specific business area of the terminal, including several possible solutions to increase the terminal performance (see Table 2) (Bielenia et al., 2020).

Table 2. Solutions for bottlenecks within the CT terminal for each business area.

Bottleneck	Possible solutions
Entrance gate	• Implementation OCR/LPR systems • Additional traffic lanes • Truck arrival pre-notification system
Storage capacity	• Expansion of storage area • Different handling equipment to improve container storage • Shorten free storage time • Digital tools for efficiency improvements
Handling equipment	• Additional handling equipment (RMGs/RTGs or RS) • Replace RS with more productive RMGs/RTGs • Digital tools to improve investment planning and current terminal logistic

Source: Bielenia et al. (2020); own elaboration.

Hinterland connectivity of CT terminals

There are also other terminal infrastructure parameters that are crucial for the handling capacity of a CT terminal other than its gate infrastructure, its size and the used handling equipment. For instance, especially for inland CT terminals, which usually focus on the transshipment between rail and road transportation but also for port terminals in terms of hinterland services, the number of rail tracks and their length are important infrastructure parameters as well. Because loading and unloading processes of train compositions can take between three and seven days, the number of rail tracks decides on how many train compositions wagon un-/loading can be carried out simultaneously. The length of the terminal rail tracks is additionally important as it decides whether a train can be un-/loaded as a whole or whether it must previously be dismantled into two or more parts for un-/loading and afterwards reassembled. CT terminals with more and larger rail tracks are therefore able to handle more trains in a certain range of time (Bielenia et al., 2020).

Terminal utilization rate

After determining a maximum terminal turnover capacity based on the parameters mentioned above, it can be put in proportion to the actual cargo turnover of the terminal. This results in the terminal utilization rate which can take values between 0 and 1 – while 0 means that there is actually no cargo turnover at all and 1 means that the actual cargo turnover equals to the maximum turnover capacity of the terminal according to its infrastructural equipment. Depending on their utilization rate, terminals can be categorized into four different stages with different recommendations for action (see Table 3) (Bielenia et al., 2020).

Among the considered BSR terminals, as the benchmark analysis showed, the utilization rate is 0.53 on average. However, there are large regional differences – some terminals show a utilization rate clearly above 0.5 whereas others are not sufficiently used. Nonetheless and especially in regard of generally increasing transport demand as well as growing interest in CT, this result gives food for thought to consider a joint, sustainable strategy for infrastructure and terminal development within the BSR and beyond (Bielenia et al., 2020).

Table 3. Terminal Categorization by Utilization Rate and Corresponding Recommendations.

Utilization rate	Recommendations
UR < 0.3	terminals are not sufficiently used and should urgently develop and expand their networks to increase their cargo turnovers
0.3 < UR < 0.5	terminals are operating with the optimum workflow and throughput
0.5 < UR < 1.0	terminal development should be initiated by the terminal management to remove the existing bottleneck(s) (e.g., handling equipment purchase, storage yard expansion, gate complex development)
UR > 1.0	terminal working processes are in congestion mode as the actual cargo flows exceed the terminal efficiency; radical reaction required as terminal stakeholders are affected

Source: Bielenia et al. (2020); own elaboration.

Application of new innovative technologies

Besides the pure expansion of the terminal infrastructure, terminal efficiency and the suitability of terminals for their use in CT can be improved through the application of new innovative technologies. Next to the basic handling equipment for the transshipment and movement of containers or other cargo units, modern (inland) CT terminals need additional valuable assets to increase their effectiveness, to improve their service quality and to add new services to their portfolio. Thus, the attractiveness of CT for customers and thereby its modal share can be increased. Such solutions include the application of innovative handling technologies as well as solutions in IT system management (Bielenia et al., 2020).

Since the primary function of CT terminals is the transshipment of cargo between different modes of transport and because the scope of services offered determines the competitiveness and attractiveness of a CT terminal and CT in general, it is of great importance which kind of cargo units and which type of goods can be handled in a terminal (Bielenia et al., 2020). For instance, within Europe, most of the overall cargo flow is made up by semi-trailers (among other things due to their compatibility with euro-pallets). However, only a fraction of them is craneable, which poses some challenges to utilize them in CT. Through the application of innovative vertical and/or horizontal handling technologies for the transshipment of semi-trailers among others – which are not yet common in European terminals – it would be possible to improve the terminals' service portfolio, attract new customers and unlock an even larger potential of CT. Available innovative handling solutions of this sort include the vertical transshipment technologies ISU system and NIKRASA as well as the horizontal transshipment technologies CargoBeamer, Modalohr, MegaSwing and Flexiwaggon (Bochynek et al., 2020). Which of these is the most appropriate technological solution for a specific CT terminal depends on several individual, terminal-related factors like the available space, planned transshipment volumes, and financial means. Although innovative handling technologies are not widely used so far due to high acquisition, operational and maintenance costs, a frequently low compatibility with existing terminal infrastructure (resulting in additional investment costs) as well as partly considerable space requirements, they will have to play a vital role in pushing CT forward in the BSR (Bochynek et al., 2020).

Digitalization, Automatization and Standardization

Next to the application of innovative handling technologies, terminal efficiency may also be improved through the exploitation of digitalization and automatization potentials. Despite several risks related to the digitalization of terminal processes, such as loss of business entity autonomy, inadequate use of data, cyberattacks, job losses or unnecessary errors of algorithms and digital infrastructure, digitalization offers numerous benefits for the CT industry. It can foster better decision making through higher transparency of processes relevant for the terminal activities, increase flexibility (which, up to now, is one of the main advantages of pure road transport compared to CT) and lower inventory costs as well as the level of business risks. Especially for entities involved in highly complex transport chains, and that is what CT chains often are, digitalization can be very supportive and valuable for the supply chain management by creating stability and transparency of the work environment. Moreover, due to growing transport volumes and increasing complexity of transport chains, more and more information needs to be processed and analyzed. Therefore, intermodal supply chains must be subject to the process of digitalization and business decisions should be based on data analysis. Digitalization (e.g., Big Data Analysis) supports an efficient, safe, and sustainable transport both economically, environmentally, and socially. Results from data analysis can also be used for forecasting delivery processes and thus allowing to utilize the terminal infrastructure more efficiently and to avoid congestions, which lead to inefficiencies as well as financial and time losses. All in all, digitalization (as well as automatization) of terminal processes can improve the efficiency of transport chains as well as the productivity of the terminal's given resources and thereby boost the competitiveness and reliability of CT (Bielenia et al., 2020).

Lastly, another kind of technological issue that affects the efficiency of terminal processes and CT in general, which is worth to be mentioned here, is the standardization of loading units (LUs). Among the beneficial effects of a widely realized standardization of LUs are the easy and economically viable handling, the optimized usage of space, easier storage as well as better options for gathering information, creating statistics and accounting (Bochynek et al., 2020). As a result, terminal processes are easier to monitor and plannable, thus terminal infrastructure can be used more efficiently, and the complexity of investment decisions regarding the terminal infrastructure can be reduced. However, the advantages of standardized LUs only fully apply if also the transport, handling, and storage processes are generally recognized and internationally standardized (Bochynek et al., 2020).

Services as a determinant of competitiveness

In the context of the transshipment possibilities of terminals, it has already been mentioned that the scope of services offered in a terminal determines its competitiveness. Aside from the pure transshipment execution and the extension of the range of cargo units or transport modes served, terminals can offer various additional services to their customers. These are also referred to as value-added services. In this regard, terminals must be multifunctional and address the transport demand and customer needs in the best way possible. With regard to the storage and handling function of terminals, a terminal can enlarge its infrastructure to allow the handling and storage of non-standard loading units and non-standard loads like reefers (which require external power supply for cooling), oversized cargo or dangerous goods. Moreover, terminals can offer extra services on the goods to attract more customers interested in those services like the composition of LCLs and FCLs as well as the picking and packing of goods, etc. Terminals can also offer tasks for the shipper and/or forwarder like customs clearance through the customs agency including, for instance, phytosanitary and veterinary controls. On top of that, various additional services concerning the loading units as well as the means of transport and packaging can be conducted in a terminal. Such services include the weighing of loading units (e.g., Verified Gross Mass (VGM) for checking and verifying the real mass of cargo before loading), cleaning, servicing, and repair of LUs and means of transport, refueling processes as well as certification of loading and packaging (Bielenia et al., 2020). Further examples of the range of services offered by CT terminals are sophisticated and efficient solutions for the last and first mile as well as cross-border transport services that go beyond the European internal market (see Box 1 and 2).

In the end, however, the decision for or against the expansion of the scope of offered services in a certain way – which is often linked to infrastructure expansion and investments and therefore additional costs – is a terminal-specific one. The current cargo flows as well as the expected development of prospective cargo flows of a terminal must be taken into consideration as the useful offer of specific services is linked to their (existing and expected) local demand.

Operating model and public accessibility

Next, we will briefly discuss operational aspects regarding CT terminals, namely the different operational models of terminals within the BSR and the issue of public accessibility of terminal activities for market participants. The benchmark analysis within the scope of Output 3.1 of the COMBINE project names four different operational models that can be found among the considered CT terminals within the BSR.

Fully in-house is the most common operational model (83 CT terminals ≙ 64%) and describes a situation where the terminal operator is also its owner. Most of them operate on the principle of public accessibility (82%). On the one hand, this may indicate that terminal operators are interested in maximizing the utilization rate of the terminal by opening it for other entities. On the other hand, it shows that the terminals have a much larger turnover capacity than would be required by the operators themselves (Bielenia et al., 2020).

The second most popular operational model is rental agreement for commercial operation (24 terminals ≙ 19%), where ownership and operational function are separated from each other. Interestingly, most of the CT terminals operated in this way are not publicly accessible (58%), meaning that operators of a rented terminal often only use it for their own operations (Bielenia et al., 2020).

Thirdly, 19 of the observed CT terminals within the BSR (≙ 15%) are operating based on an operating contract. In this case, an operator gets the order to provide terminal services for a region or city. Such terminals are therefore generally operating on a public access formula (82% of the 19 terminals). Operating contracts are generally awarded by municipalities when there is a lack of terminal services in a region due to low cargo volumes and an associated low (economic) interest for terminal operators to provide such services (Bielenia et al., 2020).

The least common operational model of CT terminals within the BSR is the concession model. It is only used in three CT terminals in Sweden (≙ 2% of the analyzed terminals). All of them are publicly accessible. Concession can be described as a model that is more far-reaching than an operating contract regarding the scope of handling services. It is applied in situations where the terminal throughput, in contrast to operating contract terminals, is so high that many people want to operate the terminal, but only one can do so (Bielenia et al., 2020).

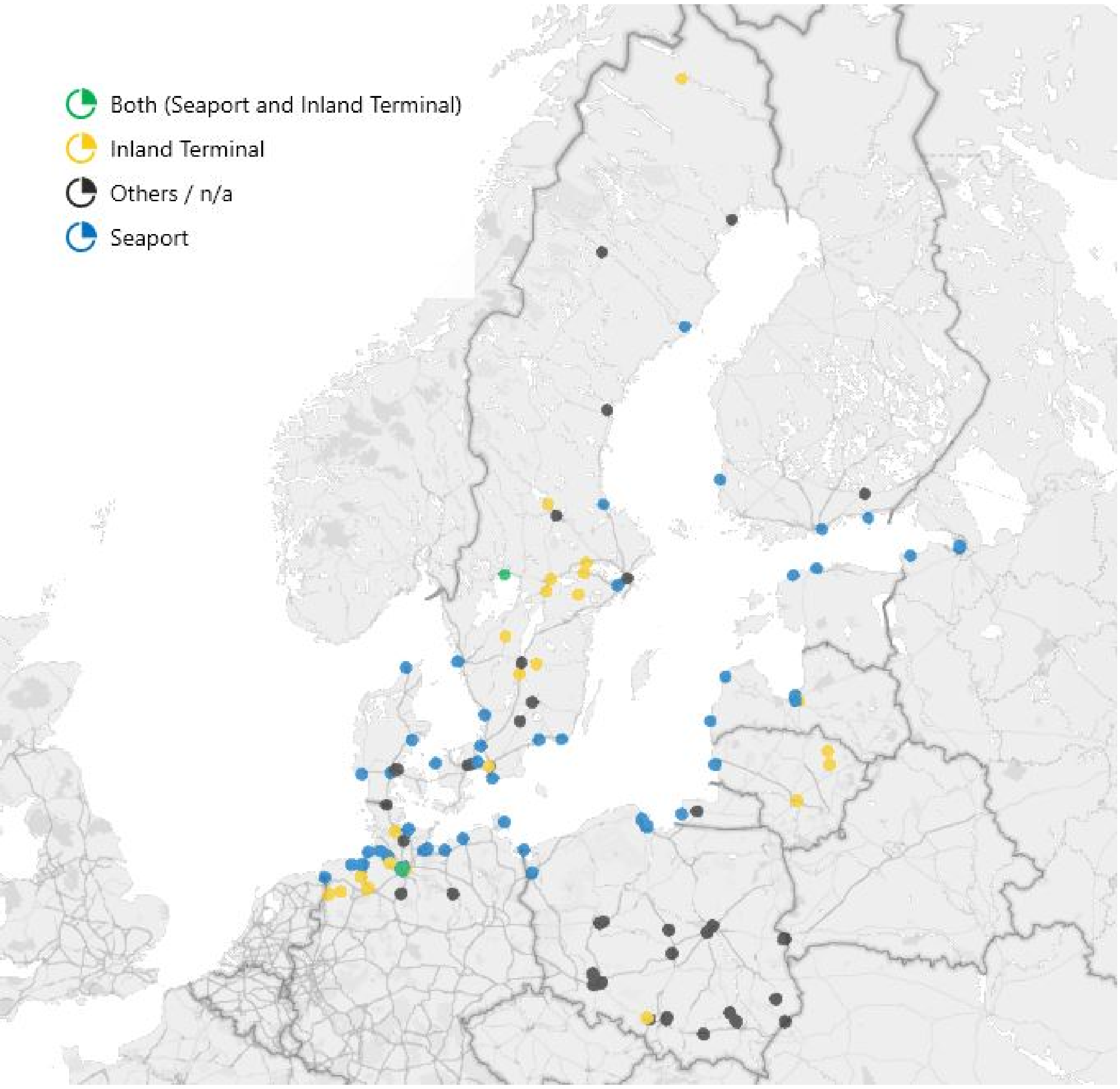
Especially from a combined transport perspective, the public accessibility is an important feature of CT terminals. The efficiency and competitiveness of CT is dependent on a sufficiently developed and accessible terminal network as terminals are indispensable for the functioning of CT and the economic viability of CT chains necessitates geographically close and high-quality terminal services. Both can be improved through a tighter network of publicly accessible and non-discriminatory intermodal terminals (European Union, 2020).

Location and distribution of CT terminals

The location and distribution of terminals is of major importance when it comes to their economic viability as well as their usability and value for the CT network. The primary reason for the location and construction of a terminal at a certain place is the local transport need. In other words, it requires a sufficient local demand for terminal activities. Usually, this results from the vicinity of a large agglomeration or a large seaport. Due to their function as the places where cargo can be transshipped between different transport modes, it is, not surprisingly, essential that CT terminals have good access to the transport infrastructure. The value and usefulness of terminals in general and particularly in CT largely depends on their usability and integrability in existing or promising future transport chains. Therefore, CT terminals are normally located close to international traffic routes. The benchmark analysis of in total 150 CT terminals within nine BSR countries shows that land terminals are mostly located within the TEN-T corridors and near large agglomerations. They are located at the crossroads of major roads and preferably at the intersection between urban roads and main railway lines (which is especially valuable for Rail-Road CT terminals). In port cities, instead, terminals are located as close as possible to the port area, since a large part of the terminals' cargo turnovers originate from sea transportation (Bielenia et al., 2020). It is useful to differentiate between land and seaport terminals, not only because they have different locational attributes, but because they also serve different trade relations and have different functions within CT. While seaport terminals are primarily known for the sea-land transshipment of cargo – and usually have higher volumes of cargo turnovers than other types of terminals – inland terminals are mostly places, where cargo is transshipped between rail and road and vice versa (Bielenia et al., 2020; Rodrigue et al., 2017).

The terminals benchmark analysis shows that CT terminals are unevenly distributed among the different BSR countries. The analysis includes a total of 150 terminals in operation. Most of them are in Germany (51), Sweden (32) and Poland (30). 12 and seven of the analyzed CT terminals are in Denmark and Russia, respectively. The fewest CT terminals can be found in Estonia (two), Finland (four), Latvia and Lithuania (both six). (Bielenia et al., 2020). Figure 1 visualizes the spatial distribution of the analyzed terminals.

Figure 1. Map of terminals in the Baltic Sea Region, colored by type of terminal.



Source: Data Combined Transport Terminal Benchmark Analysis (University of Gdansk, 2020), Combine project partners, own elaboration.

Box 1

Pilot case: Last mile solutions
(by Ernest Czermański and Jakub Jankiewicz)

The last (and first) mile of the CT can be improved in two ways. The efficiency of cargo unit carriage increases by (i.) extension of cargo capacity of the vehicle, as well as by (ii.) switching to more environmentally friendly fuels and propulsion systems. Both ways correspond to EU policy towards the decrease of CO_2 emissions in heavy haulage transport, but only alternative fuels allow achieving the main goal of zero-emissivity defined in the 2019 New Green Deal. Exploitation of current diesel-based vehicles represents a limited scope of emission reduction.

(i.) Increasing of vehicles' cargo capacity is easily achieved by using longer and/or heavier trucks (LHVs). A vast selection of vehicles and supporting equipment already exists. Launching LHV on last mile deliveries allow to receive a decrease of transport costs per unit of up to 30%, whilst GHG emissions can be reduced by 11%, respectively. The newest solution – truck platooning – is meant as an increased capacity transport mean. LHV are legally launched only in the Northern and Western part of the BSR, while in the remaining countries, it is allowed only in accordance with the EU directive standards. As far as existing infrastructure is capable of bearing LHVs, the legal adoption is required. A general conclusion is that regulation has not kept pace with the business development.

EU society expects to achieve a CO_2-free economy until 2050. This requires from truck manufacturers to develop a wide range of zero-emission trucks fleet. A group of leading European truck manufacturers declared to develop and sell only fossil-free trucks by 2040. After 2025 and the launch of the EURO VII emission standard, a drop in the share of diesel trucks in the European fleet is expected.

(ii.) Most of zero-emission propulsions are now in the research or testing process, implying that their market availability is limited, and business implementation faces considerable risk of failure, as well as unexpected costs and legal, technical, or infrastructural obstacles. The most available technology for now is a NGV (gas-propelled) truck which is widely available on the market. The total share of NGV vehicles should rise constantly until 2025, when the EURO VII emission standard might come into force. After that, LNG or LBG trucks will be phased out.

The technology of pure electric vehicles is developing dynamically. Manufacturers are capable of providing pure electric trucks with the range and power suitable for CT operations. For now, these trucks are pure custom, built-to-suit work, so the price is for now the main limitation to the development. As soon as the technology will reach commercial serial production, the availability and the price should improve significantly. In the nearest future, a proper network of charging stations also needs to be considered an important requirement.

Hybrid trucks for CT operations should rather be considered as a transitional solution towards pure electric plug-in trucks. E-highways as a cost-intensive solution will remain in use for long haul trucking and might not play a significant role in CT operations. One solution for last mile CT operations is the hydrogen propulsion, whose constant development is likely to transform CT operations in the future.

Box 2

Pilot case: Combined transport route Russia to Germany
(by Normunds Krumins and Egons Mudulis)

The aim of the CT trial run from Russia to Germany via Latvia was (i.) to test the technology, i.e., the new CT railway wagon, and describe the real handling process in Latvia; (ii.) to cross the EU external boarder to reveal any issues involving customs, differences in treatment of “transport on transport”, i.e., semitrailer on a wagon; and (iii.) to evaluate the overall feasibility, i.e., the time spent on the route, costs (including current railway tariffs), and the safety of the process.

The trial run (route from Moscow to Germany) envisaged the EU border crossing (Russia–Latvia) by rail, short sea shipping, and new rolling stock and handling technology.

Approach/action: A semitrailer was put on the specialized wagon in Russia and sent to the Latvian port of Liepaja by rail. To lift the semitrailer, a reach stacker, an adjusted metal frame, and ropes were used. The technology is applicable to tri-axle semitrailers up to 14.2 meters long.

The rolling stock used in the project was a brand new (built in 2020) wagon certified for the use within entire 1,520 mm railway system. It is intended to carry both containers and semitrailers and may reach a maximum speed of 120 km/h, and its full weight may reach 69 tons.

Results: The trial run faced organizational difficulties as Russian customs considered the wagon with the semitrailer as two transport vehicles, i.e., they treated the semitrailer not as a cargo. A solution was found by re-routing the wagon via Belarus.

It took five days for the single wagon to reach Liepaja from Moscow. Thus, it was estimated that the transit time for a single wagon could be four to six days. In case of a block train (considering transit time of existing container trains) it would take 50 to 55 hours to make the distance. It took some 27 hours to get the semitrailer by ferry from Liepaja to Travemünde.

The data of the project show that to send a semitrailer by railway as a single wagon from Moscow to Liepaja and then by a ferry to Travemünde in 2020 could cost up to 1,250 EUR. The first and last mile transportation bring additional costs depending on the distance.

Afterwards, LLA came up with legislation initiatives to support the development of CT in Latvia. For now, the Ministry of Transport has agreed to proceed with the initiatives that allow, e.g., to increase maximum weight for vehicle compositions with a semi-trailer, which consist of a three-axle towing vehicle and a two-axle or three-axle semi-trailer and which are involved in intermodal transport or CT operations, from 40 to 44 tons.

3 Combined terminal strategy

Terminals are physical nodes where freight either originates, ends, or is handled in the freight transport process. Moreover, terminals are nodes of transfer between modes. The character of a terminal is defined by three major capabilities on which the performance in freight handling depends: i) location, ii) accessibility, and iii) infrastructure.

i.| Location: Newer terminals are on the edge of urban agglomerations to avoid high land and congestion costs. Older terminals are mostly found near or on port sites and in agglomerations. The focus of the terminal location lies always on an industrial production site, i.e., economic activities or a larger population center.

ii.| Accessibility: Access to other terminals is crucial for the handling of goods. Accessibility means access to local, regional, and global terminals (hubs). The larger the network, the greater the range and accessibility of a terminal.

iii.| Infrastructure: the terminals themselves depend on a well-developed transport infrastructure.

These capabilities of the terminals are the interfaces to which politics can refer and support further development. In between, there are the framework conditions for combined transport on the route itself. The transport terminal functions themselves are defined through the connectivity (i.e., within a transport network), interface (i.e., between transport modes), and buffer (i.e., capacity and frequency) in a transport system (Rodrigue et al. 2017).

The following is a brief outline of the policy options and framework conditions (Chapter 3.1) and possible policy measures for the European Union (EU) and Baltic Sea region (Chapter 3.2).

3.1 Framework conditions and policy options

The European Union transport policy considers CT an essential concept for the transitioning of the freight transport sector. The most relevant framework conditions for Road-Rail combined transport in Europe, but also in the narrower scope of the Baltic Sea region, are defined by the et. al. UIRR (2021). Table 4 summarizes the general framework conditions. These conditions are highly relevant for the terminals since they represent the interfaces for freight traffic.

Railway infrastructure

For instance, regarding the framework conditions for the railway infrastructure, the “European Agreement on Important International Combined Transport Lines and Related Installations” (AGTC Agreement) was signed by more than 20 European states. In this agreement, minimum standards were set for the harmonization of international CT. These standards should still be taken into consideration if railway lines are upgraded, extended or even newly constructed (UIRR 2021, UNECE 2001).

The report on the “Analysis of the EU-Combined Transport” has noted the comparison of the CT rail services in the EU and United States of America, where CT rail services make up 67% more traffic than in Europe (KombiConsult et al., 2015). The reasons for this are complex. Among other things, the population centers are to be found on the coasts (with the transport distances in between, respectively overland lengths of haul), and rail transport in the USA can also be carried out in double-stack container trains. In order to achieve a significantly higher volume of CT, the rail infrastructure must be further adapted to be able to absorb growing freight rail traffic (e.g., train overtaking at railway stations, operation of separate tracks in passenger and freight rail trains).

Liberalization and regulation

The CT Directive (92/106/EEC) has made a strong restriction to load units of twenty feet or more and impedes the opportunity to introduce smaller CT units. Smaller units could also expand the scope of CT in urban and metropolitan regions. On the other hand, standardization is one of the main drivers for the development of economies of scale and reduces costs for shipped units (KombiConsult et al. 2015). Therefore, it is recommended to obtain the load units' length to create further economic benefits for CT services. The Directive is limited to distances of road and rail/inland waterway transport (EU-100 km threshold). However, the arguments suggest that these distances do not match (e.g., channel crossing ferries, extended road transportation). More flexibility would be helpful, i.e., a measure to limit the road leg in relation to the non-road leg (KombiConsult et al, 2015; EC, 2001). In conclusion, the main arguments are to i) call for adjustments of the CT Directive, or moreover, ii) to develop a new CT Directive. In addition, there is the recommendation iii) to strengthen the CT support programs (e.g., grants for terminal investments, cross-border infrastructure investments in core routes), and iv) to gather CT statistics. Overall, important aspects of measures to change EU-wide combined transport are discussed by KombiConsult et al. (2015) and should continue to be active in order to change the transport relations, also with regard to the further development towards a common European single market.

Moreover, in view of the framework conditions for liberalization, the European Commission further deals with the opening of transportation (mainly with ongoing integration of the first, second, and third railway package). The European Union drew up new framework conditions in the early 90s by means of various Community legislative instruments (Directive 91/440; Directive 92/106/EEC). The Directives clearly distinguish between infrastructure and operation. The main objective of the Directives (and Regulations), starting in the 90s, is to harmonize the European rail market (UIRR, 2021; UIRR, 2000). The study by KombiConsult et al. (2015) suggests a re-evaluation of the CT Directive to determine whether i) the measures are still relevant (relevance), ii) the measures have been met (effectiveness), iii) the relationship between costs and benefits equals efficient and iv) whether the level of EU policy is coherent, among other things.

Costs (external)

An externality arises when a person engages in an activity that influences the well-being of a third party who neither pays nor receives any compensation for the (positive or negative) effect. The social costs include the external plus the private costs of production. The social costs are always higher than the private costs. These social costs must be internalized in the production process (internalization of external costs) to achieve an efficient outcome (Jahn et al. 2020). Frémont and Franc (2010) showed that the transportation sector is the only major economic sector in the EU that accounts for a growing share of the EU's total CO2 emissions. Nevertheless, the per unit emissions have decreased significantly over the last decades, owing to, for example, cleaner engine technologies or economies of scale.

Costs (internal)

Costs that incur regardless of the length of transportation are, for example, (i.) infrastructure costs, (ii.) transshipment costs, and (iii.) administration costs. Reduced terminal costs are relevant for the competition between the transport modes and able to influence or rather to reshape their individual competitiveness. Modern terminals are subject to high fixed costs, the investment costs are immense. The utilization rate of the terminals is optimal at a maximum of 80%, after which further infrastructural adjustments are necessary to avoid additional costs due to congestion. The terminal infrastructure always includes or is defined by the superstructure and the digital infrastructure, which is becoming increasingly important. Both are relevant to be addressed by policy instruments.

Table 4 – Framework conditions

Railway infrastructure	Liberalization and regulation	Costs (external)	Costs (internal)
• AGTC Agreement • Parameters of infrastructure (particularly gauge; vertical and horizontal alignment; construction parameters) • Electrical systems • European Rail Traffic Management System (ERTMS) • Rail freight (high speed) corridors • Freight prioritization on selected routes • Special horizontal technologies terminal network	• Railway Package (first to third) • Harmonization of CT and CT terminals • Revision of CT Directive	• Costs related to GHG-emissions (in CO_2 equivalents) • Accident costs • Landscape losses costs • Noise and vibration costs • Surrounding areas value decrease corresponding to transport operation vicinity	• Infrastructure costs (e.g., construction, maintenance) • Loading units (e.g., swap body, container) • Transshipment costs • Management costs • Fixed costs

Source: UIRR (2021); Rodrigue et al. (2017); own elaboration.

Political measures – such as regulatory instruments, market-based instruments, as well as infrastructure and market liberalization instruments – can be introduced in the interface of the above mentioned four capabilities to reduce emissions and have a positive impact on the transport sector (Table 5). Other measures include CT-promotion guidelines in the EU member states (see Box 3).

Table 5 - Policy options to raise efficiency of terminals

Regulation instruments	Market-based instruments	Infrastructure instruments
• Emission standards • Fuel efficiency • Top runner program • Restriction / environmental zones • Speed limit • Driver time limits • Weekend/Holidays trucking exclusions	• Emissions trading • CO_2 eq. tax • Taxation of vehicles • Tolls • Funding for Research & Development • Incentives for green investments • Rail infrastructure access fees, strategies & tools	• Technical transport infrastructure • Improved infrastructure management • Decreasing of market barriers • TEN-T core and comprehensive network corridors

Source: Schulte (2017), own elaboration.

Box 3

Pilot case: Promotion of CT in Germany
(by Vivin Kumar Sudhakar)

The promotion of combined transport supported by transport policy takes place at various levels in Germany. This includes direct funding for the construction and expansion of combined transport handling facilities within the framework of the Federal Railway Infrastructure Expansion Act and the Combined Transport Funding Guidelines. Additionally, the upgrading of the transport infrastructure and the increase in competitiveness of the market is fostered indirectly through measures like the current reduction in train path prices. The guidelines for the promotion of transshipment facilities for combined transport (KV Förderrichtlinie) in Germany are:

- The Federal Government of Germany promotes the construction and expansion of transshipment facilities for combined transport as a non-repayable grant to investment expenditure.
- The aim is to develop infrastructure for the transshipment of goods to the more environmentally friendly modes of rail and inland waterways.
- Up to 80 per cent of the eligible capital expenditure is paid as a non-repayable grant for the construction and expansion of CT transshipment facilities.
- A prerequisite for financial support is that the facilities are publicly accessible, i.e., open to all users on a non-discriminatory basis.
- The Federal Railway Authority also offers its involvement in the planning stages of the project to clarify the funding guidelines, provide suggestions, and carry out a basic assessment of funding eligibility.
- Similarly, the Directorate General of Waterways and Shipping provides services on the funding program ‘Promotion of combined transport transshipment facilities’ to support inland waterway transport.

Further sources and readings on the promotion of CT in Germany:

- Studiengesellschaft für den Kombinierten Verkehr e.V. (SGKV) (2021). Politische Rahmenbedingungen, Retrieved March 29, from https://sgkv.de/en/combined-transport/political-framework/promotion/
- Bundesministerium für Verkehr und digitale Infrastruktur (BMVI) (2021): Richtlinie zur Förderung von Umschlaganlagen des Kombinierten Verkehrs, Retrieved June 01, from https://www.bmvi.de/SharedDocs/DE/Artikel/G/umschlaganlagen-foerderrichtlinie
- Eisenbahn-Bundesamt (EBA): Finanzierung Kombinierter Verkehr, Retrieved May 29, from https://www.eba.bund.de/DE/Themen/Finanzierung/Kombinierter_Verkehr/kombinierter_verkehr_node
- Wasserstraßen- und Schifffahrtsverwaltung des Bundes (WSV) (2021): Förderung von Umschlaganlagen des Kombinierten Verkehrs, Retrieved May 30, from https://www.elwis.de/DE/Service/Foerderprogramme/Foerderung-Kombinierter-Verkehr/Foerderung-Kombinierter-Verkehr-node.html

3.2 Scope of action for the European Union and Baltic Sea Region

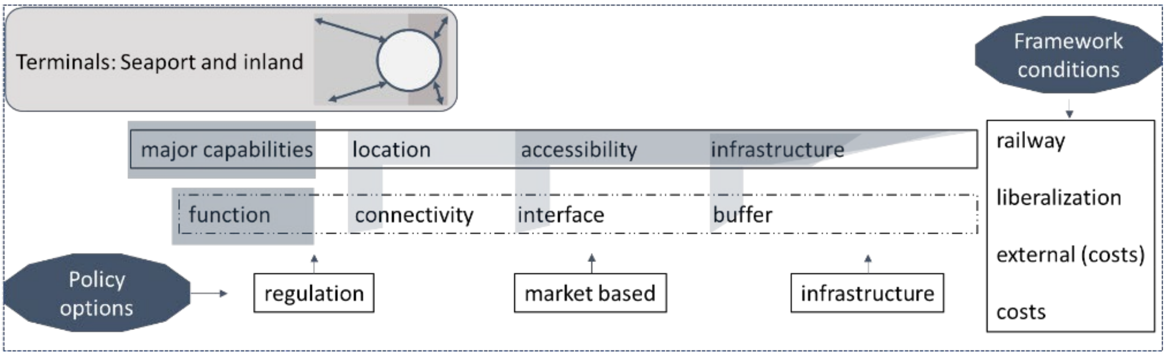
The report Combined Transport Terminal Benchmark Analysis (Bielenia et al., 2020) comprises two parts: i) a general benchmark analysis, and ii) an in-depth analysis of terminal operations. The analysis shows that combined transport terminals are an integral part of freight transport. In the Baltic Sea region, there are around 150 CT terminals in operation (whilst another 150 can be treated as supplementary infrastructural transport nodes). The largest number of terminals are located in Germany (51), Sweden (32) and Poland (30). The smallest number of CT terminals are located in Estonia (two), Finland (four), Latvia and Lithuania (six). The terminals are mainly located close to international traffic routes of the TEN-T corridors, and not surprisingly, next to large urban agglomerations (TEN-T nodes). CT terminals located outside the TEN-T core network are mainly located on national trade routes. The preferred solution is to locate terminals at the intersection of urban road rings close to main railway lines. Lines often serve port terminals by connecting the largest North Sea and Baltic Sea ports. The analysis also shows that large urban agglomerations have several terminals – logistics centers and/or a network of sub-centers located closer to the final recipients of goods.

Moreover, the UIC analysis of combined transport in Europe shows that the Baltic Sea region includes many countries with a high rail share in the link between Central and Eastern European countries such as Western Europe. The largest traffic volume goes to Germany. However, some selected characteristics of the BSR's CT market are: (i.) various sea ports with growing volumes, (ii.) different track gauges (standard gauge 1,435 mm in Germany, Denmark, and Sweden, and 1,520 mm gauges in Estonia, Latvia, Lithuania, and Finland) and track/train compatibility, (iii.) semi-interoperability for the modal shift of semi-trailers electrification, (iv) and the rail share in total freight volume as well as the intermodal share in rail freight is very heterogenous among the Baltic Sea and EU countries. The conclusion from the reports is that especially the Central and Eastern European countries have a great potential to increase the share of intermodal transport. However, increasing intermodal transport is associated with higher investment needs in terminals (Bielenia et al., 2020; Bochynek et al., 2020; Wiśnicki, 2020).

The scope of action for the development of terminals in the Baltic Sea region relies on the major capabilities outlined above. Most challenging are measures and instruments to address the function of connectivity, interface, and buffer to increase the capacities and reliability (e.g., throughput congestions, service frequency) on the one hand, and with regards to energy and environment on the other hand (e.g., emissions reduction, reduction of other external effects). Common challenges that have been identified are, amongst others, congestions and infrastructure, organizational and process optimization as well as energy and sustainability (Rodrigue et al. 2017).

Figure 2 summarizes the different levels of interaction for seaport and inland terminals, which are guided by the most important capabilities and functions.

Figure 2 – Terminals – Scope of action



Source: Rodrigue et al. (2017); own elaboration.

Bottlenecks/Congestions and infrastructure

The terminal situation can change over time regarding technology, growth opportunities, and trade relations. The quality and efficiency of terminal connections define their competition potential (Biermann et al. 2015; Rodrigue et al. 2017). Although terminals serve as destinations, they are de-facto nodes for composition (first mile) and decomposition (last mile). Moreover, terminals are linked to the concept of centrality, the "origin" or the "end" of the traffic volume, or to the concept of intermediacy, acting as an intermediate node in the freight transport chain.

Studies preparing for infrastructure investments should include a demand forecast of intermodal transport services. The transport network in which the terminal will be located should be specified, i.e., whether it is an international, national, or local node. It is necessary to determine the economic potential of the terminal service area, i.e., the number of intermodal loading units (ILU) that can be generated by industry and habitants in the close and distant area of the terminal's road haul services. As a distant service area, Wiśnicki (2020) recommends that a freight truck travel time of up to 90 minutes to or from the terminal should be assumed as the maximum value. On short and medium distances from 100 up to 300 kilometers, other authors suggest road transport to be faster and more flexible than any other mode of transport (Carboni et al., 2018; Jahn et al. 2018; UIC, 2020).

Following the *Practical Guide for Combined Transport* (ERFA KV, 2020), infrastructure bottlenecks related to combined transport can be solved by different measures (i-vi):

- Use of 740-meter-long block trains (EU standard length)
- Introduction of trains with a total length of up to 1,500 meters
- Construction and expansion of rail connections
- Usage of trailer stacking and innovative handling technologies for non-craneable loading units
- Funding support to the expansion of state-owned rail infrastructure and transshipment terminals
- For the ports within the combined transport value chain, measures like excavating port accesses, acquiring bigger jib cranes, and enlarge the land for temporary container storage

Box 4

Sustainable Intermodal Transports Through Longer and Heavier Trucks
(by Anna Kristiansson and Thomas Asp)

Longer and/or heavier trucks, also known as High Capacity Transport (HCT) in combination with traffic modes such as shipping and rail are potentially beneficial for the society. Within the HCT program, hosted by the neutral collaboration logistics platform CLOSER in Sweden, there are ongoing investigations of societal implications of a large-scale introduction of HCT trucks in parts of the Swedish logistics system. The objective is to strengthen transport efficiency and competitiveness of combined transports and through this achieve improved cost efficiency, decreased environmental impact, and reduced number of vehicles on roads. In Sweden, HCT trucks, outside what is currently allowed, means longer than 25.25 meters and/or heavier than 74 ton.

HCT trucks place new demands on terminals such as adjusted docking stations and parking lots (waiting areas). These need to be designed so that longer trucks can drive through easily. Avoiding the need of reversing will decrease the shunting time and minimize the risk of injuries on equipment and people. Resting areas for the drivers, including toilets, close to the parking area are also important to improve working conditions. They should have the ability to rest and still be prepared to move on to a dedicated docking station with short notice. Another important aspect is access to trailer parking areas. For instance, the route might include road parts where HCT trucks are not allowed and thus being able to, for a short while, park a trailer, would be an excellent service at an intermodal hub. Preferably, this area should be gated.

Organizational and process optimization

From the terminal operators' point of view, the key factor is the development of horizontally linked global corporations (i.e., market reach) and vertically integrated corporations (i.e., control of transport chains). Current developments indicate a slowdown in global economic integration; nevertheless, the integration into global value chains will continue to grow.

Internal costs are costs that a business bases its price on. The faster terminals operate and the lower the operational costs are, the higher the competitiveness of the combined transport terminals (Hanssen et al. 2012, Ishfaq and Sox 2012; Jahn et al. 2020). The effectiveness of terminals determines the (operational) costs. The business-management selection of handling equipment should be realized on a multi-stage investment process. The handling capacity of the terminal should be increased together with the increased handling and storage needs. The most common procedure in market practice is a gradual terminal transition from the stage of primary handling by reach stackers, through introducing gantry cranes (RTG or RMG), up to the stage of implementing a wide spectrum of handling and transport services on several transshipment fronts. The latter stage is related to the cooperation of a terminal with one large or several smaller logistics centers, guaranteeing a sufficient cargo volume, i.e., at a level above 0,1 million TEU.

In addition to infrastructure investments, bottlenecks can also be countered with further operational optimization measures (UIC et al., 2007, FIS 2021):

- Use of interim storage areas, loading tracks and handling equipment, for example, allowing cost reductions in off-peak times
- Improvement of punctuality in the main run to reduce buffers and to raise capacities, respectively
- Efficient monitoring and automation of processes
- Implementation and adaptation of innovative information and communication systems to push, diversify, and prioritize terminal services

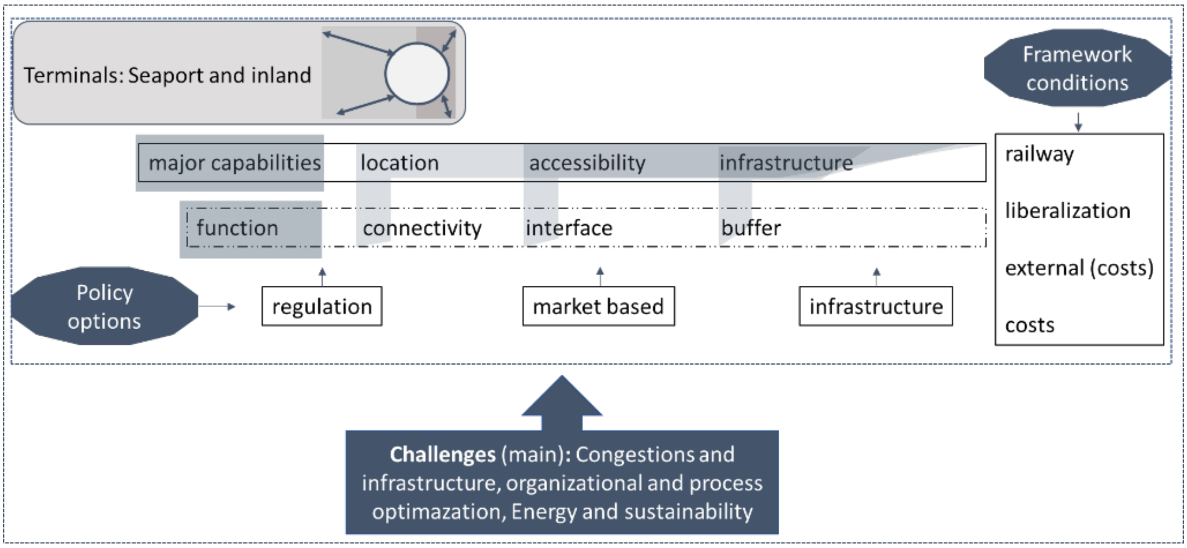
Energy and sustainability

Besides the financial costs, which we are referring to as internal costs, challenges also emerge from the impact of transportation activities on the environment (Jahn et al., 2020). Transportation tends to conflict with social and environmental conditions. Transport in general both affects and is affected by climate change, as it is responsible for a large share of the worldwide CO2 emissions of around 24% (Jahn et al., 2020; Rodrigue et al., 2017 Frémont and Franc 2010; Froese et al., 2019). Multimodal transport may have additional social benefits other than emission saving. It may reduce other forms of external costs from road freight such as land use, congestion, or noise. Thus, combined transport is likely to be less costly in terms of external costs (Jahn et al., 2020).

Moreover, new terminals should be managed and adapted to the automation of terminal processes, starting with appointment systems and inspections at the terminal gate up to selected transshipment operations. Conventional terminals will transform into fully automatic combined terminals, but technology is important for terminals that should offer their clients complex energy monitoring and carbon footprint tracking, i.e., monitoring of CO2 emissions.

Figure 3 summarizes the main challenges that affect seaport and inland terminals. The interfaces for political measures and instruments are to be set in the areas of (i.) Regulation, (ii.) Market-based solutions and (iii.) Infrastructure.

Figure 3 – Terminals – Scope of action and challenges (main)



Source: Rodrigue et al. (2017); own elaboration.

Measures and instruments in an implementation-effort model

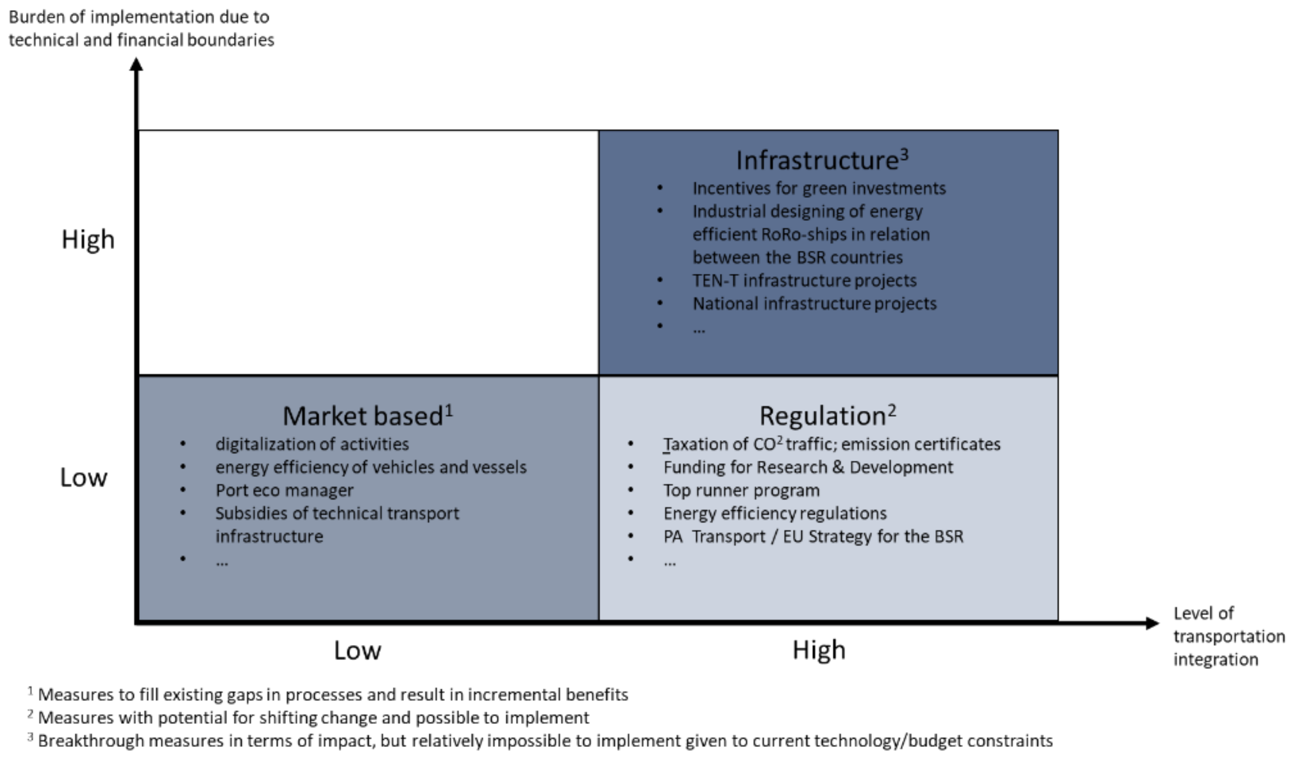
Summarizing the results, "positive" terminal projects can be simply classified along two dimensions: the "level of transportation integration" and the "burden of implementation due to technical and financial boundaries". These two dimensions form a two-by-two matrix that results in the following four groups of a "How-Now-Wow"-model (Przybyłek and Zakrzewski, 2018):

- Measures with a low "level of transportation integration" combined with a low "burden of implementation due to technical and financial boundaries" are labelled as "Marked based". They consist of process optimization (e.g., through digitization), increased measurement of environmental indicators, management problems, and enhanced efficiency. These are measures that, if applied, fill existing gaps in processes and result in incremental benefits.
- Second, measures with a high "level of transportation integration" potential but also a low "burden of implementation due to technical and financial boundaries" are classified as "Regulation". These are regulations as the taxation of CO^2, these are measures which are possible to implement by the give technology.
- Third, measures with a high "level of transportation integration" combined with a high "burden of implementation due to technical and financial boundaries" are labelled as "Infrastructure". Breakthrough measures in terms of impact, but highly impossible to implement due to current technology and/or high budget constraints are sorted here. An (visionary) example is the idea of a tube system ("hyper-loop") which could transport containers within ports or to transportation nodes in the hinterland (e.g., freight yards). Another idea in this categorization would be that, on the non-vessel side, all vehicles such as cranes or trucks switch from fossil fuels to electric engines.

- Finally, measures with a low "level of transportation integration" a high "burden of implementation due to technical and financial boundaries" are of small interest since they do not generate additional value for new concepts. Therefore, the measures are not considered further here.

In Figure 4, the results are combined with the above findings and the levels of the measures are summarized. It also becomes clear that the labeling addresses a certain temporal dimension and thus a ranking of the measures themselves. Results for the Baltic Sea region are highlighted within the matrices. However, the presentation of results is an ideal way of classifying measures for combined terminals. In a multi-dimensional diagram, it is also possible to integrate a time dimension. In that case, measures associated with "Regulation" would have to be characterized by a higher implementation effort (re-categorized in the top right).

Figure 4 – Measures and instruments for terminal development



Source: Przybyłek, A., & Zakrzewski, M. (2018); own elaboration.

3.3 Workshop output

In addition to this report, a workshop was organized and carried out in the scope of *Work Package 3, Group of Activities 3.3* of the EU-Interreg COMBINE project. Due to the ongoing COVID-19 pandemic, it was conducted as a virtual meeting via Zoom on 21st April 2021. The workshop was widely promoted both through the network of contacts of the Hamburg Institute of International Economics (HWWI) and by the COMBINE project partners. The participants included stakeholders from several fields of business, inter alia, associations and umbrella organizations, science and education, terminals, industry as well as regional and national ministries. A comprehensive overview of all registered participants can be found in the chapter *List of workshop participants* later in this report.

The aim of the workshop was, firstly, to further promote content on the improvement of terminal efficiency in Combined Transport generated within the COMBINE project as well as the general goal of the COMBINE project, namely strengthening Combined Transport in the Baltic Sea Region, to a wider audience. Moreover, another purpose of the workshop was to generate valuable information on how the performance of terminals is currently assessed by actual CT stakeholders and in which areas (i.e., political/legal framework conditions, infrastructure, technology, organization, and communication) the participants see need for action to improve the terminal performances in CT and to push forward interregional CT development in general.

In addition to introductory contents, the following methodologies were chosen as workshop format: an interactive survey (i) to evaluate the stakeholders' opinions on the present performance and integration of terminals in CT and (ii) to identify in which areas stakeholders see the most urgent need for action. Additionally, a policy discussion was carried out aimed at collecting suggestions and generating a wish list from the discussants on concrete measures in the aforementioned areas (iii), namely:

- Political/legal framework conditions: regulations associated with political decisions
- Infrastructure: fundamental facilities and basic physical systems of intermodal transport chain
- Technology: needs related to technical aspects within the intermodal transport chain
- Organization: needs regarding facilitation and speeding up of the transport flow within the intermodal transport chain
- Communication: needs related to communication between different actors of the intermodal transport chain

and assessing these in terms of their potential impact on CT and their time horizon for implementation (short to long term) (iv), thereby also taking up some results from the previously conducted interactive survey. In the following, the most valuable insights from the workshop will be presented and discussed.

First, in view of the obtained survey results, it can be mentioned that the workshop participants do not see significant differences in the performance and the overall integration into the transport chains of CT terminals within the BSR compared to the European level (see Table 6). This might be due to the generally interregional perspective of CT and the extensive cross-border freight transportation within Europe including the BSR.

Table 6 – Performance and transport chain integration of CT terminals, overall satisfaction with framework conditions (workshop survey results)

Criterion	Assessment level	Evaluable / total assessments	Average evaluation
CT terminal performance	EU	27 / 38	3.67
CT terminal performance	BSR	23 / 39	3.48
CT terminal integration	EU	30 / 38	3.37
CT terminal integration	BSR	27 / 40	3.37
CT framework conditions	EU and BSR	28 / 37	3.04

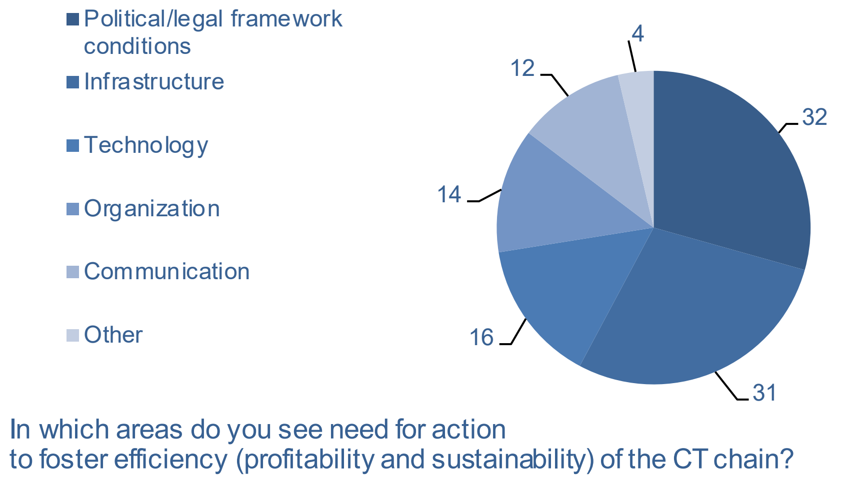
Assessment scale: 1 – not efficient/satisfactory, 2 – slightly efficient/satisfactory, 3 – somewhat efficient/satisfactory, 4 – moderately efficient/satisfactory, 5 – strongly efficient/satisfactory

Source: Interactive survey COMBINE workshop; own elaboration.

With respect to the satisfaction with the overall framework conditions for Combined Transport in the EU and the BSR, the opinions of participants who took part in the evaluation are inconclusive. While a considerable number of participants rated them as moderately satisfactory or higher (12), others regard them as not or only slightly satisfactory (nine). On balance, the average rating amounts to 3.04, thus showing neither a negative nor a positive trend (see Table 6).

Consequently, it is not surprising that need for action to improve the efficiency of CT is seen in various organizational and infrastructural areas. The workshop attendees saw the most urgent need for improvements in the areas *Political/legal framework conditions* and *Infrastructure* which accounted for 32 and 31 votes, respectively. The fields *Technology* (16 votes), *Organization* (14 votes) and *Communication* (12 votes) were not regarded as important as the former ones, but still relevant to foster efficiency of CT. Only four participants thought that improvements need to be made in fields not listed (see Figure 5). Based on this first evaluation of the participants' thoughts on the question in which fields action is mostly needed to strengthen CT in the BSR, the policy discussion was used to identify and assess a plethora of desired, specific measures in the different fields. The results of the policy discussion are presented in the following.

Figure 5 – Fields of action to strengthen CT (workshop survey results)



Source: Interactive survey COMBINE workshop; own elaboration.

In terms of improving the political and legal framework conditions for CT, the participants mentioned several changes and measures with a high expected impact on CT including short-term and long-term actions. Firstly, one mentioned urgent need to foster CT is to disincentivize road transportation. It was regarded as a measure that can be realized in a rather short-term perspective but will have a great positive impact on the CT market. Enhancing the attractiveness of CT by making the still dominant road transportation less attractive for customers, for example, by further raising the price of carbon dioxide emissions – where rail transport has a significant advantage over road transport – is likely to promote CT and a switch in the corresponding modal shares. Furthermore, three long-term measures were brought up in this field of action: a uniform regulation language, an increase in allowed gross weights, and a harmonization of national rules. Especially the latter two aspects are thought to have a very beneficial effect on CT. It was mentioned that there is still a lot to do in terms of solving issues associated with cross-border freight transportation which impede the attractiveness and use of CT in supranational trade. Consequently, the potential and benefits of CT, particularly in long-distance trade, cannot be exploited to the full. Improvements are ongoing, albeit slowly, but this harmonization process must be accelerated.

The improvement of CT infrastructure was also an essential topic that came up during the policy discussion. For many workshop participants it seems to be crucial to extend both the terminal and the rail network. Especially in the BSR, new terminals equipped with appropriate technologies, such as innovative horizontal handling equipment (e.g., CargoBeamer, Modalohr, MegaSwing and Flexiwaggon), must be built to create a dense terminal network which guarantees sophisticated transport links, comprehensive transshipment services for all intermodal loading units including semi-trailers, and good accessibility, shortening the distance covered by and reducing the costs of first and last mile transportation; thereby, increasing overall attractiveness of CT and cutting emissions. More trains need to be introduced and the rail network must be expanded to ensure tight schedules and to enhance reliability and punctuality of CT services; thus, addressing two current major drawbacks of CT compared to road transportation. It was mentioned by a participant from UIRR that punctuality and reliability of rail freight transportation increased considerably during the COVID-19 pandemic when the rail infrastructure was less utilized by passenger trains and higher rail capacities were available for freight transportation. This example, inter alia, clearly elucidates the urgent need for more rail tracks and an expansion of the rail network for freight transport. The expansion of CT infrastructure (terminals, rail corridors) was judged to be a rather long-term measure with a large positive impact on the CT market. Moreover, it was mentioned that also the service infrastructure must be improved to increase competitiveness of CT. This was regarded as a short-term measure which, nevertheless, would have a great positive effect on CT. As an example, it was mentioned that the offer of better On-/Pre-Carriage services would improve competitiveness and attractiveness of CT for customers.

In the field of organization of CT, the workshop participants also mentioned several measures to foster efficiency of CT. In the short term, night transport windows (which can be seen as a period of less frequent passenger transportation) could be better utilized, and existing capacities could be used more efficiently. This shows that CT stakeholders are aware of the need to improve the general organization of CT chains and the corresponding schedules and maximize the gains from the existing infrastructure, instead of simply expanding CT and rail infrastructure as mentioned in the previous paragraph. Through better communication among stakeholders of freight transportation and a harmonization with passenger transportation, reliability and punctuality of CT might also be improved. However, the positive impact of these two measures was only assessed as low to medium. In addition, the introduction of an international train driver’s license was mentioned as a very impactful need, albeit one that is seen as only feasible in the long term, as it is likely to significantly reduce problems associated with cross-border rail freight traffic and simplify long distance CT. Moreover, it was claimed that road transport is often more readily accessible to customers compared to CT or rail transportation. Therefore, removing the barriers for market entry for freight customers and stakeholders by enhancing the transparency of information on available CT opportunities and services is regarded as a long-term measure to considerably raise the potential of CT.

Regarding the action field *Communication*, two medium-term measures with a medium to large positive impact on the CT market were mentioned. Firstly, the transparency of CT chains and processes should be enhanced by establishing a standardized prediction model for the estimated time of arrival and data related to the entire transport process must be transmitted to the customer in a more accurate and up-to-date manner to further improve the transparency of the transportation process and thus enhance predictability for the customers and the general attractiveness of CT. Secondly, digitalization is also regarded as an essential and impactful measure to foster CT, even though this was not further specified. As already mentioned in subsection 2.2 of this report, the implementation of digitalization technologies will be of invaluable importance for enhancing efficiency of CT in the future, as it will undoubtedly contribute to a better processing and analysis of information which will lead to better decisions and a more efficient utilization of the existing infrastructure during all processes in the entire CT chain (including terminals).

The action field *Technology* played a subordinate role in the workshop's policy discussion. It has been mentioned that the technological solutions already exist. However, it is not only about the existence of appropriate technologies such as innovative horizontal and vertical handling technologies to enhance the efficiency of CT terminals, but about their adequate and effective practical use. Therefore, valuable technological solutions that can significantly improve terminal efficiency (or processes in other stages of the CT chain) must be widely recognized and extensively promoted (and maybe subsidized) to ensure their actual application. For example, the benchmark analysis showed that innovative horizontal and vertical handling technologies are not yet commonly applied in European terminals.

The portfolio diagram including and visualizing the entire set of suggestions and evaluations of measures provided by the participants during the workshop can be found in the appendix of this report (Appendix 1).

4 Conclusion

The combined terminal strategy at hand gives insights into a strategic approach to push forward the interregional CT development within the European Union and the Baltic Sea region. The results were presented and discussed in a workshop and requirements for action were formulated.

The COMBINE project aims to improve combined transport (CT) in the Baltic Sea Region (BSR) and to make freight transport more efficient and environmentally friendly. This paper gives an initial overview of the CT with a focus on the terminals and tries to develop policy measures at the level of the EU and the Baltic Sea. The discussed and presented measures are seen as strategic for further development to ensure the positioning of a sustainable and efficient CT landscape. The measures follow a comprehensive approach to strengthen terminal development.

All parts of the transport chain (first leg, main leg, last mile, and all involved terminal handling processes) need to be improved not only in the Baltic Sea region, but across Europe. New technologies regarding these different parts of the transport chain as well as modern and efficient transport organization are opportunities for transportation development. It is vital to use the benefits of the CT transport mode and to optimize where appropriate.

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LIST OF WORKSHOP PARTICIPANTS

In 2021, April 21 a workshop took place. The results of the COMBINE project were discussed with representatives of regional and national authorities, terminals and umbrella organizations as well as the COMBINE network. The results were incorporated into the conclusion. A list of participants can be found below.

Name	Organization
Dr. Jan Wedemeier	Hamburg Institute of International Economics (HWWI)
Dr. André Wolf	Hamburg Institute of International Economics (HWWI)
Jan-Niklas Müller	Hamburg Institute of International Economics (HWWI)
Elzbieta Hagemann	Hamburg Institute of International Economics (HWWI)
Melanie Mesloh	Hamburg Institute of International Economics (HWWI)
Antje Falk	Baltic Rail Gate GmbH
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Dr. Frederic v. Paepcke	CargoBeamer AG
Harri Vitikka	Centre for Economic Development, Transport and Environment Finland (ELY-keskus)
Katarzyna Napierała	City of Bydgoszcz
Mateusz Mazurkiewicz	City of Bydgoszcz
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Giulia Grassi	City University of Applied Science Bremen
Arpan Kalotha	City University of Applied Science Bremen
Prof. Dr. Hans-Martin Niemeier	City University of Applied Science Bremen
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Henrik Tornblad	Danish Transport, Construction and Housing Authority
Jakob Størling	Danske Speditører
Piotr Śmierzchała	Deutsche Binnenreederei AG
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Paweł Bukowski	Emilianowo Intermodal Terminal
Achim Klukas	Fraunhofer IML
Klaus G. Andersen	Fredericia Shipping
Amalie Laigaard Andersen	Fredericia Shipping

Tilman Benzing	German Chemical Industry Association (VCI)
Vivin Kumar Sudhakar	German Research Association for Combined Transport (SGKV)
Can Dincer	German Research Association for Combined Transport (SGKV)
Thomas Brügmann	Gesamthafenbetriebs-Gesellschaft mbH (GHB)
Dr. Jürgen Hogefoster	Hanse-Parlament
Thorben Lohse	HOYER Group
Sascha Altenau	Hupac GmbH
Simone Croci Torti	Hupac Group
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Eva Kampe	Port of Kiel
Mailin Heins	Ramboll Germany GmbH
Dino Keljalic	Region Örebro County
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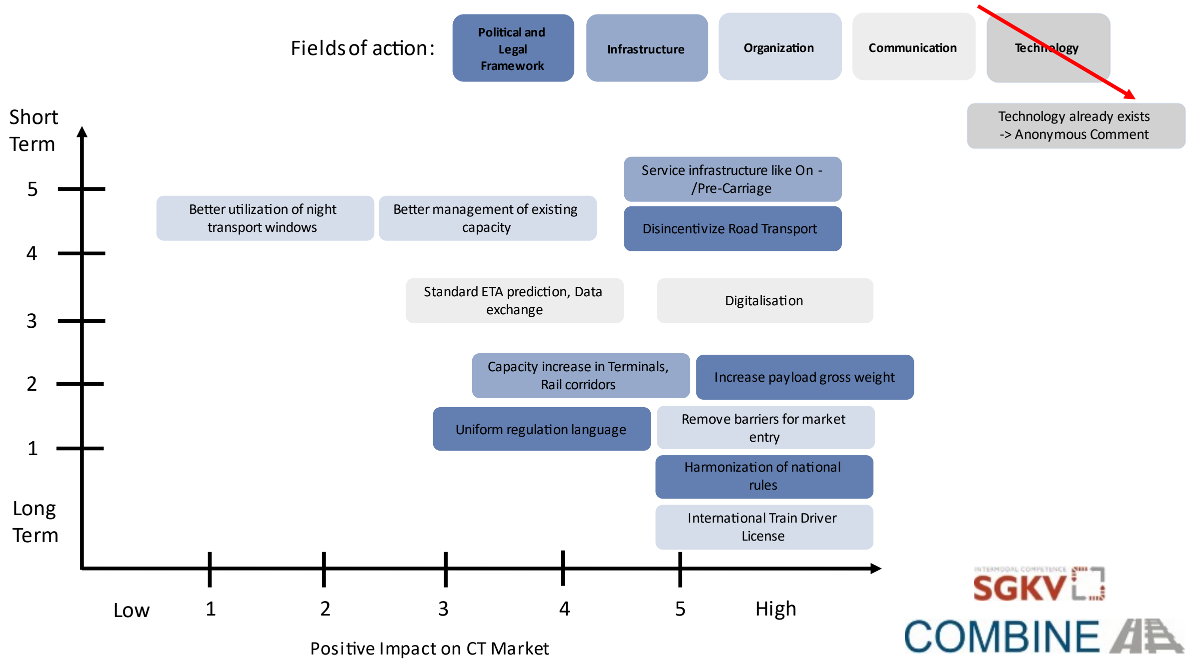
Marcin Karwasz	UTP University of Technology and Life Sciences in Bydgoszcz

LIST OF ABBREVIATIONS

BSR	Baltic Sea Region
CT	Combined Transport
EC	European Commission
EEA	European Environment Agency
EP	European Parliament
FCL	Full Container Load
GHG	Greenhouse Gas
ILU	Intermodal Loading Unit
ISU	Innovative Transshipment of Semi-Trailers (ger.: Innovativer Sattelanhänger-Umschlag)
LCL	Less-Than-Container-Load
LU	Loading Unit
RMG	Rail Mounted Gantry crane
RS	Reach stacker
RTG	Rubber Tyred Gantry crane
SGKV	German Research Association for Combined Transport (ger.: Studiengesellschaft für den Kombinierten Verkehr e.V.)
TEU	Twenty-foot Equivalent Unit
UIC	International Union of Railways (fre.: Union internationale des chemins de fer)
UIRR	International Union for Road-Rail Combined Transport (fre.: Union internationale des sociétés de transport combiné Rail-Route)

APPENDIX

Appendix 1. Portfolio Diagram of entire set of suggestions and evaluations of measures to push forward interregional CT development provided by workshop participants.



Source: Combine Workshop, SGKV, own elaboration.