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Ernest Czermański

E-book on Combined Transport in the Baltic Sea Region

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Gdańsk 2021

University of Gdansk, Department of Maritime Transport and Seaborne Trade Press

ISBN 978-83-7939-023-6

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Praca naukowa opublikowana w ramach projektu międzynarodowego współfinansowanego ze środków programu Ministra Nauki i Szkolnictwa Wyższego pn. "PWM" w latach 2014 – 2020; umowanr 5121/INTERREG BSR/2020/2.

Research work published in the framework of the international co-financed project by the funds of the programme of the Polish Ministry of Science and Higher Education entitled "PWM" 2014 – 2020; Agreement No. 5152/INTERREG BSR/2020/2.

Project co-financed by the European Regional Development Fund in the framework of the COMBINE Project, Interreg Baltic Sea Region 2014 – 2020 contract no. #R099. Deliverable of the Work Package 3, Acitvity 3.2 of the COMBINE Project.

Content

Introduction

Freight transport is responsible for around 25% of the European Union's (EU) greenhouse gas emissions, making it the second largest emitting sector after energy. Significant reductions in emissions are needed to achieve long term climate goals in the EU with projections showing an increase in the total freight transport activity of about 58% (1.2% p.a.) between 2010 and 2050.

Many efforts to achieve a modal shift have already been taken in recent history. The most promising market segment is combined transport (CT). However, even in this segment, the focus has always been on the "racetracks" with large point to point volumes, such as block trains in the rail sector and inland shipping services on the Rhine and Danube. In the Baltic Sea Region (BSR) countries CT still plays a minor role in the transport system.

To change this situation, nearly 30 partners from ten countries in the BSR have joined forces in the COMBINE project. With support from the Interreg Baltic Sea Region program, various ministries of transport, lobby organizations, and industry partners, the project has developed strategies, initiated promotion campaigns to strengthen CT, and tested new solutions and services in pilot demonstrations.

COMBINE's aim of achieving a modal shift towards ship and rail was achieved. Pilot activities in the project have proven the feasibility of CT solutions, even though it is in many cases not yet on the table, or mind-set, of relevant stakeholders.

For further development of CT and implementation of new technologies (and thus investments into CT infrastructure) this would be an important starting point. COMBINE attempted to increase knowledge about CT among relevant stakeholders by raising awareness through the political sector by demonstrating the benefits of CT and its significance—disclosing developmental aspects for CT financial need and support .

As a response to stakeholder involvement, the COMBINE partnership has developed this CT e-book to describe all CT-related issues in the BSR, e.g., terminals with their service portfolio, operators, and other stakeholders. Most important rules and regulations as well as the most promising last mile solutions and handling technologies have been looked at in a BSR-centric manner. The use of the e-book should make it easier for CT organization and development.

1. Definitions of combined transport

Intermodal transport has evolved through the convergence of different "transport worlds"—some of which have been ideologically separated for a long time. These worlds have developed their own jargon, and this makes communication between them more difficult. A crucial condition for the acceptance and success of intermodal transport is that communication is as smooth as possible since system-based cooperation is required. The aim of this chapter is an attempt to harmonize the different jargons so as to ensure complete understanding of intermodal transport within the context of COMBINE. Properly defining and adopting terms is essential to the success of the project itself. The research activities on terminology have been focused on three terms: (1) combined and intermodal transport, (2) intermodal loading unit, and (3) terminal. For each term, an analysis using the regulatory framework from EU Directives, various international glossary-based sources, and best practices from industry associations is applied.

1.1. Combined and intermodal transport

In Europe, different EU Directives integrate an official definition of CT or Intermodal Transport, i.e., (1) Directive 92/106 on the establishment of common rules for certain types of CT of goods between Member States, and (2) Directive 719/2015 laying down for certain road vehicles circulating within the Community the maximum authorized dimensions in national and international traffic and the maximum authorized weights in international traffic.

1.1.1. Directive 92/106

For the purpose of this Directive, "**combined transport**" means the transport of goods between Member States where the lorry, trailer, or semi-trailer with or without tractor unit, swap body, or container of 20 feet or more uses the road on the initial or final leg of the journey and, on the other leg, rail or inland waterway or maritime services where this section exceeds 100 km as the crow flies and make the initial or final road transport leg of the journey:

- between the point where the goods are loaded and the nearest suitable rail loading station for the initial leg, and between the nearest suitable rail unloading station and the point where the goods are unloaded for the final leg; or
- within a radius not exceeding 150 km as the crow flies from the inland waterway port or seaport of loading or unloading.

In November 2017, the College of Commissioners adopted a proposal of the Commission to revise Directive 92/106 concerning CT. Some core articles have been edited such as Article 1 in terms of its definition as well as new articles that have been drafted. However, in December 2019, the new Commission, under the supervision of the new President of the European Commission, Ursula von der Leyen, released the so-called "European Green Deal" which aims at improving the well-being of people by making Europe climate-neutral and protecting Europe's natural habitat. The related roadmap contains an action regarding a revised proposal for a Directive on CT to be released in 2021. By the adoption of this action, the previous proposal of the Commission is no longer a topical issue and has been abandoned.

1.1.2. Directive 719/2015

For the purpose of this Directive, "**intermodal transport operation**" will mean:

I. CT operations defined in Article 1 of Council Directive 92/106/EEC engaged in the transport of one or more containers or swap bodies, up to a total maximum length of 45 feet; or
II. transport operations engaged in the transport of one or more containers or swap bodies, up to a total maximum length of 45 feet, using waterborne transport, provided that the length of the initial or the final road leg does not exceed 150 km in the territory of the Union. The distance of 150 km referred to above may be exceeded in order to reach the nearest suitable transport terminal for the envisaged service in the case of:
    a) vehicles complying with point 2.2.2(a) or (b) of Annex I; or
    b) vehicles complying with point 2.2.2(c) or (d) of Annex I, in cases where such distances are permitted in the relevant Member State.

For intermodal transport operations, the nearest suitable transport terminal providing a service may be located in a Member State other than the Member State in which the shipment was loaded or unloaded.

Definitions on CT has been also collected from official glossaries such as the United Nations Economic Commission for Europe (UNECE) terminology on CT, EUROSTAT, and the terminology catalogues developed by industry associations (i.e., within Europe and worldwide).

Terminology on CT—In 2001, UNECE, the European Conference of Ministers of Transport, and the European Commission published a catalogue of principal terms used in CT (or closely related to it).

- Intermodal transport: defined as the movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport without handling the goods themselves in changing modes
- CT: an intermodal transport where the major part of the European journey is by rail, inland waterway, or sea and any initial and/or final legs carried out by road are as short as possible

Glossary for transport statistics, 5th Edition, 2019—The glossary comprises of 744 definitions and represents a point of reference for all those involved in transport statistics. In this edition, the rail, road, inland waterways, maritime, air, and intermodal freight transport chapters have been substantially revised. The intermodal definitions in each transport mode were removed from all chapters and inserted into the updated Intermodal Freight Transport chapter.

- Multimodal freight transport is a transport of goods by at least two different modes of transport
- Intermodal freight transport is a multimodal transport of goods, in one and the same intermodal transport unit by successive modes of transport without handling of the goods themselves when changing modes
- CT: no specific definition

IANA—Intermodal Glossary, 2017–IANA is the industry trade association representing the combined interests of the intermodal freight industry. IANA promotes the growth of efficient intermodal freight transportation through innovation, education, and dialogue. In 2017, IANA published an intermodal glossary.

- Intermodal transport is the movement of freight, in a container or on a trailer, by more than one mode of transportation. The movement can be made from rail to truck to ship in any order; and
- CT: no specific definition.

1.2. Intermodal loading and transport unit

In the EU legal framework (see Section 1.2.1), the terms "**intermodal loading unit**" (ILU), or "intermodal transport unit" (ITU), are not fully defined but in that they are identified by the types of units: semi-trailer, trailer, swap body, container, and road vehicle. The Commission proposed a Directive on ILUs in 2003 which was at the end revoked. In this prior proposal, ILUs were defined as either a container or a swap body.

In contrast, official glossaries (i.e., UNECE and EUROSTAT), industry standards (i.e., CEN), and European projects (e.g., COSMOS) have compiled a complete set of definitions related to the equipment transported in CT.

UNECE glossary, 2001

- Loading unit: container or swap body

- Intermodal transport unit: containers, swap bodies, and semi-trailers suitable for intermodal transport

Glossary for transport statistics, 5th Edition, 2019

- Loading unit: container or swap body
- Intermodal transport unit: container, swap body, or semi-trailer/goods road motor vehicle suitable for intermodal transport

EN 13044–Intermodal Loading Units–Marking, Part 1: Markings for identification, 2017

- Intermodal loading unit: loading unit suitable for European intermodal transport on road, rail, inland waterway, and sea, which is not an ISO-container according to ISO 830 (among others swap body, semi-trailer)

COSMOS–Marco Polo project, 2014

- Intermodal loading unit: ISO Container (i.e., freight container, according to ISO 668, 1161), standardized inland container (e.g., bulk, silo, and tank), swap body (i.e., according DIN-EN 284, 452), and semi-trailer

1.3. Terminal

The term "terminal" is used in CT operations but might cover a lot of different notions and concepts that are not similar such as hub, freight terminals, intermodal terminal, freight hubs, logistic centers, freight villages, and CT terminal.

The notion of terminal has been recently inserted in European legislative environment: (1) Directive 2012/34, (2) Implementing Regulation 2017/2177, (3) Rail Freight Corridor Regulation, and (4) TEN-T Regulation. Moreover, official legal texts, glossaries, and standards have also created definitions related to the handling of intermodal loading units (i.e., UNECE, IANA, and EUROSTAT). Table 1.1 displays all relevant identified definitions related to the terminal.

Table 1.1. An overview of existing definitions related to the CT terminals with regard to their legal sources.

Notion	Source	Definition
Terminal	UN/ECE terminology	A place equipped for the transshipment and storage of ITUs
Freight terminal	Directive 2012/34	Listed without definition
(Freight) Terminal	Implementing Regulation 2017/2177	Mentioned without definition

Freight terminals in 4 subcategories Intermodal terminals Multifunctional rail terminals Public sidings Private sidings	EU Study on European portal for all rail service facilities (related to Regulation 2017/2177)	"Intermodal terminal" means an installation for transshipment of standardized loading units (i.e., containers, swap bodies, and semi-trailers) with at least one of the modes served must be rail or inland waterway
Terminal Intermodal freight terminal	Rail Freight Corridor Regulation 913/2010	"Terminal" means the installation provided along the freight corridor which has been specially arranged to allow either the loading and/or the unloading of goods onto/from freight trains, and the integration of rail freight services with road, maritime, river and air services, and either the forming or modification of the composition of freight trains; and, where necessary, performing border procedures at borders with European third countries
Terminals freight terminal	Regulation 1315/2013: TEN-T Guidelines	"Freight terminal" means a structure equipped for transshipment between at least two transport modes or between two different rail systems, and for temporary storage of freight, such as ports, inland ports, airports, and rail-road terminals
Intermodal transport terminal	EUROSTAT Transport Statistics (glossary)	A structure equipped for the transshipment and storage of ITUs between at least two transport modes or between two different rail systems, and for temporary storage of freight, such as ports, inland ports, airports, and rail-road terminals.
Intermodal terminal	IANA Intermodal Glossary	A facility designed for the loading and unloading of containers and trailers to and from flatcars for movement on the railroad and subsequent movement on the street, sea or highway

Source: UIRR data, 2021.

1.4. Selection and recommendations for a BSR definition

For the purpose of the project, the COMBINE consortium partners have selected the following definitions:

- Multimodal transport / intermodal transport / CT: the current definition of the UNECE glossary without modifications (Figure 1.1).
- Intermodal loading units: containers, swap bodies and semi-trailers suitable for CT. This is a mix of current definitions on intermodal transport units and

intermodal loading units. Road vehicles are considered, in the context of COMBINE, as ILUs as well.

- Intermodal terminal: an installation for transshipment of standardized loading units (containers, swap bodies, semi-trailers) with at least one of the modes served must be rail or inland waterway

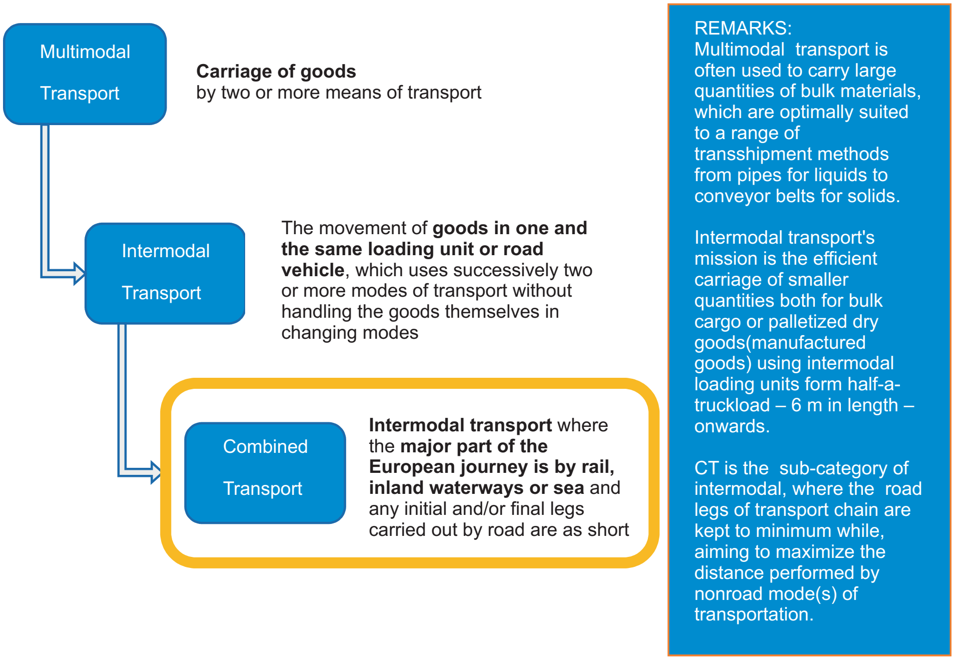


Figure 1.1. Scheme for definitions of multimodal/intermodal and CT correlations.

Source: based on Terminology on CT, UN/ECE, 2001.

For a specific BSR definition, it is recommended to promote a coherent and harmonized definition at the European level (i.e., through the revision process that will be soon started by the Commission). This definition should consider the following elements:

a) The type of legislation: Directive or Regulation
b) CT and/or intermodal transport
c) The exact scope (i.e., cross border and domestic)
d) All forms of CT should be included.
e) All types of loading units should be integrated including the minimum size.
f) The notion of "nearest suitable terminal" should be further explicated
g) Determine the distance for the road legs with various cases (i.e., hinterland maritime, continental)
h) Special clause for road-rail transport when exceeding distances

i) Temporary measures
j) Special clause for terminals
k) Greening aspects (i.e., use of alternative fuels for road legs and non-road legs)

2. Legal aspects of combined transport

2.1. Legal basis of combined transport

2.1.1. Codification system

CT deals with the conveyance of ILUs by road, rail, inland waterways, and short sea shipping. The dimensions of most ILUs (i.e., semi-trailers, swap bodies, and roller units) are optimized for road transport and, when they are forwarded on wagons, in a relevant number of cases, their upper sections may exceed the standard loading gauge in terms of height in several European Member States. The most common solution in this case is to use and apply the procedures for exceptional consignments according to UIC Leaflet 502-1. The nature of this procedure is cumbersome as it obliges the railway undertakings to obtain specific authorization from all the involved infrastructure managers and to check the size of the ILUs when loaded on the wagons to ensure that they do not exceed authorized dimensions.

The codification system as per International Railway Solution (IRS)–IRS 50596-6 was established by UIC in collaboration with UIRR to facilitate and speed up the conveyance of ILUs in a reliable manner, even when their upper dimensions exceed those compatible with the loading gauge of the line (Figure 2.1).

The codification system as defined in IRS 50596-6 has been applied for several decades by various RUs and IMs in the CT chain and ensures safe operations of ILUs loaded on compatible wagons when transported on codified routes lines. IRS 50596-6 provides the system requirements for the allocation of the compatibility code and the correction digits to the wagons, the codification of the ILUs, the codification of the lines, the verification of the compatibility between ILU's and carrier wagons, and the assessment of the compatibility between ILU's conveyed on suitable wagons and the lines.

2.1.2. Interoperability Directive and TSIs

Between 2001 and 2016, four legislative packages (known as "railway package") were adopted with the aim of gradually opening up rail transport service markets

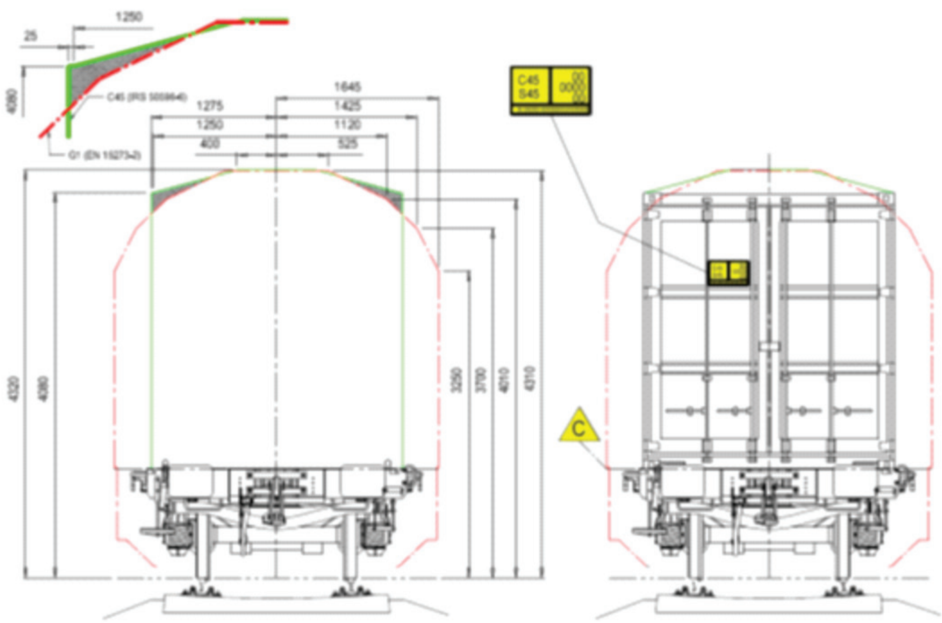


Figure 2.1. Dimensions of loading gauge and ILU.

Source: UIRR data, 2021.

for competition, making national railway systems interoperable and defining appropriate framework conditions for the development of a single European railway area. These include charging and capacity allocation rules, common provisions on licensing of railway undertakings and train driver certification, safety and interoperability requirements, the creation of the European Agency for railways, and rail regulatory bodies in each Member State as well as rail passenger rights.

Interoperability aims at the suitability of the trans-European safe rail system and continuous train service. This suitability is based on the entire regulatory, technical, and operational conditions to meet the essential requirements from the interoperability guidelines. The Interoperability Directive (i.e., revised and adopted in the context of the fourth railway package in 2015) aims to overcome the historic, peace meal creation of national railway systems with their diverse solutions to similar problems.

In the context of the railway packages, the railway Interoperability Directive 2008/57/EC of 17 June 2008 sets out the conditions to be met to achieve interoperability within the Union rail system. The Technical Specifications for Interoperability (TSI) define the technical and operational standards which must be met by each subsystem or part of subsystem in order to meet the essential requirements and ensure the interoperability of the railway system of the European Union. More than 11 TSIs have been adopted and are regularly reviewed under the coordination of the European Union Agency for Railways. The most relevant for CT operations are:

1) Freight wagon concerns the rolling stock subsystem and applies to freight wagons including vehicles designed to carry lorries;
2) Noise TSI sets out the optimal level of harmonization related to specifications on the rolling stock subsystem intended to limit the noise emission of the railway system of the EU;
3) Operation and traffic management TSI applying to the operation and traffic management subsystem of infrastructure managers and railway undertakings related to the operation of trains on the rail system of the EU; and
4) Telematics applications for freight services TSI applying to applications for freight services, including information systems, marshalling and allocation systems, reservation, payment and invoicing systems, management of connections with other modes of transport and production of electronic accompanying documents.

2.1.3. Weights and dimensions

In Europe, heavy goods vehicles, buses, and coaches must comply with certain rules on weights and dimensions for road safety reasons and to avoid damaging roads, bridges, and tunnels. Directive (EU) 2015/719 sets maximum dimensions and weights for international traffic, also ensuring that Member States cannot restrict the circulation of vehicles which comply with these limits from performing international transport operations within their territories. The Directive also aims at avoiding that national operators benefit from undue advantages over their competitors from other Member States when performing national transport. These rules are complemented by the requirements for type-approval of commercial vehicles laid out in Regulation 2018/858 which sets the framework for putting vehicles such as light-duty and heavy-duty vehicles, buses, and trailers on the market (Table 2.1).

The two legal documents include some CT-specific components:

- The maximum admissible mass for road and intermodal operations as specified in Annex 1 (see summary table);
- The maximum length may be exceeded by 15 cm for vehicles or vehicle combinations engaged in the transport of 45-foot containers or 45-foot swap bodies, empty or loaded, when integrated in an intermodal operation; and
- The use of aerodynamic devices shall be compatible with intermodal transport operations and in particular when retracted/folder they shall not exceed the maximum authorized length by more than 20 cm. The detailed technical requirements for intermodal are set in the Regulation 2018/858.

2.1.4. General terms and conditions

To facilitate the operations in CT, general terms and conditions should govern the relationship between a CT operator and its customer (i.e., entity which gives the order to transport the unit). This document should define the rights, obligation, and

Table 2.1. Vehicle combinations

Vehicle combinations	Weights
Road trains with five or six axles (a) two-axle motor vehicle with three-axle trailer (b) three-axle motor vehicle with two or three-axle trailer Road trains with four axles consisting of a two-axle motor vehicle and a two-axle Trailer	 40 tonnes 40 tonnes 36 tonnes
Articulated vehicles with five or six axles (a) two-axle motor vehicle with three-axle semi-trailer	 40 tonnes
(b) three-axle motor vehicle with two or three-axle semi-trailer	40 tonnes
(c) two-axle motor vehicle with three-axle semi-trailer carrying, in intermodal transport operations, one or more containers or swap bodies, up to a total maximum length of 45 feet	42 tonnes (modified)
(d) three-axle motor vehicle with two- or three-axle semi-trailer carrying, in intermodal transport operations, one or more containers or swap bodies, up to a total maximum length of 45 feet	44 tonnes (new)

Source: UIRR data, 2021.

liabilities of each party, the effects on the contract conclusion and its end, special clauses for specific types of products (such as dangerous goods), the payment conditions, and the terms of indemnity.

2.1.5. Standardization

The stakeholders involved in the CT have to deal with several operational and technical standards (i.e., TSIs, EN, UIC IRS, and ISO) that (1) define the design and testing requirements for the ILUs and of their constituents, and (2) fix the condition for the operational compatibility of the ILUs with the means used for their conveyance in the different transport modes (i.e., trucks, wagons, and ships) and in the terminals for their transshipment (Figure 2.2).

CEN, the European Committee for Standardization, is an association that brings together the national standardization bodies of 34 European countries. It is one of three European standardization organizations (i.e., together with CENELEC and ETSI) that has been officially recognized by the EU and the European Free Trade Association as being responsible for developing and defining voluntary standards at European level. The CEN Technical Committee 119 (i.e., ILUs and cargo securing) is responsible for all European standards related to the ILUs designed for intermodal transport and for test methods for cargo securing (i.e., 20 standards in total). For operations, the most relevant EN standard is the EN 13044 for the markings to be used in CT operations:

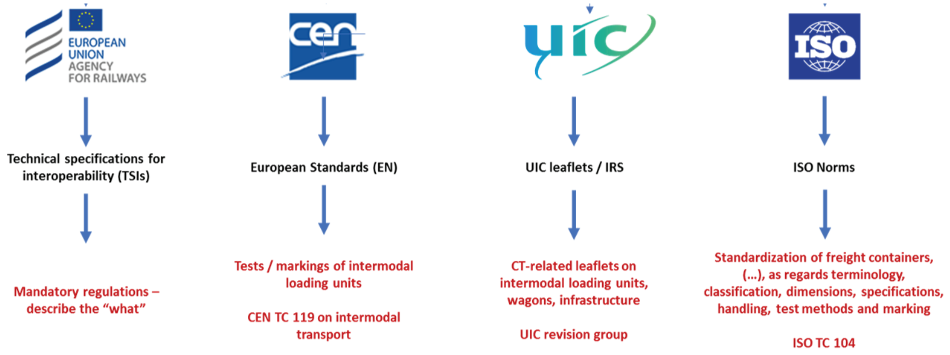


Figure. 2.2. Operational and technical standards

Source: UIRR data, 2021.

Part 1 of the standard defines the structure of the ILU identification code (i.e., 4 digits for the owner, 6 digits for the unit registration, and 1 digit for the control digit) known as the ILU-Code. UIRR is officially the Administrator of the ILU-Code since July 2011. More than 1,000 owner-keys have been reserved and all relevant information can be found under www.ilu-code.eu (Table 2.2).

Part 2 and 3 define the codification plates necessary for the swap bodies and semi-trailers. These operational markings are essential for train departure controls in order to ensure compatibility between ILUs, wagons, and selected lines.

Table 2.2. ILU Code.

ILU Code		
Owner code Assigned by UIRR or BIC	Registration number Allocated by the owner	Calculated check digit (see BIC code)
IMVE	042014	1

Source: www.ilu-code.eu.

ISO, International Organization for Standardization, is an independent, non-governmental international organization with a membership of 165 national standards bodies. Through its members, it brings together experts to share knowledge and develop voluntary, consensus-based, market relevant international standards that support innovation and provide solutions to global challenges. The ISO standards are classified according to an international coding system that is published in the International Classification for Standards. All activities are performed in Technical Committees (TCs). The ISO/TC 104 (i.e., freight containers) deal with the standardization of freight containers having an external volume of one cubic meter (35.3 cubic feet) and greater, as regards terminology, classification, dimensions, specifications, handling, test methods, and marking. The ISO/TC 104 is structured in 3 sub-committees responsible for more than 40 ISO standards.

UIC, Union Internationale des Chemins de Fer, the worldwide professional association representing the railway sector and promoting rail transport prepares and maintains the IRS which blends together a range of voluntary solutions to support the design, construction, operation, and maintenance of the railway system and the services that the sector provides. The UIC Expert Group for freight related Items (SET 03) is responsible for the maintenance and review cycles of all relevant technical and operational specificities of CT (lines, intermodal loading units, wagons, and loading guidelines).

2.2. Infrastructure-related aspects

Road-rail-road CT requires infrastructure: road links from industrial sites to the terminals CT terminals connecting first and last rail lines to the long-distance network, another terminal in the destination region and road links there as well. The European rail infrastructure is not a single homogeneous network, but instead is composed of different national railway systems with very varied technical standards, most notably at the level of the infrastructure itself, of the electrical power supply system, and of the system of safety and control. The present chapter summarizes the key reference documents and initiatives for the development of an integrated single railway area.

2.2.1. AGTC

The United Nations Economic Commission for Europe has for decades, even in the difficult times before the fall of the iron curtain, done substantial efforts to reach and extend a "European Agreement on Main International Railway Lines" and "European Agreement on Important International Combined Transport Lines and Related Installations" (AGTC)[1], defining common standards and parameter (Table 2.3). The agreement entered into force in 1989 and currently has 30 countries signed up to it. With the extension of the EU and for the creation of a European railway market it is even more important to follow and accelerate this approach, i.e., the implementation and harmonization of technical infrastructure parameters Europe-wide–relevant to the AGTC structure.

Table 2.3. Technical infrastructure parameters

Minimum standards	At present	Target values
Nominal minimum speed	100 km/h	120 km/h
Length of train	600 m	750 m
Weight of train	1 200 tonnes	1 500 tonnes
Axle load (wagons)	20 tonnes	20 tonnes (22.5 tonnes at a speed of 100 km/h)

Source: UIRR.

[1] See https://unece.org/DAM/trans/conventn/agtce.pdf

2.2.2. Trans-European Transport Network (TEN-T)

The Trans-European Network (TEN) is an EU-defined high-level transport network and instrument for the standardization of transport systems. In the long term, cross-border connections are to be improved, weak links are to be national networks, and connecting peripheral regions and combining and interconnecting the different modes of transport through better interoperability. TEN is an umbrella term which summarizes the activities of the EU in the areas of the transport infrastructure (i.e., TEN-T), the telecommunications infrastructure, (i.e., eTEN), and energy infrastructure (i.e., TEN-Energy).

TEN-T policy aims to implement and develop a Europe-wide network of railways, roads, inland waterways, maritime routes, ports, airports, and rail-road (i.e., intermodal) terminals. The objective is to close gaps, remove bottlenecks, and technical barriers as well as strengthen social, economic, and territorial cohesion in the EU.

The current TEN-T policy is based on Regulation (EU) No 1315/2013. For TEN-T, the EU Commission envisages two network layers:

I. Core network which includes most of the important connections, linking the most important nodes, with the goal of being completed by 2030; and
II. Comprehensive network which covers all European regions with the goal of being completed by 2050.

The railway infrastructure requirements for the core network are described as follows: (1) full electrification of the line tracks with as much siding as needed, (2) at least 22,5 t axle load, 100 km/h line speed, and the possibility of running trains with a length of 740 m, (3) full deployment of ERTMS, and (4) a nominal track gauge for new railway lines of 1,435 mm (Figure 2.3).

The freight terminals and their respective first and last mile connections are listed as components of the railway infrastructure and are also connected with road infrastructure as part of the comprehensive network. They partake as nodes of the TEN-T core network if their annual transshipment of freight exceeds 800,000 tonnes for non-bulk cargo and 0.1% of the corresponding total annual cargo volume is handled. Terminals shall be equipped with cranes, conveyors, and other devices to move freight between different transport modes.

2.2.3. RFC Regulation

The Regulation concerning a European Rail Network for Competitive Freight (Regulation EU 913/2010) entered into force on 9 November 2010. The Regulation requests Member States to establish international market-oriented rail freight corridors (Figure 2.4) to meet three challenges:

1. Strengthen co-operation between infrastructure managers on key aspects such as allocation of path, deployment of interoperable systems, and infrastructure development;

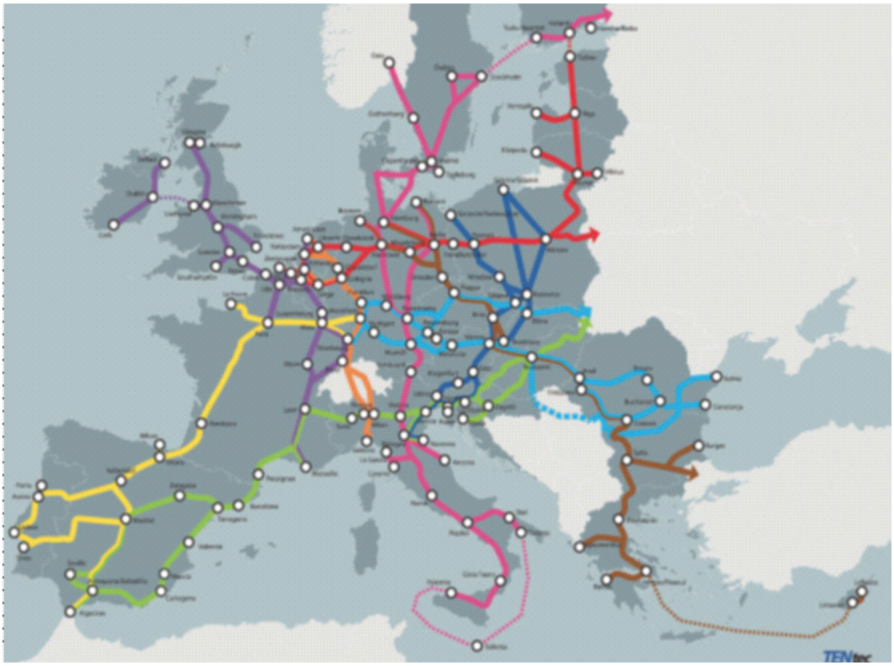


Figure 2.3. TEN-T Corridors Network (2011)

Source: www.ec.europa.eu.

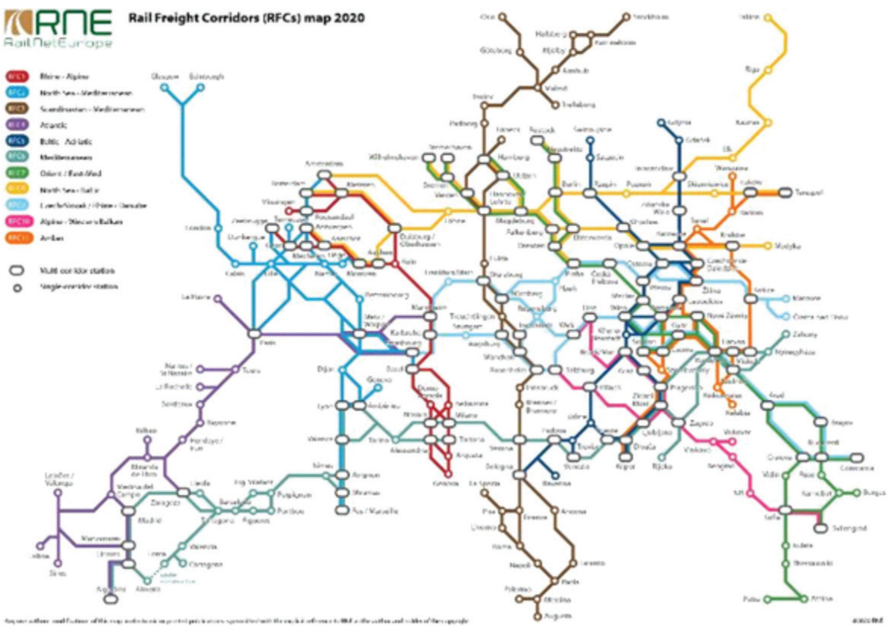


Figure 2.4. Rail Freight Corridors (RFC) map 2020

Source: https://blogcfl.lu/en/freight/european-rail-freight-corridors-2.

2. Strike the right balance between freight and passenger traffic along the rail freight forridors, giving adequate capacity and priority for freight in line with market needs and ensuring that common punctuality targets for freight trains are met; and
3. Promote intermodality between rail and other transport modes by integrating terminals into the corridor management and development.

The involvement of partners along the logistic chain is important to the management board of every RFC (i.e., Member States and IMs). On each RFC, specific advisory boards have been designed and created:

- The Railway Advisory Group (RAG) represents a platform for railway undertakings to facilitate the exchange of information, recommendations, and mutual understanding about technical and operational issues of rail operators with the Management Board. UIC is responsible for the coordination of all RAG RFC speakers.
- The Terminal Advisory Group (TAG) represents a platform for managers and owners of terminals and port authorities to facilitate the exchange of information or recommendations about technical and operational issues, respectively strategic plans for improvements with the Management Board. The TAG may issue an opinion on any proposal by the MB which has direct consequences for investment and the management of terminals. UIRR has been named as the coordinator of all TAG RFC speakers.

2.2.4. Register of Infrastructure (RINF)

Register of Infrastructure (RINF) is the common platform where railway stakeholders, e.g., railway undertakings, intermodal operators, terminal managers, manufacturers, wagon keepers, etc. The Register consults on any railway infrastructure-related information. In particular, RINF is intended to be the "stable reference infrastructure description" of all European infrastructure managers. The RINF system comprises of a web-based user interface and is accessible from any computer with an internet browser and network accessibility. The Commission Implementing Regulation (EU) 2019/777 of 16 May 2019 on the common specifications for the register of railway infrastructure can be found here: https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=uriserv:OJ.LI.2019.139.01.0312.01.ENG&toc=OJ:L:2019:139I:TOC.

Today the primary objective of RINF is to support the process of assessing the route compatibility between rolling stock and its route. For CT, the RINF data are useful to railway undertakings to fulfil their obligations to perform the railway gauge check when transporting non-ISO loading units and/or (craneable) semi-trailers. For intermodal operators it would support the planning and preparation of the freight trains. RINF should compile all intermodal railway gauges for all lines allowing the transport of intermodal loading units–C for swap bodies and P for semi-trailers. The aim is to create a map with all lines for C and P coding (see Figure 2.5 for a best practices example from the UIRR map).

Figure 2.5. CT Half Way Gauge Map

Source: UIRR data, 2021.

2.2.5. Directive 2012/34

Directive 2012/34/EU of the European Parliament and of the Council dated 21 November 2012 established a single European railway area providing a mandated track access regime for third-party railway operators. Infrastructure managers are required to grant non-discriminatory access to railway undertakings (and other possible applicants listed in the Directive) operating on the European railway network by following conditions:

- The principle of open access applies to the use of railway infrastructure for domestic and international rail services.
- Member states may exclude specific network and services from the mandated track access regime, such as local and regional stand-alone networks, networks intended for the operation of urban or suburban passenger rail services only, or infrastructure whose track gauge is different from the main rail network within the EU.
- The core provisions of the Directive set out the requirements and procedures for the allocation of railway infrastructure capacity and methods for the calculation and collection of infrastructure charges.

In addition, with the adoption of the implementing Regulation 2017/2177 on access to service facilities and rail-related services, the aim is to increase transparency in the market for all service facilities as defined in the Directive by imposing to the service facility operators to make publicly available information on their facilities such as access conditions, technical characteristics, general information etc. In this context, RNE and UIRR have jointly decided to operate a European Portal to facilitate the exchange of information between the service facility operators and the railway users such as RUs, CT operators, and shippers. The portal is available at https://rail-facilitiesportal.eu/.

2.2.6. Connecting Europe Facility (CEF)

The Connecting Europe Facility (CEF) is a key EU funding instrument to promote growth, jobs, and competitiveness through targeted infrastructure investment at the European level. It supports the development of high performing, sustainable, and efficiently interconnected trans-European networks in the fields of transport, energy, and digital services. CEF investments fill the missing links in Europe's energy, transport, and digital backbone.

CEF Transport is the funding instrument to realize European transport infrastructure policy. It aims at supporting investments in building new transport infrastructure in Europe or rehabilitating and upgrading the existing one. CEF Transport focuses on cross-border projects and projects aiming at removing bottlenecks or bridging missing links in various sections of the core network and on the comprehensive network (link), as well as for horizontal priorities such as traffic management systems. CEF Transport also supports innovation in the transport system in order to improve the use of infrastructure, as well as to reduce the environmental impact of transport, enhance energy efficiency, and increase safety.

The CEF program is supported and managed by the European Climate, Environment and Infrastructure Executive Agency which is the successor organization of the Innovation and Networks Executive Agency. Officially established on 15 February 2021, it started its activities on 1 April 2021 in order to implement parts of certain EU programs.

2.3. Responsibility of a CT operator

Responsibility of the CT operator is one of the main issues concerning intermodal transport, regulating claims against the operator for possible losses or damages of the cargo, as well as for potential delay in delivery of goods. The main principle for this responsibility is that it lasts from the moment cargo is taken over by the operator until it is delivered to the principal. Laws also regulate a situation in which the carrier is relieved of this liability (e.g., when losses or damages or the exceeding of the transit period were caused by the fault of the person entitled).

When intermodal transport is concerned, however, the issue is more complicated due to the change of legal regulations in connection to the means of transport on certain stage as well as to the place where the loss appeared. Moreover, international CT principles, regarding responsibility of the operator, may also differ in connection to the contract rules binding the parties (e.g., choosing rules of responsibility provided in INCOTERMS as a globally-recognized set of standards, used worldwide in international and domestic contracts for the delivery of goods). If, however, a different set of rules are not chosen in the contract of the carriage, international and national regulations concerning responsibility of the CT operator should be applied.

The mentioned international and national regulations differ due to the means of transport used regarding any certain stage and may differ according to the place where the loss appeared. When road transport is concerned the main legal act regulating the delivery of goods, including responsibility of the operator, is a Convention on the Contract for the International Carriage of Goods by Road (CMR) (Geneva, 19 May 1956). According to Article 1 of the convention it is to be applied to "every contract for the carriage of goods by road in vehicles for reward, when the place of taking over of the goods and the place designated for delivery, as specified in the contract, are situated in two different countries, of which at least one is a contracting country, irrespective of the place of residence and the nationality of the parties". Article 3 specifies that for the purposes of this Convention the carrier shall be responsible for the acts of omissions of his agents and servants and of any other persons of whose services he makes use for the performance of the carriage, when such agents, servants, or other persons are acting within the scope of their employment, as if such acts or omissions were his own.

For international rail transport the main legal issues are regulated in the Convention concerning International Carriage by Rail (COTIF) of 9 May 1980 (COTIF 1999). According to Article 23 of the Convention (see Appendix B of the Convention) "the carrier shall be liable for loss or damage resulting from the total or partial loss of, or damage to, the goods between the time of taking over of the goods and the time of delivery and for the loss or damage resulting from the transit period being exceeded, whatever the railway infrastructure used. The carrier shall be relieved of this liability to the extent that the loss or damage or the exceeding of the transit period was caused by the fault of the person entitled, by an order given by the person entitled other than as a result of the fault of the carrier, by an inherent defect in the goods (decay, wastage, etc.), or by circumstances which the carrier could not avoid and the consequences of which he was unable to prevent."

When international inland navigation is concerned, there are several regulations concerning it: Strasbourg Convention on the limitation of liability in inland navigation, Budapest Convention on the Contract for the Carriage of Goods by Inland Waterway, as well as Convention on the Registration of Inland Navigation Vessels.

Responsibility of the CT operator in carriage of goods by sea are included in The Hague–Visby Rules–International Convention for the unification of certain rules of law relating to bills of landing. The rules in general provide the responsibility of the carrier from the moment of loading until discharge.

International carriage of goods by air is regulated mainly in the Convention for the Unification of Certain Rules relating to International Carriage by Air, Signed in Warsaw (12 October 1929) as well as other protocols. The main document is centered on the responsibility of the carrier by way of the Air Way Bill.

For instance in Poland, its national regulations, in terms of intermodal transport, differs due to the means of transport used. The main regulation, regarding road and rail transport as well as inland navigation is included in Transport Law–Prawo przewozowe (Dz. U. 2020, poz. 8), which Article 65 provides the responsibility of the carrier for loss or damage of goods between the time of taking over of the goods and the time of delivery. Polish national regulations concerning carriage of goods by sea are included in its Maritime Code–Kodeks Morski (Dz. U. 2018, poz. 2175), where the regulations concerning the responsibility of the carrier were incorporated and are similarly drafted using The Hague–Visby Rules.

The problems connected with the presented main regulations concerning responsibility of the CT operator result mainly from the fact that there are no unified rules, common to all means of transport together. There were attempts to create some universal rules (e.g., ICC Rules issued in 1973, United Nations Convention on Contracts for the International Sale of Goods (Vienna, 1980), and The Rotterdam Rules), however, they are not legally binding, for the mentioned conventions have not been ratified by required number of states.

Together with the need to create universal rules concerning international CT, there is also a necessity to provide such rules in national law. Among others there should be some nominated structure to legally regulate an “intermodal bill of landing.”

2.4. Insurance issues of CT operating

The wide responsibility of the CT operator (as well as other participants within transport, e.g., shipment agents) in terms of possible losses or damages to cargo and potential delay in delivery of goods, requires proper risk management in which insurance plays a key role. When insurance in CT operating is concerned, it can be divided into three main aspects: civil liability insurance, cargo insurance, and insurance coverage for employees.

Civil liability insurance of the carrier allows for a reduced responsibility of the carrier for possible claims of damages in connection to loss or damage to cargo, or delay in delivery of goods. Often such insurance includes the loss connected with robbery. It includes the timeline from the moment when the cargo is taken over by the operator until it is delivered to the principal. In Polish law (Article 80-82 of Transport Law) regulates the possible amount of the damages. Similar regulation is also included in Article 23 of CMR (Geneva, 19 May 1956). Such insurance should provide a guaranteed sum in the amount of total value of the carried goods or the amount declared in the bill of landing. In the case of civil liability insurance, the insurer will cover the loss resulting from carrier's fault, however, they are not responsible for covering the damages resulting from the loss or damage of goods not dependent on the carrier. In the case of international transport, it is essential to include the whole delivery route.

Cargo insurance, in which the scope of insurance includes only goods transported, it is one the most complicated types of insurance in international trade. This is mainly due to the fact that it is necessary to precisely establish which party of the contract of carriage and from which moment responsibility is effective and for what potential damages. Another problem in cargo insurance is the diversity of means of transport used and conditions provided in a certain contract of carriage. In the case a sender and a recipient specify in the contract of carriage responsibility for potential damages, they usually include a regulation that specifies which party of the contract is responsible for the insurance. It is also possible that the parties of the contract of carriage choose rules to govern the issues of responsibility for cargo (e.g., INCOTERMS–international standards specifying conditions of the delivery of goods.). In this case, however, the parties do not provide regulations of responsibility in the contract of carriage, appropriate rules of common law should be applied. In Polish law, for instance, it regulates in circumstances that the risk connected with losses or damages of goods is transferred to the buyer (i.e., recipient) at the moment of delivery (Article 548 of the Polish Civil Code), unless the contract of carriage states otherwise. When cargo insurance is concerned, differently from civil liability insurance, the scope of insurance may include force majeure (e.g., flood, hurricane, storm, etc.). Cargo insurance secures the interests of the owner (i.e., recipient) of goods, while civil liability insurance secures the carrier (including shipment agents). Such insurance may include goods in all types of transport–road, rail, air, and sea, as well as CT.

Insurance coverage for employees includes possible damages resulting from an accident, including death or injury of the employee. The standard scope of such insurance includes compensation, costs of treatment, etc. However, the above insurance will not cover the loss resulting from the employee's fault.

3. SWOT analysis of the combined transport in the Baltic Sea Region

The CT sector is challenged by many different trends due to changing conditions under which CT has to operate. A SWOT analysis represents key insights into advantages and disadvantages as well as opportunities and threats regarding CT especially in the BSR. The listed insights include aspects concerning environment, economy, and clients and are elaborated more precisely in the following subchapters.

3.1. Advantages of CT

The **strengths** in SWOT represent current strengths of CT in BSR that can give advantages over the competing modes of transport. Very important aspects here are the environmental benefits. CT is considered as one of the most environmentally-friendly transport systems or technology. It is a sustainable alternative to pure road transportation because in CT the major part of the European journey is transported by rail, inland waterways, or sea and any initial and/or last mile carried out by road are as short as possible. In addition, the weight advantage of the 44 tonnes[1] in CT compared to the 40 tonnes in standard road traffic has a positive effect on the climate balance by reducing truck transports (ERFA KV 2020). On routes where volumes can be bundled, and distance is appropriate, combined transport provides substantial energy gains and lower CO_2 emissions (UIC 2015).

The list of business economic benefits of CT is long. The productivity is gained through higher capacities on long distances. For clients, the rail section brings savings on fuel (UIRR 2021). Distances in the BSR are long and with a growing transport distance of at least 300 km, CT is increasingly cost effective and therefore more attractive. In CT, the gross weight limit of 40 tonnes per truck in standard road freight transport does not apply for the first mile or main leg of CT, where trucks can weigh

[1] The additional tonnage allowed in combined transport differ in all countries. One of the recommendation should be therefore standarization of the increased maximum allowed tonnage across the EU or even wider.

up to 44 tonnes. Using CT technologies enables reduced toll costs, exemptions from reduction or reimbursement of road vehicle taxes, and exemptions to driving bans as well as funding support. There are national support programs and national CT funding measures in use also in the BSR (ERFA KV 2020).

CT enables better sharing of volumes between the different transport modes. When optimizing the transport chain, modes of transport are smart combined according to their strengths to improve the productivity of the entire transport chain and to offer economic advantages and allow for a better use of existing capacity. By using means of mass transport, namely freight trains and barges for the main leg, greater volumes of goods can be transported at once, which means economic and environmental advantages in comparison to trucks. CT is more flexible than rail-only freight transport because of the use of trucks on the first and last mile, allowing a point-to-point delivery (ERFA KV 2020).

By using means of mass transport, CT provides a solution to high labor costs and truck driver shortage which affects the entire logistics industry (ERFA KV 2020). The advantage of CT for clients are lower manpower costs, and for instance journey by train is recognized as rest time for the driver in accompanied CT (UIRR 2021). In the BSR, labor costs are high especially in the Nordic countries.

As a mean of transport, CT provides many advantages. Using rail and waterways instead of roads means less road traffic and congestion and less damages to roads. Rail and waterway transport are more quiet and safe modes of transport, which contribute to high level of transport safety and less accidents. CT provides a very safe and secure transportation, reducing risks of damage to goods during shipment (UIRR 2021). It is also worth to mention the high resilience to the weather conditions, especially when compared to road trucking.

In the BSR, the semi-trailer is the predominant ILU-type. Therefore, new innovative vertical and horizontal systems capable of handling semi-trailers must play a vital role in pushing combined transport in the BSR (SGKV & UIRR, 2020).

Further, several ports in the BSR with increasing volumes are a specific characteristic of the BSR that can definitely be seen as a current strength as regards to CT (UIC, 2020).

There are also new business endeavors and models in the markets such as cooperation agreements and plans between companies to enhance and develop CR, including a joint growth strategy in a shared network with synced services. Digitalization and automation of processes is required to make logistics and supply chains simpler and more efficient (Railfreight.com, 2021).

And exactly digitalization and automation is another advantage of CT. When comparing general conditions of possible road trucking and rail transportation, the second sector is more suitable for digital tools towards eliminating of human errors, manpower and costs related to the employment. Also, CT terminals represent high potential of digitalization and automation. At present, there are some full automated terminals running without staff on side. Only the management and monitoring of controlling and steering systems is performed by people. All in total, highly efficient rail transportation including all transshipments in the logistic chain allow better use of existing resources, smoother delivery process which is safer to society, as well as the environment.

At last, but not least important, the EU transport policy, which has a long-term perspective, aims at shifting a specific share of freight from road to rail or water-borne transport. In this context several regulations are already implemented but we should expect much more limitations for the pure road trucking in the near future including cost-generating technologies in trucking, alternative fuels (e.g., electric or hydrogen propulsion), work time limits for the drivers, as well as spatial access limits or bans for freight traffic.

3.2. Disadvantages of CT

The **weaknesses** in SWOT analysis describe the disadvantages of CT in the BSR. The improvement of these aspects would increase the usability of CT for freight transport.

Efficient and competitive combination of transport modes is sometimes challenging in practice, even though CT provides an opportunity for optimized transportation. There are many reasons for this situation. In the BSR, there is insufficient knowledge about CT due to long tradition of pure road transport in the area and there are comparatively low (especially CT capable) transport volumes in this region. The transport volumes are spatially scattered and in the BSR the last mile is typically long due to rural structures. This affects the competitiveness of CT, since the longer the main leg and shorter the last mile, the more competitive CT is, in general, because the handling efforts must be compensated by lower transport cost of the main leg and the last mile.

This is due to the most important disadvantage of the CT—additional transshipment cost. This results from the specificity of the intermodality, where at least two times a load unit has to be transshipped from first mile to main leg and afterward, from the main leg to the last mile. All existing transshipment technologies are offered in specialized CT terminals, equipped with costly gantry cranes or reach stackers, operating on the special prepared terminal infrastructure. Only selected horizontal technologies allow low-cost transshipment in the whole chain. In all other cases it is necessary to bear these costs.

The missing links in transport networks also hinder the use of the potential of CT. As an example, the volumes transported on barges are almost negligible in the BSR (SGKV & UIRR, 2020). For instance in Sweden, there is a lot of IWT potential that is not used sufficient or even at all. When it comes to weaknesses in using rail, there are different track gauges within the BSR. Rail share in total freight volume and intermodal share in rail freight is very different between specific BSR countries (UIC 2020).

The CT sector needs further improvements regarding the velocity and liability of its processes. Cost and time-intensive handling processes constitute one weakness for CT. New handling technologies in terminals would improve this weakness, but in the BSR, there is a lack of application of these new handling technologies. In general, bottlenecks at terminals are disadvantages of CT (UIC, 2020). Main reason for that are high costs of infrastructure construction.

Very often as disadvantage for the CT is mentioned a shortage of rail wagons (i.e., pocket wagons or container platforms), especially intermodal (universal) ones. Despite of the cost-intensive investment in the fleet, self-supply of intermodal wagons shows serious barriers for future development.

All these above-mentioned disadvantages cause problems considering the strong competition on freight market, especially with road transport.

3.3. Chances for CT

The list of opportunities for CT is long. These include, for example, trends such as digitalization that could improve combined transport by creating new assets for business.

In the list of **opportunities**, an extremely important aspect is the political will in the EU, as well as in the BSR and on national level to increase the use of sustainable modes of transport. The Green Deal states that "*Multimodal transport needs a strong boost. This will increase the efficiency of the transport system. As a matter of priority, a substantial part of the 75% of inland freight carried today by road should shift onto rail and inland waterways…*" (European Commission 2019). The Commission's "Sustainable and Smart Mobility Strategy" together with an Action Plan of 82 initiatives will guide their work for the next four years. The concrete milestones include, for instance, that by 2030 automated mobility will be deployed at large scale and zero-emission marine vessels will be market-ready. By 2050, rail freight traffic will double and there will be a fully operational, multimodal TEN-T for sustainable and smart transport with high-speed connectivity measures to manage better, and to increase the capacity of railways and inland waterways. To make this vision a reality, the Commission has committed to reinforcing efforts and investments to complete the TEN-T by 2030 and support the sector through increased investments, both public and private, in the modernization of fleets in all modes (European Commission, 2020). This political backbone will help to boost sustainable CT also in the national level, with the help of governments' climate policies, carbon neutrality targets and national transport system plans. National measures to support CT, such as funding programs, subsidies, and tax allowances, are therefore opportunities for CT. Boosting CT in the BSR requires transnational approach in national planning too.

Sustainability of CT can also be used as a selling point: CT can improve the image of the transport industry and can be used as a tool for positive marketing, as green logistics is currently becoming more and more important to clients (ERFA KV, 2020). According to 2020 Report on Combined Transport in Europe, sustainability seems to be highly important issue for the various players in CT (UIC, 2020).

The improved regulatory framework is needed to fulfil the political will. The stronger support for the BSR specifics regarding combined transport is needed both in the European and national legislation. The support for standardization and minimization of the bureaucratic burden related to CT processes is important (UIC, 2020).

Taking advantage of the potential of digital technologies and solutions has a great impact on the whole logistic industry. One of the biggest opportunities for CT is the increased digitalization and automation of transport and logistics. Examples for new developments are tracking and tracing, the increasing number of booking platforms for a better price comparison and more transparency, and the use of big data to enable forecasts of capacity planning and environmental influences in the supply chain (ERFA KV, 2020). It is also possible to implement the internet of things into the CT chain, where specific transport means, infrastructure elements and the cargo unit communicate to each other towards improving the chain efficiency.

In addition to improving processes through digitalization, the capacity of CT can be increased by building new terminals or expanding the capacities of existing terminals (UIC 2020). New innovative solutions and improved processes through digitalization, such as truck and train gates, allow for a fast-digital collection of information on the loading units when entering or leaving the terminal. The digitalization has also led to an increasing number of automated CT terminals (ERFA KV 2020).

In the light of the considerable gap particularly between road and rail transport in terms of cargo volumes, the question arises how the modal split can be shifted towards more sustainable modes of transport in the CT chain within the BSR. Having in mind that a considerable share of road transport is realized in semi-trailers, economically viable innovative vertical, and horizontal handling technologies could potentially unlock the potential of combined transport in the BSR (SGKV & UIRR, 2020). To achieve a shift of freight traffic volumes off the road to rail or waterways, there is a great potential in the use of innovative handling technologies for non-craneable loading units which cannot be handled with conventional equipment (ERFA KV, 2020).

The improved standardization and interoperability create opportunities for CT in the BSR as well. CT profits from a continuing development of an increasing use of containers. The future development of transport connections and links in the BSR, for instance the enhanced use of inland waterways, can increase CT in the region.

As stated earlier, the BSR is traditionally an area with a long tradition of pure road transport. Introducing new transport opportunities can contribute to new markets and business models that include CT too.

And the biggest chance for the CT development should be seen in the economy of scale, when the commonplace of cargo unit shipment to the CT chains will ensure sufficient transportation work and therefore incomes to cover not only operational costs, but also giving some funds for the further development of improved services and additional capacity building investment.

3.4. Barriers of the combined transport

External **threats** create barriers for CT. For instance, a technology shift or a change in legal framework could endanger the profitability of the business. Market and price development could create a threat to CT—but could of course turn to an opportunity as well. The impact of COVID-19 on transport volumes and costs has created a threat to CT market and created ambiguity concerning the market in general (UIC 2020). Legislative and regulatory challenges as well as limitations on government funding and limited support for development of sustainable transportation modes creates barriers to CT. Also, low interoperability is a serious threat to CT, since the need for improved standardization environment for the use of ILUs is considered an important topic in future CT (UIC 2020).

One of the most important barrier are additional costs related to the process. It results from the obligatory transshipment process, as mentioned before. Cost-related issue is also rail access fee, differing much when analyzing all EU Member States. In addition, there is a huge disproportion between rail access fees and road access fees. Then, the differences in discounts system for intermodal trains (if applicable, because there are countries without such supporting systems) is another issue.

With cost, are also related rail and IWW infrastructure investments, bared mainly by the governance or regional authorities, eventually by the rail infrastructure management bodies. For the IWW in addition, the access fee is not directly related to the cost of maintenance of the infrastructure, since it is built to ensure many other public goals i.e., flood protection, water retention, irrigation purposes, and energy production (Figure 3.1).

An important technical barrier consists of rail infrastructure standards regarding:

- Track gauge, which requires technologies to change the gauge with or without wagons;
- Electrical voltage, which requires multisystem locomotives;
- Electrification rate of the rail system, which implicates capability to use electric locomotives instead of diesel-powered ones;
- Maximum length of a freight train, which results in the efficiency of one train form theoretical 82-84 TEU on average to 70 TEU in practice (where 630 m are the limit);
- Maximum payload of a freight train, closely connected to the length but being a separate factor/indicator for rail operators in train planning and setting;
- Maximum speed of a freight train, resulting in the infrastructure efficient use, especially when average speed is calculated as main factor for the competition with road trucking;

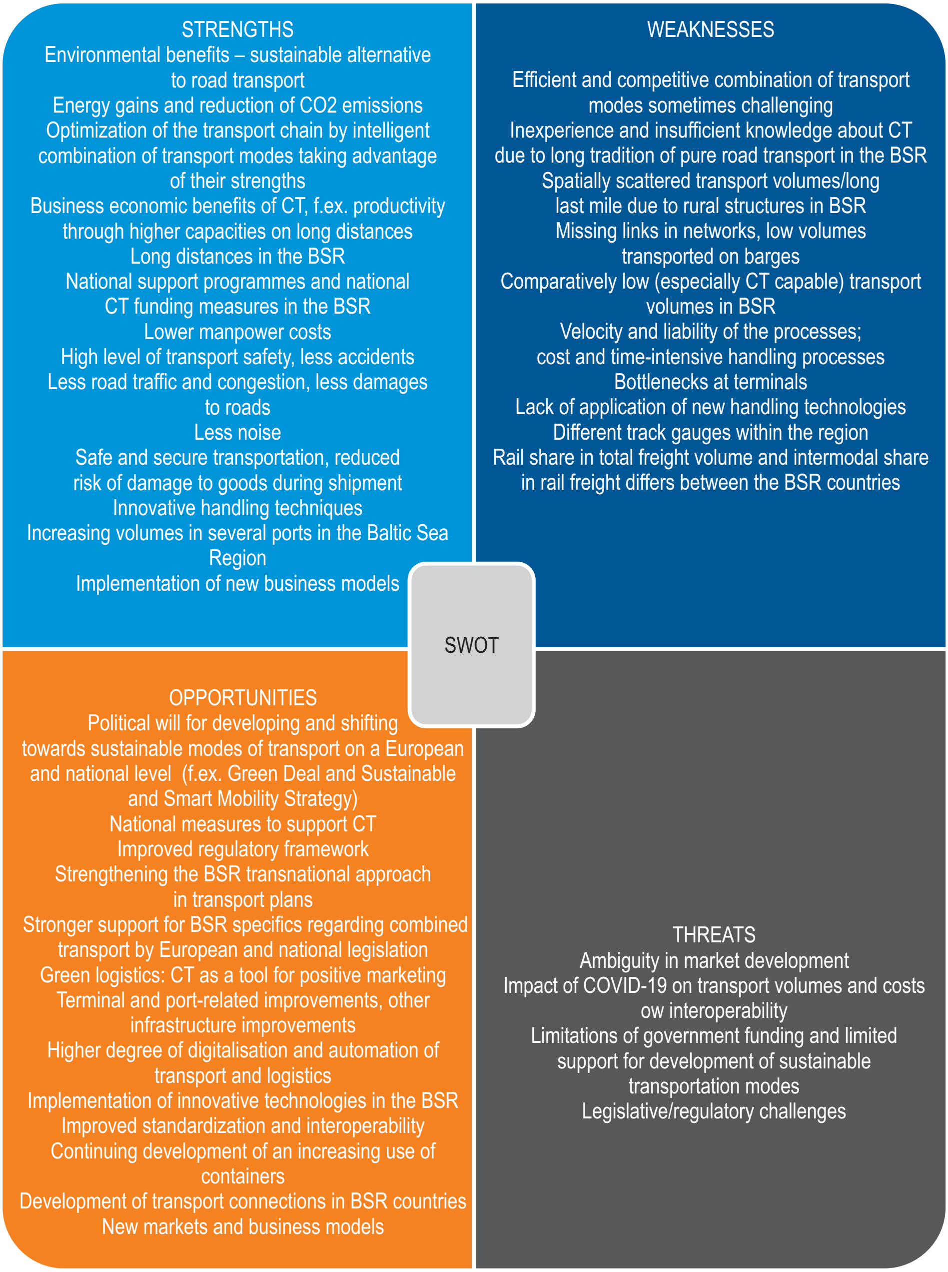


Figure 3.1. SWOT analysis

Source: Own elaboration.

- Advancement of ERTMS/ETCS systems in specific EU countries, unequal and differing, which results in being still incompatible and non-efficient rail system in the whole EU; and
- Bottlenecks in AGTC and AGN transport networks, where several white spots can be observed i.e., on the Polish IWW map.

There are also other barriers for the CT development, such as:

- Inadequacy of infrastructure and capacity of existing CT terminals;
- Not sufficient density of CT terminals location;
- Delays in cargo handling at CT terminals, as well as in rail traffic;
- Hydrological limitations for IWW (insufficient water level);
- Lack of governmental incentives or transport policy measures supporting CT implementation;
- IT and ICT solutions being not implemented into the rail services (while in road transport the track & trace is well developed);
- Long time is needed for the operator to organize a service, while the forwarders are often obliged to make on the spot decisions on the shape of the chain;
- Lack of a (digital) rail booking stock, similar to the maritime freight;
- A general delays in investment processes; and
- Non-coordinated investment in logistics centers unlike the CT terminals location.

In addition to the above, there are also some organizational barriers to be overcome, including:

- Lack of education and trainings for new employers, while the existing one shows a high average age;
- Long and difficult process of certification and staff authorization in rail and maritime transport, as well as not unitized across the whole of the EU for standard requirements of locomotive drivers;
- National policies preventing own staff against foreign competition (e.g., in rail business); and
- Limited willingness by customers to pay for the greening process of transport and all kind of consequences resulting from the process (cost increase, time-consuming indirect work.

4. Development strategies supporting the combined transport

4.1. New Green Deal goals

The global challenges of climate change and environmental degradation required a worldwide response. Climate has an important place on the political agenda of the EU. Climate and environment are the most important tasks the current generation has to face. The concept of the New Green Deal is a part of the discussions about the necessary changes and redefinition of the directions and goals related to the development of the global economy actors.

The New Green Deal is a new EU climate strategy announced by the European Commission. On December 11, 2019, EC President Ursula von der Leyen asked the European Parliament to approve the New Green Deal, a plan for the EU and its citizens to achieve climate neutrality by 2050. Among other important timelines, the Commission has called for a 50% increase to the EU 2030 climate target, which currently calls for a 40% cut in greenhouse gas emissions and an increase in the use of renewable energy. The European Commission has approved the European Green Deal. For now, the most important EU climate policy strategy is the European Green Deal. The EU Green Deal is the EU's first such a comprehensive strategy to protect the environment and counteracting climate change. It also aims to protect, preserve and enhance the EU's natural capital and safeguard the health and well-being of citizens from risks and negative impacts linked to the environment.

The European Green Deal is a new strategy for growth that aims to transform the Union into a just and prosperous society living in a modern, resource-efficient and competitive economy that achieves zero net greenhouse gas emissions by 2050. This is to be the EU's new holistic economic strategy with the main goal of achieving climate neutrality by 2050. This means that by mid-century, the EU economy is expected to emit only as much greenhouse gas as it can absorb (e.g., through forests or CO_2 capture technology). According to New Green Deal goals, the economic growth is to be decoupled from the use of natural resources.

EC President Ursula von der Leyen assured that the joint goal of the European Commission and the European Investment Bank would be to mobilize funds of around EUR 100 billion for it between 2020 and 2027.

The New Green Deal is an integral part of the strategy developed by the current Commission to implement the UN 2030 Agenda for Sustainable Development and the Sustainable Development Goals. Under the New Green Deal, the Commission will change the process of macroeconomic coordination to take account of the UN Sustainable Development Goals, to put sustainability and the well-being of citizens at the heart of the economic policy and to put sustainable development at the heart of the EU policy and action.

The EU Emissions Trading System (EU ETS) is the most important tool of the European Union's climate policy. The New Green Deal implies the introduction of new measures to implement climate policy. New actions involve: the inclusion of new sectors in the EU ETS, involving the maritime sector, and updating of the existing reduction targets. The New Green Deal aims at transforming the EU economy for a sustainable future.

The European Green Deal is a strategy for transforming the EU economy for a sustainable future. Implementing the European Green Deal requires a set of policies that will bring about a profound transformation. These include: more ambitious EU climate targets for 2030 and 2050; delivering clean, affordable and secure energy; mobilizing industry for a clean, closed-loop economy; building and renovating in ways that save energy and resources; accelerating the transition to sustainable and intelligent mobility; from farm to table: creating a fair, healthy and environmentally-friendly food system; protecting and restoring ecosystems and biodiversity; and zero emissions for a non-toxic environment. In transforming the EU economy for a sustainable future, the strategy includes: promoting green financing and green investment and ensuring a just transition; greening national budgets and ensuring appropriate price signals; supporting research and boosting innovation; activating education and training; and fulfilling the green pledge: „Do No Harm".

Analysis of the New Green Deal goals in relation to CT development and possible input from CT to these goals achievement

The CT is popularized in the EU through the Combined Transport Directive (Council Directive 92/106/EEC). The aforementioned Combined Transport Directive is supported by other EU policies, such as the Weights and Dimensions Directive (Directive (EU) 2015/719 amending Council Directive 96/53/EC), which provides for Member States to allow heavier intermodal loading units to be moved by road when used in combined transport operations. In addition, the EU also provides financial support for CT projects.

Transportation must undergo major changes to reduce greenhouse gas emissions by as much as 90%. The New Green Deal strategy emphasizes the importance of transportation by dedicating an item entitled Accelerating the Transition to Sustainable and Smart Mobility to the topic of transportation. It was also stressed that transport needs a strong impulse for development, as it is responsible for a quarter of EU greenhouse gas emissions and this value is still growing. Therefore, in order to achieve climate neutrality, transport emissions have to be reduced by as much as 90% (by 2050). All modes of transportation – road, rail, air, and water – will have to contribute. The document also indicates that intermodal transport needs strong support, which will positively influence the efficiency of the entire transport system. The priority will be to shift a significant proportion of transport carried out today by road (which accounts for 75% of all transport) to waterways and rail. In aviation, the Commission announces a new start for the Single European Sky.

The Commission is also considering the withdrawal of the current legislative proposal and presenting a new proposal to amend the Combined Transport Directive. The proposal for a Directive amending Directive 92/106/EEC on the establishment of common rules for certain types of combined transport of goods between the Member States COM(2017) 648.

The plan also includes, intelligent traffic management systems, which are made possible by digitalization. The automated and networked multimodal mobility will play an increasing role. The Commission envisages developing the EU's transport system and infrastructure in such a way that the proposed solutions support new sustainable mobility services with the potential to reduce congestion and pollution, especially in cities. It will also contribute to the development of intelligent traffic management systems and mobility-as-a-service solutions through its funding instruments (such as the Connecting Europe Facility).

The Commission's recommendations on transport prices are also relevant from a CT perspective. The Commission stated that the price of transportation must reflect its external costs (health and environmental ones were mentioned). According to the Commission, subsidies for fossil fuels should terminate – including for aviation fuels and maritime transport.

It is to be proposed that the emissions trading scheme can be extended to the maritime transport sector, and considered for road transport. The number of free emission permits issued to airlines is to be reduced. This is to be coordinated with "action at global level" in conjunction with global maritime and air transport organizations. The document also mentions the need to look at a system of road access charges.

One of the main recommendations related to this point of accelerating the transition to sustainable and intelligent mobility is to develop the production and introduction of alternative sustainable transport fuels. As part of these measures, the Commission envisages more charging points for electric cars and refueling of alternative fuels. Already by 2025, 13 million low-emission cars are expected to be on the road, for which about one million public charging stations are to be available, so that almost every family in the EU can travel by electric vehicle without worrying about where to charge their car.

The document also states that the level of pollution generated by transport, especially in cities, must be drastically reduced. Through a combination of measures, the Commission aims to tackle emissions and congestion in cities and improve public transport.

The Commission plans to introduce stricter air pollution standards for vehicles powered by combustion engines. The legislation on CO_2 standards for cars and vans should be reviewed by June 2021 so that there are no longer any obstacles to carbon-free mobility from 2025. At the same time, the Commission is considering the inclusion of the road transport sector in the European emissions trading scheme as a complement to the current and future CO_2 standards for vehicles. The action is also planned for the maritime sector, which will include regulating access to EU ports for the most polluting ships and obliging ships at dock to use shore-side electricity. The issues of improving air quality around airports by tackling aircraft emissions and airport operations were also raised.

4.2. Blue Growth Strategy

On 13 September 2012 the Commission's Statement Blue Growth – opportunities for sustainable growth in the maritime sectors (COM(2012)494) was announced. The initiative on Blue Growth was to be one of the main topics of discussion at the Integrated Maritime Policy Ministerial Conference held in Limassol, Cyprus on 8 October 2012. The strategy was endorsed at the ministerial level through the Limassol Declaration. The European Parliament has expressed its support on this issue.

The European Commission presented prospects for sustainable growth in maritime sectors. The Commission has unveiled promising signs of growth and job prospects in the maritime sectors that could contribute to Europe's economic recovery.

The maritime sectors employ about 5.4 million people and contribute to a total of around EUR 500 billion in gross value added. According to the Commission's plans, these figures should have risen to 7 million and to almost EUR 600 billion respectively by 2020.

The strategy consisted of three parts. The first concerned specific measures for an integrated maritime policy. The aforementioned part deals with issues such as: marine knowledge – to improve access to marine information; maritime spatial planning – to ensure effective and sustainable management of maritime activities; and integrated maritime surveillance – to give competent authorities a clearer picture of the situation at sea.

The second part was devoted to a strategy for specific sea basins with the aim of providing appropriate measures to promote sustainable growth, taking into account local climatic, oceanographic, economic, cultural, and social factors. Examples include: the Adriatic Sea with the Ionian Sea, the Arctic Ocean, the Atlantic Ocean, the Baltic Sea, the Black Sea, the Mediterranean Sea, and the North Sea.

The third component indicated targeted approaches in some areas: aquaculture (fisheries website), coastal tourism, marine biotechnology, ocean energy, and seabed mining.

Following the 2012 Communication, the Commission launched various initiatives to explore and develop growth potential in these areas, including statements on coastal and marine tourism, marine and ocean energy, blue biotechnology, and marine mineral mining, as well as strategic guidance on aquaculture. All initiatives were to be undertaken in consultation with Member States and stakeholders.

Two years later, in May 2014, the Commission issued an Initiative on innovation in the blue economy. Then, five years after the 2012 Communication, the European Commission published the report on the Blue Growth Strategy. Towards more sustainable growth and jobs in the blue economy. Description of the Blue Growth Strategy in the context of transport, e.g., the CT and container shipping role in the EU economy. An attempt to specify possible input of CT into the strategy implementation.

On March 31, 2017, the report on the Blue Growth Strategy stressed "more sustainable growth and jobs in the blue economy". Moreover, the document addresses the issues of transportation and shipbuilding in the sixth chapter entitled "making blue growth strategy fit for future challenges – today's trends in the blue economy."

The role of CT and container shipping in the EU economy is illustrated in terms of employment in the blue economy and turnover (EUR 1 trillion). The Communication then identifies specific areas where targeted action can provide additional support. Referring to data from the above-mentioned report about 97% of the more than 5 million people working in the blue economy are employed in five sectors: (1) shipping, (2) shipbuilding, (3) non-living resources (mainly oil and gas), (4) living resources (i.e., fishing, aquaculture, and processing), and (5) coastal tourism. According to the Commission, the five specific areas presented above show particular potential for growth where targeted action can provide an additional stimulus.

In this study, the main focus is on transport by sea. Shipping carries 75% of the European external trade by volume and just over 50% by value. About 30% of the tonne/km of freight within and between the EU Member States is carried by sea. These proportions have remained relatively stable over the past 20 years.

According to the report, sea and coastal passenger water transport, sea and coastal freight water transport, inland passenger water transport, and inland freight water transport are increasing in importance.

The growing containerization of rail and sea transport favors the contribution of CT to the Blue Growth Strategy.

In the perspective of the objectives listed in governmental and European strategy documents, which emphasize the need to reduce the importance of road transport, this trend is positive.

4.3. Baltic Sea Region Strategy (EUSBSR)

The EU Strategy for the Baltic Sea Region (EUSBSR) is one of four macro-regional strategies implemented within the EU. EUSBSR was approved by the European Council in 2009 following a communication from the European Commission. It covers eight EU countries bordering the Baltic Sea (i.e., Sweden, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, and Poland) and four neighboring countries (i.e., Belarus, Iceland, Norway, and Russia).

EUSBSR is based on three main thematic pillars: protecting the sea, connecting the region, and increasing prosperity. The objectives of the EUSBSR from the perspective of the first pillar are as follows: save the sea, clear water in the sea, rich and healthy wildlife, clean and safe shipping, and better cooperation. Taking the second pillar into consideration, namely connecting the region, the following objectives were adopted: good transport conditions, reliable energy markets, connecting people in the region, and better cooperation in fighting cross-border crime. The third thematic pillar entitled increasing prosperity relates to the following objectives: improved global competitiveness of BSR, climate change adaptation, risk prevention, and management. EUSBSR is achieving leadership in deepening and completing the single market, contributing to the EU 2020 strategy.

Within each pillar and on a horizontal basis, 13 so-called thematic areas have been identified. (1) bioeconomy – agriculture, forestry, and fisheries; (2) culture – culture and creative industries; (3) education – education, research, and employability; (4) energy – Baltic Energy Market Interconnection Plan (i.e., BEMIP Action Plan) for competitive, secure, and sustainable energy; (5) hazards – to reduce the use and impact of hazardous substances; (6) health – to improve and promote human health including social aspects of health social aspects of this issue; (7) innovation – to realize the full potential of research, innovation, and SMEs using the digital single market as a source of attraction for talent and investment; (8) biogens – to reduce marine discharges of nutrients to acceptable levels acceptable levels; **(9) safety – to put the region at the forefront of maritime safety and maritime security**; (10) security – to protect against emergencies and accidents on land and cross-border crime; **(11) shipping – to create exemplary conditions for environmentally sound shipping in the region**; (12) tourism – to strengthen the cohesion of the macro-region through tourism; and **(13) transport – to improve internal and external transport links.**

The aforementioned 13 thematic areas include four horizontal actions, which are as follows:

1. Spatial planning: to encourage maritime and land spatial planning in all Member States in the Baltic Sea and terrestrial spatial planning in all Member States in the Baltic Sea area and develop a common approach to cross-border cooperation;
2. Neighbors: to create added value to the Baltic Sea cooperation through the collaboration of regions and neighboring countries;
3. Capacity: to build capacity and commitment; and

4. Climate.

The four horizontal actions are focused on capacity building, climate change, co-operation with neighboring non-EU countries, and spatial planning.

Each thematic area and horizontal action (i.e., 17 in total) has its own coordinator (Policy Area Coordinator/PAC, Horizontal Action Coordinator/HAC). Poland acts as a coordinator for three EUSBSR thematic areas:

1. Thematic Area Nutrition "Reduction of nutrient discharges to the sea to an acceptable level" – National Water Management Authority;
2. Thematic Area Innovation "Exploiting the full potential of the region in the field of research, innovation and SMEs" – Ministry of Science and Higher Education; and
3. Thematic Area Culture "Culture and creative industries" – Ministry of Culture and National Heritage.

According to the three main thematic pillars mentioned, namely the objective entitled protecting the sea, the European Commission has designated the sub-goal: ecological and safe sea transport. The importance of this issue is caused by the fact that the maritime transport in the Baltic Sea is growing steadily, ecological, and safe transport is becoming increasingly important for the whole area – both sea and land.

In terms of the second pillar, connecting the region, the sub-goal good transport conditions have been appointed by the Commission. In the European Commission document on the EUSBSR it was highlighted that transport plays a particularly important role due to very long distances (within the region, in relation to the rest of Europe and to the rest of the world) and very difficult transport conditions (i.e., forests, lakes, snow and ice in winter, etc.) in the BSR. The BSR area is located on the periphery of the economic center of Europe. It is largely dependent on foreign trade in goods, which makes a well-functioning transport infrastructure essential for the economic growth.

In the context of possible input of CT into the strategy implementation it is worth to take a look at the four important challenges of the EUSBSR.

Of the many challenges requiring an agreed action across the BSR, the four most important challenges are:

1. To create conditions for a sustainable environment;
2. To develop prosperity in the region;
3. To increase the accessibility and attractiveness of the region; and
4. To ensure safety and security in the region.

According to the European Commission, accessibility is still low in many areas of the region: northern Finland, Sweden, and the Baltic States have the lowest accessibility rates in the whole Europe, both in terms of internal and external connections. This is due to the size of the region and the associated long distances and travel times, as well as geographical and climatic conditions. The low density of infrastructure and services is associated with high prices. Improvements in this area should be made in the form of sustainable modes of transport.

4.4. Baltic Sea Region Combined Transport Development Strategy

4.4.1 Framework conditions and policy options

The EU transport policy sees CT as a major player in the transitioning of the freight transport sector. The most relevant framework conditions for road-rail CT in Europe, but also in the narrower sense of the BSR are defined by UIRR (2021). Table 4.1 summarizes general framework conditions. These conditions are highly relevant for the terminals since these conditions represent the interfaces for freight traffic.

Railway infrastructure

For instance, for the framework conditions of 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 harmonization of international CT. These standards should be still taken into considered if railway lines are upgraded or even if new lines are built (UIRR 2021, UNECE 2001).

The report on a the "Analysis of the EU-Combined Transport" has noted the comparison of the CT rail services in the EU and United States, where CT rail services makes 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 United States can also be carried out in double-stack container trains. In order to achieve a significantly higher volume of transport in the CT, the rail infrastructure must be further adapted in order to be able to absorb growing freight rail traffic (e.g., train overtaking at railway stations, operating 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 units or more and hinder 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 economics 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 benefit to the 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 non-road leg (KombiConsult et al, 2015; EC, 2001), and the limiting of the road leg in CT rail/road ratio operation. The main arguments in conclusion are to call for adjustments of the CT Directive, or moreover to develop a new CT Directive.

In addition, there is the recommendation to strengthen the CT support programs (e.g., grants for terminal investments, cross-border infrastructure investments in core routes), and 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, for the framework conditions of liberalization, the European Commission deals further with the opening up of transportation (mainly with ongoing integration of the first, second, and third railway package). The EU drew up new framework conditions from the early 90s by means of various Community legislative instruments (Directive 91/440; Directive 92/106/EEC). The Directives clearly distinguishes between infrastructure and operation. The main objective of the Directives (and Regulations) starting in 1990s is to harmonize the European rail market (UIRR, 2021; UIRR, 2000). The study by KombiConsult et al. (2015) suggests to re-evaluating the CT Directive to determine whether, among other things: (1) the measures are still relevant (relevance), (2) the measures have been met (effectiveness), (3) whether the relationship between costs and Benefit equals efficient, and (4) whether the level of EU policy is coherent.

External (costs)

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) in order to achieve an efficient outcome (Jahn et al. 2020). Frémont and Franc (2010) showed that the transportation sector is the only major sector of the economy in the EU that is responsible for a growing percentage of CO_2 in total emissions of the EU. Nevertheless, the per unit emissions have decreased significantly over the last decades, for reasons of cleaner engine technologies or economies of scale. However, the action for policy is enormously and the acceptance of combined transport is highly relevant from the external costs relations to other transport modes as trucks to haul freight.

Costs (internal)

Costs, for example, that incur regardless of the length of transportation are:
1) infrastructure costs,
2) transshipment costs, and
3) administration costs.

Reduced terminal costs are relevant for the competition between the modes and are able to re-distribute or rather to reshape the competition of the modes. Modern terminals are subject to high fixed costs, the investment costs are immense. The utilization of the terminals is optimally at a maximum of 80%, after which further infrastructural adjustments are necessary due to avoiding congestion costs. The terminal infrastructure always includes or is defined by the superstructure and the digital infrastructure, which is becoming increasingly important. They are all relevant to be addressed by policy instruments.

Table 4.1. Framework conditions for the combined transport development

Railway infrastructure	Liberalization and regulation	External (costs)	(Internal) Costs
• 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	• CO_2 eqv. costs • 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 4.2). The further adjustment screw is in which modal split changes are to be brought about in order to achieve a corresponding control towards more combined traffic and terminal efficiency.

Table 4.2. Policy options to raise efficiency of CT 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 eqv. 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 • Eliminating market barriers • TEN-T core and comprehensive network corridors

Source: Schulte (2017), own elaboration.

4.4.2. Scope of action for the EU and BSR

The CT in Europe shows that the BSR includes many countries with a high rail share in the link between Central and Eastern European countries such as Western Europe. The most traffic goes to Germany. However, some selected characteristics for the BSR CT market is: (1) various number of sea ports with growing volumes; (2) different track gauges (standard gauge 1,435 mm in Poland, Germany, Denmark, and Sweden, and 1,520 mm gauges in Estonia, Latvia, Lithuania, and Finland) and track/train compatibility; (3) semi-interoperability for the modal shift of semi-trailers electrification; and (4) and rail share in total freight volume and intermodal share in rail freight is very heterogenous distributed between the Baltic Sea and EU countries. The conclusion is that especially the Central and Eastern European countries have a great potential to increase the shares of intermodal transport. The fact of this increasing intermodal transport results in more investments needs for terminals (Bielenia et al., 2020; Bochynek et al., 2020; Wiśnicki, 2020).

The scope of action for the development of terminals in the BSR relies on the above outlined major capabilities. 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 and service frequency) on the one hand, and with regards to energy and environment on the other (e.g., emissions reduction and other external effects reduction). Common challenges that have been identified are congestions and infrastructure, organizational and process optimization, such as energy and sustainability (Rodrigue et al. 2017).

Figure 4.1. summarizes the different levels of interaction for seaport and inland terminal, which are guided by the most important capabilities and function.

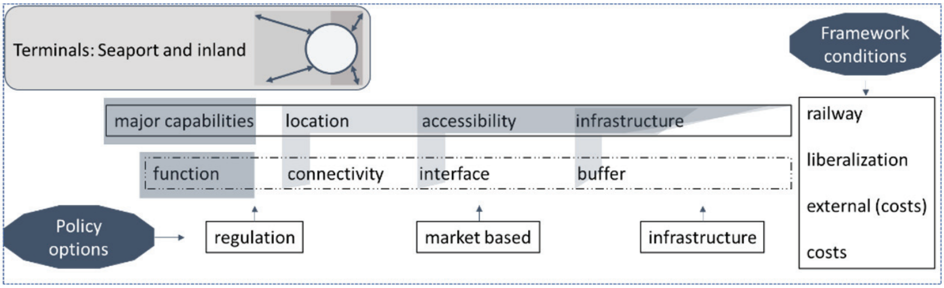


Figure 4.1. Terminals—scope of action

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

Congestions and infrastructure

The terminal position is relative, the situation can change over time regarding the 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 terminal serve as destinations there are de-facto nodes for composition (first mile) and decomposition (last mile). Terminal, moreover, are linked to the concept of centrality, the "origin" or the "end" of the traffic volume, or to the concept of intermediacy, the intermediate node in freight transportation.

Studies preparing for infrastructure investment should include a demand forecast of intermodal transport services. The transport node 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 ITU that can be generated by industry and habitants in the close and distant area of terminal road haul service. As a distant service area, Wiśnicki (2020) recommend a freight truck travel time of up to 90 minutes to/from the terminal should be assumed as the maximum value. However, other authors recommend on medium and short distances up to 100 to 300 km goods, road transport is at this distance faster and presents more flexibility than any other mode of transport (Carboni et al., 2018; Jahn et al. 2018; UIC, 2020).

A new terminal location should be of multi-criteria choice, of which the most important criteria is the access to transport infrastructure and the economic potential of the terminal service area. In the first group of criteria, locations with access to transport infrastructure of international significance within TEN-T corridors. Trimodal terminals should be considered with access to the waterway network. In the second group of criteria, large areas for investment are consumed, i.e., large rail-road terminals are determined by a minimum area of at least 50 ha.

Organizational and process optimization

From the point of view of the terminal operator, 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, but still the integration into global value chains will continue to grow.

Internal costs are costs that a business bases its price on. The faster these terminals operate and the lower the operational costs are, the higher the competitiveness of the combined transfer (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 in market practice is a gradual terminal transition from 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 terminal cooperation with one large or several smaller logistics centers guaranteeing sufficient cargo volume, i.e., at a level above 0,1 million ITU.

In addition to investments in the infrastructure, 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 through price reductions in off-peak times;
- Improvement of the punctuality in the main run to reduce buffers, respectively to raise capacities;
- Efficient control and automation of processes; and
- Implementation and adaptation of innovative information and communication systems to push, diversify and prioritize terminal services.

A large number of national and European directives and standards are relevant for the legal background of combined transport. Main EU-directives are 92/106/EEC, 96/53/ECC, and 2015/719/EU (amending of 96/53/EEC (EC 1992, EC 1996, EC 2015, SGKV 2021.) The directives help particularly to standardize cross-border traffic, also in the BSR. Consistent implementation helps to integrate planning reliability and legal certainty.

Energy and sustainability

Besides 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 is always in conflict with social and environment conditions. Transport in general has an impact on climate change and is impacted by climate change. Transportation amounts for an enormous percentage share of CO_2 emissions (around 24% worldwide) (Jahn et al. 2020; Rodrigue et al. 2017 Frémont and Franc

2010; Froese et al. 2019). Terminal can be regarded as a major player in the transition of the transportation sector. Intermodal 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, accidents, congestion, or noise. CT is less costly in external costs (Jahn et al. 2020).

Moreover, new terminals should be managed and adapted to the automation of terminal processes, starting with appointment system and inspections at terminal gate up to selected transshipment operations. Conventional terminal will transform into a fully automatic combined terminal, but technology is important for terminals that should offer their clients complex energy monitoring and carbon footprint tracking, i.e., monitoring of CO_2 emissions.

Figure 4.2. summarizes the main challenges that affect the seaport and inland terminals. It becomes clear that the interfaces of the measures and instruments should influence the policy options (1) regulation, (2) market based, and (3) infrastructure.

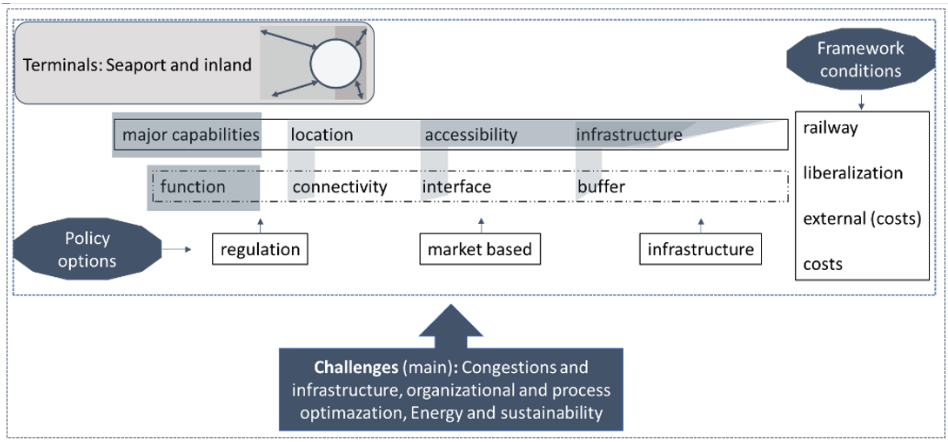


Figure 4.2. CT Terminals scope of action and (main) challenges

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

Measures for action in a time dimension 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 2x2 matrix that results in the following four groups of a "How-Now-Wow"-model (Przybyłek and Zakrzewski 2018).

1. 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" that fill existing gaps and result in incremental benefits. They consist of process optimization (e.g., through digitization), increased measurement of environmental indicators, management problems, and enhanced

efficiency. These are measures that fill existing gaps in processes and result in incremental benefits.

2. Second, measures with a low "level of transportation integration" combined with a high "burden of implementation due to technical and financial boundaries" are labelled as "Regulation". Breakthrough measures in terms of impact, but absolutely impossible to implement given to current technology/budget constraints are sorted here.
3. Third, measures with a high "level of transportation integration" potential but also a high "burden of implementation due to technical and financial boundaries" are entitled as "Infrastructure" and contain breakthrough measures that are somehow impossible to implement with the current state of technology and budget. Similar to the previous two groups, the focus lies on process optimization. An example, but visionary, 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 or dry ports). On the other hand, on the non-vessel side, all other vehicles such as cranes or trucks shall switch from fossil fuels to electric engines.
4. 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.

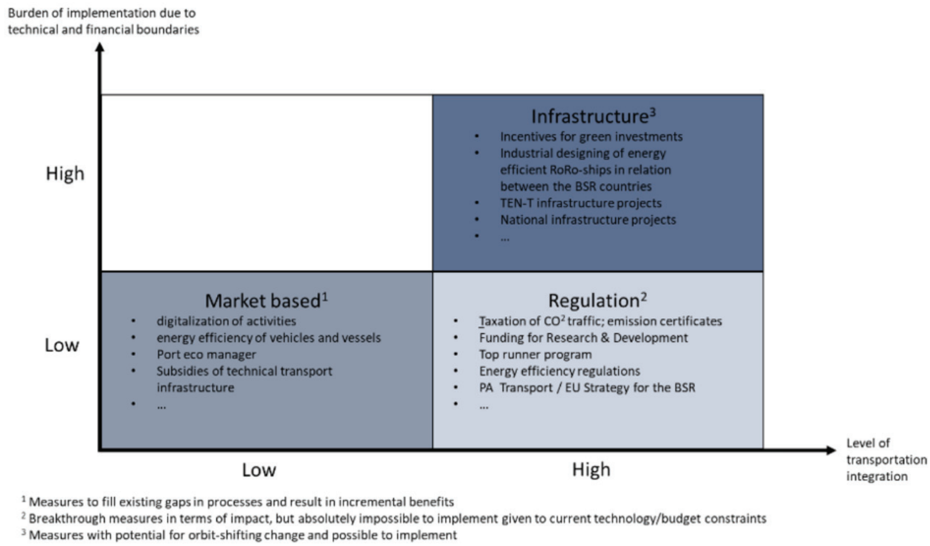


Figure 4.3. Measures and instruments for terminal development

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

In Figure 4.3, 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 BSR are highlighted within the matrices.

5. Loading units used in combined transport

In CT, loading units represent the object of transshipment while protecting the goods to be transported. Handling of loading units takes place in terminals and is a central component within combined transport chains where the mode of transport is changed. Transshipment systems are used to switch consignments from one mode of transport to another (i.e., road, rail, and waterway). The most common and widely known type of loading units are containers, as these can be transported across all modes in CT. A vehicle itself can also be loading unit. In course of various innovations of transport modes, different forms of loading units as well as corresponding specific handling systems have been developed and adapted to the individual requirements of loading units. Due to bulk freight transport, particularly as a consequence of international / intercontinental maritime transport, standardization with respect to the size and feature of loading units has prevailed. As a consequence of the mentioned standardization, loading units ensure:

- economically viable and easy handling,
- beneficial utilization of space ,
- easier storage, and
- better options for gathering information, statistics, and accounting.

However, the advantages outlined above only apply if transport, handling and storage operations are generally recognized and internationally standardized. Within global cargo flows, several loading unit systems have been developed that support various types of transport and handling. Characteristic are hereby maritime and continental loading units, each having different technical properties, possible applications and variations due to their respective use (SGKV & UIRR, 2020).

According to 2020 Report on Combined Transport in Europe, in the BSR the structure of maritime and continental transports was 74% of maritime and 26% of continental services (UIC 2020). A country-by-country examination shows a large variety of ILU mix in the BSR countries: for Denmark and Poland, mainly containers are transported whereas in Sweden most of the consignments are based on the use of semi-trailers. It is therefore essential to understand the logistics needs in terms of equipment by the various BSR countries (SGKV & UIRR, 2020).

5.1. Containers

In CT, containers represent the most important loading unit, as they can be transported by all means of CT, namely road, rail, and barge. Containers are also used in maritime shipping, which is why hinterland transport in particular can be handled by CT. The standardization of containers makes it easier to switch between modes of transport, as the handling equipment in terminal is geared to standardized dimensions. In CT, mainly 20-foot and 40-foot containers are used (Figure 5.1) (SGKV, 2019).

Figure 5.1. An exemplary 40' container

Source: UIRR Picture Gallery.

In the BSR, ISO-containers consist of 40% of used units (following semi-trailers, which account for 58%). It is worth pointing out that when it comes to the European CT market, the ISO-containers account for almost two thirds of the whole market (Table 5.1) (UIC, 2020).

Table 5.1. Maritime Loading Units

Maritime Loading Units	
Container	
	
	
Advantage	**Disadvantage**
Standardization	Lack of compatibility with Euro pallets
Robust	Difficult loading and unloading (parking only possible on the ground)
Stackable	Non side-doors possible
Space-saving storage	
Worldwide application	

Source: Maritime and Continental Loading Units (SGKV, 2019).

Since containers can be moved by all transport modes, they represent the most important loading units in CT and allow for easy handling between modal systems. Containers are designed to be moved with common handling equipment, thereby enabling high-speed intermodal transfers in economically large units between ships, railcars, truck chassis, and barges using a minimum of labor (SGKV & UIRR, 2020). Containers enable good logistical management of the areas used for loading and unloading goods, since their rigid structure enables them to be stacked in one pile (UIC 2015).

There are different types of containers and the type of container suitable for transport depends on the goods to be transported (Table 5.2, note the pictures *(i.e., illustrations by SGKV 2019)* represent different kinds of available containers with special features and purposes).

Table 5.2. Types of containers

Standard 20-foot container	Standard 40-foot container	45-foot container	Hardtop	Ventilated container
				
Tank container	Reefer	Open-top	Bulk container	Flat rack container
				
				

Source: Illustrations by SGKV 2019.

Containers are identified by various markings on the door side containing important information for players along the transport chain to ensure smooth operation (Figure 5.2).

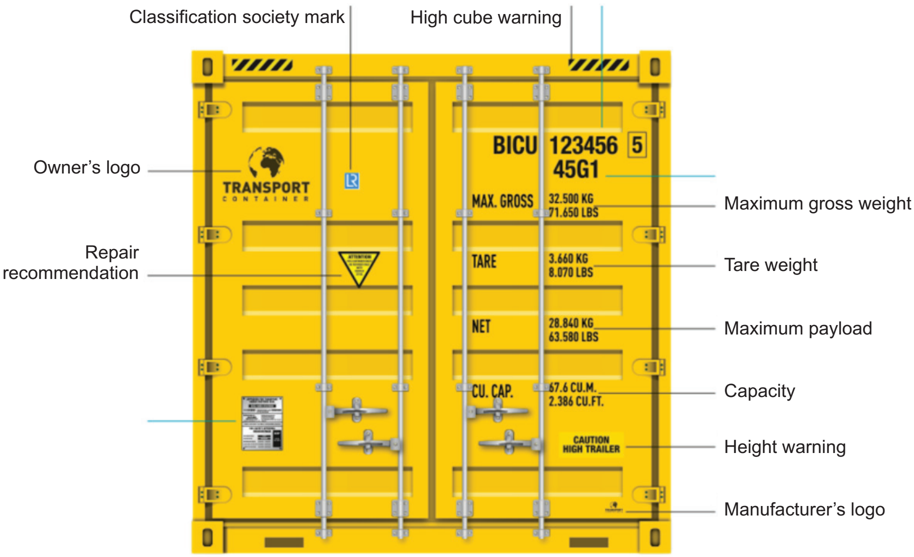


Figure 5.2. Various markings on the door side

Source: SGKV 2019.

The classification of containers is presented in Figure 5.3 (UIC 2020, source UIRR).

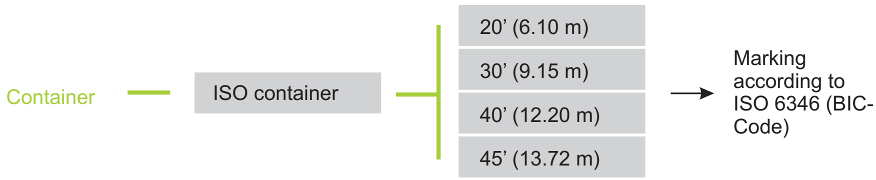


Figure. 5.3. Classification of containers

Source: UIRR data, 2021.

The average technical transport lifetime for ISO-containers is 17.8 years with an average age of 9.3 years (UIC, 2020).

5.2. Semi-trailers

In the BSR, the semi-trailer is the predominant ILU-type (58%), whereas on the European CT market, the market share for semi-trailers is 21% (Figure 5.4 and Table 5.3) (UIC, 2020).

Figure 5.4. An exemplary semi-trailer

Source: UIRR Photo Gallery.

Table 5.3. Continental Loading Units—Craneable and non-craneable semi-trailers.

Continental Loading Units	
Craneable and non-craneable Semi Trailer	
	
	
Advantage	Disadvantage
European dimension requirements	No stackability
Compatible with European pallets	Partly no intercontinental transport from overseas possible (e.g. semi-trailer)
Europe-wide application and in continental non-European countries (e.g. China)	Tractors required for any kind of movements

Source: Maritime and Continental Loading Units (SGKV, 2019).

The advantage of semi-trailers is that they can be coupled directly to a tractor and do not require a road chassis, unlike containers and swap bodies. However, they are more costly and heavier (UIC, 2015).

The classification of semi-trailers is represented in Figure 5.5 (UIC, 2020, source UIRR).

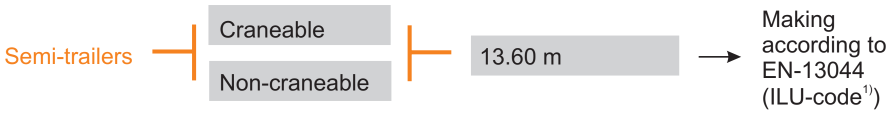


Figure 5.5. The classification of semi-trailers

Source: UIRR, 2021.

Craneable semi-trailers are utilized in CT (30% in total). However, approximately 70% of all semi-trailers are still non-craneable, most of which are standard non-craneable semi-trailers (UIC, 2020).

Semi-trailers are used in continental logistic chains due to their compatibility with Euro Pallets. However, the fact that only a fraction of semi-trailers is craneable, poses several challenges for utilizing them in combined transport. In addition, specific handling technologies are not common in European terminals, which in turn poses another bottleneck for unlocking the potential of continental CT. However, some innovative transshipment solutions are in operation also in the BSR (SGKV & UIRR, 2020). In order to achieve a further shift of freight traffic volumes off the road to rail or waterways, there is great potential in the use of innovative handling technologies for non-craneable loading units (ERFA KV, 2020).

The average technical transport lifetime for semi-trailers is 10 years and average age 7.4 years. According to 2020 Report on Combined Transport in Europe, interoperability for the modal shift of semi-trailers electrification is needed in the BSR (UIC, 2020).

5.3. Swap bodies

Swap bodies, standardized loading units equally suitable for carriage on road vehicles and on railway wagons, can be used in a broad range of situations, are simple in design and reasonably priced. Swap bodies cannot be used in combined rail-sea transport but are sometimes used in transport by inland waterway (UIC 2015). Their main disadvantages are limited stackability and lack of wheels. In the BSR, swap bodies only account for 2% when it comes to CT structure regarding used units. On the European CT market, the market share of swap bodies is 17% (Figure 5.6 and Table 5.4) (UIC, 2020).

Figure 5.6. An exemplary swap body

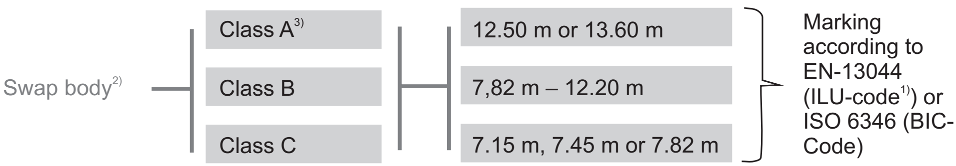
Source: UIRR, picture gallery.

Table 5.4. Continental Loading Units—swap body.

Continental Loading Units	
Swap Body	
	
Advantage	Disadvantage
European dimension requirements	No stackability
Compatible with European pallets	Partly no intercontinental transport from overseas possible (e.g. semi-trailer)
Europe-wide application and in continental non-European countries (e.g., China)	

Source: Maritime and Continental Loading Units (SGKV, 2019).

The classification of swap bodies is represented in Figure 5.7 (UIC 2020, source UIRR):



1) Consists of three parts: owner-key, registration number and check digit
2) Known as non-ISO containers
3) Incl. 45PW containers, refrigerated- and tank-containers

Figure 5.7. The classification of swap bodies

Source: UIRR data, 2021.

Classes A (41%) and B (37%) make up nearly 80% of all swap bodies used in CT, whereas the remaining 21% are class C swap bodies. The average technical transport lifetime for swap bodies is 10.7 years with an average age of 7.6 years (UIC, 2020).

6. Transshipment technologies used in combined transport

The transshipment of loading units takes place in terminals and is a central component within CT chains. Transshipment systems are used to switch consignments from one mode of transport to another (road, rail, inland waterway, and short-sea-shipping).

The most important transshipment systems are divided into horizontal and vertical functions (type of movement or transshipment):

- With vertical transshipment, CT load units are lifted and reloaded from or onto different modes of transport using a lifting system and stacked for intermediate storage. This type of handling is standard equipment in many terminals and has proven itself as almost all ILUs might be turned vertically.
- Horizontal means that the loading unit is turned across or lengthways or diagonally to the transport carrier. Horizontal transshipment is mainly used for non-craneable loading units and is particularly suitable for transshipment between trucks and trains.

6.1. Vertical transshipment technologies

This section presents current state of most important and most often used in CT vertical transshipment technologies in a most user-friendly form using a common template for presenting special characteristics and features of selected technologies, complemented by information referring to main sources describing specific technology.

6.1.1. ISU (Innovativer Sattelauflieger Umschlag)

<table>
<tr><th colspan="2">ISU Innovativer Sattelauflieger Umschlag</th></tr>
<tr><td>Classification</td><td>Description</td></tr>
<tr><td>Semi-trailers
☐ Craneable
☒ Non craneable

Containers /Swap Bodies
☐ Maritime
☐ Continental</td><td>The ISU-System includes a small mobile platform. First the trailer is parked on a small mobile loading platform. After the tractor has left, the trailer is lifted into a classical pocket wagon by special lifting gear with wheel grippers. This system allows direct handling of non-craneable trailers without any new terminal infrastructure or modifications. This lifting can be operated by a reach stacker or a gantry crane. The system allows lifting of trailers with measures 4m (height) by 2,6m (width). As part of the ISU-system (wheel grippers, traverse) travels with the cargo, for parallel transshipments acquisition of multiple systems is necessary. Loading time per LU is six minutes.</td></tr>
<tr><td colspan="2">Market Segment</td></tr>
<tr><td colspan="2">☐ maritime CT   ☒ continental CT</td></tr>
<tr><td colspan="2">Sources</td></tr>
<tr><td colspan="2">(1) https://blog.railcargo.com/en/artikel/lkw-chassis-huckepack-auf-schiene
(2) https://www.youtube.com/watch?v=a_83Z7SH5RU&t=87s</td></tr>
<tr><td colspan="2">Illustration</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Source: https://blog.railcargo.com/en/artikel/lkw-chassis-huckepack-auf-schiene

6.1.2. NiKRASA

<table>
<tr><th colspan="2">NiKRASA</th></tr>
<tr><td>Classification</td><td>Description</td></tr>
<tr><td>Semi-trailers
☐ Craneable
☒ Non craneable

Containers /Swap Bodies
☐ Maritime
☐ Continental</td><td>The system NiKRASA is a system consisting of a terminal platform and a transport platform. It consists of two components: An easy to install terminal platform onto which trucks can drive, and the transport platform. The transport platform is used as a tool to shift a non-craneable semitrailer from road to rail. The system does not require any changes of the trailer, wagons or terminals. It is a system which enables non-craneable semitrailers to be loaded onto standard pocket wagons.
NiKRASA was developed by TX Logistik AG, Bayernhafen Gruppe and LKZ Prien GmbH and was officially launched in 2014. It is a type of vertical transshipment technology, as the NiKRASA-racks are moved by cranes. The total time of transshipment process per loading unit is 3 minutes.</td></tr>
<tr><td colspan="2">Market Segment</td></tr>
<tr><td colspan="2">☐ maritime CT ☒ continental CT</td></tr>
<tr><td colspan="2">Sources</td></tr>
<tr><td colspan="2">(1) https://www.txlogistik.eu/en/services/nikrasa/
(2) https://youtu.be/yJ3XD_AFhQw</td></tr>
<tr><td colspan="2">Illustration</td></tr>
<tr><td colspan="2">
The truck drives onto the terminal platform and sets the trailer down at the centre.

The trailer, on the NiKRASA transport platform, is then lifted by a gantry crane or reach stacker.

...onto a pocket wagon. The terminal platform remains at the loading point, while the transport platform goes with the semitrailer on its journey by rail.</td></tr>
</table>

Source: https://www.txlogistik.eu/en/services/nikrasa/.

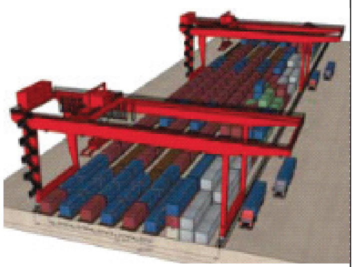
6.1.3. Reachstackers (or mobile cranes)

Reachstackers (Mobile Cranes)	
Classification	Description
Semi-trailers ☒ Craneable ☐ Non craneable Containers /Swap Bodies ☒ Maritime ☒ Continental	A Reachstacker is a mobile crane that is the most widely used CT technology on terminals to unload, reload, pile up or move containers. With an empty weight of approx. 100 t it can move loads up to 50t. Reachstackers are designed to manage loading units. They are produced by different companies and in usage since 1980. The reachstacker is used on most terminals. At small terminals it might be the leading technology, at big terminals an addition for specific situations.
Market Segment	
☒ maritime CT ☒ continental CT	
References	
(1) https://www.youtube.com/watch?v=kpY_PSkySwc	
Illustration	

Source: UIRR data, 2021.

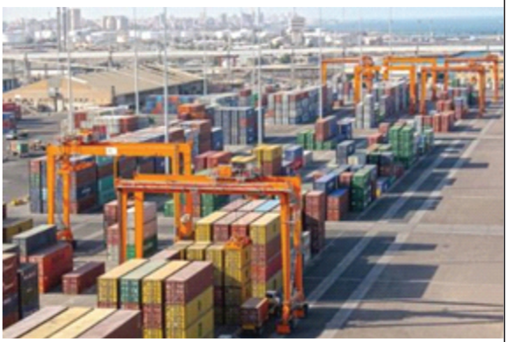
6.1.4. Cranes

<table>
<tr><th colspan="2">Rail Mounted Gantry cranes (RMGs)</th></tr>
<tr><td>Classification</td><td>Description</td></tr>
<tr><td>Semi-trailers
☒ Craneable
☒ Non craneable

Containers /Swap Bodies
☒ Maritime
☒ Continental</td><td>Rail Mounted Gantry Cranes (RMG) stand on both a rigid support and a pendulum support, which compensates for the temperature-related material expansion of the steel structure. These cranes are used for loading and unloading trains or direct transshipment between trains as well as for managing blocks.
They usually span several tracks. In addition, RMGs with longer overhangs on one side permit transshipment between road and/or rail and inland waterway. In this case, the gantry crane is also a quay crane. Due to the rail guidance, gantry cranes can only travel longitudinally between directly adjacent blocks.
They can serve blocks with several rows due to their large span, being able to traverse up to 13 rows and have spans of up to 60m (sometimes up to 80m). Under the crane, the loading units can be stacked in six to ten layers high depending on the design, though one layer must be kept free for the longitudinal and transverse transport of loading units. Their advantage is better access to loading units in a container block, as access is from above. Depending on parameters such as carrier mix, loading unit mix and plant layout an RMG can perform up to 30 lifts per hour.</td></tr>
<tr><td colspan="2">Market Segment</td></tr>
<tr><td colspan="2">☒ maritime CT ☒ continental CT</td></tr>
<tr><td colspan="2">References</td></tr>
<tr><td colspan="2">(1) (1417) Liebherr - Rail Mounted Gantry Cranes (RMG)–YouTube</td></tr>
<tr><td colspan="2">Illustration</td></tr>
<tr><td colspan="2"> </td></tr>
</table>

Source: UIRR data, 2021.

<table>
<tr><th colspan="2">(2) Rubber Tired Gantry cranes (RTGs)</th></tr>
<tr><td>Classification</td><td>Description</td></tr>
<tr><td>Semi-trailers
☒ Craneable
☒ Non craneable

Containers /Swap Bodies
☒ Maritime
☒ Continental</td><td>Rubber Tired Gantry Crane (RTG) is similar to an RMG with rubber tires instead of steel wheels on tracks. Depending on the model, they are equipped with 4, 8, or 16 wheels and are able to span between five and nine rows plus lane. The wheels can be rotated 90°, thus allowing a high degree of flexibility. The loading gear usually consists of a spreader and can also be equipped with grippers. Most RTGs are assigned to one or more blocks and can be moved freely between them.
RTGs offer the advantage that they can move between different tracks/ blocks and thus also serve blocks that are not directly adjacent. The performance of RTGs is up to 25 movements per hour - these values, however, depend essentially on parameters such as carrier mix, load unit mix and system layout.</td></tr>
<tr><td colspan="2">Market Segment</td></tr>
<tr><td colspan="2">☒ maritime CT ☒ continental CT</td></tr>
<tr><td colspan="2">References</td></tr>
<tr><td colspan="2">(1) (1417) Liebherr–Rubber Tire Ganry Cranes working at Dublin Port, Ireland–YouTube</td></tr>
<tr><td colspan="2">Illustration</td></tr>
<tr><td colspan="2"> </td></tr>
</table>

Source: UIRR data, 2021.

<table>
<tr><th colspan="2">(3) Ship to Shore cranes (STS)</th></tr>
<tr><td>Classification</td><td>Description</td></tr>
<tr><td>Semi-trailers
☐ Craneable
☐ Non craneable

Containers /Swap Bodies
☒ Maritime
☐ Continental</td><td>STS (also known as ocean terminal cranes) are the direct interface between the ocean vessel and the land and are frequently fixed in position though there are versions which can move on wheels as indicated. Their function is to unload containers from ships as quickly as possible by moving them from ship to shore only. They can be divided into three classes: 1-cat (single-trolley), 2-cat (double-trolley) and 3-cat (triple-trolley) cranes with double-deck container transfer wagons.
Operationally they move 22 to 30 containers per hour. For large ships several cranes can be mounted side by side or opposite each other.</td></tr>
<tr><td colspan="2">Market Segment</td></tr>
<tr><td colspan="2">☒ maritime CT ☒ continental CT</td></tr>
<tr><td colspan="2">References</td></tr>
<tr><td colspan="2">(1) (1417) How to operate a STS Gantry Crane? Joystick CAM!! Loading a BIG vessel in the Port of Antwerp–YouTube</td></tr>
<tr><td colspan="2">Illustration</td></tr>
<tr><td colspan="2"> </td></tr>
</table>

Source: UIRR data, 2021.

6.1.5. Forklift truck

Forklift Truck	
Classification	Description
Semi-trailers ☐ Craneable ☐ Non craneable Containers /Swap Bodies ☒ Maritime ☒ Continental	Equipped with two forks at the front, depending on size, it is able to lift a wide variety of loads, from pallets to 20ft containers with sockets in the base in which the forks fit. As loads are carried close to the ground, they can move quickly but their ability to stack containers is limited.
Market Segment	
☒ maritime CT ☒ continental CT	
References	
(1) (1417) Maritime Training: Container Yard Forklift Safety–YouTube	
Illustration	
 	

Source: UIRR data, 2021.

6.1.6. Straddle carriers

<table>
<tr><th colspan="2">Straddle Carriers</th></tr>
<tr><td>Classification</td><td>Description</td></tr>
<tr><td>Semi-trailers
☒ Craneable
☐ Non craneable

Containers /Swap Bodies
☒ Maritime
☒ Continental</td><td>These are rubber tired devices for vertical handling, moving and container stacking on a level and paved surface. They are also referred to as gantry stackers. They consist of a gantry and a lifting device with a spreader suspended in between, which can be used for exact positioning above the container with transverse and rotational movement. With power applied to up to eight rubber wheels, they can transport 20ft and 40ft containers. In addition to container operation the loading and unloading of trucks and semi-trailers is also possible. As they are not fixed to a location they are very flexible and can be used everywhere within a terminal.</td></tr>
<tr><td colspan="2">Market Segment</td></tr>
<tr><td colspan="2">☒ maritime CT ☒ continental CT</td></tr>
<tr><td colspan="2">References</td></tr>
<tr><td colspan="2">(1) (1417) Kalmar automated straddle carriers at TraPac, Los Angeles–YouTube</td></tr>
<tr><td colspan="2">Illustration</td></tr>
<tr><td colspan="2"> </td></tr>
</table>

Source: UIRR data, 2021.

6.1.7. Masted Container Stacker

Masted Container Stacker	
Classification	Description
Semi-trailers ☐ Craneable ☐ Non craneable Containers /Swap Bodies ☒ Maritime ☐ Continental	In these vehicles, the driver's position is elevated to provide better visibility. With only vertical lifting it is only possible to stack containers in the front row of a block of containers which limits their use. In side lift configuration they can only move empty containers. Stacking containers high uses space efficiently, when stacked, strong wind can affect the stability.
Market Segment	
☒ maritime CT ☒ continental CT	
References	
(1) (1417) Kalmar Empty Container Handler DCG80-100–YouTube	
Illustration	
	

Source: UIRR data, 2021.

6.2. Horizontal transshipment technologies

Comparable to the innovative vertical handling technologies, horizontal systems are mainly used for non-craneable loading units. In the light of the increasing demand for transport of semi-trailers by rail, these horizontal technological systems have been developed to facilitate and increase the efficiency of transshipment–although cost-effectiveness and compatibility of the systems have to be evaluated on a case-to-case basis.

The main characteristic of horizontal transshipment systems is that during the handling process the loading units are not raised at all or just slightly in order to be removed from the attachment of the transport carrier. Horizontal means that the loading unit is handled transversely, longitudinally or diagonally to the transport carrier. This system is particularly suitable for transshipment between trucks and trains.

No special equipment is required for horizontal-longitudinal transshipment, as the loading unit either travels independently onto the means of transport (truck) or is driven by means of a special terminal tractor (semi-trailers in the RoRo process). Special handling equipment is required for horizontal-parallel and diagonal handling. Horizontal-diagonal transshipment is a special requiring specific terminal infrastructure. In addition, special wagons are needed (Table 6.1).

Table 6.1. Horizontal handling according to type of movement

Longitudinal	Parallel	Diagonal
Rolling Motorway (Ro-La)	CargoBeamer	Modalohr
Roll-on Roll-off (RoRo)		MegaSwing^{TM} Duo

Source: UIRR data, 2021.

6.2.1 Ro-La

Ro-La describes the loading of the complete truck, including tractor and loading unit, onto the rail. Loading is carried out by means of a mobile loading ramp (without additional handling equipment). Then the truck is driven onto the pocket wagons by the driver himself. In other words, Ro-La can be described as the system of transporting a lorry by rail on a special rail wagon. The truck, i.e., tractor unit with semi-trailer or truck with trailer, travels specific sections of its route across Europe by rail–thus combining road and rail transport in this valuable combination. It is worth mentioning that the Ro-La loading system is called sequential loading (one vehicle after another through a moving ramp). At this point, it is worth mentioning the advantages and disadvantages of the Ro-La reloading system.

The main economic advantages include: cost savings (e.g., fuel and toll), time saving by avoiding traffic jams, and bypassing night and weekend driving bans (i.e., a driver can comply with statutory rest period without interrupting transport).

The main environmental advantages are: reduction of GHG emissions (e.g., CO_2) due to transport by rail instead of by road, high personnel costs (i.e., not only the train conductor but also the truck drivers take part in the transport), and high dead load (i.e., weight of the tractor unit), as the cab or tractor apart from the semi-trailer unit is also transported.

In practice, Ro-La is only profitable on a few routes, usually over long distances with geographical obstacles (e.g., mountains in transalpine traffic to/from Austria and Switzerland).

6.2.2. CargoBeamer

CargoBeamer	
Manufacturer	CargoBeamer Ag, Germany
Picture	 https://www.cargobeamer.com/Technologie-758631.html
Applicability	Craneable and non-craneable semi-trailers, Megatrailer, Tank-, silo-, and refrigerated trailers
Functional Principle	The core of the system is a special tub-shaped wagon attachments, which can be loaded and unloaded at the same time. In a CargoBeamer terminal, the loading unit is delivered by truck, which drives with the semi-trailer onto the waiting CargoBeamer wagon attachment, saddles off and drives out. The tank-shaped wagon attachments are pushed onto the wagon by a special conveyor system known as the CargoBeamer Jet. The loading and unloading of the wagon attachments can take place simultaneously. After the side walls of the wagon have been closed, the wagon top including the semi-trailer is lowered and secured at the kingpin. The side walls lock automatically. Subsequently, the side wall swivel units move out of the clearance gauge. The train is now ready to leave. The wagon attachments are craneable (by crane, reach stacker, etc.) and can therefore be handled in conventional CT terminals. This system is a modular construction: 36 modules or semi-trailers form a 700 m track.
Capacity (handling time)	With approximately 9 minutes, the loading time for an entire train is short. This involves the loading and unloading of 76 (non-)craneable units or 36 handling modules.
Area required	21.4 x 750 m, approximately 16,000 m^2
Energy required	36 kWh per transshipment of an entire train
Investment costs	Approximately EUR 16.5 million for 36 modules (700 m of track). However, these values are location-dependent and fewer modules can be installed. Transport costs per loading unit approx. between 0-0.35 and 065 €/Km (manufacturer’s data)

Personnel	Personnel costs are low because the system is fully automated, one person is sufficient for the handling process. One additional driver might be necessary who parks the trailer correctly.
Parallel handling	Yes
Fully automated	Yes
Special terminal infrastructure	Yes, CargoBeamer Terminals
Correspondence terminal	No
Pro's	Time savings during transshipment; delivery and transshipment of the trailers are decoupled from each other since the truck does not have to wait for the train and vice versa. The exchange concept of the tubs enables fast transshipment at borders to countries with broad gauge. Furthermore, no correspondence terminal is necessary, as the tubs can be craned (gantry crane or reach stacker). Compared to pure road traffic, the CargoBeamer reduces costs by more than 10% per transport unit, depending on the route.
Con's	Relatively high investment costs; the system is designed for block train line traffic / haul and thus dependent on certain infrastructure; exchange wagons have to be carried along (dead weight).
More information	https://www.cargobeamer.eu/

Source: https://www.cargobeamer.eu/.

6.2.3. Modalohr / Lohr

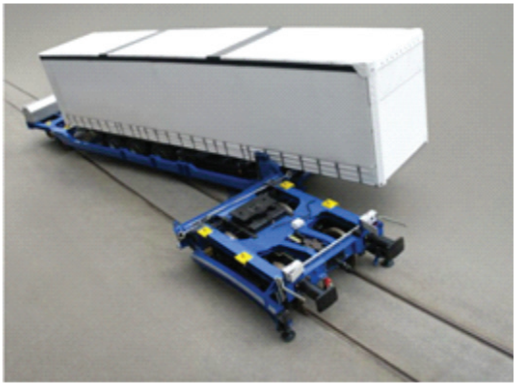
Modalohr[1]	
Manufacturer	Groupe LOHR, France
Picture	 https://lohr.fr/de/lohr-railway-system/

[1] A table listing terminals in Europe where the Modalohr technology is in operation including the corresponding handling volumes can be found in the appendix.

Applicability	Craneable and non-craneable semi-trailers (max. 4.04 m corner height, max. 13.7 m length, max. 38 t), Megatrailer, Tractor unit
Functional Principle	The LOHR Railway System (Modalohr) has a lift-swivel system installed between the rails. After the train has entered, the wagon pockets are unlocked by this system and swung out for loading (30°) using hydraulically driven idlers. The truck or a terminal tractor drives over the ramp into the swing-out tub of the special wagon, places the semi-trailer and leaves the tub in the direction of traffic. The pocket wagon then swings in again and the loading unit is loaded. Instead of two ramps, the track can also be lowered, i.e., to the asphalt surface of the terminal. The third generation of the LOHR UIC wagon is already available.
Capacity (handling time)	Fast transshipment possible as complete train can be loaded and unloaded at the same time (depending on existing terminal structure); if sufficient personnel is available, the complete train can be loaded and unloaded in less than 15 minutes. Assuming a loading time between 30 and 60 minutes, unloading takes approximately 60 to 90 minutes is, however, more realistic. This results in a capacity of 9 to 16 trains or 345 to 576 trailers per day for a load of 36 trailers per train.
Area required	High, 57 m x 800 m for a 750 m train, approximately 45,600 m^2
Energy required	N/A
Investment costs	An average of EUR 11,000,000 is estimated for the construction of a new Modalohr terminal
Personnel in three-shift operation	12
Parallel handling	Yes
Fully automated	No
Special terminal infrastructure	yes
Correspondence terminal	yes
Combination with other systems	The system is designed for block train service within the Modalohr network. It can also be combined with regular pocket wagons.
Parallel handling	Yes
Pro’s	All standard semi-trailers (incl. mega-trailers) can easily be transported; Fast loading and unloading; Tested system that has proven its viability; transshipment under overhead / contact wire possible; trailers can drive in the direction of traffic on pocket wagons.
Con’s	Low flexibility (only block train line traffic); high investment in infrastructure required; relatively complex technology, very high area requirement (57m x 800m for 750m train); correspondence terminal necessary
More information	https://lohr.fr/de/lohr-railway-system/das-lohr-system/

Source: https://lohr.fr/de/lohr-railway-system/das-lohr-system/.

6.2.4. Megaswing

MegaSwingTM Duo	
Manufacturer	Helrom
Picture	 https://helrom.com/ https://www.zukunft-mobilitaet.net/1400/konzepte/megaswing-das-eigene-intermodale-terminal/
Applicability	Craneable and non- craneable semi-trailers
Functional Principle	The Megaswing system is a special pocket wagon with a swiveling tub-receptacle for semi-trailers. Hydraulic supports serve as stabilization when the tub swings out to the left or right. The tub is loaded backwards with a semi-trailer. After the semi-trailer has been uncoupled, the hull is lifted and swivels back in again. The semi-trailer is slightly lowered and firmly connected to the wagon; it is now securely stowed on the wagon. The technology is built into the wagon.
Capacity (handling time)	With the MegaSwing system it takes approximately 4.5 minutes handling one semi-trailer. A complete train is transshipped within 60-90 minutes, depending on personnel expenditure / availability
Area required	Low
Energy required	Low, comparable to container handling
Investment Costs	With EUR 270,000-340,000, Megaswing wagons are considerably more expensive than conventional pocket wagons. The costs for the terminal infrastructure, however, are largely eliminated.
Personnel	Personnel requirements are low since the MegaSwing can (theoretically) be operated by the truck driver.
Combination with other systems	The system is suitable for block train and single wagon traffic and can be carried with other wagons.
Parallel Handling	Yes, at high personnel deployment
Fully automated	No

Special terminal infrastructure	no
Correspondence Terminal	no
Pro’s	Flexible applicability, since the wagons can be used on almost any loading track (paved area required, loading and unloading also possible under overhead wires); all standard truck trailers can be transported; no terminal infrastructure required; the entire train is not affected if one wagon fails.
Con’s	High investment costs for the purchase of the special freight wagons; the receiving pocket of the MegaSwing pocket wagon can only be loaded backwards and requires high precision; technology installed on the wagon side which may be susceptible to maintenance; mutual obstruction possible when unloading in terminals with gantry cranes.
More information	http://www.kockumsindustrier.se/en-us/start/

Source: http://www.kockumsindustrier.se/en-us/start/.

6.2.5. Flexiwaggon

Flexiwaggon	
Manufacturer	Flexiwaggon AB, Sweden
Picture	 https://www.flexiwaggon.se/ what-does-the-mobile-truckstop-really-mean/
Applicability	Truck (from 9 m to 18.75 m length, max. 80 t)
Functional Principle	The swivel wagon is operated by hydraulics. Fully automated loading of the complete vehicle (incl. tractor). Unloading is also possible without a terminal. In contrast to MegaSwing, the trailers can be loaded forwards on the wagon and the tractor is carried along.
Capacity (handling time)	approx. 15 min per train (loading and unloading); loading and unloading on both sides possible (according to the manufacturer)

Area required	8m x length of the train (appr. 6,000 m^2)
Energy required	N/A
Investment Costs	Approximately EUR 300,000 per wagon, depending on equipment. More expensive than regular wagons: 0.45 €/km (according to the manufacturer)
Personnel	Personnel costs are low since the system is fully automated. One person can extend / swing out the wagon and, if necessary, another one can be deployed to drive the truck onto the wagon.
Parallel Handling	Yes
Fully automated	Yes
Special terminal infrastructure	No
Correspondence terminal	No
Combination with other systems	The system can be integrated in wagon group- and single wagon traffic
Parallel handling	Yes
Pro's	No additional terminal and no additional terminal infrastructure required. Loading and unloading on gravel possible. The vehicle can additionally be loaded and unloaded via three divergent options as well as under power lines. 80t vehicle load capacity.
Con's	Tractor unit accompanies the wagon, meaning that fewer semi-trailers can be transported and the proportion of dead load per container increases. The hydraulics of the wagons may be susceptible to maintenance; Experienced drivers required; Either time or personnel-intensive (depending on alignment)
More Information	http://www.flexiwaggon.se/

Source: http://www.flexiwaggon.se/.

7. Last mile solutions for the combined transport

One of the reasons indicated as the borders of CT development in BSR is big market competition from road heavy haulage. The BSR is home to a number of international road transport companies. Statistically, nearly two-thirds of Europe's heavy-duty fleet is registered in the BSR. As a result, it is crucial to understand the need to constantly develop necessary technologies in all CT operations to keep (continuously) improved economic effectiveness which can lead to bigger competition potential towards pure road haulage market. A closer look at the costs of the whole CT chain indicates that the largest costs per unit are connected with last mile operations, playing a crucial role for the overall CT chain efficiency. For the purpose of the e-book, technologies which are already in use or in the introduction/test process for CT last mile operations have been divided into two main groups–ncreasing capacity and alternative propulsions.

In general CT first/last mile operations (in the EU, inclusive of the BSR) are performed by road transport. It is of course connected with the definition of CT, but it is a result of high flexibility of road transport, which can be performed with the minimal infrastructure. Despite this, contemporary green deal policy leads the market towards providing low or zero emission solutions, thus for some European cities like Karlshruhe or Dresden solutions involving trams for last mile deliveries are under development (Karlsruhe) or in use (Dresden).

7.1. Last mile solutions–status quo

As it was mentioned, nowadays last mile operations are performed by road transport. Most popular combination for this task is to use a tractor unit. To keep the EU regulation regarding increased maximum permissible gross mass (Directive 96/53), some of the units are equipped with 6x2 axles configuration, however, the most popular are standard 4x2 units.

For ILUs like container or swap body, a tractor requires also proper container chassis. In the BSR and the EU, the most popular are three axle chassis with multiple configuration to transport variety of units starting from 1x20' in center or rear position, through 2x20’, and 1x40’ up to 1x45’ containers. Transportation of special ILUs require use of spatial chassis. Bulk containers requires chassis with tipping equipment, reefer needs energy gen-sets on trailer to plug in reefer unit, tank containers needs hoses to discharge or fill up the ILU, etc. (Figure 7.1).

Figure 7.1. Variety of European container chassis
Source: Schmitz Cargobull.

A wide range of trailer configurations available across the BSR and the whole of Europe means nothing in the case of improving the economic efficiency, due to capacity limited only to 2 TEU. Thus, the CT industry including trucking companies, supply chain stakeholders and equipment manufacturers continuously work on innovative solutions to increase the transportation capability.

7.2. Increasing cargo capacity solutions

The increasing capacity puts pressure on innovation which allows for a gain in efficiency on last mile operations. Referring to the definition, the capacity of the last mile has direct influence of economic spheres of the process. This chapter shows three innovative solutions for the different phases of development, that is: longer and/or heavier vehicles (LHV) are a solution partially in use with developmental advantages in all BSR countries. Trucks platooning and autonomous trucks are technologies where the first tests in Europe already are arranged. However, these two technological innovations are still not widely used in the market.

7.2.1. LHV Trucks

LHV Trucks in LM operations have risen from the development of EMS Technology widely used in Scandinavian countries starting from 1980s. The constant development and research on LHV led the market providing solutions suitable for LHV-use as the last leg for CT operations. Such development included the building fleet of container or swap body trailers, dollies, or B-double suitable for transporting ILU.

In fact, the current status of the modular system and access of LHV is not homogenous in all Member States. The status quo for maximum allowed vehicle parameters in the EU is indicated in the Directive 96/53. It gives allowance to work on 40 tonnes of Permissible Laden Mass (i.e., 44 tonnes for intermodal traffic) with a length of 18.75 m) (Council Directive 96/53/EC, 1996).

Presently, trucks longer or heavier than the indicated Directive 96/53 are accepted on roads in Finland, Sweden, Denmark, and Germany. Conditions of LHV carriage and maximum allowed parameters differ for each particular Member State. The BSR is divided into northwest–where LHV are allowed or are currently under trial (Table 7.1) – and southeast – where the limits are still set according to Directive 96/53.

Table 7.1. Maximum allowed truck parameters in BSR countries.

Country	Max weight [t]	Max length [m]
Finland	76	34.7
Sweden	74	25.25
Estonia	40	18.75
Latvia	40/42/44	18.75
Lithuania	40/44	18.75
Poland	40/42/44	18.75
Denmark	60	25.25
Germany	40/44	25.25

Source: own elaboration.

In general understanding LHV refers to trucks 25.25 m or longer developed in Scandinavia. In this e-book, to better understand specific BSR market conditions, the LHV definition will include also truck combinations which do not exceed the length but give the possibility to extend laden mass only.

LHV equipment

In order to meet legal requirements for the maximum weight of trucks, length or axle loads vehicle manufacturers prepare a sort of equipment used in CT in Europe. Currently, there are four main ways to build LHV according to EU legal requirements (Figure 7.2).

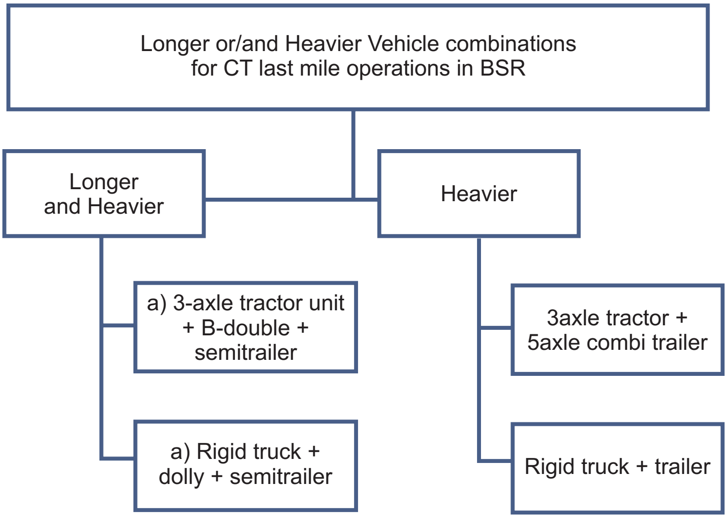


Figure 7.2. LHV combination varieties for CT operations

Source: own elaboration.

Base vehicles for most LHV, similar as for the standard configurations are tractor units. To meet legal requirements regarding CT operations and permissible axle loads, tractors used in LHV need to be equipped in three axles. Such units with a variety of engines and cabs are in portfolios of most truck manufacturers in Europe and BSR. Trucking companies can choose between 420-760 HP diesel engines but, lately, many manufacturers also offer LNG or CNG propelled units – with the near future looking at full plug in electric trucks. According to test runs recently conducted in Sweden, also fully electric trucks can serve the last mile up to 150 km one way in 60 tonnes LHV truck configuration (Volvo Trucks, 2021).

Heavier truck combinations

A number of ILUs transported in CT are considered as heavy units. This refers mainly to units of 20' containers which can be transported on trailers in two-unit combinations without exceeding the maximum length. Unfortunately, combining ILUs to utilize the maximum capacity of a truck, in terms of TEU capacity and weight, is complicated and limited to current workflow on last mile operations. This is the basis for the development of combi trailers. Combi trailers are a solution developed in the Netherlands by manufacturers such as D-Tec (Figure 7.3) and Broshuis. The trailer consists of two modules which can work as separate trailers or as one vehicle. Thanks to an additional two axles of the combination, trailers are combined with a 3-axle tractor unit which can transport heavier units with a total capacity of 2 TEUs.

Higher permissible weight is not the only advantage of combi trailers. For CT operations, cargo discharging time is one of the crucial performance factors. Thus, the possibility of detaching one container for the stripping process and transferring it

Figure 7.3. D-Tec combitrailer

Source: D-tec.

from one container to another location allows for valuable time management. In this place, it has to be noticed that second-hand market led the BSR trucking companies to equip the fleet in combi trailer units. It is widely visible on roads in Poland, where combi-trailers became a popular solution for lots of container trucking companies, despite lack of legal framework prepared for such technology.

Longer and heavier vehicles

Longer and heavier trucks up to 25.25 m can be built up based on tractor unit or rigid truck. Both options can apply 3 TEU capacity, but in countries which allows LHV traffic the most popular is the tractor unit configuration. In this configuration, three TEU capacity is allowed due to equipment use called B-double. It allows for the load of one TEU directly on the tractor's fifth wheel. The additional fifth wheel allows to attach any kind of semitrailer and, if needed, a 5-axle combi trailer with 2 TEU capacity. Such trailer combinations are available on Scandinavian and Benelux markets – where manufacturers such as VAK, Broshuis, and D-Tec supply the market. To this point, South Baltic markets are still a niche for those companies. As soon as LHV trucks will be launched on South Baltic regional roads, it will push the development of vendors and relating service network. A question on the real limitations of launching LHV still remains.

LHV launching limitations

A number of expert interviews and desk research led to indicate general topics to be resolved before launching LHV in whole BSR market.

Maximum axle loads

Truckers involved in CT last mile operations are not always aware of the cargo distribution inside the ITU. Most of the newbuild container chassis are equipped with the axle weight balancing systems, but we still have to remember that ILU also means intermodal trailers which mostly are not equipped in such solutions. This cause the needs to develop the CT terminals infrastructure to avoid overweight trucks across the last mile operations. On the other hand, for example, in Poland there are a varieties of axle load limitations on public roads. Depending on the ownership of the road (i.e., national, municipal) axle loads can vary from 11.5 through 10 up to 8 tonnes per axle. This indicates the need to create coherent network of infrastructure suitable for LHV trucks.

Road sections availability, parking infrastructure, distribution centers

Launching LHV requires proper infrastructure works not only on the roads and intersections. LHV will require retrofitting parking lots and building infrastructure required for coupling and maneuvering inside terminals and distribution centers.

Vehicle registrations

B-doubles, dollies and combi-trailers are special equipment which requires to be mentioned in legal framework. In some countries i.e., Poland based on current legal framework it is restricted to combine three-module vehicles, so proper legal works to create coherent market for LHV are a must.

Society and transport market effects

The lack of information about the technology can let the citizenry to create false image on LHV trucks safety. Tests conducted in the past prove that LVH in many aspects were safer on the road than standard trucks. For example, braking performance in LHV due to more axles can be higher than in standard trucks. First, longer combination leads to improving the road safety though a smaller number of vehicles used to carry the same payload.

On the other hand, risen maximum permissible mass can be boosted to unfair competition – market-wise. Technically LVH equipment can bear the cargo weight up to 80 tonnes and it can be used by some entrepreneurs to overweight their trucks.

Economic backgrounds of launching LHV

Within the scope of COMBINE project Report 4.1, the University of Gdansk in cooperation with the forwarding company conducted a trial test of LHV truck in the Polish market. For a one week a tractor unit with combi-trailer performed a number of last mile deliveries of 2x20' containers with raw material for a factory located 120 km away from CT terminal.

Trial runs showed that using combi trailers can led to decrease unit costs even up to 30% in comparison to using standard tractor units with semi-trailers (Figure 7.4).

Trucks platooning

Trucks platooning technology allows to connect the trucks into a convoy with small distances in-between. This to reduce space-use on roads and to decrease the wind resistance by promises on reduced fuel consumption. Communication between

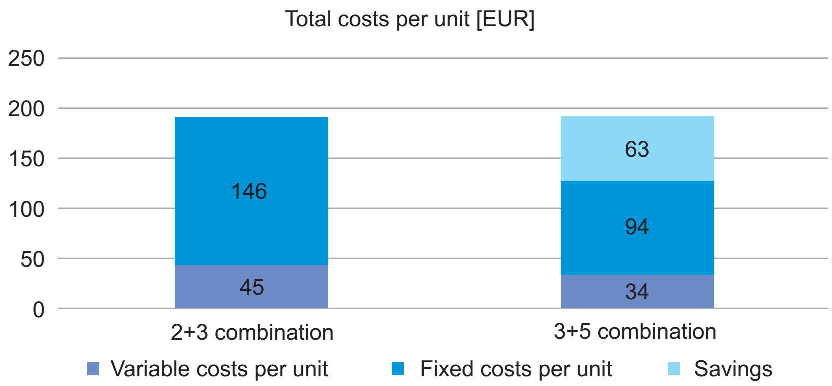


Figure 7.4. Costs per unit for standard truck and semitrailer and 3+5-axle combi trailer combination

Source: COMBINE Report 4.1 Innovative last mile solutions to strengthen combined transport.

vehicles (v2v) allows to follow the first leading vehicle and in the future development to release driver's attention.

Development on platooning technology is divided into four stages, starting from only longitude control on vehicles, through an increased automated transport process with diver's reaction needed in critic situation up to introduction of fully autonomous vehicles (Table 7.2).

Table 7.2. Platooning stages of development

Stage	Launch Year	Level explanation – driver's work
1+2	2020	Hands on, feet off, eyes on the road
3	2023	Hands off, feet off eyes partially off the road
4	2030	Hands off, feel off, eyes off in following vehicles

Source: own elaboration based on TNO data, 2021.

7.2.2. Economic calculation for BSR market

Trucks platooning technology for now is not widely available on the market, so the price only can be estimated based on prearranged tests. TNO report estimated cost of equipment needed for truck platooning on EUR 12,000 for first stage, for third EUR 16,000, and fourth for EUR 20,000 (TNO, 2017).

Such an investment requires a proper investment return rate. Platooning can provide economic savings mainly due to decreased fuel consumption but also in next stages of development – labor costs savings (Table 7.3).

Table 7.3. Estimated depreciation costs for different stages of platooning development.

Stage	Year	Investment per truck	2-truck platoon		3-truck platoon	
			Fuel costs decrease (Team)	Labour cost decrease	Fuel costs decrease (Team)	Labour cost decrease
1+2	2020-2021	12,000 EUR	6%	0%	9%	0%
3	2023	16,000 EUR	8%	8%	12%	8%
4	2030	20,000 EUR	10%	90%	14%	90%

Source: own elaboration based on TNO data, 2021.

Setting together 1+2 stage estimations into the BSR market, it can be said that the following assumptions can apply:

- average diesel consumption 35l/100 km;
- costs of technology: EUR 12,000 / truck;
- average diesel price EUR 1.10, max EUR 1.30, min EUR 0.93, and EUR 1.50 as a reference;
- average monthly mileage per truck in CT last mile operations may vary between 4,000 and 7,000 km depending on factors like: distances, awaiting time, traffic conditions etc.; and
- depreciation time for trucks is set on 60 months (5 years).

Two trucks platooning gains the efficiency of investment after braking 7,000 km mileage per month of driving. Such mileage levels are possible to gain only in heavy, long distance road haulage, not in CT operations; hence, for BSR is necessary to consider platoons with three trucks coupled (Figure 7.5).

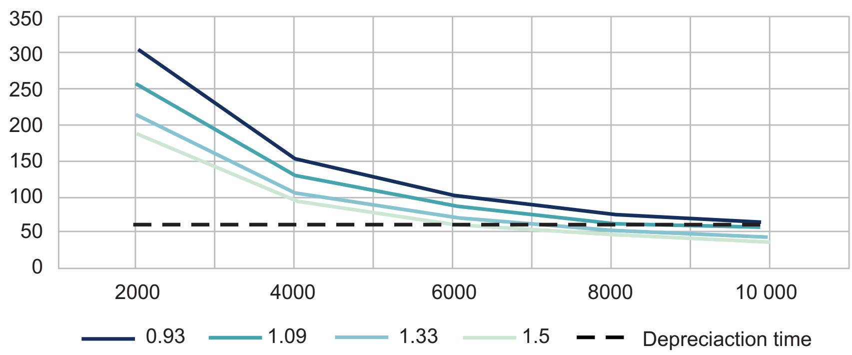


Figure 7.5. Time of return (in months) of the investment in 2-trucks platoon combination depending on distance [km] and fuel price [EUR]

Source: own elaboration based on TNO data, 2021.

Extending the platoon for another truck moves the investment efficiency point at the level of approx. 5,000-6,000 km per month, depending on real fuel prices (Figure 7.6).

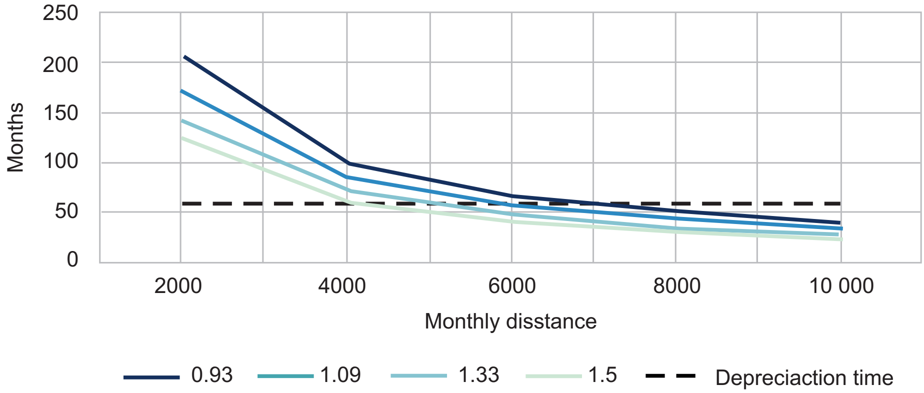


Figure 7.6. Time of return (in months) of the investment in 3-trucks platoon combination depending on mileage [km] and fuel price [EUR]

Source: own elaboration based on TNO data.

Another level of platooning development allows to receive further costs decrease closely connected not only with fuel consumption, but also with labor costs. In the fourth phase of technology development, platoons might be able to give up to 90% costs decrease of labor which refers to 20-25% of total costs of truck ownership. Different studies estimate, that the last stage of truck platooning development may lead to decrease of ownership cost by 55% (W. Schildorfer, 2019).

7.2.3. Business Case – suitability for BSR

A well-developed and legally introduced innovation means nothing when it's unusable in practice. The point is to outline the business environment where platooning can be successfully implemented.

Close connection to Highways

Truck platoons are expected to be allowed on highways and expressways. Also, its value case remains valid if the technology can be used as often as possible. Thus, investment in truck platoons makes sense only for last mile deliveries from/to terminals situated nearby such roads. By analyzing the localization of CT terminals in the BSR – some of the terminals do not have direct access to motorway, nor any kilometer within the vicinity of the terminal based on a 20-50 km radius (see Malaszewicze terminals, Poland).

Proper cargo at proper time and place

Pairing the trucks into platoons during CT last mile operations requires to move ILUs at one time into the same time or as much as possible a similar destination. This requirement actually may have negative influence on CT. Combined transport is often considered as a solution to create a "rolling warehouse". That is, ILUs stored at a terminal can be flexibly delivered at a destination due to its close location. Trucks platooning limits this flexibility of delivery time as trucks in platoon will deliver a number of ILUs at once. Secondly, last mile operations time is of crucial importance. On the one hand, platooning in its third stage of development will allow the extension of driver's daily working time. On the other, waiting for the possibility to create platooning might overcome the potential savings in drivers operational working time.

Based on above conditions an individual studies should be conducted to analyze the flow of last mile traffic from terminals in order to give a real potential of platooning for CT operations. In all probability, platooning can be a proper and efficient solution only for particular supply chains in CT operations.

Distance

As it was mentioned, the distance of last mile deliveries is limited in the legal framework. Limitation is set on the nearest suitable station or to the radius 150 km from seaport/ CT terminal. The largest profits in terms of platooning is available on long(er) distances, with the high share of motorways in the voyage. Also, the length of road has the influence on the possibility to successful platooning. In CT operation chance for platooning is possible mainly for traffic to/from the terminal.

Market fragmentation

Last mile deliveries are conducted in a variety of business models, depending on the country, local markets, and specific agreement between involved stakeholders. Last mile operations can be arranged by self-employed operators, transport subcontractors, or CT operator's owned trucking fleet. Such fragmentation builds upon the obstacles and innovation to create a coherent platooning network. The ENSEMBLE project will provide the solution to build upon a common interface for different truck manufacturers. Technology and ability are the first case, the second case is the proper planning to concentrate the stakeholders. This would be possible with proper software which automatically notifies interested parties about the possibilities of platooning within CT last mile.

7.2.4. Autonomous Vehicles

The next step to last mile technologies development is to introduce fully autonomous vehicles. This technology was first commercially tested by Volvo in 2019. The

Swedish manufacturer tested a vehicle called Vera in container transport operations in Gothenburg.

Tests in commercial operations were conducted also by the company Einride. Those were taken in the terminal of Schenker in Jonkoping, Sweden. The special permission allowed for testing on public road with a max speed of 5 km/h. T-Pod truck had a maximum capacity of 20 tonnes and a battery allowance to drive a maximum of 200 km on one charge. The first test of Einride autonomous trucks in use under container transport operations are planned in the port of Helisngborg, SE. Einride as one of the first autonomous trucks manufacturers provided commercial price of the T-Pod truck which is estimated at USD 150,000 (40ton.net, 2018).

How can autonomous vehicles approach commercial last mile operations in BSR? Observing the very first tests where autonomous trucks were applied, terminals with a nearby location to the logistics or distribution centers is a start.

Access of autonomous trucks on public roads requires a lot of legal work in which is similar to tuck platooning. Thus, it seems, such vehicles will require additional infrastructure like internal roads or paths between terminals and nearby warehouses or distribution centers to allow for them to work – despite legal issues on public roads. Example terminals which might easily access such vehicles include: CLIP terminal Swarzędz – with its close location to distribution park CLIP II or DCT Gdansk.

New innovation in technology may also lead to the rise of an innovative market structure. Autonomous vehicles will need providers of IT solutions, controllers, and maintenance services. Such services can be offered by manufacturers directly or with the outsourced subcontractors which can become a new part of Last Mile solutions market.

7.2.5. Summary and recommendations

LHV trucks are the easiest way to improve the efficiency on last mile CT operations. BSR region is divided into northwest where LHV technology is legally allowed, and southeast where only trucks in EC directive parameters are allowed. This leads the BSR region countries to work on coherent network of LHV allowed countries.

Within the scope of biggest limitation of LHV has to be indicated the need of infrastructure retrofitting. As most of the newbuild roads in BSR are suitable for heavy traffic, the biggest infrastructure works should take place on the distribution centers and parking lots. Longer vehicles needs extra place for parking, coupling and maneuvering, so works on point infrastructure is a must. Indicating the proper linear infrastructure can take place based on best practices from Western BSR. As the good example can be the “PositiveNetz” in Germany – a clear network of roads where longer and heavier vehicles are allowed.

The next step required to setup the LHV in whole BSR is to regulate the legal base for registration of vehicles. The models required for such traffic like b-double or even combi trailers are not regulated in national or EU level legal framework. Despite that,

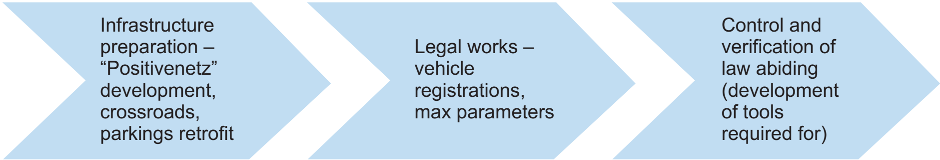


Figure 7.7. LHV introduction phases – proposal

Source: own elaboration.

transport market overtakes the legal works, and trucking entrepreneurs are already equipped in proper equipment (Figure 7.7).

Legal regulations and infrastructure retrofit will not be enough for proper market functioning. Increasing maximum truck weight may lead to unfair competition and abusing the law by overweighting the LHV. Thus, proper market regulation and penalties for companies which abusing the law will be a must. The verification of a proper execution of LHV development may be conducted by variety of new technologies including GPS and geofencing which allows to constantly control the traffic flow.

Trucks platooning is an innovative technology which may not be widely introduced on CT last mile market. Research conducted within the scope of COMBINE 4.1 Report showed that based on current available technology costs it may be suitable only for a very short number of CT operations. Despite its increasing capacity function truck platoons makes economic sense only under specific conditions which seriously limits its usability in BSR. Thus, future development or investments in truck platooning technology in BSR has to be preceded by feasibility studies and CT traffic research to make sure if platooning will be usable in particular business environment.

The next step after trucks platooning leads the last mile operations to autonomous vehicles. Market research showed that the technology is on an advanced tests level. Although, its wide introduction to the market can be held by a legal works required to launch the technology on public roads. In real CT operations environment autonomous vehicles can be easily introduced on CT facilities with distribution centers or warehouses in its surroundings. This may lead to the preparation of internal paths or roads for autonomous vehicles to be in use before launching on public roads with proper legal framework.

7.3. Alternative fuels and propulsion solutions

In the end of 2019 the European Commission introduced the official communication called the European Green Deal. The document consists of official aims which leads the EU to create coherent, sustainable economics with 90% reduction of GHG emissions in transport till 2050. This will be possible mainly by introducing the new emission standard – Euro 7 which start is scheduled after 2025. Currently, most of the automotive industry insists that new standard leads to phase off diesel engines in heavy transport. This means that last mile operations will require transition from standard diesel tractor units up to low emission and zero emission vehicles.

Based on the above incentives, manufacturers are developing various powertrains which most of them are on early stages of production or tests so the market availability is limited. Thus, it is hard to clearly indicate its suitability for CT operations and especially economic effects. The subject of this chapter indicates only solutions which are based on author's choice has at the moment the biggest change to develop and be used in future CT operations (Figure 7.8).

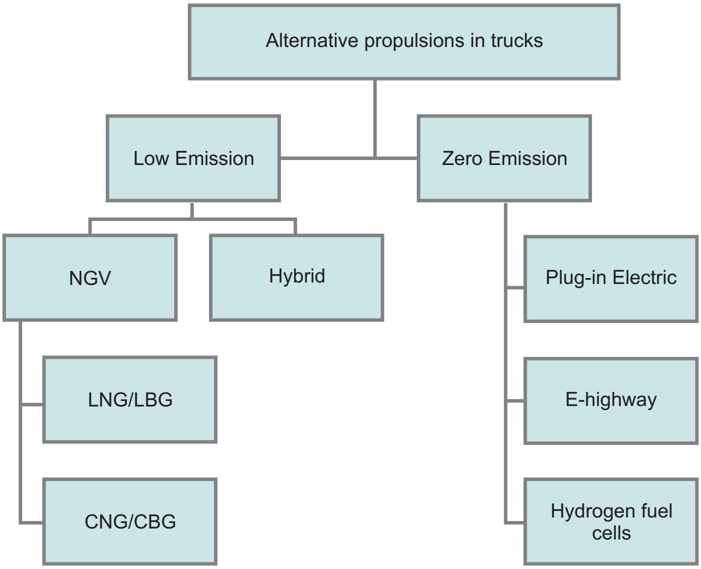


Figure 7.8. Alternative propulsion systems in trucks, suitable for CT last mile operations
Source: own elaboration.

Medium (above 3.5 t.) and heavy haulage fleet in the EU consist on approx. 6.5 mln vehicles. Above 1/3 of them are registered in BSR, mainly in Poland and Germany. The average fleet growth in region is leveled at 2.7% y/y which is a bit above the EU average – 2.31%. The biggest fleet growth can be noticed in Poland (4.16%) and Lithuania (7.37%) (ACEA, 2020).

The European medium and heavy haulage fleet mainly consists of diesel-powered vehicles with 98% of trucks in the EU equipped with diesel engines. Rest propulsions play a marginal role, and their share in the EU do not exceed 1% per kind of propulsion. Hybrid and electric vehicles actually do not exist in European goods transport. The registrations of this kind of trucks is noticed on in a few countries which can even mean that trucks are registered as a test or demo trucks for manufacturer or dealer.

BSR do not surpass much of the overall EU statistically (Table 7.4). Due to unclear statistics in Poland, BSR average of diesel is lowered, but based on observations, much of unknown number should be considered as diesel trucks. In the coming years, it is expected a rise in the number of LNG propelled trucks both in the EU and BSR is expected. Main reasons for such a perspective is a relatively good availability of this technology and government support for LNG fleet development. This gives opportunity for a fast market response to future CO_2 emission limits (ACEA, 2020).

Table 7.4. Propulsion composition for medium and heavy trucks in BSR.

Country	Petrol	Diesel	Hybrid electric	Plug In Electric	LPG+Natural Gas	Other+ unknown
Denmark	0.70%	99%	0.00%	0.00%	0.40%	0.00%
Estonia	15.40%	84.50%	0.00%	0.00%	0.10%	0.00%
Finland	1.60%	98.10%	0.00%	0.00%	0.1	0.00%
Sweden	n/a	n/a	n/a	n/a	n/a	n/a
Lithuania	1.90%	95.70%	0.00%	0.00%	0%	2.40%
Latvia	1.50%	97.40%	0.00%	0.00%	1.10%	0.00%
Poland	2.70%	78.80%	0.10%	0.00%	1.00%	17.40%
Germany	0.20%	99.50%	0.00%	0.10%	0.10%	0.00%
BSR average	3.43%	93.29%	0.00%	0.00%	1.81%	2.83%
EU	1%	98.30%	0.00%	0.00%	0.40%	0.20%

Source: own elaboration based on ACEA, 2020.

7.3.1. CNG/LNG/LBG/CBG

Technology description

The increasing number of vehicles and limited worldwide resources of crude oil gave another ignition position on the development of alternative propulsions. One of the most popular LEV technologies, which now is relatively widely developed is using natural gas to propel the vehicles called natural gas vehicles (NGV), referred to as Methane (CH_4). It still is considered a fossil fuel, but is still a good alternative for diesel fueled vehicles.

There are two main types of trucks propelled with natural gas: LNG and CNG.

LNG which is abbreviation of Liquified Natural Gas is a fuel resultant from the methane cooled and stored at the temperature -160°C. Such low temperature allows to shrink the volume of methane and change physical state to liquid. Low temperature requires to use proper cryogenic tanks to store the fuel in the trucks. To keep the safety, special tanks are equipped with valves which allows to deploy the gas which increase the volume due to rising temperature. The combustion process may be conducted with pure LNG or mixture of LNG with diesel, then the vehicles are referred to dual fuel engines.

LNG trucks are in general recommended for long and heavy haulage. The reason for this application is longer range in comparison with CNG or electric propelled vehicles. The manufacturers of LNG tractors declares its range up to 1,000 km with engine which generates up to 460 HP which is also sufficient for heavy haulage up to 40 or 44 tonnes.

CNG as the abbreviation from compressed natural gas refers to the vehicles equipped fueled with compressed methane. The compression of methane is possible due to cylinder tanks installed on vehicles. Tanks allows to fill up and store methane compressed up to 21 to 25 MPa.

The biggest disadvantage of CNG trucks is the limited range. For example, Iveco, for their latest generation of CNG tractor units set the maximum range between 400-500 km depending on engine and tanks configuration. The other disadvantage of this technology is the diversified fueling time. Depending on station efficiency we can diversify "slow fueling stations" where total time for tractor units is considered between 5-7 hours, and fast fueling sites, where the process last maximum 20-25 minutes.

LNG/CNG vehicles for CT operations – market availability

Market research arranged at the beginning of 2020 shows three main suppliers of CNG/LNG trucks across Europe and the BSR which are Scania, Volvo, and Iveco. All of them offer wide range of axle configurations and cabin sizes. The well-developed supply side of the market is a prove that LNG/CNG is the most available alternative propulsion for trucks. Most of the dealers offer them in regular sales, not only based on bespoken orders. However, the widest offer can be found in light and medium trucks for local distribution, which are not suitable for last mile in CT transport due to its comparatively low power, torque, or chassis configuration limited to rigid trucks. Below shortlist shows trucks are considered as suitable for CT operations. Optimal configuration for CT operation according to haulage companies and based on current EU directives was described as: tractor unit in 4x2 axle configuration for light ILU and 6x2 for 42-44 tonnes configuration. Engine power according to haulers experience should be considered at approx. 400 HP for light ILU, and above 500 HP for safe transport of heavy ILUs in 42-44 tonnes configuration.

On the other hand, it is important to notice that manufacturers like Daimler (Mercedes-Benz) or Paccar (DAF) declared that they are considering natural gas as short-term solution and they will not develop NGV technology. For those manufacturers future of truck propulsions belongs to electricity or hydrogen and their R&D activities focus on mentioned propulsions.

Fueling stations availability

The increasing number of NGV's requires well-covering network of fueling stations. At the beginning of 2020, there are 2.1 million registered NGV across Europe. Based on NGVA statistics only in 2019 in Europe registered almost 90,000 NGV vehicles among of 21,000 CNG and 45,000 LNG trucks. The same association forecasts that in the next 10 years the total number of registered NGV vehicles in Europe will grow six-fold, reaching 13 million (NGVA, 2020).

The average number of CNG stations per 100 km of highway in the EU area do not exceed three. BSR shows bigger availability of such fuels. Drivers can fill up CNG six times on each 100 km of highway. The biggest density to road network shows Estonia and Sweden, approx. 10 stations /100 km. The development of CNG stations network seems to grow stable year by year in whole EU countries and region. It's developing mainly due to local municipalities, who invested in CNG vehicles such like buses or communal vehicles, i.e., dump trucks. What must be also underlined, a lot of the stations are built for purpose of municipalities and are not for the open public, or access requires additional agreements with station operators.

LNG filling locations show a much bigger dynamic for development. In last year, the number of locations across Europe increased almost 200%, mainly due to development of network in Germany. The average increase in BSR in last year also rise for almost 180%. Unfortunately, dynamic development seems to be still not sufficient for forecasted number of vehicles. As per research arranged by ACEA it should reach 750 fueling stations across EU by 2025 and 1,500 by 2035 (ACEA, 2020). In 2019, the total number of those sites did not exceed 400 (Figure 7.9). This means that average number of stations per 100 km highway in the EU and the BSR do not exceed 0.3 locations. If we take a look at each country, Finland is a leader when comparing LNG stations with motorways length. In average, there is a possibility to fill up LNG every 100 km of motorway in Finland. The density of stations per 1,000 km^2 in the BSR is on average level of 0.03 and it is 1/3 of average density in the EU. What is important to say, there is still no fueling infrastructure available in three countries, i.e., Latvia, Lithuania, and Denmark (EAFO, 2020).

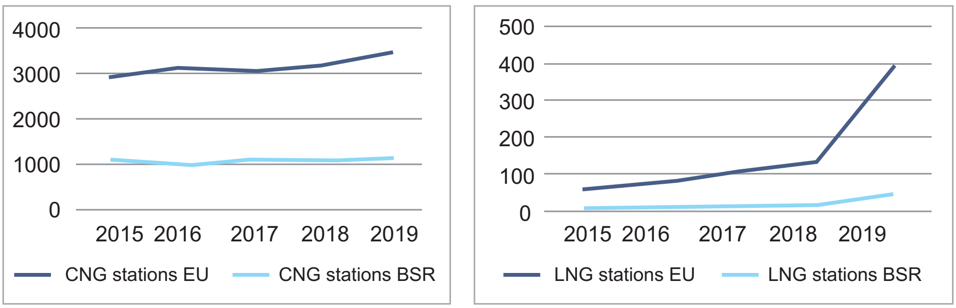


Figure 7.9. CNG/LNG filling stations number in EU and BSR region between 2015-2019

Source: Own elaboration based on European Alternative Fuels Observatory (EAFO)

From the angle of CT last mile operations, it is important to install filling stations in the near radius of terminal – to keep fluent supply of NG to trucking companies. As an example of good practice, the station open in Vuosaari Port in Helsinki can be indicated (Figure 7.10).

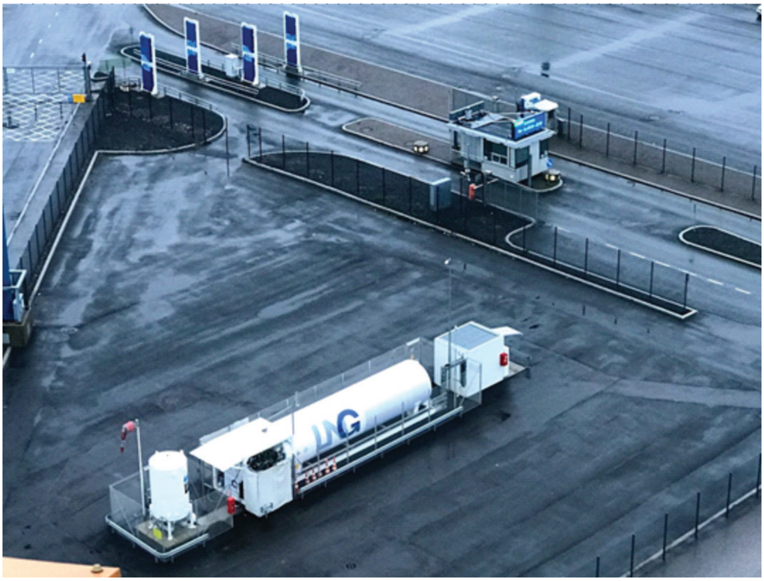


Figure 7.10. LNG Station in Vuosaari Port, Helsinki

Source: Own archive.

LBG/CBG

LBG which is the abbreviation for "Liquified Bio Gas" is the alternative fuel for the fossil natural gas and LNG as fuel. Biogas is the product of the breakdown of organic matter in the absence of oxygen. This reaction is possible in the biogas plants which are commonly connected with sewage or waste plants to deliver raw, organic material for production.

The natural source of the biogas makes that it is considered as a renewable, non-fossil energy. It offers a huge potential for all the NG trucks. Although biogas in its first stage contains Hydrogen sulfide (H_2S). This compound reacts with the machinery due to its corrosive nature, thus biogas needs to be upgraded and cleaned. Carbon dioxide, water, and particulates also must be removed from biogas composition before it will become biomethane which after cooling or compression can become Liquid biomethane as substitution for natural gas. Due to the high costs of biogas cleaning and upgrading, truck manufacturers spreads the researches to allow LNG/CNG vehicles to be filled up with biogas.

Germany is a main producer of biogas. In 2018 there were almost 11,000 launched plants in Germany. In the BSR, the second country is Poland with 308 plants and then

Sweden with almost 200 locations (EBA, 2019). That gives a great potential to BSR to develop the fleet of eco-friendly trucks as the next step for development of gas-powered fleet.

IRR for LNG truck on CT operations

In the last few years a lot of road haulage companies decided to develop their fleet fueled with LNG tractor units. Most of those fleets are used for long haulage transport across Europe. In the opposite to long haulage CT last mile operations characterize more frequent transport on shorter distances. Such work conditions can make LNG equipment less economical efficient for this purpose. Table 7.5 shows general assumptions for calculating economic efficiency of LNG truck in CT last mile operations:

Table 7.5. Tractor unit's comparison diesel vs LNG.

	Tractor Unit LNG 460HP	Tractor Unit Diesel E6 480HP
Power/Torque	460 HP / 1,700 Nm	480 HP / 2,300 Nm
Mass (tare)	7,505 kg	7,000 kg
Fuel consumption (12 t cargo)	21 kg/100 km = 0.018 kg/tkm	23,3l/100 km = 0.019 l/tkm
CO_2 emission	559 g/km (-9,1%)	615 g/km
Tanks capacity	2 x 500 l (400 kg LNG)	1 x 550 l
Price (EUR)	105,000	75,000

Source: Own elaboration based on internal data of manufacturer.

The comparison of diesel and LNG tractor parameters from same manufacturer with same chassis and cab configuration shows that LNG units are heavier by about 0.5 t compared to a diesel-powered unit. This aspect is crucial for CT operations. A heavier tractor leaves less space for cargo weight; thus, it gives another reason to consider implementing LHV in all BSR countries or at least give a legal space to increase the maximum allowed weight of truck/trailer combination.

What is more, LNG trucks are more expensive than its diesel equivalent. Depending on country markets and individual negotiations difference in price can exceed 30%.

If we consider upkeep costs between LNG and diesel truck on similar levels the decision of buying LNG truck should be considered only based on average monthly mileage and transported cargo weight with spread between diesel and LNG price in filling station.

Table 7.6 shows the months of using LNG truck needed to get return in investment. Cells colored in green indicates time below five years which is considered as optimum time of operation for trucks. The bigger spread between prices, the faster return on investment is possible to get.

The prices of the fuels are flexible in mentioned countries. At the beginning of 2020 average spread between LNG and Diesel price (excl. VAT) in the BSR was set at EUR 0.16.

Table 7.6. Time (in months) of return (IRR) on LNG Truck based on LNG/Diesel price spread EUR 0.11, 0.16, and 0.20 (excl. VAT).

Price spread 0.16 EUR								
	Monthly mileage [1,000 km]							
		6	7	8	9	10	11	12
Average cargo Weight [tonnes]	12	112	96	84	75	67	61	56
	14	96	82	72	64	58	52	48
	16	84	72	63	56	50	46	42
	18	75	64	56	50	45	41	37
	20	67	58	50	45	40	37	34
	22	61	52	46	41	37	33	31
	24	56	48	42	37	34	31	28
	26	52	44	39	34	31	28	26

Price spread 0.11 EUR					
	Monthly mileage [1,000 km]				
		9	10	11	12
Average cargo Weight [tonnes]	16	74	66	60	55
	18	66	59	54	49
	20	59	53	48	44
	22	54	48	44	40
	24	49	44	40	37
	26	45	41	37	34

Price spread 0.16 EUR									
	Monthly mileage [1,000 km]								
		5	6	7	8	9	10	11	12
Average cargo Weight [tonnes]	10	135	113	97	84	75	68	61	56
	12	113	94	80	70	63	56	51	47
	14	97	80	69	60	54	48	44	40
	16	84	70	60	53	47	42	38	35
	18	75	63	54	47	42	38	34	31
	20	68	56	48	42	38	34	31	28
	22	61	51	44	38	34	31	28	26
	24	56	47	40	35	31	28	26	23
	26	52	43	37	32	29	26	24	22

Source: Own elaboration.

As it is shown in Table 7.6, depending on all factors, IRR in LNG truck can be reached starting from two-three years. However, this can be achieved only if the equipment will be working on heavy loads on long distances. In CT operations the distance factor is strictly limited by the law to 150 km per one way. On the other hand, the limitation of monthly mileage is the working time of drivers. Taking into consideration the average last mile delivery at distance 50 km, trucker can perform even three roundtrips per day which can give average mileage 6,000 km monthly based on 20 workdays/month.

Trucking companies in the BSR that are considering investing to LNG trucks in CT operations shall strictly calculate expected workflow to keep the efficiency of investment. For many of them from the economic point of view LNG truck might be not the best solution due to specific of their last mile works.

In Germany, federal authorities launched a special support program for LNG/CNG vehicles. All the trucks propelled with CNG or LNG are exempted from toll on the roads. This was another argument for investment in the LNG fleet for many trucking companies, not only from Germany but also for all international long-distance truckers.

At the moment, Germany is the only country in the BSR which offers such benefits for the companies equipped in NGV vehicles. At the beginning of 2020 German government discussed if the program will be continued only till end 2020 or extended. One of the arguments was to support other alternative propulsions like hydrogen or electric which are considered as zero-emission vehicles. However, the authorities decided to prolong the LNG support program till the end of 2023 (IRU, 2020).

7.3.2. Full electric trucks / Plug-in trucks

Fully electric propulsion for trucks is at the moment the domain of light trucks up to 7.5 tonnes, which plays an important role in city logistics and distribution. However, the future task for automotive industry is to implement fully electric trucks for heavy transport, including last mile in CT operations. Currently, there are few manufacturers who are working on development electric trucks suitable for CT operations (see market availability).

The biggest limitation for development is the balance between truck weight, maximum speed, and range of the vehicle. Figure 7.11 shows that increasing the range of electric trucks is closely connected with the substantial increase in weight of battery installed on board. If comparing the weights of electric trucks with its diesel equivalents, difference can reach 10-15%. Such difference in weight can be crucial for CT operations with heavy loading units which are common in CT.

Market availability – trucks and charging stations

As it was said in previous paragraph, there are few manufacturers developing electric trucks on the European Market. E-trucks market can be divided into two groups of

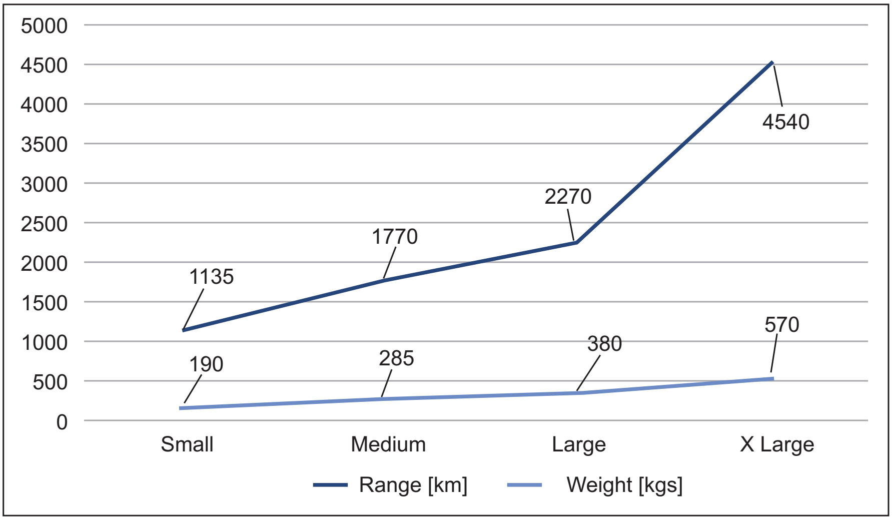


Figure 7.11. Relation between battery weight and truck range for different size of batteries

Source: Own elaboration based on https://www.futuricum.com/.

manufacturers. The first one includes biggest players like DAF or Volvo which announced to develop a full range of electric trucks by end 2021. The second group consists of small developers, i.e., Futuricum and Framo.

Taking into consideration CT-suitable trucks only, for the beginning of 2021 DAF is the only one from the "great 7" of trucks manufacturers who offer commercially fully electric tractor unit. Electric DAF CF configuration allows to build max 37 tonnes truck + trailer combination. Electric engine generates 286 HP, and it is supplied from 170 kWh battery which allows to drive up to 100 km between charging.

The next market competitor which is expected to launch a full electric tractor unit according to the last press release is Nikola which is a sister-company of Iveco. The vehicle Is planned to launch on the European market during 2020-2021. Nikola Tre will be an electric unit based on Iveco S-way. Truck configurations allow to get 500 km range with engine power 650 HP.

Although, at the moment the biggest development and availability of electric trucks takes place in small companies who are developing electric trucks based on common tractor units.

Trucks under brand Futuricum are manufactured and designed in Switzerland based on Volvo FM/FMX cabs. Those tractor units allow to get over 600 km range on single charging. Units are equipped with the electric engine which generates up to 680 HP.

Another example of "new-born" truck manufacturers or companies who offer electric vehicles is Framo. Units built by Framo in Germany are based on MAN TGX tractor units with an electric engine on board. It allows to build 44 tonnes combination with maximum range of 150 km. In 2019-2020 Framo trucks have been tested in CT operations under Dutch-German Interreg project eGLM, Electric Green Last Mile.

Despite the large number of projects underway, electric trucks are not widely available on the market as for diesel or NGV trucks. Sales network for small developers actually does not exist. Only DAF CF electric, Nikola Tre and Volvo electric trucks will be available in sales network of DAF and Iveco. Furthermore, also lead times for electric trucks which for now are truly custom-made products is much longer than diesel equivalents. One of the manufacturers declare lead time around 20-22 weeks.

Limited availability and costs of technology development have the influence on the price of such vehicles. Built-to-suit constructions are even two times more expensive than conventional diesel units, and the price can exceed EUR 200,000 (Table 7.7).

Table 7.7. Fully Electric tractor units available in EU market – comparison

	DAF CF Electric	Futuricum unit	Framo Tractor Unit	Emos TYPE 4220
Max permit weight /t/	37	44	44	50
Range /km/	100	600	150	180
Power /HP/	326	680	400	495

Source: Own elaboration based on manufacturer's materials, press releases.

The number of projects which are developing electric trucks generates the influence on new trucks registrations in the EU. In 2019, there was registered 747 pure electric trucks, whereas 608 in Germany which is the leader of Electric trucks fleet in Europe. Comparing that to 2018, the number of electric trucks registered in the EU has risen by 109%, specifically in the BSR by 115% mainly due to the German market. The growth number of such vehicles in other BSR countries is marginal and is noticed only in Denmark and Sweden. Hybrid electric trucks are marginal in BSR trucks fleet and consist of 23 new registrations in 2019 which is 53% more comparing to 2018 y/y (Table 7.8).

Some organizations provide estimates for the demand on public charging stations. What has to be noticed, the technical specification of chargers for trucks differs from those known from passenger cars. Because of their significantly higher power and energy demand, as well as the many parking spots required along all major routes in Europe, heavy duty trucks cannot use charging infrastructure for passenger cars.

Currently the network of charging points for trucks across EU actually does not exists. According to ACEA estimations, the need of public charging points for trucks till 2025 exceed 16,000 points. By 2030 this number might be even four times higher. Such a development of network requires financial support from local and European authorities. It is crucial for electric trucks fleet development to build stable efficient network of charging points (Table 7.9).

Table 7.8. New electric trucks registration in 2018-19 in BSR countries.

Country/Region	Electrically-Chargeable			Hybrid Electric		
	2019	2018	% change	2019	2018	% change
Denmark	3	3	0	0	0	0
Estonia	0	0	0	0	0	0
Finland	0	0	0	5	5	0
Sweden	2	2	0	6	5	20.0
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a
Latvia	0	0	0	0	0	0
Poland	0	0	0	2	1	100.0
Germany	608	279	117.9	10	4	150.0
BSR	613	284	115.8	23	15	53.3
EU	747	357	109.2	272	305	-10.8

Source: ACEA.

Table 7.9. Public charging stations for trucks – forecast

Power	Current availability	Needed by 2025	Needed by 2030
DC <100kW	<10	4,000 (+20,000**)	50,000 (+20,000**)
DC 350kW	0	11,000	20,000
DC >500kW	0	2,000	20,000

Source: ACEA ** charging station on private depots.

7.3.3. E-highway and hybrid trucks

The limitation of range due to battery capacity and the charging stations for e-trucks were one of the reasons to develop the project called e-highway. The project assumes to build on the motorways overhead power lines as the source of energy for trucks equipped in pantograph. The connection between truck and lines is arranged automatically in speed range up to 90 km/h. Road sections without the lines like internal roads in logistics centers or local streets can be covered using battery installed on board of truck. To improve the efficiency of the system, energy inverters installed on board can give back energy produced, i.e., during braking.

Based on available data, in 2020 there were only four sections of e-highway within the BSR, in Germany and Sweden. E-highway section in Sweden between Sandviken and Kungsgården has been built as the very first one and tested from 2016 till 2020. The plan for the nearest future is to close this project and evaluate the technology on first state e-highways planned on road E20 between Örebro and Hallsberg and Road 73 between Nynäshamn and Västerhaninge.

The three sections in Germany are developed during project ELISA which was started in 2018. In 2019 first section on A5 motorway in Frankfurt/Main area was ready to launch five test trucks. On A1 motorway in Lübeck area first trucks started tests in December 2019. Tests will take place until 2022, to collect the data under differentiated transport environment. First tests on the third section – on state road in Baden-Württemberg will take place probably in 2020 (Anon., 2020).

For ELISA project the exclusive truck manufacturer is Scania. The Swedish manufacturer expects to provide 15 trucks (5 for each test fields). As the project is on early stages and only few trucks have been delivered so far, it is hard to indicate the market availability of vehicles suitable for e-Highway.

An interesting option seems to be retrofitting old trucks with combustion engines into e-Highway suitable vehicles. The process includes changing the combustion engine to electric one with full equipment as inverters, batteries, and pantographs. It is also a good solution for the rising number of trucks which are not comply to latest Euro emission standards. A similar retrofitting has been arranged within the scope of project Trolley, where diesel buses were converted to trolleybuses (Anon., 2014).

The costs of developing e-Highway on A5 in Germany is estimated on ca. EUR 15,000,000 which means that each kilometer of infrastructure costs EUR 1.5 million. A5 motorway in Germany bears average load of 135,000 cars per day. Approx. 10% of them are heavy haulage trucks (Anon., 2020).

At the beginning of 2021 Siemens Mobility notified to plan the electrification of A15 motorway in the Netherlands; 50km section between Maasvlakte and Ridderkerk in Rotterdam port is a main way for heavy traffic flow through the port of Rotterdam. A huge part of this traffic is connected with the CT last mile operations and inside-port ILU shunting, as most of the container and ro-ro terminals in Rotterdam are located nearby A15 motorway. The first estimations provided by Siemens shows the electrification cost of EUR 2.5 million per each km of motorway. If the project will be launched, it can become a good benchmark for BSR LM operations market.

The above-mentioned examples and estimations shows that e-highway as a solution for CT last mile operations can be economic efficient only for the crowded transport nodes like ports or airports.

E-highway requires a close cooperation not only between infrastructure manager, power supplier and financing party. Every infrastructure has their users, here trucking or forwarding companies. What has to be noticed, transport services market in Poland or the Baltic States is fragmented. The trucking companies own on average few trucks which are universal, suitable for many destinations or types of cargo. Thus, projects such as e-Highway will require additional investment on vehicles, to be conducted by stakeholders like freight forwarders, 3PL companies or terminal operators. Further development of this kind of technologies may lead to trucking company's consolidation, to concentrate the assets on specific part of the market.

The market of hybrid trucks for CT operations is actually limited to diesel tractor units with electric engines to support the transport in urban areas. This solution is provided by Paccar (DAF) in CF trucks as an alternative to short distance pure electric. CF hybrid is propelled with diesel truck on standard roads and highways. In urban areas truck can be switched into electric propulsion with max range 30-50 km. Thanks to the fast charging, batteries can be filled up in 0.5 hours, time that can be used for example during stripping or stuffing ILUs.

7.3.4. Fuel cells – hydrogen

Trucks propelled with hydrogen are actually vehicles with installed electric engine propelled with fuel cells. These cells need the hydrogen to generate the energy, so the H_2 is considered as the fuel.

Hydrogen heavy duty vehicles market in Europe is in its early stages now. Scania tests their trucks with Cummins cells in Norway for local distribution. Volvo and Daimler (Mercedes) started the cooperation to develop the hydrogen fueled trucks.

At the most advanced level seems to be Hyundai. Its Xcient H_2 truck was nominated for Truck Innovation Award 2020, and Korean manufacturer started to deliver the truck to first customers in Switzerland. The truck with 34.5 kg of H_2 on board can reach total gross mass of 34 tonnes and keep 400 km range between fueling. Unfortunately, based on current data, Hyundai offers only rigid trucks configuration for hydrogen fuel, not tractor units needed got CT operations. This means that hydrogen, similar as electric trucks can be of the nearest future of CT last mile operations. For now, trucks suitable for last mile operations propelled by H_2 are not available on the market.

Not any single hydrogen truck will work without efficient fueling network. ACEA calculates, that in 2020 there were 16 H_2 fueling stations across Europe. Future development of technology will require the dynamic development of fueling points. Referring to ACEA estimations in 2030 Europe will need at least 500 H_2 fueling points.

7.3.5. Summary and recommendations

The nearest future of propulsion for last mile deliveries is closely connected with EU policy to decrease CO_2 emissions in heavy haulage transport. EU policy expects to obtain zero-emission economy until 2050. This requires from truck manufacturers to develop wide range of zero-emission trucks fleet. The group of leading European truck manufacturers declared to develop and sale only fossil free trucks by 2040. After 2025 and launching Euro 7 emission standard is expected dynamic drop of diesel trucks in total share of European fleet. The exact details of planned Euro 7 standards are still under preparation, but it is expected that the levels will be hard to achieve by conventional diesel trucks.

Most of the propulsions are now under research or testing process so its availability on the market is limited. The most available technology for now are NGV trucks which are widely available on the market. The total share of NGV vehicles should rise constantly up to 2025 whereas Euro 7 emission standard might get into force. After that, LNG or LBG trucks will be phased out of the market.

The technology of pure electric vehicles is developing dynamic. Manufacturers are capable to provide pure electric trucks with range and power suitable for CT operations. For now, those 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 get in commercial serial production, the availability and the price should improve significantly. In the nearest future, the proper network of charging stations has to be considered as the must for this technology Hybrid trucks for CT operations should be considered more as transitional solution towards pure electric plug-in trucks. E-highway as a cost-intensive solution will remain in use for long haul trucking, and might not play a significant role in CT operations.

The third propulsion which can be considered as a solution for last mile CT operation is the hydrogen, which its constant development will transform from last mile city logistics to heavy trucking used for CT operations.

Taking into consideration transport decarbonization process all the stakeholders involved in the CT last mile should consider relevant action plans. Obviously the biggest challenge is in front of the trucking companies. Fleet lifecycle is considered for 4-6 years period, so most probably it is the last moment to invest in Euro 6 vehicles to fully utilize it before Euro 7 comes into force. After that, trucking companies will require government support or big financial reserves to upgrade the fleets to the new standards. The European standards are the first issue. The second, maybe even a more important are the heavy traffic limitations in the cities. The biggest cities in Europe already launched some restrictions of such traffic. It is connected with the emission from diesel trucks (Berlin) or with the safety of bikers and pedestrians in the blind spots (London). It can be expected that similar limitations may affect other cities causing costs for trucking companies.

New propulsion standards for CT last mile operations will have the impact on CT terminal owners or operators. To provide electrified last mile for customers require creating proper charging stations network in the nearest surroundings of terminal. Before that, fueling stations for NGV will become a must for some CT facilities.

Finally, new propulsions and fuels will affect the government, municipalities and road infrastructure administrators. Increasing number of electric vehicles should oblige the governments in all counties to adapt the legal regulations. Those should cover the increasing maximum permitted gross mass for electric vehicles to avoid lowering the capacity of the trucks due to batteries installed on board. The proper network of fueling and charging points cannot be limited to CT facilities. It should include also parking and rest points in the motorway infrastructure which belongs to road administrators.

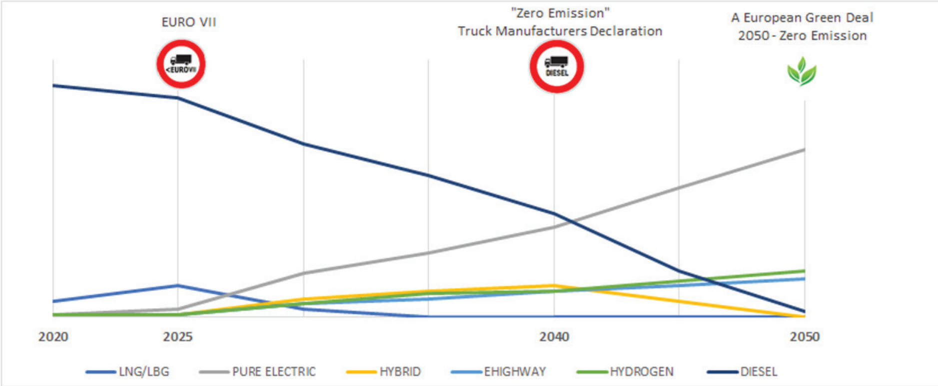


Figure 7.12. A roadmap of propulsion development in heavy duty transport in EU
Source: Own elaboration.

All above analyzed trends and processes can be summarized in form of a roadmap (Figure 7.12), where specific trends can be observed in a long-term line, where the end-point is the 2050 zero-emission economy declared in the New Green Deal. It can be predicted that two energy sources will be the core propulsion for the whole transport sector, namely electric power and liquefied hydrogen (i.e., fuel cells).

8. Combined transport terminals in the BSR

8.1. Elements, types, and functions of CT terminals

In the EU's economic development policy, the BSR is seen as an area of increasing socioeconomic importance in Europe. A number of land and sea intermodal transport chains, connecting the highly developed economies of Scandinavia with the countries of Central and South Europe, run through the Baltic Sea. Maritime transport in the Baltic Sea is provided by ocean and short-sea shipping. The basic form of general cargo transportation in the Baltic Sea shipping is by rolling stock. Hence, the Baltic Sea concentrates a significant part of global ferry traffic in its area and intermodal road – sea and rail – sea transport techniques are widely used in the transport processes of Scandinavia – Central and South Europe.

This arrangement is directly reflected in the CT network and location of the terminals. Spatial distribution of CT terminals in the BSR are presented on map (Figure 8.1). Analyzing the geographical distribution of CT terminals, a large number of them are found in the region of the Jutland peninsula. In the northeast of the Baltic Sea (i.e., Lithuania, Latvia, Estonia, and Russia) there are fewer of them. The situation is similar in the north of the Baltic area.

Table 8.1. Division criteria of CT terminals by size

Criteria	Small	Medium	Large
Number of handled units per year	< 25,000 UTIs or 50,000 TEUs	25,000 – 50,000 UTIs or 50,000 – 100,000 TEUs	> 50,000 UTIs or 100,000 TEUs
Surface area (in m2)	0 – 40,000	40,000 – 70,000	> 70,000
Equipment	Mobile crane / forklifts / reachstackers	3-4 gantry cranes	More than 4 gantry cranes

Source: COMBINE internal agreement. The benchmark analysis includes 150 CT terminals in nine countries. The analysis of the CT terminals is broken down and presented by country.

A CT terminal is basically defined as a place with access to at least two transport modes (i.e., rail and road, or sea and rail, etc.), where transshipment of a unitized

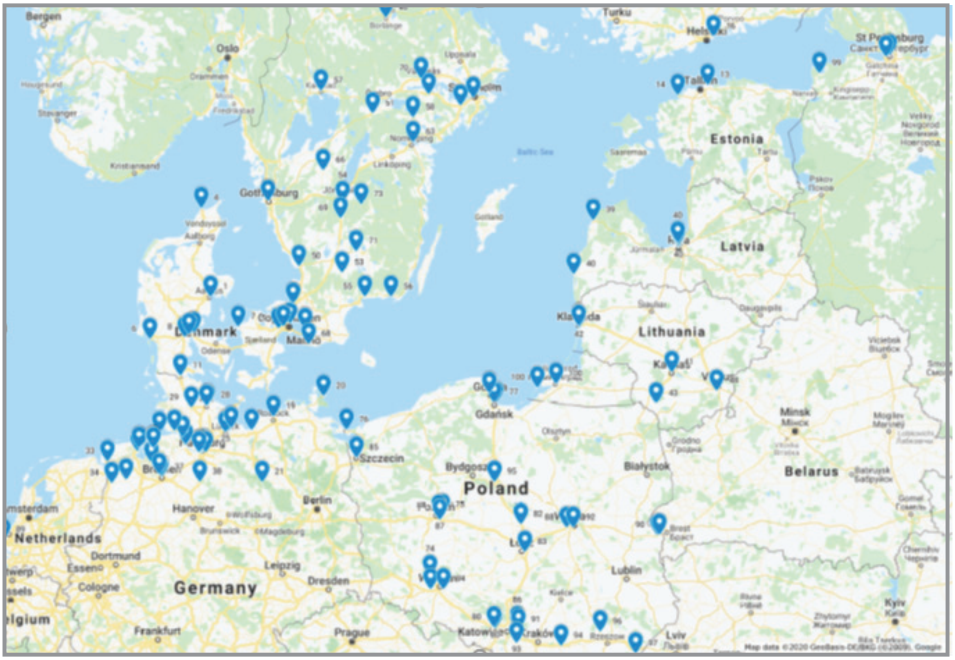


Figure 8.1. Spatial distribution of CT terminals in the BSR

Source: www.googlemaps.com.

cargo take place and where other services related to the cargo units and/or transport means can be offered (Table 8.1).

8.2. Sea port terminals in the BSR

This subchapter will deal with seaport and inland terminals. At first, a comprehensive definition of both seaport and inland terminals is given, and their general characteristics are discussed. Then, the focus should be placed on the seaport and inland terminals within the BSR that have been analyzed in the scope of the *Combined Transport Terminal Benchmark Analysis*[1] of the Combine project. In this regard, a list of the observed terminals for both seaport and inland terminals as well as a map to visualize their spatial distribution will be presented.

Seaport terminals – definition and general characteristics

Historically, seaports play a major and supportive role regarding the emergence and development of trade networks as we know them from today (Notteboom et al.,

[1] EU-INTERREG Combine project work package 3, Activity 3.1.

2021). From a supply chain perspective, and as stated by Notteboom et al. (2021), seaports can be defined as complex and multi-faceted logistic and industrial nodes in global supply chains that have a strong maritime character and both host and fulfil a broad range of activities related to the transportation, transformation and information processes within global supply chains. Ports represent essential nodes in global trade relations and can be described as transit areas or gateways for the movement of goods and people from and to the sea. In other words, they are places where the land and maritime spheres are coming together, and ocean and inland transport systems interact, consequently, leading to the convergence of different modes of transportation in ports (Notteboom et al., 2021; Rodrigue and Notteboom, 2020). Despite their strong maritime character, it would be wrong to consider seaports solely as maritime terminals, since they are simultaneously functioning as land terminals where inland traffic originates and ends (Rodrigue et al., 2017).

There are several locational characteristics that seaports must meet to be considered as such they cannot be located everywhere, and the location of ports is constrained as they have to fulfill certain geographical attributes. Traditionally, as ports are primarily dedicated to serve ships, the access to navigable waterways has been the most important factor regarding the localization and construction of a port (Rodrigue and Notteboom, 2020). Historically, land transport was hardly possible, which means that cities were mostly settled nearby waterways or sea. As a result, many settlements became city ports. Due to the requirement of maritime access, meaning the physical capacity to serve ship operations, possible locations for ports are sites along a coastline, in a bay or natural harbor, in an estuary, in a delta or along a river (Notteboom et al., 2021). In the past, many ports with convenient locations and therefore advantageous conditions over other sites became, and usually still are, trade hubs (Rodrigue and Notteboom, 2020). While Notteboom and Rodrigue (2021) only consider ports in bays or natural harbors as seaports and the others as mainland ports, in the scope of this e-book each port with any of the mentioned geographical location can be considered as a seaport as long as it offers maritime access by not only serving inland but also deep-water waterways (e.g., Port of Hamburg) (SGKV, 2020). In this regard, seaports with direct coastal access might have an advantage as they usually do not face as many problems related to tides, water depth, river width, sedimentation (requiring improvements through dredging and landfills), and/or periods of flooding and drought (Notteboom et al., 2021; Rodrigue and Notteboom, 2020).

In addition to pure maritime access, there are further requirements that seaports must meet. At first, they have to offer enough space that is suitable for the execution of maritime operations, which can be referred to as maritime interface. Especially in view of the construction of ever larger ships, the growing land consumption requirements (through, inter alia, containerization) and often limited possibilities for expansion of port sites, in particular in combination with the frequently observed competition for the same land between ports and cities as well as other urban and environmental constraints, this is an increasing and costly challenge for many port locations, particularly city ports (Rodrigue and Notteboom, 2020).

Moreover, ports require infrastructure and equipment. They need suitable infrastructures such as piers and basins to enable the mooring of modern cargo ships and to conduct the ship-to-shore transshipment process. Furthermore, enough stacking and storing capabilities as well as warehouses for temporary storage of cargo is needed, requiring additional space which can be scarce. For the transshipment and handling operations and the movement of cargo around the terminal, equipment such as (gantry) cranes, straddle carriers or reach stackers is required. All in all, all these requirements involve extensive capital investments and again, enough space (Rodrigue and Notteboom, 2020).

Lastly, which is an important and very valuable feature, especially from a CT perspective, seaports must have good land access. For the growth and importance of a seaport and its purpose within Combined Transport, it is highly relevant to be connected to industrial complexes and the market. Therefore, it is essential that the port area is integrated into an efficient inland distribution system including inland waterway and rail and road transportation. Especially for ports in densely populated urban areas, the land access of ports can be hampered by congestion problems. In this case, it might be useful to expand the rail infrastructure to promote inland access and reduce truck congestion (Rodrigue and Notteboom, 2020).

Due to several reasons, seaports play a key role for the comprehensive and effective implementation of CT. On the one hand, seaport terminals handle a larger amount of freight than any other types of terminals combined (Rodrigue et al., 2017, 185). Hence, in order to achieve the greatest possible benefit from CT, it is essential to integrate seaports and the corresponding cargo flows into the CT supply chains. On the other hand, because seaport terminals function as maritime and land terminals at the same time and thus are a place of convergence for different transportation modes, as already mentioned above, and are, moreover, equipped with the required handling technologies, seaports offer great opportunities in terms of intermodal transport, especially regarding the transshipment of cargo between sea and rail transportation. In this regard, seaports can be regarded as "turntables within global supply chains and global transportation networks" which not only handle ships but act as logistic platforms for international trade and hinterland transportation (Rodrigue and Notteboom, 2020). Therefore, they play a significant role for the distribution of cargo both on the water and on land. Seaports with (large) container terminals are of particular importance, since containers are the most frequently used transport units in CT (SGKV, 2020).

Inland terminals – Definition and general characteristics

Next to seaports, inland terminals also play an essential role for the efficient application of CT. They can be described as transshipment facilities, where cargo units can be transferred between at least two different modes of transportation, which are not directly located on coastal sites but in the hinterland. Through existing transport infrastructure including roads, rail systems and inland waterways which are again embedded in higher-level European transport networks (e.g., TEN-T network and

Rail Freight Corridor), inland terminals are connected to seaports and, therefore, represent important nodes within the multi-link transport chains of CT. Some inland terminals are even directly located on the area of a seaport (SGKV, 2020).

In the previous section, seaports have primarily been defined by the fact that they can serve deep-sea ships due to their beneficial geographical location in coastal sites or other locations that allow for the navigation of deep-sea vessels, for example, along a river, in a delta, or in an estuary. In contrast, the definition of inland terminals used within the scope of this e-book includes all terminals that do not serve deep-sea waterways, i.e., inland terminals as well as inland ports.

In this context, following the recommendations of the UNECE, inland (freight) terminals are defined as any facilities that neither represent a seaport nor an airport and which are operated on a common-user basis and are dedicated to transshipment and dispatch of internationally traded cargo (UNECE, 1998). Regarding the definition of inland ports, one must somewhat be cautious as this term can be used to describe two conceptually different facilities. However, both are included in the wider definition of inland terminals used here. On the one hand, the term can simply describe a port that is located inland and is accessible by barges via inland waterways such as rivers, canals, or lakes but does not serve deep-sea vessels. The latter distinguishes it from a seaport. On the other hand, inland ports are often also referred to as dry ports. Inland ports in terms of dry ports can be described as merging points of various transport modes – road, rail, air but not necessarily inland waterways. Their key characteristic is that they are directly connected to a seaport. They are deeply involved in the transshipment of cargo that comes from the seaport and its distribution to inland destinations, i.e., the seaport's hinterland services. Both facility types usually provide several logistic and distribution services like freight forwarding, consolidation, temporary storage, customs clearance, and transshipment activities (Notteboom et al., 2021).

Based on the number of different modes of transportation served, inland terminals can be basically distinguished into two types. CT Inland terminals can be either categorized as bimodal or trimodal. While bimodal terminals can tranship loading units between two transportation modes, trimodal can handle cargo between three modes of transport. Regarding bimodal inland terminals and in correspondence with our previous definition of inland terminals, there are two possibilities: (1) terminals that switch cargo between road and rail transportation and (2) terminals that transfer cargo between road vehicles and inland vessels. Accordingly, trimodal terminals serve all three modes of transportation, namely rail, road, and inland waterway transport. Depending on the type and number of transport modes served, the terminal's handling equipment and infrastructural design differ and have to be adapted to the local requirements (SGKV, 2020).

Seaport and inland terminals in the BSR

The conducted *Combined Transport Terminals Benchmark Analysis* of the COMBINE project included a total of 150 CT terminals located in the BSR countries (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, and Sweden). The analysis as well as the corresponding data collection was carried out by project partners from the University of Gdansk. Thereby, all terminals were analyzed with respect to numerous variables and characteristics related to organizational, legal, and operational issues (Bielenia et al., 2020). However, in the following, we are solely making use of and present the observed data regarding two selected criteria: (1) spatial distribution of terminals within the BSR and (2) different types of terminals, namely seaport and inland terminals.

The terminals benchmark analysis reveals that the analyzed 150 CT terminals are unevenly distributed among the different BSR countries. Most of them are located in Germany (51), Sweden (32), and Poland (30). 12 and 7 of the analyzed CT terminals are in Denmark and Russia, respectively. The fewest CT terminals can be found in Estonia (2), Finland (4), and Latvia and Lithuania (both 6) (Bielenia et al., 2020).

Besides the uneven spatial distribution of the terminals across the BSR countries, Table 8.2 also shows that there are significant differences regarding the frequency of seaport and inland terminals. Among the 150 terminals, 69 have been categorized as seaport terminals while only 26 terminals are referred to as inland terminals illustrating that there are much more seaport terminals than inland terminals. However, it must be mentioned that not every terminal could be assigned to one of the two terminal types. As shown in Table 8.2, a total of eight terminals is labelled as "Both" and almost one third of the 150 terminals investigated (47) is referred to as

Table 8.2. BSR CT terminals by country and type of terminal.

Country	Total number of CT terminals	Type of terminal			
		Seaport	Inland	Both	Others / n/a
Germany	51	27	10	7	7
Sweden	32	10	11	1	10
Poland	30	6	1	0	23
Denmark	12	7	0	0	5
Russia	7	6	0	0	1
Lithuania	6	3	3	0	0
Latvia	6	5	1	0	0
Finland	4	3	0	0	1
Estonia	2	2	0	0	0
Total	150	69	26	8	47

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

“Others / n/a”.[2] The former is valid for terminals that fulfil the functional criteria for both seaport and inland terminals and thus cannot solely be assigned to one of the main types of terminals; the latter category encloses all facilities that neither fulfil the functions of a seaport terminal nor an inland terminal (e.g., storage sidings or other technical facilities) as well as terminals where data regarding the terminal type was not available.

Several insights can be derived from the above assigned Figure 8.1. At first, the visualization underlines the already mentioned uneven spatial distribution of terminals across the BSR. In the BSR part of Germany, Denmark as well as in southern Sweden, the terminal network is very dense in comparison to other areas of the BSR. The density of terminals is particularly low in the northern Baltic area (northern Sweden and Finland) and in the Baltic states (Estonia, Latvia, and Lithuania) including the BSR part of Russia. Moreover, the visualization emphasizes that terminals are primarily located in or close to urban agglomerations. In Poland, terminals are mainly found in large cities such as Warsaw, Krakow, Gdansk, Wroclaw, Poznan, and Lodz. In Estonia and Latvia, the terminals are almost only concentrated on the capital cities Tallinn and Riga, respectively. Other large cities in the BSR like Hamburg, Copenhagen, Stockholm, or St Petersburg also show a clear concentration of terminals. Lastly, the map also highlights that the BSR is well-equipped with seaport terminals. Seaports can be found all along the coastline of the Baltic Sea, creating a good transportation network for maritime transport. In contrast, many BSR countries are lacking a dense network of inland terminals which are also of high importance for the efficient application of Combined Transport. As recommended in the *Combined Transport Terminal Benchmark Analysis*, to strengthen Combined Transport in the BSR, a stronger focus should be placed on inland terminals in the future (Bielenia et al., 2020).

8.2. Dry port option

According to the original concept, a dry port was defined as an inland terminal to and from which shipping lines could issue their bills of lading, including all types of cargo.[3] This concept has evolved in a direction closely related to the rapid development of containerization, influencing the changing functions of the coastal areas of many port cities, and has begun to be applied in various contexts, the common feature of which is that they refer directly to: „(...) a place inland that fulfils primary port functions”[4]. The dry port concept is based on a direct link between the seaport

[2] The present classification of the terminals was based on the data used for the *Combined Transport Terminals Benchmark Analysis* of the COMBINE project (data provided by University of Gdansk).

[3] *The dry port concept – Theory and practice,* Maritime Economics & Logistics, 14/2012, s. 1–13.

[4] K.P.B. Cullinane, G. Wilmsmeier, *The contribution of the dry port concept to the extension of port life cycles.* In: J.W. Bo¨se (ed.) Handbook of Terminal Planning, Operations Research Computer Science Interfaces Series, Vol. 49. Heidelberg, Germany, Springer 2011, s. 359–380.

and an intermodal terminal located at the back of the port[5]. Another definition is that a dry port is an intermodal terminal located inland, serving a region connected to one or more ports by rail and/or road. It offers specialized services between the dry port and overseas destinations. Typically, a dry port is container-oriented and provides all the logistics services that shippers need in a port[6]. Therefore, the name dry port has been adopted by analogy with a seaport, due to the similarity of much of the infrastructure and functionality. Regardless of the terminology used, there are three basic characteristics associated with it[7]:

- An intermodal terminal, whether by rail or barge, that has been built or expanded.
- Sea terminal connection using rail or inland waterways or trucks based on high capacity of the corridor.
- A range of logistics activities that support and organize transit cargo, often co-located with an intermodal terminal.

As Andrzejewski and Fechner write, the dry port concept enables the creation of a qualitatively new organizational and functional structure of sea-land intermodal transport solutions. Thus, the main tasks related to sorting and organizing the dispatch of intermodal transport units in the form of containers delivered by sea are shifted from the seaport to the hinterland. This increases the rotation frequency of containers on the storage yards of maritime container terminals and increases their handling capacity, which is limited by the lack of storage space for containers after unloading from container ships, which have the capacity to carry an increasing number of containers. The dry port concept is shown in the Figure 8.2.

Figure 8.2 shows that the dry port is a logistics hub with a variety of logistics and multi-branch transport infrastructure. It is a hinterland port with an infrastructure for intermodal transport in the form of container terminals. Due to the distance to the seaport, dry ports can be distinguished[8]:

- in the immediate vicinity of a seaport (close dry port);
- in the middle distance from a seaport (midrange); and
- at a great distance from the seaport (distant).

The advantage of the dry port concept is that it makes it possible to increase the capacity of a sea port without increasing its area in coastal areas. In addition, reducing the transport-intensity of the seaport, activating areas located at long distances from the seaport and increasing the share of rail transport in serving the seaport having a dry port.[9]

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5 V. Roso, *The Dry Port Concept. Department of Technology Management and Economics*, Chalmers University of Technology. Göteborg 2009, s. 1 i nast.

6 L. Trainaviciute, K. Bentzen, M. Stie Laugesen, A. Caruso, *The Dry Port – Concept and Perspectives,* StratMoS WP C, 2009, s. 6.

7 J.-P. Rodrigue, T. Notteboom, *Dry ports*, Port Economics, Management and Policy, https://porteconomicsmanagement.org/pemp/contents/part2/dry-ports/

8 M. Wołek, Suchy port w Falköping – studium przypadku, TTS. Analizy 5-6/2010

9 Ibidem.

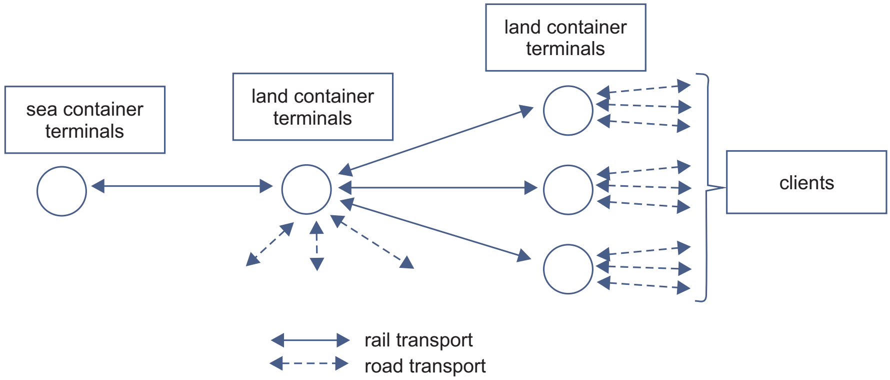

Figure 8.2. Graphical diagram of a transport chain with an inland container terminal (dry port) mediating the distribution of containers between a maritime container terminal and container terminals of destination.

Source: L. Andrzejewski, I. Fechner, *Suchy port jako aglomeracyjny węzeł logistyczny na przykładzie aglomeracji poznańskiej*, Zeszyty Naukowe Politechniki Śląskiej 2014, Seria: Organizacja i Zarządzanie z. 70, Nr kol. 1909, s. 9.

In addition to the main advantages of dry ports listed, a list of other benefits can be found. These include[10]:

- reducing overall transport costs;
- shifting from road to rail transport, which is more environmentally-friendly.
- strengthening the role of ports in transport chains;
- strengthen multimodal solutions;
- reducing the use of expensive, centrally located areas in the port;
- avoiding traffic bottlenecks, resulting in less congestion on roads near the port, due to the modal shift;
- reducing local environmental problems in cities;
- especially in less developed countries, hinterland development can be beneficial to the area in terms of job creation in the area of influence; and
- the possibility of speeding up the customs clearance process for goods transported abroad can be achieved through the creation of dry ports with customs clearance rights.

With the implementation of the dry port concept and the possibility of extending their hinterland to areas further inland from the water, ports can outsource certain services to another terminal, such as container storage and distribution or customs clearance. The benefits of implementing the dry port concept also accrue to other stakeholders, such as the government, for which it is increased trade, higher competitiveness rates providing the benefits of implementing the dry port concept also benefit other stakeholders, such as the government, for whom it means increased trade, higher competitiveness rates providing an incentive for higher GDP growth

10 L. Trainaviciute, K. Bentzen, M. Stie Laugesen, A. Caruso, *op. cit.,* s. 38.

and higher incomes, and the public, for whom it means increased employment opportunities, reduced road congestion and pollution, and fewer road accidents[11].

The implementation of a dry port can bring significant benefits, but the implementation of such terminals or their subsequent operation can be hampered by several major challenges. The main obstacles to implementing this solution on a larger scale relate to land use, the degree of development of transport infrastructure and the organization of the rail transport market. It is important to remember that dry ports are an additional transshipment point between two different modes of transport. This means an increase in additional costs in the total expenditure of the transport chain. In addition, the planning and implementation process of dry ports can take a long time. This becomes a problem when a dry port project is initiated because of already existing bottlenecks in the transport chain, for example congestion in the port, pollution in the port city or road congestion in the port city and access to the port area[12].

In Western Europe, the construction of inland terminals is most advanced due to the close integration of port terminals with rail transport and barge services. Dry rail ports are found throughout Europe and are often linked to the development of logistics zones[13].

The examples of the application of the dry port concept can be found in many countries. For example, in the Netherlands, the end of the 20th century saw the implementation of a policy that was unfavorable for ports especially for the massive expansion of terminals. Therefore, many operations were transferred from the Port of Rotterdam to inland terminals. Terminal operators at the Port of Rotterdam and the Port Authority itself established transshipment and storage facilities away from the city in order to relieve pressure on the largest port in the Netherlands and Europe.

For example, a number of inland terminals (also called satellites) have been built in Moerdijk and Venlo, where distribution and logistics companies have been encouraged to open intermediate wholesale and distribution centers. These are connected by rail to the Port of Rotterdam and thus guarantee port traffic and relieve space within the port area that is used for more essential business transfers.

In Poland, measures have been taken to build an intermodal terminal in Emilianowo Bydgoszcz, which is part of the Strategy for the Development of the Port of Gdynia until 2027, which envisages increasing the share of rail transport in goods handling. Steps have also been taken to modernize the railway line to ensure fast and efficient transport of goods to the port. On 28 July 2020, the special purpose company Intermodal Terminal Bydgoszcz Emilianowo was established. This is the implementation of an agreement concluded in 2019, the signatories of which were PKP S.A., the Gdynia Sea Port Authority, PKP Cargo S.A., the Bydgoszcz Industrial and

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[11] Development and operation of dry ports of international importance, Economic and Social Council, E/ESCAP/CTR(4)/3, s. 12; https://www.unescap.org/sites/default/files/4E_Development%20and%20operation%20of%20dry%20ports%20of%20international%20importance.pdf

[12] *Ibidem,* s. 82.

[13] J.-P. Rodrigue, T. Notteboom*, op. cit.*

Technological Park, the National Agricultural Support Centre, the Nowa Wieś Wielka municipality and the Kujawsko-Pomorski voivode. A special purpose vehicle will prepare the design and documentation of the new logistics center. The construction of such a dry port is also planned in Zajączkowo Tczewskie and it will also serve the Port of Gdansk.[14] The Intermodal Container Yard, a dry dock, is a distribution and transshipment facility that will enable efficient and effective handling of cargo and optimization of the supply chain both from the sea inland (and vice versa) as well as in intra-European relations from west to east and from north to south. The investment will improve transport accessibility of Pomerania and enable the ports of Gdansk and Gdynia to compete effectively with international ports. The project will relieve the Tri-City ring road from the heavy traffic of cars with containers and will transfer the cargo traffic currently travelling on the roads of Gdansk, Gdynia and Sopot to the tracks. The location of the Intermodal Container Yard is shown in Figure 8.3.

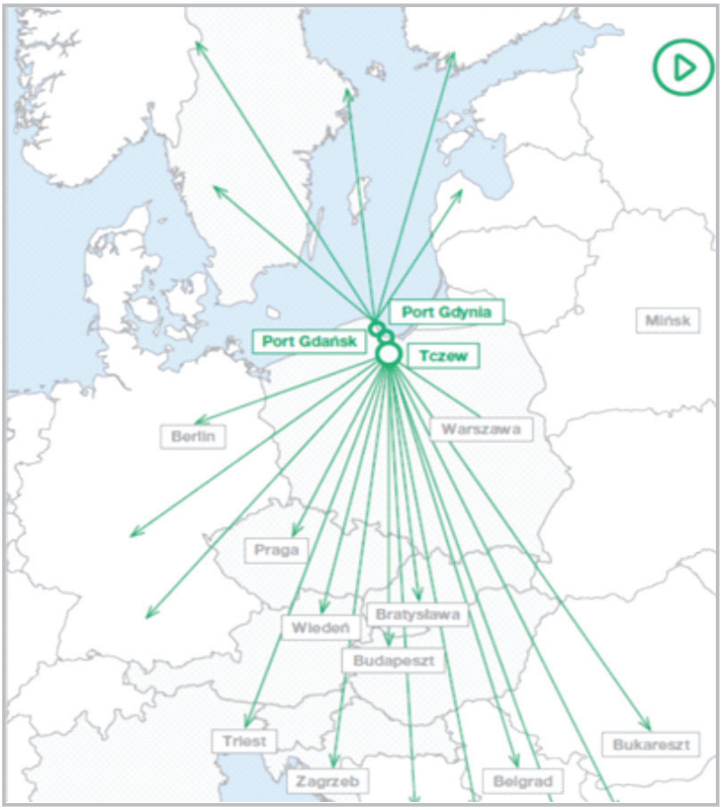


Figure 8.3. Location Intermodal Container Yard

Source: Suchy port w Zajączkowie Tczewskim jako infrastruktura wspomagająca działania portów morskich Gdańska i Gdyni. Opis projektu.

14 https://netka.gda.pl/suche-porty-w-bydgoszczy-i-zajaczkowie-tczewskim-potrzebne-sa-portom-morskim-port-gdynia/

The investment is located at the back of the ports of Gdansk and Gdynia, in Zajączkowo Tczewskie, at the main railway junction of line 131, in the immediate vicinity of the national road No 91 and the A1 motorway. The shuttle trains between marine and ICY terminals running according to fixed timetables will allow better organization of cargo traffic in the Tricity agglomeration area, making a better use of drivers' working time and at the same time improving the use of the limited capacity of railway lines. The link between the national road No 91 and the A1 motorway will relieve the heavy traffic around the city of Tczew. The project will improve cargo distribution logistics through more efficient supply chain management. For efficient flow of goods in the Baltic-Adriatic corridor the infrastructure is of course necessary, but for its proper use smart logistics, oriented towards the demanding expectations of the market, is of great importance. ICY will allow better use of modernized port infrastructure and improve access to ports from the land side.[15]

8.4. Baltic CT terminal benchmark

8.4.1. Quantitative dimension of the benchmark

These connections are important parts of the land and sea transport corridors connecting the Scandinavian countries with Central and South Europe, as well as part of the network of transport links connecting northwestern European countries with Central and southeastern Europe. The analysis shows that terminals are an integral part of large logistics centers. They are located on the outskirts of large cities, at a considerable distance from residential areas. Access to transport infrastructure is a priority. The largest number of CT terminals are located in Germany (51), Sweden (32), and Poland (30). The smallest number of CT terminals are located in Estonia (2), Finland (4), Latvia (6), and Lithuania (6). CT terminals are mainly located close to international traffic routes. This has meant that land terminals are mostly located within the TEN-T corridors and near large agglomerations (i.e., at the crossroads of major roads, for example Kutno-A2 and A1 motorway). CT terminals located outside the TEN-T network are located on national trade routes. The preferred solution is to locate the terminals at the intersection of the urban road ring road with the main railway line. In port cities, a large part of the turnover of terminals is made up of sea transport loads, hence their location is as close as possible to the port area. Port terminals are most often served by lines connecting Baltic ports (e.g., Gdynia-Karlskrona, Helsinki-Tallinn, Lubek-Malmo, Rostock-Hamina / Kotka, etc.) and are located in the largest Baltic seaports, thus having a close correlation with other port cargo turnover. The analysis also shows that large urban agglomerations have several terminals – logistics centers or a network of sub-centers located closer to the final

[15] Suchy port w Zajączkowie Tczewskim jako infrastruktura wspomagająca działania portów morskich Gdańska i Gdyni. Opis projektu.

recipients of goods (Table 8.3). The average number of CT terminals per 1,000,000 inhabitants for the region is 1.0 (with Russia at 0.6), while the average number of CT terminals (units) region-wide per 100,000 km^2 is 8.59 (with Russia at 0.08).

Table 8.3. Spatial intensity factors of CT terminals location in BSR countries

Country	Average number of CT terminals (pcs) per 100,000 km^2	Average number of CT terminals per 1,000,000 inhabitants
Germany	43.1	2.4
Sweden	7.3	3.1
Poland	9.6	0.8
Denmark	28.0	5.5
Russia	0.4	1.7
Lithuania	9.2	2.1
Latvia	9.3	3.2
Finland	1.2	0.7
Estonia	4.4	1.5

Source: own elaboration.

8.4.2. Benchmark of operational and ownership aspects

The operation of CT terminals results from the ownership structure of the terminal itself as well as the operator company operating the terminal. Both of these issues are not always combined in one, many countries in their legal systems separate ownership and operator functions. The most common sector where such separation occurs is port activity and therefore all terminals located there. It is also less common on land. In this section the ownership and management of terminals is analyzed.

At the outset, it should be explained that the basic issue in this respect is the ownership of the property on which the terminal is located. Depending on the country in question, this may be land owned by the government, regional or local authorities, or private property, or the ownership of a railway company that owns the tracks and associated point facilities. The ownership title also determines who the investor in new terminal investments is and who is obliged to bear the maintenance costs of existing infrastructure. In special cases, however, the investor's responsibility can be transferred to the operator by placing the land itself at the disposal of the operator, who builds the land according to his own needs on the basis of a contract or lease agreement (usually for a long period of even 25-30 years). There may also be situations in which local or central authorities invest in a finished terminal and entrust the operation to private entities on the basis of a bidding or tender or concession.

The issue of ownership of land and infrastructure elements in the BSR states is extremely difficult to collect, as there are no publicly available real estate databases with their owners, which have simply answered the question of ownership. This issue is the subject of a separate study within the COMBINE project.

The research shows that we cannot speak on the BSR scale of one, exclusive or the most common model of terminal ownership. In the following section this issue is analyzed in detail by country.

The second area of analysis concerns the issue of the operational model of the terminal. This model is only partly due to the adopted ownership model, hence the necessity to separate it. The role of a terminal operator can be played by the following entities: state enterprises, private enterprises and public transport service providers (i.e., rail, road, or sea). Such an operator may also be a combined or intermodal transport operator, which, within the framework of its network of connections, based on public access to line infrastructure, creates its own terminal network (i.e., regardless of whether it owns the land underneath). It can also be a specialized operator which, thanks to its experience, locates its terminals in optimal locations and makes its potential available to all those willing to do so on a public access basis. It is then in the interest of such an operator to spread its offer as widely as possible among all railway undertakings, freight forwarders and intermodal operators. The opposite is the case when an intermodal operator creates a network of terminals exclusively for its own needs without making them available to other entities. In this case, the model adopted is an element of competitive advantage over other operators who do not have the possibility of transshipment in a given terminal, and thus in its nearest region. It is rare for several terminals to be very close to each other.

To sum up this thread, four basic operational models of a terminal can be distinguished:

1) Fully in-house,
2) Concession,
3) Operating contract, and
4) Rental agreement for commercial operation.

The above options were adopted in the benchmark analysis for the BSR.

The issue of public availability of terminals is an important element of the whole market, as it shows the extent to which new and independent operators can develop their activities.

Table 8.4. presents the summary results of the correlation analysis between the adopted operational model of the terminal and the extent of terminal availability for public entities.

Table 8.4. Correlation between operation model and public accessibility of a BSR CT terminal

Operation model	BSR country	Publicly accessible	Not publicly accessible
Fully in-house (1)	Denmark	5	1
	Estonia	0	0
	Finland	0	1
	Germany	32	4
	Latvia	0	0
	Lithuania	6	0
	Poland	10	9
	Russia	7	0
	Sweden	15	0
Total model 1	BSR	68	15
Concession (2)	Denmark	0	0
	Estonia	0	0
	Finland	0	0
	Germany	0	0
	Latvia	0	0
	Lithuania	0	0
	Poland	0	0
	Russia	0	0
	Sweden	3	0
Total model 2	BSR	3	0
Operating contract (3)	Denmark	3	1
	Estonia	0	0
	Finland	0	0
	Germany	0	1
	Latvia	0	0
	Lithuania	0	0
	Poland	0	1
	Russia	0	0
	Sweden	13	0

Total model 3	BSR	16	3
Rental agreement for commercial operation (4)	Denmark	0	1
	Estonia	0	2
	Finland	3	0
	Germany	0	1
	Latvia	0	6
	Lithuania	0	0
	Poland	5	5
	Russia	0	0
	Sweden	1	0
Total model 4	BSR	9	15
Grand Total	BSR	96	33

Remark: data has been cleaned off the missing data (for 21 terminals was impossible to indicate approved operating model).

Source: own elaboration based on data analysis.

As one can observe, the most popular among the above four models is the model based on the full ownership formula, i.e., a situation in which the terminal operator is also its owner. About 64% of terminals in the BSR have adopted such a model. The vast majority of them operate on the principle of public access (almost 82%). Only 15 terminals managed in this way operate for the exclusive needs of the operator itself. It should be emphasized that this may indicate that the operators still want to maximize the level of utilization of their transshipment capacity by making it available to other entities. It also means that existing terminals are much larger (in terms of turnover capacity) than would be required by the operator himself. The largest number of such publicly accessible terminals are located in Germany (32) and Sweden (15). In Poland, on the other hand, they number 10 which almost equals the number of terminals closed to other operators (9).

The second most popular operator model is rental agreement for commercial operation. This means that the ownership function of the terminal is separated from the operational sphere. In total, there are 24 terminals of this type in the BSR, which constitutes 19% of all analyzed. Interestingly, most of them operate in a closed formula, without public access. This means that if a given operator has undertaken operations on a leased terminal, it is mainly for its own needs. Serving other entities may interfere with their own work and distract them. This is the case in all analyzed terminals in Latvia, which is 100% operating in the presented formula. Also 10 Polish terminals use this model, where the issue of public availability is equally divided into half – half of the terminals offer services for all, the other half do not.

The third most common operating model is the operating contract. It operates on the basis of an order given to an operator selected through a competition or from a free hand. Its task is to provide reloading services for the region or city, i.e., in the public access formula. This is the case in Sweden, where 13 terminals implement this model and in Denmark (four terminals). A total of 19 terminals operate in this way, which is 15 % of all analyzed terminals in the BSR. Of these only three operate in a closed formula, the rest are public. From the accompanying circumstances it can be concluded that such contracts are awarded by municipalities in a situation of market shortages and low interest in this type of activity in a given region i.e., where the volumes of cargo weight do not justify market interest in this industry.

The last operational model, based on a concession, works only in three terminals, which constitutes 2% of the analyzed market. This model is only used in Sweden and takes the form of public access. This applies to two terminals in the port of Gothenburg and one in Gavle. This can be interpreted as a more far-reaching formula than an operating contract to commission specific handling work for a region or city at a specific location on a specific infrastructure. This model, in turn, is more likely to be used in situations where the loading weight of a terminal is so high that many people want to handle it, although only one can physically do so.

To sum up the issue of accessibility, it should be stressed that almost three-fourths of them operate in an open formula. Only 25.6% of the terminals in the BSR are not publicly accessible. Almost half of them (15) operate in Poland while for the remaining countries they are sporadic cases.

8.4.3. Benchmark of operation range

The scope of services offered in the terminal's CT constitutes the basic area of competitive advantage of each operator. It can be concluded that the primary reason for the location and construction of the terminal is the transport need, which usually results from the vicinity of a large agglomeration or industrial center, or a large seaport. However, as the operational activity develops, the terminal should expand the scope of its service offer, apart from strictly reloading and storage (and of course cargo handling of means of transport). Additional activities may be related:

1) a wider range of cargo units (ro-ro, Ro-La, Modalohr, CargoBeamer);
2) non-standard loading units and non-standard loads (reefers, dangerous cargo, and oversized cargo);
3) new (in relation to the originally operated) modes of transport;
4) services on the goods (LCL/FCL formation, packing, picking, packing, etc.);
5) services for the shipper and/or forwarder (customs, phytosanitary and customs agency); and
6) services to loading units, means of transport and packaging (weighing, repair, servicing, refuelling, certification, etc.).

All the above-mentioned groups of ancillary services are referred to as value-added services and are increasingly common in all types of terminals in the BSR. This often determines the further activity of the terminal especially in case of close proximity to other terminals (e.g., near Poznan/Poland, where we have four terminals located within 60 km radius).

The general conclusions of the conducted analyses allow to determine the typical features that CT terminals in BSRs show and these are:

- 91% of BSR CT terminals are ready to storage of containers and general cargo;
- 77% of BSR CT terminals are ready to storage and handling of reefers;
- 100% of BSR CT terminals are ready to storage of dangerous goods;
- no correlation observed between the service of weighing of wagons/loading units and TEN-T network;
- no correlation observed between the service of weighing of wagons/loading units and RFC;
- correlation between storage of containers / general cargo service and TEN-T network observed;
- none Ro-La units/services in volumes handled in 2018 in BSR CT terminals;
- Ro-La not accepted in Latvia at all;
- no correlation observed between Ro-La acceptance and TEN-T network nor RFC;
- Loading /unloading / transshipment: 100% basic service in Estonia and Latvia; and
- Loading /unloading / transshipment: 100% basic + additional + ancillary service in Lithuania, Finland and Russia.

The direct result of the range of services provided is the terminal's turnover. It can be measured in units of cargo corresponding to 1 TEU, 1 UTI, or in tonnes. The choice of the statistics is up to the terminal operator. However, the biggest problem encountered during the research is the availability of data in any form. It turns out that the operational results of a terminal are usually strictly confidential information covered by trade secrets. Therefore, it was impossible to present and analyze this turnover for the whole BSR. Most of such cases occur in Germany. Full results, in turn, are given by Scandinavian terminals and Baltic States and Russia. Therefore, in the absence of data for some terminals, an estimation method based on data from previous years (rather than 2018) and available transshipment infrastructure and equipment was used. This made it possible to determine the total national turnover and average turnover figures for the terminal by country with the exception of Germany, where the number of unknown turnovers was significantly higher than the number of known results. These are summarized in Table 8.5.

Table 8.5. Volumes handled in BSR CT terminals by country (except Germany) in 2018.

	Total terminals turnover	Average turnover per terminal
Denmark	880,940	97,882
Estonia	22,540	11,268
Finland	919,112	229,778
Latvia	586,538	97,756
Lithuania	390,700	195,350
Poland	3,655,000	243,667
*without DCT	1,729,000	123,500
**without seaports	916,000	76,333
Russia	1,333,000	669,500
Sweden	896,040	35,842
TOTAL	7,856,669	52,378
*without DCT	5,930,669	39,800
***without DCT and Russia	4,597,669	32,152

Source: own elaboration based on data analysis.

Besides above, based on collected data (Table 8.6) the following general conclusions could be drawn on this basis for the BSR CT terminals:

- total BSR CT terminals yearly turnover exceeds 7,5 million of TEU (equivalent number for all cargo units);
- highest share for Poland, where one terminal – DCT Gdańsk – represents 1.9 million TEU volume a year. The sum of the Polish seaport terminals container turnover exceeds 2.7 million TEU;
- if calculations were to include Russian terminals, which all are located in seaports and service yearly ca. 1.3 million TEU;
- in other BSR countries the volumes handled are influenced by seaports;
- the highest average turnover per terminal is in Russia (669 500 TEU);
- the lowest average turnover per terminal is in Estonia (11 268 TEU);
- an average result per terminal for the whole BSR equals to 52,000 TEU, and when corrected by eliminated DCT high score, the value falls to 39,800 TEU. Further on, corrected by DCT and Russian terminals, the average BSR volume handled is reduced to 32,152 TEU a year; and
- 100% containers at CT terminals (2018) in Lithuania, Estonia, and Russia. In other countries the structure of units serviced includes also trailers and swap bodies, but in a very limited dimension.

Table 8.6. Average volumes handled in 2018 per CT terminal by country (except Germany).

	average (1 000 TEU)	median (1 000 TEU)	minimum (1 000 TEU)	maximum (1 000 TEU)	wherein: Containers (%)
Denmark	97.9	161.0	29.93	494.0	72.0
Estonia	11.3	11.26	7.33	15.2	100.0
Finland	229.8	653.0	265.0	1 112.0	67.0
Latvia	97.8	80.53	40.0	280.0	87.0
Lithuania	195.4	202.5	0.6	386.7	100.0
Poland	243.7	85.0	21.0	1 926.0	85.0
Russia	669.5	198.9	27.1	722.0	100.0
Sweden	35.8	20.0	5.0	90.0	99.9

Source: own elaboration based on data analysis.

8.4.4. Benchmark of infrastructure and transshipment aspects

The spatial location of the terminal is a strategic issue. The operational issue is its reloading capacity. This depends on two basic components of each terminal – infrastructure and reloading equipment (i.e., suprastructure). Both of these elements are crucial for determining the capacity of each terminal. It can be measured both dynamically and statically.

Dynamic measures relate to the rate at which the transshipment of loading units in the terminal is or can be performed, e.g., the number of TEUs trans-shipped per hour, per shift, per month or per year or the maximum number of loading units that can be handled in the terminal within a given time. As such, the first example shows the reloading work performed and the second example shows potential reloading capacity. The difference between the two is important and tells us how much the terminal uses its capacity. The ratio of the first meter to the second is between zero and unity. In this group of meters, you can also find retail indicators that tell you about the speed of operation of individual handling equipment or the acceptable speed of movement within the terminal by different means of transport. However, these are individual meters for each device and for each manufacturer, which makes a more general comparative analysis impossible. Therefore, within the framework of data collection, the number of the main handling equipment has been limited, without going into details about its brand and model.

Static meters speak of the number of loading units that may be present in the terminal at any given time, distinguishing between location and nature. This can be distinguished by the capacity of the storage yards, the storage area, including covered storage, the number of rack stands, parking spaces for trucks, the number of siding tracks and loading tracks.

Next, the results of benchmarking analysis will be presented according to particular parameters: storage area, number of tracks, number of cranes, number of mobile handling equipment and weight limits of handled units as the most important parameters speaking about CT handling capacity of terminals.

Parameters related on terminal area

This parameter determines the one-time amount of cargo units that a terminal is able to absorb at one time. For seaport terminals this is crucial in terms of the capacity to accommodate the largest container vessels (22,000 TEU and more). For inland terminals this is important in terms of the capacity to handle a certain number of trains per shift or day in the knowledge that stripping and forming a train composition requires an average of three to seven days to deposit the cargo unit at the terminal (in some standards it can be 14 days). This parameter may be supplemented by additional information. For example, the number of places for refrigerated containers for which a power supply system is prepared (for the connection of refrigeration units) is additionally given. Under special conditions, this allows for the handling of reefers on long distances (e.g., Italy-Scandinavia, for fruit, vegetables, fish and meat). A lack of mention of such a service in the official data of the terminal, which was met very often during the research, may indicate a lack of such service, although not necessarily. Often terminal operators forget to provide such data, which has been confirmed many times during research. Another type of detail is the information about the covered area of warehouses available in the terminal. This means that not only the forming services of FCL/LCL load units can be performed in the terminal, but also value-added services on the cargo themselves.

Based on the analysis results, it can be determined that:

- the average size of the CT terminal in the BSR is 183,743 m^2 (18.4 ha);
- this corresponds to a storage capacity of approximately 7,900 TEU, but in reality, this capacity measured in container slots is much lower;
- this average is overestimated by port terminals, which are approximately 3 to 4 times larger than the land terminals in the BSR;
- the smallest average terminal areas are in Finland, Lithuania and Sweden;
- the highest average terminal areas are in Denmark and Russia (with only seaport terminals analyzed in Russia);
- the average storage area needed for a storage capacity equivalent to 1 TEU is 23.3 m^2, with two important correlations: port terminals, despite storing containers in a larger number of layers (which underestimates the consumption rate of m^2 per 1 TEU), require more space per balance for the movement of larger cargo handling equipment and thus overestimate this rate, while land terminals, despite their smaller size, make better use of available storage areas for cargo units;

- the average size of a terminal in the BSR is between 50,000 and 70,000 m^2, while in TEU units it is 2,000-3,000;
- this average does not reflect the reality well enough and it is necessary to analyze the size of the terminals according to the initial division into three types: small, medium and large (Table 8.7), where small size terminal means area below 40,000 m^2, medium size terminal means area between 40,000 and 70,000 m^2 and large size terminal means area above 70,000 m^2;
- of the three types of terminal size, the most common one is large (69 units), followed by small (48 units) and then medium (34 units); these values include a total of 90 port terminals, including 35 very large port terminals; and
- average values of terminals areas for all BSR terminals are interesting, where only Lithuania terminals oscillate around 50,000 m^2 and all other exceeds 100,000 m^2 (except Sweden with average area of 93,000 m^2).

Table 8.7. BSR CT terminals structure by size.

	Small	Medium	Large	Total	Where in:	
					Seaport terminals	Large seaport terminals
Denmark	7	2	3	12	7	4
Estonia	0	0	2	2	2	2
Finland	0	2	2	4	2	2
Germany	6	12	32	50	43	6
Latvia	1	1	4	6	6	4
Lithuania	3	1	2	6	3	2
Poland	11	12	8	31	6	5
Russia	1	0	6	7	7	7
Sweden	19	4	10	33	14	3
Total	48	34	69	151	90	35

Source: own elaboration based on data analysis.

Parameters related on rail infrastructure

The basic transport mode for inland terminals is rail. It is also crucial for all port terminals with high container turnover in terms of hinterland services. Hence, not only the availability of international terminal rail services (i.e., whether the terminal is part of the TEN-T network and the RFC, as discussed in Section 3.1) is important, but also the number of tracks inside the terminal on which wagon loading can be carried out. This issue is not clear, as there may be tracks inside the terminal for warehouses waiting to be handled, in transit, but mainly for the handling itself, unloading and loading. There may also be tracks for the train marshalling, especially when the length of these tracks within the terminal is less than 400 m, which makes it impossible to place the entire train on a single track, and makes it necessary to disconnect the wagons into two or three groups and dismantle them into two or three tracks respectively, and then, after loading, form them again into one depot. The most common train length limits in Europe are 650-700 m. As practice shows, however, most often the tracks located in the terminal are used first of all for cargo handling, and in addition, they also serve for parking or forming trainsets.

On the basis of analyzed data, BSR CT terminals are characterized by the following features:

- the average number of tracks in one terminal for the whole BSR equals to four;
- the most common number of tracks (dominant feature) is two;
- the average is overstated by large land terminals and port terminals; the highest ratio was recorded in one terminal in the port of Hamburg-14;
- the lowest value of this parameter was recorded for Estonia (2), while the highest for Finland (6), and Russia (5.7);
- high number of rail tracks plays important role for seaport terminals, especially the largest ones, which export to the hinterland up to 35-40% of containers by rail;
- the average small inland terminal is served by two tracks, with a fairly short length of up to 450 m;
- the longest trains are allowed in Sweden – up to 950 m;
- the smallest discrepancies are found in the German terminals, where it is standard to be able to handle freight trains up to 700 m long. Terminals in other countries show very big differences, both spatially and generically and allow handling sets from 300 to 650 m long; and
- an exception in the region is the Kouvola terminal, where it is possible to handle trains up to 1,100 m long - however, this is the result of specialization in handling empty containers from Finland to China, which was until recently the case at this terminal.

Summarized detailed data is shown in the Table 8.7.

Parameters related on transshipment equipment

Equipping the terminals with gantry cranes determines its role in the national and international transport system. At the beginning, however, it is necessary to distinguish very clearly between seaport terminals, where STS (ship-to-shore) gantries are the basis of activity. Their quay outreach and lifting height are proof of the gantry generation. Currently, the most modern ones handle up to 28 containers from the quayside and up to a height of about 73.5 m above the ground. Their capacity is counted in 30-35 operations per hour for single crane trolleys, and it is also possible to operate sets of two or more containers at the same time. However, such types of cranes are not yet available on the Baltic Sea.

The basic equipment of large land terminals is RMG (rail moulded gantry cranes, which cover up to four railway tracks and up to four vehicle lanes. RMGs with a width of 3+3 (3 tracks + 3 lanes for lorries) are standard. Importantly, RMG's equipment of the terminal demonstrates its high level of infrastructural development, as this type of gantry requires larger areas with a paved surface and is also equipped with mobile cranes (RTG – rubber tyred gantry crane). Therefore, RMG does not meet in small terminals, while in medium-sized ones it is sporadic. They are mainly used in border terminals, especially when there is a change in track width (1435/1520 mm).

From the analysis it can be concluded that:

- in the BSR the average number of gantries per one terminal is 4.4;
- the extreme values of this parameter for individual countries range from 0.3 (in Sweden) to almost 25 (in Russia, but only port terminals were included in the analysis, with the largest ones in St. Petersburg, which significantly disturbs the region's average);
- in Poland, the average values of the index are overstated by the three largest container terminals, with 56 cranes self in DCT Gdansk. Excluding these three port terminals, this parameter reaches 1.2 with a simultaneous number of 16 terminals in Poland that do not have this type of gantries at all;
- in Sweden, only 9 terminals have any type of gantry at all, with a maximum of two per terminal; similarly, in Denmark, where half of the total number of gantries are STS, the rest are located in five land terminals;
- as many as 61 terminals in the BSR do not have any gantry and are mostly small or medium size CT terminals;
- a typical arrangement for a small inland terminal is one crane or one or two reachstackers instead;
- in inland terminals equipped with gantries, there is an average of 1,000-2,000 TEU of storage capacity per one gantry, with a maximum of 50,000 TEU in extreme cases; and
- port terminals equipped with cranes have an average storage capacity of 3,000-3,500 TEU per crane station, with a maximum of 75,000 TEU (Ventspils) in extreme cases.

Parameters related on mobile equipment

Terminal mobile cranes are used in two ways. First, basic and handling equipment, is especially used in small or medium size terminals, where there are no gantries, or accompanied by one RMG. Mobile cranes are most effective in this type of terminal due to their high flexibility of application, both in terms of the type of units they serve (i.e., universal spreaders make it possible to pick up both containers and craneable trailers or swap bodies) and spatially (i.e., anywhere in the terminal the handling in a truck-truck or trick-train or truck-barge relation). From this point of view, mobile cranes constitute the basis of operational activity. The second way of using them is as complementary devices, mainly for back-up activities or short movements within the terminal. This is the case in large terminals, which are based on the operation of STS or RMG railway gantry cranes and cooperation with RTG's on storage yards.

Both ways lead to a similar scale of application, as the small terminals require two or three such devices, while the large terminals still support the handling work on the gantries, while the mobile cranes are treated as peripheral or complementary equipment.

The following conclusions can be drawn from the data analysis:

- the average number of mobile cranes in BSR terminals is 3.1;
- this value is very significantly influenced by 440 devices in Germany alone and 100 in Poland; in the other BSR countries the total number of these devices oscillates between 13 and 19; only Estonia shows a total of three such devices;
- the national averages also show large disparities, ranging from 1.3 (Sweden) to 11.9 (Germany); and
- these are mainly reachstackers, less mobile cranes or straddle carrier - these are very rarely used in terminals of universal character or with the lowest infrastructure development threshold.

Parameters related on weight limits for cargo units

From the point of view of accessibility, the terminal is also determined by the maximum permissible weight of the cargo units to be handled. This is important in the case of heavy containers and semi-trailers, especially in relation to imports from China and in the conditions of cross-border transport of heavy units.

In general, similar standards can be observed in the BSR (Table 8.8), which have their origin in the cooperation within the EU of all countries. This standard is defined by the weight of 40 tonnes per unit of cargo. Of the analyzed countries, only Poland shows a lower value of this parameter (38.85 tonnes on average). On the other hand, there are two countries – Lithuania and Russia, in which there are no such limits at all. Sweden deserves to be mentioned as well, as it allows for a maximum weight of 60 tonnes as standard, and there is a discussion on the introduction of 80 tonnes in road traffic in this country.

As an exception for CT, the permissible increase of the limit to 60 tonnes of a lorry in Germany on certain roads can be regarded as an exception, which also results in increased limits for the units handled at terminals. In the case of the MPs, it is permissible to increase the limit by one tonne provided that the transport is carried out using the last mile technology, which is defined as a section of up to 150 km between the last terminal where the unit left the railway and the destination of the transport.

Table 8.8. Key infrastructural elements of CT terminals.

	Total terminals area (m²)	Total number of gantry cranes	Total number of mobile cranes	Average					
				Terminal area (m²)	Area use per 1 TEU (m²)	Trailer weight limit (T)	Number of mobile cranes	Number of (gantry) cranes	All facility tracks: number
Denmark	1,523,500	16	17	126,958	25,19	41	1,4	1,3	2,7
Estonia	305,000	10	3	152,500	43.02	40	1,5	5,0	2
Finland	1,689,600	19	16	422,400	7.19	40	4,0	4,8	6
Germany	–*	66	440	192,357	–	–	11,9	2,0	4,8
Latvia	1,171,100	18	19	105,183	16.48	40	3,2	3,0	3,8
Lithuania	305,800	16	13	50,967	11.25	no limit	2,2	6,0	5
Poland	3,524,800**	135	100	117,493**	29.24	38,85	3,2	4,4	3,1
Russia	2,749,660	172	15	392,809	22,57	no limit	2,1	24,6	5,7
Sweden	2,976,732	11	39	93,023	31.41	60	1,3	0,3	3
TOTAL	14,246,192	463	662	183,743	23,3	–	3,1	4,4	3,9

* – due to lack of data of majority terminals, this parameter is unfeasible to sum up.

** – value without one seaport terminal - DCT Gdańsk – with the area of 700 ha, which would introduce incorrect values differing from other countries.

Source: own elaboration based on data analysis.

8.5. New trends in energy saving in CT terminals

Electricity and fuels that are consumed by the combined terminal have very large impact on operating costs and the amount of harmful emissions. Both parameters are of key importance today for assessing the terminal's operational efficiency and it seems that this importance will grow in the future. Hence, terminals use a monitoring system of energy consumed, which is often part of the Environmental Management System (EMS) implemented by terminal operator. Available publications on this subject relate mostly to terminals in seaports but may also be used in the analysis of combined terminals. The same container handling equipment is used in port container terminals and combined terminals, and the same transshipment technologies for handling land and river transport means are used.

In research carried out in 2016 in a group of 91 European ports, as many as 80% of them implemented a system of continuous energy monitoring, which means an increase of 9% compared to 2013. Moreover, the reduction of fuel and electricity consumption belong to the three top environmental priority areas in terminal management next to the air quality and noise reduction activities. Appropriate tools for monitoring, reporting, and optimization of energy consumption, often integrated with Terminal Operating Systems (TOS), are used in both seaport and inland terminals.

The starting point for any analysis and optimization is the knowledge of the volume and structure of electricity and fuel consumption generated by the terminal. Based on data from seaport container terminals, we can distinguish the following basic areas of energy consumption at the combined terminal:

1) Electricity for:
   a) handling equipment (Rail Mounted Gantries – RMGs, Ship-to-Shore crane – STS, Rubber Tired Gantries – RTGs, Empty Container Handlers – ECHs, Terminal Tractors – TTs),
   b) storage yard lighting,
   c) offices, and
   d) container reefers.
2) Liquid fuels (diesel oil, LNG, LPG) for:
   a) handling equipment (Reach Stackers - RSTs, RTGs, ECHs, TTs),
   b) locomotives,
   c) terminal staff cars, and
   d) client trucks.

In the group of terminal handling equipment, replacement of classic diesel engines with electrically assisted drives, i.e., hybrid (diesel-electric) or fully electric (Figure 8.4-8.6) is observed. Another trend is the use of dual-fuel (diesel-gas) engines or powered exclusively with alternative fuels (LNG, CNG, LPG, and Hydrogen). This applies in particular to RTGs, ECHs and TTs handling units. The biggest challenge in this respect seems to be changing the Reach Stacker (RST) diesel engine, which is characterized by an extremely demanding work regime. This challenge was taken up as part of the H2Ports project that aims to develop a zero-emission eRST

Figure 8.4. Hybrid RTG with rechargeable power pack

Source: www.moveitmagazine.com/2019/03/22.

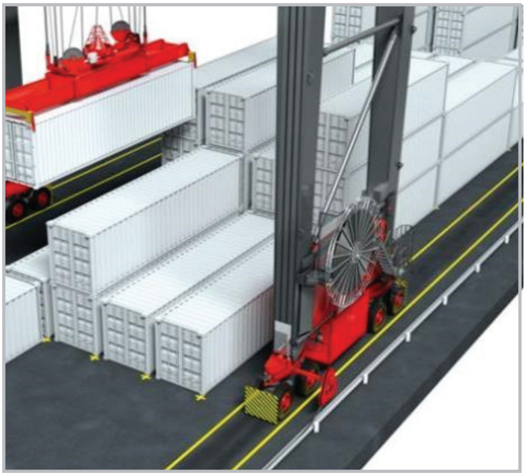


Figure 8.5. eRTG with cable reel

Source: www.moveitmagazine.com/2019/03/22.

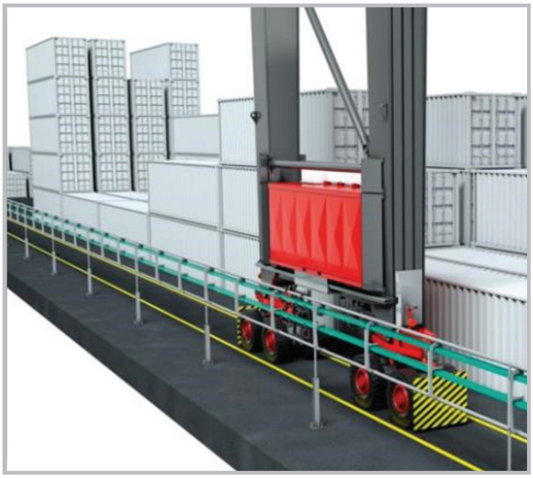


Figure 8.6. eRTG with busbar

Source: www.moveitmagazine.com/2019/03/22.

featuring a hydrogen fuel cell on board. The new Reach Stacker is expected to enter operation in 2021 at the MSC Terminal Valencia (MSCTV) in Spain[16].

There is a huge capacity of energy transition from fossil fuels to alternative fuels and electric power for all handling equipment. Creates a simple way to achieve the strategic goal, which is "zero emission CT terminal" which would be completely neutral for the environment and society. This goal can be achieved by 2025.

16 Hyster begins development of electric reachstacker for Port of Valencia, https://moveitmagazine.com/2019/03/22/.

The structure of electric energy and fuel consumption is always related to the specificity of the terminal infrastructure and equipment as well as the volume of transshipments. The differences would be large even within the terminals of the same operator similarly equipped. The available data on energy management of seaport container terminals shows that two container terminals at the Port of Gdansk have completely different approaches to the energy sources used. The larger Deepwater Container Terminal (DCT) has a 54% share of electrically powered transshipment facilities, and at the smaller Gdansk Container Terminal (GTK) this share is equal to zero. The average number of electrical transshipment devices in five Polish container terminals is 41% (Blue Baltics, 2020; Go LNG, 2020; ICF, 2020). Data for container terminals in other countries show that this share has similar values, i.e., 34% for Rotterdam and 53% for ports in Finland.

The energy balance for a typical rail-road terminal will be presented below (Figure 8.7). The assumption is that this is a new terminal with a reloading capacity of 130,000 ITU equipped with: one eRTG, two RSTs and two TTs with semitrailers (adapted for the transport of containers and semitrailers). The infrastructure of the terminal with a total area of 6 ha includes: load tracks with a length of 650 m, storage yards of about 30,000 m^2, seven power supply points for refrigerated containers, an office and social building with a usable area of about 250 m^2, a workshop of 3,000 m^3 space area, parking lots, a covered shed and washing point.

Table 8.9. presents basic data determining the energy demand of basic infrastructure elements and handling devices of the model combined terminal. Based on these

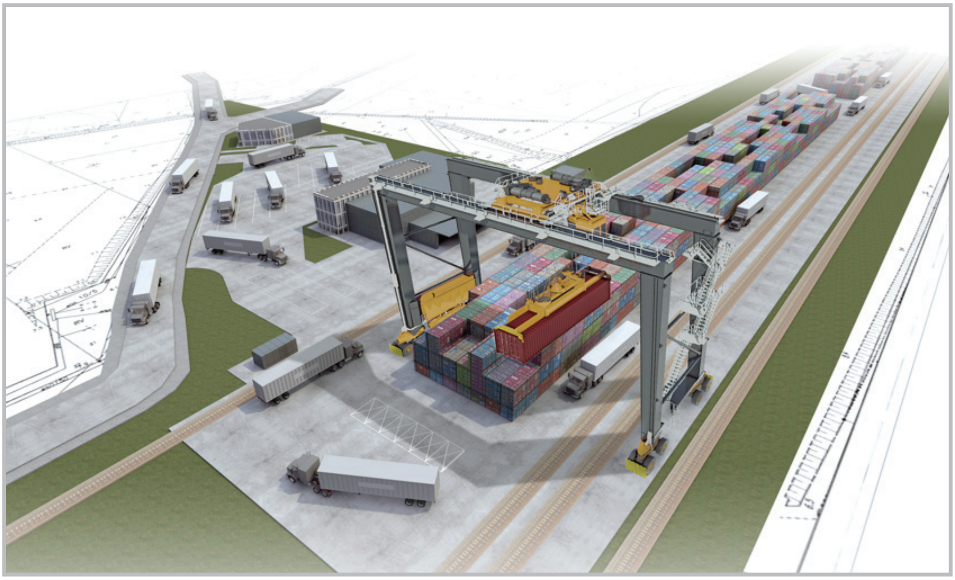


Figure 8.7. Visualisation of a model rail-road CT terminal

Source: CCIC Intermodal Depo Dunikowo, http://serwer1847329.home.pl/autoinstalator/wordpress1/.

data, you can calculate the daily, monthly or annual energy demand including fixed and variable consumption. For example, for the adopted model of rail-road combined terminal, the estimated total fixed annual energy demand is equal to 390,000 kWh/year. This figure considers seasonal fluctuations in energy demand during one year of operation, e.g., no heating and shorter daily lighting time during the summer.

Table 8.9. Estimated energy demand for infrastructure elements and handling equipment of the model combined terminal

Facility/ device	Key parameter	Demand for diesel oil	Demand for gas	Demand for electric power
eRTG	electric, power 400-500 kW 30 moves/hour	–	–	2.5-3.0 kWh/move
RST	diesel, 45 t 20 moves/hour	20 litres/hour	–	–
TT (tug+semitrailer)	diesel, 90 t 20 moves/hour	10 litres/hour	–	–
Office and social building	250 m^2 usable area	–	32 kW	13 kW
Workshop	600 m^2 usable area	–	60 kW	11 kW
Washing point	160 m^2 usable area	–	35 kW	6 kW
Terminal lighting (LED)	30,000 m^2 storage yards	–	–	300 kW
Other electrical equipment	n/a	–	–	50 kW

Source: own elaboration.

Variable demand is proportional to the volume of transshipments. We will calculate them by multiplying the unit energy consumption by the number of intermodal units handled or by the number of movements performed by the primary handling equipment of the terminal (Table 8.10)[17].

The obtained results show that the variable energy demand of the model terminal ranges from 887,500 kWh to 3,747,500 kWh depending on the transshipment volume. Hence the total fixed and variable energy demand of this terminal ranges from 1.28 MWh to 4.13 MWh (Table 8.11). On this basis, a marginal consumption can be calculated, which in the case of the model terminal is 25.6 ÷ 31.8 kWh per ITU. It should be remembered that only part of this demand relates to pure electricity, i.e., 5.8 ÷ 10.6 kWh per ITU. Importantly, the structure of unit electricity is less

17 The relationships between the trans-shipment volume and the number of movements of primary handling equipment were adopted on the basis of publication: S. D. Stoilova, S. V. Martinov, Choosing the container handling equipment in a rail-road intermodal terminal through multi-criteria methods, Materials Science and Engineering 664 (2019)

favorable when transshipment volume increases and the share of handling movements done with diesel-powered devices, i.e., RSTs and TTs, increases. This last parameter is consistent with research studies related to energy consumption of seaport container terminals. They indicate average electric energy consumption values 5.00 ÷ 7.25 kWh/move (Delft, 2014).

Table 8.10. The annual energy demand of the model combined terminal depending on the transshipment volume

Parameter	Unit	Result		
Terminal transshipment volume	ITU	50,000	90,000	130,000
eRTG moves	moves	50,000	90,000	130,000
eRTG time	hours	1,667	3,000	4,333
eRTG energy consumption	kWh	137,500	247,500	357,500
TT moves	moves	50,000	90,000	130,000
TT time	hours	2,500	4,500	6,500
TT energy consumption	diesel oil litres	75,000	283,500	409,500
RST moves	moves	50,000	189,000	273,000
RST time	hours	2,500	9,450	13,650
RST energy consumption	diesel oil litres	50,000	189,000	273,000
RTS+TT energy consumption	diesel oil litres	75,000	234,000	338,000
RS+TT energy consumption[18]	kWh	750,000	2,340,000	3,380,000
eRTG+RS+TT energy consumption	kWh	887,500	2,587,500	3,737,500

Source: own elaboration.

Table 8.11. The structure of the annual energy demand of the model combined terminal

Parameter	Unit	Result		
Terminal transshipment volume	ITU	50,000	90,000	130,000
fixed energy consumption	kWh	390,000	390,000	390,000
variable energy consumption	kWh	887,500	2,587,500	3,737,500
Total energy consumption	kWh	1.277,500	2,977,500	4,127,500
Energy consumption per ITU	kWh/ITU	25.6	33.1	31.8
Electricity consumption per ITU	kWh/ITU	10.6	7.1	5.8

Source: own elaboration.

[18] Calculations based on the estimated energy value of diesel oil (1 litre of diesel = 36 MJ = 10KWh)

In conclusion, the vast potential for energy efficiency measures existing in the area of terminal infrastructure and handling equipment should be emphasized. The main trends in the energy management of terminals are identified below.

1. The most significant potential for energy saving in infrastructure includes low-energy yard lighting, passive/low energy office buildings, efficient heating systems;
2. Handling equipment should be powered by electricity, alternative fuels and hybrid systems in drives,
3. Terminals possess favorable conditions for operating Renewable Energy Sources (RES) technologies including producing renewable energy in the terminal area;
4. Terminal area can be used for provision LNG/CNG/electrical charging infrastructure;
5. Conditions (e.g., terminal gate systems, TOS) for efficient train and trucks servicing and handling (e.g., slot system) should be applied;
6. Incentive scheme rewarding carriers and operators that uses less energy and/or alternative energy sources should be applied.

Energy consumption and efficiency criteria and good operational practices should be incorporated in tendering procedures associated with terminal investments.

9. Combined transport operators in the BSR

9.1. Activities and obligations of a CT operator

CT refers to intermodal transport where the main leg is carried by rail, sea or inland waterway. In contrast, the initial and/or final sections, which are intended to be as short as possible, are performed by road transport[1]. According to the definition presented by L. Mindur and M. Gąsior, combined transport is classified as the European intermodal transport, in which a load unit in long-distance traffic is transported (without reloading the goods) between terminals by rail, inland waterway or coastal sea, and its arrival and departure, over the shortest possible distances, is carried out by road [2]. It is therefore an orderly sequence of operations to organize and ensure the delivery of goods from the producer to the final customer.

The characteristics of combined transport, which must be classified as a complex transport process, are four elements[3] :

1. organizational structure comprising specialized economic operators responsible for the comprehensive management of transport processes. These are so-called combined transport operators (intermediaries) who undertake to organize combined transport, i.e., carriage of goods by different modes of transport (particularly rail and road transport). Only one carrier is involved in[4] the transport;
2. the technical-technological link between the linear (roads, waterways, and railways) and point-to-point (terminals, maritime ports) infrastructures of the various modes of transport adapted to handle the same unified load unit;
3. the Commission has proposed a single transport document for the entire supply chain (the combined transport bill of lading), a single legal regime regulating the

[1] J. Neider, *Introduction to forwarding* [in:] *Manual of a forwarder*. Ed. D. Marcinia-Neider, J. Neider, Gdynia 2020, p. 68; . Barcik, L. Bylinko, Perspektywy transportu intermodalnego w Polsce [in:] Transport. Scientific Papers of the Warsaw University of Technology, No. 120, 2018, p. 10.

[2] L. Mindur, M. Gąsior, Intermodal transport, Technika Transportu Szynowego. Eksploatacja, Nr 6/2003; http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-article-BGPK-0638-3047

[3] Ibid, p. 46.

[4] https://www.timocom.pl/lexicon/leksykon-transportowy/operator-transportu-kombinowanego-cto

conditions of supply and the liability of the parties (a single contract that covers the entire transport process with the stipulation of a rate for the entire supply process); and

4. a unified transport unit such as a semi-trailer, swap body or container (the element physically linking the whole).

CT operators accept transport orders from freight forwarders and organise CT throughout the supply chain. They also contract licensed rail hauliers to carry out transport between terminals/stations/loading points[5].

The CT supply chain is shown in Figure 9.1.

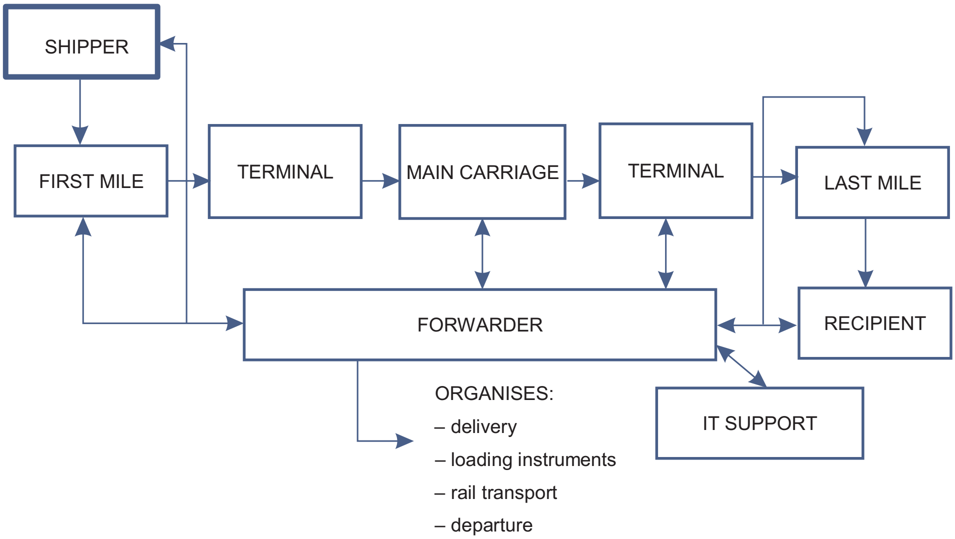


Figure 9.1. The combined transport supply chain

Source: J. Brill, Z. Łukasik, Aspekty ekonomiczne, techniczne i strategiczne transportu intermodalnego, Technika Transportu Szynowego. Analizy, No. 3/2014, p. 15.

In CT, the main part of the haulage is carried out by rail or sea transport, while the so-called "feeder" sections are carried out as little as possible by road. An example of CT is shown in Figure 9.2.

The role of the combined transport operator is to organize the transport of goods between the sender and the receiver. It is therefore an intermediary whose task is to organize the transport in such a way that the goods are delivered to their final destination in accordance with the customer's wishes, with the need to carry out any additional operations, e.g., customs clearance or collection of payment for the goods. In practice, it may happen that the combined transport operator is at the same time

[5] M. Kozerska, P. Smolnik, Intermodal transport in Poland on the example of PKP Cargo, Zeszyty Naukowe Wydziału Ekonomicznego Uniwersytetu Gdańskiego, Ekonomika Transportu i Logistyka No. 62 (2017), p. 235.

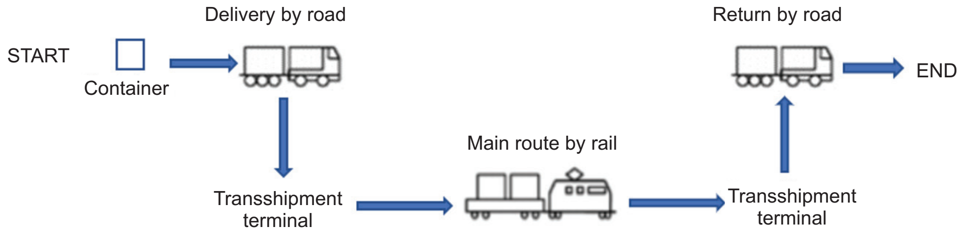


Figure 9.2. Implementation of combined transport

Source: R. Rogaczewski, Intermodal transport in the national economy, Acta Universitatis Nicolai Copernici, Management XLV- NR 4 (2018), p. 93.

a forwarding agent. He then acts as an adviser on transport processes for various branches of transport. In order to organize this process properly, it is necessary to carry out the activities in a certain order, in a certain way and in mutual connection with each other[6].

If the main part of the cargo is carried by maritime transport, the operator/forwarder begins cooperation with the terminal by agreeing on the conditions. These agreements concern the handling of cargo in the port and especially the prices for handling, manipulation, and storage services. If the goods are shipped in a container, the operator/forwarder takes the empty container and gives the carrier (e.g., road carrier) the order for transport. Then, after the consignor fills the container, it is delivered to the port and the operator/forwarder orders reloading in the relation: means of transport, yard, ship's side. In the case of general cargo and bulk cargo, in order to complete a ship's lot within a certain time limit, the operator/forwarder establishes the possibility of the terminal accepting a certain cargo lot for storage on the yard or in the warehouse. He then advises the operator of the cargo by issuing a transshipment order for the relation: inland means of transport - yard/warehouse together with the number of the means of transport, quantity, and weight of the cargo and its characteristics. After completing the ship's batch (or slightly before), the operator/shipper informs the terminal about the planned loading of the ship. The port confirms that the ship can be accepted at the given time or the parties agree on another date. The operator/forwarder then updates the vessel's time of arrival, obtains confirmation from the operator on the vessel's ability to handle the vessel and issues an order for the activities to be paid for. Most often, the operator/shipper will order the terminal operator to carry out reloading in the relation: yard/warehouse – ship's side – loading. Depending on the transport competence, he may also order the lashing or securing of the cargo in the hold. In the case of bulk cargoes, there are reloading relations and the so-called loading trim, so in practice the reloading relation

6 K. Długokęcka, P. Simiński, Forwarder as an important link in the supply chain, Zeszyty Naukowe Uniwersytetu Przyrodniczo-Humanistycznego w Siedlcach, Seria: Administration and Management (32), No. 105/2015, p. 45.

means filling the ship's hold with cargo in the order and quantity agreed with the ship's command (the so-called loading sequence)[7].

If the main part of the transport is carried out by rail, the operator/forwarder is obliged to order a specific transport by submitting the relevant documents to order the wagons. The next phase is dispatching. These depend on the assortment but also on the capacity of the loading station.[8] "Thanks to the possibility of using electronic letters and concluding station service contracts, the problems associated with the need to sign many documents, fill in original waybills, make payments and visit the freight counter, have been reduced. In addition, for most of the operators formal and operational activities related to sending and delivering the consignment and making entries in the consignment note (in the part filled in by the operator) are performed by a two-person crew driving the train. With the support of carrier's own dispatching points along the route, the necessity to maintain railway stations and dispatching offices in places of clearance of consignments (sent for transport and handed over at destination) was eliminated. This kind of simplified organization of transport is proving possible for full-train transports, which is not without an impact on the cost of such a service"[9].

When organizing road transport, the operator/forwarder usually hires a hauler to whom he orders transport[10]. The order, apart from the type of vehicle ordered, the receiver's address, or the properties of the goods, also includes provisions that are to protect potential claims for transport damages, such as the obligation for the carrier to have liability insurance in the amount corresponding to the value of the transported goods. The forwarding process ends with settling the transaction by: issuing an invoice to the customer, including the settlement of possible additional costs related to the performed transport, settlement of invoices received from the carrier, after checking the correctness of received transport documents and checking the correctness of customs procedures if the transport was related to the necessity of their performance[11].

In all cases the decision to engage intermodal transport technologies bases on four main factors:[12]

1. transport mode characteristics,
2. cost and service requirements,
3. consignment factors, and
4. operational factors.

[7] G. Kita, *Handling of cargo in the sea port* [in:] *Manual of a forwarder*. Red. D. Marcinia-Neider, J. Neider, Gdynia 2020 , pp. 364-366.

[8] T. Truś, M. Biadacz-Marek, Railway transport: railway network in Poland and Europe, Przegląd Naukowo- Metodyczny. Education for Safety no. 1, 2013, p. 49.

[9] A. Dudkowski, Transport kolejowy [in:] Speditor's handbook. Red. D. Marcinia-Neider, J. Neider, Gdynia 2020, p. 440.

[10] W. Miotke, J. Stróżyk, Transport drogowy [in:] Podręcznik spedytora. Red. D. Marcinia-Neider, J. Neider, Gdynia 2020, p. 398-402.

[11] Ibid.

[12] G. Eriksson, M. Yaruta, Mapping barriers in intermodal transportation, Chalmers University of Technology, Gothenburg, Sweden 2018, p. 31.

9.2. CT service operational models

From the dynamic development of unitized cargo transport technologies at the turn of the twenty-first century, intermodal/CT of containers, semi-trailers and swap bodies developed very intensively in Europe. These technologies are based on two relative types of CT – sea-land transport of containers and ro-ro units, as well as land (i.e., rail-road) transport of containers and other cargo units (i.e., semi-trailers, swap bodies, and trucks).

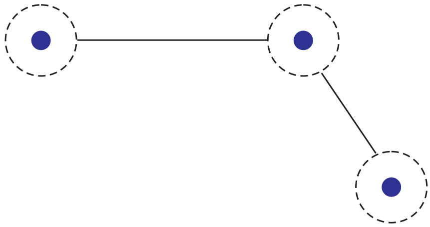
Maritime transport is based on regular shipping – i.e., container, ro-ro, and ro-pax lines. Appropriate, deeply specialized vessels carry containers and ro-ro cargo (i.e., semi-trailers, roll-trailers, and trucks) between ports. These ports can be divided into three basic types. The first consists of numerous ports where final cargo arrives (i.e., final destination ports). The second consists of large terminals and transshipment ports (i.e., gateways, hubs), which are gates linking smaller ports and local/regional shipping lines network with overseas shipping lines. The third consists of ports supplementing of road systems through connections by passenger-car ferries, passenger-car-rail, and ro-pax or ro-ro units.

The BSR is one of the most intense sea areas in terms of navigation. There are approximately 4,000 ships operating at one time with more than 350 of these are ro-ro or ro-pax vessels operating exclusively in the Baltic ferry market. Another 350 are container ships sailing in this area as feeder ships or in the short sea shipping scheme.

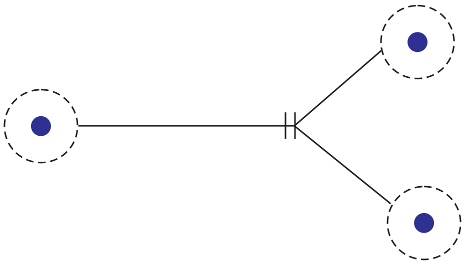
The second part of the market – rail-road CT serves by way of two forms. First, the sea-land network can be described as hinterland services for shipping based on regular rail services or inland waterways shipping lines. The road section plays the role of the last mile delivery phase. The second part consists of a multi-liner rail service network across the whole of Europe. These services can work as national or international rail connections. Analyzing these types of services, six illustrative examples are derived:

1. **Shuttle service**, where only two terminal are connected by the operator and serviced in a given frequency.

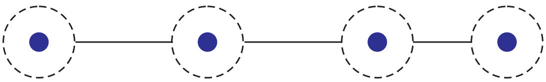
2. **Antenna-shuttle service**, where one terminal is serviced by an operator alternately with two other terminals by ensuring regularity an frequency to the forwarder.



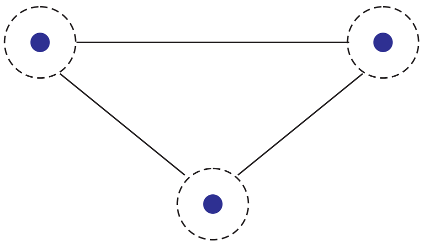
3. **Y-shuttle service**, where one terminal plays a role of marshalling yard for dismantling one train into two separate destinations, and in the opposite option, two cargo rail sets are formed into one set merging several origins of cargo towards one destination.



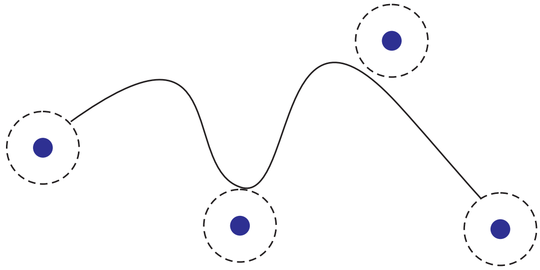
4. **Linear service**, where several terminals are connected in a linear manner, with a regular stops in intermediate terminals. Also, here the given frequency is an obligation of the rail operator.



5. **Round service**, where the train performs regular trips form terminal A to B, than to C and then comes back to A, from where it starts next round trip. It is possible to include more terminals in one round service than 3.



6. **Aggregating service**, where the main criteria of service is cargo collection on the highest possible extend independently from the distance. In other words, the operator allows to trip extension in order to collect more cargo from the hinterland notwithstanding that these terminals are not located on the one rail route.



The above types of CT services are flexible and easily replaced by another type due to the cargo volume. A set of such services creates a CT network, i.e., where CT terminals are crucial infrastructural elements that play different roles for the market and for the carrier. Depending on hinterland borders and services, three relational types of CT network can be selected:

1. **Hub-and-spoke network** (Figure 9.3) – where one terminal plays the roles of hub and receives cargo units from two different regions/hinterland areas and exchanges them between each other. The hub function has been developed not only due to national borders, but mainly due to the best location giving the advantage of being effective node in global transport network. In so, the hub function helps to exchange all existing trade relations in one place, for many independent operators and haulers.

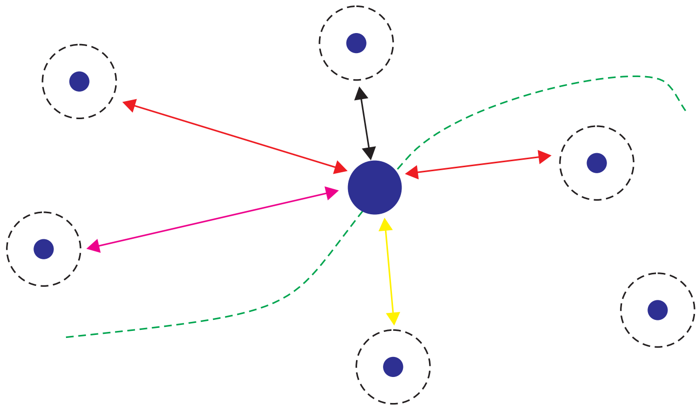


Figure 9.3. Hub-and-spoke network
Source: own elaboration.

2. **Gateway network** (Figure 9.4) – is related more to one-operator transport system. From several terminals included in the CT scheme of a given operator, one plays a crucial role as exchange place, to which all services serving one region coverage delivering cargo destined to another region/area, and mutually, receiving cargo originated from this region destined to the first one. Such type of network

is often correlated to the regional differentiation and bottlenecks between regions, where only one place can play the role of interregional exchange node.

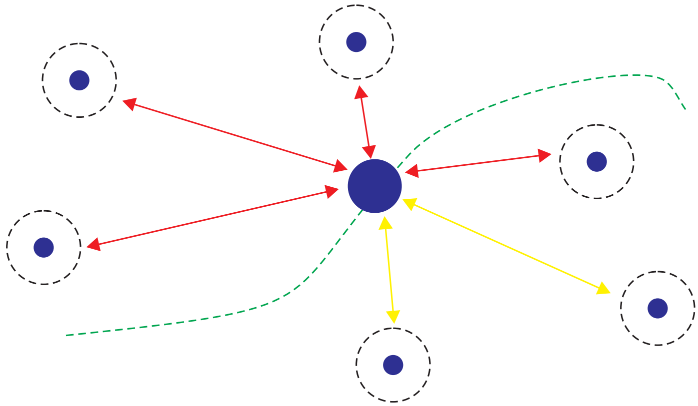


Figure 9.4. Gateway network

Source: own elaboration.

3. **Shuttle network** (Figure 9.5) – as a result of advanced CT system of one operator (or several, but cooperating in the framework of one network), where a given number of shuttle services are compiled into a single system. In such, the main issue is to adjust all transit times of trains and terminal arrivals/ departures in order to minimize waiting time at terminal, eliminate yard storage and allow a smooth transit for several trade relations.

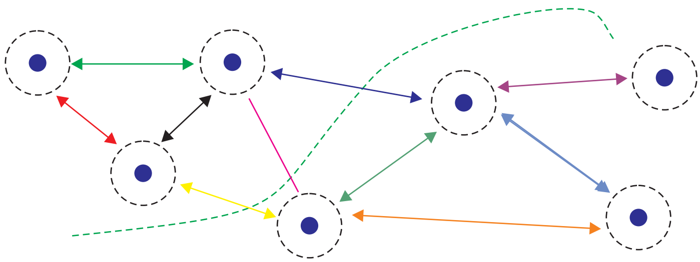


Figure 9.5. Shuttle network

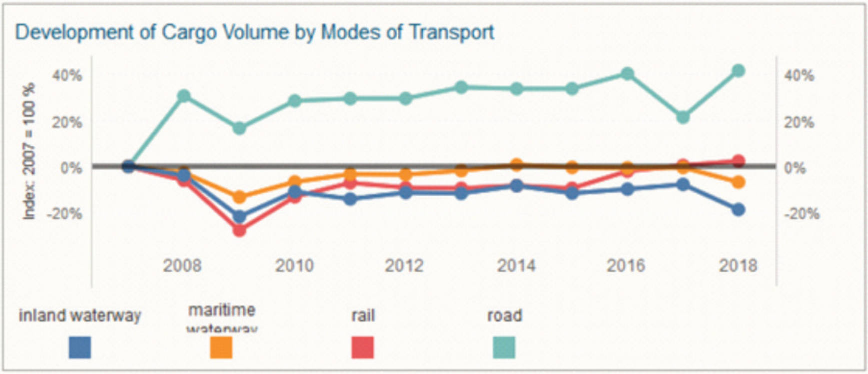
Source: own elaboration.

9.3. Trade flows in the BSR

Due to unaggregated and inconsistent data connected with the different understanding of definitions exact trade flows, especially in CT traffic between BSR countries is hard to describe. Although, three sources of data which are Eurostat, UIRR, and UIC can give a strong foundation to at least sketch a flow of cargo across BSR.

First source of data is the Eurostat which provides the numbers on transported goods between BSR countries in tonnes. Unfortunately, the data includes the modes of transport only, excluding the type of cargo. Thus, potential to shift the goods from road to CT in BSR is hard to estimate. Data provided, shows, that most of the cargo exported from BSR counties travels on the road, with relatively small share of other means of transport, i.e., export from Poland to Germany is in almost 90% arranged by road, with some share of rail and maritime waterways. Trade between Poland and Lithuania is in 85% transported by road. Due to geographical location the traffic from Scandinavia to continent is mainly arranged via maritime waterways.

Trade flows to/from Scandinavia use mostly maritime waterways, both container short sea and roro traffic. Cargo coming/departing from/to the Western Europe (Benelux, France) is more balanced between different transport means. Eastern side of BSR characterize bigger share of the trade flows transported by rail. Mainly in terms of import from Russian Federation using the broad-gauge infrastructure. It is



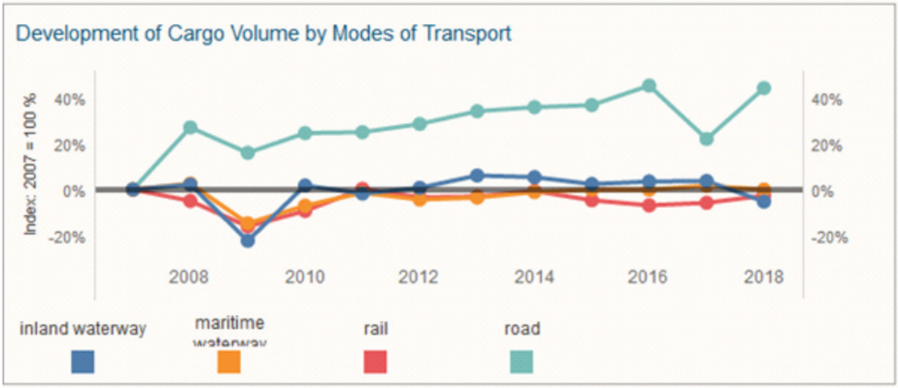
Top O-D-Relations (Cargo Volume in thousand tonnes)

		Mode of transport			
	Total Cargo Volume	inland waterway	maritime waterway	rail	road
Germany with Netherlands	288,112	53,746	6,891	4,503	222,972
Germany with Belgium	147,318	45,272	6,760	3,156	92,130
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		9,626	99,276
Germany with Italy	62,769		1,694	15,231	45,844
Poland with Czech Republic	38,250	1		5,776	32,473
Sweden with Denmark	23,521		15,340	360	7,821
Poland with Sweden	22,119		12,946	103	9,070
Poland with Netherlands	21,914	4	6,717	562	14,631
Finland with Germany	21,659	14	21,493		152
Sweden with Finland	21,396		14,692	1	6,703
Poland with Slovakia	21,219			2,697	18,522

clearly visible in cargo flow to Lithuania from Russia or Belarus, where almost 100% of cargo is transported by rail, mostly in conventional wagons.

The biggest exporter in BSR countries is Germany which export in terms of tonnes generate most of the cargo traffic in BSR and EU (above 1.3 bln tonnes per year). Most crowded lanes includes the routes to Benelux, Poland, and France. Second biggest exporter is Poland with almost 0.5 bln tonnes and the biggest potential in traffic to Germany and Czech Republic but also to Sweden, Netherlands and Slovakia. Other important cargo flows in BSR includes the internal traffic in the Scandinavian countries and Scandi to Germany and Poland.

In terms of import the biggest potential shows Germany (almost 1.4 bln tonnes) with the biggest trade exchange with the neighbors: Benelux, Poland, France, and Czech Republic. Second place belongs also to Poland with the 0.4 mld tonnes of cargo imported mainly from Germany but also from Sweden, Netherlands, and Czech



Top O-D-Relations (Cargo Volume in thousand tonnes)

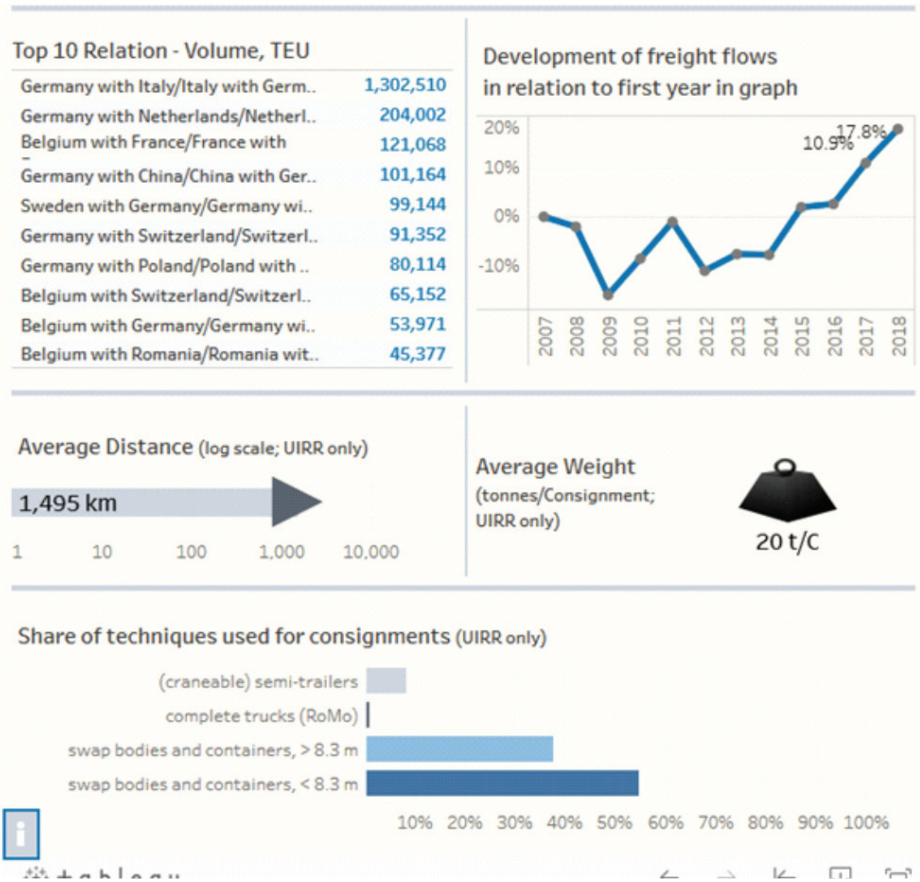
		Mode of transport			
	Total Cargo Volume	inland waterway	maritime waterway	rail	road
Netherlands with Germany	387,438	146,235	10,632	17,565	213,006
Belgium with Germany	145,867	43,547	4,339	3,659	94,322
Poland with Germany	141,959	651	9,571	5,753	125,984
Germany with Poland	129,707	361	6,700	4,628	118,018
France with Germany	121,077	12,816	5,123	2,925	100,213
Austria with Germany	83,399	556		7,738	75,105
Czech Republic with Germany	59,939	97		7,871	51,971

Germany with Poland	129,707	361	6,700	4,628	118,018
Germany with Denmark	47,579	1	20,150	622	26,806
Germany with Sweden	36,112	43	24,552	2,691	8,826
Russian Federation with Poland	32,239	6	28,853		3,380
Denmark with Sweden	30,833		21,177	38	9,618
Norway with Sweden	30,034		14,446	2,153	13,435
Russia with Latvia	28,387			28,387	

Republic. Other important routes indicates intra Scandi traffic and the trade exchange between Germany and all Scandi counties.

Considering import to BSR countries from outside partners it is also visible flow of cargo from Russian Federation which has big potential to shift to CT due to constantly developing transcontinental traffic rail from China to Europe.

Much more detailed data in CT traffic can be extracted from the statistics provided by UIC/UIRR. Unfortunately, the data consists only from the CT operators included in UIRR union.



Analysis of those database showed, that between 2007-2018 the development of CT units transported in BSR rose by almost 18%, whereas in all Member States the rise is on approx. 27% level. The most frequented lanes in terms of CT from/to BSR are Trans-Alpine corridor Germany-Italy with 1.3mln TEU transported in 2017. The second place is occupied by Germany-Netherlands (200,000 TEU transported). The third place, which might be a surprise, belongs to Germany-China corridor, and it response for above 100.000 TEU in 2017. Most probably the share of this corridor will increase in the further statistics as in 2020, market observed significant rise of rail traffic between China and Europe. Other important lanes connected with German economy are corridors to France/Benelux but also to Czech Republic and Hungary.

Excluding Germany from the UIRR BSR statistics, other promising lanes for CT development are Sweden and Denmark from/to Italy (approx. 40,000 TEU in 2018), probably with new corridors from Sweden via Poland, and corridors from Poland to Adriatic/ Black Sea area.

Historic data does not show relevant statistics for CT in Baltic countries. It is directly connected to lack of access to the European rail gauge and needed infrastructure. However, the development of Rail Baltica will probably lead the countries to reach fast increase of CT volumes in next years.

Average distance of transported ITU in BSR is considered at approx. 1500 km, with the weight of 20tonnes. In terms of equipment, above 50% of transported units consists of swap bodies and containers below 8 meters. Huge share of short containers and swap bodies is directly connected with its usage in Trans-alpine corridor. On the other lanes in BSR much bigger share of 40' sea containers and huckepack trailers can be observed.

9.4. CT services in the BSR mapping

Railway corridors for intermodal transport run through the territory of the Baltic States, connecting eastern Europe with the west, north and south, thus linking Russia and East Asia with western Europe[13]. The railway network in the Baltic Sea Region is characterized by one of the highest capacities in freight traffic in Europe. Of great importance for intermodal transport is the development of the railway network within the framework of the north-south international rail link Rail Baltica, which is expected to contribute to an increase in the quality of connections and the efficiency of the connection between the Baltic States[14]. Therefore, only the full implementation of Rail Baltica will enable easy movement of goods and services by rail between the Baltic States. The direct connection between Western and Central Europe including the Baltic States is a very important hub for land connections to eastern and northern markets such as China and Asia. It should be taken into account that rail transport plays a major role in the Baltic States. The extent to which it is used varies from country to country, e.g., in Poland road transport dominates in international traffic,

[13] A. Kuczyńska-Zonik, Bałtycki hub transportowy, [w:] Komentarze IEŚ, Nr 219 (122/2020), 16.07.2020

[14] J. Nazarko, J. Urban, Projekt Rail Baltica Growth Corridor w rozwoju usług logistycznych Rail Baltica Growth Corridor project in logistic services development, p. 5. http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-article-BPBB-0003-0007.

whereas rail has a larger share in domestic freight transport. In Germany the distribution of transport tasks in international traffic is the most even[15].

Figure 9.6. shows that the countries like Germany, Lithuania or Latvia have more services with countries outside the BSR. On the other hand, the countries Estonia, Poland, Denmark, Russia, and Sweden have more services within the BSR, but in Sweden and Russia domestic traffic dominates.

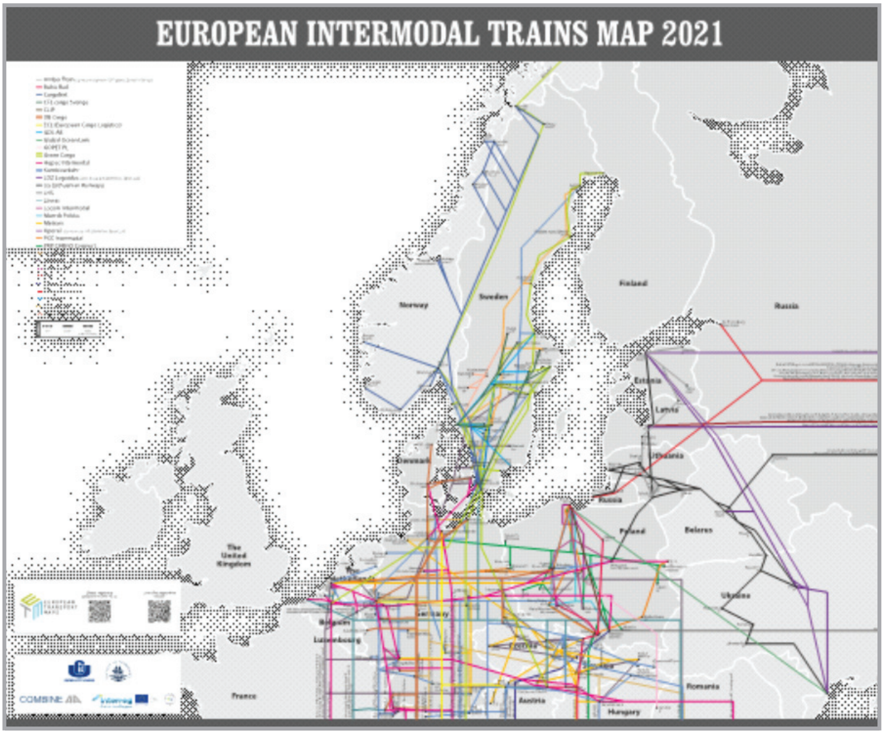


Figure 9.6. European Intermodal Trains Map 2021

Source: COMBINE project internal materials.

9.4.1. Denmark

The main role in rail transport in Denmark is played by passenger traffic, but there is also freight traffic, mainly on international routes to Germany and Sweden. Freight transport in Denmark is operated by 3 railway operators. The first of these, DB Cargo, operates 1 domestic container service. The second operator, Kombiverkehr, carries combined freight, of which 1 service is domestic and 1 international and in both cases the terminal of origin is Fredericia. The third operator is among the global operators Hupac Intermodal, which offers 1 service named Fredericia-Milano in combined

[15] North Sea – Baltic Sea. TEN-T corridors network, 2018, p. 22.

transport technology outside the BSR Region. The country of destination is Italy. It is worth mentioning here that the predominant terminal of origin is Fredericia. The existing CT network of Denmark can be seen on the Figure 9.7.

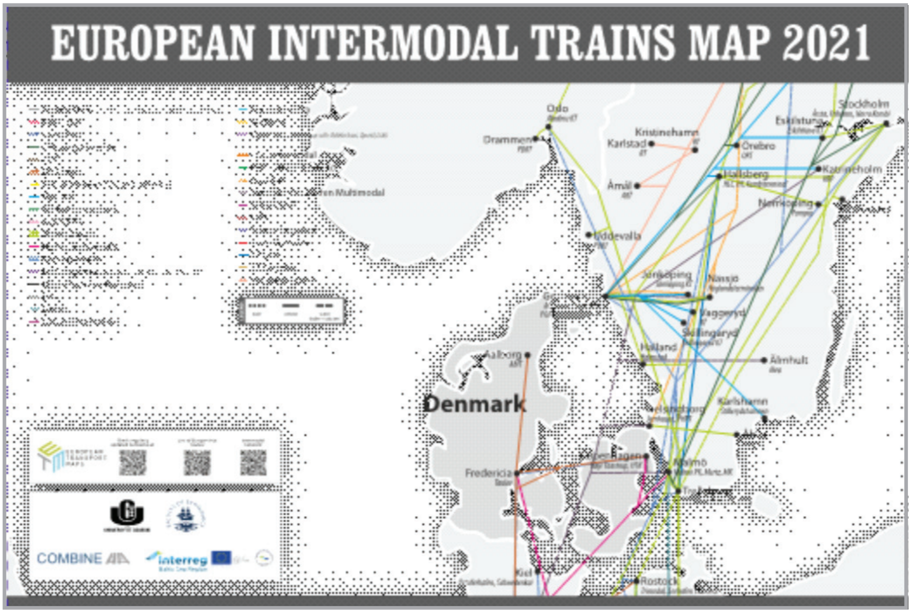


Figure 9.7. European Intermodal Trains Map 2021 - Denmark

Source: COMBINE project internal materials.

9.4.2. Estonia

In Estonia container freight transport is served by one main operator called Amber Train, which operates four Amber Train Option 1-4 services. Two of these services are local, with the start terminal being Tallinn and the terminals being Tartu and Sillamäe respectively. The other two are international lines, where the starting terminal is also Tallinn and the terminals are Šeštokai. Figure 9.8 shows that the dominant terminal in Estonia is Talin, while the service type is containerized. The importance of the terminal in Tallinn is even greater as there are two interconnected seaports. One is the old port of Tallinn (Vanasadam), which handles mainly passenger flows and ro-pax ferries and to some extent freight traffic. However, it is not connected to the railway in any way. The second port is the freight port of Muuga, which is connected to the railway network with a track gauge of 1520 mm. The Rail Baltica Corridor project envisages the port of Muuga to be included in the network and connected by a track gauge of 1435 mm. In Estonia, rail-road terminals operate alongside ports, but they

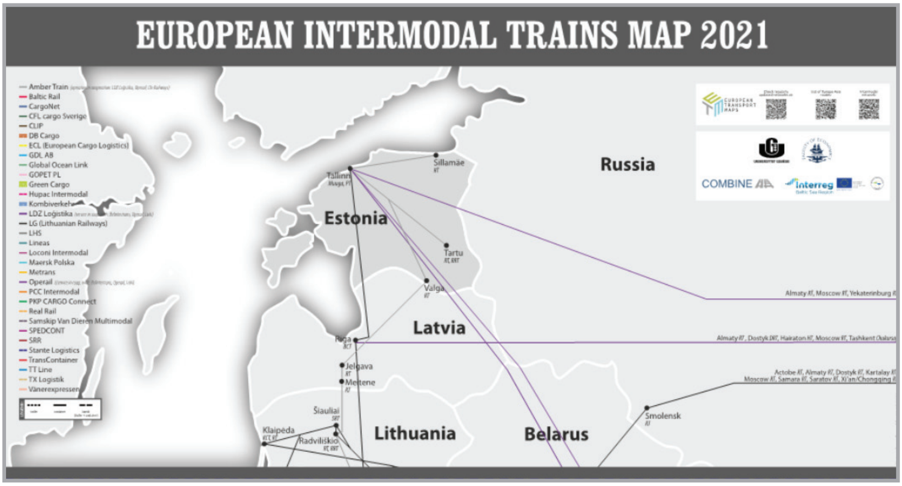


Figure 9.8. European Intermodal Trains Map 2021 - Estonia

Source: COMBINE project internal materials.

are not stand-alone terminals. There are plans to build a dry port (rail-road terminal) on the outskirts of Tallinn in Ülemiste.[16]

9.4.3. Germany

In Germany, cargo transport is handled by 8 operators that offer national and international services. Container services are operated by the following operators: DB Cargo, Metrans and PCC Intermodal. The first one called DB Cargo operates 9 service lines, 4 of which are in the BSR Region and 5 to non-Baltic countries, namely Italy and the Czech Republic. The second operator is Metrans, which operates 6 domestic service lines, where the main terminals of origin are Hamburg, Bremerhaven and München and 9 international lines, where the end countries are Czech Republic, Slovakia and Poland. The third operator is PCC Intermodal, which operates 3 service lines. One of them is a domestic line and two, whose end country is Belarus. Additionally, the operator ECL European Cargo Logistics operates 5 combined transport services, including 3 domestic and 2 international. Another global operator Hupac Intermodal operates 29 service lines, including 10 to the Baltic States and 19 outside the BSR region, where Italy is the dominant end country. Three further operators handle combined transport cargoes. These are the operator Kombiverkehr offering 66 service lines, Samskip Van Dieren Multimodal offering 10 service lines including 7 to countries in the BSR Region and the operator TX Logistik offering 23 services including 10 domestic. Figure 9.9 shows that the dominant terminals are those located in the ports of Hamburg, Hannover, Berlin, Bremen, Bremerhaven, Dortmund

[16] North Sea – Baltic Sea. TEN-T corridors network, 2018, p. 19, 38.

and Cologne, which have the character of tri-modal terminals with a well-developed rail-road terminal network.

Germany has four seaports located within the corridor: Hamburg, Bremerhaven, Bremen and Wilhelmshaven, which are connected by rail. It is worth mentioning that all ports have at least one terminal with open access for all operators[17].

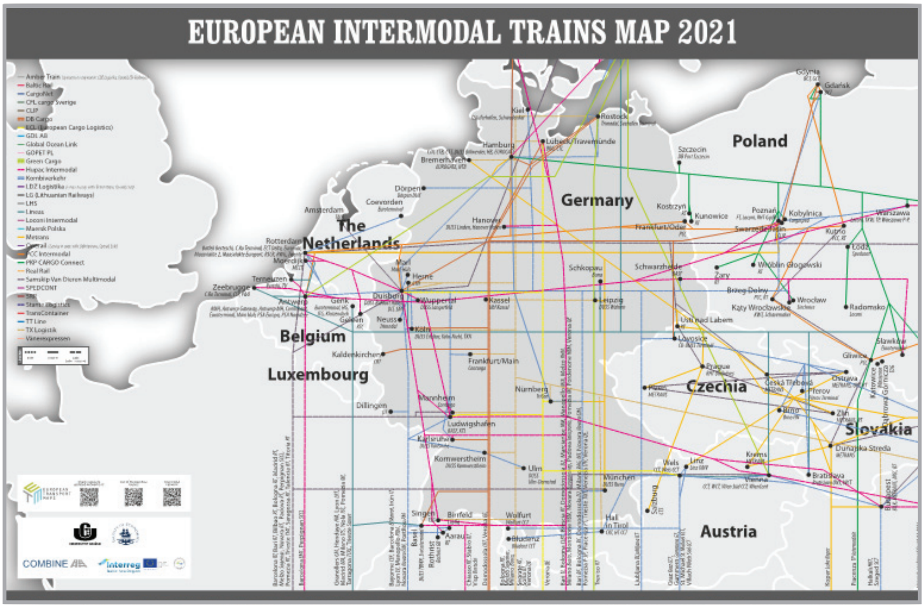


Figure 9.9. European Intermodal Trains Map 2021 - Germany

Source: COMBINE project internal materials.

9.4.4. Finland

In Helsinki, the west port and south port, located in the city centre, form part of the combined Port of Helsinki. These ports mainly handle passenger ferries and ro-pax ferries and to some extent freight traffic. In contrast, the third Port of Vuosaari is connected to the railway. It is the new Vuosaari cargo port located east of the city and handles mainly cargo traffic (Figure 9.10).

17 North Sea – Baltic Sea. TEN-T corridors network, 2018, p. 38.

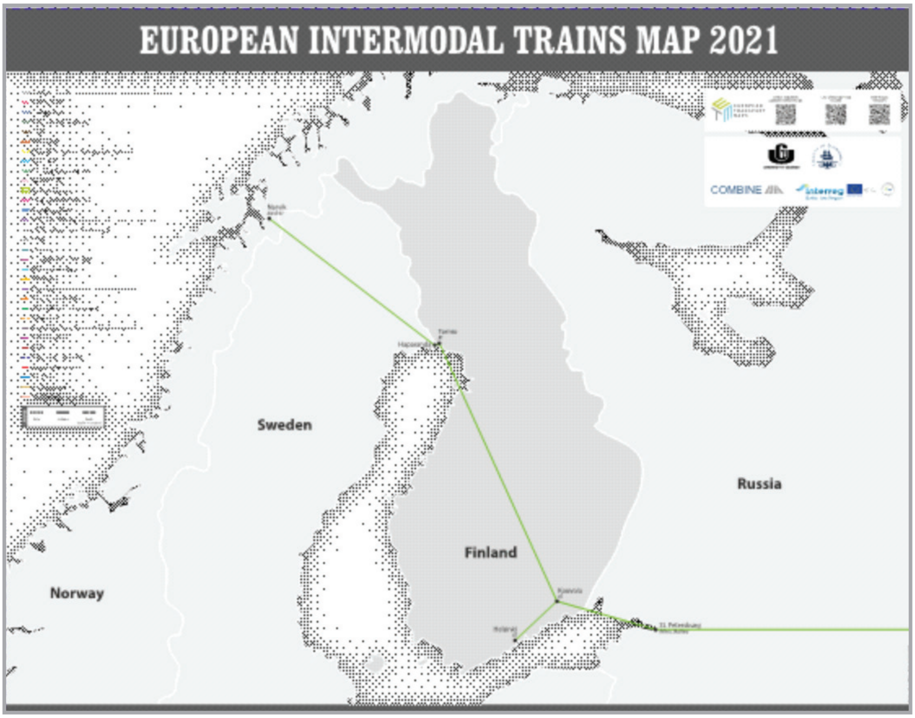


Figure 9.10. European Intermodal Trains Map 2021 - Finland

Source: COMBINE project internal materials.

9.4.5. Lithuania

In Lithuania, container cargo transport is handled by one main operator called LG (Lithuanian Railways), which operates 10 services, including 1 domestic, 3 in the Baltic Sea area and 6 outside the Baltic States. The terminals within the BSR are Moscow, Smolensk and Tallinn. Whereas the terminal countries within the international connections are Ukraine, Kazakhstan and China. From Figure 9.11 it can be seen that the predominant starting terminal for all connections is Klaipėda, where the seaport is located. It is a large non-freezing port on the east coast of the Baltic Sea with well-developed rail connections to inland areas. It is also Lithuania's most important and largest transport hub, connecting sea, road, rail routes from east to west. The Public Logistics Centre, which is being built there, will contribute to increasing the competitive advantage of the region, including railways. It is worth mentioning that two independent rail-road terminals have been completed in Lithuania - in Vilnius and Kaunas.

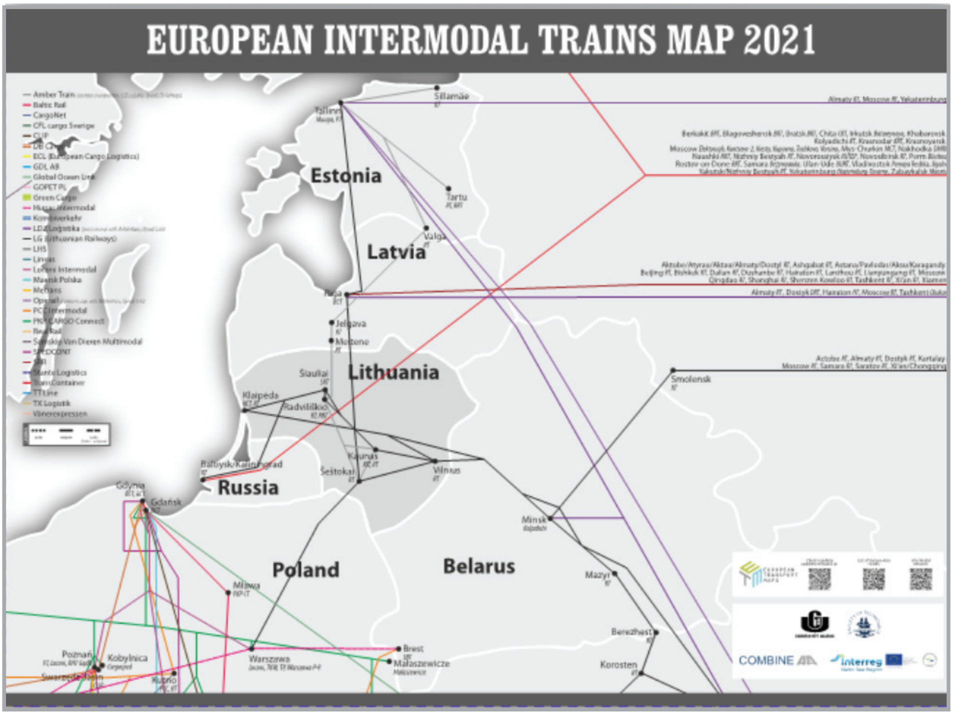


Figure 9.11. European Intermodal Trains Map 2021 - Lithuania

Source: COMBINE project internal materials.

9.4.6. Latvia

In Latvia, container cargo transport is operated by two operators. The first one named LDZ Loģistika operates four Baltic Transit 1 service lines and one named Riga Express. All of them are international in character. The second operator is SRR, which operates 14 service lines of international character to countries outside the BSR Region and these are mainly Asian countries. From Figure 9.12 it can be seen that the dominant terminal in Latvia is Riga, while the service type is containerised. The Free Port of Riga is also located in Riga, which is the largest port in the Baltic States and it is connected to the railway network. Freight traffic in Riga is carried out on local roads which have limited capacity, therefore it is envisaged to connect the port directly to the TEN-T network via the Northern Riga Transport Corridor, including improved rail access to the port. The construction of the Rail Baltica railway line also envisages connecting the port to the future intermodal transport terminal near Salaspils. Another Latvian port is the non-freezing Vindava Freeport, which has convenient road and rail access[18].

[18] North Sea – Baltic Sea. TEN-T corridors network, 2018, p. 31.

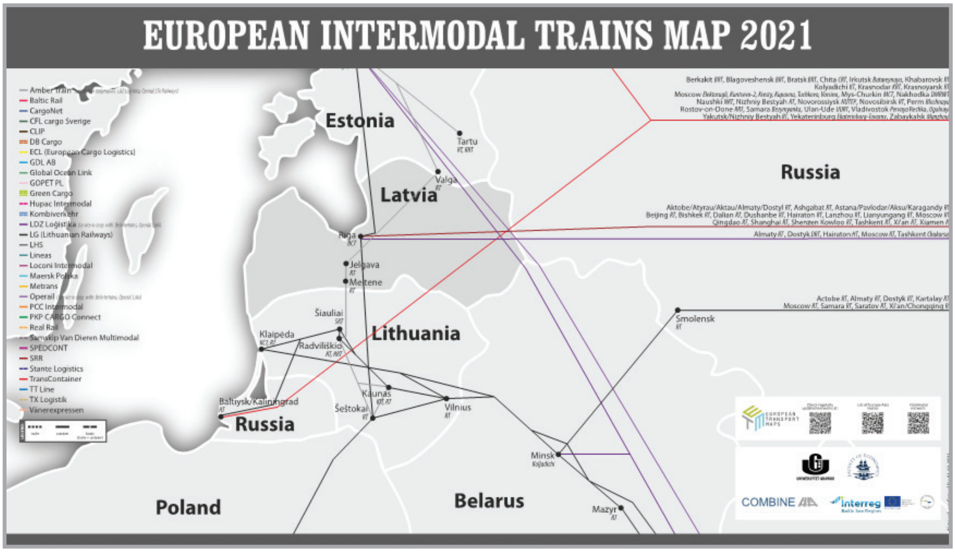


Figure 9.12. European Intermodal Trains Map 2021 - Latvia

Source: COMBINE project internal materials.

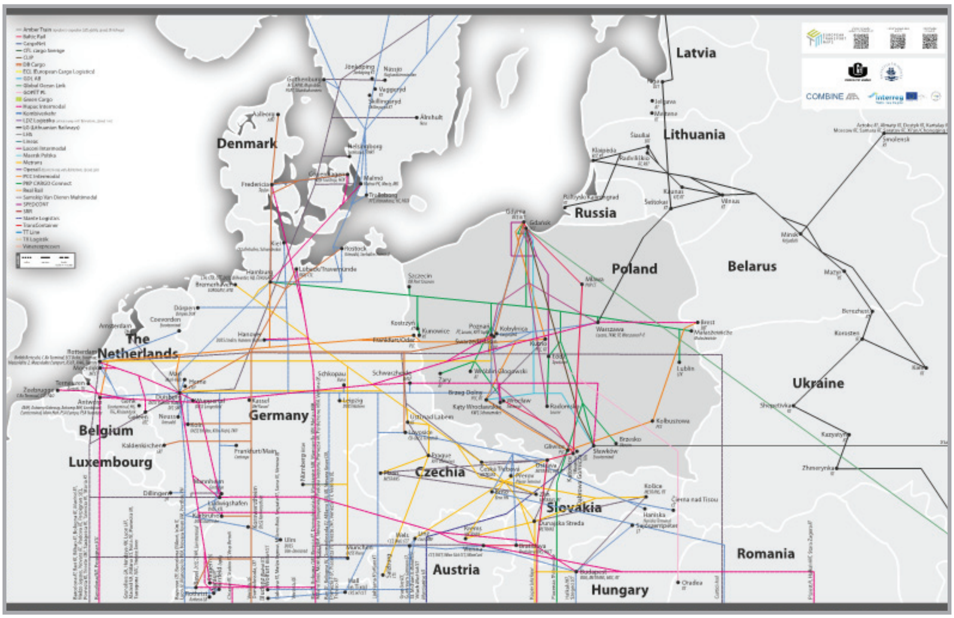


Figure 9.13. European Intermodal Trains Map 2021 - Poland

Source: COMBINE project internal materials.

9.4.7. Poland

In Poland containerized cargo transport is served by one operator Baltic Rail, which operates two services. The first one called Baltic Trains is a domestic service, with Gdynia as the departure terminal and Wroclaw as the destination terminal. The second service called Adriatic Trains is an international service with Katowice as the starting point and Koper in Slovenia as the terminus. From the figure 9.13 it can be seen that the dominant terminal in Poland is Gdynia, while the service type is container terminal. The three main areas for the location of rail-road terminals are Poznań, Łódź and Warsaw. They are conveniently located at the intersections of two TEN-T corridors (Baltic Sea - Adriatic Sea and North Sea - Baltic Sea corridors).

9.4.8. Russia

In Russia, container cargo transport is handled by two operators. The first one called Ruscon operates five service lines of domestic nature, where the main terminals of origin are Novorossiysk and Moscow, as can be seen from Figure 9.14. The second operator is TransContainer, which operates 56 service lines that are also domestic in nature, where the main terminals of origin are St. Petersburg, Moscow, Yekaterinburg and Novosibirsk.

9.4.9. Sweden

In Sweden, cargo transport is handled by eight operators that offer domestic services. Container services are operated by the following operators: CFL Cargo Sverige, GDL AB, Metrans, TT-Line and Vänerexpressen. The first operator called CFL Cargo Sverige operates 8 domestic service lines with the main terminals of departure being Gothenburg and Malmö/Trelleborg. The second operator is GDL AB, which operates 8 domestic service lines with Gothenburg as the main terminal of departure. The third operator is Metrans, which operates one service line with the start terminal in Koper and the end terminal in Budapest. Another container freight operator is TT-Line, which operates a domestic line with a starting terminal in Trelleborg. The last container-only operator is Vänerexpressen, which offers two service lines with a starting terminal in Gothenburg. Additionally, the operator Green Cargo operates 10 container services, 6 combined transport services and 1 trailer. Two further operators handle cargo in combined transport. These are the operator Kombiverkehr with 6 domestic service lines and the operator Real Rail with 10 service lines. Figure 9.15 shows that the dominant terminals in Sweden are Geteborg and Malmo.

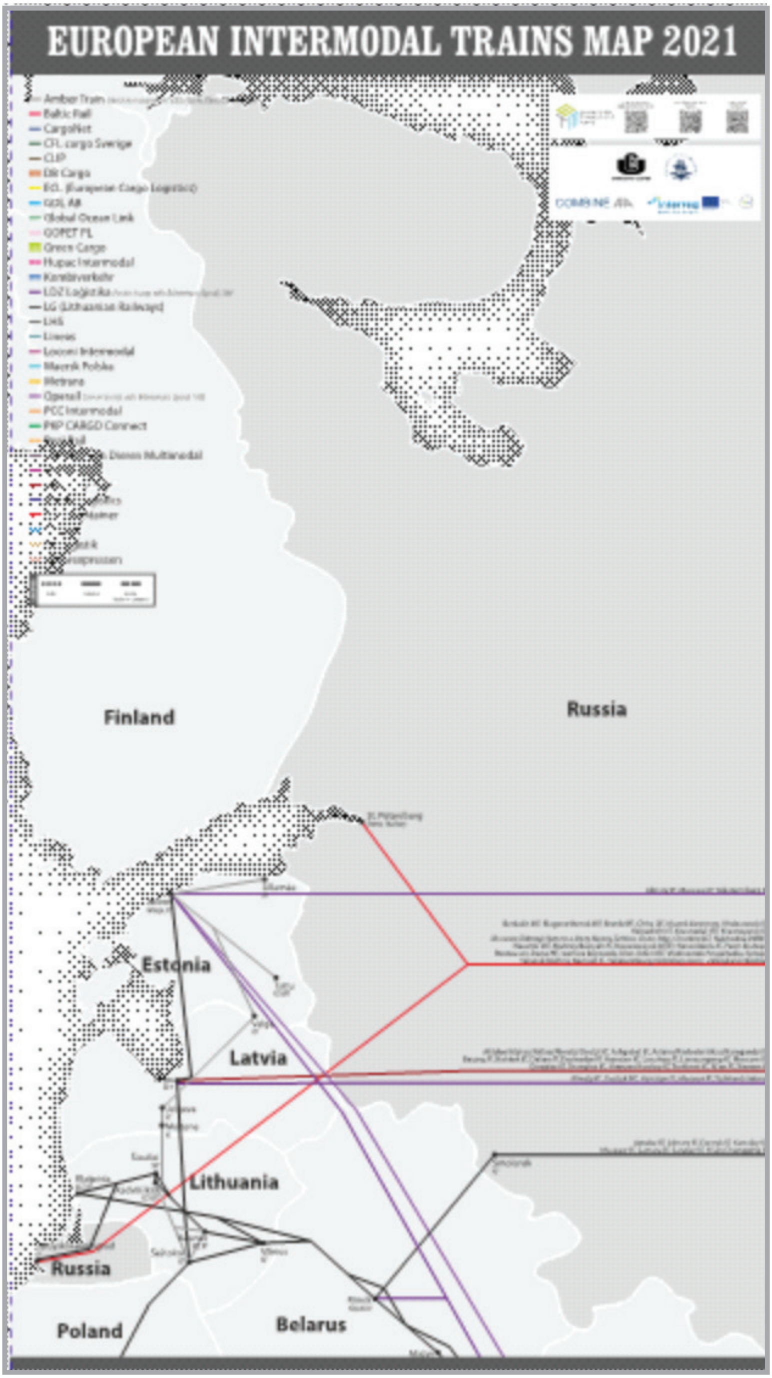


Figure 9.14. European Intermodal Trains Map 2021 - Russia
Source: COMBINE project internal materials.

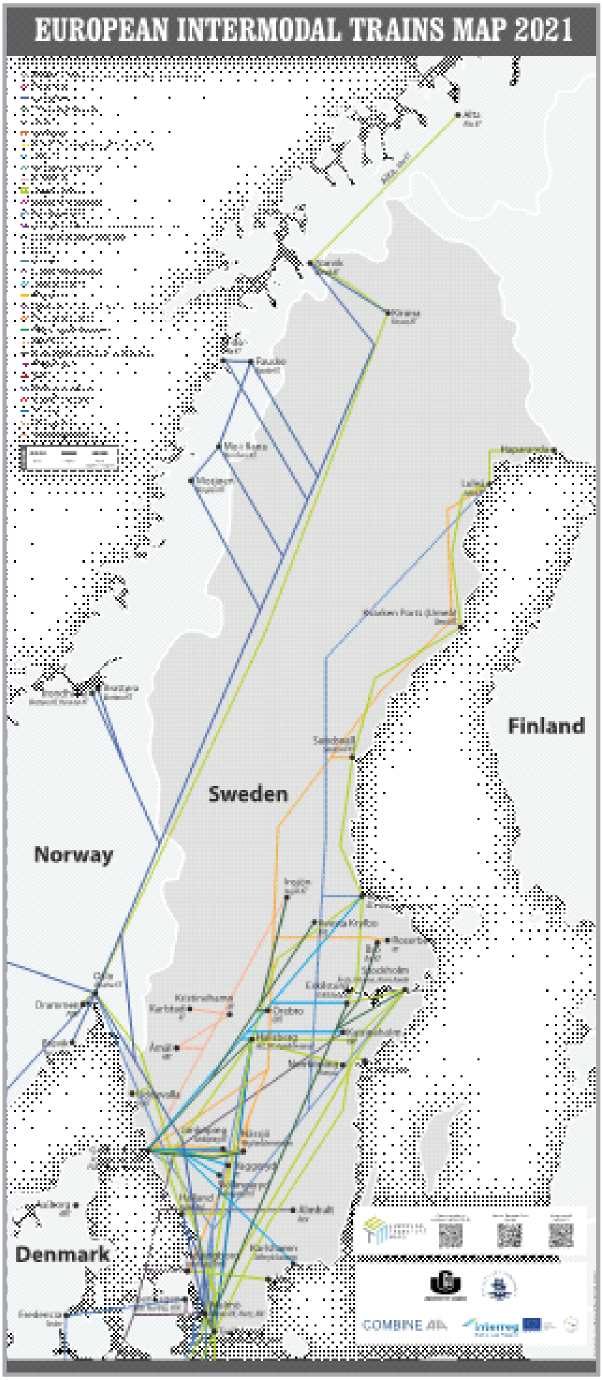


Figure 9.15. European Intermodal Trains Map 2021, Sweden
Source: COMBINE project internal materials.

9.4.10. BSR in the New Silk Road corridor

The BSR is in a special location regarding the trans-continental trade and is the crucial area of the New Silk Road (NSR) connecting East Asia and Europe. As from Figure 9.16 can be seen, there are some links going via the Middle East and Turkey but, the main corridor leads via the Belarus and Poland to Germany towards the Netherlands and Belgium. Not only due to the capacity of specific rail track, but also due to some local obstacles (like in Malaszewicze), some new routes are being developed in the general framework of the NSR (vide: Klaipeda or Ventspils nodes-based alternatives). This gives the region another impulse for the development of the CT network with a more global perspective and dimension. Yearly container traffic on the NSR does not exceed 350,000 TEU and 2 million tonnes and the growth rate gives not any justification to expect that in some day this corridor overtakes the role fo the container shipping. But, even the current dimension of the container traffic being realized on the NSR should give the impulse to the additional function that the CT network of the BSR should play as a transit system to themselves and to the western part of Europe.

Figure 9.16. New Silk Road Map 2021

Source: COMBINE project internal materials.

Summary

This publication is the result of the work of many teams working within the framework of the COMBINE Interreg BSR project in the years 2019-2021. The ambition of the authors was to present as comprehensively as possible the issues of organization, operation, and development of CT with particular emphasis on the BSR. Of course, the e-book could not lack references to the pan-European experience of the industry, or even worldwide, as it is a system of vessels connected very often by networks of rail and sea services. Moreover, the technological and organizational achievements are quite quickly translated into global dissemination.

A number of key conclusions can be drawn from the analysis presented in this e-book, which can then be translated into fundamental recommendations for decision-makers who will shape the future of combined transport, especially in the BSR.

Firstly, it is necessary to define uniformly the sector we are talking about. Experiences vary widely and lead either to a misunderstanding of the fundamental element which determines whether a process can and/or should be classified as combined transport, or to the exclusion of certain phenomena or services from this type of transport. This is particularly important when it comes to implementing programs to promote the development of combined transport by means of financial or non-financial incentives for haulers and operators. To this end, it is necessary to implement as soon as possible the new Directive on Combined Transport, which would clearly define the conceptual scope of the technologies and transport processes involved in the application of these technologies within the framework of CT. In this respect, the authors suggest a wide coverage of door-to-door or part of door-to-door unitized cargo transport services within the EU using at least two different modes of transport without the need to transship the goods themselves between the modes. This definition should therefore include both land-sea and land transport: rail-road or trimodal, including inland waterways. In this connection, future legislation should also deal with the interface between the concepts of combined transport and intermodal transport, since current practice more often uses the concept of combined transport to refer to rail-road transport, and intermodal transport to refer to sea-land transport. However, both can apply to the same logistic chain, but in a different scope. Rail-road transport carried out by European operators to/from a seaport, where the maritime leg is taken over by a third party, can be considered as combined transport, where the European operator's final leg is a port terminal or its immediate hinterland. This is why we are seeing a slow blurring of the boundaries between intermodal and combined transport, which is helping to unify the terminology of the industry. The definition of combined transport itself should be followed by uniform definitions of terminals and combined transport operators. Furthermore, the methodology of statistical data collection should be standardized so that it will ultimately be possible to create a universal system for statistical reporting of the activities of operators, both in terms of transport and transshipment. National transport statistical systems should also be adapted in order to eliminate the sometimes-considerable discrepancies that arise. It often happens that CT in the aggregate of operators is significantly different from that reported by administrative bodies or rail infrastructure managers. Without such a system it is currently impossible to create common conditions for the development of CT on a level playing field.

Common statistics will make it possible to correctly capture both the quantitative and qualitative dimensions of the market for CT services. This, in turn, will translate into comparability and scalability of actions and investments that should or could be undertaken to improve the operating conditions and development of CT operators. This should create a common basis for an EU CT Strategy for the development of CT, not only as a separate economic sector but, above all, as one of the key tools of transport policy, especially in supporting the objective of shifting the desired volume of freight from road to waterborne and rail transport. In the long term, this should make it possible to develop a strategy to move the transport sector towards zero-emissions by 2050, as set out in the New Green Deal.

In this context, it is necessary to draw up a road map for achieving this zero-emission status. An attempt to this was proposed in the Chapter 7. It would be helpful to draw up, on the basis of the abovementioned strategy, specific objectives, as well as a mission and vision for the development of combined transport for the future position and function of combined transport in the trade of the EU.

On this basis, a master plan should be drawn up for the individual EU Member States and the EU as a whole to achieve the desired objectives, indicating what needs to be prepared, carried out and implemented in order to make the desired objectives feasible and achievable.

In this way, a future EU CT development policy will be defined, which aims to achieve zero-emissions and, in so doing, to fulfil the functions set by the White Paper 2011 in the field of freight transport.

The authors hope that this publication will have a positive influence on the abovementioned path of future development of the combined transport sector, whose potential and technical possibilities are certainly capable of significantly improving the sustainable transport development path in the EU. At the same time, they are aware that they have not exhausted the topic with this publication, but have only highlighted areas in which there is already a lot going on and which are important from a functional and legal point of view.

To the end, the authors would like to thank all who have supported the COMBINE project by their knowledge, data sharing and discussions, and the Interreg BSR to enable the whole consortium to perform the project despite the tough period from the COVID-19 pandemic.

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