ReMuNet

Pioneering resilient and adaptive multimodal transport networks

D1.2

Standard framework to describe European intermodal transport

UIRR sc

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ABBREVIATIONS

4PL	Fourth Party Logistics
CEN	European Committee for Standardisation
CIP	Customer Information Portal
CT	Combined Transport
CTO	Combined Transport Operator
CTP	Combined Transport Profile
EMDS	European Mobility Data Space
EN	European Norm
ERA	European Union Agency for Railways
ETA	Estimated Time of Arrival
EU	European Union
GCU	General Contract of Use
ILUs	Intermodal Loading Units
IM	Infrastructure Manager
IRS	International Railway Solutions
ISO	International Organisation for Standardisation
IT	Intermodal Transport
ITO	Intermodal Transport Operator
ISU	Innovativer Sattelauflieger Umschlag
KPI	Key Performance Indicator
LSP	Logistic Service Provider
NSB	North Sea Baltic
RD	Rhine - Danube

RFC	Rail Freight Corridor
RFP	Rail Facilities Portal
RINF	Register of Infrastructure
RMG	Rail Mounted Gantry Cranes
ROLA	Rolling Motorway
RTG	Rubber-Tyred Gantry cranes
RU	Railway Undertaking
SDG	Sustainable Development Goal
SMS	Safety Management System
STS	Ship to Shore cranes
TAF	Telematics Applications for Freight
TC	Technical Committee
TEN-T	Trans-European Transport Network
THC	Terminal Handling Charge
TIS	Train Information System
TN	Technical Number
TSI	Technical Specifications for Interoperability
TTR	Timetable Redesign for Smart Capacity Management
UCT	Unaccompanied Combined Transport
UIC	Union Internationale des Chemins de fer
UIRR	International Union for Road-Rail combined transport
UNECE	United Nations Economic Commission for Europe
VAS	Value-Added Services
WCC	Wagon Compatibility Code

1 Introduction

This deliverable consolidates the results of the task 1.2 aiming at developing a standardised framework to better understand the complexity of the intermodal transport ecosystem in which the ReMuNet project and its consortium partners are evolving.

In Europe, different 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 authorised dimensions in national and international traffic and the maximum authorised weights in international traffic. In addition, definitions on intermodal transport have 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.

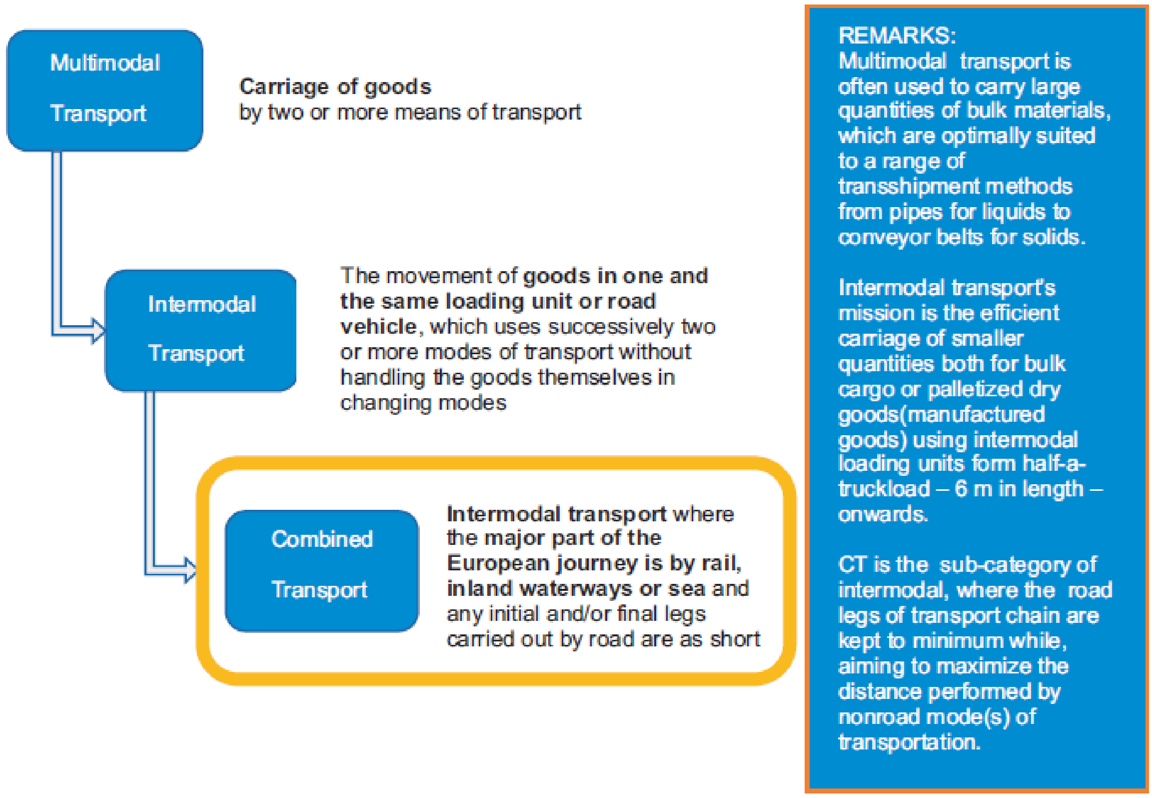


Figure 1 - Definitions of multimodal/intermodal and CT

For the purpose of the project, we have opted for a simplified definition based on the UN/ECE terminology from 2001 (see Figure 1 for definitions of multimodal, intermodal and combined transport).

The European intermodal rail freight market is a backbone of the overall intermodal system and is hence to be seen as the starting point of the assessment at hand. It has a size of 143,000 million tkm in 2023. This is just 4,000 million tkm more than in 2019, before the start of the Covid pandemic, and 10,500 million tkm or 6.8% less than in 2022. Reasons for this development, which is the biggest drop in a single year since 2009, are a downturn in container trade and the reorganisation of the European economy in the aftermath of the Ukraine war. Despite this downturn, intermodal still counts for 32% of the whole rail freight market (see Figure 2).

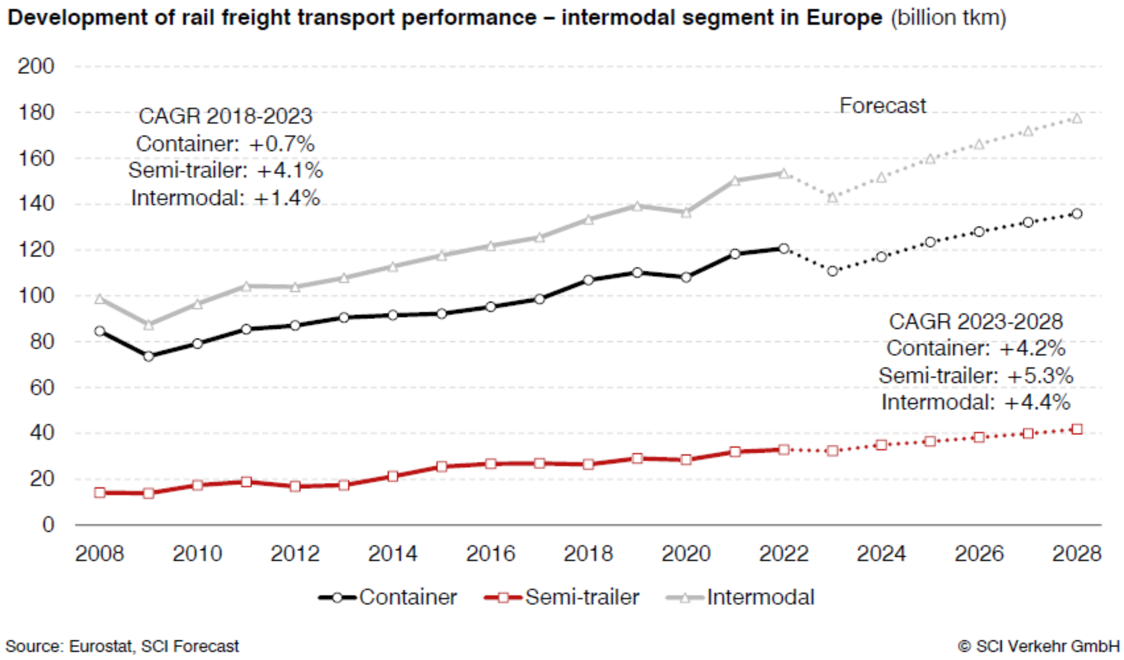


Figure 2 - Development of intermodal rail transport performance in Europe

In addition to the planned activities, UIRR has designed and developed with a subcontractor a catalogue of national country sheets related to intermodal transport. This catalogue contains valuable information such as transport volumes, the active market stakeholders (Combined Trasport Operators, Railway Undertakings…), the key contacts for authorities (Ministries, Parliament, Regulatory Bodies…), list of key legislations and national strategies and, funding schemes and non-financial support programs. This catalogue will serve as one of the instruments to estimate the intermodal potential as mentioned in the Deliverable 1.1 on need analysis of relevant stakeholders for the European multimodal transport network. The findings of this analysis are documents in a separate file.

This deliverable has been structured in eleven different chapters:

- The first chapter summarises the key aspects of the Task 1.2 and the importance of intermodal transport in Europe.
- The second chapter describes the various elements of the CT ecosystem with a focus on the stakeholders and their roles and responsibilities.
- The third chapter details the operational process of a standard intermodal train.
- Chapter 4 provides a catalogue of existing technical standards related to wagons, lines, and intermodal loading units.
- Chapter 5 portrays the types of transported intermodal loading units and wagons.

- Chapter 6 lists the of existing vertical and horizontal transshipment technologies for handling intermodal loading units.
- Chapter 7 details the digital intermodal ecosystem by listing the current digital platforms and the data exchange formats.
- Chapter 8 compiles information of the main terminals in Europe and its main characteristics.
- Chapter 9 describes the key components of an intermodal network corridor based on the two ReMuNet TEN-T corridors.
- Chapter 10 provides key figures related to the sustainable assessment of different routes in terms of energy savings and CO_2 reduction.
- Chapter 111 consolidates the main conclusions related to the Task 1.2.

2 The intermodal ecosystem

The intermodal transport system brings together several partners with specific roles & responsibilities which are briefly defined below. The particularity of this system is that the functions of certain entities can also be covered by others, meaning that a same organisation can consecutively embody several roles at certain point of the transport chain. An overview of the ecosystem is also available in ReMuNet's report on the "Needs analysis of relevant stakeholders for the European multimodal transport network".

2.1 Stakeholders involved

The combination of transport modes in an intermodal perspective implies that many stakeholders might be involved. The parties involved in a road-rail intermodal transport combination are included in Figure 3.

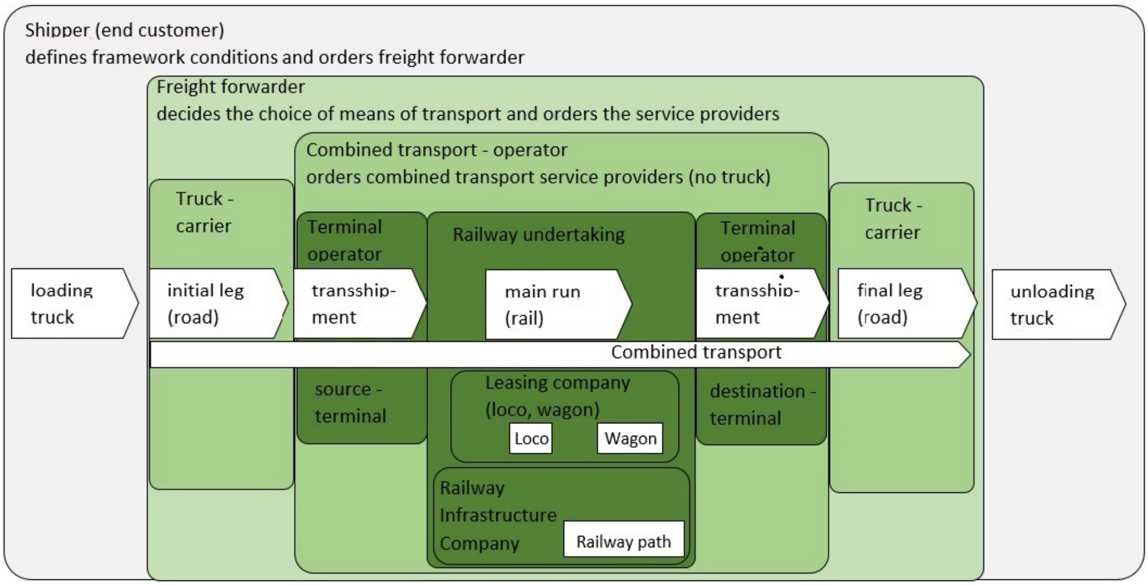


Figure 3: The intermodal stakeholders

The shipper is the party named on the consignment note or waybill as the shipper and/or concludes the contract of carriage with a carrier (or has a contract of carriage concluded in their name). They are often the owner of goods to be shipped and are responsible for packing and preparing the shipment to be handed over to the carrier for transport.

The freight forwarder / Logistics Service Provider (LSP) are contracted by a shipper to organise the transport of its shipment from one place to another. The logistics service provider distinguishes itself from the freight forwarder as it can also organise the insurance policy, the warehousing, the handling of the shipment.

The road haulier carries out the road transport of a loading unit, thus covering the road section, also called leg, of an intermodal operation. Road transports often occur in the first and last legs of an intermodal operation. When it is the first leg, the loading unit is transported from its departure point to an intermodal terminal where it will be loaded on a train. When it occurs at the end of the operation, the loading unit is attached to a truck which delivers it to its destination.

The Terminal Operator performs the transshipment of the loading unit from one mode of transportation to another. It is responsible for the sound stowage of the loading unit when it is not transhipped directly.

The Infrastructure Manager (IM) is responsible for the development, upkeep, and usage of the rail tracks infrastructure it owns. It is the entity from which Railway Undertakings or Intermodal Transport Operators book a time slot, also known as segment, to allow a train to move on designated tracks.

The Railway Undertaking (RU) is a railway company in charge of the traction of the freight train between terminals. It can also arrange wagons for the purpose of the transport.

The Intermodal or Combined Transport Operator (ITO or CTO) is contracted by a shipper, a freight forwarder, or an LSP to seamlessly organise the transport of the loading unit from its pick-up point to its drop-out point, using different modes of transport, namely road, rail, short sea shipping or inland waterways. It distinguishes itself from freight forwarders as it owns certain assets (e.g. wagons, trucks, locomotives, terminals) allowing it to perform parts of the operation itself.

For instance, in a road-rail configuration, the ITO can request traction from a Railway Undertaking, make sure that appropriate wagons are brought together to form a train, book a slot at a terminal, and book a (time) segment to allow the train to circulate.

When the ITO conducts a door-to-door operation, it is responsible for the organisation of the whole transport chain, i.e. to complete the shipment of the loading unit from its departure point to its final destination. It is therefore in charge of the first and final leg of the transport chain and can contract with a road haulier to cover them.

2.2 Service Portfolio of intermodal Transport Operators

To further elaborate on the role of the ITO and explore its Service Portfolio, hereinafter its business model, it is necessary to analyse which players in the Intermodal Transport industry can take on the role of an ITO:

- Intermodal Transport operators;
- Logistics service providers acting as operators;
- Railway undertakings acting as operators;
- Shippers, terminal and port operators in operator role.

Within each category, there are companies specialising either in continental or maritime Intermodal Transport services or providing the entire spectrum of Intermodal Transport services. The variety of the market results in specific business models, which will be further explained and exemplified through the Combined Transport (CT) operator business model, similar to that of Intermodal Transport operator.

This analysis is an addon to the chapter 5.4 of the deliverable 1.1 which briefly describes the role of a multimodal transport operator which can be compared with that of an intermodal transport operator.

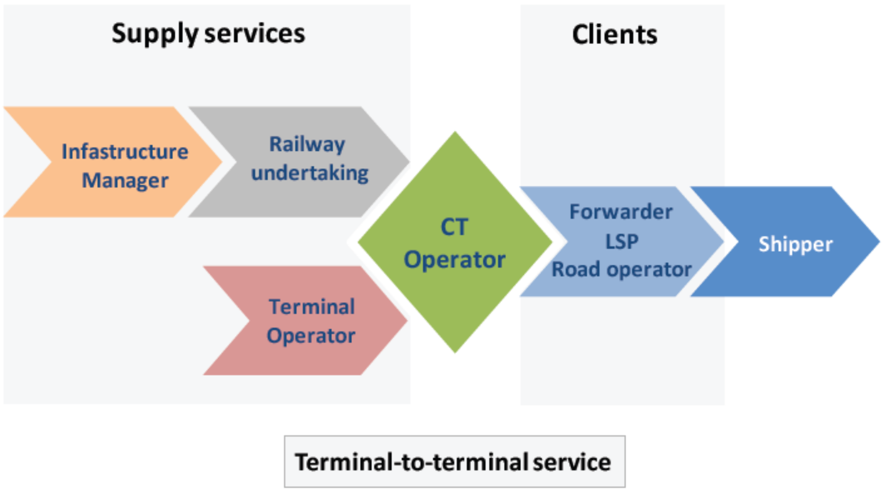
2.2.1 CT operators for continental of Maritime Combined Transport services

The overarching service portfolio of CT operators can be outlined as follows:

- CT operators that design and implement CT services for external parties, abstaining from transporting their own goods or offering exclusive CT loading units.
- A rising tendency among CT operators in the operation of block trains.
- CT operators that offer service capacity to their clients, frequently organising multi-user services.
- Organisation of "company trains," assembled exclusively for a single user, assuming the economic risks associated with the operation.

The principal goal of CT operators is to minimise asset ownership. In practice, they procure rail traction from railways, which acquire train paths from infrastructure managers (IMs). They secure terminal slots (the handling time for inbound and outbound trains) from terminal operating companies, either directly or through arrangements with railway undertakings. Many CT operators maintain a fleet of intermodal wagons, supplemented by rentals from railway undertakings and specialised firms.

In essence, these characteristics apply to all CT operators, regardless of whether they serve the continental or maritime market. The disparity between the two business models lies primarily in the scope of the supply chain and logistics services offered.



Source: KombiConsult

Figure 4 - CT operator for continental services

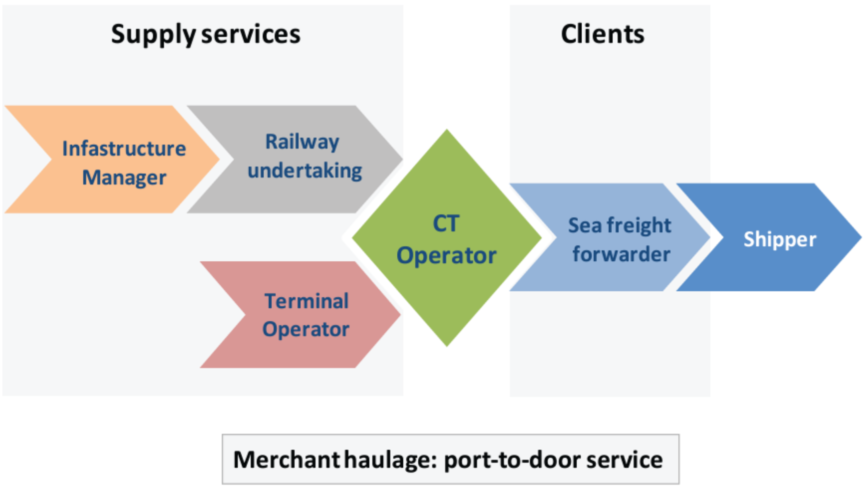
For CT operators serving the continental market, their primary clientele consists of logistics service providers, forwarders, and road operators, who orchestrate door-to-door logistics for shippers. These operators utilise either their own or rented CT equipment, arranging, and executing the pickup and delivery of CT loading units via trucks.

Consequently, CT operators in the continental services sector provide terminal-to-terminal transport services, encompassing the following components of the CT supply and value chain:

- Rail transport of clients' loading units with wagon provision.
- Terminal handling (transhipment) of loading units at both ends of the rail journey.
- Administrative clearance of pick-up and delivery trucks (check-in / Check-out).
- Technical and safety checks of loading units at both terminals.

CT operators serving the maritime CT market are mandated to provide a comprehensive port-to-door service for marine containers to their clientele. They must be capable of delivering each element of the CT supply and value chain, even if not every client requires it. This entails:

- Rail transport of marine containers, inclusive of wagon provision.
- Terminal handling of containers at the inland terminal, while the responsibility for transhipment of containers at the port-related rail terminal lies with the shipping line (the cost of transhipment between seaport terminal and any hinterland mode of transport is encompassed in the Terminal Handling Charge - THC).
- Administrative clearance of pick-up and delivery trucks (check-in/check-out), and technical and safety checks of containers at the inland terminal.
- Pre- or post-haulage of containers by road at the inland terminal, encompassing the pick-up or delivery of empty containers at empty container depots.
- Customs clearances.



Source: KombiConsult

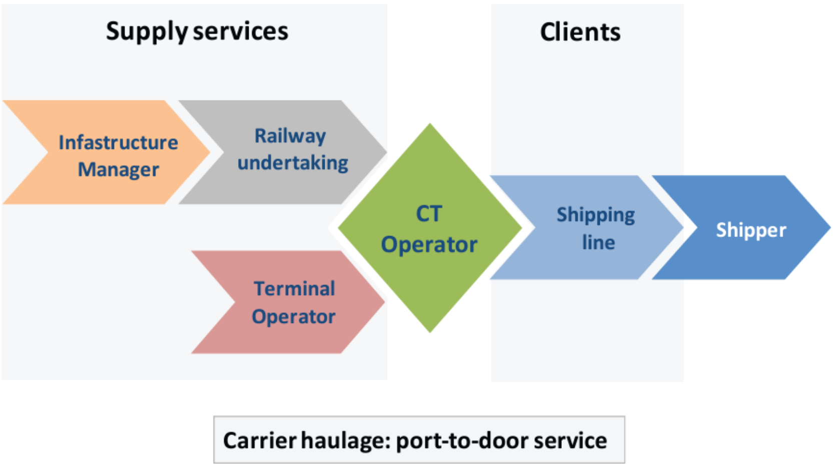
Figure 5 - CT operator for maritime services (merchant haulage)

Maritime transport involves two methods of handling container movement, depending on who oversees the inland haulage:

1. In the case of merchant haulage, a shipper (also known as a merchant) takes charge of the door-to-door transport and negotiates terms for both sea and hinterland transport directly with a shipping line. Typically, the shipper outsources operations to

a sea freight forwarder, who, in the case of a CT service, becomes the client of a CT operator (see Figure 5).

2. Carrier haulage entails the movement of containers under the control of the shipping line (carrier), utilising a haulage contractor nominated by the shipping line. If the carrier opts for a CT service provided by a CT operator, they may procure full port-to-door logistics for only certain components, such as port-to-(inland) terminal transport (see Figure 6).



Source: KombiConsult

Figure 6 - CT operator for maritime services (carrier haulage)

2.2.2 Logistics service provider in operator role

The emergence of logistics service providers in an operator role has reshaped the landscape of Combined Transport (CT) services. Traditionally, CT services were delineated between the demand and supply sides. However, since the early 2000s, logistics service providers, such as forwarders, shipping lines, or barge operators, historically positioned on the demand side, have ventured into the CT market, evolving a new business models as logistics service providers in an operator role.

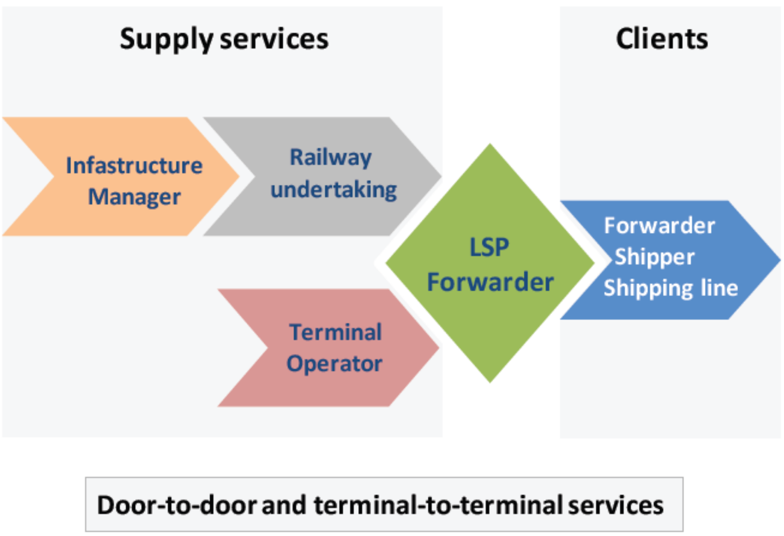


Figure 7 - Logistics service provider in operator role

Initially, they began with proprietary CT services to transport their own shipments but swiftly extended spare transport capacity to other users to enhance capacity utilisation. This transition marked their shift towards assuming the role of an operator, eventually offering tailored CT services for third parties. Some of these new operators have even pursued further integration by obtaining licenses as railway undertakings or acquiring terminal handling facilities.

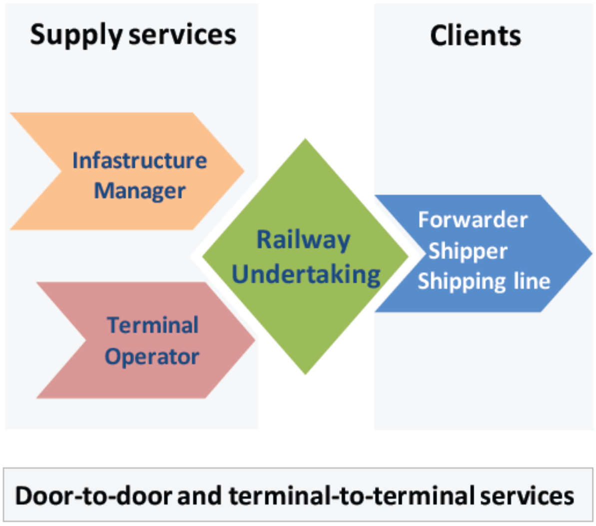
By establishing CT services, these companies expanded their existing value chains and integrated the supply chain, thereby eliminating the intermediary role of the CT operator. Depending on the sector covered—continental or maritime CT services—and the requirements of their customers—other logistics service providers, shippers, or shipping lines (in the case of maritime CT)—they may offer door-to-door or terminal-to-terminal services. Consequently, their services encompass various elements of the CT supply chain, including:

1. Own and third-party road haulage.
2. Terminal handling, including administrative clearance of pick-up and delivery trucks (check-in/check-out), and technical and safety checks of containers at the inland terminal.
3. Road pick-up and delivery services.
4. Supplementary logistics services, such as customs clearances and empty container depot management.

2.2.3 Railway undertakings in operator role

Railway undertakings have become significant players in the realm of Combined Transport services, with virtually all established European railway undertakings and numerous new entrants engaging as train operating companies. These railway companies have adopted varying roles within the CT supply chain and offer different scopes of services, which can be categorised into two main groups:

1. Incumbent railway undertakings that typically maintain a network of domestic and international wagonload services. While these allow customers to transport intermodal loading units, railway undertakings that haven't actively designed specific CT services to limit themselves to a more passive role in an operation are not considered CT operators.
2. Railway undertakings that are actively involved in designing, operating, and selling dedicated CT services, can position themselves as CT service providers. Their service offering closely resembles that of logistics service providers, as they establish direct connections with customers, bypassing the traditional operator role.



Source: KombiConsult

Figure 8 - Railway undertaking in operator role

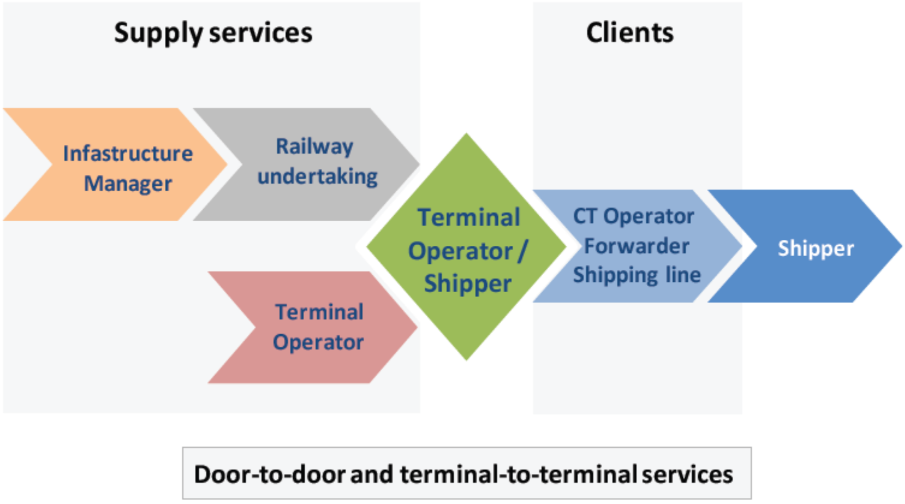
Railway Undertakings acting as CT operators may offer a comprehensive range of CT services tailored to the segments they serve (maritime, continental, domestic, or international CT services), or they may opt to focus on specific market segments and services. As a result, their portfolio may include door-to-door, port-to-door, or terminal-to-terminal services. They may also operate multi-user CT systems as well as company trains.

2.2.4 Shippers, terminal, and port operators in operator role

Recent years have shown a notable trend towards vertical integration of the Combined Transport supply chain, extending beyond railway undertakings and logistics service providers. Shippers and operators of seaport terminals or inland ports, traditional customers or suppliers of subservices for CT trains, have also entered the market. Typically, these parent companies establish specialised subsidiaries to take on the role of CT operators. By doing so, terminal and port operators primarily aim to enhance and expand their core business by implementing more efficient CT services to and from their operating locations. (Figure 9)

As for shippers, two main developments have emerged:

1. Some Shippers, and particularly those in the construction industry who handle large cargo volumes via conventional rail, have capitalised on liberalised rail access to establish railway undertakings, aiming to reduce costs. This has become a way for them to broaden their portfolio to offer rail traction services to third parties, thereby entering the CT business.
2. For others, the motivation may stem from the need for tailored services. Like terminal operators, they typically outsource CT activities and establish CT service providers. By opening services to other users and enhancing CT train capacity utilisation, they transition into the role of CT operators.

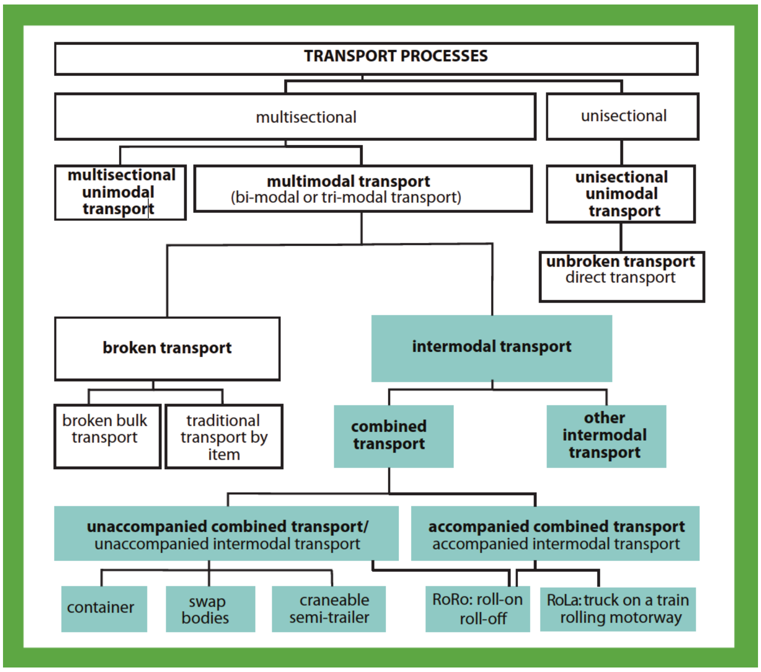


Source: KombiConsult

Figure 9 - Terminal operators and shippers in operator role

3 Intermodal process analysis

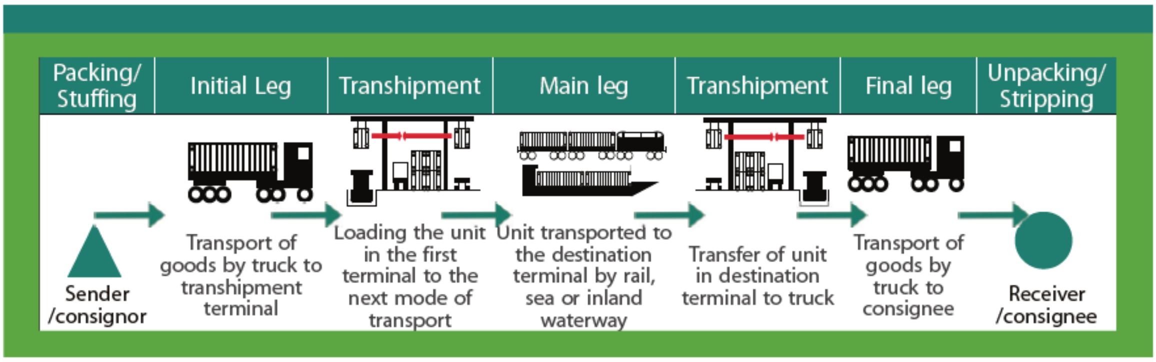
The following figure gives an overview of the possible types of transport processes and classifies the term “intermodal transport”. Intermodal transport is a subcategory of a multi-sectional multimodal transport process.



(Source: see reference 7)

Figure 10 - Outline of the intermodal transport process

For this process analysis, we will focus on the unaccompanied combined transport of intermodal loading units (containers, swap bodies, semi-trailers). In Unaccompanied Combined Transport (UCT), only the loading units are transferred from one carrier to another ("transhipped"). The towing vehicle (tractor), the driver and the skeleton chassis do not accompany the transport and are available for other trips. At the destination of the train, suitable trucks must be available for onward transport.



(Source: see reference 7)

Figure 11 - Intermodal transport - main process elements

Intermodal transport uses the terms initial legs, transhipment, main leg, and final leg as shown in Figure 11. In some cases, packing (stuffing) and unpacking (stripping) are also added. In the next section, the operational processes of the different legs will be detailed with a particular attention on the main leg on rail.

3.1 Initial and final road legs

The **initial road leg** describes the first part of the transportation of the loading unit(s) holding the cargo from one or more shippers to a terminal by road. In intermodal transport, the loading unit holding the cargo of the consignor (shipper) is usually brought to a terminal by truck in order to be transported from there onto the rail that performs the main leg of the journey. The **final road leg** describes the transport of the loading unit(s) from the receiving terminal to the final destination (consignee / shipper).

3.2 Terminal processes

The change of mode between road and rail is called transhipment. A loading unit (container, swap body or semi-trailer) is transhipped from one mode of transport to another. Intermodal transport chains always include transhipment and the use of multiple modes of transport.

Table 1 provides the main terminal processes: check-in & check-out procedures, the loading procedures, and the train closure. The check-in procedures must be respected in case of a truck driver delivering a loading unit. The truck driver arrives at the gate-in with a booking confirmation for a specific loading unit. In case of check-out procedures, the driver must present to the terminal agency the pick-up order (number) received from the CT operator.

Terminal process	Description
1. Check-in and check-out procedures	**Check-in** - The truck driver arrives at the entrance gate with the intermodal loading unit - The terminal operator checks the status of the loading units, verify the documents and drivers' identity. In case of dangerous goods, labels and markings are verified. - The shipment order will be verified by the terminal agency. - If all checks are positive, the truck driver may enter the terminal and bring the loading unit to the parking position. - The driver may leave the terminal without any further controls (if he does not pick-up a loading unit at the same time) - All steps are documented (either paper-based or digitally). **Check-out** - The truck driver arrives at the entrance gate. - The terminal operator verifies if a pick-up order has been established and that the ILU is available, and the driver is identified. - If positive, the truck driver enters the terminal and goes to the pick-up position. The crane operator loads the ILU on the ground or on the road chassis. - The driver goes to the exit gate for additional control ensuring that the right ILU has been picked up. - The truck driver leaves the terminal. - All steps are documented (either paper-based or digitally).

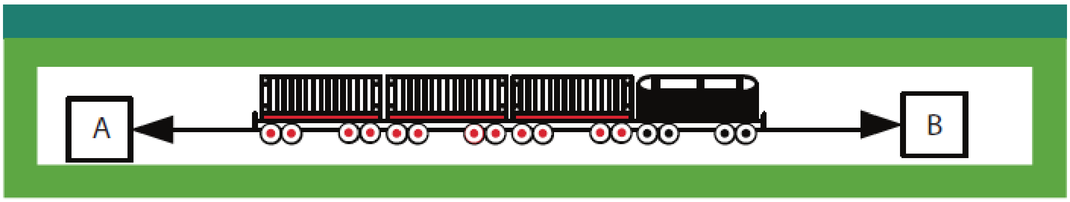
2. **Loading procedures**	- Preparatory activities: the terminal operational staff verify that the ILU can be loaded on the given wagon (according to the manual instructions of the wagon) and that all technical requirements are met. - The crane operator picks up the ILU and loads it onto the wagon. - The terminal operational staff verify that the ILU is rightfully loaded onto the wagon. - All steps are documented (either paper-based or digitally).
3. **Train closure**	- The terminal operator hands over the train to the railway undertaking by providing all necessary documentation (consignment note, dangerous goods, waste…). It means that the terminal operator is no longer responsible for the train.

Table 1 - Terminal main processes

3.3 Main leg: Railway

The main leg refers to the transportation of the loading units from the transhipment node nearest to the consignor to the transhipment node closest to the consignee.

In this process analysis, we will concentrate on the main leg on railway. The type of train services handled is of great significance as they influence the type and manner of handling processes. Loading can be done for single wagons, block trains, shuttle trains and company trains. Block trains transport large quantities between destinations, with train length and train access established by demand whereas shuttle trains run between two terminals to both a fixed timetable and composition (see Figure 12).



(Source: see reference 7)

Figure 12 - Shuttle train

Table 2 consolidates the various operational processes in case of a standard shuttle train between two terminals without marshalling yards connecting two different countries as for example between Antwerp (BE) and Duisburg (DE).

Main railway process	Description
1. **Train Path & Terminal Slot**	- **Reservation of a regular infrastructure train path** A train path is the infrastructure capacity (spatial and temporal use of the infrastructure) required to operate a train between two locations over a period of time. A railway operator must purchase a train path from a railway infrastructure manger in order to operate a train on its tracks. The ordering of train paths is regulated by various European Directives.

	- **Reservation of a regular terminal slot** A slot describes the time window assigned to a movement operation. The slot consists of an undivided time window in the standing process and two time windows in the flow process.
2. Train preparation & train ready to start at departure terminal	- After the train closure by the terminal operator, the railway undertaking prepares the train for departure. It performs all necessary technical and operational checks according to the existing regulations, its safety management system (SMS) and contractual arrangements (for example the General Contract of Use – GCU). - After all checks are positive, the railway undertaking informs the infrastructure manager that the train is ready to start its journey on the reserved train path. - The IM (local) traffic control decides to accept or not to release the train for real departure. - All steps are recorded either paper-based or digitally (TAF TSI obligation).
3. Train running on the infrastructure	- The train leaves the terminal area and enters the entry point of the network of the first infrastructure manager (Belgium in the example between Antwerp and Duisburg). - The railway undertaking (locomotive) must follow the instructions of the infrastructure manager in case of any incidents or deviations from the original agreed train path. - If required, in case of several operators, the train has to be handed over - at an agreed handover point (very often at border-crossing points) - from the departing railway undertaking to the next one. - The train enters in the second infrastructure network (Germany in the case of the relation between Antwerp and Duisburg). - All steps are recorded either on paper or digitally (TAF TSI obligation).
4. Train arrival at destination terminal	- The train arrives at the exit point of the network of the second infrastructure manager. - The train arrives at the destination terminal. - The train is handed over to the terminal operator. - All steps are recorded either on paper or digitally (TAF TSI obligation).

Table 2 - Main rail leg processes

4 Standardisation in rail intermodal

The stakeholders involved in intermodal rail freight transport must deal with several regulations and standards (TSIs, EN, IRS, ISO, etc.). These define the design/testing requirements for ILUs and wagons and their constituent parts and set the conditions for the compatibility of ILUs and wagons with the means used for their conveyance in the different transport modes (trucks, wagons, and ships) and for their handling and transshipment in terminals.

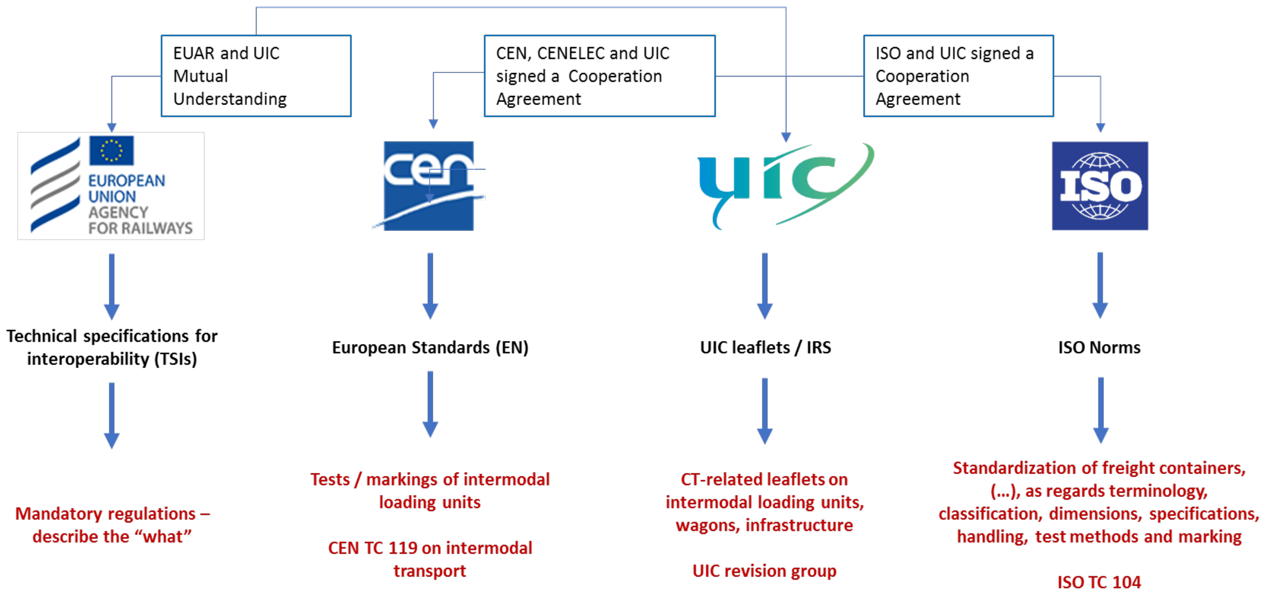


Figure 13 - The standardisation entities for intermodal transport

Figure 13 summarises the standardisation ecosystem of intermodal transport with a focus on the road-rail application.

- **ERA; the European Union Agency for Railways,** is an agency of the European Union (EU) that sets mandatory requirements for European railways and manufacturers in the form of Technical Specifications for Interoperability (TSI). 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. 11 TSIs have been adopted and are regularly reviewed under the coordination of the European Union Agency for Railways. The most relevant for intermodal rail freight are the TSI wagon, TSI Noise, TSI Operations and TSI Telematics.

- **CEN, the European Committee for Standardisation**, is an association that brings together the national standardisation bodies of 34 European countries. It is one of three European standardisation organisations (i.e., together with CENELEC and ETSI) that has been officially recognised 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).

- **ISO, International Organisation for Standardisation**, is an independent, nongovernmental international organisation 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 standardisation 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 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).

4.1 Codification system

Intermodal rail transport deals with the conveyance of Intermodal Loading Units (ILUs) by road, rail, inland waterways, and short-sea shipping.

The dimensions of most ILUs (semi-trailers, swap bodies and roller units) are optimised for road transport and when forwarded on wagons, their upper sections exceed the standard loading gauge in terms of height in several European Member States in a relevant number of cases.

The most common solution 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 railway undertakings to obtain specific authorisation from all involved infrastructure managers and to check the size of the ILUs when loaded on the wagons to ensure that they do not exceed the authorised dimensions.

The codification system as per 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 (see Figure 14).

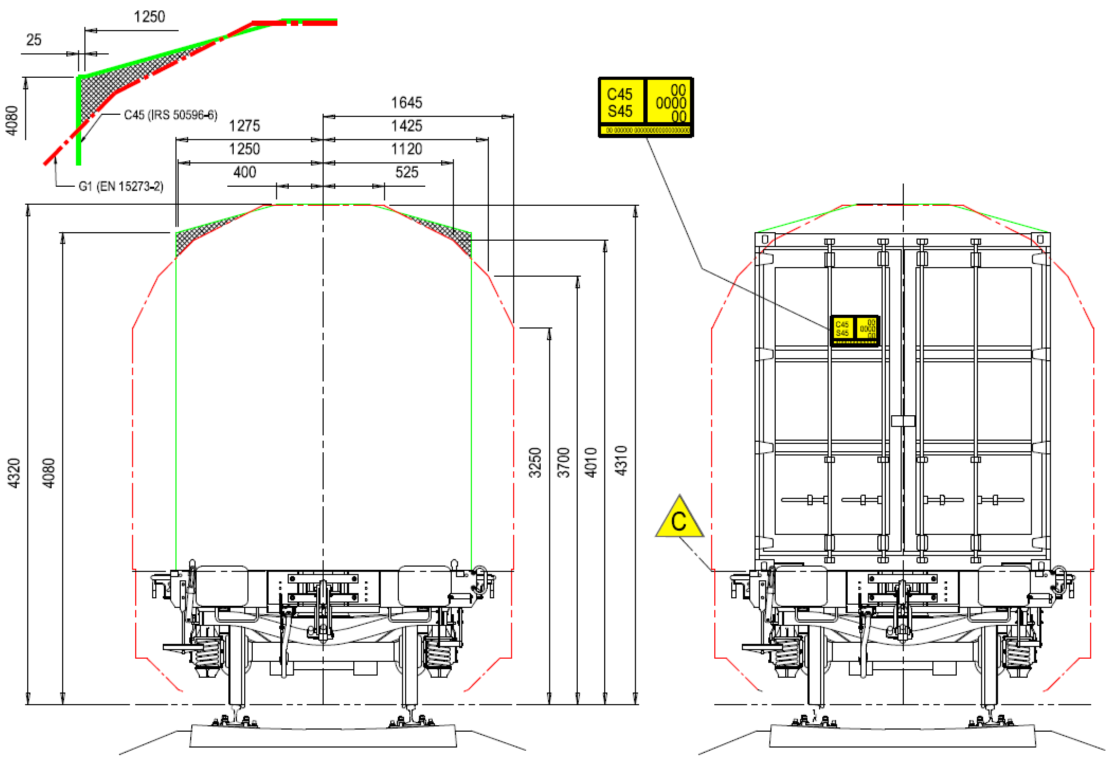


Figure 14 – Combined Transport Profile (example of C45)

The codification system as defined in IRS 50596-6 has been applied for several decades by various RUs and IMs in the intermodal rail transport chain and ensures the safe operation of ILUs loaded on compatible wagons when transported on codified lines. IRS 50596-6 provides the system requirements for:

- the allocation of the wagon compatibility code and correction digits to wagons.
- the codification of ILUs.
- the codification of lines.
- the verification of compatibility between ILUs and wagons.
- the assessment of compatibility between ILUs conveyed on suitable wagons and lines.

The next chapters will describe in detail the various elements of the codification and their relevant standards.

4.2 Loading units

The following ILUs can be conveyed on suitable wagons within the framework of codified combined transport:

- Semi-trailers that comply with IRS 50596-5 and the relevant ISO and EN standards
- ILUs types that comply with IRS 50592 and the relevant ISO and EN standards:
    - ISO containers
    - EN Class C ILUs
    - EN Class C stackable ILUs
    - EN Class C refrigerated ILUs
    - EN Class A ILUs
    - EN Class A stackable ILUs
    - EN Class A refrigerated ILUs
    - EN tank ILUs
    - Intermediate frames
    - ILUs that do not comply with the above-mentioned types but have dimensions that allow them to be coded according to IRS 50596-6
    - ILUs with a base width > 2,600 mm
    - ILUs that, due to their dimensions and MGM, cannot be loaded on wagons marked with WCC C
    - Hybrid ILUs (non-ISO ILUs fitted with upper fittings, but no grappler arm grooves)
    - Non-standard ILUs which can be conveyed stacked.
- Roller units that comply with IRS 50591.

The codification of ILUs is based on the technical number (TN). The purpose of the technical number is to code the key characteristics of ILUs for rail conveyance.

By reading the technical number, loading and inspection staff can ascertain on which type of wagons, and on which combined transport lines ILUs can be conveyed with no operating restrictions.

The technical number is made up of the WCC (B, C, N or P), the standard Combined Transport Profile number (2 or 3 digits), and if required, the special Combined Transport Profile number (2 or 3 digits preceded by "S"). The special Combined Transport Profile number is mandatory for traffic on UK routes. The technical number of the UTI appears on the codification plate on each side of the ILU (see Figure 14).

Codification plates are defined in EN 13044-2 (swap bodies), EN 13044-3 (semi-trailers) and IRS 50591 (roller units) (see figure 15 for various types of codification plates):

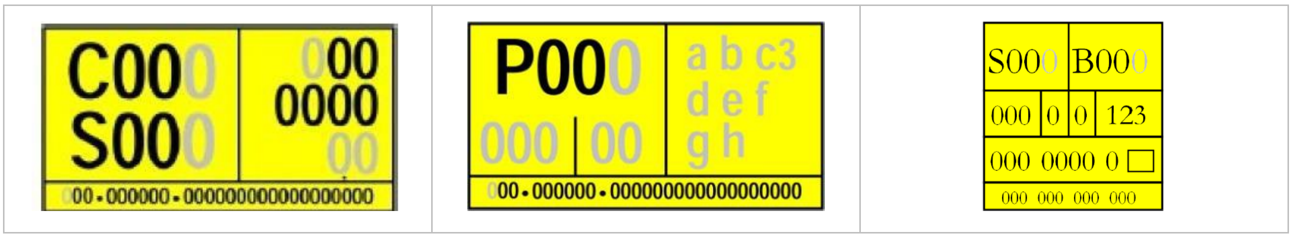


Figure 15 - Codification plates

The following tables provides an overview per type of ILU (semi-trailers, swap-bodies, and ISO containers) of the regulations, standards and guidelines that are to be considered when designing, testing and operating such ILUs on the European territory.

ILU Type: SEMI-TRAILER	
European Legal Framework	• 94/20/EC: Directive relating to the mechanical coupling devices of motor vehicles and their trailers and their attachment to those vehicles • EC/661/2009: Regulation concerning type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended for that • EU/2015/166: Commission Regulation supplementing and amending Regulation (EC) No 661/2009 of the European Parliament and of the Council as regards the inclusion of specific procedures, assessment methods and technical requirements, and amending Directive 2007/46/EC of the European Parliament and of the Council, and Commission Regulations (EU) No 1003/2010, (EU) No 109/2011 and (EU) No 458/2011 • 96/53/EC: Directive laying down for certain road vehicles circulating within the community the maximum authorised dimensions in national and international traffic and the maximum authorised weights in international traffic • EU/2015/719: Directive amending Council Directive 96/53/EC laying down for certain road vehicles circulating within the community the maximum authorised dimensions in national and international traffic and the maximum authorised weights in international traffic • 2014/45/EU: Directive relating to the periodic roadworthiness tests for motor vehicles and their trailers and repealing Directive 2009/40/EC
UNECE	• Regulation No. 55: Uniform provisions concerning the approval of mechanical coupling components of combinations of vehicles, Ed. 2018 • ADR: European agreement concerning the international carriage of dangerous goods by road, Ed. 2019 • ATP: Agreement for the international carriage of perishable foodstuff and on the special equipment to be used for this carriage, Ed. 2020
CEN	• EN 12195-1+ 1/AC: Load restraining on road vehicles - Safety - Part 1: Calculation of securing forces, Ed. 2014/1.AC 2019 • EN 12195-2: Load restraint assemblies on road vehicles - Safety - Part 2: Web lashing made from manmade fibres, Ed. 2000 • EN 12195-3: Load restraint assemblies on road vehicles - Safety - Part 3: Lashing chains, Ed. 2001 • EN 12195-4: Load restraint assemblies on road vehicles - Safety - Part 4: Lashing steel wire ropes, Ed. 2003 • EN 12640: Intermodal loading units and commercial vehicles - Lashing points for cargo securing – Minimum requirements and testing, Ed. 2019 • EN 12641-1: Intermodal loading units and commercial vehicles - Tarpaulins - Part 1: Minimum requirements, Ed. 2019 • EN 12641-2: Intermodal loading units and commercial vehicles - Tarpaulins - Part 2: Minimum requirements for curtainsiders, Ed. 2019 • EN 12642: Securing of cargo on road vehicles - Body structure of commercial vehicles – Minimum requirements, Ed. 2016 • EN 13044-1: Intermodal Loading Units - Marking - Part 1: Markings for identification, Ed. 2011/AC 2014 • EN 13044-3: Intermodal Loading Units - Marking - Part 3: Markings of semi-trailers related to rail operation, Ed. 2011 • EN 16973: Road vehicles for combined transport - Semitrailer - Vertical transhipment, Ed. 2017
UIC	• IRS 50571-4: Wagons for combined transport - Vertical transhipment - Characteristics, Ed. 2020 • IRS 50596-5: Transport of road vehicles on wagons - Technical organisation - Conveyance of semi-trailers with P coding or N coding on recess wagons, Ed. 2020 • IRS 50596-6: Conditions for coding intermodal loading units in combined transport, combined transport ILU-related topics lines and wagons, Ed. 2018 • IRS 50596-7: Railway applications - Rolling stock - Conformity assessment - Requirements for bodies performing the certification of coding in accordance with UIC Leaflet 596-6 (Competent Authorities), Ed. 2017 • Loading Guidelines, Volume 1: Code of practice for the loading and securing of goods on railway wagons - Principles, Ed. 2020 • Loading Guidelines, Volume 2: Code of practice for the loading and securing of goods on railway wagons - Goods, Ed. 2020

ISO	• ISO 337 + Tech. Corr. 1: Road vehicles - 50 semi-trailer fifth wheel coupling pin - Basic and mounting and interchangeability dimensions, Ed. 1981/Tech. Corr. 1 Ed. 1990 • ISO 1161: Series 1 freight containers - Corner and intermediate fittings - Specifications, Ed. 2016 • ISO 1726-1: Road vehicles - Mechanical coupling between tractors and semi-trailers - Part 1: Interchangeability between tractors and semi-trailers for general cargo, Ed. 2000/Tech. Corr. 1 Ed. 2007 • ISO 1726-2: Road vehicles - Mechanical couplings between tractors and semi-trailers - Part 2: Interchangeability between low-coupling tractors and high-volume semi-trailers, Ed. 2007 • ISO 1726-3: Road vehicles - Mechanical couplings between tractors and semi-trailers - Part 3: Requirements for semi-trailer contact area to fifth wheel, Ed. 2010 • ISO 17025: General requirements for the competence of testing and calibration laboratories, Ed. 2017 • ISO 17065: Conformity assessment - Requirements for bodies certifying products, processes and services, Ed. 2012

Table 3 - Semi-trailers: list of regulations and standards

ILU Type: ISO CONTAINERS	
European Legal Framework	• 96/53/EC: Directive laying down for certain road vehicles circulating within the Community the maximum authorised dimensions in national and international traffic and the maximum authorised weights in international traffic • EU/2015/719: Directive amending Council Directive 96/53/EC laying down for certain road vehicles circulating within the Community the maximum authorised dimensions in national and international traffic and the maximum authorised weights in international traffic
UNECE	• ADR: European agreement concerning the international carriage of dangerous goods by road, Ed. 2019 • ATP: Agreement for the international carriage of perishable foodstuff and on the special equipment to be used for this carriage, Ed. 2020 • CSC: International Convention for Safe Containers
UIC	• IRS 50571-4: Wagons for combined transport - Vertical transhipment - Characteristics, Ed. 2020 • IRS 50592: Intermodal Transport Units (other than semi-trailers) for vertical transhipment and suitable for carriage on wagons - Minimum requirements, Ed. 2019 • IRS 50596-6: Conditions for coding intermodal loading units in combined transport, combined transport lines and wagons, Ed. 2018 • UIC Leaflet 592-3: Large containers (CT), swap bodies (CM) and transport frames for horizontal transhipment (CA) - Standard report on acceptance tests, Ed. 1998 • Loading Guidelines, Volume 1: Code of practice for the loading and securing of goods on railway wagons - Principles, Ed. 2020 • Loading Guidelines, Volume 2: Code of practice for the loading and securing of goods on railway wagons - Goods, Ed. 2020
ISO	• ISO 830: Freight containers - Vocabulary, Ed. 1999/Tech. Corr.1 Ed. 2001 • ISO 668: Series 1 freight containers - Classification, dimensions and ratings, Ed. 2020 • ISO 6346: Freight containers - Coding, identification and marking, Ed. 1995/AMD 3 Ed. 2012 • ISO 1161: Series 1 freight containers - Corner and intermediate fittings - Specifications, Ed. 2016 • ISO 1496-1: Series 1 freight containers - Specification and testing - Part 1: General cargo containers for general purposes, Ed. 2013/ AMD 1 Ed. 2016 • ISO 1496-2: Series 1 freight containers - Specification and testing - Part 2: Thermal containers, Ed. 2018 • ISO 1496-3: Series 1 freight containers - Specification and testing - Part 3: Tank containers for liquids, gases and pressurised dry bulk, Ed. 2019 • ISO 1496-4: Series 1 freight containers - Specification and testing - Part 4: Non-pressurised containers for dry bulk, Ed. 1991/AMD 1 Ed. 1994/COR 1 Ed. 2006 • ISO 1496-4: Series 1 freight containers - Specification and testing - Part 5: Platform and platform-based containers, Ed. 2108 • ISO 3874: Series 1 freight containers - Handling and securing, Ed. 2017 • ISO 3874: Freight containers - Coding, identification and marking, Ed. 1995/AMD 3 Ed. 2012 • ISO 10374: Freight containers - Automatic identification, Ed. 1991/AMD 1 Ed. 1995 • ISO/TR 15070: Series 1 freight containers - Rationale for structural test criteria, Ed. 1996/AMD 1 Ed. 2005 and AMD 2 Ed. 2007 • ISO 9669: Series 1 freight containers - Interface connections for tank containers, Ed. 1990/AMD 1 Ed. 1992

Table 4 - ISO containers: list of regulations and standards

ILU Type: ILUs other than ISO containers and semi-trailers	
European Legal Framework	• 96/53/EC: Directive laying down for certain road vehicles circulating within the Community the maximum authorised dimensions in national and international traffic and the maximum authorised weights in international traffic • EU/2015/719: Directive amending Council Directive 96/53/EC laying down for certain road vehicles circulating within the Community the maximum authorised dimensions in national and international traffic and the maximum authorised weights in international traffic
UN/ECE	• ADR: European agreement concerning the international carriage of dangerous goods by road, Ed. 2019 • ATP: Agreement for the international carriage of perishable foodstuff and on the special equipment to be used for this carriage, Ed. 2020
CEN	• EN 283: Swap bodies - Testing, Ed. 1991 • EN 284: Swap bodies - Non-stackable swap bodies of Class C - Dimensions and general requirements, Ed. 1992 • EN 452: Swap bodies - Swap bodies of Class A - Dimensions and general requirements, Ed. 1995 • EN 1432: Swap bodies - Swap tanks - Dimensions, requirements, test methods, operation condition, Ed. 1997 • EN 12406: Swap bodies - Thermal swap bodies of Class C - Dimensions and general requirements, Ed. 1999 • EN 12410: Swap bodies - Thermal swap bodies of Class A - Dimensions and general requirements, Ed. 1999 • CEN/TS 13853: Swap bodies for combined transport - Stackable swap bodies type C 745- S16 - Dimensions, design requirements and testing, Ed. 2003 • CEN/TS 14993: Swap bodies for combined transport - Stackable swap bodies type A 1371 - Dimensions, design requirements and testing, Ed. 2005 • EN 12640: Swap bodies - Thermal swap bodies of Class A - Dimensions and general requirements, Ed. 2019 • EN 12641-1: Intermodal loading units and commercial vehicles - Tarpaulins - Part 1: Minimum requirements, Ed. 2019 • EN 12641-2: Intermodal loading units and commercial vehicles - Tarpaulins - Part 2: Minimum requirements for curtainsiders, Ed. 2019 • EN 12642: Securing of cargo on road vehicles - Body structure of commercial vehicles - Minimum • requirements, Ed. 2016 • EN 13044-1 + AC: Intermodal Loading Units - Marking - Part 1: Markings for identification, Ed. 2011/AC, 2014 • EN 13044-2: Intermodal Loading Units - Marking - Part 2: Markings of swap bodies related to rail operation, Ed. 2011 • pr EN 17321: Intermodal loading units and commercial vehicles - Transport stability of packages – Minimum requirements and tests (under approval) • EN 12195-1 + AC: Load restraining on road vehicles - Safety - Part 1: Calculation of securing forces, Ed. 2014/1.AC, 2019 • EN 12195-2: Load restraint assemblies on road vehicles - Safety - Part 2: Web lashing made from manmade fibres, Ed. 2000 • EN 12195-3: Load restraint assemblies on road vehicles - Safety - Part 3: Lashing chains, Ed. 2001 • EN 12195-4: Load restraint assemblies on road vehicles - Safety - Part 4: Lashing steel wire ropes, Ed. 2003
UIC	• IRS 50571-4: Wagons for combined transport - Vertical transhipment - Characteristics, Ed. 2020 • IRS 50592: Intermodal Transport Units (other than semi-trailers) for vertical transhipment and suitable for carriage on wagons - Minimum requirements, Ed. 2019 • IRS 50596-6: Conditions for coding intermodal loading units in combined transport, combined transport lines and wagons, Ed. 2018 • IRS 50596-7: Railway application - Rolling stock - Conformity assessment - Requirements for bodies performing the certification of coding in accordance with UIC Leaflet 596-6 (Competent Authorities), Ed. 2017 • Loading Guidelines, Volume 1: Code of practice for the loading and securing of goods on railway wagons - Principles, Ed. 2020 • Loading Guidelines, Volume 2: Code of practice for the loading and securing of goods on railway wagons - Goods, Ed. 2020
ISO	• ISO 830: Freight containers - Vocabulary, Ed. 1999/Tech. Corr.1 Ed. 2001 • ISO 668: Series 1 freight containers - Classification, dimensions and ratings, Ed. 2020 • ISO 1161: Series 1 freight containers - Corner and intermediate fittings - Specifications, Ed. 2016

Table 5 - ILUs other than ISO containers and semi-trailers: list of regulations and standards

4.3 Wagons

ILUs are conveyed on wagons which may be compatible with one or more types of ILUs. The CT wagons currently used are as follows:

- Fixed pocket wagons for the conveyance of (craneable) semi-trailers which are compliant with IRS 50571-4
- Flat wagons equipped with spigots for the conveyance of swap bodies and containers which are compliant with IRS 50571-4
- Flat wagons equipped with pivoting frames for the conveyance of roller units which are compliant with IRS 50571-5

They may differ by:

- the height of their loading plane above the reference plane, constituted by the running surface of the rails; and/or
- the distance between the bogie pivots (for bogie wagons) or the wheelbase (for 2-axle wagons).

A wagon compatibility code (WCC) has been created to check the suitability of ILUs and their wagons (IRS 50596-6, Point 3.1 and Appendix 11 of the GCU).

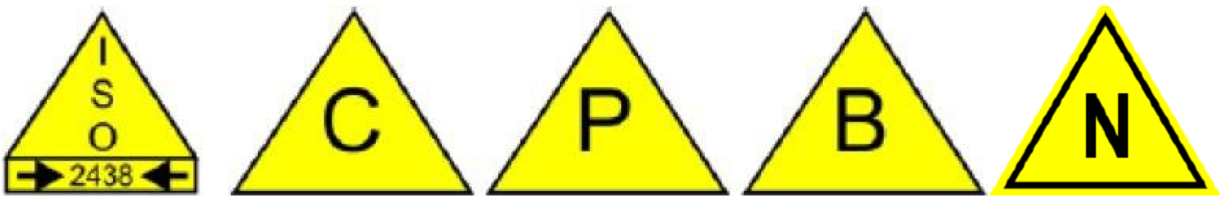


Figure 16 - Example of WCC markings

The WCC consists of a letter within a triangle on a yellow background (see Figure 16).

- Fixed pocket wagons suitable for the conveyance of semi-trailers are marked with the “P” and/or “N” wagon compatibility code.
- Flat wagons suitable for the conveyance of swap bodies are marked with the “C” wagon compatibility code.
- Fixed pocket wagons suitable for the conveyance of swap bodies, containers and semi-trailers are marked with the “C” and “P” wagon compatibility codes.
- Wagons suitable for the conveyance of roller units are marked with the “B” wagon compatibility code.
- Flat wagons with a distance between the pivot of the bogies between 16,150 mm and 20,000 mm and suitable for the conveyance of ISO containers only are marked with the “ISO” wagon compatibility code.

In addition to the WCC, wagons with more or less favourable geometric characteristics in relation to those provided by IRS 50596-6, Appendices A.1 to A.4 may carry a positive or negative correction digit (see Figure 17).

- If the correction digit “n” is preceded by a “+” sign, it means that the wagon’s loading plan is “n” centimetres lower than wagons with the geometric characteristics provided by IRS 50596-6, Appendices A.1 to A.4. It can carry ILUs which are “n” centimetres higher than the reference one.
- If the correction digit “n” is preceded by a “-” sign, it means that the wagon’s loading plan is “n” centimetres higher than wagons with the geometric characteristics provided by IRS 50596-6, Appendices A.1 to A.4. It can only carry ILUs that are “n” centimetres lower than the reference one.

 *Marking for wagons with more favourable characteristics than those defined in IRS 50596-6, Appendices A.1 to A.4 and applicable on the entire TEN-T network*	 *Marking for wagons with less favourable characteristics than those defined in IRS 50596-6, Appendices A.1 to A.4 and applicable per network*

Figure 17 - Marking for wagons with less or more favourable characteristics

In other words:

- The maximum permissible codification of an ILU (see Point 3.2) on a wagon carrying a positive correction digit “+n” corresponds to the Combined Transport Profile number (CTPn) of the line used plus the value of the correction digit.
- The maximum permissible codification of an ILU (see Point 3.2) on a wagon carrying a negative correction digit “-n” corresponds to the Combined Transport Profile number of the line used minus the value of the correction digit.

The following table provides an overview of the regulations, standards and guidelines that are to be considered when designing, testing, and operating wagons on the European railway infrastructure.

Entity	Inventory
European Legal Framework	• EU 2016/797: Directive of the European Parliament and of the Council on the interoperability of the rail system within the European Union • EU 2016/798: Directive of the European Parliament and of the Council on railway safety • EU 321/2013: Commission Regulation concerning the technical specification for interoperability relating to the subsystem 'rolling stock - freight wagons' of the rail system in the European Union and repealing Decision 2006/861/EC • EU 1299/2014: Commission Regulation on the technical specifications for interoperability relating to the 'infrastructure' subsystem of the rail system in the European Union • EU 2019/773: Commission Implementing Regulation on the technical specification for interoperability relating to the operation and traffic management subsystem of the rail system within the European Union and repealing Decision 2012/757/EU • EU 2019/776: Commission Implementing Regulation amending Commission Regulations (EU) No 321/2013, (EU) No 1299/2014, (EU) No 1301/2014, (EU) No 1302/2014, (EU) No 1303/2014 and (EU) 2016/919 and Commission Implementing Decision 2011/665/EU as regards the alignment with Directive (EU) 2016/797 of the European Parliament and of the Council and the implementation of specific objectives set out in Commission Delegated Decision (EU) 2017/1474 • EU/2020/387: Commission Implementing Regulation amending Regulations (EU) No 321/2013, (EU) No 1302/2014 and (EU) 2016/919 as regards the extension of the area of use and transition phases • EU 1304/2014: Commission Regulation on the technical specification for interoperability relating to the subsystem 'rolling stock - noise' amending Decision 2008/232/EC and repealing Decision 2011/229/EU • EU 2019/774: Commission implementing Regulation amending Regulation EU 1304/2014 as regards application of the technical specification for interoperability relating to the subsystem 'rolling stock - noise' to the existing freight wagons • EU 445/2011: Commission Regulation on a system of certification of entities in charge of maintenance for freight wagons and amending Regulation (EC) No 653/2007
CEN	• EN 15551: Railway applications - Railway rolling stock - Buffers, Ed. 2009 + A1, Ed. 2010 • EN 15566: Railway applications - Railway rolling stock - Draw gear and screw coupling, Ed. 2009 + A1, Ed. 2010 • EN 16116-2: Railway applications - Design requirements for steps, handrails, and associated access for staff - Part 2: Freight wagons, Ed. 2013 • EN 12663-1: Railway applications - Structural requirements of railway vehicle bodies - Part 1: Locomotives and passenger rolling stock (and alternative method for freight wagons), Ed. 2010 + A1, Ed. 2010 • EN 12663-2: Railway applications - Structural requirements of railway vehicle bodies - Part 2: Freight wagons, Ed. 2010 • EN 15877-1: Railway applications - Marking on railway vehicles - Part 1: Freight wagons, Ed. 2012 • EN 15273-2: Railway applications - Gauges - Part 2: Rolling stock gauge, Ed. 2013 • EN 15528: Railway applications - Line categories for managing the interface between load limits of vehicles and infrastructure, Ed. 2008 • EN 15437-1: Railway applications - Axle box condition monitoring - Interface and design requirements - Part 1: Track side equipment and rolling stock axle box, Ed. 2009 • EN 14363: Railway applications - Testing and simulation for the acceptance of running characteristics of railway vehicles - Running behaviour and stationary tests, Ed. 2016 • EN 15839: Railway applications - Testing for the acceptance of running characteristics of railway vehicles - Freight wagons - Testing of running safety under longitudinal compressive forces, Ed. 2012 • EN 15687: Railway applications - Testing for the acceptance of running characteristics of freight vehicles with static axle loads higher than 225 kN and up to 250 kN, Ed. 2010 • EN 15827: Railway applications - Requirements for bogies and running gears, Ed. 2011 • EN 16235: Railway applications - Testing for the acceptance of running characteristics of railway vehicles - Freight wagons - Conditions for dispensation of freight wagons with defined characteristics from on-track tests according to EN 14363, Ed. 2013 • EN 13749: Railway applications - Wheelsets and bogies - Method of specifying the structural requirements of bogie frames, Ed. 2011 • EN 13260: Railway applications - Wheelsets and bogies - Wheelsets - Product requirements, Ed. 2009 +A1, Ed. 2010 • EN 13979-1: Railway applications - Wheelsets and bogies - Monobloc wheels - Technical approval procedure - Part 1: Forged and rolled wheels, Ed. 2003+ A1, Ed. 2009 + A2, Ed. 2011 • EN 13262: Railway applications - Wheelsets and bogies - Wheels - Product requirements, Ed. 2004 • EN 13103: Railway applications - Wheelsets and bogies - Part 1: Design method for axles with external journals, Ed. 2009 + A1, Ed. 2010 • EN 12082: Railway applications - Axle boxes - Performance testing, Ed. 2007 + A1, Ed. 2010 • EN 15355: Railway applications - Braking - Distributor valves and distributor-isolating devices, Ed. 2008 +A1, Ed. 2010 • EN 15611: Railway applications - Braking - Relay valves, Ed. 2008 + A1, 2010

	• EN 15624: Railway applications - Braking - Empty-loaded changeover devices, Ed. 2008 + A1, 2010 • EN 15625: Railway applications - Braking - Automatic variable load sensing devices, Ed. 2008 + A1, 2010 • EN 15807: Railway applications - Pneumatic half couplings, Ed. 2011 • EN 286-3: Simple unfired pressure vessels designed to contain air or nitrogen - Part 3: Steel pressure vessels designed for air braking equipment and auxiliary pneumatic equipment for railway rolling stock, Ed. 1994 • EN 286-4: Simple unfired pressure vessels designed to contain air or nitrogen - Part 4: Aluminium alloy pressure vessels designed for air braking equipment and auxiliary pneumatic equipment for railway rolling stock, Ed. 1994 • EN 14601: Railway applications - Straight and angled end cocks for brake pipe and main reservoir pipe, Ed. 2005 + A1, Ed. 2010 • EN 15595: Railway applications - Braking - Wheel slide protection, Ed. 2009 + A1, Ed. 2011 • EN 14531-1: Railway applications - Methods for calculation of stopping and slowing distances and immobilisation braking - Part 1: General algorithms utilising mean value calculation for train sets or single vehicles, Ed. 2015 • EN 14531-6: Railway applications - Methods for calculation of stopping and slowing distances and immobilisation braking - Part 6: step by step calculations for train sets or single vehicles, Ed. 2009 • EN 50125-1: Railway applications - Environmental conditions for equipment - Part 1: rolling stock and onboard equipment, Ed. 2009 • EN 1363-1: Fire resistance tests - Part 1: General requirements, Ed. 2012 • EN13501-1: Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests, Ed. 2007 + A1, Ed. 2009 • EN 50355: Railway applications - Railway rolling stock cables having special fire performance - Guide to use, Ed. 2013 • EN 50343: Railway applications - Rolling stock - Rules for installation of cabling, Ed. 2014 • EN 45545-2: Railway applications - Fire protection on railway vehicles - Part 2: Requirements for fire behaviour of materials and components, Ed. 2015 • EN 45545-7: Railway applications - Fire protection on railway vehicles - Part 7: fire safety requirements on flammable liquid and flammable gas installations, Ed. 2009 • EN 15085 -1: Railway applications - Welding of railway vehicles and components - Part 1: General part, Ed. 2007 + A1: 2013 • EN 15085 -2 to 5: Railway applications - Welding of railway vehicles and components - Part 2: Requirements for welding manufacturer / Part 3: Design requirements / Part 4: Production requirements / Part 5: Inspection, testing and documentation, Ed. 2007
UIC	• IRS 50571-4: Wagons for combined transport - Vertical transhipment - Characteristics • IRS 50571-5: Wagons for combined transport - Roller units for horizontal transhipment - Characteristics • IRS 50596-6: Conditions for coding intermodal loading units in combined transport, combined transport lines and wagons, Ed. 2018 • IRS 50596-7: Railway Application - Rolling Stock - Conformity Assessment - Requirements for bodies performing the certification of coding in accordance with UIC Leaflet 596-6 (Competent Authorities), Ed. 2017 • UIC Leaflet 502-1: Exceptional consignments - Regulations concerning the preparation and management of exceptional consignments, Ed. 2016 • UIC Leaflet 572: Wagons composed of permanently coupled units (multiple wagons) and articulated wagons, Ed. 2011 • UIC Leaflet 430-1: Conditions with which wagons must comply in order to be accepted for transit between standard gauge railways and the Spanish and Portuguese broad-gauge railways, Ed. 2012 • UIC Leaflet 430-3: Freight wagons - Technical conditions for freight wagons capable of running on both standard-gauge and Finnish broad-gauge systems, Ed. 1995 • UIC Leaflet 535-2: Standardisation and positioning on wagons of steps, end platforms, gangways, handrails, tow hooks, automatic coupler (AC), automatic draw-on coupling and brake valve controls on the UIC member RUs and OSJD member RUs, Ed. 2006 • UIC Leaflet 575: Wagons - Label holders (Interchangeability) and hazard identification panels, Ed. 1996 • UIC Leaflet 540: Brakes - Air Brakes for freight trains and passenger trains, Ed. 2006 • UIC Leaflet 541-1: Brakes - Regulations concerning the design of brake components, Ed. 2014 • UIC Leaflet 541-4: Brakes - Composite brake blocks - General conditions for certification and use, Ed. 2010 • UIC Leaflet 542: Brake parts - Interchangeability, Ed. 2015 • UIC Leaflet 544-1: Brakes - Braking performance, Ed. 2014 • Loading Guidelines, Volume 1: Code of practice for the loading and securing of goods on railway wagons - Principles, Ed. 2020 • Loading Guidelines, Volume 2: Code of practice for the loading and securing of goods on railway wagons - Goods, Ed. 2020

Table 6 - Wagons: list of regulations and standards

4.4 Railway Infrastructure

Railway infrastructure is a railway term used to distinguish the two relevant activities in the railway sector, namely the provision of railway services (railway undertakings) and the construction and operation of the necessary facilities (railway infrastructure undertakings), in accordance with the relevant European Regulation & Directives.

The following section will focus on key aspects of the infrastructure such as train paths, performance parameters for freight traffic in the context of the infrastructure TSI and profile gauge for Combined Transport. This part will also provide an inventory of the most relevant standards related to the railway infrastructure.

4.4.1 Train Paths

A train path is the infrastructure capacity (spatial and temporal use of the infrastructure) required to operate a train between two locations over a period of time. A railway operator must purchase a train path from a railway infrastructure company in order to operate a train on its tracks. “Train path” and “time slot” are not synonyms. Train path is the right to access the railway network valid for 24-72 hours depending on conditions, while a Time Slot is fixed for the first 5 minutes of the Train Path, which if missed, will be replaced by travelling on ad hoc time slots as available.

The train paths are offered internationally about 15 months before the annual timetable changes are implemented at scheduling conferences where prior applications for track access are. This takes place on the first Monday in April for the timetable change to begin the following December. Some train paths are reserved for future demand which may be required at short notice if anticipated demand does not materialise. It takes longer if a route must be newly planned and coordinated. Small timetable changes can be made at meetings held every six months. With implementation after three months. If there are no suitable paths due to capacity constraints the application has to wait until the next timetable conference.

The annual timetabling regime described above has been in use in Europe ever since the end of World War II. The railway sector, having understood that this form of timetabling does not correspond to the accelerated needs for the rail transport sector to react to market demand, is presently developing a new method of timetabling under its redesign for the International Timetabling Process (TTR) project (http://rne.eu/sales-timetabling/ttr/).

4.4.2 Performance parameters for freight traffic

The Commission Regulation 1299/2014 (Infrastructure TSI) covers two aspects of the railway infrastructure: (1) the infrastructure structural subsystem such as line layout, track parameters, switches and crossings, platforms, track resistance to applied loads, structures resistance to traffic loads, immediate action limits on track geometry defects,… and (2) the part of the maintenance functional subsystem relating to the infrastructure subsystem such as plants for external cleaning of trains, water restocking, refuelling, fixed installations for toilet discharge and electrical shore supplies. This TSI applies to all new, upgraded, or renewed infrastructure.

Lines shall be classified based on the type of traffic (traffic code) characterised by the following performance parameters: — structure gauge, — axle load, — line speed, — train length, — usable length of platform. Table 7 consolidates the performance parameters for freight traffic. The performance parameters “structure gauge” and “axle load” are considered as “Hard” parameters; it means that it is mandatory to provide at least their precise value. The performance parameters “line speed”, “usable length of platform” and “train length” are considered as “Soft” parameters; that means that values of these parameters for specific line may be selected from the range/value given in the table.

Infrastructure performance parameters for freight traffic

(route compatibility checks are subject to point 4.2.2.5 and Appendix D.1 of TSI OPE)

Traffic code	Structure gauge	Axle load [t]	Line speed [km/h]	Train length [m]
F1	GC	22,5 (1)	100-120	740-1 050
F2	GB	22,5 (1)	100-120	600-1 050
F3	GA	20 (1)	60-100	500-1 050
F4	G1	18 (1)	n.a.	n.a.
F1520	S	25 (1)	50-120	1 050
F1600	IRL1	22,5 (1)	50-100	150-450

(1) To be used for static checks of infrastructure, based on design mass in working order for power heads and locomotives and design mass under normal payload for other vehicles (mass definitions in accordance with the specification referenced in Appendix T Index [1]). This axle load may be linked to limited speed.

Table 7 - TSI Infrastructure: performance parameters for freight traffic

The Commission Implementing Regulation (EU) 2019/777 sets the common specifications for the register of railway infrastructure (RINF) that has to be maintained by ERA. Table 7 contains all items that should be integrated into the application. More than 100 parameters have been identified covering aspects such as performance parameter, tracks, switches and crossings, tunnels, and operational points. The performance parameter ‘train length’ applies to freight traffic because the train length determines the minimum length of a siding to be provided.

RINF is the common platform (https://rinf.era.europa.eu/rinf/) where railway stakeholders such as railway undertakings, intermodal operators, terminal managers, manufacturers, wagon keepers, etc. can consult 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 a web-based user interface and is accessible from any computer with an internet browser and network accessibility.

Today the primary objective of RINF is to support the process of assessing the route compatibility between the rolling stock and the route. For intermodal transport, 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.

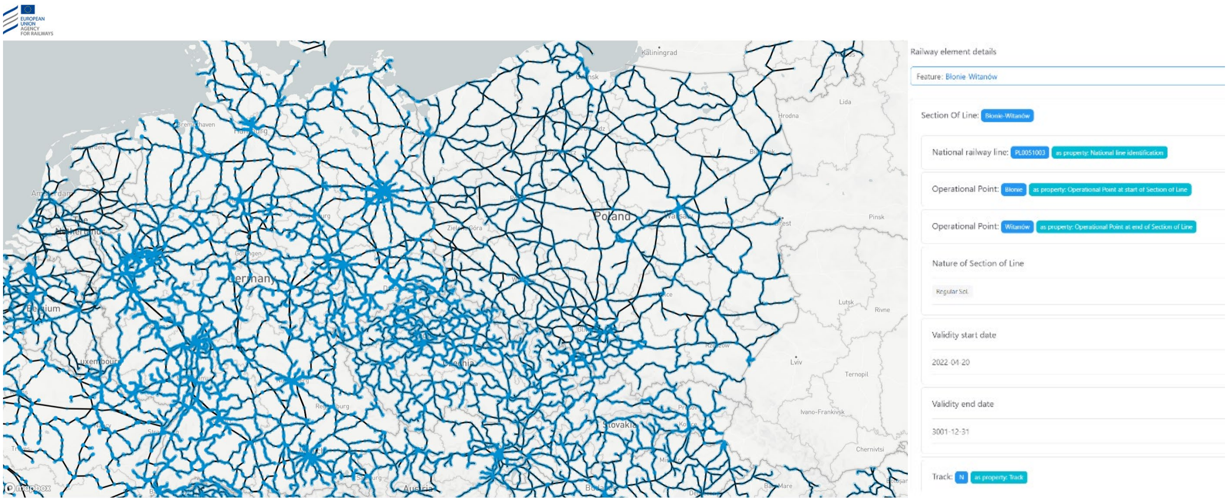


Figure 18 - RINF application (map view)

4.4.3 Profile gauge for Combined Transport

The organisation of combined transport requires the verification and check of at least the following elements:

- Compatibility between ILUs and wagons.
- Compatibility of ILUs loaded on compatible wagons with the Combined Transport Profile of the relevant routes.

To facilitate the verification of the compatibility of ILUs loaded on suitable wagons and the route, IMs provide the Combined Transport Profile numbers allocated to the lines in accordance with IRS 50596-6.

The codification of a combined transport line corresponds to the maximum loading heights per type of ILU when loaded on the reference wagon in the clear gauge on that line. The Combined Transport Profile represents a complete closed envelope with a specified shape and dimensions which a given ILU loaded on a carrier wagon shall not exceed.

Two types of Combined Transport Profiles have been defined:

- Normal profiles, identified by a 2- or 3-digit number preceded by the letter C and P
    - **2-digit profile numbers** (00 to 99) apply to ILUs with a width of 2,550 mm or less (2,500 mm for semi-trailers). These numbers indicate the height deviations in centimetres of the side or profile face of the ILU from a reference ILU (code 00), loaded on its reference wagon, whose loading plane height is 1,175 mm above the reference plane (the height of the loading plane for fixed-pocket wagons is 330 mm above the running surface).

  - **3-digit profile numbers** (330 to 429) apply to ILUs with a width greater than 2,550 mm and less than or equal to 2,600 mm (between 2,500 mm and 2,600 mm for semi-trailers). These numbers indicate the total height in centimetres of the top angle of the side face of the ILU loaded on its reference wagon, in relation to the reference plane.
- Special profiles, identified by a 2- or 3-digit number preceded by the letter S. This is a profile created specifically for the traffic from/to UK.

UIRR, as the voice of intermodal freight transport, has designed a map compiling the profile numbers of the main European routes for semi-trailers and swap-bodies (see Figure 19).

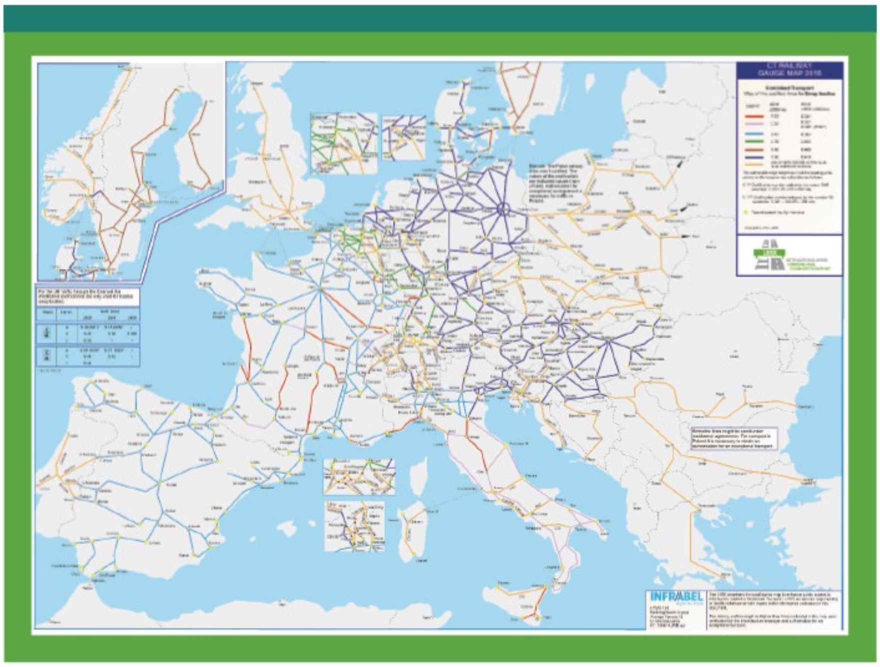


Figure 19 - UIRR map of codified lines

4.4.4 Relevant standards

The following table provides an overview of the regulations, standards and guidelines that are to be considered when designing, testing, and operating a railway infrastructure in Europe.

Entity	Inventory
European Legal Framework	• EU 321/2013: Commission Regulation concerning the technical specification for interoperability relating to the subsystem 'rolling stock - freight wagons' of the rail system in the European Union and repealing Decision 2006/861/EC • EU 1299/2014: Commission Regulation on the technical specifications for interoperability relating to the 'infrastructure' subsystem of the rail system in the European Union • EU 2019/773: Commission Implementing Regulation on the technical specification for interoperability relating to the operation and traffic management subsystem of the rail system within the European Union and repealing Decision 2012/757/EU • EU 2019/776: Commission Implementing Regulation amending Commission Regulations (EU) No 321/2013, (EU) No 1299/2014, (EU) No 1301/2014, (EU) No 1302/2014, (EU) No 1303/2014 and (EU) 2016/919 and Commission Implementing Decision 2011/665/EU as regards the alignment with Directive (EU) 2016/797 of the European Parliament and of the Council and the implementation of specific objectives set out in Commission Delegated Decision (EU) 2017/1474 • EU 2019/777: Commission implementing Regulation on the common specifications for the register of railway infrastructure and repealing Implementing Decision 2014/880/EU • EU/2020/387: Commission Implementing Regulation amending Regulations (EU) No 321/2013, EU) No 1302/2014 and (EU) 2016/919 as regards the extension of the area of use and transition phases
CEN	• EN 15273-3: Railway applications - Gauges - Part 3: Structure gauges, Ed. 2013
UIC	• IRS 50571-4: Wagons for combined transport - Vertical transhipment - Characteristics • IRS 50571-5: Wagons for combined transport - Roller units for horizontal transhipment - Characteristics • IRS 50596-6: Conditions for coding intermodal loading units in combined transport, combined transport lines and wagons, Ed. 2018 • IRS 50596-7: Railway application - Rolling stock - Conformity assessment - Requirements for bodies performing the certification of coding in accordance with UIC Leaflet 596-6 (Competent Authorities), Ed. 2017

Table 8 – Infrastructure: standards

5 Typology of intermodal assets

5.1 Intermodal Loading Units (ILUs)

An Intermodal Loading Unit (ILU), also known as an Intermodal Transport Unit (ITU), refers to a standardised container or transport unit used in intermodal transportation (see previous sections). These units can include ISO maritime containers, swap bodies, or semi-trailers. They are designed to facilitate the seamless transfer of goods between different modes of transportation, such as ships, trains, and trucks, without the need to unload and reload cargo. ILUs play a crucial role in optimising logistics efficiency and reducing handling costs in global supply chains.

5.1.1 Containers

ISO containers are renowned for their strength and versatility, being stackable and widely used in international trade. The most common sizes are the 20-foot and 40-foot-long units, which dominate deep-sea vessels. Containers are often measured in multiples of 20 feet, known as Twenty-foot Equivalent Units (TEU), with a standard height of 8 feet 6 inches. However, high cube containers, measuring 9 feet 6 inches in height, are increasingly popular for their extra volume capacity within weight limits. Standard width in the EU is 8 feet, although 8 feet 2 inches, also known as pallet-wide width, is also common as it aligns with semi-trailer load capacities. The maximum gross mass for a 20-foot container is 30,480 kg, and for a 40-foot container, it is 34,000 kg. The tare weight, or empty weight, is 2,800 kg for a 20-foot container and 3,900 kg for a 40-foot container. Intra-European shipments frequently utilise 45-foot containers, which are available in both standard height and high cube variants.

Refrigerated containers, commonly known as reefers, are specially designed for transporting temperature-sensitive goods like fresh produce. Unlike traditional refrigerated holds that rely on a ship's continuous power supply, reefers have their own cooling systems, providing greater flexibility. However, to maintain the desired temperature during transit, reefers need to be plugged into a power source while on the ship, truck, train, or at the quay. This ensures the preservation of perishable goods throughout the journey, maintaining their quality and freshness until they reach their destination.

Open-top containers have no roof. They are primarily utilised for transporting bulky or oversized goods and general cargo that cannot be loaded through the end doors but instead need to be loaded from the top. This design facilitates the loading and unloading of goods that exceed the dimensions of standard containers or require overhead crane access. Open-top containers offer versatility for handling a wide range of cargo types, including machinery, construction materials, and other large items that cannot fit within the confines of traditional closed containers.

Flat containers, distinguished by their lack of roof and walls, are commonly utilised for transporting general cargo, mechanical goods, and vehicles. This design facilitates the loading and unloading process, particularly for items that may not fit within the standard profile of closed containers. Mechanical goods and vehicles, such as machinery or automobiles, are often transported in flat containers due to their irregular shapes or sizes. These containers offer a convenient and efficient solution for shipping a wide range of goods that require easy access and flexible loading configurations.

Tank containers consist of a tank enclosed within a steel frame, conforming to standard container dimensions for simplified handling. They are specifically designed for transporting liquids and gases, offering a secure and efficient solution for such cargo. Tank containers are widely utilised in various industries to transport a diverse range of substances, including chemicals, fuels, foodstuffs, and hazardous materials. Their standardised dimensions and robust construction ensure compatibility with common transportation modes, such as ships, trains, and trucks, making them an essential component of global logistics operations for liquid and gas shipments.

Foldable containers, also referred to as collapsible containers or foldable intermodal containers, are innovative shipping containers designed to collapse for space-saving storage and transportation when empty or not in use. These containers feature collapsible walls and/or floors that can be folded inward, allowing them to be stacked more compactly or nested within each other, thus optimising storage space. Foldable containers offer several benefits, including reduced storage footprint when not in use, and improved operational efficiency in container handling and storage facilities. Foldable containers are so far substantially more expensive than regular containers (most of the time approaching €4000 compared with €2000).

5.1.2Swap-bodies

Swap bodies can transition between road and rail vehicles but lack the strength for stacking or use on sea transport. They may feature fully rigid or curtain-sided designs for side loading and often share external dimensions with general-purpose containers, incorporating folding legs beneath the frame. Unlike containers, they are more fragile and require specialised techniques for lifting from below rather than above. Swap bodies offer advantages such as easier connection to truck tractions due to their ground-level positioning with legs.

Additionally, they have a lower tare weight compared to containers, enabling them to accommodate heavier cargo. Swap-bodies can be designed to open from the sides (curtain-sided unit) or in any other configuration that is best suited for the transport purpose (see figure 20).

Figure 20 - Swap-Body

5.1.3Semi-trailers

5.1.3.1 Vehicle configuration

Standard semi-trailer configuration, also known as articulated lorry of truck, is the combination of a standard-size semi-trailer measuring 13,6 meters in length, and a tractor. Unlike a rigid vehicle, a semi-trailer can be separated from its chassis and can rest on foldable legs when uncoupled with a tractor.

Figure 21 - Semi-trailer

They can be designed to be craneable, meaning that the sides of the trailer are reinforced and designed to be gripped by a crane, making them therefore eligible to vertical and horizontal transhipment techniques. Craneable semi-trailers are often distinguished by yellow marking as illustrated in Figure 21. When semi-trailers are not designed to be craneable, as is the case of a majority of the European fleet, they can only be eligible for horizontal transhipment technique.

Road trains are semi-trailers with two or more trailer units connected to a single road tractor unit that can't measure over 13,6 in length. They are only compatible with intermodal transport in Rola techniques or when all units used in this configuration are craneable.

5.1.3.2 Trailer type

The box trailer, also known as van trailer, is the most common type of trailer and features a fully enclosed rectangular cargo area. It provides protection from the elements and is versatile for transporting various types of goods.

Curtain Sider, also known as a curtainside trailer, are equipped with curtains instead of solid sides. The curtains can be easily opened from the sides, allowing for quick and convenient loading, and unloading of goods, especially when using forklifts (see Figure 22).

Reefer trailers, or refrigerator truck, are equipped with a heating or cooling unit to maintain a controlled temperature inside the cargo area. They are used for transporting perishable goods such as fruits, vegetables, dairy products, and pharmaceuticals that require specific temperature conditions to prevent spoilage.

Figure 22 - Semi-trailer Curtain Sider

Dry bulk trailers are used for transporting dry, free-flowing materials in bulk quantities, such as sugar, flour, grains, cement, or plastic pellets. They feature a large, open-top cargo area.

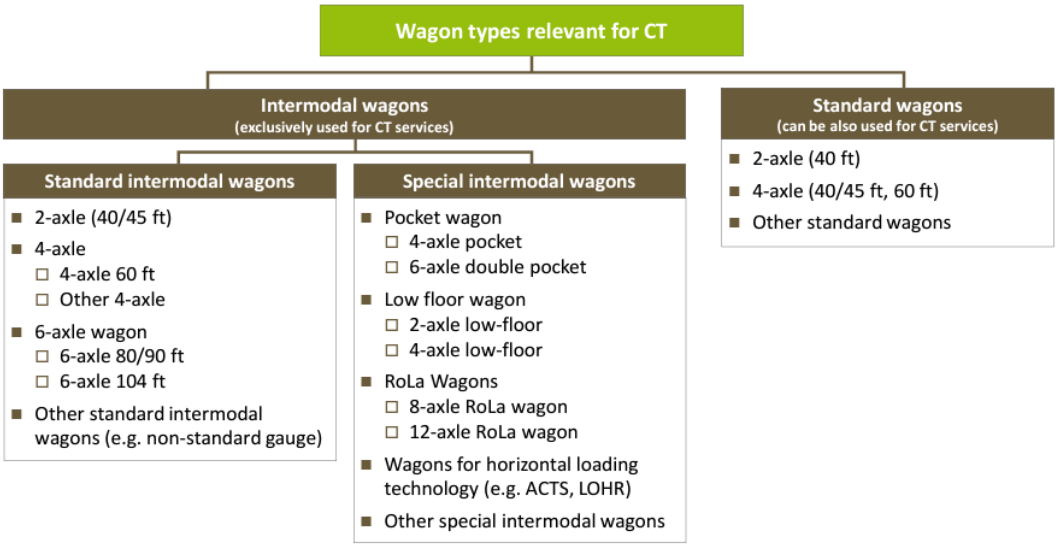
Tanker trailers are specially designed to transport liquids such as gasoline, milk, chemicals, or liquefied gases. They feature a cylindrical tank with reinforced walls and are sealed to prevent leaks or spills during transportation.

Double-deckers trailers feature an integrated second floor, effectively doubling the cargo space compared to single-deck trailers. They are commonly used for transporting lightweight goods or items that can be stacked, such as parcels, boxes, or palletised goods (see Figure 22).

Mega trailers, also known as mega semi-trailers, are a type of large cargo trailer used in the transportation industry. They are characterised by their increased height compared to standard trailers (3 meters). While the dimensions can vary slightly depending on regulations and regional standards, mega trailers typically have an internal height ranging from around 3 meters (10 feet) to over 4 meters (13 feet), significantly taller than traditional trailers.

5.2 Wagons

A train wagon is a vehicle designed to carry goods and can vary greatly in size and configuration depending on the type of cargo being transported (see Figure 23). Train wagons can be attached to one another to form a train, which is propelled along the railway tracks by a locomotive. They play a crucial role in the efficient movement of goods over long distances, offering a reliable and environmentally friendly alternative to other forms of transportation.



Source: BSL Transportation.

Figure 23 - Wagon types

5.2.1 Standard wagons

Flat wagons are the most common type of rail wagon used for intermodal transport. They feature a flat, level surface without any sides or ends, providing a stable platform for carrying containers, trailers, or other cargo. Flat wagons come in various lengths and configurations to accommodate different types of road vehicles.

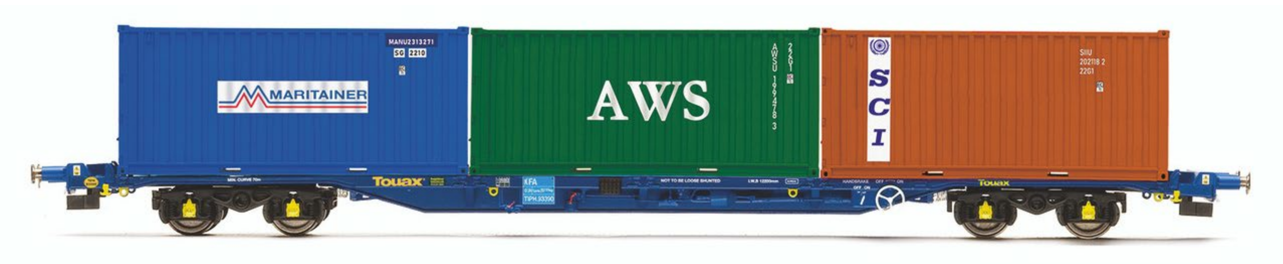


Figure 24 - Flat wagon for containers

Pocket wagons are specialised rail wagons designed for transporting intermodal containers. They have recesses or pockets where containers can securely fit. These wagons enhance stability and security during transit and streamline loading and unloading operations.

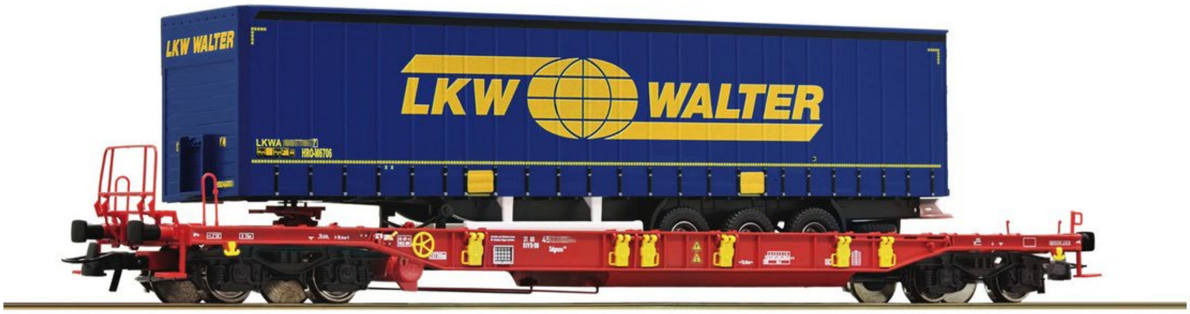


Figure 25 - Pocket wagons for semi-trailers

5.2.2 Special wagons

Low-floor wagons are specially designed to accommodate the loading and transportation of trucks and trailers onto freight trains. These wagons have a lower floor height compared to traditional freight wagons, allowing trucks and trailers to be driven or rolled onto the train more easily (see Figure 24).

Figure 26 - Low-floor wagons

Modalohr refers to a specific type of intermodal transport system used for carrying semi-trailers or road vehicles on rail wagons. The Modalohr system involves the horizontal loading of semi-trailers onto special rail wagons equipped with a pivoting platform. Modalohr wagons are placed in a special track that allows trucks to roll on it at ground level. The tractor can then be uncoupled to the trailer, allowing the latter to pivot freely for it to align with the train. (see Figure 27).

Figure 27 - Modalohr system

Flexiwagon wagons pivot entirely to deploy a ramp that allow complete vehicle (incl. tractor) to roll on it. No infrastructure is needed for the operation as unloading is also possible without a terminal (see Figure 28).

Figure 28 - Flexiwagon

CargoBeamer wagons feature tub-shaped wagon attachments for trains. The unit is delivered by truck onto the waiting attachment, while tank-shaped attachments are grabbed and lifted by a crane onto the wagon. Once loaded, the wagon's side walls close automatically, securing the cargo for transportation.

6 Inventory of transshipment technologies

The transshipment of intermodal loading units takes place in terminals and is a central component within CT chains. Transshipment systems are used to transfer all types of ILUs (see chapter for detailed inventory) 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):

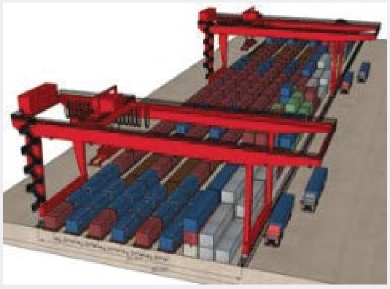
- With **vertical transshipment**, CT load units are lifted and reloaded from or onto different modes of transport using a lifting system and may be stacked for intermediate storage. This type of handling is standard equipment in many European terminals and has proven itself as almost all ILUs might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

6.1 Vertical transshipment technologies

This section presents the current state-of-the art of the most often used vertical transshipment technologies in Europe. Each technology is described and classified according to the market segment and to the types of intermodal loading units.

6.1.1 Cranes

Rail Mounted Gantry cranes (RMGs)	
Classification	**Description**
Semi-trailers ☒ Craneable ☐ Non craneable Containers /Swap Bodies ☒ Maritime ☒ Continental	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 transhipment between trains as well as for managing blocks. They usually span several tracks. In addition, RMGs with longer overhangs on one side permit transhipment 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.

Market Segment
☒ maritime CT ☒ continental CT
Sources
1. https://www.liebherr.com/en/int/products/maritime-cranes/port-equipment/rail-mounted-stacking-cranes/rail-mounted-gantry-cranes.html 2. https://www.konecranes.com/port-equipment-services/container-handling-equipment/rail-mounted-gantry-cranes 3. https://www.youtube.com/watch?v=0UdMStGoJ2U
Illustration
 

Rubber-Tyred Gantry cranes (RTGs)	
Classification	**Description**
Semi-trailers ☒ Craneable ☐ Non craneable Containers /Swap Bodies ☒ Maritime ☒ Continental	Rubber Tyred Gantry Crane (RTG) is similar to a RMG with rubber tyres 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 90º, 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.
Market Segment	
☒ maritime CT ☒ continental CT	
Sources	
1. https://www.konecranes.com/port-equipment-services/container-handling-equipment/rubber-tired-gantry-cranes 2. https://www.youtube.com/watch?v=j9_UHiMhzQs	
Illustration	


Ship to Shore cranes (STS)

Classification	Description
Semi-trailers ☐ Craneable ☐ Non craneable Containers /Swap Bodies ☒ Maritime ☐ Continental	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

Market Segment

☒ maritime CT ☐ continental CT

Sources

1. https://www.youtube.com/watch?v=GZQPxl9zssk
2. https://www.liebherr.com/en/int/products/maritime-cranes/port-equipment/container-bridges/ship-to-shore-container-cranes.html

Illustration


6.1.2 Reachstackers (or mobile cranes)

Reachstackers (or 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. 100t 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	
Sources	
https://www.youtube.com/watch?v=kpY_PSkySwc	
Illustration	

6.1.3 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
Sources
1. https://www.kclifttrucks.com/products/forklifts-10-65-tonnes 2. https://www.sanyglobal.com/product/port_machinery/forklift_truck/
Illustration
 

6.1.4 Straddle carriers

Straddle carriers	
Classification	**Description**
Semi-trailers ☒ Craneable ☐ Non craneable Containers /Swap Bodies ☒ Maritime ☒ Continental	These are rubber tyred 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.
Market Segment	
☒ maritime CT ☒ continental CT	
Sources	
1. https://www.konecranes.com/port-equipment-services/container-handling-equipment/straddle-carriers 2. https://www.youtube.com/watch?v=jn34FHktKpA	
Illustration	

6.1.5 Master 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	
Sources	
1. https://www.kalmarglobal.com/equipment-services/masted-container-handlers/empty-container-handler-DCG80/ 2. https://www.svetruck.se/en/container-handlers/ 3. https://www.youtube.com/watch?v=OC3PKIPT31M	
Illustration	


6.1.6 NiKRASA

NiKRASA	
Classification	**Description**
Semi-trailers ☐ Craneable ☒ Non craneable Containers /Swap Bodies ☐ Maritime ☐ Continental	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 semi-trailer 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.
Market Segment	
☐ maritime CT ☒ continental CT	
Sources	
(1) https://www.txlogistik.eu/en/services/nikrasa-2/ (2) https://youtu.be/yJ3XD_AFhQw	
Illustration	


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.

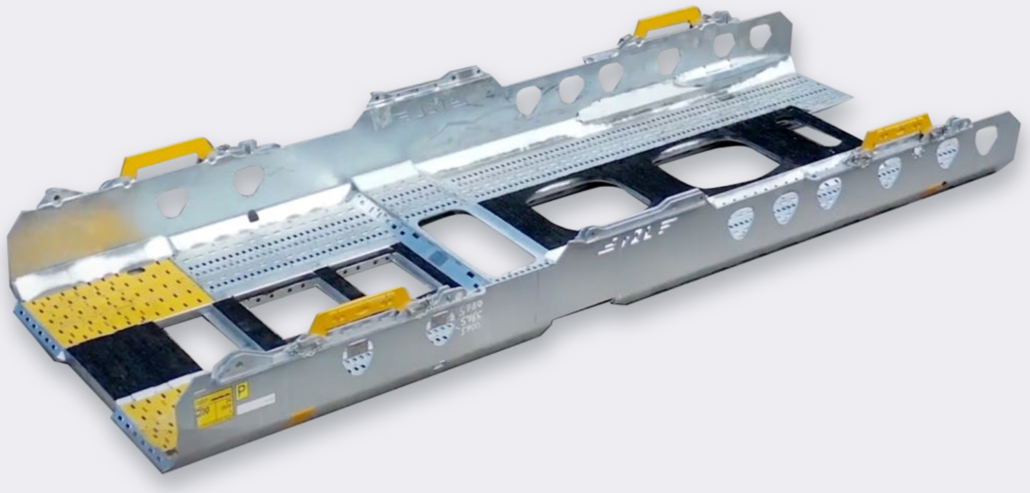

...onto a pocket wagon.
The terminal platform remains at the loading point, while the transport platform goes with the semitrailer on its journey by rail.

6.1.7 ISU

ISU Innovativer Sattelauflieger Umschlag	
Classification	**Description**
Semi-trailers ☐ Craneable ☒ Non craneable Containers /Swap Bodies ☐ Maritime ☐ Continental	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.
Market Segment	
☐ maritime CT ☒ continental CT	
Sources	
(1) https://blog.railcargo.com/en/artikel/lkw-chassis-huckepack-auf-schiene (2) https://www.youtube.com/watch?v=a_83Z7SH5RU&t=87s	
Illustration	
	

6.1.8 Vega

r2l 2.0 road rail link (VEGA)	
Classification	**Description**
Semi-trailers ☐ Craneable ☒ Non craneable Containers /Swap Bodies ☐ Maritime ☐ Continental	Developed by VTG in collaboration with its partner VEGA International, this horizontal transshipment and transport technology is made for the loading of non-craneable semi-trailers on all types of pocket wagons. This is accomplished with a fully galvanised solution: a platform or ramp that terminal cranes and reach stackers can lift vertically onto and off double pocket wagons.

Market Segment
☐ maritime CT ☒ continental CT
Sources
(1) https://www.vtg.com/news-and-insights/stories/combined-transport-made-easy (2) https://www.youtube.com/watch?v=tIYKWuABVjA&t=6s
Illustration


6.2 Horizontal transshipment technologies

This section presents the current state-of-the art of the most often used horizontal transshipment technologies in Europe. 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.

Longitudinal	Parallel	Diagonal
Rolling Motorway (RoLa)	CargoBeamer	Modalohr
Roll-on Roll-off (RoRo)		MegaSwingTM Duo

Table 9 - Horizontal handling according to the type of movement

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 (see table 9).

6.2.1 RoLa

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 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 semitrailer 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). 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).

Figure 29 - RoLa at the Brennersee Terminal

6.2.2 CargoBeamer

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. More information can be found under https://www.cargobeamer.com/technology.

Figure 30 - The CargoBeamer system

6.2.3 Modalohr / Lohr

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. More on information on the Lohr website: https://www.lohr.fr/catalogue/the-lohr-system/

Figure 31 - The Lohr horizontal system

6.2.4 Helrom

The Helrom wagon is a proprietary rail wagon and terminal technology designed specifically for European trailers. While legacy technology wagons require lifting of the trailers into the pockets of the wagons, the Helrom wagon opens and closes horizontally to load and unload. For that reason, the Helrom technology allows us to transport all standard trailers by rail. The system can be visualised here https://vimeo.com/451156213.

Figure 32 - The Helrom technology

7 Digitalisation in the intermodal ecosystem

The concepts of ‘digitisation’ and ‘digitalisation’ are currently often (mis)used and misunderstood. Whereas ‘digitisation’ is the process of converting information into a digital computer-readable format, digitalisation means the use of digital technologies to change processes and provide new revenues and value-producing opportunities through enhanced products and services.

Successful digital transformations require the active involvement and intense engagement of multiple stakeholders in a cooperative and at the same time competitive environment. Effective digitalisation can help to increase integration, utilisation, and cost efficiency of all transport modes by generating smart data, optimise and monitor the flow of goods and information.

This section is split into two parts. The first one provides a (non-exhaustive) description of current existing collaborative digital platforms bringing together stakeholders aiming at improving the exchange of accurate and real-time data useful for optimising the intermodal operations. The second one describes the main data exchange formats used in intermodal freight transport with a particular focus on railway.

7.1 Collaborative Digital Platforms

7.1.1 LSP customer-oriented platform: Transporeon

Transporeon originated as a start-up of university graduates from the University of Ulm more than 20 years ago. They are growing globally (organically and via 3 acquisitions) and recently the majority was bought by a US shareholder.

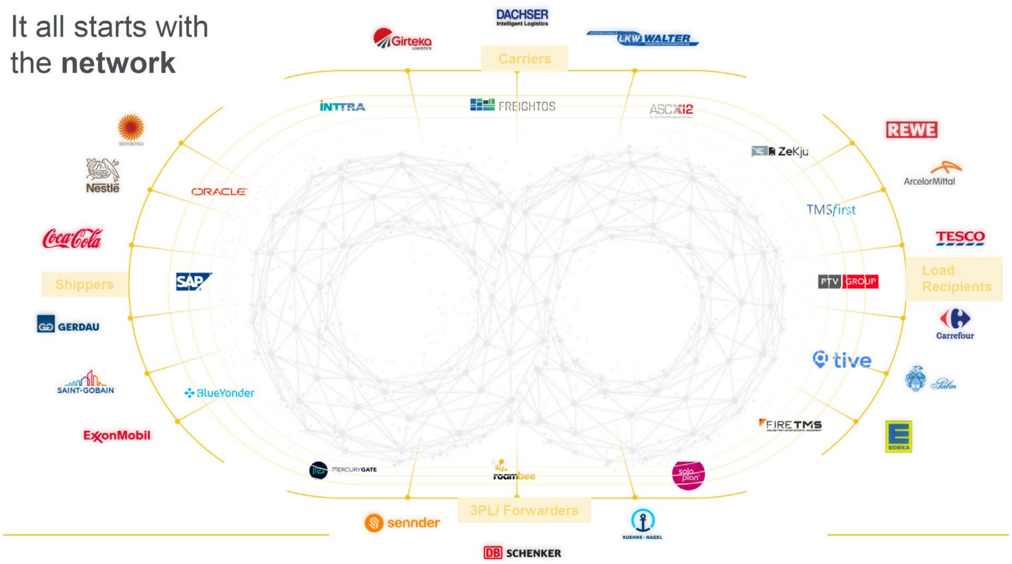


Figure 33 - Transporeon’s platform

Transporeon is a SaaS-based transport management solution with a focus area on LSP and shippers (manufacturers, retailers). They aim for a high interoperability with other service providers (see figure 33) to offer a rich access to information, transactions, and reporting capabilities for their customers.

7.1.2 Customer-oriented: 4PL Intermodal - Imslot

The company was founded in 2018 to bridge the gap between the stakeholders of road-rail and short sea and hinterland connectivity.

Figure 34 - 4PL intermodal customer foucs

4PL Intermodal can cover shippers with assets in intermodal rail, road, and barge transports. Forwarders, deep sea shipping lines and shippers as well as container depots, CTOs for inland and sea are part of the possible networks. They manage several processes focusing on supply chain visibility and free capacity matching to foster a shift to rail or waterways.

7.1.3 CESAR-NEXT

CESAR-NEXT (www.cesar-next.com) is a virtual collaborative platform for combined transport and is one of the largest community platforms with more than 1,400 active users. CESAR-NEXT provides its users (LSPs, freight forwarders) with the most up-to-date information on their consignments. Several operators come together as one virtual company with a single address where customers can obtain detailed information on the status of their consignments, wherever they are.

Figure 35 - The CESAR-Next system

CESAR-NEXT is mainly a powerful tracking & tracing tool providing the following transport status information: (1) booked, (2) delivered in departure terminal, (3) loaded on wagon, (4) departed from departure terminal, (5) forecast unit pick-up at destination terminal, (6) Ready for pick-up in arrival terminal, (7) pick-up completed in arrival terminal, and (8) arrived for gateway in intermediary terminal.

The company CIS ensures the functioning of the CESAR-NEXT system with the latest state-of-the-art technologies, implements new features for the CESAR-NEXT user community and connects new customers and operators. CESAR-NEXT is supported by six major intermodal operators.

7.1.4 LSP-CT oriented: KV4.0 operated by DXI

The company DX intermodal GmbH (https://www.dx-intermodal.com/) was founded after the completion of the KV4.0 project financed by the German Ministry of innovation. The shareholders are the project partners representing LSPs, CTOs, RUs and TOs from Germany and Switzerland.

Figure 36 - Main features of KV4.0

The KV4.0 data hub offers the interconnection between CT Operators, Terminals, LSPs and RUs (see Figure 33). The focus is on enabling the connectivity by providing conversion between standards (e.g. TAF TSI to EDIGES) and message exchange between legitimate partners of a transport via a software-as-a-service platform.

7.1.5 LSP-CTO oriented: Modility

Modility (https://www.modility.com/) is a start-up developed and financed by the transport and warehousing provider HHLA and 11 LSPs (Germany). It was founded in 2019 by Hendrik-Emmanuel Eichentopf and went live in August 2021.

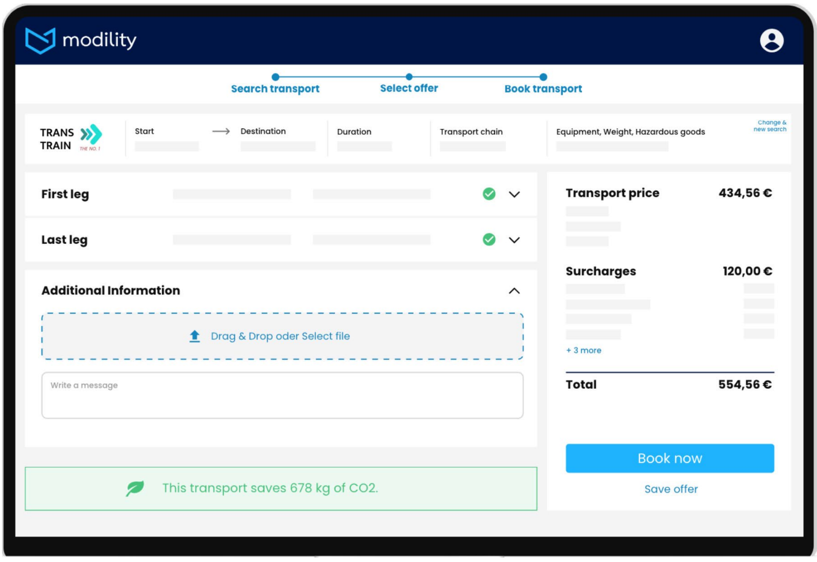


Figure 37 - Modility (booking)

Modility focuses on the matching process to attract more volume to be shipped via CT and rail. Integration of the deep sea and inland seaports with the road and rail-road stakeholders is core of Modility's combined transport booking offering. Figure 35 provides a schematic overview of a booking option via the Modility platform and the cost as well as CO_2 impact.

7.1.6 Catkin

Catkin GmbH focuses on the seamless communication between humans and machines. Catkin's platform solution allows that all information is maintained centrally and shared with the relevant stakeholders and their authorised representatives to process business orders and to allow their tracking and tracing.

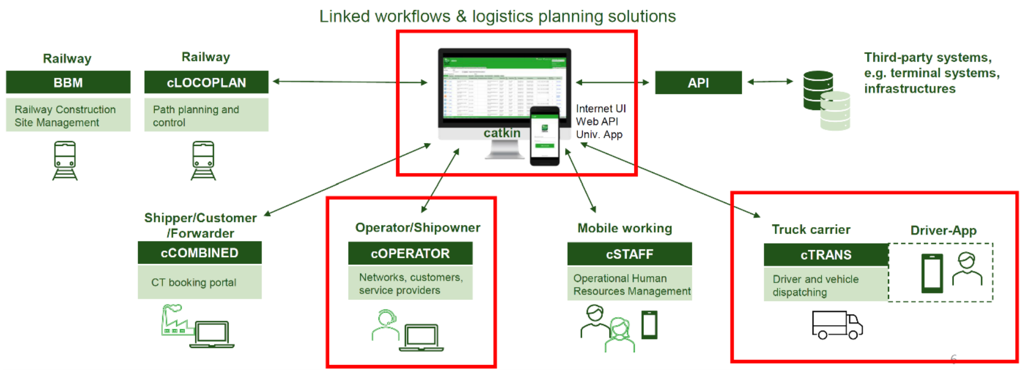


Figure 38 - Catkin functional overview

Intermodal supply chains and inter-organisational processes can be configured to foster the information exchange (see Figure 36). The key focus area is the ordering of rail or combined transport shipments originating from port terminals and status feedback but not limited to.

7.1.7 Multi-stakeholder oriented: Rail-Flow

Rail-Flow (http://www.rail-flow.com/) was founded in 2020 by Dominik Fürste and Osman Akdemir with the focus on intermodal capacity brokering. The solution developed from a match making and ordering towards a supply chain visibility and partial transaction platform in 2023 for several CT stakeholders.

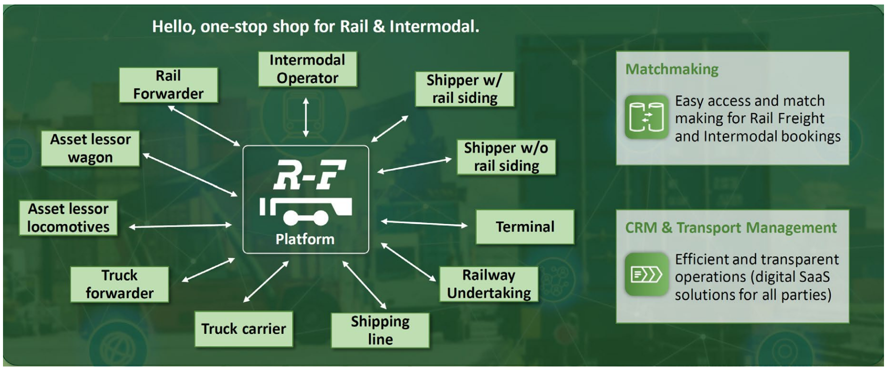


Figure 39 - RailFlow multi-stakeholder application

The solution developed from a match making and ordering towards a supply chain visibility and partial transaction platform (Transport Management System) in 2023 for several CT stakeholders. Rail-Flow's solution is delivered and hosted by Rail-Flow to provide the visibility and transaction functionality (e.g. ordering) for different stakeholders.

7.1.8 IM-oriented: RNE TIS

The TIS (Train Information System - https://rne.eu/it/rne-applications/tis/) is the central offering of RailNetEurope (RNE) – Association for facilitating traffic on European rail infrastructure - with respect to railway tracking and tracing information from IMs towards RUs. The purpose of TIS is to "monitor international trains from origin to destination on the involved IMs' networks. It serves as information source for international performance reports and quality analysis and standardises the exchange of data between different players.

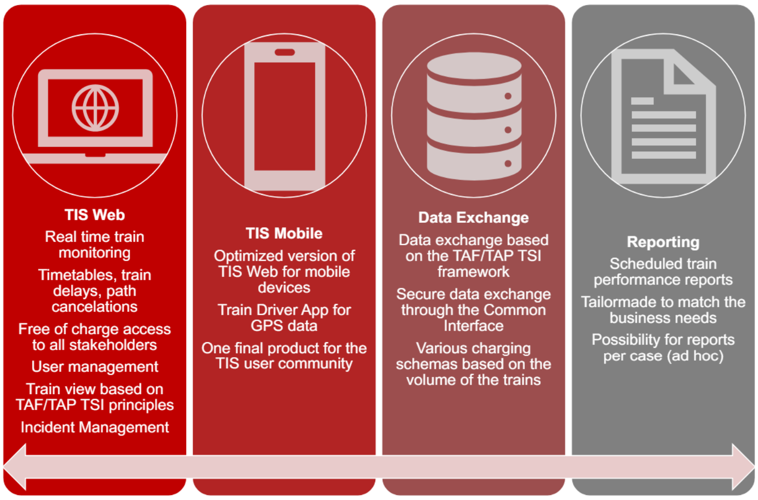


Figure 40 - RNE TIS services

TIS also allows the identification of problems due to different national processes (for international trains) and triggers appropriate corrective actions. The relevant data is obtained directly from the Infrastructure Managers' systems.

7.2 Data exchange formats

Data Exchange Formats are standardised means of structuring and transferring data between systems. They play a crucial role in modern software development, allowing for interoperability and seamless integration across diverse platforms and programming environments.

In this section, we will detail the two main standard formats that are currently available and used in a road-rail intermodal combination. The first one - TAF TSI - is an EU Regulation on a data exchange obligation imposed on the IMs and RUs whereas the second one – EDIGES – is an industry-based standard coordinated by UIRR- the voice of the intermodal freight transport in Europe.

7.2.1 TAF TSI

The Technical Specification for Interoperability related to Telematic Applications for the Freight Subsystem of the Rail System in the European Union (TAF TSI), aims to set a framework for the efficient interchange of information between IMs and RUs. The underlying concept of the TAF TSI specifications is that all service providers must work together through efficient exchange of communications, cooperation, and open access in order to provide a seamless freight transportation service.

The TAF TSI, defines the IM as the provider for the allocation and reporting of paths, and the controlling and monitoring of trains. The RU is the provider for operating trains and managing fleets. The TAF TSI also defines the Lead Railway Undertaking (LRU) as the provider that takes into account the costumer's request, defines the transport service and coordinates with additional RUs that might be involved in the transport chain.

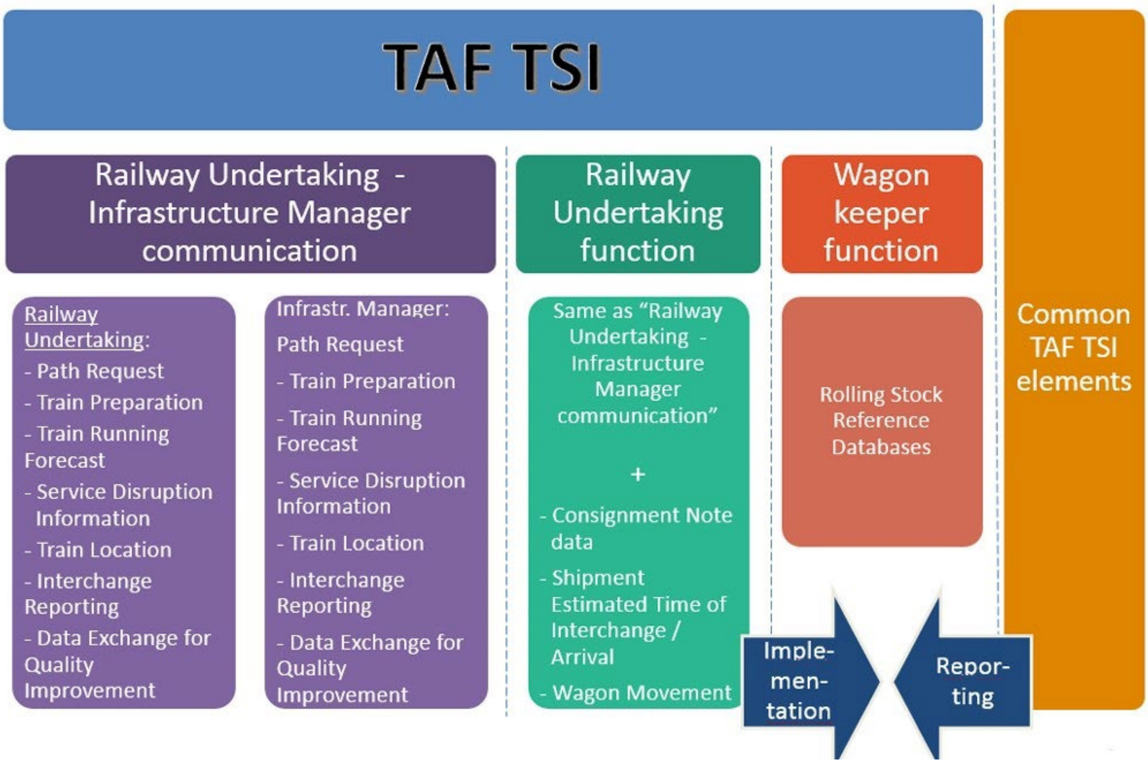


Figure 41 - TAF TSI functions

The information flow needed for a freight transportation service considered in the specifications include the consignment orders made by the client to the LRU, the train path definition between IMs and RUs (Path Request), the train preparation (i.e., to communicate the train composition or when the train is ready) the train running information, eventual service interruption information, the ETA, and the wagon movements, among others.

The main TAF TSI message types that are of relevance for the intermodal ecosystem are: (1) Path Detail Messages (PDM), (2) Path Section Notification Messages (PSN), (3) Train Running Information Messages (TRI), (4) Train Running Forecast Messages (TRF), (5) Train Running Interruption Messages (TRIM), (6) Train Composition Messages (TCM) and (7) Wagon Performance Messages (WPM).

7.2.2 EDIGES

Under the coordination of the industry association UIRR, Combined Transport Operators, members of UIRR, have created the UIRR data message to facilitate their digital exchange of train information. A standardised data message structure and harmonised codes have been commonly developed and used since more than 20 years.

In recent years, Combined Transport's requirements have been gradually improved and adapted due to the consequences of the digital transformation of the CT sector, by sharing transparently transport-related data with the entire supply chain. Therefore, the integration of the other CT stakeholders (LSPs, freight forwarders, terminals, Railway Undertakings, and ports) had to be included in the standard data exchange format. For this reason, a new format, EDIGES, an XML-format inspired by the UIRR data message structure, has been designed and implemented. The EDIGES has now been recognised as the European standard for EDI integration in Road-Rail Combined Transport and is fully supported by UIRR.

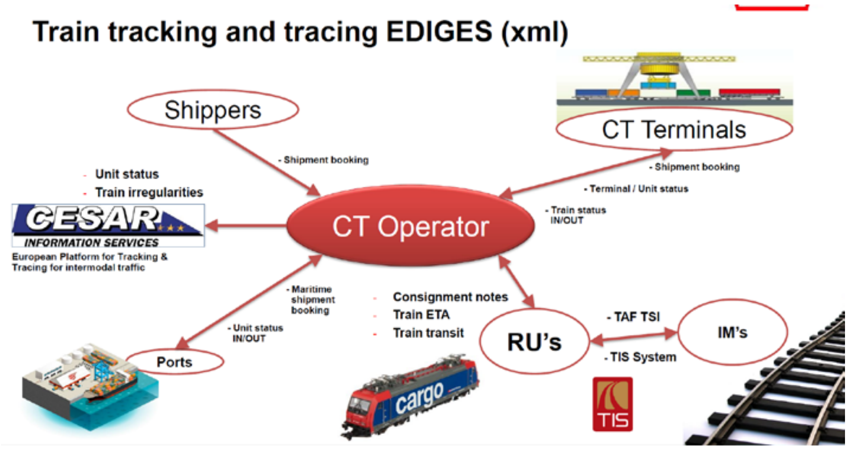


Figure 42 - EDIGES main data flows

The EDIGES standard is specifically developed to exchange relevant information between CT stakeholders (CTOs, RUs, terminals, LSPs...) to ensure reliable intermodal transport. Some elements of the messages such as stations, terminals and country codes are based on the TAF TSI reference files and on UIRR master data (customer codes, gateway codes...) which enables an easy connection between these message types.

The EDIGES format facilitates the data exchange between the following actors (see figure 42):

- CT operators and Customers: transport booking data
- CT operators and CT terminals: transport booking data, train, and unit status messages
- CT operators and Ports: maritime transport booking data, unit status
- CT operators and Railway Undertakings: consignment note data, train running information with transit and ETA-related data

8 Mapping of European Terminals

The notion of terminal has been inserted in various European legislative acts which impose to terminals to publish information on their facilities:

(1) **Directive 2012/34** establishing a single European railway area: publication of information about access to service facilities (such as terminals) in the network statements of the rail infrastructure managers.

(2) **Implementing Regulation 2017/2177** on access to service facilities and rail-related services: publication of mandatory service facility information by all service facility operators with three options: own portal, common portal, or network statement of the national rail infrastructure manager.

(3) **Regulation 913/2010** concerning a European rail network for competitive freight (Rail Freight Corridor Regulation): publication of list and characteristics of terminals in the Corridor Information Documents

(4) The Trans-European Transport Network (TEN-T) policy, **based on Regulation (EU) No 1315/2013,** establishes a two-layer network (core and comprehensive) with defined infrastructure requirements in which 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

8.1 Existing EU Terminal Mapping Tools

In the following section, we will explore the various tools that have been designed by the intermodal sector as a response to the above-mentioned legally imposed information obligations on the terminals. The various identified business solutions have been excluded from this analysis.

8.1.1 Rail Facilities Portal

Art. 4 of Implementing Regulation (EU) 2177/2017 obliges operators of service facilities to establish a service facility description for the facilities and services for which they are responsible. The service facility description shall include at least the list of information set out in the abovementioned Article. A common template has been developed by the RNE Network Statement and Corridor Information Document Working Group together with the sector to facilitate the preparation of the service facility description.

One of the possibilities for operators of service facilities to make the above information available is to publish it on a common web portal and provide the IMs with a link to be included in the Network Statements.

The RFP is the ideal common European web portal for this purpose since it is compliant with the Implementing Regulation as well as with the common template for service facility information (see Figure 43).

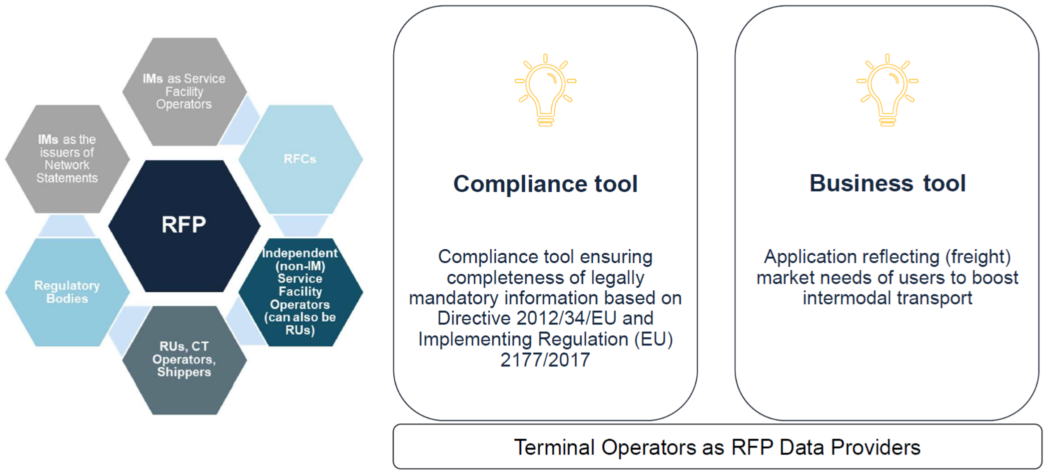


Figure 43 - RFP as compliance & business tool

Rail Facilities Portal (RFP) provides quick and centralised access to information on rail service facilities for customers. RFP has been developed under a contract signed by the European Commission and is coordinated by RailNetEurope (RNE) with the support of UIRR. The operation of RFP belongs to railway stakeholders who are responsible for uploading and updating the information and for making the best use of its services. The success of the portal will depend on the quality of information provided through it.

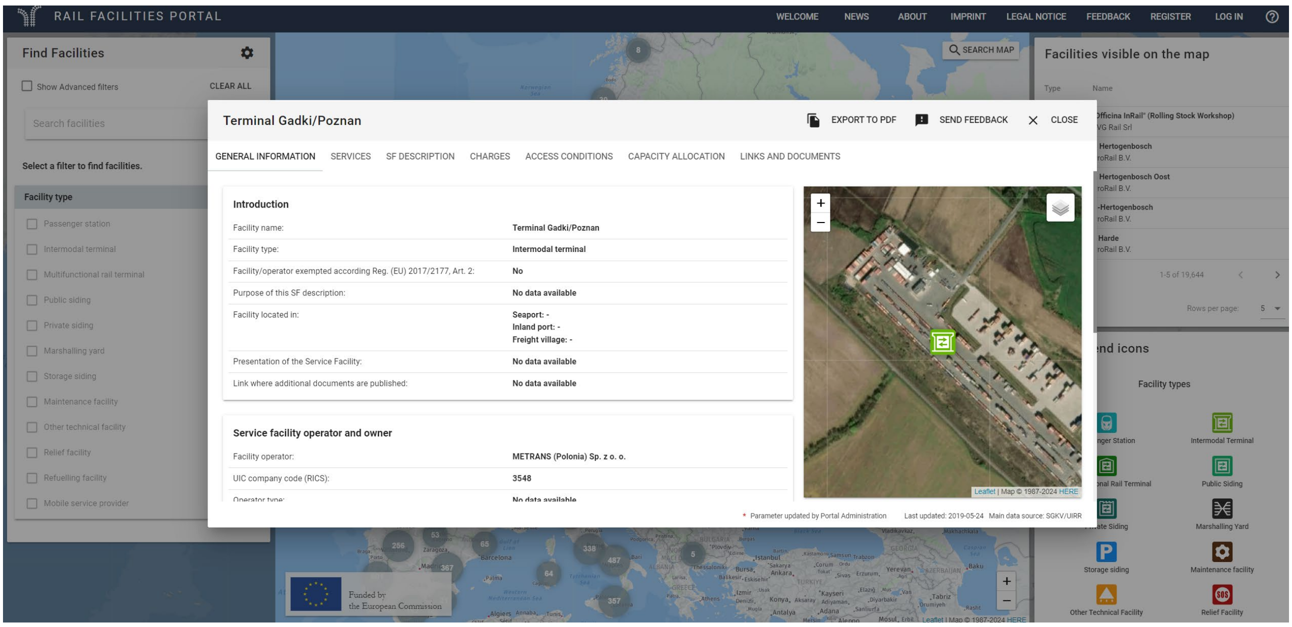


Figure 44 - Rail Facilities Portal - terminal information

The RFP consolidates detailed information on the following rail service facility types: (1) passenger station, (2) intermodal terminals, (3) public and private sidings, (4) marshalling yard, (5) maintenance facility, (6) refuelling facility and (7) mobile service provider.

For the terminals, the information to be provided by a terminal operator has been divided into 7 categories:

- General Information: facility name, service facility operator, contact details
- Services: basic services, additional services, and auxiliary services (as requested by the Implementing Regulation)
- Service facility description: exact location with GPS coordinates, opening times and infrastructure characteristics (tracks, types of equipment…)
- Charges: Information on charges for getting access to SFs and charges for the use of each rail-related service supplied therein.
- Access conditions: loading unit acceptance, permitted length and axle load….
- Capacity allocation: requests, booking conditions, temporary capacity restrictions
- Links and documents

8.1.2 Customer Information Platform (CIP)

Article 18 of Regulation (EU) 913/2010 concerning a European rail network for competitive freight requires RFC Management Boards to publish Corridor Information Documents providing information on the rail infrastructure including terminals of each Rail Freight Corridor (RFC), in particular as regards commercial and legal access conditions, thus facilitating international business on RFCs. The RNE Network Statement and Corridor Information Document Working Group has developed the Corridor Information Document Common Texts and Structure (CID) designed to help actors finding the same information, at the same level of detail, in the same place in each document. It complies with the requirements of the above-mentioned Regulation. The section 3 of this document details the requirements for the terminals in terms of information to be provided.

The Customer Information Platform (CIP) is a free of charge interactive, internet-based information tool available on https://cip.rne.eu/. By means of a Graphical User Interface (GUI), CIP provides precise information on the routing, terminals, specific track properties and infrastructure investment projects, as well as ICM lines and their re-routing options of the participating Rail Freight Corridors (RFCs).

At the request of several RFCs, RNE took over the ownership, hosting, and maintenance of the CIP from the Corridor Rhine-Alpine, thereby enabling it to evolve into a multi-corridor tool providing harmonised information and communication processes. RNE has further developed the CIP according to the decisions of the CIP Change Control Board (CCB) and following the approval, if necessary, of the RNE General Assembly.

At the moment, CIP displays information on railway infrastructure in 26 European countries, covering the complete network of all 11 RFCs: Rhine-Alpine, North Sea-Mediterranean, Scandinavian-Mediterranean, Atlantic, Baltic-Adriatic, Mediterranean, Orient/East-Med, North Sea-Baltic, Rhine-Danube, Alpine-Western Balkan and Amber. As of 2021, several Infrastructure Managers decided to have their entire railway network covered in CIP.

In the RNE CIP, the user might find the following information regarding the terminal-related information:

- A list all terminals connected to the corridor: it contains the name of the terminal the operator, the terminal type, the address, and the website. The list contains 623 entries of which 70% are identified as ‘container / intermodal terminal’. The remaining 30% are loading and unloading facilities for the rail conventional traffic.
- An interactive map of the corridor with lines, nodes, and terminals properties (see figure 45)

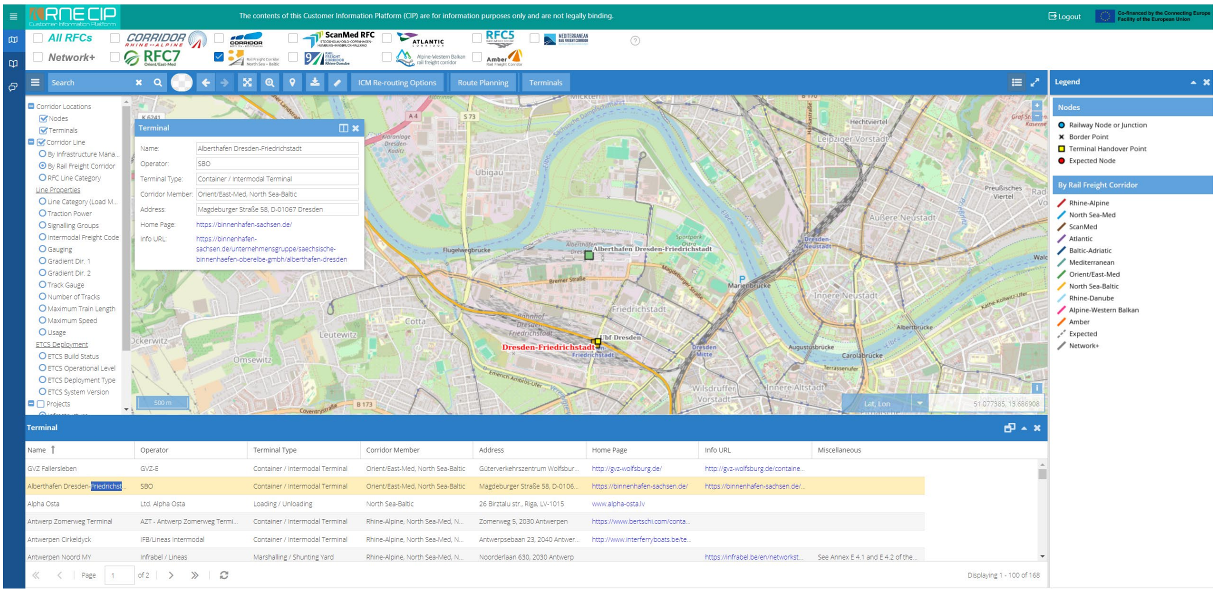


Figure 45 - RNE CIP Interactive Map

8.1.3TENtec Interactive Map Viewer

TENtec is the European Commission's information system set up to coordinate and support the Trans-European Transport Network (TEN-T) policy. TENtec has two pillars:

- Policy-related: TENtec stores and manages technical, geographical, and financial data. This is analysed and used in the management of TEN-T, as well as political decision-making linked to TEN-T and the related funding programme, the Connecting Europe Facility (CEF).

- Grant management: TENtec is used in the grant management workflow, from proposal submission to the issuing of grant agreements, which is overseen by the Innovation and Networks Executive Agency (INEA).

TENtec is developed in close cooperation with Member States and key stakeholders - and acts as bridge for transport modelling needs, such as future policy and budgetary scenarios and the mapping of TEN-T/CEF co-funded projects as well as alternative fuel infrastructure and secure and safe parking areas. TENtec also plays an integral role in the Core Network Corridor studies, providing vital data collection services and compliance maps.

The TENtec Public Portal provides timely information to the public (citizens and professionals) through interactive maps, a map library, and various audiovisual elements. This Public Portal provides a systematic and comprehensive overview of the European Commission's work in relation to TEN-T and is intended to raise awareness of the benefits of TEN-T policy among EU citizens.

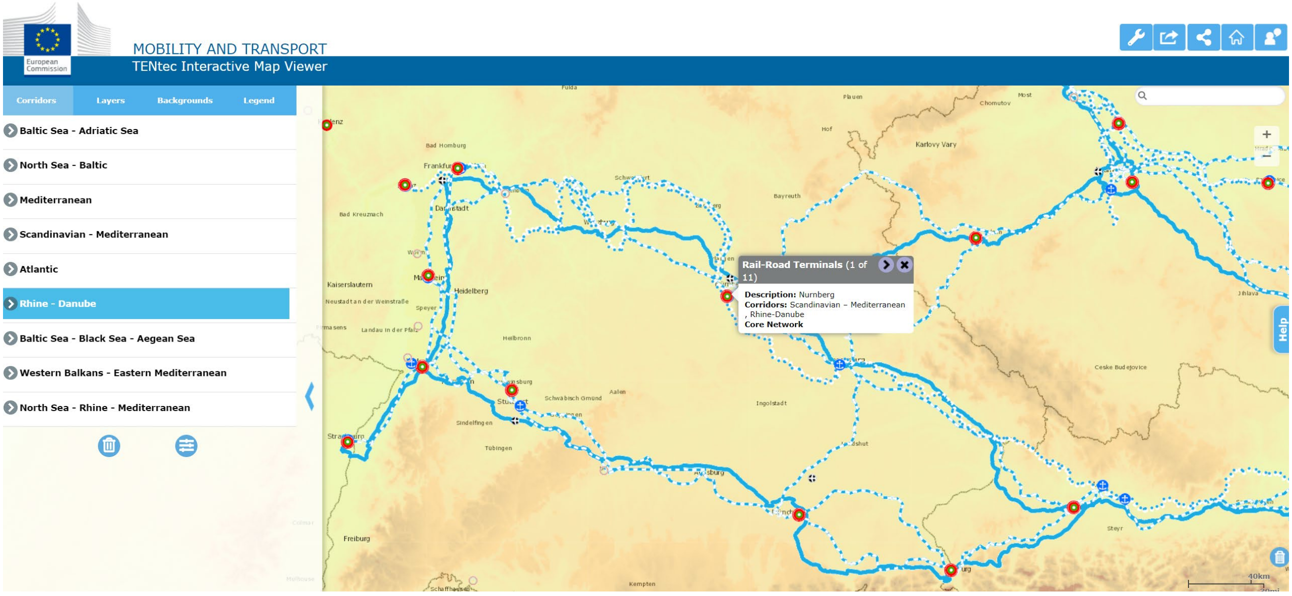


Figure 46 - TENtec interative map

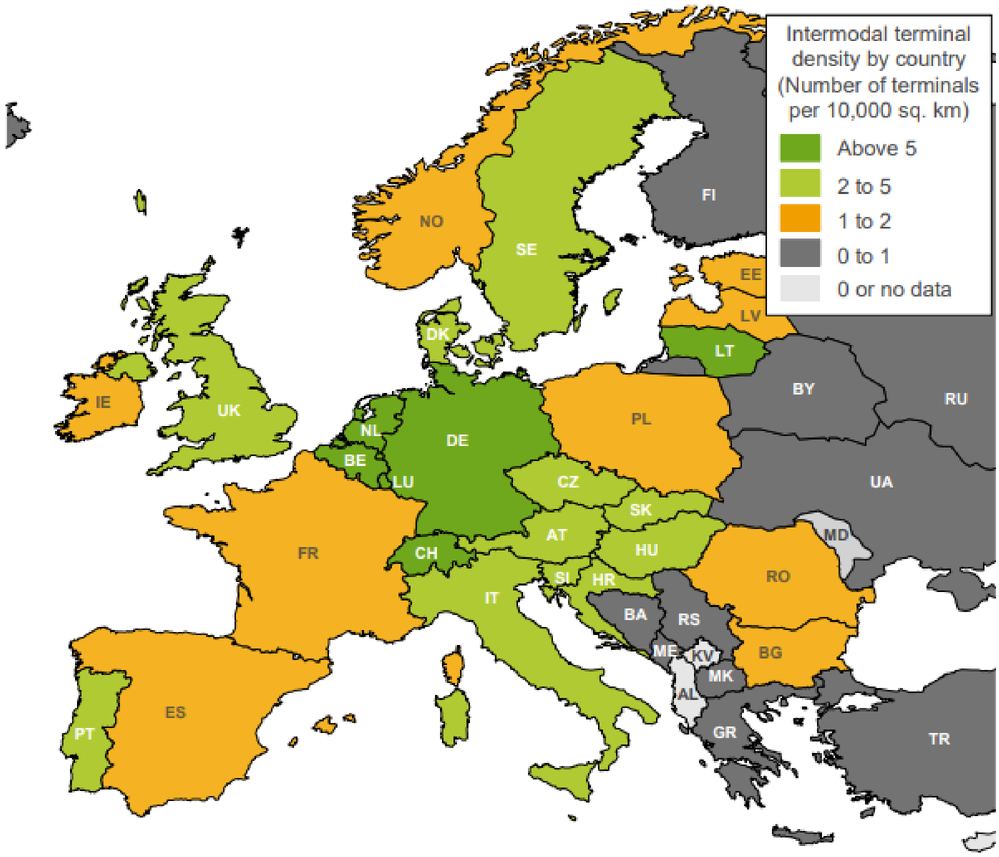
The TENtec interactive map viewer (see figure 46 as example on the Rhine-Danube TEN-T corridor) displays among others all rail-road Terminals, logistic platforms and freight terminals that record an annual transhipment volume of 800,000 tonnes per year. The information provided is simple as only the location (city), the corridor and the position of the facility (core or comprehensive network).

8.2 Terminal characteristics

8.2.1 Density

The density and capacity of terminals determine the performance of the intermodal network, which is a key factor for business opportunities and market share. For the ReMunet project, we have selected the Rail Facilities Portal web tool as basis for our analysis. RFP has compiled detailed information on more than 1,200 terminals in Europe and beyond to evaluate the density of the European terminal network. For the analysis, we have defined the intermodal road-rail terminal density as the number of terminals per 10,000 sq. km in a given country.

The CT terminal network in the European countries is very diverse, reflecting the different economic and spatial structures and market volumes of intermodal transport. While the density is high in the countries located in the heart of Western Europe, which have a key function as transport hubs, such as Belgium, Germany, and the Netherlands, it may be lower - but still above average - in countries that are part of the main intermodal transport trade routes such as Austria, Italy and Sweden.



Country	No of CT terminals
Austria	23
Belarus	20
Belgium	44
Bulgaria	13
Croatia	15
Czech Republic	22
Denmark	11
Estonia	7
Finland	19
France	101
Georgia	1
Germany	214
Greece	7
Hungary	23
Ireland	7
Italy	76
Kasachstan	1
Latvia	6
Lithuania	7
Luxembourg	2
Moldova	1
Montenegro	1
North Macedonia	2
Norway	34
Poland	44
Portugal	28
Romania	28
Russia	104
Serbia	7
Slovakia	18
Slovenia	5
Spain	51
Sweden	92
Switzerland	50
The Netherlands	30
Turkey	13
Ukraine	19
United Kingdom	58
TOTAL	1,204

Figure 47 - Terminal density in European countries

8.2.2 Market segment

The categorisation in terms of market segment focuses on the equipment (type of loading units) handled. This determines the capability to serve selected market segments. First of all, as trade routes, maritime and continental flows are distinguished by the use of different equipment. Secondly, the technology applied is a relevant factor for the categorisation that distinguishes vertical from horizontal transhipment.

For the categorisation, typical mixed CT terminals serve maritime and continental services with vertical transhipment technology, such as Combinant Antwerp, DUSS-Terminal München-Riem, HUPAC Busto Arsizio Gallarate, TCA Aschaffenburg, TIP Žilina, and Wien Süd CCT, which belong to this category and can be distinguished from the other ones offering both vertical and horizontal transhipment technology such as CFL Bettembourg-Dudelange.

90% of European CT terminals accept both ISO containers and continental containers. Only 25% of them accept swap bodies. Most facilities do not accept semi-trailers (75%) and only 0.3% accept non-craneable semi-trailers. A large proportion of the installations accepting swap bodies and semi-trailers are located in Germany and neighbouring countries, as well as in countries on the main trade routes using this equipment such as Sweden.

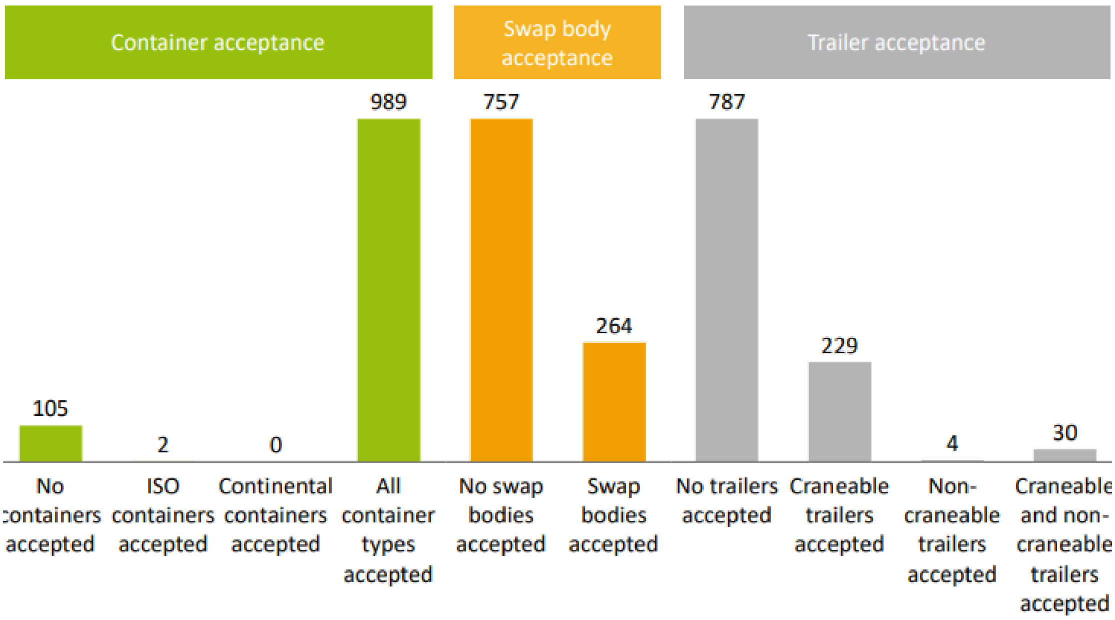


Figure 48 - Terminals' market segment

8.2.3Terminal Size

An analysis of the European CT terminal network based on the data collected and the data available in the RFP shows that most installations only provide vertical transhipment technologies and focus on containers. Only a small proportion handles other equipment (swap bodies, semi-trailers). However, the majority handles continental and maritime equipment. Irrespective of these facts, they tend to concentrate on a certain market segment linked to the routes operated by the CT operator. Nevertheless, this aspect is difficult to analyse because the route portfolio and schedules are not under the control of the terminal operator. The high proportion of "mixed vertical" CT terminals is in line with the results of the categorisation of the seven terminals that were subject to the validation process. Six terminals belong to the "Mixed vertical" market segment with sizes ranging from "Small" to "X-large", while one terminal belongs to the "Mixed vertical + horizontal" "X-Large" category. These are certain facilities with horizontal transhipment technologies, in particular for non-craneable semi-trailers.

Criteria	Size category			
	Small	Medium	Large	X-Large
Capacity	≤ 75,000 LU	75,000 LU < x ≤ 150,000 LU	150,000 LU < x ≤ 300,000 LU	> 300,000 LU
Total transshipment track length	≤ 1,000 m	1,000 m < x ≤ 2,500 m	2,500 m < x ≤ 4,000 m	> 4,000 m
Surface area	≤ 45,000 m^2	45,000 m^2 < x ≤ 100,000 m^2	100,000 m^2 < x ≤ 210,000 m^2	> 210,000 m^2
Number of modules	1	1	≤ 2	> 2
Number of handling equipment: gantry cranes (vertical) / system tracks (horizontal)	≤ 1	1 < x ≤ 2	2 < x ≤ 5	> 5

Table 10 - Terminal categorisation by size (matrix)

According to the actually available RFP data, the majority of CT terminals can be considered ‘small’, as more than half of them with data entries do not have a gantry crane and entirely rely on mobile equipment. Only a small proportion is equipped with five or more gantry cranes. In addition, the data show that a large number of medium and large terminals form the basis of the CT terminal network in Europe, while the “X-large” category represents only a small number of them.

8.2.4 Value-added services

The term “value-added services” is not legally defined, and it includes any type of services potentially offered by the terminal operator that complements the main function of the facility. All these “value-added services” must be defined by the operators themselves in accordance with the principle of freedom of contract and, where appropriate, allocated to the regulated area. In order to get an overview of all VAS offered in European CT terminals, different sources and previous projects have been analysed.

Table 11 presents the most common VAS on the market at a glance. The services specifically marked with:

> * Access, including track access, shall be granted to services facilities, if any, and to the services provided in these facilities
>
> ** Additional services
>
> *** Ancillary services

are also listed in the Directive 2012/34/EU Annex II “Services to be supplied to the railway undertakings” and are divided in basic, additional, and ancillary services.

VAS for loading unit	VAS for rail	VAS for road	VAS for waterway	Other VAS / further logistics services
Agency	Brake testing facility	Accommodations for truck drivers	Berths - break places	Access to telecommunication networks***
Cleaning (tank container)	Electrified access	Cleaning trucks and equipment	Charging current	Conference rooms
Container lashing	Locomotive cleaning*	Filling station (patrol station/gas station)	Logistic Services for neighbouring shippers	Hotels, restaurants, shops, cafeteria, etc.
Container sales/leasing	Locomotive parking*	OCR documentation	Mechanic access	Integrated C02 calculator
Customs clearance	Locomotive repair/maintenance (light)*	Own chassis and trailers	OCR documentation	Offices (for rent)
Dangerous goods	OCR documentation	Own trucks	Shore leave facilities/terminal access	Order picking, warehousing
Empty container depot	Provision of emergency equipment	Parking options	Supply and disposal of water	Packing, labelling and tagging
Fumigation/ disinfection	Refuelling*	Repair/maintenance chassis and trailers	Waste disposal	Provision of supplementary information
Reefers	Shunting	Repair/maintenance trucks		Quality control (checking)
Repair/ maintenance	Technical inspection of rolling stock***	Sanitary facilities (showers, toilets, etc.)		Quality-focused service
Security services	Traction current (extra charges)**	Supply control and slot management		Stuffing/stripping
Tracking and tracing	Wagon cleaning*	Trucking		Time-focused services (JIT, JIS)
Ventilation	Wagon parking*			
Waste	Wagon repair/maintenance (light)*			
Weighing				

Table 11 - Most common Value-Added-Services (VAS) of CT terminals

Depending on the market situation, different transhipment facilities also offer VAS in the area of road access and focus on the digitalisation of processes. VAS in the waterway or rail sector are mainly limited to the improvement of handling processes and not to the maintenance or repair of heavy wagons, locomotives, or vessels. CT terminal managers revealed that all services beyond transhipment and temporary storage of loading units are offered outside the regulated area and on a voluntary basis after examination of their market potential. No facility can be obliged - nor allow third parties - to provide such services within its boundaries.

9 Key components of an intermodal network

Today's intermodal network is composed by interdependent elements that are significantly impacted by developments of:

- **physical assets** (infrastructure, wagons, terminals, loading units, cargo)
- **stakeholders** (infrastructure managers, railway undertakings, CT operators, terminal Managers, trucking companies, logistics companies, shippers)
- **authorities** (policy-makers, customs authorities, regulators)
- **information flows** with processing capabilities and data sharing

This purpose of this chapter is to provide a better understanding of the importance of an interoperable, reliable, and resilient railway infrastructure asset for the further development of intermodal transport in Europe. It will explore current and future infrastructure parameters and standards necessary to improve cross-border intermodal transport services in Europe.

9.1 Infrastructure parameters and standards

Railway infrastructure consists of several key components that work together to facilitate the movement of trains safely and efficiently. Here are the main components:

- **Tracks**: Tracks are the foundation of the railway infrastructure, consisting of rails made of steel laid on wooden or concrete sleepers (ties) and supported by ballast (typically crushed stone). The rails provide a smooth and continuous surface for the train wheels to roll on.
- **Railway Stations**: Stations are where passengers board and disembark trains. They typically include platforms for passengers to wait on, ticket counters, waiting rooms, and other amenities such as restrooms and shops.
- **Signaling Systems**: Signaling systems ensure safe operation by controlling train movements and preventing collisions. This includes trackside signals, which indicate to train drivers when it is safe to proceed, as well as interlocking systems that manage the movement of trains at junctions and crossings.
- **Overhead Wires**: In electrified railways, trains draw power from overhead wires (catenary) or a third rail. These power supply systems provide electricity to power the locomotives and trains.
- **Bridges and Tunnels**: Bridges and tunnels are used to traverse obstacles such as rivers, valleys, and hills. They enable the railway to maintain a relatively straight and level path, reducing travel time and energy consumption.
- **Level Crossings**: Level crossings, also known as grade crossings, allow roads to intersect with railway tracks. They typically include barriers, lights, and warning signals to alert road users of approaching trains and ensure safe passage.

- **Yards and Depots**: Yards and depots are facilities where trains are stored, serviced, and maintained. They include tracks for parking and sorting trains, as well as workshops for maintenance and repair work.
- **Rolling Stock**: Rolling stock refers to the locomotives, passenger cars, freight cars, and other vehicles that travel on the railway tracks. These vehicles are essential for transporting passengers and goods.
- **Control Centers**: Control centers monitor and manage the operation of the railway network. They coordinate train movements, respond to incidents or emergencies, and ensure the efficient use of infrastructure and resources.

The nature of all these elements influences the capacity and the flexibility of the rail network, including the number of trains that can run, their operating speeds and their schedules. Infrastructure managers are responsible for setting the rules that govern the use of infrastructure, rules which are based on network capability. For example, variables influencing the network capability are:

- track and route mileage,
- kilometres of electrified tracks,
- permissible line speeds,
- gauge capability,
- route availability,
- length capability,
- gradients and total tonnage capability.

The variables that influence the most the intermodal flows are the following:

- **Gauge and loading gauge capability**: the ability to move a railway wagon and its intermodal loading unit on a particular part of the network depends on the height and width profile, known as the loading gauge of the route concerned.
- **Train length capability**: maximum train length is governed by the length of passing loops, yard, and terminal sidings and in some cases the characteristics of the signalling systems.
- **Route availability**: fundamentally it refers to the maximum axle weight permissible on a given route

In late December 2023, the European Parliament and the European Council have compromised on the amendment of the TEN-T Guidelines Regulation and has been endorsed by the European Commission. The most important new aspects of the TEN-T Regulation from an intermodal rail freight perspective were the following (only those influencing the three above-mentioned variables):

1. **4-metre loading gauge (P400)** on sections of line used by freight trains or designated to be a bypass route in case of a traffic disturbance for freight trains. the definition was agreed to be 27cm over the top of the rails; the TEN-T Core Network has been agreed to be upgraded to this standard by 2040. There is no indication to

the rail last mile sections, which connect terminals to the TEN-T Core sections (these sometimes belong to the TEN-T Comprehensive Network, not the Core).

2. **740-metre train length** should be made possible with a 2,000-tonne gross train weight throughout the network used by freight trains. The requirement will be fulfilled on the TEN-T Core network by providing at least 1 train path for such 740-metre-long train every 2 hours (instead of 1/hour, as proposed by the Commission). A particular attention should be given to the possibility to develop an infrastructure length above 740m and up to 1500m as well.
3. **Axle load of at least 22.5 tons** on the rail comprehensive network by 2050 and further analysis for a 25.0t axle load when constructing and modernising railway lines relevant for freight traffic.
4. **Full electrification** as regards line tracks and also sidings

In the next sections, we will provide a status of the intermodal compliance (rail infrastructure and terminal) towards the current TEN-T requirements on the two selected ReMuNet corridors.

9.2 North Sea – Baltic (NSB) Corridor

The North Sea-Baltic corridor is multimodal and connects the Baltic Sea region with the countries of the North Sea region, improving the accessibility of the northern Member States and the connection between the northwest and the northeast of the European Union. The corridor passes through Belgium, the Netherlands, and northern Germany, Poland and then north through the Baltic States. Since its extension in 2021, the whole of Finland and the northern part of Sweden are part of the corridor and a section in Poland up to the border with Ukraine. As since its extension, the North Sea-Baltic Corridor now consists of 9031 km of railways, 6655 km of roads and 2741 km of inland waterways.

The overall objective is to develop and complete a competitive and interoperable trans-European transport network at the highest standards, to connect the regions along the corridor, to accelerate the green transition in the transport sector, and to tap into the economic potential of the region. The main instrument to implement the NSB Corridor objectives are transport infrastructure projects, including roads, railways, and inland waterways. The corridor’s most significant project is Rail Baltica, a European standard gauge railway connecting Estonia, Latvia, and Lithuania to Poland. In July 2022 the European Commission proposed to extend the corridor further, also to Ukraine. The co-legislators, i.e. the European Parliament and the Council, are still working on the proposal.

The table below presents the summary of technical compliance for rail. The table includes the Baltic States and Finland, but it should be noted that their 1520 mm and 1524mm networks are exempt because they are isolated networks according to the TEN-T Regulation. Rail Baltica will be compliant in the Baltic States when completed.

RAILWAYS		All entries: Share of all sections fulfilling the respective standard									
TEN-T parameters		**NL**	**BE**	**DE**	**PL**	**LT**	**LV**	**EE**	**FI**	**SE**	***Corridor***
Length of all sections (in km)		477	395	2.038	2.916	848	594	442	816	195	9.031
Electrification	Electrified	100%	100%	97%	95%	18%	11%	17%	97%	100%	84%
Track gauge	1.435mm	100%	100%	100%	100%	13%	0%	0%	0%	100%	75%
Line speed (core freight lines)	≥100km/h	100%	80%	100%	68%	88%	0%	100%	99%	100%	83%
Axle Load (core freight lines)	22.5t	100%	100%	100%	86%	100%	100%	100%	100%	100%	96%
Train length (core freight lines)	min. 740m	100%	100%	100%	56%	100%	100%	100%	94%	100%	83%

Table 12 – NSB TEN-T corridor - rail compliance with TEN-T regulation requirements

Compliance for electrification is 84%. The whole NSB Corridor is electrified in Belgium, The Netherlands and Sweden. In Germany, Finland, and Poland it is almost compliant, except for approximately 60 km between Oldenburg and Wilhelmshaven in Germany (compliance to be reached in 2022), a 94-km section between Ełk and the Polish-Lithuanian border in Poland, and the section between Laurila and Haparanda / Tornio-raja (border between Finland and Sweden) in Finland. In Lithuania the Kaunas – Vilnius line (about 149 km) is electrified. It is also planned to electrify the bypass around Vilnius (about 42 km) and the Kaišiadorys – Klaipėda line (322 km). In Latvia and Estonia sub-regional lines for passenger transport around the capitals are electrified.

Track gauge is 1435 mm on the western and central parts of the NSB Corridor. The total compliance is 75%, with full compliance in Belgium, The Netherlands, Germany, Poland, and Sweden. In the Baltic States and in Finland the gauge is mostly 1520 mm and 1524 mm, respectively.

The **minimum line speed requirement of 100 km/h for freight lines** is fulfilled in The Netherlands, Germany, Estonia, and Sweden. In Finland, it is almost fully compliant, with only the section from Tampere to Lielahti not compliant. Parts of the Belgian network receiving freight traffic are not compliant with the line speed requirement; this includes sections from Glons to the German border (39 km), from Angleur to Liège Guillemins (3 km), from Lier to Antwerp (10 km) and locally in the railway nodes of Aarschot (0.5 km) and Hasselt (2 km). In Poland significant parts of the network are not compliant, including the Polish part of the Rail Baltica section of approximately 94 km between Ełk – Suwałki and Trakiszki (LT border) and over 300 km of the section between Łuków and Poznań. In the Baltic States not all lines are compliant with line speed requirements, however, once the Rail Baltica project is completed they will be.

The NSB Corridor is compliant with the axle load standard of minimum 22.5 ton except for a limited number of sections in Poland. The corridor is 83% compliant with train length requirements. In Poland trains of 740 m can be accommodated on 56% of the sections. In Belgium, The Netherlands and Germany the score is 100%, but long trains are not possible under all circumstances due to the combined use of lines by freight and passenger trains. In Belgium this is due to the existing train length restrictions of 650 m during peak hours and in Germany due to capacity bottlenecks during peak hours. Bottlenecks at certain times of the day and lacking sidings at certain locations also exist in The Netherlands. For Finland, almost all sections are fit for 740 m trains, reaching a KPI of 94%.

The rail projects on the NSB Corridor contribute to the achievement of one or more of the following KPIs: electrification (10 projects), track gauge 1435 (1 project), **structure gauge** (8 projects), **intermodal gauge** (6 projects), ERTMS (1 project), line speed (21 projects), axle load (11 projects). Furthermore, these projects will help meet needs of the transport market and make intermodal transport more competitive. For example, the project Rail Baltica will be implemented to provide for loading gauge GC on all tracks. Main advantage of this gauge profile compared to loading gauges still used in Central Europe is the additional space in the upper part of the profile. While international transports are limited to smaller loading gauge G2, e.g. for existing line sections in Poland, transports between stations in the Baltic States will benefit from this loading gauge. This is especially relevant for intermodal and exceptional oversized cargo.

The number of rail-road-terminals located on the NSB Corridor has increased from 19 to 24, with all the new terminals located in Poland (Kraków, Sławków, Wrocław, Szczecin, Świnoujście). There are no compliant rail-road terminals available, only at Member State level. For example, in the Netherlands while some terminals in the port of Rotterdam have the infrastructure to handle 740-meter trains, most of the railway shunting and marshalling yards in the port of Rotterdam do not meet the TEN-T requirements for 740-meter trains. In Poland improvements would still be required at rail-road terminals for the promotion of intermodal transport along the NSB Corridor, particularly relating to enhance 740-meter train terminal accessibility.

9.3 Rhine Danube (RD) corridor

The Rhine-Danube Corridor is the main east-west link in continental Europe. It comprises nine Member States (France, Germany, Austria, Czech Republic, Slovakia, Hungary, Croatia, Romania, and Bulgaria) and four neighbouring countries (Serbia, Bosnia and Herzegovina, Moldova, Ukraine) all along the Main and Danube rivers to the Black Sea.

The alignment of the Corridor consists of the following main connections, as reported in the maps of the Core and Comprehensive Network of the TEN-T Guidelines (Regulation 1315/2013) and according to Annex 1 of the CEF Regulation 1316/2013:

- Strasbourg – Stuttgart – München – Wels/Linz;
- Strasbourg – Mannheim – Frankfurt – Würzburg – Nürnberg – Regensburg – Passau – Wels/Linz;
- München/Nürnberg – Praha – Ostrava/Přerov – Žilina – Košice – UA border;

- Wels/Linz – Wien – Bratislava – Budapest – Vukovar;
- Wien/Bratislava – Budapest – Arad – Brasov/Craiova – București – Constanţa – Sulina.

Bulgaria and Croatia are only included in the Corridor as regards waterborne transport. This concerns ports and inland waterways of the Danube and Sava Rivers. The Corridor includes around 5,800km of rail network, 4,500km of roads and 3,900km of waterways (incl. 19 ports).

The results of the compliance rail analysis are shown in table 13.

KPI	AT	FR	DE	CZ	SK	HU	RO	Total
Electrification	100%	100%	79%	91%	100%	100%	96%	**91%**
Line speed 100 km/h (freight)	100%	100%	100%	87%	88%	99%	95%	**96%**
Axle load 22.5t	100%	0%	97%	92%	100%	84%	25%	**76%**
Track gauge	100%	100%	100%	100%	100%	100%	100%	**100%**
Train length 740m	100%[1]	100%	100%	0%	0%	100%	34%	**57%**

Table 13 - RD TEN-T corridor - rail compliance with TEN-T regulation requirements

The compliance analysis showed that:

- **91% of the railway lines are electrified** and gaps only relate to some sections in Germany (München-Mühldorf-Salzburg), the cross-border sections between Germany and the Czech Republic and in Romania.
- The **entire rail infrastructure of the Corridor provides for standard gauge** (1,435 mm).
- **An operating speed of at least 100 km/h for freight traffic is enabled at more than 96%** of the rail lines. Line sections with insufficient operating speeds are located on the "CS branch" (Czech Republic, Slovakia) and on the "Black Sea branch" (Slovakia, Romania; Hungary: local speed drops in the Budapest node).
- **76% of the rail network allows for 22.5 tonnes axle load**. Line sections not fulfilling the requested standards are mostly located in Romania (if speed limitations are taken into account, the required axle load can be reached in Hungary and partly in the Czech Republic).
- **A maximum train length of 740m is permitted at 57%** of the rail infrastructure. Sections which only provide for shorter trains are located on the "CS branch" (CZ/SK) as well as in Romania.

KPI	AT	FR	DE	CZ	SK	HU	RO	Total
Intermodality	100%	50%	56%	25%	25%	67%	25%	**50%**
740m train length	17%	0%	6%	0%	25%	33%	0%	**9%**
Electrified access	50%	0%	38%	0%	25%	0%	0%	**23%**
Open availability	100%	100%	100%	100%	100%	100%	100%	**100%**

Table 14 - Rail/Road Terminal compliance

The analysis of the 44 rail-road terminals that are currently in operation in the RD core nodes revealed only low compliance to these market-driven parameters (see table 14).

- **Only half of the terminals are able to handle all three types of loading units** (containers, swap bodies, semi-trailers). The focus on single types of loading units might be explained by the past/current market orientation (e.g. focus on maritime or continental transport, key customers with special logistics profiles).
- The compliance rate for **electrified access is only 23% and the limited length of the handling tracks, where only four sites fulfil the KPI target**, creates a real burden for an efficient supply of intermodal transport services.
- **Many of the existing rail/road terminals were constructed as re-use of obsolete sidings in the peripheral areas of marshalling yards or port areas**. Thus, the rail infrastructure of these terminals is characterised by one-side connection to the main line, by non-electrification and by short usable length of the transhipment tracks. Despite their unfavourable conditions, many of these “historically grown” terminals are still in operation and are only gradually/partially being replaced by modern facilities.

10 Sustainable intermodal assessment

Goods transport by road, rail, and inland waterway in the EU (plus Great Britain, Switzerland and Norway causes around 275 million tons of CO_2 equivalents per year - that is about one third of the total transport emissions on the continent. A considerable share of these CO_2 emissions is caused by the classic transport of goods by truck from door-to-door (unimodal trucking).

10.1 UN Sustainable goals

The core of the United Nations 2030 agenda was its 17 Sustainable Development Goals (SDGs). They give equal weight to all three dimensions of sustainability – social, environmental, and economic. The SDGs are indivisible and interdependent: only economic stability creates the opportunity to create sustainable and secure working conditions and, at the same time, to meet our responsibility for the environment and society – thus making our behaviour suitable for future generations. The goals of the 2030 Agenda are further detailed with 169 targets comprising of multiple Key Performance Indicators (KPIs). These indicators can be used as a tool to evaluate and initiate actions towards realising sustainability. Furthermore, the agenda states that these goals can only be achieved through intensive and global cooperation, whereby everyone has an equal responsibility to contribute to the necessary change. Sustainable development goals (United Nations).

10.2 Sustainable tools

In a modern economy, energy is the driving force behind every aspect, from production to transportation, forming the basis of any added value generated worldwide. When value emerges from the interaction of energy, machinery, and raw materials, this production method inevitably yields byproducts, known as externalities, which may not always be desired. These externalities, whether positive or negative, such as air pollution or greenhouse gas emissions, have garnered significant attention from our societies.

The choice of transportation mode for goods has significant environmental implication. The prevalent use of internal combustion engines in the European truck fleet contributes to climate change through emissions of greenhouse gases like carbon dioxide, methane, nitrous oxide, and other substances. Additionally, fuel consumption leads to increased levels of particulate matter, adversely affecting public health. The emission of these pollutants represents costs that have not been internalised in the economic process, thereby imposing burdens on health and the environment.

While it may appear more economical to rely on polluting modes of transportation, the indirect costs they impose on society need to be addressed according to the polluter pays principle. This is why various tools have been designed to evaluate the environmental consequences that economic activities, such as transport, entail.

10.2.1 ECOTRansIT

ECOTRansIT is a tool developed to evaluate the environmental performance of freight transport chains. It provides users with insights into the environmental impacts associated with transporting goods, allowing for informed decision-making to optimise transport routes and modes.

EcoTransIT World (ETW) serves as a prominent platform for analysing the energy consumption and emissions associated with freight transport on a global scale. It adheres to established standards such as the EN 16258 and GHG Protocol, and holds accreditation from the GLEC Framework, ensuring credibility and reliability in its methodologies.

ETW facilitates the calculation of emissions across various transport modes, including trucks, trains, ships, river barges, and airplanes. This comprehensive approach encompasses transshipment and warehousing activities, offering a holistic perspective on the environmental impact of freight movement.

By integrating parameters such as cargo weight, origin, destination, and mode of transport, ETW enables detailed assessments of intermodal transport chains. This granularity enhances the precision of emission calculations, providing valuable insights for stakeholders involved in logistics, transportation, and environmental management.

The results generated by ETW play a crucial role in decision-making processes, offering valuable data for understanding the environmental footprint of freight transport. Whether it's determining CO_2 emissions, facilitating internal and external communication within organisations, or devising sustainable strategies, ETW's insights are invaluable.

Furthermore, ETW's flexibility extends to its interfaces, accommodating the diverse needs of users. From automatic SOAP XML web services to manual data loading in .csv format, ETW caters to a wide range of preferences, ensuring accessibility and ease of use.

Continuously updated by independent research institutes such as Ifeu, Infras, and Fraunhofer IML, ETW maintains its scientific rigor and reliability. Its methodology, documented in detail and available for scrutiny, undergoes validation processes to ensure accuracy and transparency.

10.2.2 CE Delft Handbook

The CE Delft Handbook on external costs of transport is a comprehensive resource developed by CE Delft, an independent research and consultancy organisation specialising in environmental and sustainability issues. This handbook serves as a guide for assessing the external costs associated with various modes of transportation.

The CE Delft Handbook provides methodologies and input values for estimating the external costs of transport across different modes, including road, rail, maritime, and aviation. It covers a wide range of factors that contribute to these costs, such as emissions of greenhouse gases and pollutants, noise levels, infrastructure wear and tear, and accident rates.

By providing a standardised framework for assessing external costs, the handbook enables policymakers, researchers, and transportation professionals to better understand the full societal impact of transportation activities. This information can then be used to inform policy decisions, improve transportation planning, and promote sustainable transport solutions.

The CE Delft handbook has played a crucial role in shaping the European Commission's proposal for revising the directive on Combined Transport. This proposal mandates Combined Transport operators to demonstrate to their national authorities that their operations result in a 40% reduction in external costs compared to those of unimodal road transportation. These calculations are to be conducted on specific transport routes. Meeting this 40% cost-saving threshold enables the intermodal transport operator to attain the designation of a Combined Transport operator. Consequently, they become eligible for subsidies from their member states. Additionally, these member states are obligated to implement measures aimed at reducing costs within the intermodal transport sector by 10% within seven years following the directive's publication.

10.2.3 CountEmissionEU (ISO Standard 14083:2023)

CountEmissionsEU is a significant initiative proposed by the European Commission to address the crucial issue of quantifying greenhouse gas (GHG) emissions across various modes of transport. Its primary objective is to establish a unified framework for calculating these emissions, providing standard methodologies, default values, and verification standards to ensure the reliability and accuracy of emissions data. This initiative encompasses both freight and passenger transport operations, including emissions generated from hub operations, thereby offering a comprehensive approach to assessing the environmental impact of the entire transport sector.

One of the key reasons for the importance of this initiative lies in the necessity for a common methodology and harmonised set of default values to facilitate the reliable quantification of GHG emissions. By establishing a standardised approach, CountEmissionsEU seeks to enable fair comparisons between different transport services and modes, thereby promoting transparency and accountability within the industry. This transparency is crucial as it can influence the decisions of transport users and incentivise the adoption of more sustainable transportation options.

At the heart of CountEmissionsEU is the adoption of the methodology outlined in the EN ISO 14083:2023 standard. This standard provides a robust framework for calculating emissions based on the 'well-to-wheel' concept, which considers emissions generated throughout the entire lifecycle of a vehicle, including both vehicle use and energy provision. By adhering to this internationally recognised standard, CountEmissionsEU ensures consistency and comparability of emissions data, even across international transport operations involving multiple modes.

While CountEmissionsEU does not mandate the calculation of GHG emissions for businesses, it sets forth rules and guidelines for entities that choose to disclose such information. Adherence to CountEmissionsEU rules guarantees the accuracy and comparability of GHG emissions data, thereby enhancing transparency and accountability within the industry. This regulatory predictability creates a level playing field for GHG emissions accounting, encouraging gradual market uptake of the initiative, including by small and medium-sized enterprises (SMEs) that often provide services to larger transport organisers.

A crucial aspect of CountEmissionsEU is the verification of GHG emissions data and the underlying calculation processes. This verification process is essential for improving trust in emissions data on the market, thereby enhancing the credibility of the initiative. However, to mitigate potential burdens, particularly for SMEs, CountEmissionsEU exempts SMEs from mandatory verification requirements. This exemption aims to reduce complexity and costs for SMEs while ensuring the reliability of emissions data.

In terms of data requirements, CountEmissionsEU prioritises the use of primary data obtained from actual transport operations. However, recognising that primary data may not always be available or feasible for certain stakeholders, particularly SMEs, the initiative also allows for the use of secondary data sources, including default values and modelled data. This flexibility ensures that stakeholders have access to reliable emissions data while accommodating different resource constraints and data availability.

Furthermore, CountEmissionsEU acknowledges the importance of technical calculation tools in facilitating the adoption of its methodology among transport stakeholders. External calculation tools, such as web-based applications or software, are permitted under CountEmissionsEU, provided they adhere to the framework's requirements. Certification under the CountEmissionsEU framework ensures that these tools conform to the common reference methodology, modeling parameters, and input data standards, thereby maintaining data accuracy and consistency.

10.2.4 SGKV

The Studiengesellschaft für den Kombinierten Verkehr e.V. (SGKV), translated as the German Promotion Centre for Intermodal Transport seeks to promote the relevance of intermodal and rational transport chains. The goal of the research association is to strengthen and further develop Combined Transport by bringing the research and practice together.

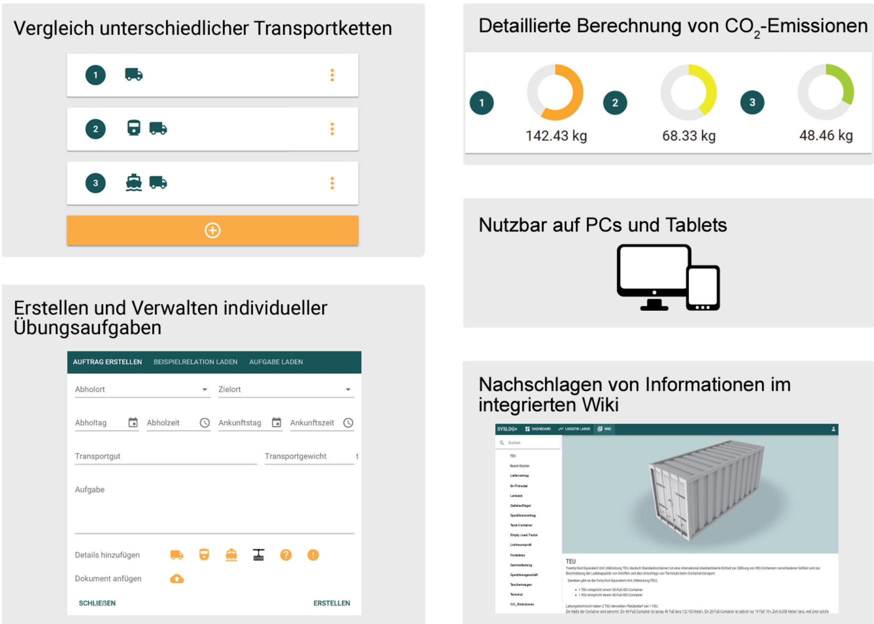


Figure 49 - SYSLOG+ as CO_2 calculator for intermodal transport

SGKV has developed the virtual logistics laboratory: it is a free online application for use in vocational training in the field of logistics. It supports the trainees to learn about Combined Transport in a playful approach. The laboratory tool allows the users to design complex transport chains and compare them on parameters such as the amount of CO2 emissions, transportation times and costs. It also provides the teachers or trainers, the possibility to create individual exercises for the transport chains that can be solved by the trainees either by themselves or in teams. The SYSLOG+ initiative has been integrated on the laboratory.

In the context of the Baltic Sea Region project COMBINE, SGKV has studied and identified the appropriate SDGs for the CT market and grouped them into the three pillars for a basic orientation as shown in the figure below.

Figure 50 - UN SDGs for CT market

The SGKV has also developed a Sustainability Practices Review toolkit to transfer such knowledge about sustainability to the CT market and allow users to easily test score their sustainability. The toolkit is based on the KPI assessment technique. Reporting on the sustainability initiative of CT stakeholders can help promote CT as the freight transport solution of the future. It also helps companies plan strategically in line with the United Nations Sustainable Development Goals discussed here.

10.3 Intermodal case studies

As early as 2003, a study carried out with EU funding - as part of the PACT program - concluded that a switch from the dominant unimodal road transport to combined road-rail transport could reduce CO_2 emissions by about 45 percent on average.

	01 Vienna - Melzo	02 Malmö - Duisburg	03 Rotterdam - Vienna	04 Cologne - Busto	05 Munich - Verona	06 Hamburg - Budapest	07 Valenton - Miramas	08 Dourges - Lyon	09 Ludwigsh. - Barcelona	10 Venlo - Poznan
Locational Properties										
Start latitude	48,14	56,68	51,95	51,01	48,18	53,51	48,91	50,66	49,44	51,44
Start longitude	16,49	16,28	4,15	6,98	11,56	9,98	2,33	3,00	7,69	5,71
Terminal 1	Vienna South Cargo Center	Malmö KT	Rotterdam RSC	Köln Eiffeltor	München Riem	Hamburg Burchardkai	Valenton	Delta 3 Dourges	Ludwigs-hafen Contargo	Cabooter rail terminal Kal-denkirchen
Terminal 2	Melzo (RCO)	Samskip Mul-timod. Termi-nal Duisburg	WienCont	Busto Arsizio-Gallarate	Verona Interterminal	Budapest Metrans	Miramas	Lyon-St. Priest	Barcelona Morrot	CLIP Contai-ner Terminal Swarzędz
Destination latitude	45,50	51,38	48,18	45,64	45,42	47,42	43,61	45,69	41,37	52,40
Destination longitude	9,41	6,68	16,47	8,84	10,92	19,05	4,99	4,91	2,17	17,12
Distances[08]										
Road transport	856 km	1166 km	1197 km	832 km	403 km	1241 km	772 km	684 km	1226 km	865 km
CT road leg 1	13 km	278 km	29 km	19 km	14 km	5 km	22 km	33 km	70 km	45 km
CT road leg 2	34 km	27 km	7 km	38 km	2 km	92 km	54 km	25 km	8 km	7 km
CT rail leg	823 km	922 km	1180 km	838 km	441 km	1208 km	709 km	631 km	1342 km	847 km

Table 15 - CO_2 study: 10 selected relations

As in Europe the environmental awareness as well as the technical possibilities have increased since this first study, the International Union for Road-Rail Combined Transport (UIRR) has conducted a recent study to investigate the current potential for saving CO_2 emissions by transporting goods door-to-door in combined transport. d-fine GmbH (Frankfurt/Germany), which was commissioned with the study, has analysed ten heavily used TransEuropean transport routes – as Rotterdam-Vienna or Ludwigshafen-Barcelona – in order to gain realistic and practical insights.

For this exercise, 23 existing CO_2 emission calculators have been evaluated according to defined criteria and finally eight have been selected and used (EcoTransit and SGKV SYSLOG) for the calculations.

The study shows that for all 10 presented relations and scenarios, a considerable CO_2 saving potential could be determined: present day door to door combined transport has the ability to save between 63% and 90% of CO_2 emissions for the respective relation compared to unimodal road transport by a Euro VI trucks. This is mainly due to mainly two effects contribute to the CO_2 savings: greater energy efficiency in general and better use of zero carbon energy.

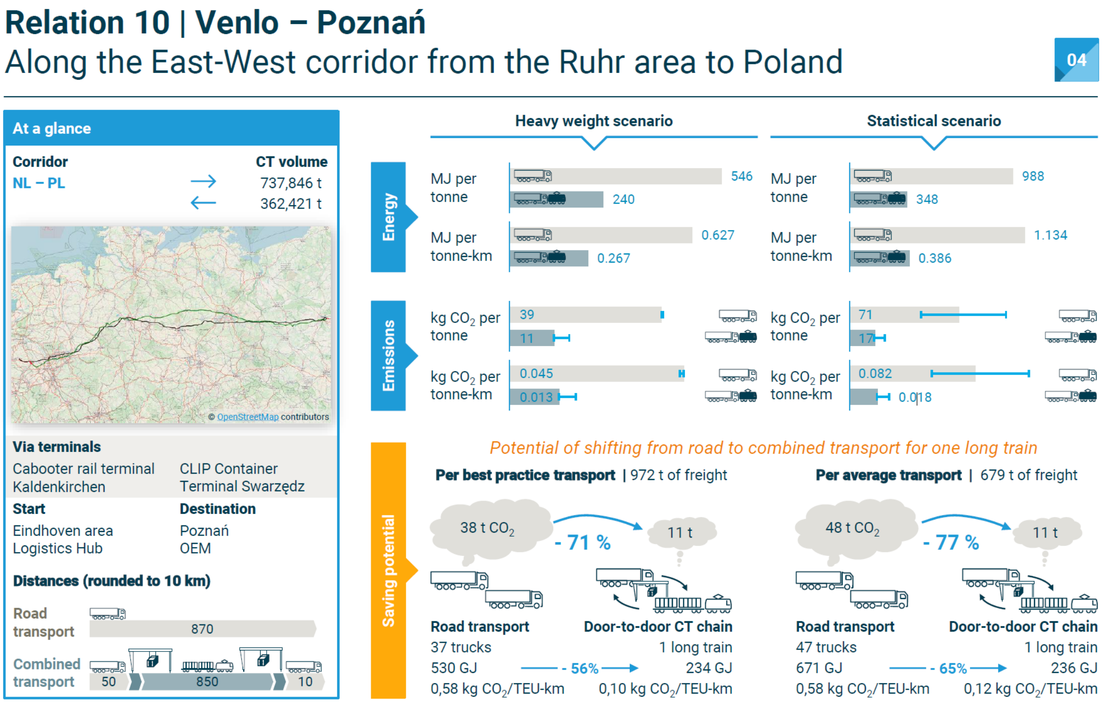


Figure 51 - CO_2 reduction and energy savings on the route Venlo (NL) to Poznan (PL)

11 Conclusions

This deliverable summarises the activities performed in Task 1.2 of the ReMuNet project. The main objective of this task was to provide an exhaustive comprehension of the complexity of the intermodal rail freight ecosystem in which the ReMuNet project is evolving. The analysis has covered aspects such as the stakeholders involved in door-to-door supply chains, the used assets (wagons, loading units and infrastructure lines), the existing vertical and horizontal transhipments technologies, the terminal network, the key components of a corridor and the sustainability performance of intermodal freight transport. Figure 52 illustrates the various components of the analysed standard intermodal freight ecosystem.

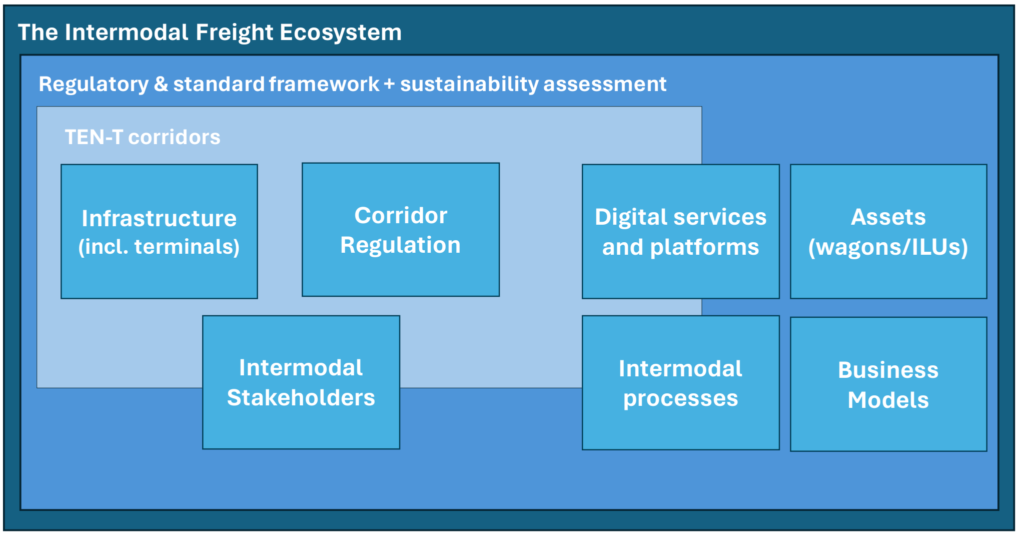


Figure 52 - The standard intermodal freight ecosystem

The standard intermodal freight ecosystem is in constant evolution thanks to regular adaptations of the current features and/or to the integration of innovative services and solutions aiming at creating the right conditions for transportation of goods in Europe. In the following section, we are pointing out the key elements that should and/or will influence the future ecosystem of intermodal transport in the next 10 years.

1. Clear evidence of the sustainable performance of intermodal rail freight transport

International and European goals have been set to face the dramatic impacts of human behaviour on the climate change. Land freight transport based on unimodal road largely contributes to the overall CO_2 emissions in the world. Different standards and tools have been developed to assess the sustainable impacts of the various transport modes. The main parameters used are energy reduction and CO_2 emissions. However, recent trends show that the external costs of transport which include not only a climate perspective but also accident, noise, well-to-tank are considered as indicators to evaluate the overall performance of the transport modes. The latest proposal of the European Commission on the Combined Transport Directive is one of such case.

Various initiatives and studies clearly demonstrate that, compared to unimodal road transport, door-to-door intermodal freight services based on railway can contribute significantly to reduce energy consumption by up to 71% and CO_2 emissions by up to 90%

(depending on the types of routing based on shorter on longer first and last mile road operations).

In case of planning, deficiencies or rerouting, door-to-door supply chains based on railway should always be considered as a viable alternative to achieve the sustainable goals set by international and European policy initiatives and legal acts.

2. Trends and drivers impacting European intermodal business models

The intermodal freight market has been characterised by four major drivers:

- **The biggest shipping companies are striving to control hinterland services by expanding their European networks**. Four shipping companies play a major role in the European intermodal market: MSC, Maersk, CMA CGM, and Cosco. All have different strategic approaches and expand their hinterland networks in different ways. The respective rationale behind all activities can be assumed to be building more and more complex networks to maintain and expand volumes and provide flexibility regarding transportation routes within owned or fully controlled systems. The result is – already today - a specific market power around hubs and respective transportation networks with often no or little alternatives. This market power can rarely be expressed through market shares, as neither transport performance nor transshipments at terminals are the key factor but the control of the whole transport chain – esp. when looked at as part of the international rail market.

- **Hinterland terminal networks are key in every operator's strategy.** While the biggest terminal operators are focused on (more or less) the operation of owned terminals as a stand-alone service, rail operators see a strategic necessity in having the control over terminal services. They are building their networks around strategic approaches to the transportation market. In this way availability as well as capacities are ensured and even under-utilisation could be accepted if it served the strategy.

- **The ongoing losses of incumbents open a wide range of opportunities for other players and limit the influence of national and European politics**. European incumbents have lost significant market shares in the past and – in a business-as-usual-scenario – this development is likely to continue.

- **Regulatory interventions are a further driver of change**. The recent decision of the European Commission against Fret SNCF shows that Europe is willing to enforce competition rules in the rail freight sector regardless of the size of an actor. This will shape the market in the future, as incumbents will have to be careful to play within the rules of competition law and strictly adhere to market rules, while on the other hand this opens opportunities for private-sector investments in markets currently shaped by incumbents.

3. Interoperability must be ensured between a large variety of assets

The analysis has shown the diversity of assets that have been designed and used to meet the customers' logistics needs and requirements. Specific wagons and transhipment technologies have been created in order to transport any types of goods and intermodal loading units.

The interoperability of all these elements are critical and essential for seamless and safe rail operations in the European Union. Interoperability in the intermodal rail transport means that the intermodal loading units may be easily handled by any types of transhipment technologies and that a train may travel freely and safely on any railway infrastructure.

In intermodal transport, a codification system based on wagons, ILUs and lines was established to facilitate and speed up the operational conveyance of ILUs in Combined Transport. This system, not yet mandatory, has been proven to be safe, simple and robust. It must be for this reason incorporated into an existing legislative framework for example by the creation of a specific TSI on Intermodal Transport that would cover all necessary components of the codification.

4. Push towards mandatory intermodal standards for infrastructure

A 'standard' or 'norm' is a technical document designed to be used as a rule, guideline, or definition. It is a consensus-built, repeatable way of doing something. Standards are created by bringing together all interested parties such as manufacturers, consumers and regulators of a particular material, product, process, or service. All parties benefit from standardization through increased product safety and quality as well as lower transaction costs and prices.

Only official recognised standardisation bodies such as for example ISO (international) or CEN (European level) can use the term 'standard' whereas industry associations such UIC may not. The European Standards published by CEN and CENELEC are developed by experts, established by consensus, and adopted by the Members of CEN and/or CENELEC. It is important to note that the use of standards is voluntary, and so there is no legal obligation to apply them. In other words, EN standards become mandatory only if they are clearly referenced in European legislation (Regulations, Directives, Implementing and Delegated Acts). This can be understood as 'legal standards'.

In intermodal rail freight, from the analysis, we can deduce the following:

- Intermodal wagons: the TSI Wagon imposed a large variety of technical elements to be met by any types of intermodal wagons including the obligation to be compliant with EN standards.
- Railway Infrastructure: the TSI Infrastructure imposes technical performance for any types of freight lines including EN standards
- Intermodal Loading Units: the design and the testing of a large variety of ILUs are covered either by ISO norms (maritime containers) or by EN standards (swap bodies, semi-trailers) but are not all directly referenced in legal acts.

Intermodal rail freight is still mostly governed by the so-called International Railway Solutions developed by the UIC. The investigation has shown that some key elements related to wagons, ILUs and infrastructure are specified in various IRS. It would be highly recommended to 'transform' some of these IRS into EN standards.

5. Towards a TEN-T network of harmonised parameters for intermodal transport

Through the Trans-European Transport Network policy, the EU aims to build an effective EU-wide transport infrastructure network including railways, roads, inland waterways, maritime routes, ports, airports, and railway terminals. Two network layers are envisaged: (1) the Core Network includes the most important connections, linking the most important nodes, and is to be completed by 2030 and (2) the Comprehensive Network covers all European regions and is to be completed by 2050.

The recent revision of the TEN-T guidelines has been proven to be extremely important towards an improved harmonized of key parameters for the intermodal transport: (1) the implementation of a **4-metre loading gauge (P400)** on sections of line used by freight trains or designated to be a bypass route in case of a traffic disturbance for freight trains, (2) a **740-metre train length** should be made possible with a 2,000 tonne gross train weight throughout the network used by freight trains, (3) a permitted **axle load of at least 22.5 tons** on the rail comprehensive network by 2050 and (4) a **full electrification** as regards line tracks and also sidings

In the chapter 7 of the deliverable D1.1, five major challenges impacting intermodal transportation have been identified: the information management and quality, the system interoperability, the information exchange, regulatory factors, and capacity management. For each of this challenge, five distinct stakeholder needs have been identified.

Based on T1.2 activities, we could complement the first initial ideas of D1.1 as follows. The different proposed elements should be integrated into the core functionalities of ReMuNet.

- **Technological factors (information management, data exchange, collaborative platforms, standards)**

  Data accessibility, quality and accuracy are indeed the most crucial components for an efficient data-sharing in intermodal transport. It is to be observed that most of the legal barriers have been removed with the adoption of several important EU legislation in the last years (TAF TSI, eFTI, EMDS…). However, it must be noticed that data-sharing and exchange of information may be in some cases limited (or even forbidden) by the intermodal customers themselves. New clauses are inserted in the contractual arrangements or data sharing agreements between intermodal customers and their service providers such as the CTOs. If such a trend would continue, a seamless exchange of intermodal data would be jeopardised, and the European legislator would need to impose a minimum set of data that all intermodal stakeholders have to agree upon.

  A unique intermodal data exchange standard for all will never exist. However, it has to be pointed out that the TAF TSI or the EDIGES exchange formats are accelerating their adoption and implementation demonstrating that a certain standardisation is in progress and that digital collaborative platforms are integrating those formats into their applications and even are mapping both formats as for example in the case of the KV4.0 platform that will accommodate both EDIGES and TAF TSI messaging.

A large variety of digital collaborative platforms have been created in the last years offering a range of services starting from booking and/or tracking functionalities towards more complex features such as CO_2 savings tools and/or intermodal route planner. Even if those services might be considered as very attractive by stakeholders such as LSPs and CTOs, they are reluctant to integrate such a platform for pricing and connectivity reasons. For pricing, the solution might be in implementing solution based on the 'data for data' principle which would allow stakeholders to exchange data through digital platforms but without paying a fee as the data are beneficial for all stakeholders using the platform. On the connectivity side, the stakeholders would like to limit the number of interfaces and the inherent costs for such connectivity. The software providers should reflect on the idea to interconnect their systems in order to reduce the number of interfaces. They should develop a kind of digital data hub connecting and integrating the various intermodal stakeholders.

An efficient data exchange is also based on agreed standardised harmonised codes (known also as reference files) easily and open to all intermodal stakeholders. These codes are either already harmonised as part of the legislation (e.g. customs, waste…) or are developed by recognised industry associations or stakeholders representing the interests of intermodal freight transport. For example, UIRR has proposed a common application (UIRR CDM) compiling all relevant codes to be used in a road-rail intermodal transport combination. A synchronisation with the ReMuNet platform could be envisaged.

For any open digital collaborative platforms, data governance is key for organisations looking to create a data-driven culture by ensuring that the right users can get to and use data they trust. To be successful, organisations need clear data governance models and rules. The acceptance of the ReMuNet collaborative platform by the intermodal stakeholders is only possible if the portal is governed and maintained by one or several recognised players of the intermodal sector.

- **Infrastructure-related factors (interoperability, assets, and standards)**

  The intermodal transport network, especially on rail, is currently facing significant challenges related to its physical infrastructure. As a result, the trains are either significantly delayed or simply cancelled. In case of re-routings, alternatives cannot be found as the interoperability between the TEN-T corridors are not yet a reality. Harmonised infrastructure parameters (train length, axle load, CT profiles) are essential for a resilient and efficient rail transport infrastructure. The ReMuNet platform could offer a standard service comparing the implementation of the TEN-T parameters on the different TEN-T corridors (based on the workplans of the various corridors) and develop an interactive map of the codified combined transport lines in Europe (based on the RINF database).

  The codification system based on wagons, ILUs and lines is a best practice developed by UIC and UIRR to be used by all intermodal stakeholders. The UIC IRS 50596-6 covering this aspect should be transformed into EN standard and should be also referenced in a newly created TSI for intermodal transport. In addition, a new EN standard on the calculation methods for the combined transport profiles should be envisaged.

The design and testing of intermodal assets such as wagons and intermodal loading units are contained in a series of well-established international and European standards. After analysis, it would be however recommended to develop the following standards: (1) an EN standard on the terms and definitions related to all types of ILU, and (2) an EN standard compiling all different markings related to all types of ILUs.

- **Regulatory factors**

The European Commission has issued a series of Regulations, Directives, Implementing & Delegated Acts to create a single European Transport Area by eliminating the barriers between modes and national systems, easing the process of integration, and facilitating the emergence of multinational and multimodal operators. The special report 08/2023 from the European Court of Auditors concluded that intermodal freight transport can still not compete on equal grounds with road transport due to regulatory and infrastructure barriers. In the same report, some important recommendations are addressed to the Commission.

The ReMuNet platform could offer to the Commission the possibility to monitor some of the key implementation such as the evolution of the modal share on all TEN-T corridors and the investments needed, the collection of intermodal data on national level based on the national country sheet developed in task 1.2 and the catalogue of the current national implementation plans for terminals.

In this context of significant changes of the intermodal freight ecosystem, it is highly recommended to reinforce the role of an intermodal transport operator by adding a clear definition into any relevant legal initiative (as for example in the proposal on the Combined Transport Directive).

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The project

ReMuNet identifies and signals disruptive events and assesses their impact on multimodal transport corridors. It reacts quickly and seamlessly upon disruptive events in real-time. It supports TMS providers to improve route planning resilience. ReMuNet communicates alternative, pre-defined, multimodal transport routes to logistics operators and subsequently to truck drivers, locomotive drivers and barge captains. Through this, it enables a faster and adaptive multimodal network response. ReMuNet orchestrates route utilisation, suggests transshipment points and optimises capacity allocation, minimising damage and shortening the recovery time. What is ReMuNet's core objective? As trailblaser for the Physical Internet, ReMuNet pursues the vision to enable and incentivise synchro-modal relay transport on European rail, road, and inland waterways to increase the holistic network resilience. It significantly reduces emissions and boosts freight transport corridor efficiency in case of disruptive events. stakeholders to ensure Europe-wide practicability and acceptance.

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	FRAUNHOFER AUSTRIA RESEARCH GMBH	FHA
	HAFEN WIEN GMBH	HWI
	WHITE RESEARCH SRL	WRE

	UNION INTERNATIONALE DES SOCIETES DE TRANSPORT COMBINE RAIL-ROUTE SCRL	UIR
	CONTARGO GMBH & CO KG	CON
	VEDIAFI OY	VED
	DANSK RODE KORS (DANISH RED CROSS)	DRC
	ILMATIETEEN LAITOS	FMI
	ALLIANCE FOR LOGISTICS INNOVATION THROUGH COLLABORATION IN EUROPE	ETP-ALICE
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