UIC FREIGHT DEPARTMENT

2022 Report on Combined Transport in Europe

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Foreword

UIC / Eric Lambert

This 8th edition of the Report is perfectly aligned with the festivities of the 100 years of the UIC and its three leading values:

"Unity, Solidarity, Universality"

Indeed, the events of the last few years have clearly shown the essential role of the rail transport mode, and of Combined Transport as the backbone of trade flows between our countries.

At a time when politicians were closing the borders in the early hours of the pandemic, Combined Transport continued to operate, thus maintaining the exchange of essential goods, and preventing the complete collapse of our economies.

Similarly, the war in Ukraine has shown how these three values are more relevant than ever.

In these dark times, we must in addition not forget the other challenges that are knocking at our door, the price of energy and climate issues, to mention only the most important.

Here too, Combined Transport is proving its relevance!

UIRR / Ralf-Charley Schultze

The current edition of the Report on Combined Transport is the second issued jointly by UIC and UIRR. It accurately reflects the increasing importance of intermodal trains within rail freight: whether in the form of shuttle trains or block trains, freight trains carrying goods contained in intermodal loading units produce every second rail freight tonne-kilometres in Europe.

Bringing about "Zero-Carbon Combined Transport" has been declared as the mission of UIRR in 2021. The uniquely dense, electrified railway infrastructure of Europe makes fully electrified Combined Transport the ideal door-to-door means of decarbonising longer distance inland freight transportation, while dramatically improving the pro-rata energy efficiency of transport chains.

The European intermodal sector has launched the CT4EU Campaign (www.ct4e.eu) to highlight the contributions that door-to-door Combined Transport can make to the greening of European freight transportation and to accompany the upcoming legislation known as greening freight package which includes the revision of the Directives on Combined Transport and on Weights and Dimensions of road vehicles, the Capacity Management Regulation and a new regulation on Count Emissions.

In 2022, European Combined Transport is on track to further advance its absolute historic peak performance achieved a year earlier, and this despite the new reality we are confronted with. Whereas market interest remains high, demand for Combined Transport is stronger than ever. The railway sector has to make sure that it remains capable of supporting Combined Transport's unabated growth. Capacity is key.

The 8th Edition of the Report on Combined Transport will contribute to the understanding of transport policymakers and railway sector decisionmakers of the strong capabilities and unique needs of Combined Transport.

UIRR hopes that an improved understanding will bring about greater support and the ultimate solution to Combined Transport's growth-impeding railway challenges.

European Combined Transport market – facts and figures

Note on the Methodology and the Approach

This report presents an elaborated view on the Combined Transport (CT) market (focus on Road - Rail and Road - Inland Waterway), volumes, current and future developments within Europe. For this purpose, several data sources were collected, consulted, pooled and validated.

In addition to the evidence-based view on CT and the corresponding insights of the CT market, three focus themes were selected and pursued:

- The digitalization in Combined Transport
- A study of the costs of Combined Transport and a comparison with other modes
- Analysis of the potential Impacts of a revised Weights & Dimensions (W&D) Directive on CT

The data was collected through two distinctive surveys sent out to relevant European CT market participants such as CT operators, logistics service providers and loading units operators. Participants were asked to share their individual data on CT activities in terms of volumes and geographical scope, as well as their assessment of future prospects, policies and challenges in CT. In collecting the data, attention was paid to monitoring and verification. The data collection compensates for the lack of an existing comprehensive and comparable database of the European CT market.

For this reason and to provide a solid methodological basis, this report also relies on several additional sources, which have been taken into account for a plausibility check:

- Data and views obtained through workshops and personalised interviews.
- A cross-check with the UIRR and UIC database
- Desk research with relevant data sets and statistics for the different market segments
- The Eurostat database

The figures presented for Europe refer to all European Member States that share their data with Eurostat. The reference year is set to 2021. The term “Intermodal rail freight transport” is used in the Eurostat database but is closely related to Combined Transport as it is defined by Eurostat as “multimodal transport of goods, in one and the same intermodal transport unit by successive modes of transport without handling of the goods themselves when changing modes”[1]. Combined transport is a specific form of intermodal transport in the sense that the main leg of the trip should be done by rail or IWT, with only the first and/or last mile done by road.

Furthermore, the approach also follows the methodology of the previous reports, ensuring continuity and comparability of market volumes and development. However, data in Eurostat and other tables have been updated retrospectively and are corrected to the most recent and complete dataset as possible. Therefore, historical figures may differ from timelines in previous reports. Data from the surveys were anonymously processed and are always presented as aggregated figures.

[1] Source: Eurostat (2019): Glossary for transport statistics. 5th edition.

Definition, market structure and key elements of Combined Transport

Goods can be moved using a single transport mode (unimodal transport), or in a sequence of multiple modes (multimodal transport), as goods are transhipped or transloaded between modes. Intermodal transport is a specific form of multimodal transport whereby the goods are only handled at the origin and destination, whereas during a mode change at an intermodal terminal, only the loading unit (container, swap body, semi-trailer) is handled. Combined Transport is a further specification of intermodal transport, where the major part of the journey is by rail, inland waterway (IWW) or short-sea shipping (SSS), and the initial and/or final legs are carried out by road that are kept as short as possible. Combined Transport is acknowledged and supported in EU legislation through the **Combined Transport Directive** (**Council Directive** 92/106/EEC). In order to promote this form of intermodal transport, clear minimum eligibility requirements read as follows:

Combined Transport means the transport of goods:

- between Member States where the lorry, trailer, semi-trailer, with or without tractor unit, swap body or container of 20 feet or more uses the road on the initial or final leg of the journey and, on the other leg, rail or inland waterway or maritime services where this section exceeds 100 km as the crow flies and makes the initial or final road transport leg of the journey;
- between the point where the goods are loaded and the nearest suitable rail loading station or inland port for the initial leg, and between the nearest suitable rail unloading station or inland port and the point where the goods are unloaded for the final leg;
- within a radius not exceeding 150 km as the crow flies from the inland waterway port or seaport of loading or unloading.

Clearly, this way of transport has many advantages as it contributes to the modal shift of freight transport from road to rail or inland waterways, and as such, it is a great advance in the commitment to the Green Deal and to the Sustainability Developments Goals in the EU. These advances are of great importance to Europe from an economic, environmental and health perspective. Combined transport reduces pollution, climate change, noise, congestion and road accidents. For that reason, the support of the EU to combined transport is paramount and logical.

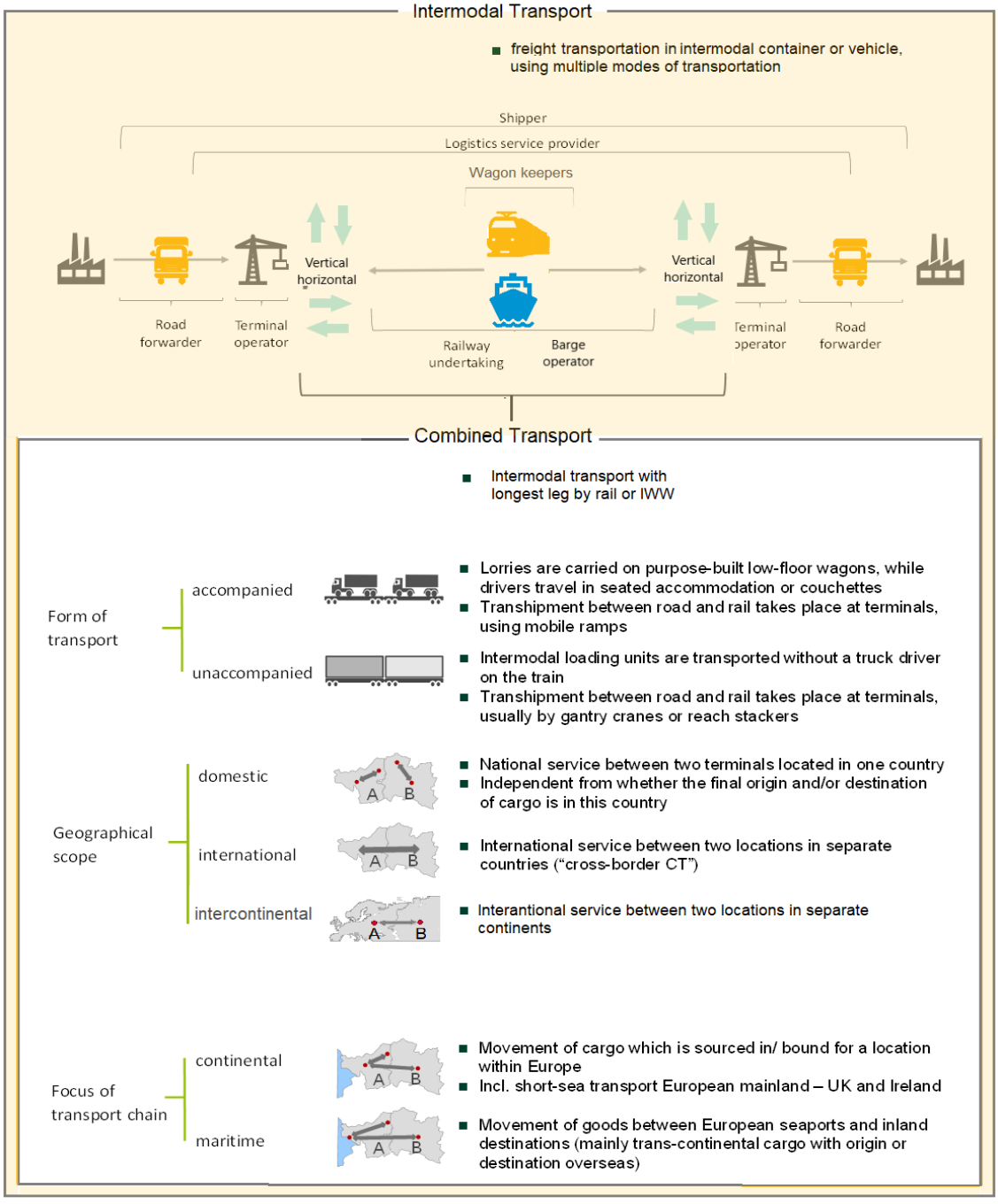
Freight transport grows and road freight transport is projected to increase by around 40% by 2030 and by little over 80% by 2050[2]. The EU transport policy aims therefore at reducing road transport towards less polluting and more energy efficient transport modes.

The CT Directive seeks to promote Combined Transport operations through the elimination of authorisation procedures and quantitative restrictions for these operations; it clarifies that the cabotage restrictions on road journeys do not apply; and it provides financial support through fiscal incentives. The CT Directive is supported by other EU policies, such as the Weights and Dimensions Directive (Council Directive 96/53/EC) which is the process of revision (see chapter “The revision of the Weights and Dimensions Directive”). The Directive holds a conservative definition of Combined Transport. In the remainder of the paper, we consider Combined Transport to be intermodal transport with the longest leg, the rail or IWW leg and the truck leg the shortest. Combined Transport will relate with intermodal transport and the Eurostat tables of multimodal transport are used as an estimation of combined transport when no numbers were available.

[2] European Commission, Multimodal and combined transport, text retrieved from https://transport.ec.europa.eu/transport-themes/logistics-and-multimodal-transport/multimodal-and-combined-transport_en.

Different types of Combined Transport can be distinguished by the form of transport, the geographical scope of the service, and the focus of the transport chain. Based on these aspects, six different market segments of Combined Transport can be determined, described in Figure 1.

Figure 1: Overview of market segments in Combined Transport



Source: Own representation.

The first split is with regard to the proximity and role of the truck driver with respect to the load unit. This role often depends on the **form of transport**. The freight movement can be carried out in one of two ways:

- Accompanied, which means the truck driver drives the freight to the terminal and travels by train or ship along with the truck or the tractor unit all the way to the offloading terminal.
- More often however, the transport is carried out unaccompanied, whereby the intermodal load units are transported without a truck driver or without a tractor unit on the train or vessel.

Secondly, Combined Transport can be distinguished by its **geographical scope** of the loading unit.

- The transportation services can be conducted domestically with the origin, destination and intermediate terminals entirely located on the territory of a single country.
- Alternatively, the trip can be international, crossing border between countries.
- Then again, the trip can be intercontinental, crossing borders between Europe and Asia.

In specific cases, it is difficult to define the primary origin and/or final destination of a shipping as the first and last terminal operating in the CT process are not always the beginning or end of the journey.

The last differentiation is the **focus of the transport chain** and distinguishes between the origin of the transported intermodal loading unit.

- Continental CT or hinterland CT transport is characterised by the fact that it both originates from and is destined for a country within Europe (including short sea).
- Maritime CT involves transcontinental shipments via a deep-sea link. As such, this form of CT always has its (European) origin or destination in a major seaport. It is known as the hinterland transport of maritime ports.

The transport chains

The goods, transported in intermodal loading units (ILUs), travel a long way before they arrive at the final destination which can be an industry, business or a customer. In CT, a lot of actors are or can be involved. Actors are the operators, shippers, carriers, railway undertaking, barge operator, infrastructure manager, wagon owners/keepers, logistic service provider, terminals, and authorities.

1. **Shippers:** companies responsible for organising and transporting goods from one point to another – often they are the owner of the cargo.
2. **Logistics service providers (LSPs):** outsourced companies that provides supply chain management services such as transportation, warehousing or distribution services.
3. **CT operators:** companies who offer the services of carriage by more than one mode of transport. CT operators active in Rail-Road CT usually take the commercial risk and obtain transport capacities from railway companies with volumes ranging from a wagon-by-wagon basis to block trains.
4. **Railway undertakings:** companies which provide traction services for the transport of goods and/or passengers by rail.
5. **Barge operators:** companies that operate freight vessels on inland or coastal waterways.
6. **Wagon owners/keepers:** companies owning wagons and providing or renting them to railway undertakings.
7. **Terminal operators:** Typically, inland terminals focus on CT. They have terminal handling activities moving the goods from one mode of transportation to another mode. Vertical transhipment technologies like gantry cranes and reach stackers are usually handling containers, but several horizontal container loading systems exists nowadays. (See EU study on transhipment technologies[3]).
8. **Infrastructure manager:** is responsible for the design, installation, and maintenance of railway or IWW infrastructure.

[3] https://transport.ec.europa.eu/news/study-analyses-transhipment-options-more-competitive-intermodal-transport-and-terminal-capacity-ten-2022-05-05_en

European Rail/Road/IWW CT market – facts and figures

Freight is moved by ships across the deepsea and shortsea routes, by vessels along inland waterways, and by rail and by road over land. In this section, the structure of the freight transport market in the EU is depicted by a number of general overview charts. Analysis is based on Eurostat and data from surveys conducted by TML among CT operators. As a general remark, it is noted that Eurostat does not distinguish combined transport specifically in its datasets – it only presents data on intermodal transport.

Modal split

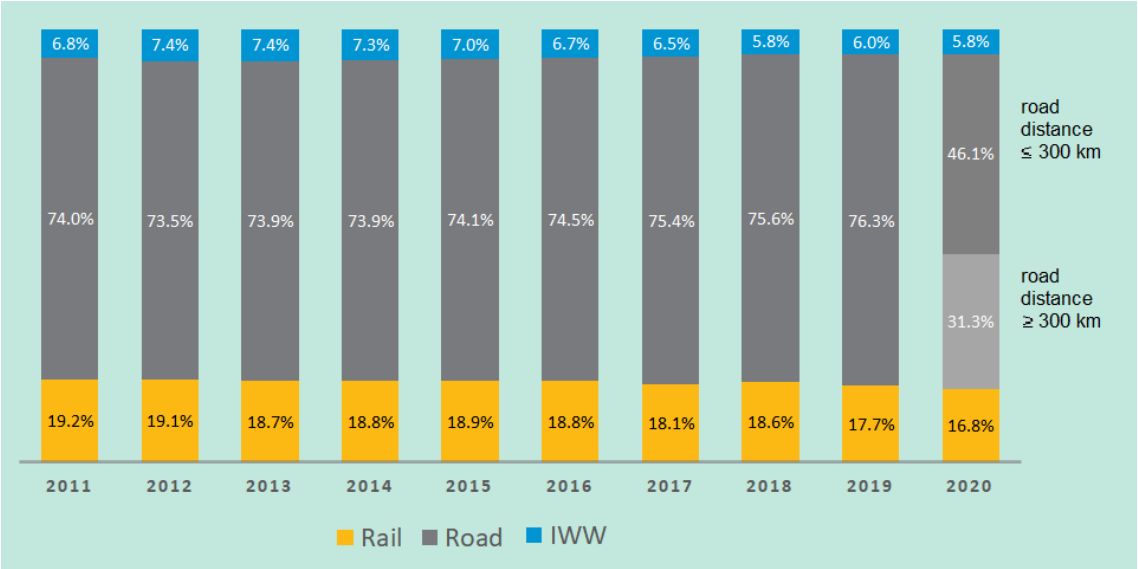
The modal split of the main freight transport modes in the EU is depicted in **Figure 2**. The modal split trend is characterized by stable shares for more than a decade with more or less 6% for IWW, 18% for rail and 75% for road. Although these shares remain more or less constant, there is a great potential to shift a considerable portion from road to the other modes of freight transport. 31.3% of all road freight transport take place in containers over a distance of more than 300 kms[4], and can therefore be considered as the market potential for Combined Transport.

Rail freight transport and inland waterway had a market share of 16.8% and 5.8% respectively in 2020 (see **Figure 2**), continuing a decreasing trend of the past years. Although the share of road transport rises compared to the shares of rail and waterways, all modes of freight transport have grown in absolute volume.

The decrease in rail's share in the modal split from 2011 to 2019 was 1.5% in pre-corona time. Although the share declined slightly, the total volumes for rail have increased from around 384 million tonne-kilometre in 2011 to more than 408 million tonne-kilometre in 2019. According to Eurostat[5], the volumes took a dive in the corona year 2020 to 380 million tonne-kilometre, but a rebound is noticed in 2021 reaching volumes of 411 million tonne-kilometre for rail freight transport in Europe.

[4] Eurostat table: TRAN_IM_MOSP: https://ec.europa.eu/eurostat/databrowser/view/tran_im_mosp/default/table?lang=en
[5] Eurostat table RAIL_GO_TOTAL: https://ec.europa.eu/eurostat/databrowser/view/rail_go_total/default/table?lang=en

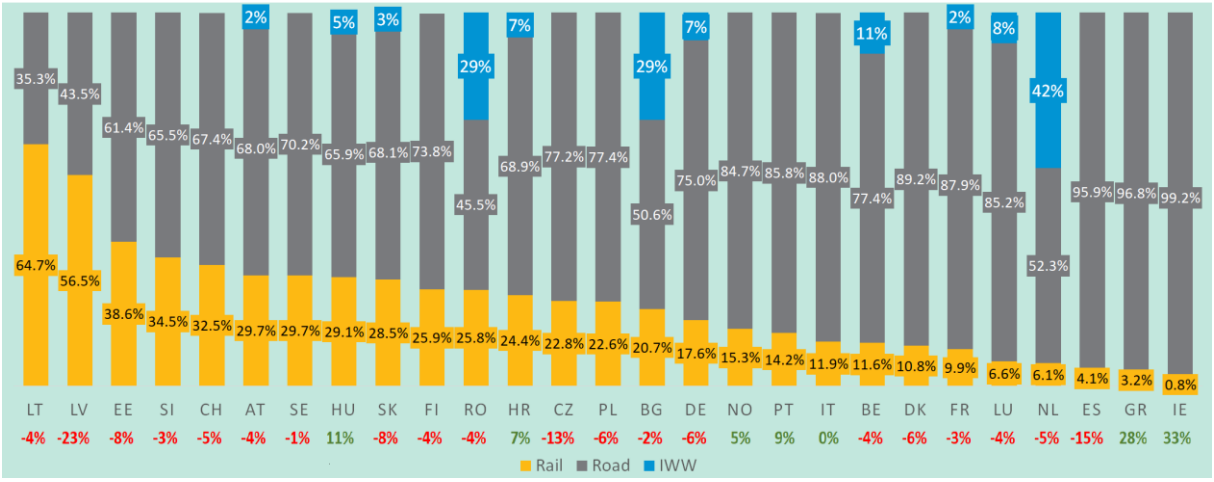
Figure 2: Development of modal split of European freight transport (in % of tkm)



Source: Eurostat (2022), last database update by Eurostat: modal split of freight transport (tran_hv_frmod) on 20 April, Modal shift potential of long-distance road freight in containers - tonne-kilometre [TRAN_IM_MOSP] on 28 Mars.

This general overview is the result of very distinct patterns in national figures. The modal split per country is lined up in **Figure 3**. It shows that there are substantial differences between European countries and in particular that the share of rail freight transport varies considerably. The range of the modal split of the rail share fluctuates from 0.8% in Ireland to maximum of around 64.7% in Lithuania. There is variation in growth with respect to the modal split from the year before, 2019. The growth from 2019 to 2020 for each country is shown below the bars in green percentages for growing tkm and red percentages for decreasing tkm.

Figure 3: Modal split in 2020 for 27 European countries

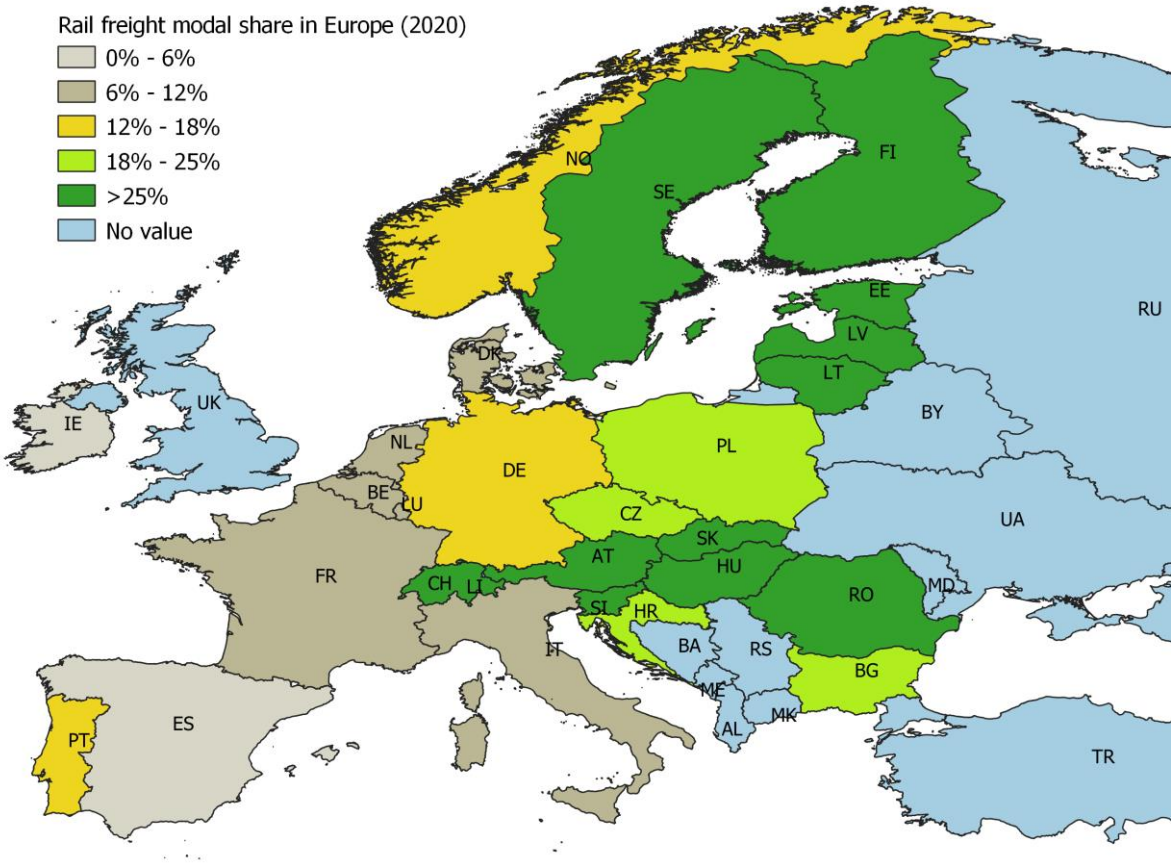


Note: Selection of countries based on data availability.
Source: Eurostat (2022), last database update by Eurostat: modal split (tran_hv_frmod) April 20, 2022.

While in some countries such as Latvia, Spain, Czech Republic and Hungary, there have been large shifts in the share of rail freight transport (up or down), the general trend in most other countries is a decrease of market share of around 5%.

The illustration of the data on a map of Europe (see **Figure 4**) shows that the market share of rail freight transport is higher in Northern and (mainly) Eastern Europe, continuing a historic trend.

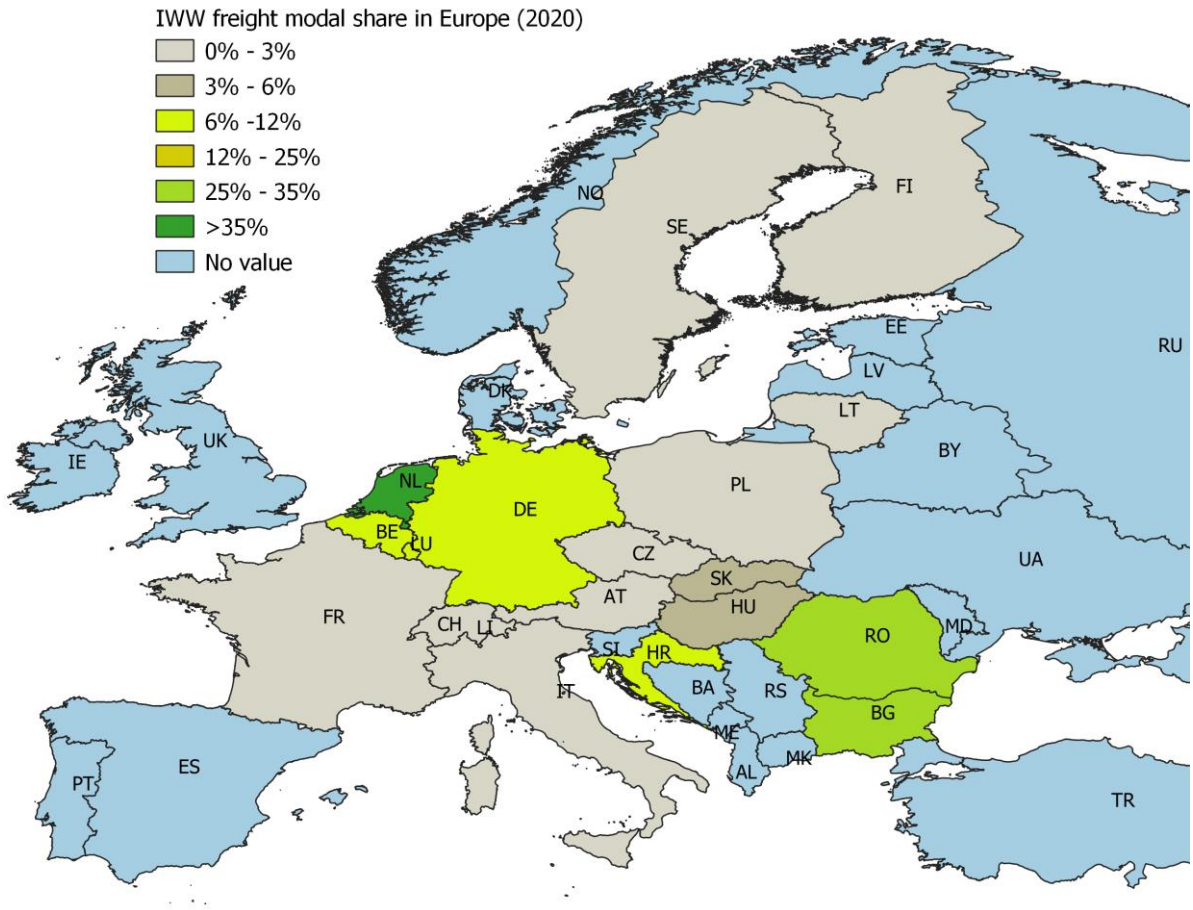
Figure 4: Map of rail modal split of freight transport in Europe by country in 2020 (% in total inland freight tkm)



Source: Eurostat (2022), last database update by Eurostat: modal split (tran_hv_frmod) April 20, 2022.

The modal split share of IWW is shown on a map of Europe in **Figure 5**. The presence of navigable waterways is obviously a deciding factor for the existence of IWW transport, but even between those countries, it is notable that market shares are either low or very high. There are no countries with an IWW freight transport share between 12% and 25%, but there are multiple countries with a share lower or higher. The Netherlands has the highest IWT modal split at 41.6% in 2020.

Figure 5. Map of IWW modal split of freight transport in Europe by country in 2020 (% in total inland freight tkm)



Source: Eurostat (2022), last database update by Eurostat: modal split (tran_hv_frmod) April 20, 2022.

Rail freight transport data

The total European rail freight performance in million tonne-kilometres has remained relatively stable in the past decade. **Figure 6** demonstrates the relative evolution of the volumes of rail freight in tonne-kilometre with base year 2011. Rail growth has been stable since 2011, except for a dip in 2019 that was likely reinforced by the COVID19 situation in 2020. However, 2021 shows signs of recovery. The dashed virtual lines show the continuation of the trend in case the corona crisis would not have happened. These virtual trendlines demonstrate that there is further recovery expected in the coming years knowing the corona crisis but it might be held back because of the Ukraine war and the energy crisis. Intermodal transport is experiencing great growth compared to rail freight in general. Intermodal transport experienced an overall growth of approximately 50 % in terms of tonnes-kilometre by 2021. Since 2020 this increase has added up to 12.4% in recovering from the corona period[6]. Similar observations can be made for the trend in tonnes. Overall, the growth in intermodal transport results in a total volume of nearly 363 million tonnes and about 135 billion tonne-kilometres transported by rail throughout Europe in 2021, accounting for 33% of the total rail freight volume (in terms of tkm).

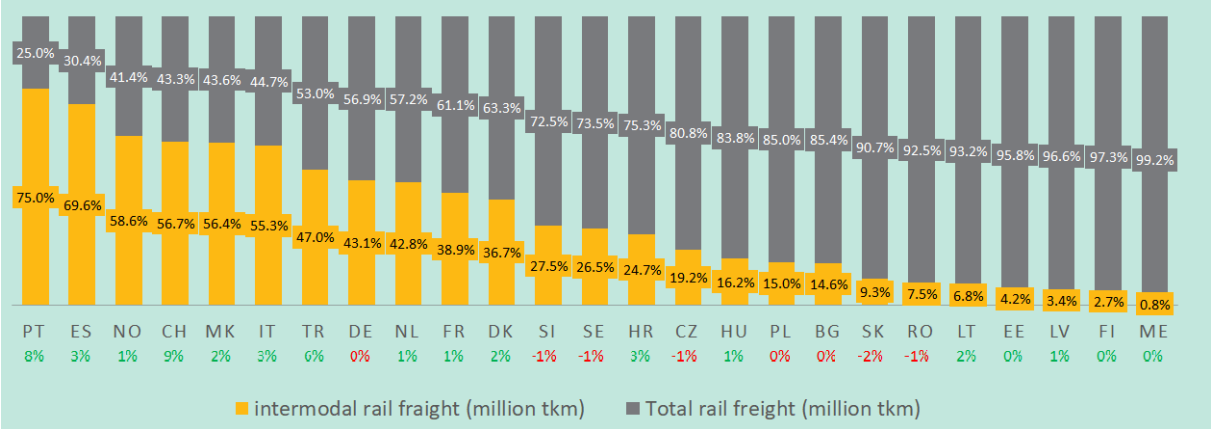
[6] Methodological remark: The numbers are based on the Eurostat database. Imputation was used for 5 countries lacking values in 2021. Imputation was done by extrapolating the year 2020. The volume of the imputed numbers is less than 3% of the total volume.

Figure 6: Development of total rail freight performance vs. rail transport of goods in intermodal transport units in Europe (Index 2011 = 100)

Source: Eurostat (2020), last database update by Eurostat: intermodal rail freight (rail_go_contwgt) 21 July 2022, total rail freight (rail_go_total) 21 July 2022.

In 25 selected European countries, the share of intermodal rail freight transport varies considerably (see **Figure 7**). While in Latvia and Finland (countries with high modal shares for rail freight as a whole) the share of intermodal rail freight transport was only 1% of total rail freight transport in 2021, in Spain and Portugal (where rail has a low modal share) this figure is close to 75%. On average, the share of intermodal rail freight transport in total rail freight in Europe was around 30%. With regards to the year 2021, we see a strong rebound compared to the corona year 2020. Developments can be observed in the intermodal market. While in some countries the share of intermodal services has not changed, growth has been recorded in most countries. In Portugal a strong increase of +8% is expected for the year 2021, but this is mainly due to a decrease in total rail freight transport for 2021 compared to 2020. In most countries, rail freight transport is increasing, and intermodal rail freight even more so. While countries such as Spain, Norway and Portugal have a high percentage of intermodal freight transport, their rail freight sector is only of minor importance compared to road transport (see **Figure 3**). Conversely, Lithuania shows a high modal split in rail freight of 65%, of which only 7% is accounted for by intermodal rail freight.

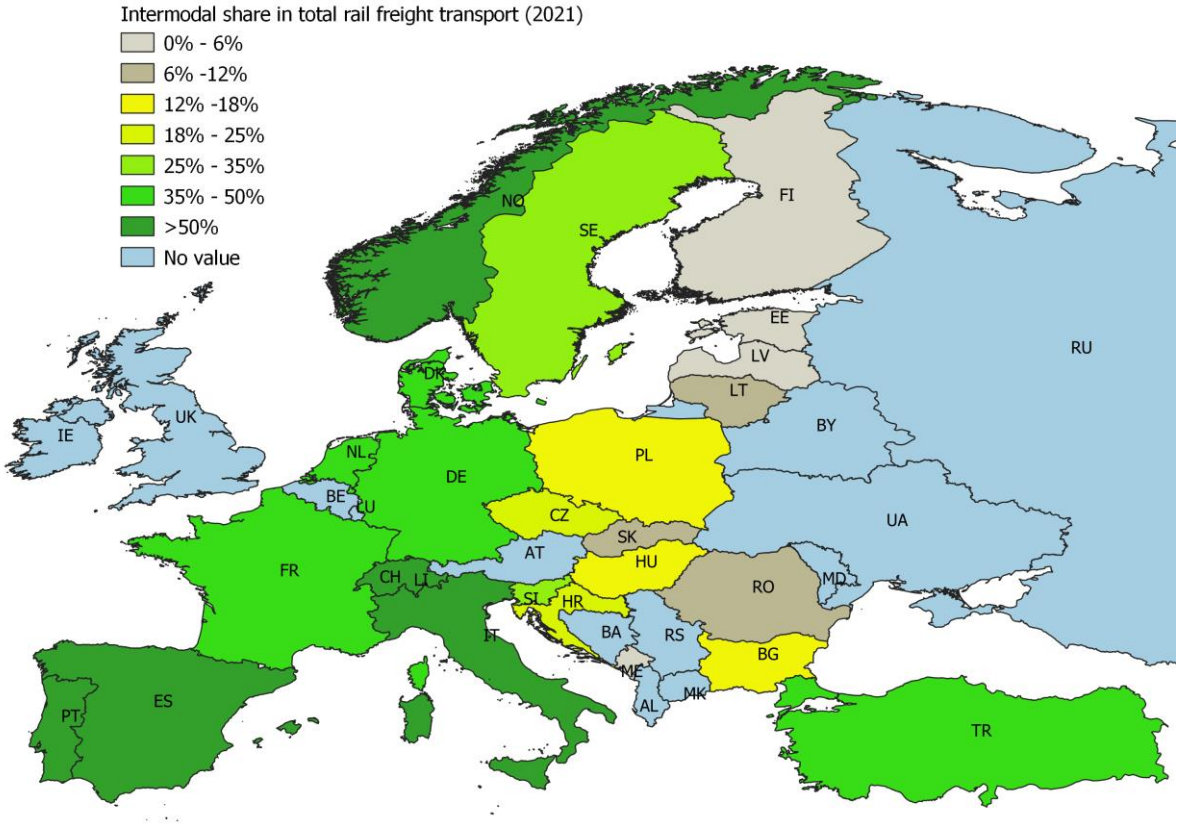
Figure 7: Share of intermodal rail freight (in tkm) for European countries in 2021



Source: Eurostat (2022), last database update by Eurostat: intermodal rail freight (rail_go_contwgt) 21 July 2022, total rail freight (rail_go_total) 21 July 2022.[7]

This inverse relation between modal rail freight share and the share of intermodal transport can also be concluded from the differences between the **Figure 7** and **Figure 8**. While the Eastern countries have the largest modal share for railway transport, they have a lower intermodal share. The Middle and Western countries in Europe have larger shares for intermodal rail freight transport but only a modest rail freight modal share with respect to all modes of freight transport. The presentation of the data collected on a map of Europe illustrates that there are strong geographical differences. Countries like Italy, Switzerland, Germany, Denmark, the Netherlands, and France have an intermodal rail freight share of more than 35%.

Figure 8: Intermodal rail freight transport in Europe (% in total rail freight tkm) in 2021



Source: Eurostat (2022), last database update by Eurostat: intermodal rail freight (rail_go_contwgt) 21 July 2022, total rail freight (rail_go_total) 21 July 2022.

[7] We used imputation for Portigal (PT), Montenegro (MT), North Macedonia (MB), Finland (FI), Estonia (EE) and Denmark (DK)

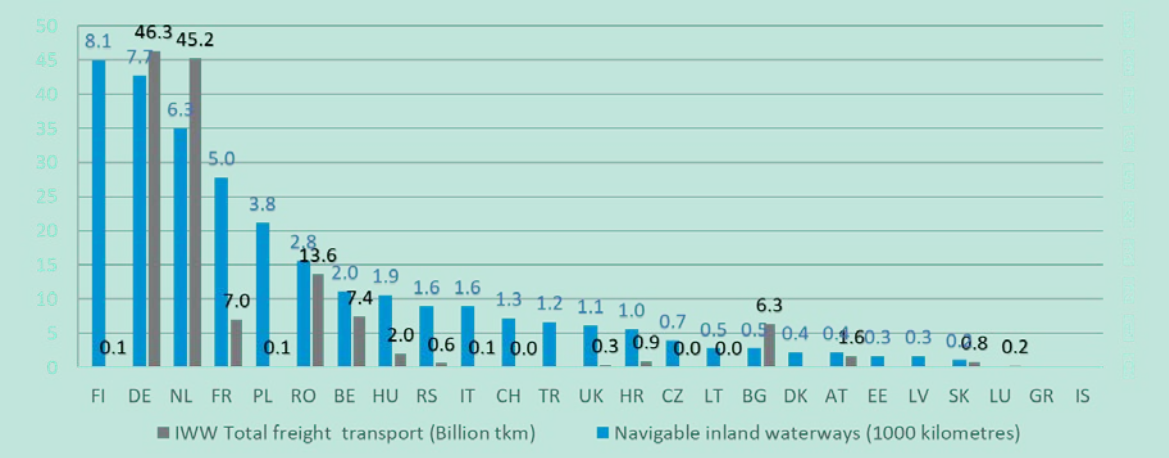
Inland Waterway freight transport data

Inland waterway transport concerns any movement of goods using navigable rivers, canals, lakes and sometimes estuary trajectories. Different type of vessels is used such as barges, tankers, coupled convoys, motorised (self-propelled) or pushed. Tankers transport liquids or gases and are therefore not used in combined transport. Barges are generally used to transport either dry bulk goods, or containers, and in the latter case, are usually part of a CT chain. Given the amount of containers that can be moved by a single vessel, they are mostly transhipped in intermodal terminals and then transported to their final destination using trucks (or vice versa).

In **Figure 9** and **Figure 10**, only statistics of navigable inland waterways are reported (i.e. not including short sea). Multiple sources were used. Inland waterway transport statistics are mainly based on Eurostat data. Gaps are filled with UNESCO data and data from the website "www.nationmaster.com".

In **Figure 9**, the total length of navigable waterways per country is indicated. This number provides an idea of the available infrastructure, natural and manmade, to carry vessels for the transportation of goods. Countries like the Netherlands and Germany have the largest total networks. Countries such as Finland and Poland have extensive (natural) waterways as well, but they are mostly not accessible for large commercial vessels, leading to low transport volumes. Germany and the Netherlands have the highest IWW freight transport volumes in Europe. Expressed in tonne-kilometre, volumes are almost equal, but when volumes are expressed in tonnes (without including distance), the Netherlands have twice as much volume than Germany (not displayed in the figures). In particular, the Netherlands make extensive use of their waterways with respect to their geographical surface area, i.e. over short distances. They have a modal split for IWW of more than 40%.

Figure 9. IWW infrastructure navigable waterways length (kilometres) and the total IWW transportation of goods per country (million tkm) for the year 2020



Source: Eurostat (2022), last database update by Eurostat: Transport by type of good (IWW_GO_ATYGO) 14 July 2022, data retrieved from "https://w3.unece.org/PXWeb/en/Table?IndicatorCode=55" and from "https://www.nationmaster.com/country-info/stats/Transport/Waterways#countryon" the 5 August 2022

When looking at the share of IWW transportation of goods in containers, the four countries with the highest container loads are the Netherlands, Germany, Belgium and France, all located in the extended Rhine basin. Other countries (namely those in the Danube area) did not report container load to Eurostat or have low volumes. The transportation of goods in containers for these four countries are depicted in **Figure 10**. These high numbers of loaded vessels with containers are associated with the maritime ports of Antwerp, Rotterdam and Hamburg. The share of container transport varies from 0 to 13% among states in Europe.

Figure 10. IWW transportation of goods in containers and goods not in containers for the year 2021 for the top four highest container IWW transport countries.

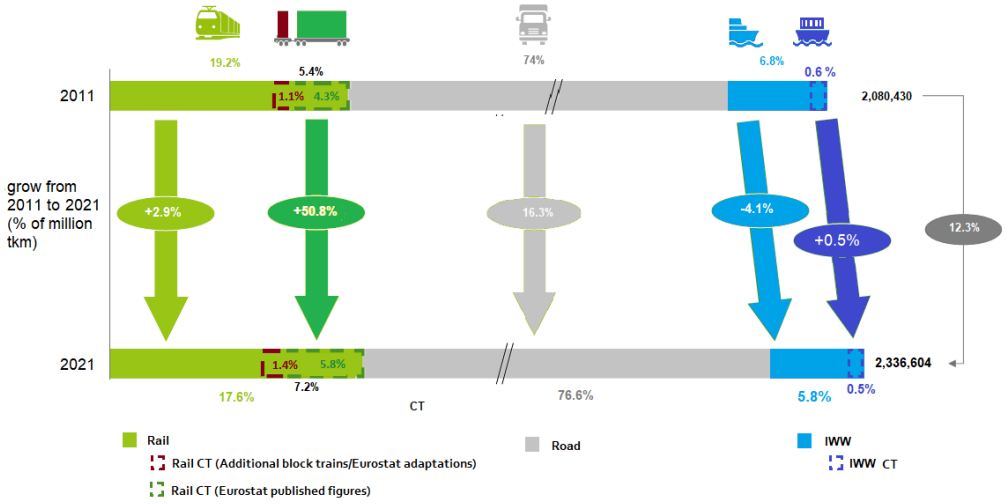
(Share of loaded container transportation with respect to total IWW freight transport are depicted by orange diamonds)

Source: Eurostat (2022), last database update by Eurostat: Transport by type of good (IWW_GO_ATYGO) 14 July 2022, data retrieved from "https://w3.unece.org/PXWeb/en/Table?IndicatorCode=55" and from "https://www.nationmaster.com/country-info/stats/Transport/Waterways#countryon" the 5 August 2022

Intermodal freight

In **Figure 11**, multiple shifts are exposed between the year 2011 and 2021 for the major freight transport modes (rail, road and IWW). Intermodal transport is depicted as parts of the rail freight transport and IWW transport, respectively. The growth percentages in the arrows represent relative growth of the freight transport in tkm from 2011 to 2021. From **Figure 2** we know that the railway activity has recovered a great deal from the Corona crisis, but some positive developments are still expected.

Figure 11: Share of intermodal and total freight in the overall modal split (in million tkm) and percentage growth (in million tkm)



Source: Eurostat (2022), last database update by Eurostat: modal split (tran_hv_frmod) April 20, 2020, intermodal rail freight (rail_go_contwgt) 21 July 2022, total rail freight (rail_go_total) 21 July 2022, Annual road freight transport by type of cargo and distance class (ROAD_GO_TA_TCRG, 12 july 2022, Transport by type of good (IWW_GO_ATYGO), 14 July 2022.

Important remark

The main message from Figure 11 is that Combined Transport has grown with more than 50% over the last 10 years. From the official Eurostat transport database, the share of 4.3% in 2011 has grown to 5.8%. As already mentioned in the previous report, this relative share of 5.8% is underestimated due to probable reporting errors by several Member States. From bilateral exchanges with Eurostat's experts, it has been confirmed that a certain number of trains currently categorised as "block trains" should most probably be allocated to 'intermodal trains' which will thus increase the total number of TKM for intermodal transport. Our own analysis, based on our market surveys, estimates the actual market share of intermodal transport at around 7.2% in 2021: it is assumed that at least 25%-30% of the TKM categorised as "block trains" should be transferred to "intermodal trains".]

Specific Combined Road-Rail Transport data

Clearly, the Combined Transport sector has developed strongly in the past 10 year (see **Figure 2** and **Figure 11**). In this section, the different CT market segments are analysed.

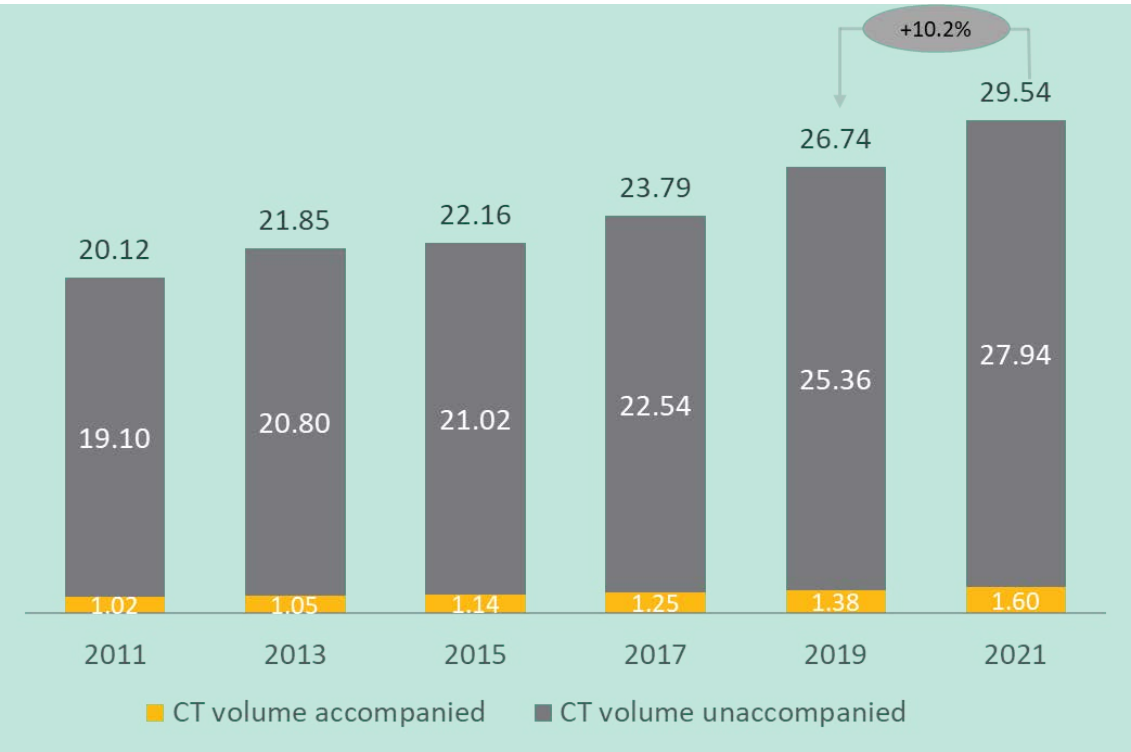
The sources for the data presented below are a survey run by TML, UIC and UIRR among stakeholders in the CT sector (CT operators, terminal operators, railway undertakings), as well as internal data collection by UIRR among its members. This section will share the results of the data collection efforts on traffic volumes for different types of Combined Transport.

Total Road-Rail CT volumes

Figure 12 and **Figure 13** show the evolution of Combined Transport volumes between 2011 and 2021, in TEU and in tonnes, split according to whether the transport was accompanied (RoLa) or unaccompanied (UCT). Despite a worldwide difficult momentum, CT has grown by 10% (expressed in TEU) or 16% (expressed in tonnes) since 2019. The discrepancy between these figures suggests that loading units are becoming relatively heavier, trip distances are becoming shorter, or a combination of both. Growth is the strongest in the market for unaccompanied transport.

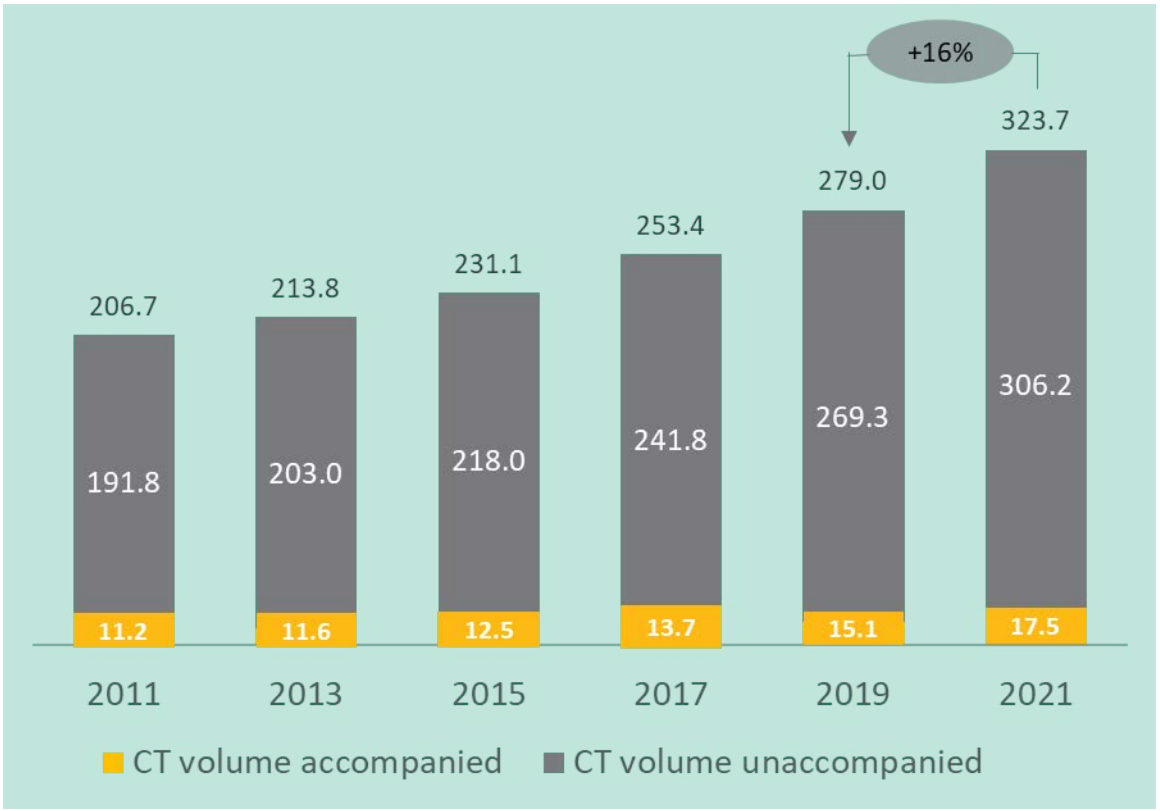
Since 2011, CT has grown by around 43% in TEU, and 57% in tonnes. A significantly larger part of the growth in tonnes was realised since 2015 compared to the growth in TEU. An explanation could be the weight derogation for Combined Transport that was instated in 2015 by an amendment of the Weights and Dimensions Directive for road transport (Council Directive 96/53/EC), which allowed 2 to 4 tonnes of additional weight for containers in the road leg of intermodal transport.

Figure 12: Development of total CT volumes 2011 to 2021 (in million TEU)



Source: TML analysis based on survey, UIRR data and Eurostat.

Figure 13: Development of total CT volumes 2011 to 2021 (in million tonnes)



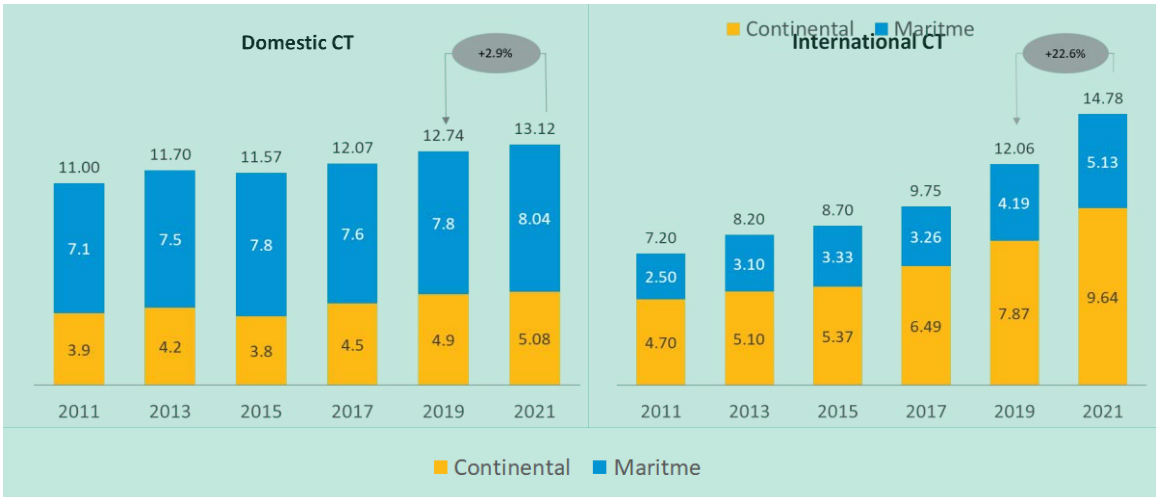
Source: TML analysis based on survey, UIRR data and Eurostat.

Unaccompanied Road-Rail CT

Unaccompanied CT remains the most significant market in CT. A further distinction can be made between domestic and international transport, and between continental and maritime CT. **Figure 14** and **Figure 15** show the relative evolutions in these markets since 2011, again with a separate view for TEU and for tonnes. Domestic transport represents around 45% of the market, both in TEU and in tonnes. However, this share has been decreasing, with only a moderate growth (15-20% over 10 years). The international market has experienced a much stronger increase, more than doubling in volume since 2011.

The domestic market is dominated by maritime transport – moving sea containers from the port to inland terminals. Around 60% of maritime containers moved by Combined Transport do not cross a country border. In international transport, there is no major difference in growth between continental and maritime CT; continental transport maintains a share of around 2/3.

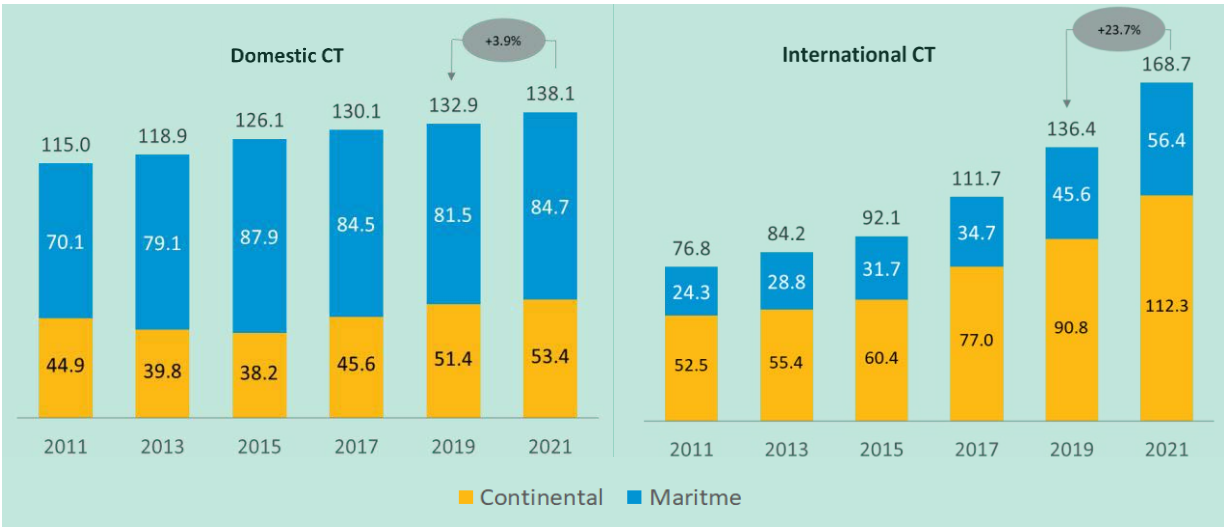
Figure 14: Development of domestic and international unaccompanied CT 2011 to 2021 (in million TEU)



Note: The split in continental and maritime is estimated on the year 2020

Source: TML analysis based on survey, UIRR data and Eurostat.

Figure 15: Development of domestic and international unaccompanied CT 2011 to 2021 (in million tonnes)



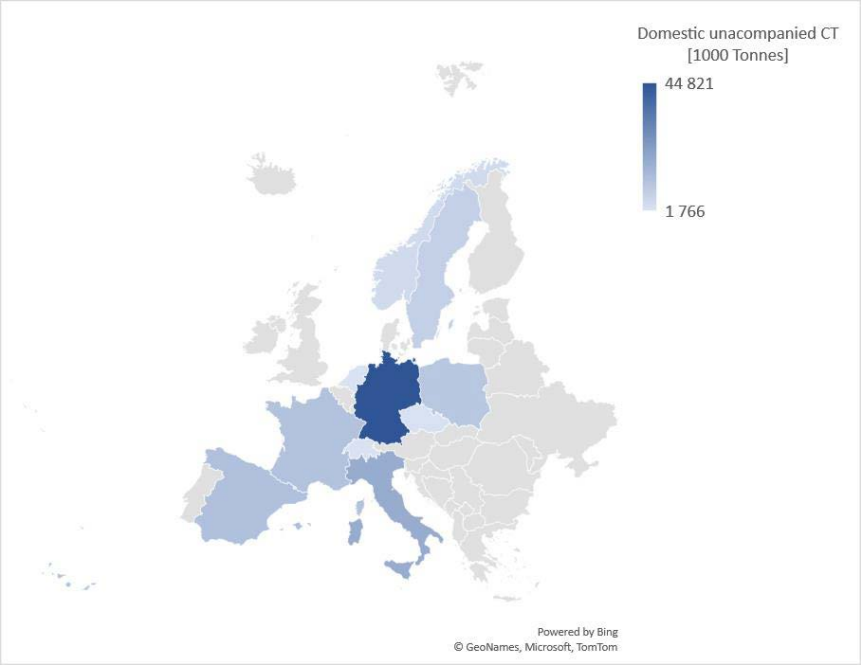
Note: The split in continental and maritime is estimated on the year 2020

Source: TML analysis based on survey, UIRR data and Eurostat.

It should come as no surprise that the largest countries also make up the largest markets for domestic transport, with Germany and Italy as the leaders – both countries also having several major seaports where maritime cargo can enter or leave the country.

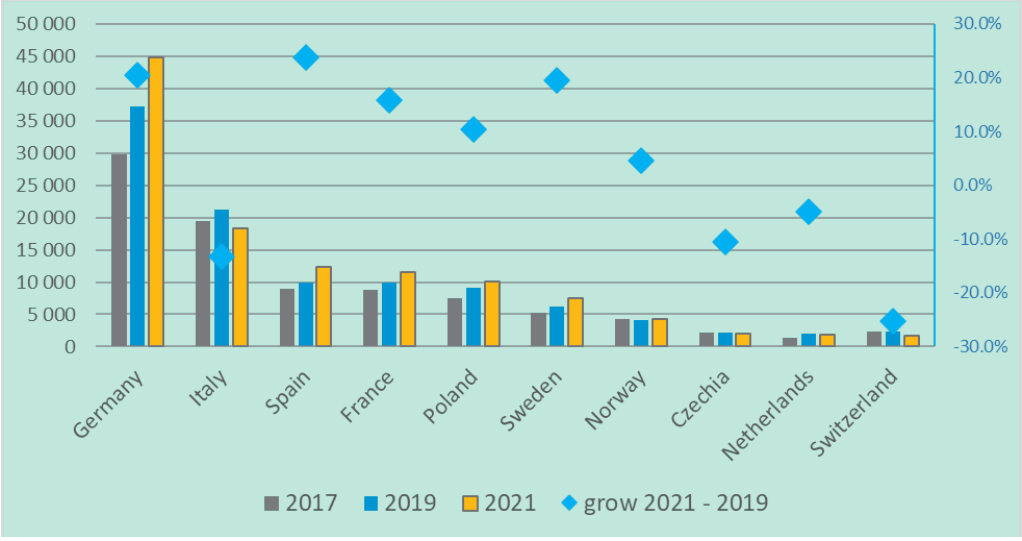
Figure 16 and **Figure 17** illustrate the development of domestic unaccompanied Combined Transport for the European countries with the highest CT volumes from 2017 to 2021. Strong differences between European countries appear for domestic unaccompanied CT volumes. The ten largest European markets represent approx. 80% of the total market. Eurostat does not include data for certain countries including Austria and Belgium, both of which likely have significant shares of combined transport.

Figure 16: Top 10 domestic unaccompanied CT per country in 2021 (in 1000 Tonnes)



Source: TML analysis based on survey and Eurostat.

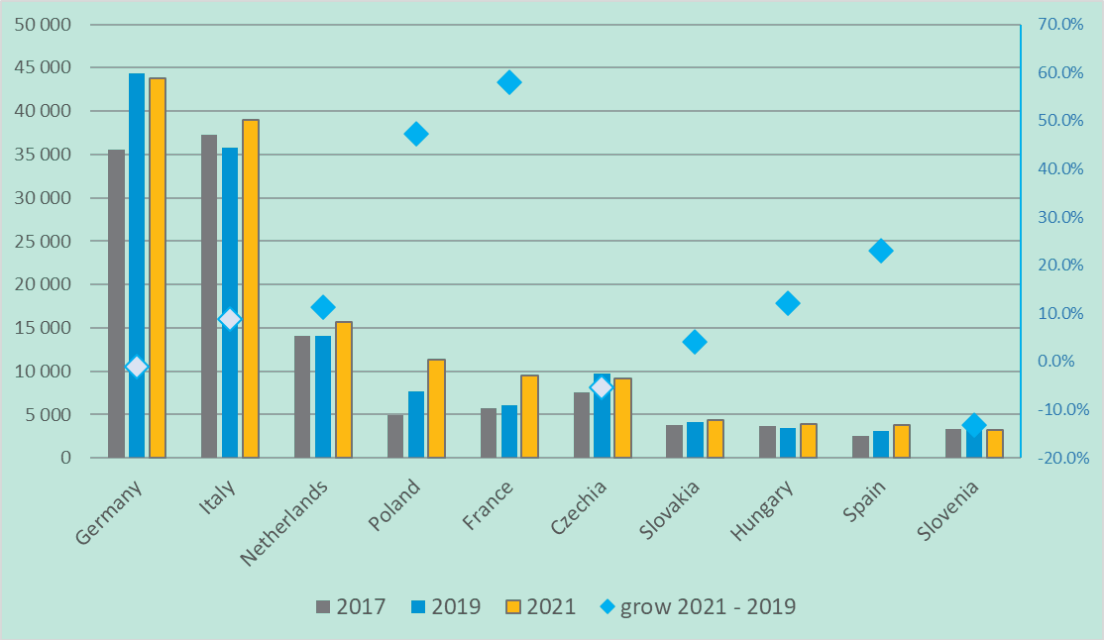
Figure 17: Development of the Top 10 domestic unaccompanied CT per country from 2017 to 2021 (in 1000 Tonnes)



Source: TML analysis based on survey and Eurostat.

In international Combined Transport, other countries enter the picture. The Netherlands comes in as the third largest user of international CT – mainly because of the cargo that needs to be moved to and from the port of Rotterdam. While there are no statistics for Belgium available, it is likely that similar if not larger international CT volumes are processed there: traffic to and from the port of Antwerp. International CT is growing notably, by 40-50%, in countries like France and Poland.

Figure 19: Development of the Top 10 international unaccompanied CT per country from 2017 to 2021 (in 1000 Tonnes)



Source: TML analysis based on survey and Eurostat.

As the largest markets for international CT, the trade lanes between Germany and Italy are also the largest in Europe, followed at a large distance by the lanes between Belgium and Italy and the Netherlands and Italy. In all cases, there is an imbalance in the relation, with Italy receiving more goods than it ships back. The difference amounts to around 20% for each relation.

It is noteworthy that the relation between Germany and the Netherlands is lower on the list, while that between Germany and Belgium is not even listed at all. With much lower distances and the presence of a well-developed inland waterway connection, the market for rail/road CT is not as strong on these lanes.

Transport on the North-South axis that includes the largest lane (between Germany and Italy) also has the connection between Sweden and Germany, Austria and Germany and Austria and Italy on the list and can thus be considered the main corridor for Combined Transport in Europe. This corridor is formalised as the ScanMed Rail Freight Corridor (RFC3) in European context.

Table 1: Major European trade lanes in international unaccompanied CT (gross weight and tonnes-kilometres)

Origin	Destination	Gross weight (1000 tonnes)	Tonnes-kilometres (1000 tkm)
Germany	Italy	10 632	9067
Italy	Germany	8 845	7413
Belgium	Italy	3 578	3934
Italy	Belgium	2 813	3245
Netherlands	Italy	2 332	2542
Italy	Netherlands	1 785	2137
Luxembourg	France	1 707	1451
France	Italy	1 618	901
Germany	Netherlands	1 342	726
Netherlands	Germany	1 147	565
Germany	Sweden	1 111	1269
Sweden	Germany	1 043	1197
France	Luxembourg	1 043	868
Germany	Austria	917	790
Austria	Italy	841	345
Belgium	France	827	616
Austria	Germany	779	667
France	Belgium	762	589
Italy	Austria	761	317
Czechia	Germany	747	634
Italy	France	707	645

Source: TML analysis based on UIRR data. The numbers are lower bound of the actual volumes.

Accompanied CT

Accompanied CT mainly takes place in the Alps, over relatively short distances compared to unaccompanied transport

Table 2: Volumes in accompanied Combined Transport 2021 (in TEU and tonnes)

Unit	Domestic	International	Total
1000 tonnes	9 720	7 817	17 537
1000 TEU	887	710	1 557

Source: TML Transportation analysis based on survey and Eurostat.

IWW major European trade lanes in containers

As described above, Combined Transport of containers between Germany, Belgium and the Netherlands is dominated by inland waterway transport. Combined transport over waterways is predominantly maritime, oriented towards Europe's largest seaports Rotterdam and Antwerp. The strong growth numbers for the Netherlands to the south can reflect the recovery from the corona crisis.

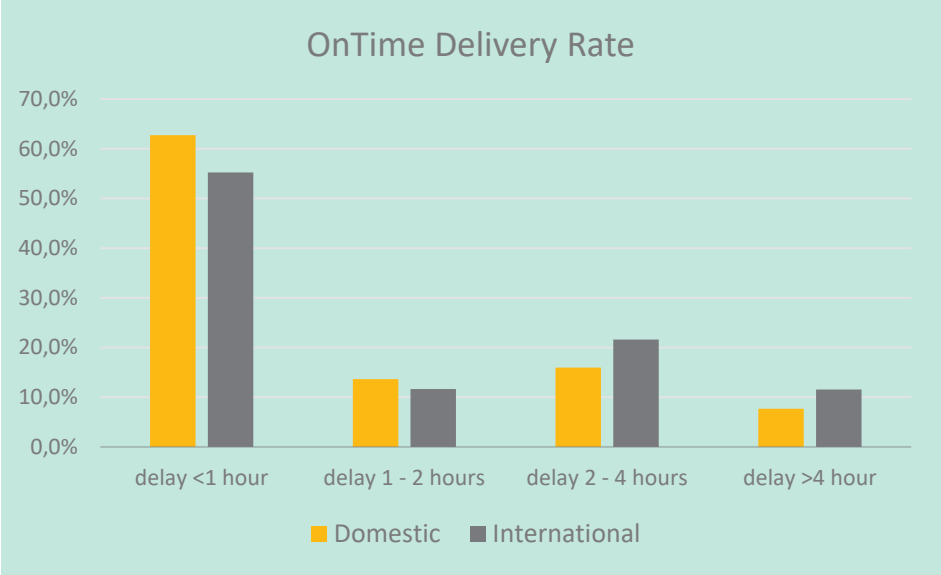
Loading country	Unloading country	2020 (TEU-kilometres)	2021 (TEU-kilometres)	Annual growth
Germany	Belgium	220 898	212 867	-3.6%
Netherlands	Germany	207 271	204 896	-1.1%
Germany	Netherlands	172 470	174 061	0.9%
Belgium	Germany	107 019	105 819	-1.1%
Netherlands	Belgium	64 969	77 654	19.5%
France	Belgium	42 077	39 158	-6.9%
Belgium	Netherlands	40 556	41 345	1.9%
France	Netherlands	29 676	31 734	6.9%
Netherlands	France	24 771	30 343	22.5%
Netherlands	Switzerland	10 297	10 635	3.3%
Other routes		28 606	29 308	2.5%

Source: Online rapport "Statistics Explained: Inland waterways – Statistics on container transport" from Eurostat, data extracted in September 2022

Combined transport: additional aspects

Around 60% of CT trains arrive with a delay of less than 1 hour. Domestic trains are usually more punctual than international journeys, which are of course longer and require certain procedures upon crossing borders (such as driver changes), which could also cause delays.

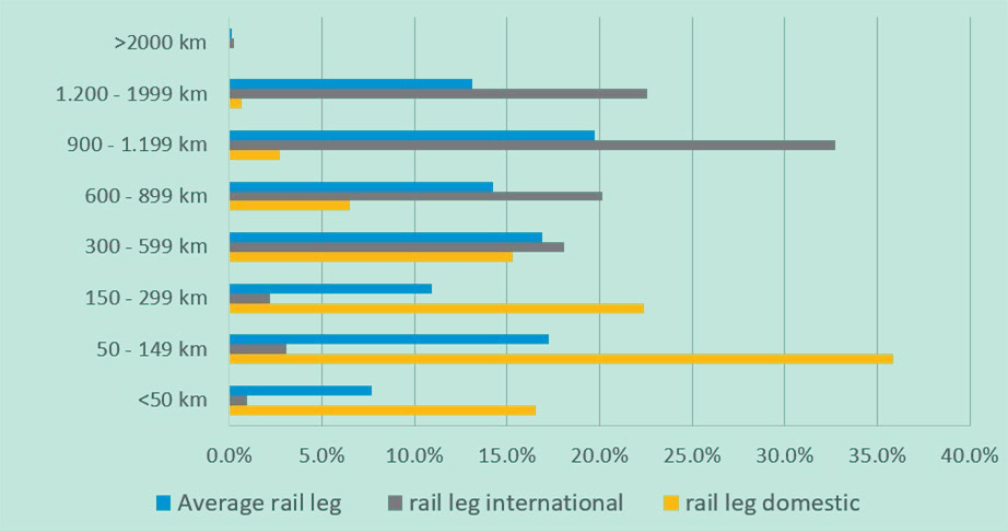
Figure 21: On time delivery rate



The rail leg distance split by geographic market in domestic and international transport in **Figure 22** clearly demonstrates that domestic distances are much lower. This is the result of a conceptual artefact in the definition of domestic and internationals transport. As rail leg distance is limited to a country's national territory, it can never reach longer distances than the transverse distance through a country. More than 1/3 of the domestic market has a rail leg distance of less than 150 km. In international CT, more than 2/3 of rail distances are over 600 km, and close to half is over 900 km.

The average rail leg is the rail leg irrespective of geographic scope involving domestic and international transport. There we find that a large majority of rail legs is above 300 km, and most are in the distance class between 900 and 1200 km. For transport below 300 km, there is notably more traffic on shorter routes (50-150 km) than on medium distance routes (150-300 km). The shorter routes are likely high volumes of maritime containers to the direct hinterland, to avoid road congestion in and near seaports.

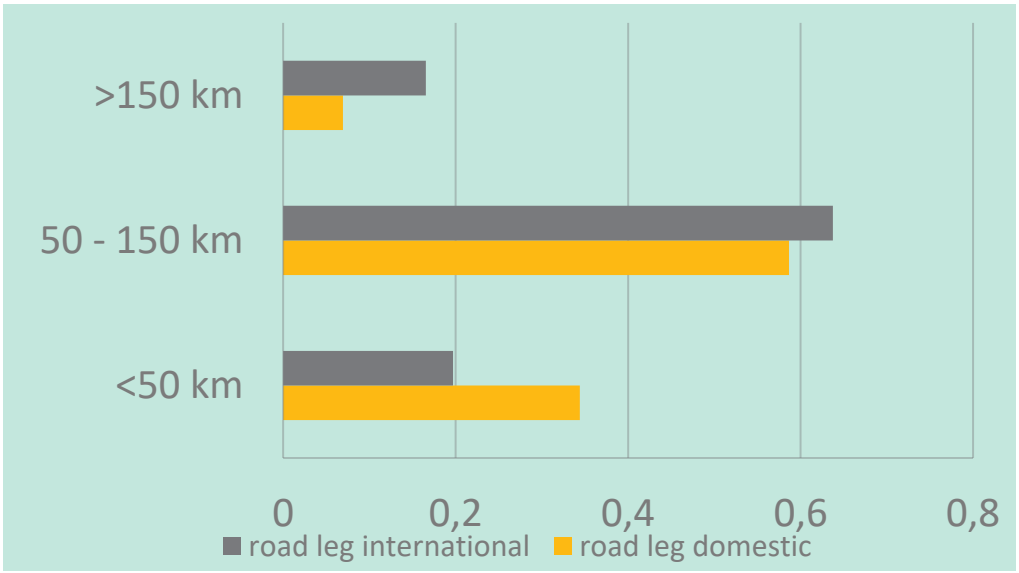
Figure 22: Total rail leg of CT trains



Source: TML analysis, Inference based on survey sample

Figure 23: Single Road leg in CT

Around 60% of road leg distance in Road-Rail CT is between 50 and 150 km.



Source: TML analysis based on survey sample.

General framework and key elements of CT in Europe

Expectations for the CT sector, as cited by stakeholders

The survey asked stakeholders to share their views on trends and tendencies in the CT sector, both internal and external.

Internal trends

- Operators will take more control of their supply chain, by becoming more asset-intensive – i.e., owning their own traction, wagons, even terminals. This will improve coordination between trains, allow for faster handling, improve punctuality and stabilize costs. Increase in scale to become more cost-efficient.
- At the same time, sales could be outsourced to agencies with a specific focus, which in turn could lead to a resurgence of mixed trains.

External trends

- CT will continue to gain importance as a result of issues in the road sector, such as driver shortages and increasing pressure to reduce CO_2 emissions and dependency on fossil fuels.
- Stakeholders express a mixed opinion on European policy: on the one hand, it is expected to boost CT, e.g., through a harmonization of regulatory standards and a regeneration of the infrastructure; on the other hand, there is a fear that increased bureaucracy could disturb innovation.

Support mechanisms for rail and combined freight transport, provided by EU Member States

Many EU member states have policy measures in place to support rail freight transport, and often with specific attention for combined transport. Based on a search in DG Competition's database for State Aid measures, 13 countries which have set up financial support measures since 2016 have been analyzed

Austria has received approval for 5 support schemes.

- The first was an extension of an existing scheme to support the construction and maintenance of intermodal transshipment infrastructure, submitted in 2017. The extension runs until the end of 2022 and has an annual budget of 10 million €.
- Austria in 2017 also requested an extension until 2022 to a support scheme for rail freight operators (more specifically those active in Single Wagon Load transport, in unaccompanied Combined Transport and in accompanied Combined Transport), with an annual budget of 120 million €. This budget was later increased to 188 million.
- In 2020, the COVID pandemic prompted the Austrian government to extend this support scheme to all rail freight transport, i.e. also including full train transport. The budget reserved for SWL and CT was however reduced again to 150.7 million, as there was a risk for cumulation with another support scheme that reduced track access charges (not covered here). This only applied to the year 2020.

- A similar amendment was made for the first half of 2021, this time with a budget reduction to 175 million €.
- The final approved measure is another extension of the COVID exemptions for the 2nd half of 2021.

Belgium has 3 approved support measures.

- A federal support scheme to promote both combined rail transport and single wagon load transport. For Combined Transport, the financial support is only applicable to domestic transport. It consists of a fixed part per Intermodal Transport Unit, plus a variable part per km. The scheme that was approved in 2017 was an extension of an existing program, and this extension ran until 2020. Annual budget for the entire scheme was 13.4 million €.
- This scheme was then extended for the year 2021 under the same conditions. It was however not extended for 2022.
- The Flemish regional government installed a support scheme for the bundling of rail and IWT transport volumes to and from the seaports of Antwerp, Ghent and Zeebrugge. For rail, the support is mainly intended to bundle containers that come in at different locations in the port and could best be bundled to improve the cost efficiency of the trains going to and from the port. The subsidy is a fixed amount per train. For rail, a total annual support of 6 million € is budgeted, for a period of 5 years.

Croatia has 1 relevant measure, similar to the one from Belgium. A subsidy is provided to Combined Transport operators, consisting of a fixed amount per loading unit, plus a variable amount depending on the distance. The total budget is around 3 million €, and the scheme runs from 2018 until 2022.

The **Czech Republic** implemented a subsidy for the purchase of intermodal transport units (adapted road trailers, swap bodies, inland containers and special transport units) to promote continental Combined Transport. The scheme runs from 2018 until 2023 and has a total budget of approximately 16 million €.

Denmark has a support scheme for ERTMS implementation (not covered further) and one for the compensation of environmental externalities. The latter scheme is relevant here. While it applies to all rail freight transport operators, Combined Transport is an important part of that market. The basis for the subsidy is the amount of tkm realized. The scheme was an extension of an earlier support mechanism and ran from 2018-2020, with an annual budget of approximately 2.5 million €.

France has 3 relevant support measures in place.

- Financial aid for the development of intermodal rail terminals. The scheme runs from 2018-2022 and has an annual budget of 12 million €.
- A joint support mechanism with Italy aimed at transalpine RoLa rail transport, which is an extension of an existing scheme that was in place since 2015, and now ran until the end of 2021. The total budget amounted to a maximum of 17.5 million € per country, i.e. 35 million in total.
- An extension of a support scheme for Combined Transport (rail, IWT and maritime) specifically, which has been in place since 2008, which will now run until the end of 2022. The aid consists of a part that is proportional to the actual traffic volume, and a fixed subsidy per loading unit. The annual budget available amounts to 40 million €.

For **Germany**, 3 relevant measures were identified.

- Germany also has a subsidy for the development of transhipment facilities, which has been in place since 2002. The latest approved scheme ran until the end of 2021. The support is based on the amount of loading units transhipped in the terminal. For the period of 2017-2021, the total budget amounted to 463.5 million €.
- The state of Saxony-Anhalt has a separate scheme for other rail infrastructure investments that aim to improve rail freight accessibility. The total budget is 3 million € for the period 2018-2024.
- A scheme to reduce track access charges for both freight and passenger rail transport has been in place for some time, but the COVID pandemic prompted the government to increase the budget for this measure for the years 2020 and 2021. Total annual budget for this measure became 605 million € in 2020 and 722 million € in 2021.

Italy has the most support schemes for rail freight transport among EU MS, with 20. For many of them, the initiative lies with the local authorities (Trento, Bolzano, Piemonte, Emilia-Romagna, Genoa, …) rather than the national government, though there are also several national initiatives, often with a regional focus as well. Bases for pay-outs are trainkm, loading units transported or tkm, while some schemes also target infrastructural development. Like Germany, Italy also installed a track access charge reduction program because of the COVID pandemic. Local schemes usually have an annual budget of several 100 000 to a few million €, whereas national initiatives have annual budgets of multi-ple 100 million €.

Luxemburg has a support scheme for Combined Transport, the current version of which is applicable from 2019 until the end of 2022, with a total budget of 44 million €. The support consists of a fixed part per train (decreasing with the distance of the train's journey) and a variable part per loading unit on the train.

The Netherlands have a support scheme for rail freight transport in general, running from 2019 until 2023, with a total budget of 70 million €. The support is paid out per trainkm and is therefore equivalent to a reduction in track access charges by 57% - 66.2%.

Poland has one rail freight support measure in place, an extension of an earlier scheme to support the development of intermodal terminals and specialized equipment required for their operation. The current measure is in place until 2023. Its total budget is 465 million €.

Romania requested approval for a support scheme for RoLa Combined Transport for the period 2018-2020. However, the scheme did not make any payments – which had also been the case for an earlier version of the scheme, when the budgeted amount was not made available by the financing party (i.e. the national government).

Sweden has a environmental cost compensation scheme in place for rail freight transport, which is paid out per tkm performed. This scheme was already extended several times. It currently runs until 2025 with an annual budget of 40 million €.

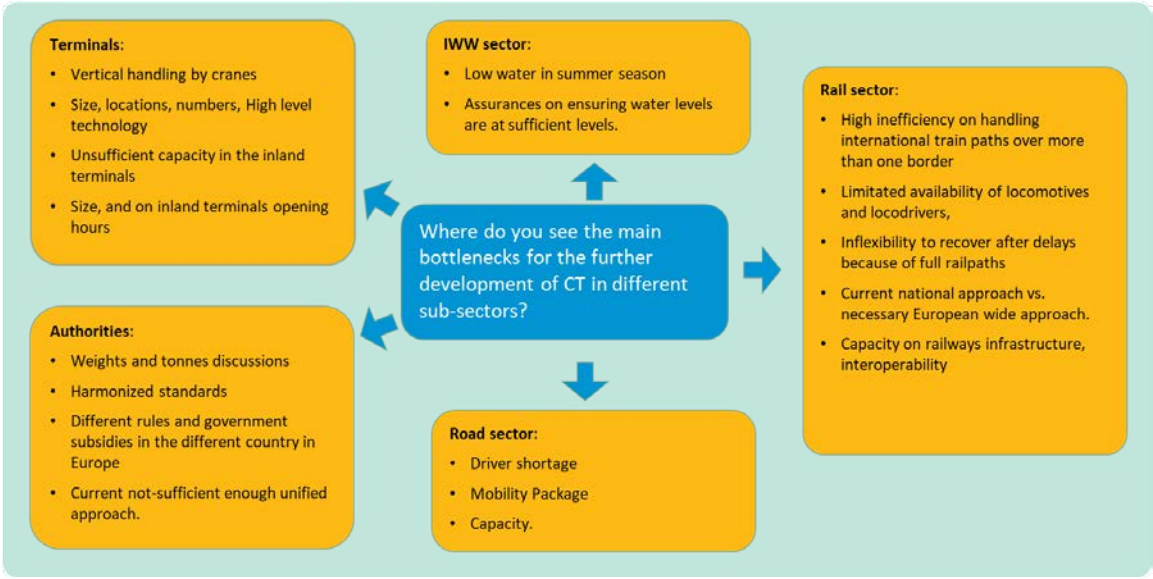
Conclusion

Many MS have financial support mechanisms in place for rail freight transport and/or Combined Transport. Notably absent in the list of countries are southern countries (except for Italy). The type of aid ranges from infrastructure development to operational support. Where Combined Transport operators are addressed, one component of the support is usually the amount of loading units transshipped, often combined with a distance measure. The distance-based measure in several countries come in the form of support programs in the form of reductions of infrastructure charges. These help to level the playing field between rail and road transport.

The COVID pandemic has brought some member states to increase their budgets for support programs, to guarantee that any demand reduction did not impact the sector negatively.

Key bottlenecks for Combined Transport

Figure 26 Bottlenecks for different actors in CT



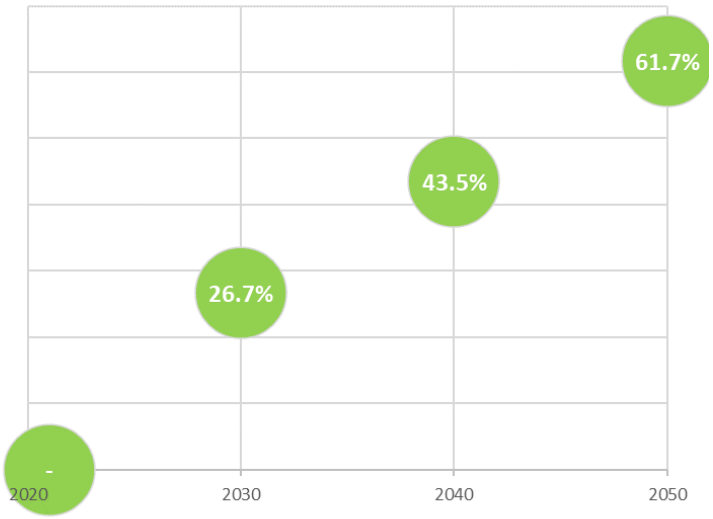
Source: TML analysis of survey.

Bottlenecks are sector dependent. For instance, the water level is concern raised by barge operators but not by the other stakeholders. Driver shortage is a concern raised by the road and rail sectors. Overall, capacity in rail infrastructure and at terminals is a recurrent bottleneck. A recurrent concern is overall capacity. Capacity shortage at inland terminals, capacity on railway infrastructure, capacity on locomotives and containers, even capacity shortage on road. Capacity shortage makes smart planning important to use assets in efficient ways.

CT market forecast

Stakeholders expect continued growth of total CT volumes. The strongest growth is expected in the short term (by 2030). However, at the time that the respondents submitted the surveys, the perspectives were more positive than what they are now given the escalations in the Ukraine war and the energy – fuel prices.

Figure 27: Expected volume growth of the total CT market in the long-term with regard to 2021



Source: TML Transportation analysis based on survey.

Spotlight analysis

Cost chain analysis in an end-2-end perspective

Introduction

This note is prepared as a partial deliverable of the contract to compile the Combined Transport report 2022. It reflects the findings of a cost analysis of combined transport, considering different cost components and several case studies.

Literature

To scope the domain, a search and review of available literature on freight transport costs in Europe was performed.

Two types of sources can be distinguished. First, an extensive base of literature can be found that focusses on the modelling of freight transport costs: which types of costs should be considered, how they are estimated and how they are attributed to the different steps in the transport process. A distinction is made in most of the cases between distance-based costs, time-based costs and (semi) fixed costs. Distance-based costs include aspects like fuel costs, maintenance costs (in part), infrastructure access charges, … while time-based are mostly personnel costs (wages). Fixed costs include components such as equipment costs (investment in assets), insurance and overhead costs (administration, management, …). Other cost components that come into play when considering combined transport are terminal handling costs. The papers and sources of this first category mainly focus on methodological aspects. While useful for establishing the framework for a cost chain analysis, these papers are mainly theoretic and contain little useful information for the current exercise.

A second group of papers and documents is more focused on the practical analysis of selected case studies. (Cansiz & Unsalan, 2018), (Fremont & Franc, 2010) and (Kordnejad, 2014) published such document, which provide us with a reference for this study. Their transferability to other applications is, however, limited, and given the objective of this spotlight analysis, further information still was needed.

Cost figures

The two main data sources used in this section are recent publications that cover a relevant part of the European freight market, and contain figures that can be used in different applications.

KiM

The first is the publication “Cost figures for Freight Transport”, published by the Dutch Kennisinstituut voor Mobiliteitsbeleid, and compiled by Panteia. This publication includes a report and a set of data tables that contain cost figures for all freight transport modes and for different transport types means. For example, for rail transport, block trains, single wagon load and container shuttles are included. The latter will be an important element for this analysis. Similar distinctions are made for road transport (bulk, general cargo, containers for trucks, tractor-semitrailer combinations, and LHV) and inland waterway transport (different ship sizes for bulk, general cargo, and containers). The latest version of the data pertains to the year 2018 for the Netherlands. As such, it does not (yet) reflect recent phenomena such as the rising energy costs, reduced track access charges in certain countries, etc.

A distinction is made between fixed costs, variable costs, personnel costs, specific transport costs, and general business costs, in line with the common cost calculation methodologies.

Table 1: KiM cost components for rail transport

Fixed costs	Variable costs	Personnel costs	Specific cost	Business costs
Equipment	Energy	Wages	Shunting costs	Buildings
Maintenance	Maintenance	Social contributions	Track access charges	ICT
Insurance			Transhipment costs	
Taxes				

Furthermore, it is important to consider what assumptions are applied for the usage profile attached to these costs. It is stated that container trains are assumed to run 178 750 km and 3 600 hours annually, with a total weight of 2 800 tonnes and an average cargo weight per trip of just under 900 tonnes. No mention is made of the amount of containers/TEU. We will assume that a container train carries 80 TEU, equivalent to 40 truckloads.

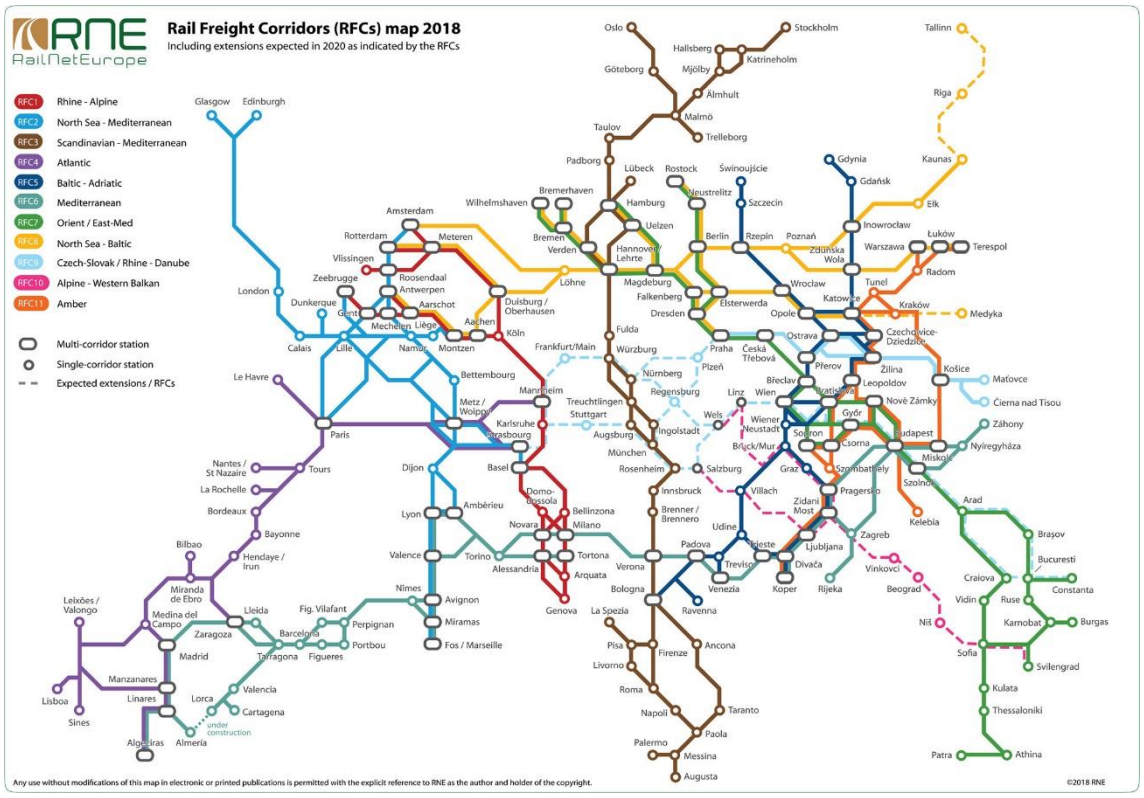
For road transport, the reference will be a tractor – semi-trailer combination that carries 2 TEU and runs an average of 105 000 km and 2 585 hours annually. Specific costs for road transport are licences and cargo insurance. Infrastructure charges are not included in the cost database but will be added in the calculations.

For inland waterway transport, the reference is a medium-size container ship with a total weight of 1 360 tonnes, i.e. a CEMT class IV type vessel that can navigate all major international waterways. It has a total capacity of around 100 TEU, the equivalent of 50 trucks. It covers a total annual distance of 34 002 km and sails for 4 679 hours per year. Specific costs are mainly port dues and other infrastructure charges.

Cost analysis for Rail Freight Corridor 3 (ScanMed)

Rail Freight Corridors are formalised organisations that are intended to manage and promote the use of rail freight transport between certain European regions. There are 11 in total.

Table 2: Rail Freight Corridors



These corridors produce regular reports on capacity and use. One of the corridors, the RFC 3 Scandinavia – Mediterranean, which covers some of the most important international combined transport relations (Germany – Italy, Sweden – Germany and Sweden - Italy), has taken the initiative of making a thorough assessment of the cost position of different transport modes (intermodal, pure rail, pure road) (ScanMed RFC, 2020), which also provides useful insights for the current analysis.

This study follows a similar approach in that it assesses different cost components of transport (following the same general outline as the KiM data but in more details) and make a relative comparison of them. It also makes the same calculation for different modes, including pure road, pure rail, and intermodal transport, for 3 reference cases and 10 more use cases. One downside is that the report does not publish absolute figures but only relative shares.

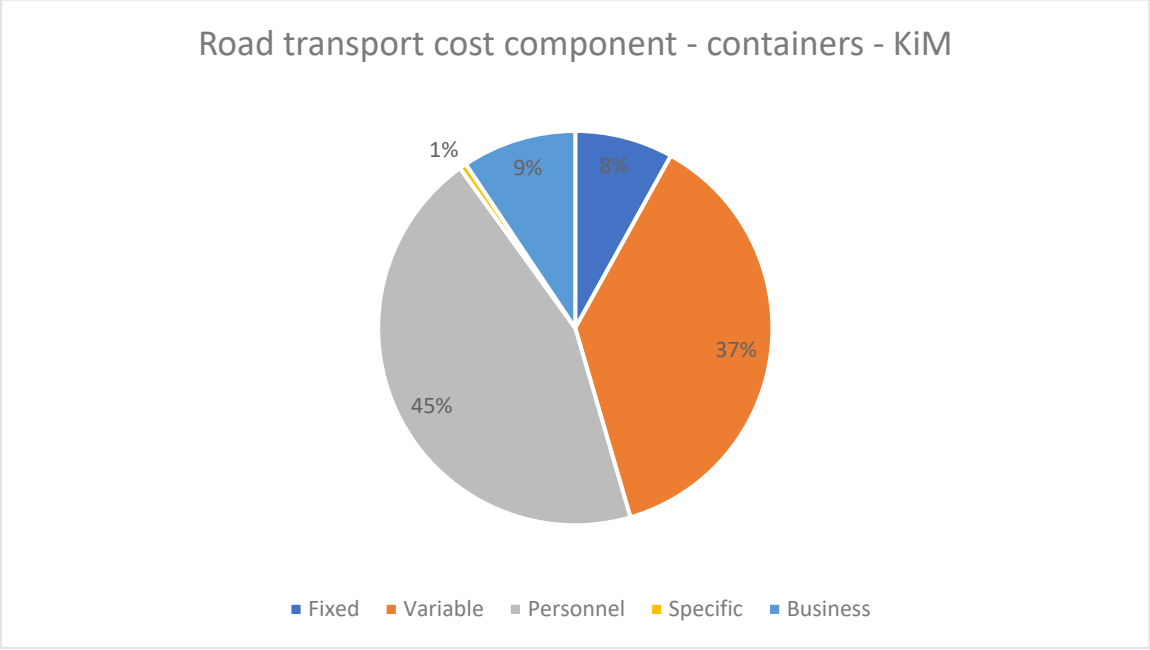
Cost chains

This section will detail the costs associated with the different steps in the combined transport chain, from door to door.

Road leg (first and last mile)

The first step is the pickup of the loading unit at the shipper's location. In maritime CT (assuming an inbound flow), this can be a port quay, while in continental CT, this could be an industrial site or a logistic yard. The loading unit (a container or swap body) is either already installed on a chassis, or is moved onto an empty one brought by the truck driver. From there, the loading unit is moved to an intermodal terminal. The main cost driver is to a large degree determined by the distance from the pickup location to the intermodal terminal. While road transport cost is generally expressed in terms of a given cost per distance unit (which is determined by energy costs and in some countries by the road user charge), on shorter distances, the total time needed for the move could become the most important determinant. Apart from moving the loading unit, the road journey also comprises the vehicle driving to the pick up location, taking care of the administration, helping with moving the loading unit on the vehicle, and after dropping off the cargo (following a similar procedure), driving to his next assignment.

The shorter the distance, the lower the share of actual driving in the total activity, which nonetheless needs to be paid for. As such, in typical combined transport legs, it is often the hours that are paid, not the kilometers. The KiM data for 2018 shows an average cost per vehicle km of 1.52€.[8] For a 20 km trip, this would amount to just over 30€. However, when it is considered that such a trip takes the driver 1 hour, the cost of the trip would be 62€. For reference, the cost per tonne km for road is estimated at 0.115€. The main cost components are variable costs (fuel) at 37% and wage costs at 45% - noting that this is for the Dutch market, where wages are higher than the EU average.



These costs can vary significantly depending on the operational organisation of the road operator. Costs per kilometre will be lower if the operation fits within a full schedule, i.e. when the driver can pick up another load after he drops off the loading unit at the intermodal station. Congestion and waiting at terminals can in turn increase the cost of the trip.

A recent publication by the IRU (IRU, Upply, 2022) shows that road rates per km can be as high as 3.71€/km or as low as 1.07€/km, depending on the market.

[8] The largest components of this cost are variable costs (fuel) at 0.57€ and wage costs at 0.68€. In the current situation, fuel costs have about doubled since then. For wages, the KiM data use Dutch figures, so the average for the EU are probably lower than that – though driver shortages are also putting upward pressure on wage costs.

Transhipment

After the initial road leg, the loading unit needs to be transhipped onto the train or vessel for the principal part of the journey.

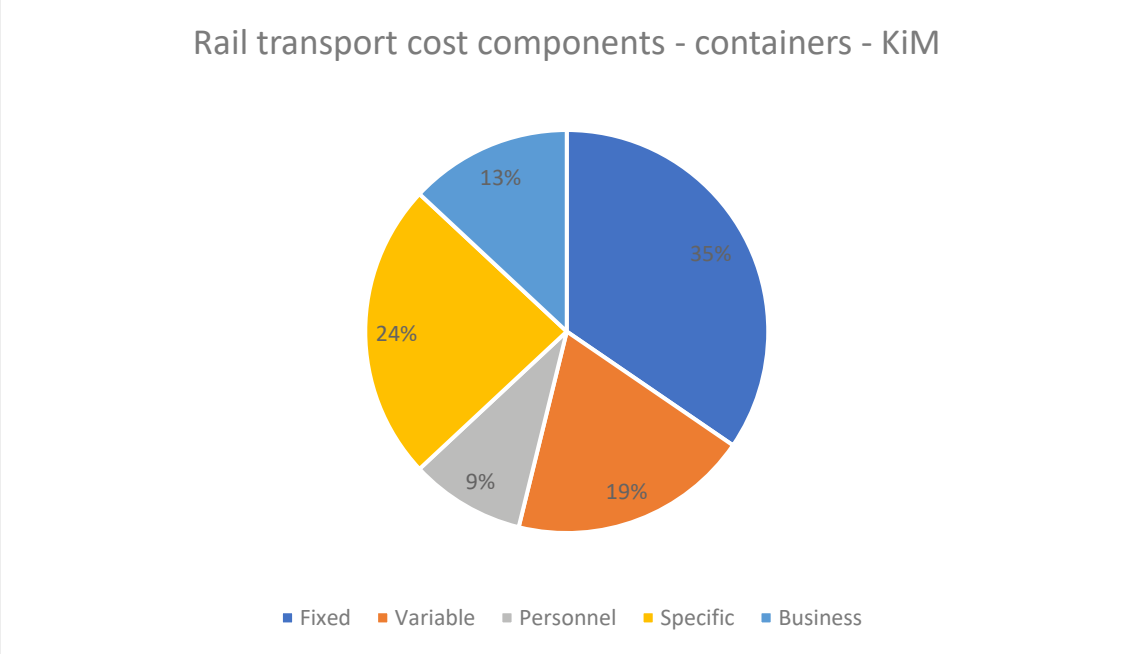
To move the loading unit (container, swap body, semi-trailer, full vehicle) onto the train or vessel, several options exist. The most common remains vertical handling, when a crane (fixed or mobile) picks up the loading up from the chassis and moves it onto the wagon or ship.

The cost of this action is not described in the KiM data. The cost of transhipment is determined mostly by the equipment cost, the wage cost of the operators, and its utilisation (the amount of moves per day). Several intermodal terminal operators publish tariff listings, e.g the RailCargo group (Austria), which applies a handling charge of 49€/lift for containers, or the Bulgarian terminal Stara Zagora, where the charge is 30€/lift. A study by IRG-rail (IRG-Rail, 2020) found that charges for container handling are usually in the range of 15-50€/move. This confirms the findings of the review of support mechanisms for combined transport discussed earlier in this report, for those measures that explicitly or implicitly aim to compensate the extra cost of handling in combined transport. The support per loading unit is typically in the range of 10-30€ - about 50% of the actual cost, in accordance with the rules on support for these operations set by DG Competition.

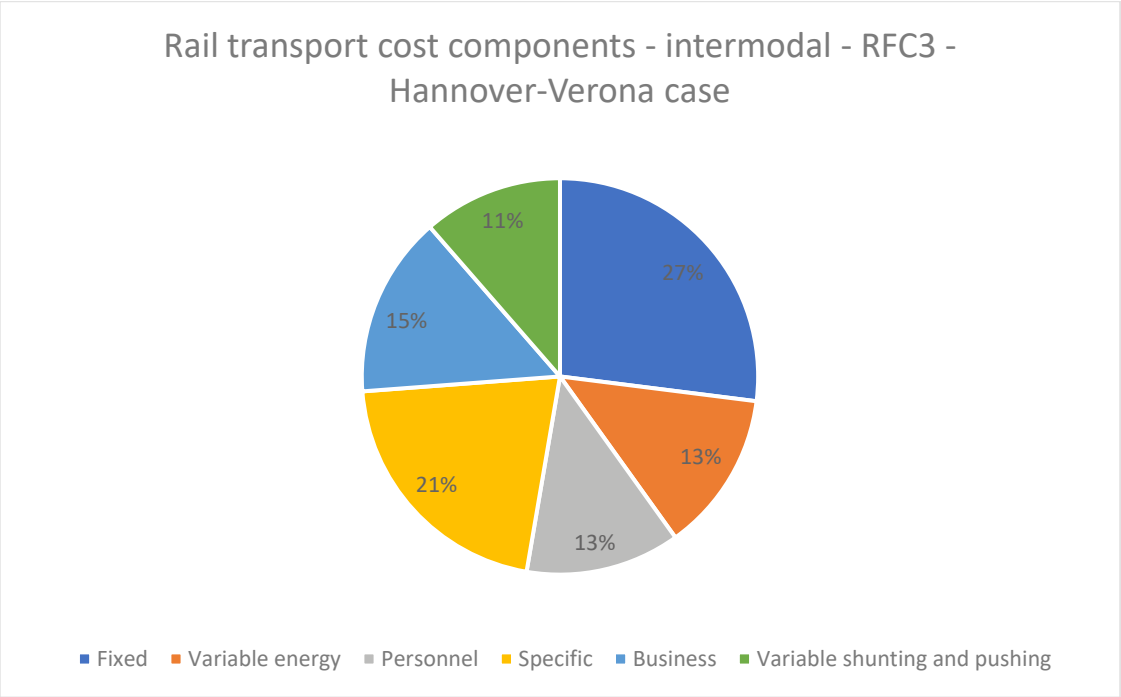
A recent European study by PWC and KombiConsult (PWC, KombiConsult, 2022) has reviewed different transhipment technologies and their costs. Depending on the exact usage profile, costs per transhipment are estimated to be in the range of 30-60€ for most cases.

Main leg via rail or IWT

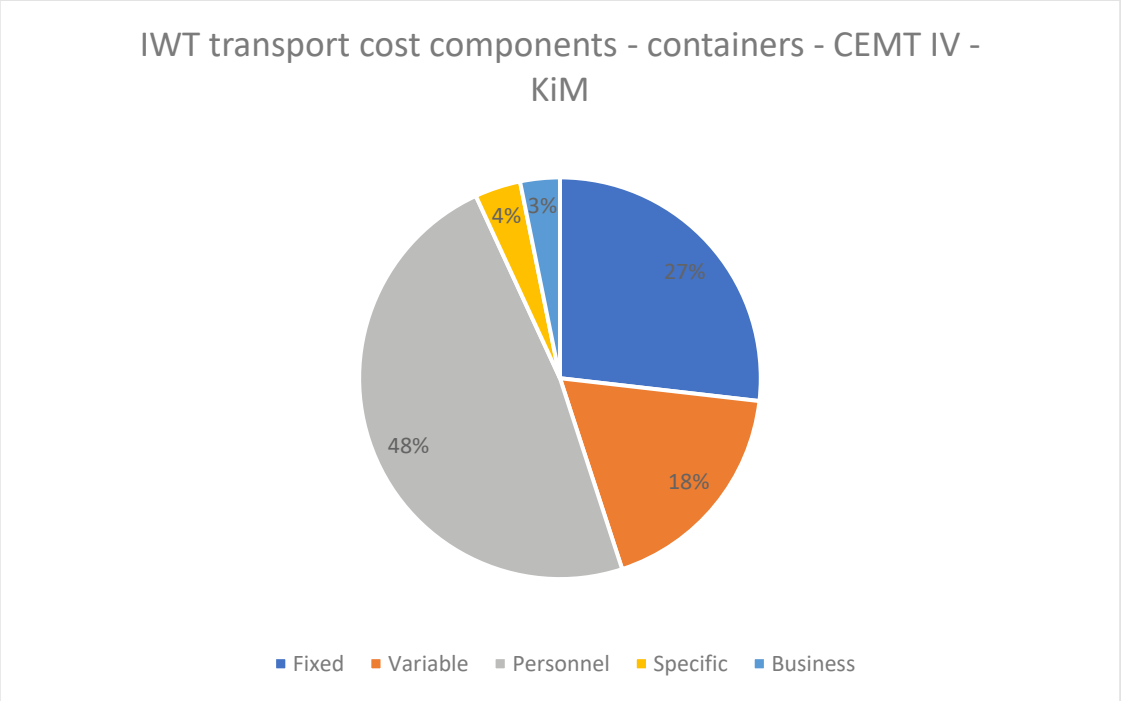
The main cost components of rail transport according to the KiM data for 2018 are fixed costs (equipment) at 35% and specific costs (track access charges) at 24%. Variable (energy) costs were at 19% in 2018, but current prices are a factor of 3-10 higher than they were then.



This matches reasonably well with the cost components considered in the RFC3 study, with the exception of an additional cost component from shunting and pushing services. On the RFC3 corridor, traffic to and from Italy, Austria and Switzerland has to go through the Alps, which requires additional pushing locomotives to moves up the mountains. The KiM data, which in principle is focussed on the domestic transport circumstances in the Netherlands, does not include this type of cost.



For inland waterway transport, the main cost component are personnel costs (almost half) and fixed costs (equipment), though energy costs are also substantial at 18%, and have also risen, though probably more along the lines of a doubling of costs like in road transport, rather than factor 3-10 as for rail electricity.



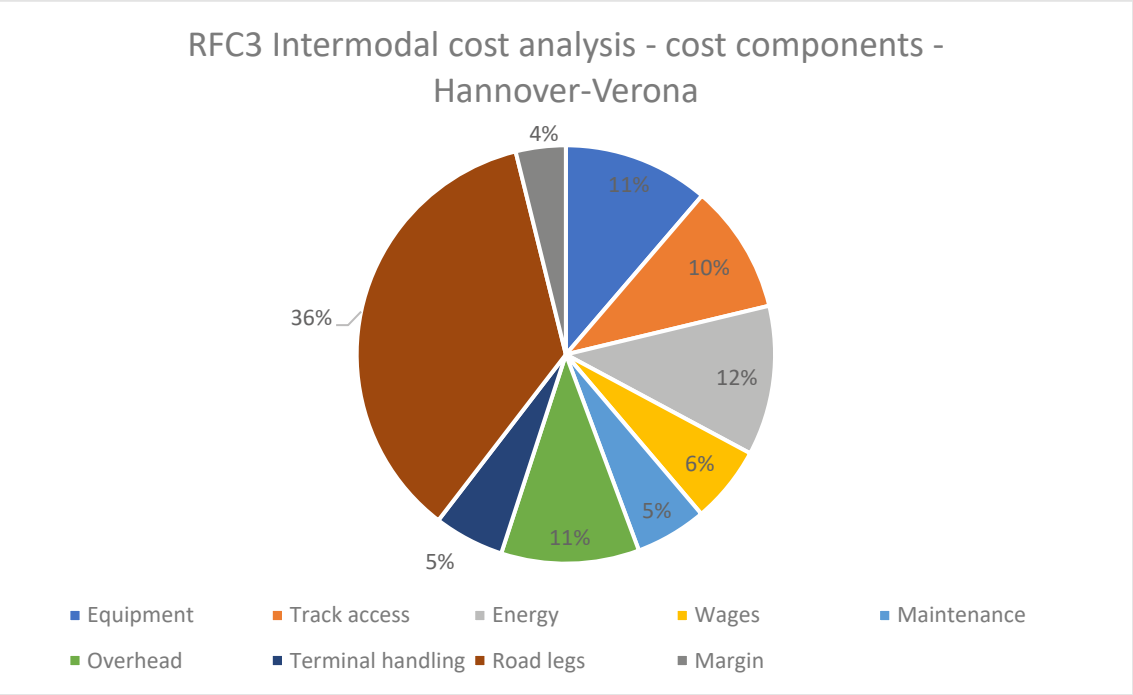
Total costs per tonne km for rail are estimated in the KiM data at 0.017€, which is just 15% of the road estimate. For IWT, the cost is about double the rail cost, at 0.033€/tonne km. However, as for the road estimate, the underlying assumptions with regard to the operational circumstances have a major impact on the results. Load factor, not only on the journey under consideration but also on the return journey, is a crucial determinant, given the higher share of fixed costs in rail and IWT compared to road that need to be covered by income from payload.

Case study review

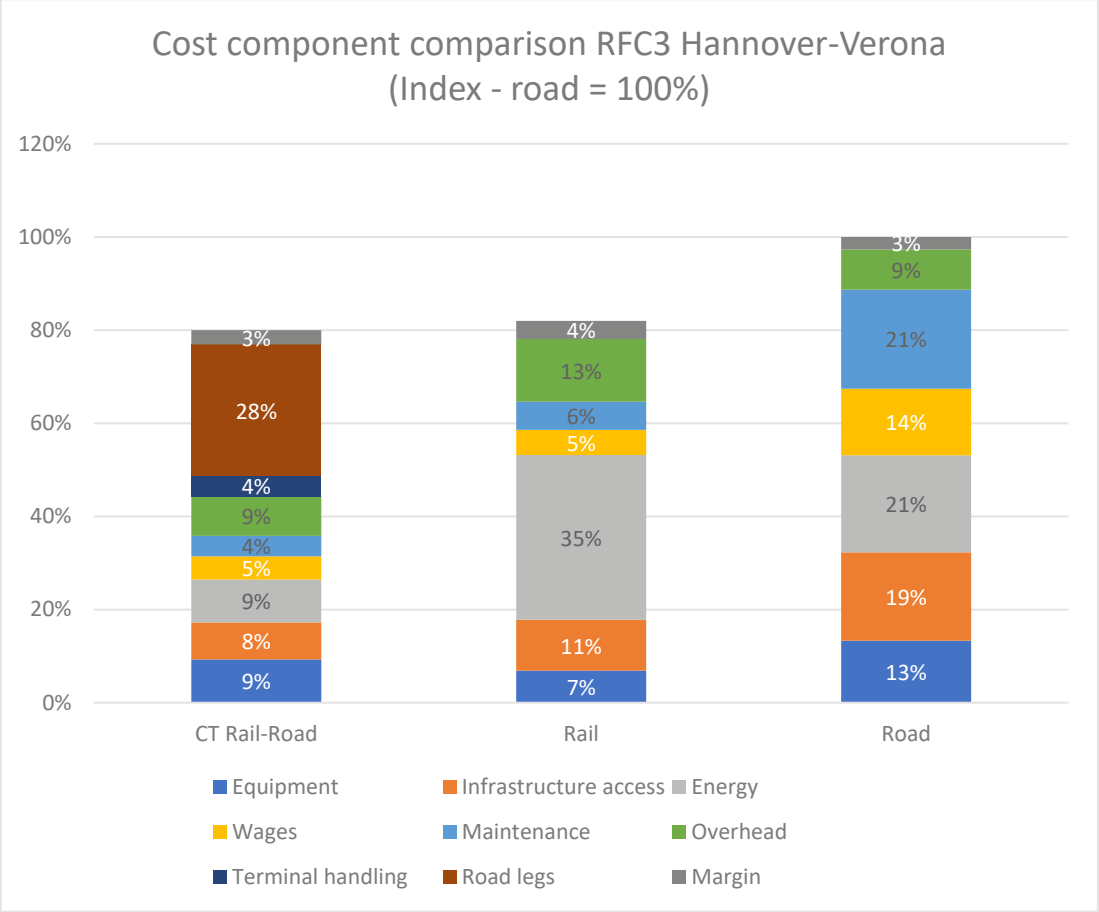
In this final section, we will summarise the results of one of the reference cases in the RFC3 study, namely that from Germany to Italy, which for this case means from Hannover to Verona.

This specific case covers a distance of just over 1 000 km and follows the route Würzburg-Nürnberg-München-Kufstein-Brenner-Bolzano. The rail leg of the combined transport trip includes the use of an additional pushing locomotive to cross the Alps.

The cost components of the rail leg for this case were shown above. For the entire combined transport chain, including pre- and post-haulage and terminal handling, the analysis shows that the road legs (distance not mentioned, but likely short) represent the most import cost component, at 36% of the total cost. Energy costs, equipment and track access charges are the next most important, but together they only amount to about the same cost as the road haulage.



The analysis also made a comparison of the combined transport solution with pure road transport and pure rail transport. For this case the combined transport solution is the cheapest, slightly cheaper than pure rail and about 20% cheaper than pure road.



Of the three cases considered in that study, CT rail-road transport came out as the cheapest solution for 2 of them. Only for the case from Göteborg to Hannover, the road solution was cheaper. This was also the shortest journey of the 3 cases (at 935 km). As distance increased (1041 km and 2316 km for the other cases), the competitive position of CT improved.

The aforementioned study by PWC and KombiConsult also made a general comparison of intermodal system costs (for different transhipment options) with total road transport costs, for trips of 600 km and 1000 km.

- For the 600 km journey (which includes 2x75km of road haulage and 450 km of rail transport), road transport is always the cheapest option at a total cost of 636€ per loading unit. The cheapest intermodal option was 651€, with most around 700€, i.e. around 10% more expensive than pure road.
- For the 1000 km trip (with an 850km rail leg instead of 450 km), road cost was estimated at 1021€ per loading unit, but here the cheapest combined transport option is at 697€, with most around 800€, i.e. around 20% cheaper than pure road.

The study also accounts for external costs of transport. When these are included, combined transport performs better than pure road transport (except for a few extreme cases), for both 600 km and 1000 km trips.

Digitalisation Models in Combined Transport

The organization of several transport modes is by definition more complex compared to the unimodal case. For example, handling activities at terminals involve a multitude of secondary and ancillary services such as storing, loading, unloading, planning, queue arrangements, operational management, etc. Intermodal transport, compared to one modal transport, involves numerous actors and activities that increase operational uncertainty. Managing these uncertainties requires prompt anticipation of fluctuating demand volumes, capacity planning and delays, while in the meantime, pursuing low costs and fast transportation times to ensure the attractiveness of the intermodal transport model. A high-level digitalisation with real-time information flows and connectivity is very helpful to cope with these uncertainties. Therefore, engaging in digitalisation, mutually and collaboratively, is extremely important for all parties involved, in particular for the Combined Transport sector.

The digital transformation holds great promise when the mainstream in the sector embarks on the digital transformation. It will shape benefits in terms of efficiency of data exchange and service quality to name a few of these advantages:

- Data captured by sensors and GPS units can provide real-time logistic information for tracking and tracing the load, and as such, allowing proactive anticipation of disruptions and unexpected hazards in multiple transport schedules at the same time.
- The digital transformation provides new services that arise from the visibility of the transport chain such as door-to-door solutions with shipment status information presented in real-time to end-users or to retailers. These new services will become regular commodities that will raise the bar in the competitive transportation playing field.
- Besides visibility, more benefits are acquired such as routing optimalisation with lower energy-use and shipment costs, more efficient loading and supply chain planning with high fidelity of the product origin which secures the authenticity of the products, and less administrative burden thanks to e-documents when contracting or booking carriers.

Advanced technologies such as wireless communication, sensors, positioning technology, web-based platforms, electronic data interchange, are the drivers leading to the new digital era of massive information flows and connectivity. In this new era, the digital transformation is shaping up and regulating the behaviours, business performances, and standards of individuals, organisations, and societies. Therefore, digitisation in the Combined Transport is rightly put at the spotlight in this report. The focus analysis will elaborate on different aspects of this irreversibly ongoing digital transformation with a scope on

- the state of play, the challenges to be met, the barriers to overcome,
- the playing field with digital service providers,
- its impact on business and transport models.

Surveys conducted in the sector gauged opinions and views. The results of these surveys are framed in boxes that guide the content. In addition to the surveys, this analysis is also based on literature review and interviews.

Definitions

Digitalisation progresses in steps. Three steps are often framed in the literature by making a semantic distinction between *digitisation, digitalisation and digital transformation*[9]:

- Digitisation is the conversion of physical or analog media into digital format, so it can be reused, stored, linked and transferred easily.
- Digitalisation is the next step in which tools, applications or platforms are developed so that digitised data can be used in the workplace, primarily to process data into information, to improve efficiency, or to support analysis and decision making. It changes how a business operates. Companies themselves have a lot of influence in taking the first two steps but have only partial influence in taking the third step.
- The third step is digital transformation, when digitalization efforts are advanced across the different actors of the playing field to the extent that it is changing the way how services are offered and how customers request services. It holds a change in mindset and attitude in people, customers, and employees. It will affect how employees are doing their job, what is important, and how business is done. It will create value to the customer and generate new business models that adapt the business to the new trends in transport.

However, for this last step to take place, and this is needed for the Combined Transport sector, there are lots of interdependencies between different stakeholders and performers in the sector. Each operator holds a bit of information in the global transport demand and supply chain. All these fragments need to be put together to get a complete picture of the ins and outs in the sector before the digital transformation has the capacity to generate great value.

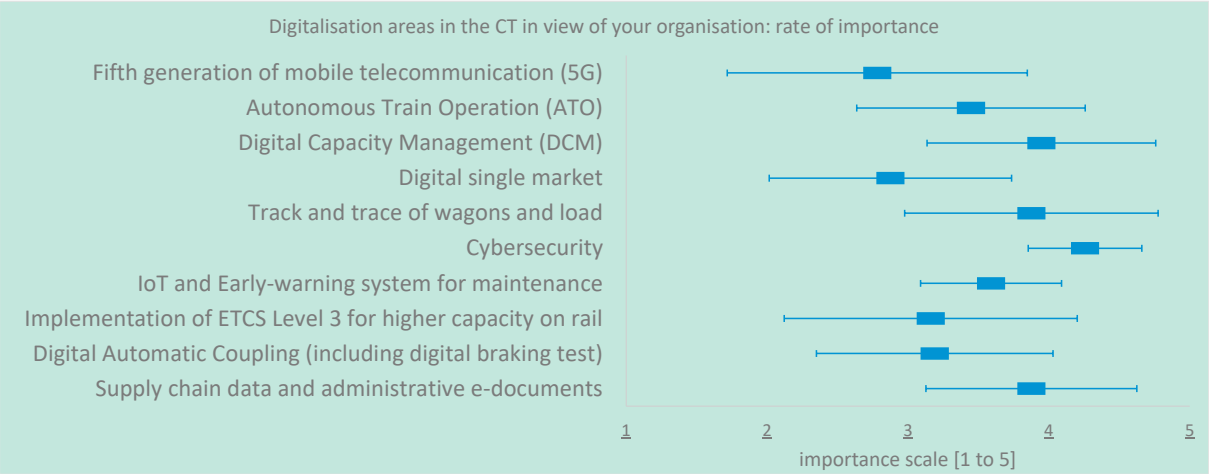
[9] Referring to an article from Jason Bloomberg at “Digitization, Digitalization, And Digital Transformation: Confuse Them At Your Peril (forbes.com)”

Challenges and barriers

Digitization has no single definition but is a large umbrella term with multiple working areas. In Box 1, different digitalisation working areas were rated according to their importance to the Combined Transport sector.

Box 1. The different digitisation areas in the Combined Transport sector rated by importance.

The survey was administered to people working in the Combined Transport sector involved in digitalisation. The outcome can be considered as an indication of what goes on in the sector. Participants rated the importance of digitalisation areas from one to five. The rectangle shows the average rating while the error bars show the standard deviation. The larger the standard variation, the less agreement among the participants.



Cybersecurity was ranked with high consensus as the most important domain. Digital capacity management, track and trace of wagons and load and supply chain data were counted as important areas too.

A few of these areas aim at improving the operational efficiency of rail infrastructure. Examples are:

- Digital Automatic Coupling (DAC) that will automate and accelerate technical wagon inspection, wagon registration and brake test without manual efforts.
- The implementation of ETCS Level 3 will improve accuracy of train positioning and change the safeguarding principle from one train in one fixed areal block to one train in one moving block, thereby increasing the capacity of the railway infrastructure. ETCS L3 is currently still going through standardization processes.
- Operational efficiency will also be improved by Autonomous Train Operation (ATO), particularly for stops and starts in stations.
- IoT can track operating status throughout the equipment and infrastructure life cycle, enabling proactive maintenance and early anticipation of failures.

However, one of the main challenges in digitalization lies in the exchange of data, in information flows, standardization and connectivity between all actors in the field. Speed and timing are important assets in the supply chain that is increasingly becoming a real-time economy. In this respect, data exchange and electronic documentation are useful to create a faster and more effective connectivity.

Another example is Digital Capacity Management (DCM). DCM will connect the systems of Infrastructure Managers and railway undertakings to facilitate the complete capacity management process of assets.

In the survey conducted within the sector, **cybersecurity** was pointed out as the greatest challenge of all. Marketers can capitalize on private, sensitive information such as hacking recipients and their performed orders, or unauthorized persons can break into the train traffic with malicious intent, disturbing railtraffic. Cyberattacks comes in different forms, e.g. malware installed by clicking on a malicious link, or Denial of Service (DoS). Malware can try to capture login credentials. They can also block access to key network components such as the company's data (ransomware) and give back access when paying money. A DoS is a type of cyber attack that floods a computer or network so it cannot respond to requests.

Blockchain is widely accepted as the holy grail to improve cybersecurity. A block consists of a header and a body. Blocks are timestamped and form a chain by defining a pointer to the previous block. The header contains a cryptographic hash of the previous block, ensuring the interconnection of the data. The network is decentralised as information is stored on multiple nodes. A consensus mechanism is used to validate new blocks of data transfer and a majority vote determines its trustwothiness. That is a predefined number of nodes reaching a consensus on whether the new data block is valid given the hash, checking integrity of past transactions and new data blocks. Hackers can use IoT to obtain access to a system. Blockchain can prevent this as a hacker would need to infiltrate many interlinked blocks at the same time. Many applictions involving booking, orders and invoices are using blockchain. Blockchain has the potential to improve security, trust in data, and logistics management.

The success of digital transformation will depend on the adoption and implementation of digital technologies in small and medium-sized enterprises in the transport chain[10]. Larger companies are more aware regarding the effects of digitalization for their business. They select the most beneficial digital solutions, often tailored by inhouse development. Still, in the Combined Transport sector, larger companies often are issued from state-owned organisations managed with due care and the tradition of being cautious towards disruptive changes. The digital transformation is driven by disruptive technological evolutions, and it might take some courage to embrace it. Small and medium-sized companies are more risk-minded but find it more difficult to estimate the potential economic benefits of digitalisation solutions, so that incorrect selection and prioritization of implementation follows[11]. In the state of play, efforts have been undertaken, but overall, the digital transformation is still at a mild pace in the Combined Transport sector. Rail and Combined transport operators are well aware of their moderate advances in the digital transformation (see Box 2). Other modes like road, maritime and inland waterways are more advanced in this digitalization process.

In the interviews that underly this focus on digitisation, one digital service provider explained that rail has made progress in the past 5 years with sensors and GPS installed in wagons providing real time track information. For the rail sector, there can be hesitation in deciding to board on a digitalization journey, but when decided to move, the sector does it fast and profound. Rail is still lagging in some areas delaying data availability and quality. Data of rail can be complemented with data from terminals where the provision from high quality shipment tracking data of road and ocean carriers is collected before and after the train journey, as such, complementing rail data and improving data quality in both directions.

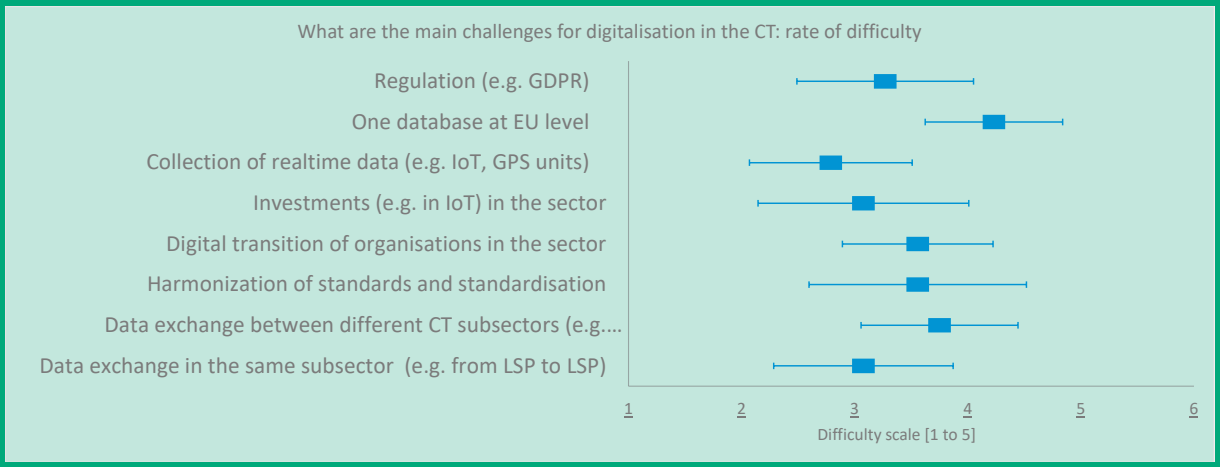
[10] Andulkar, Mayur; Le, Duc Tho; Berger, Ulrich (2018): A multi-case study on Industry 4.0 for SME's in Brandenburg, Germany. In: Proceedings of the Annual Hawaii International Conference on System Sciences 2018 (HICSS 2018).
[11] Sommer, Lutz (2015): Industrial revolution - industry 4.0. Are German manufacturing SMEs the first victims of this revolution? In: Journal of Industrial Engineering and Management, vol. 8, no. 5.

Another interviewee explained that maritime container terminals have embraced the digital transformation after the 2008-2009 financial crisis to improve financial KPI's in a capital-intensive industry. The crisis had a lesser impact for smaller (intermodal) inland terminals, reducing the sense of urgency for modernization. With the European Green Deal and more stringent carbon emission regulations, inland terminals are now on their way to catch up and to become an attractive digital location within the CT chain, in terms of carbon footprint, speed and cost. The call for greener transport, the current container crisis and increasing labour cost are the key drivers for automation.

Another shortage that was mentioned in more than one conversation was the lack of shared rail reference data at European level for an exhaustive list of rail stations and their data fields, e.g., geofence data and their coordinate systems of registration. The Register of Infrastructure (RINF) is a tool describing the static rail network characteristics with a focus on rail Interoperability. Alignment to the needs of digital service platforms might improve this shortage.

Box 2: The main barriers for digitalisation

The main barriers for digitalisation have been rated by IT professionals in the CT sector according to difficulty. The rectangle shows the average rating while the error bars show the standard deviation. The larger the standard variation, the less agreement among the participants.



The integration and convergence to one database is rated as the most difficult challenge. Data exchange in the vertical direction of the transport chain, that is from operator to LSP or LSP to terminal of from operator to the railway undertaking is rated higher than for the horizontal direction. This might be an indication of an issue of interoperability for companies exerting different activities compared to companies exerting the same activity. Surprisingly, the collection of real-time data is not perceived as a difficult barrier, probably because the sector has carried out a lot of effort in this field. Harmonisation and standardisation is rated high. This barrier was also mentioned in multiple interviews.

One barrier in this respect is the different paces of different companies by which they engage in the digital transformation (see Box 2. for different rated barriers). Some companies are lagging behind still partially using pen and paper, or recently accepted spreadsheets, while others are extremely advanced with own inhouse developments such as (web-based) applications. This is one of the reasons why some digital service providers provide low-threshold usable portal services that allow joining companies to digitize their own processes and operations, before they can share their data with others. Data sharing requires harmonization in standards and communication protocols. Herein lies another big challenge: the standardisation of data models and protocols. Lack of common standards and semantics are complicating integration of different data sources of which some are digitised, some not; some use API, others do not.

Another related issue therefore is the data quality. High-qualitive data is a challenge when there is little time for data cleaning in real-time services. Data standards do exist but still need to be implemented by a considerable number of companies in the sector. Many efforts have been done to design standards driven by EU Directives and EU initiatives such as the Hermes data portal exchange, the Electronic data-exchange Intermodal Global European Standard (EDIGES), Technical Specification for Interoperability relating to Telematics Applications for Freight (TAF TSI), and Electronic Data Interchange for Administration, Commerce and Transport (EDIFACT) (see Table 3 for a description of these standards).

Table 3: Data exchange messages

Data exchange	Short	Description
Hermes data portal exchange	Hermes	autonomously carries out the complete porting data exchange independent of the porting software. It can perform a simultaneous administration of several porting identifications.
the electronic data-exchange Intermodal Global European Standard	EDIGES	is a EDI standard composed by EDI messages related to business interaction and logistic processes between CT Operators, Logistic Services Providers, CT Terminals and RUs for intermodal traffic. Automatic integration of transport information is possible with the Cesar system.
Technical Specification for Interoperability relating to Telematics Applications for Freight	TAF TSI	define the technical and operational standards in the EU which must be met by Infrastructure Managers and Railway Undertakings in order to meet the essential requirements to ensure the interoperability of the railway system.
Electronic Data Inter-change for Administration, Commerce and Transport	EDIFACT	a set of internationally agreed standards, directories, and guidelines for the electronic interchange of structured data, between independent computerized information systems.

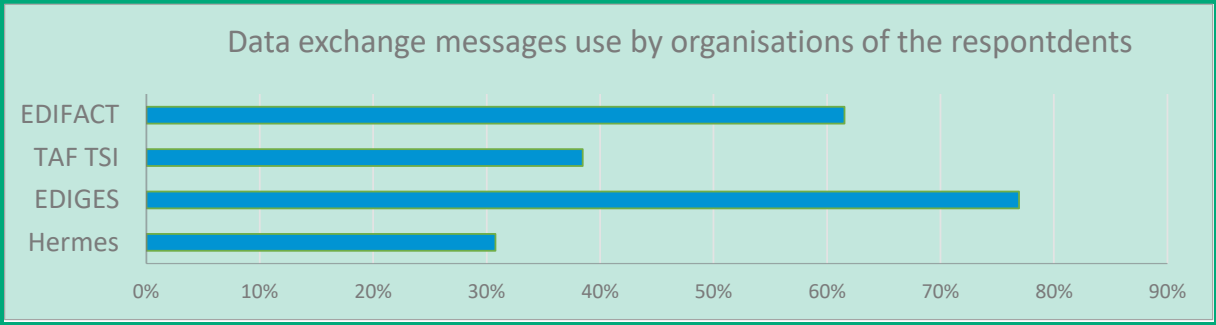
The stakeholder survey gauged the use of these standards or the intension to adopt it (See Box 4). The respondents indicated that they were using the standards, or that they were planning to adopt them in the coming years, but few respondents were implementing it at the time of filling out the survey.

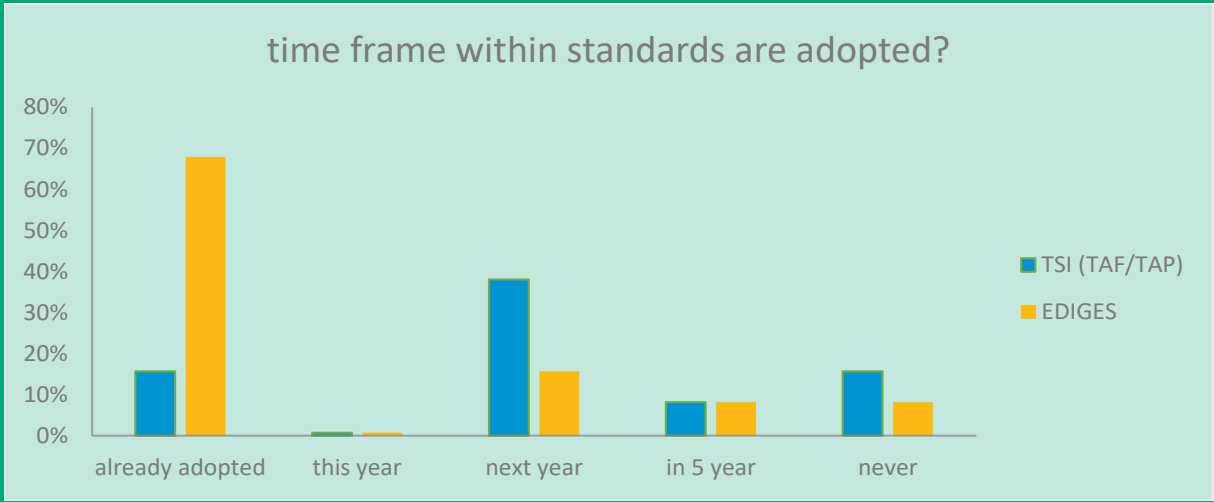
Significant top-down efforts from the EU and other umbrella associations have pushed digitalisation forward such as the Horizon Europe programme for research and innovation, and the Connecting Europe Facility for digital infrastructure.

- “The Digital Europe Programme” (DIGITAL) has been founded with a focus on bringing digital technology to businesses, citizens, and public administrations. The program operates in the areas of high-performance computing and data processing, artificial intelligence, cybersecurity, advanced digital skills, best use of digital capacities and interoperability. It complements the other EU funding programs.
- In the CEF program several relevant projects are ongoing.
  - One example of a CEF-initiative is the FEDeRATED project which is part of the Digital Transport Logistic Forum (DTLF). Its purpose is detailing a masterplan, including leading principles and a reference architecture to be adopted in the European freight transport community and covering several modes of transport emphasizing multi-modal concerns. Sharing data requires understanding another, speaking a common language. FEDeRATED refers to this by the term semantic interoperability for which the projects develop the FEDeRATED Semantic model. A bridge is built to enable any logistics stakeholder to access various (standard-based) data silos through this bridge.

- A second CEF initiative is the FENIX project in which an architecture for data sharing is built serving shippers, logistics service providers, mobility infrastructure providers, cities, and authorities to improve collaboration for Business to Administration (B2A) and Business to Business (B2B) data exchange. The implementation of existing and new standards in the whole sector is still a challenge.

Box 3. Four different types of data exchange methods were enquired to the respondents. Many respondents seem to make use or acknowledge to be involved in one of these platforms. For those that responded that the standards were not installed yet, the timeframe was requested by which they adopt it. Most respondents forecasted implementation within a short timeframe of 1 or 2 years.





The playing field with digital service providers

Many kinds of digital services exist such as Digital capacity management (DCM), Transport management system (TMS), Terminal operating system, etc. Different service providers cover one, or a (partial) combination of two or three services. We will demonstrate a few service providers[12] by way of example.

[12] In this section, a few essential services are explained, and different service providers are mentioned by way of example. The list of companies and organisations that are mentioned is non-exhaustive; companies that are not mentioned can be equally prominent and qualitative digital service providers in the Combined Transport sector (The absence simply means that the authors were not aware of the organisations at the time of writing).

- Digital capacity management (DCM), already mentioned above, aims at optimising infrastructure capacity and asset utilisation. DCM can contribute to freeing up capacity and reduce congestion on lines. Infrastructure Managers (IM) use DCM to ensure sufficient infrastructure capacity in quantity and quality in today's short term and flexible market. Data flow and connectivity from the sector to the digital service providers is mandatory to obtain full transparency of the supply chain and to optimize capacity optimisation services. Planning optimisation of wagon rotation and demand-oriented optimisation of train loading are typical features in DCM. DCM-like features are offered by multiple players such as Hupac (referred to as the SPEAK capacity management system), or the Rail Facilities Portal to name a few. The Rail Facilities Portal provides information on rail freight facilities supporting the planning of rail services.
- Closely linked with DCM are platforms that create a digital marketplace for Combined Transport in Europe where operators market their transport capacities and freight forwarders can book the offers. Examples are Rail-Flow and Modility.
- A different category of digital services is Transport Management System or TMS. TMS provides visibility into day-to-day transportation operations, exchange compliance information and documentation. It streamlines the shipping process in an (semi-)automated way, and depending on the provider, this includes booking, invoicing, and tracking shipping from order to delivery. There is a lot of competition among TMS service providers with IT majors such as Oracle, Siemens or IBM who develop solutions that underly TMS and covers similar utilities. There are also niche players such as Everysens who provide TMS services using real-time data to enhance the visibility of transport activities in a dynamic way. Some digital service providers in this class are:
  - Hupac with the WOLF platform,
  - Transporeon aiming at real-time visibility solutions underlying TMS,
  - Alpega TMS which is a cloud-based solution,
  - Logistische Informationssysteme AG supporting electronic order and booking of intermodal transport.

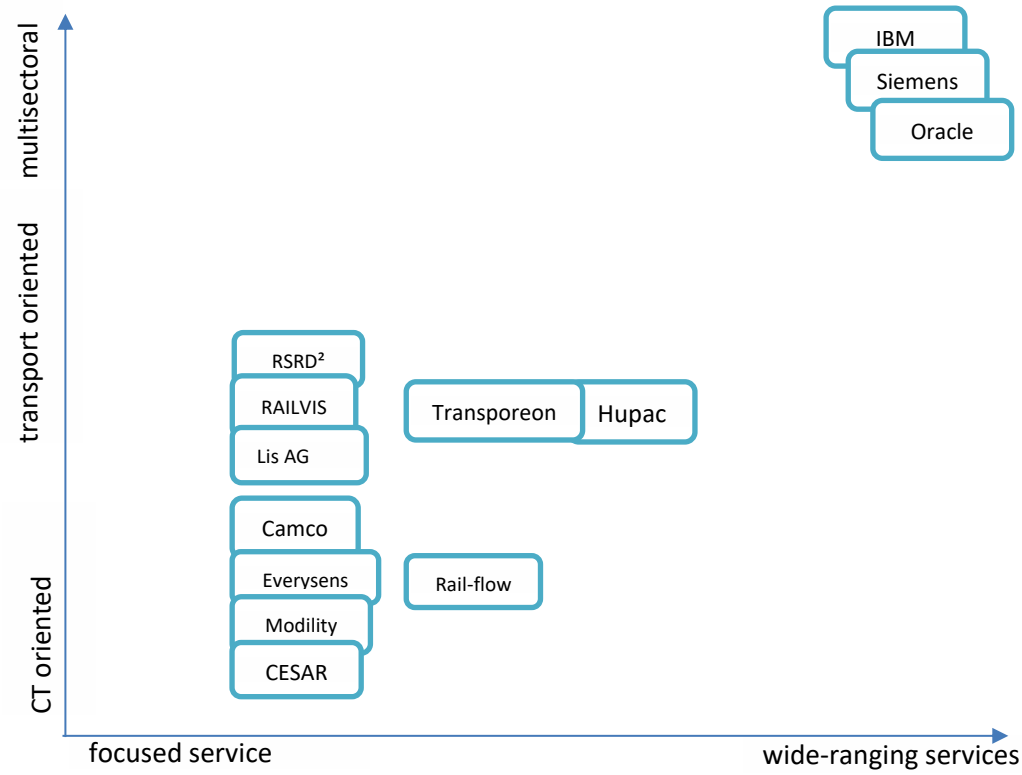
There are many initiatives in the EU and umbrella associations that support data exchange and that are becoming mature providers on which other platforms can rely. For instance, wagon keepers started a non-profit organisation to establish the Rolling Stock Reference Database (RSRD²) providing wagon freight data and easy train assembly.

A different example is the Train Information System (TIS) hosted by RNE. This web-based application provides real-time train data concerning international passenger and freight trains. CESAR is one more platform of this kind, particularly oriented to Combined Transport and providing up-to-date status information on trains, wagons and intermodal loading units in Combined Transport in the EU.

Shipment status data and real-time Information is also accumulated at terminals where sensors, cameras and IoT are monitoring the shipping process and automating the check-in and check-out operations. Service providers at terminals like Hupac, INFORM, and Camco automate intermodal terminals and provide yard control to streamline gate and rail processes. The digitalisation of intermodal shipment at terminals provides valuable information on the timing of arrivals and departures of trains, vessels and trucks. This information can add service to clients by improving shipment details and delivery status tracking.

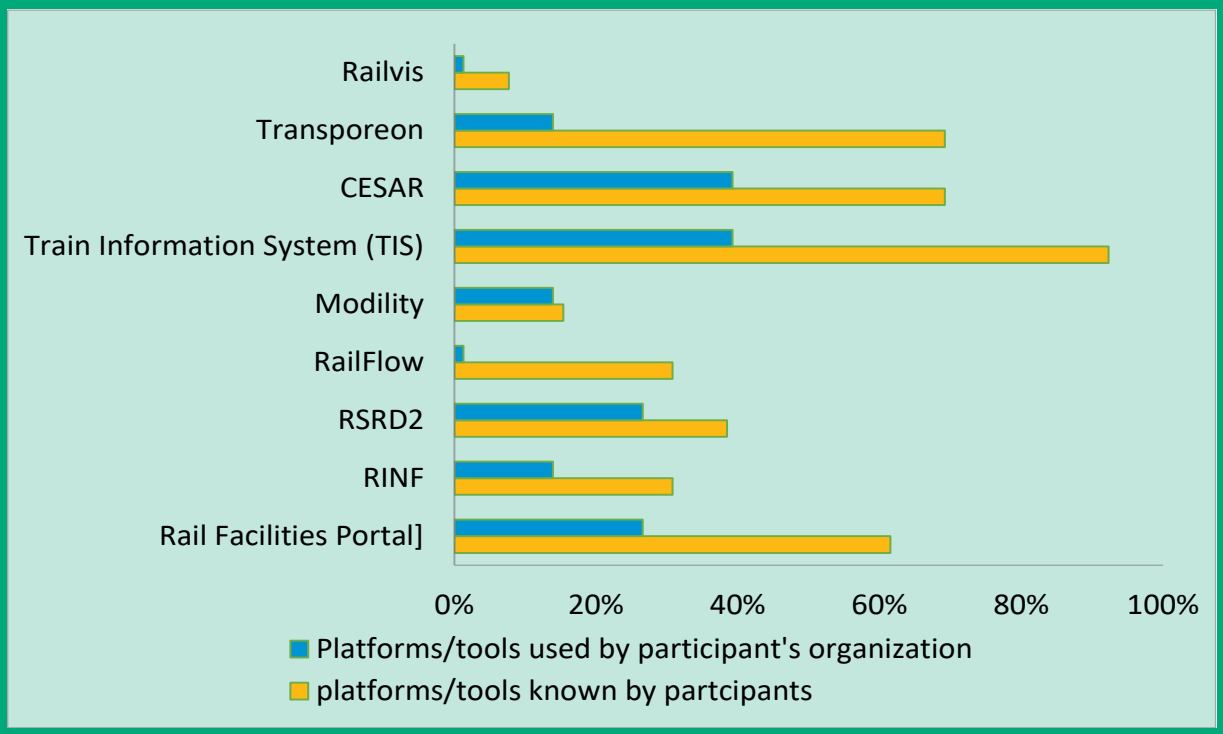
In Figure 28, companies are ranked according to their focus (niche player versus multiple service provider) and their service orientation inside or outside the Combined Transport sector. Box 5 presents survey results on the familiarity of a few platforms among respondents.

Figure 28. Digital service providers are positioned on two dimensions: orientation as a company towards the Combined Transport sector and focus of their services



(Disclaimer: this is a non-exhaustive list of companies positioned on two axes according to the authors' personal views. Prominent companies not displayed reflects the unawareness of the authors at the time of writing.)

Box 4. The result of a poll aimed at the familiarity of a few platforms in the sector.

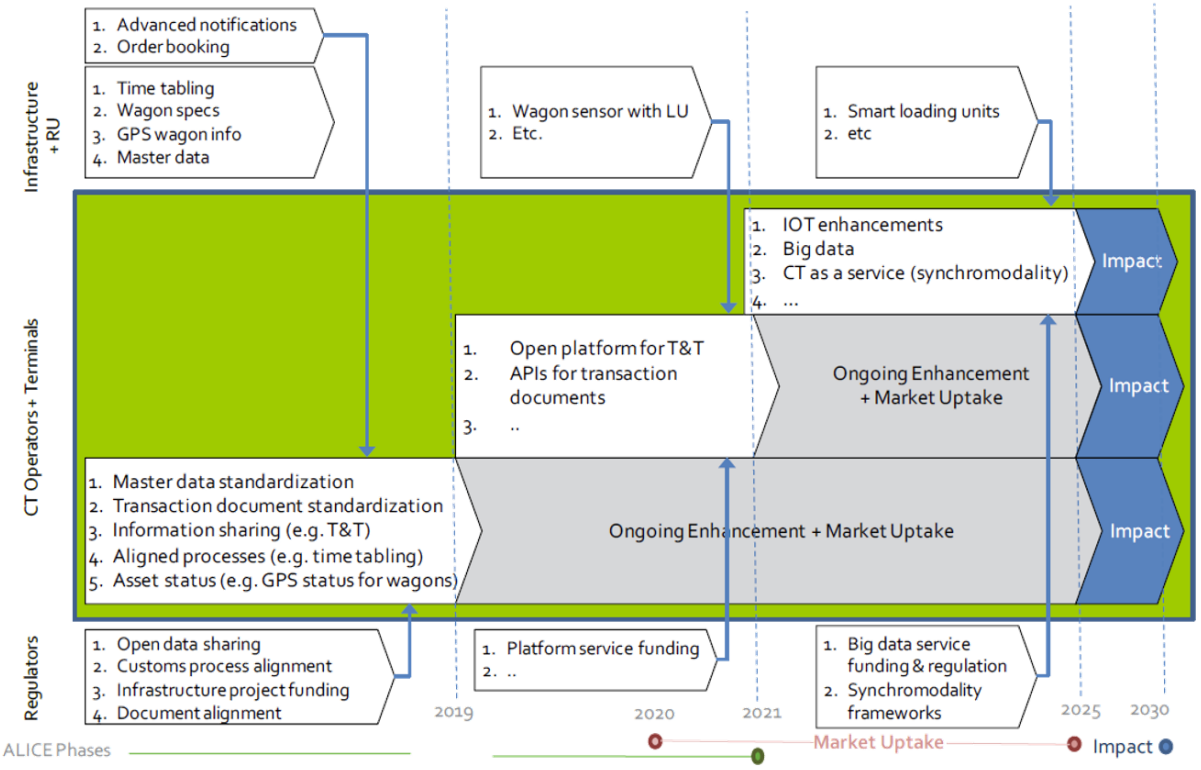


Trends in digitalisation and business models

Digitalisation is one of the key enablers to boost the Combined Transport sector and help the transport industry to achieve its 2030 and 2050 emission targets.

Data sharing can spark the collaboration needed to move forward to one integrated network in one digital ecosystem. Digitalisation goes hand in hand with upscaling operational borders and opening up the relevant data, through a standardisation of data exchange systems and data interoperability. A set of EU directives aims to break down borders in Europe and pave the way to a single digital market and common standards for interoperability. Regulators are pushing digitalisation with numerous standardisation initiatives, such as TAF-TSI and Rail Freight Corridors (RFC), that harmonise the international railway system and break down the barriers of data exchange, both vertically (between the next players in the intermodal transport chain) and horizontally (between different competitors in the same operational segment). In this integrated network, cross-border operations will become commonplace with the support of information powered by connectivity and digital transformation.

Figure 29. *Roadmap for CT digitalisation*



Sources: UIRR Roadmap 2019

UIRR developed a roadmap of the digital transformation of Combined Transport, depicted in Figure 29. The roadmap contains different phases and different layers. There is one layer for the regulators at the bottom, one layer for CT operators and terminals in the middle and one layer for the infrastructure managers and railway undertakings. The transformation proceeds in different phases with target for the third phase in 2025 and maturing of the accomplishments thereafter.

In the first phase, different aspects needed to be treated.

- The first aspect concerns the master data; that is the reference data that the sector needs in a standardised format, to ensure connectivity and data interoperability. Data sharing is aligned with the standardisation and also implies the willingness to share and to adopt the regulated standards. An example of a commodity in data sharing is track and tracing by using GPS and RTLS information.

- More aspects involved in this phase are electronic document transactions and the alignment of processes, which is important in particular for the CT sector, with its multifaceted organisation.
- Asset status is also one aspect that is ongoing with IoT providing the status of assets. The first phase sparks many developments in the wagons, in the terminals and on the load.

The market uptake of these different ongoing processes leads to a second phase with open platforms and API's that will nourish digital service providers. In the future, the physical transport chain will be mirrored in a digital twin, that will lead to smarter real-time solution and that will be enhanced with the aid of big data, IoT, and AI to client-oriented transparent services.

From the customer's perspective, broader services are created by enriching existing services with new information from digital systems. The impact is expected to be significant, to the extent that new services may emerge that give rise to new business models. Such value adding information could include:

- ETA or Estimated Time of Arrival. ETA is an important feature because it forecasts delays and allows anticipation in terminals and routing schedules. It is a digital service that has already been marketed but when information flows grows and wagons become smarter, spurred by the provision of IoT, GPS and RTLS technology, it will be a strong asset and a game changer in the way how transport is organised and how service are presented. ETA will definitely enrich TMS and DCM platforms, and terminal operating systems.
- Artificial Intelligence (AI) is an umbrella term for computing advanced information out of data. For example, huge volumes of data can be plugged into AI algorithms to train neural networks to make smart decisions in operations and businesses, to make predictions in a glance, or to automate processes and make controllers adaptive to particular circumstances.
- When all physical processes and objects are digitized and sending real-time data, a virtual representation is created that captures the entire system. This digital representation is referred to as a digital twin. Whatever goes on in the physical world will be mirrored in the digital twin. It is expected the digital twin representation to emerge first at (large) terminals (making the whole yard digital) and from there to expand to the entire transport chain. This level of digital representation will make the entire network transparent in real-time. It will drive analyses, simulation, and prediction improving safety and efficiency.
- Internet of Things (IoT) interconnects smart components on board of objects. Maintenance can be tailored on the basis smart object's reports. The Industrial Internet of Things (IIot) evolved in the slipstream of the digital transformation in the industry, referred to as industry 4.0. It refers to flexible information exchange between smart entities throughout the entire product lifecycle. In that sense IoT on physical parts will guide the products through the assembling, the supply, and the transport chain. A related concept is the Internet of Services (IoS) referring to a decentralized access to inter- and intra-organisational services, making these available to all the participants of the entire value chain, inclusive the client. IoT is one of the pillars that supports a client- and service-centred architecture in the development of platforms and web-based application.

Cybersecurity was recognized as an important subject in the sector (see Box 1). Secure data exchange will probably imply blockchain technology in the future. Cloud computing with Software as a Service (SaaS) might gain popularity. In the far future, data storage and generic services might be increasingly outsourced to companies such as AWV, Microsoft Azure, and Google, or others. Digital platforms will tend to put their focus on front-end development enhanced with AI and business analysis to create added value. The data itself is then expected to be integrated in more specialised organisations or institutions that collect and master the data in the back end, as such, supporting the digital service providers. A convergence of databases in the backend and edge computing giving the ability to scale is a possible development for the future.

As digitalisation continues, end customers increasingly expect that services are catering to them according to the norms and standards of the day. The digital transformation will push these standards to a higher level. Services can be tailored to the customer's needs through the whole supply and transport chain. For example, repetitive time-based transport that feeds production lines is different from one-time transport of a fragile item. Services become smart when decisions and responses tailor to these characteristics, for example, to unexpected inconvenience. Timing for instance, is more important for production lines, while secure transport is more important for fragile cargo.

When considering new business models in CT, it is advisable to think about the customer and the unique value proposition one can provides. The digital transformation can augment the value proposition in the business model. This can be done by offering more reliable shipping lines, by automatic assembling of the transport schedule, and in the meantime, considering the customer's wishes concerning the ecological footprint, the speed, or the price of transport. Information about shipping status will also augment the value proposition. This will affect customer relationships and customer experiences positively. The digital transformation will support flexibility to market strategies with respect to geographic coverage, the type of transportation modes, and the size and type of the target market (e.g. big industries against door-to-door services for one individual). The digital transformation will drive automation of freight forwarding, improve accessibility of services and improve the overall quality of the Combined Transport.

Acknowledgement

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The revision of the Weights and Dimensions Directive

Weights and Dimensions of road transport vehicles have an important impact on Combined Transport, both in a cooperative sense (loading units used on the road are also transferred onto the rail section) and in the competitive sense (combined transport and pure road transport compete for cargo in certain market segments). With the upcoming review of EC Directive 96/53 on Weights and Dimensions of Heavy Commercial Vehicles, UIC/UIRR wanted to gain additional insight in the current market situation, potential new standards and deviations, their attractiveness and their potential impact on Combined Transport.

Overview of current W&D regulations in the EU

The governing Directive 96/53/EC lays down the maximum authorised dimensions of vehicles and vehicle combinations used for commercial transport, both of passengers and goods, in national and international traffic, and the maximum authorised weights in international transport.

In general, the maximum dimension rules applying to all vehicles are:

- Maximum trailer: length: 12.00m
- Maximum articulated vehicle length: 16.50m
- Maximum road train length: 18.75m
- Maximum height 4.00m
- Maximum turning circle for any motor vehicle or vehicle combination which is in motion: outer radius of 12.50m and an inner radius of 5.30m.

The weight rules are:

- Road trains with 5 or more axles: 40 tonnes
- In intermodal transport: 42 tonnes for 2-axle motor vehicles with 3-axle semi-trailers, 44 tonnes for 3-axle motor vehicles with 2- or 3- axle semi-trailers

However, exemptions are possible to both weights and dimensions in national transport, if this does not affect international competition in the transport sector.

Weights

The following table reflects the current limits for weights of heavy commercial vehicles in Europe (source: OECD-ITF, 2019):

Country	Weight per non-drive axle	Weight per drive axle	Lorry 2 axles	Lorry 3 axles	Road train 4 axles	Road train 5 axles and +	Articulated vehicles 5axles and +
Albania	10	11.5 (1)	18	26 (2,3)	36	40	44
Armenia	10	10	18	22	36 (4)	36 (4)	36 (4)
Austria	10	11.5	18	26	36	40 (5)	40 (5)
Azerbaijan	10	10	18	24	36	42	44
Belarus	10	10 / 11.5	18 / 20	25	38 / 40	40 / 42	42 / 44
Belgium	10	12	19 (6)	26 (6)	39 (7,8,9)	44 (10,11,12,13,14)	44 (10,14,15)
Bosnia-Herzegovina	10	11.5	18	25 / 26	36 / 38	40 / 42	42 / 44 (16,17)
Bulgaria	10	11.5	18	26 (2)	36	40	40
Croatia	10	11.5	18	25 (18)	36	40	40 (5)
Czech Republic	10	11.5	18	26 (2)	32	48	48
Denmark (19)	10	11.5	18	24 (20)	38	44 (21)	44 (21)
Estonia	10	11.5	18	26 (2)	36 (22)	40 (23)	40 (23,24)
Finland (25)	10	11.5	18	28 (2)	36	44 (26)	44 (26)
France	12 (27)	12 (27)	19	26	38 (28)	40 / 44 (29)	40 / 44 (29)
Georgia	10	11.5	18	25 / 26 (30)	36	40	40 / 42 (16) (17)
Germany	10	11.5	18 (31)	26 (31)	36	40 (32)	40 (32)

Country	Weight per non-drive axle	Weight per drive axle	Lorry 2 axles	Lorry 3 axles	Road train 4 axles	Road train 5 axles and +	Articulated vehicles 5axles and +
Greece	7/10	13	19	26	38 (33,34)	40 / 42 (35)	40 / 42 (24)
Hungary	10 (36)	11.5 (36)	18 (37)	25 (38)	36 (39)	40	40 / 42 (16) (17)
Ireland	10	11.5 (40)	18	26 (41)	36 (42)	42 (2,43,44,45)	44 (45,46,47,48)
Italy	12	12	18	26 (2)	40	44	44
Latvia	10	11.5	18	25 / 26 (30)	36	40	40 (24,49)
Liechtenstein	10	11.5	18	26 (2)	36	40	40
Lithuania	10	11.5	18	25 (18,50,51)	36	40 (49)	40 (24)
Luxembourg	10	12 (52)	19	26	44	44	44
Malta	10	11.5	18	25	36	40	40 (53)
Moldova	10	11.5	18	25 (18)	36	40	40 (53)
Montenegro	10	11.5	18	26 (54)	36	40	40 (53)
Netherlands (19)	10	11.5	21.5	21.5-30.5 (55)	40	50	50
North Macedonia	10	11.5	18	25	36 (22)	40	40
Norway (19,56)	10	11.5	19	26 (57)	39	46-50 (58)	46-50 (59)
Poland	10	11.5	18	26 (2)	36	40	40
Portugal (19)	10 (60)	12	19	26	37 (61)	44 (60)	44 (62)
Romania	10	11.5	18	25 / 26 (30)	36	40	40 / 42 (16) (17)
Russia	10	10 (63)	18	25 (64)	36 (28)	40 (65)	40 (65)
Serbia	10	11.5	18 (66)	25 (18,67)	36 (68)	40	40 / 42 (16) (17)
Slovakia	10	11.5	18	26 (2)	40	40	40
Slovenia	10	11.5	18	25 (18,50)	36	40	40 / 44 (16,69)
Spain	10	11.5	18	25 (18)	36 (68)	40	42 (49) / 44 (24)
Sweden	10	11.5	18	25 / 28 (30)	38	40 (70)	44 (53)
Switzerland	10	11.5	18	26 (71)	36	40	40
Turkey	10	11.5	18	25 (72)	36 (28,73)	40	40 (74)
Ukraine	11	11	16 (75)	22 (76)	38 (77)	40 (77)	40 (77)
United Kingdom	10	11.5	18	26 (78)	36 (79)	40 / 44 (80)	40 / 44 (80)

Dimensions

Country	Height	Width	Length		
			Lorry or Trailer	Road Train	Articulated Vehicle
Albania	4	2.55 (1)	12	18.75	16.50
Armenia	4	2.55	12	20	20
Austria	4	2.55 (1)	12	18.75	16.50
Azerbaijan	4	2.55 (1)	12	20	20
Belarus	4	2.55 (1)	12	20	24
Belgium (2)	4	2.55 (1)	12	18.75	16.50
Bosnia-Herzegovina	4	2.55 (1)	12	18.75	16.50
Bulgaria	4	2.55	12	18.75	16.50
Croatia	4	2.55 (1)	12	18.75 (3)	16.50
Czech Republic	4	2.55 (1)	12	18.75 (4)	16.50
Denmark	4	2.55 (1)	12	18.75	16.50
Estonia	4	2.55 (1)	12	18.75	16.50
Finland (5)	4.40	2.60 (6)	18	34.50	23
France	not defined	2.55 (1)	12	18.75 (7)	16.50
Georgia	4 (8)	2.55 (1)	12	18.75 (9)	16.50
Germany	4	2.55 (1)	12	18.75	16.50 (10)
Greece	4	2.55	12	18.75	16.50
Hungary	4	2.55 (1,11)	12	18.75 (12,13)	16.50
Ireland	4.65 (14)	2.55 (1)	12	18.75 (15)	16.50
Italy (16)	4	2.55 (1)	12	18.75	16.50
Latvia	4	2.55 (1)	12	18.75	16.50
Liechtenstein	4	2.55 (1)	12	18.75	16.50
Lithuania	4	2.55 (1)	12	18.75 (4)	16.50
Luxembourg	4	2.55 (1)	12	18.75	16.50
Malta	4	2.55 (1)	12	18.75	16.50
Moldova	4 (17)	2.55 (1)	12	18.75 (18)	16.50
Montenegro	4	2.55 (1)	12	18.75 (19)	16.50
Netherlands (2)	4	2.55 (1)	12	18.75	16.50
North Macedonia	4 (16a)	2.55 (1)	12	18.75	16.50
Norway (20)	not defined	2.55 (1)	12	19.50 (21,22)	17.50 (23)
Poland	4	2.55 (1)	12	18.75	16.50
Portugal (2,16)	4 (24,25,26)	2.55 (1)	12	18.75	16.50
Romania	4	2.55 (1)	12 (27,28)	18.75 (27,28)	16.50
Russia	4	2.55 (1)	12	20	20
Serbia	4	2.55 (1,29)	12	18.75	16.50 (30)
Slovakia	4	2.55 (1)	12	18.75	16.50
Slovenia	4.20	2.55 (1)	12	18.75 (31)	16.50
Spain	4 (32)	2.55 (1)	12	18.75 (33)	16.50
Sweden	not defined	2.60	24	25.25	24
Switzerland	4	2.55 (1)	12	18.75	16.50
Turkey	4	2.55 (1)	12	18.75 (34)	16.50
Ukraine	4 (17)	2.60	22	22	22
United Kingdom	not defined	2.55 (1)	12	18.75	16.50

Summary for EU27 countries

The standard in the EU, as prescribed by Directive 96/53/EC, is that vehicles involved in international traffic can have a maximum length of 16.5m (Articulated Vehicle: road tractor + semitrailer) or 18.75m (Road train: lorry + trailer), with a maximum total weight of 40 tonnes (42/44 tonnes for intermodal transport), for 5 axle vehicle combinations.

Notable exceptions

- Belgium, France, Luxemburg, Italy, Ireland allows 44 tonnes for all traffic, not just intermodal. For France, certain conditions apply.
- In the Walloon region, up to 50 tonnes is allowed for vehicle combinations with at least 6 axles.
- The Czech Republic allows up to 48 tonnes for 5 axle vehicles.
- Estonia allows 44 tonnes for 6 axle vehicles.
- The Netherlands allows 50 tonnes for 5 axle vehicles.
- The Netherlands, Sweden and Finland allow longer EMS combinations of up to 25.25m and 60 tonnes, without restrictions.
- In Spain and Portugal, these vehicles can be used with a permit and on a specific part of the network.
- Belgium and Denmark also allow EMS of 25.25m and up to 60 tonnes on a trial basis, also requiring special permits and restricted to certain parts of the road network.
- Finland permits vehicles up to 34.5m and 76 tonnes, with trials running for a weight up to 104 tonnes.
- Similar trials run in Sweden for vehicles up to 32m and up to 90 tonnes.
- Countries like Estonia (25.25m, 52 tonnes), Czech Republic (25.25m, 48 tonnes) and Germany (25.25m, 44 tonnes) allow vehicles with extended length but not up to the standard EMS weight of 60 tonnes.
- Germany allows extended trailer vehicles with a maximum length of up to 17.88m
- Vehicle carriers usually have a maximum allowed length of 20-21m.

Deviations from standards

In this section we will discuss which deviations from the standard are the strongest candidates to be adopted further in European or national legislation.

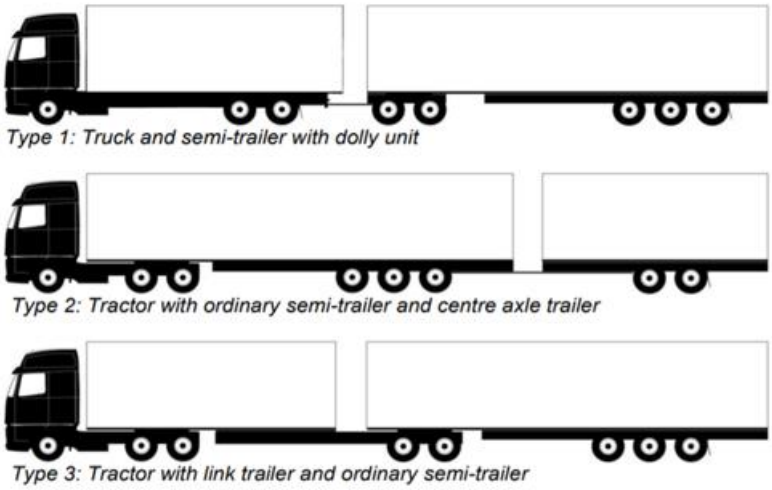
European Modular System (EMS)

Vehicles classified as EMS are composed of standardised modules (trucks, tractors, (semi-)trailers, dollies) combined into longer and/or heavier configurations. By using these standardised modules, in principle there is no limit to the length and weight that can be achieved – only the power of the towing vehicle needs to be sufficient to drive safely under all circumstances.

Longer Heavier Vehicles (LHVs)

Longer Heavier Vehicles (LHVs) known as eco-combis, gigaliners, megatrucks, etc., are the most common name given to vehicles of the EMS type where the current standard vehicle is coupled (using a dolly) with an additional (semi-)trailer to reach a maximum length of 25.25m. The maximum weight varies between applications. Most countries apply a maximum of 60 tonnes, where the weight increase is proportional to the length increase. These LHVs usually have 8 axles (up from 5 on most standard vehicles), which means that the average weight per axle decreases compared to a standard vehicle.

Figure 30: The most common configurations of LHVs in Europe



Sweden and Finland have the longest history with EMS, having used them for several decades. Their joining the EU in 1995 was one of the main reasons for the revision of Directive 85/3/EEC, with the main new inclusion the possibility for national exemptions to the standard rules, clearing the path for Sweden and Finland to keep using the vehicles they had been using already. Traditionally, these vehicles have been used in the forestry industry.

After a period of trials between 2001 and 2010, the Netherlands has fully adopted LHVs. Spain and Portugal have followed similar paths. Belgium and Denmark have been running trials with LHVs for about a decade.

In countries like Germany and the Czech Republic, vehicles of these configurations are allowed but with a maximum weight equal to that of standard-length vehicle, i.e. 44 tonnes (Germany) or 48 tonnes (Czech Republic). Most cited reasons for this limit are the preservation of infrastructure (some older bridges are sensitive to the weight of a single vehicle) or protecting rail transport (which historically has always been used to transport heavy goods).

Countries that allow these vehicles in free circulation:

- Finland
- Sweden

Countries that allow these vehicles with a permit and on a restricted part of the network:

- Netherlands
- Portugal
- Spain

Countries that allow these vehicles on a trial basis, with a permit and on a restricted part of the road network:

- Belgium
- Denmark

Countries that allow these vehicles at a lower weight, on a restricted part of the road network:

- Czech Republic
- Germany

As a rule, these vehicles can only circulate within the national territories of each country. Cross-border transport of LHVs has been a contentious issue. Commissioner for Transport Siim Kallas issued a letter attempting to clarify the issue in 2012, stating that LHVs were allowed to cross one border, provided that both countries allowed it. In the legislative process to amend Directive 96/53/EC in 2015, a proposal was made by the Commission to formalise this. However, this provision was not adopted by the other parties, leaving the initial unclear situation unsettled. However, several national governments have since adopted bilateral agreements to allow LHVs to cross their mutual border, under certain conditions. This includes the Nordic countries, Germany/Netherlands and the Benelux countries.

High-Capacity Vehicles

High-Capacity Vehicles (HCVs) are an advanced form of EMS. They are composed of the same modular units but can be longer and heavier. Finland allows vehicles op up to 34.5m and 76 tonnes, with a trial ongoing to allow up to 104 tonnes. Sweden is trialling vehicles of up to 32m and 74 tonnes. In Spain, a trial with 32m, 60 tonne vehicle started recently.

Several European research projects have worked on the development of HCV, including the DUO-trailer project (which started in 2012) and the AEROFLEX project (which ran from 2017-2021).

Extended semi-trailers

Some European countries allow semitrailers that are longer than the standard 13.6m. These longer semi-trailers have additional floorspace and volume, but not extra weight. In order to be compatible with intermodal transport, a detailed technical study of the current rail wagon fleet needs to be carried out to guarantee a full technical interoperability. Unless the rail journey of the intermodal chain ends directly at the destination (and no final road leg is needed), these loading units can only be used in domestic intermodal transport or between countries that both allow semi-trailers with this additional length.

Information available on this topic is limited.

- **Germany** has the longest history with these vehicles, allowing tractor-semi-trailer combinations of up to 17.88m, an additional length of 1.38m.
- In **Italy**, semi-trailer length can be up to 15m for a total vehicle length of 18m, i.e. slightly longer than in Germany. Italy has conducted a trial with these extended semi-trailers since 2009, with 30 such units in circulation at the end of the trial in 2012. A new trial started in 2014. By mid-2015, 300 extended semi-trailers were being used.

These extended trailers are mainly used to transport palletised goods. The extended unit allows for the transport of 4 additional pallets compared to a regular semi-trailer, which is equivalent to 12% extra capacity.

Although the main conclusion of the trials in Germany was that much more long during testing would be needed to come to appropriate conclusions, the experts formulated that:

- The market potential and size would remain limited (amongst others due to the regulatory restrictions on its use)
- A multitude of risks were identified as acceptable and manageable. The main reason why was the probability given the limited potential market share
- The total number of vehicle KMs reduced resulting in lower emissions.

General allowance of 44t on 5 axles for all road vehicles

A Gross Vehicle Weight (GVW) of 44 tonnes is currently allowed for the road leg of intermodal transport in all EU countries. In several countries (Belgium, France, Luxemburg, Italy, Ireland), 44 tonnes in the current general rule for all domestic transport, for 5 axle vehicles (in some cases with additional conditions relating to axle weights). Other European countries have higher weight allowances for domestic transport, but these are often only applicable to 6 axle vehicles. The impact of a general allowance of 44t on 5 axles on the current modal split is not investigated in depth. Some Indications into the direction of a risk of reverse modal shift seem to be available.

Impact on efficiency and externalities

Moving freight with larger vehicles, be it in an EMS combination or with an elongated semitrailer, is mainly done as an efficiency measure. By moving more cargo in a single vehicle (combination), there can be savings in terms of fuel, wages and possibly also road charges. Furthermore, when fewer vehicles are needed to transport a given amount of cargo, this also has a positive impact on emissions of local pollutants that affect air quality, on noise levels and on safety.

Regarding the latter aspect, there is a balance between the reduction of the number of vehicles and the total distance driven, and the fact that these larger vehicles are heavier and could cause more damage in case of an accident. However, at least for EMS combinations, trials and research have demonstrated that there is a third effect in play. Mostly, tractors in EMS combinations are more modern, better equipped, better maintained and its drivers are trained better. More axles (60% more axles for only a 50% increase in maximum weight) also means more powerful braking capabilities. It is noteworthy though that this does not apply to all EMS combinations. Some combinations suffer from worse stability when the modules of which it is composed are not equipped properly. Whether or not the safety of vehicles with extended trailers is the same or better than that of regular HDV could not be assessed due to a lack of supporting evidence.

Fuel (and CO_2) savings of LHVs are typically estimated at 15-20% (per tonne.km). For HCVs, the savings could be as high as 33% according to some studies, depending on the application. Ideally, these vehicles are used over longer distances, where optimal cruising speed can be held for longer periods. For comparison purposes, fuel and CO2 savings in combined transport are estimated between 63% and 90%.[13]

The extended trailer has 12% extra load capacity with close to zero fuel consumption penalty (except for the extra weight of the additional cargo). The extra length does not impact the manoeuvrability of the vehicle (turning circle) and can be compatible with intermodal transport operations using suitable pocketwagons.

[13] Source: d-fine (2021): “A comparative study on CO2 emissions in door-to-door combined transport”

Increasing the maximum allowed GVW from 40 tonnes to 44 tonnes for all HDV would only affect that part of the market that currently experiences a weight restriction (such as the chemical sector, construction industry, … - i.e. heavy bulk goods). In these segments, transport efficiency gains of 5-10% could be expected. It should be noted that many of these goods are often only transported by road over short distances. For longer journeys, rail or inland waterway transport is the preferred mode because of the cost advantages.

In addition to the transport efficiency gain, relaxed weight restrictions also affect road infrastructure as an externality, as was highlighted in the PIARC study "Overweight Vehicles: Impact On Road Infrastructure And Safety" (2022). The damage to infrastructure done by an axle is governed by the so-called "4th power law" for asphalt pavements (OECD ITF, 2011). In short, this law implies that increasing axle weight by 20% more than doubles the impact it has on road pavements.

This is not an unrealistic situation. While Directive 96/53 sets axle load limits for non-driven axles at 10 tonnes, some countries already set it at 12 tonnes. This suggests that several countries already have roads designed with buffer capacity to accommodate heavier vehicles (including those active in combined transport at 44 tonnes). However, this is unlikely to be the case in all Member States.

Impact assessment of new standards on Combined Transport

The previous section revealed that container transport could be among the market segments where LHVs could have the largest impact. This is indeed a sector where intermodal competition is strongest, and factors like costs, time, reliability, security, etc. all play a role in determining the mode choice made by shippers or transporters.

Current European rules make weight exemptions for the road legs of intermodal transport, allowing for (at least) 4 tonnes extra weight – a compensation for the additional weight of the loading unit required for intermodal transport.

In general, most studies that review the link between the use of LHVs and the risk of reverse modal shift are theoretic ex-ante calculations, including OECD-ITF (2019) "High-capacity Transport: Towards Efficient, Safe and Sustainable Road Freight", AEROFLEX (2017-2021), and K+P (2011) "Study on the Effects of the Introduction of LHVs on Combined Road-Rail Transport and Single Wagonload Rail Freight Traffic".

Reviewing the evidence, the conclusion is that it is not unlikely that the wider allowance of LHVs, especially in medium distance markets, could affect the volume of Combined Transport based on the cost advantage these vehicles provide compared to regular HDVs. Shippers often use costs as their primary KPI, and all other factors being equal, LHVs may push the threshold for modal shift to Combined Transport a bit further, as the cost advantage for rail is likely to remain with increasing distance. However, those same cost advantages could also improve the position of Combined Transport as the road legs – which in many cases represent a significant fraction of the total cost - become cheaper as well.

Several other aspects could impact the outcome of a potential policy change:

- The impact of cost changes independent of weights and dimensions in road or rail. This could include
  - wage costs (due to driver shortages, increased standard of living in Eastern Europe, cabotage rules…);
  - equipment costs (due to e.g. environmental or safety requirements);
  - operational costs (road charging, congestion, fuel costs…).

- The precise modalities of the new legislation (W&D directive or other). Weight and length (for 45ft containers) exemptions for Combined Transport could remain, but other potential provisions could include network access limits (e.g. with certain weight limitations), lower road access charges for Combined Transport…

As for extended trailers, the concept is not yet fully standardised and some current units are compatible with Combined Transport (using pocket wagons according to standard EN16973, such as the T3000E), while others are not (namely those with increased height in addition to increased length). The market for extended trailers in Combined Transport mostly lies in continental transport of unaccompanied semitrailers (which represent around 21% of total the total fleet of intermodal loading units), one of the submarkets with the most growth potential. To maximise the market potential of these units, further development should focus on improving intermodal transport compatibility.

First indications of possible impact of the introduction of LHVs were given by K+P (2011) concluding that at the same time Combined Transport and for sure Single Wagon Load transport would be negatively impacted. “For sure Combined Transport would lose market share. In the light of the huge investment programmes already made to establish Combined Transport in Europe, this effect needs to be carefully considered”.

The impact of a generalisation of 44 tonne HDVs on 5 axles is also most likely to affect the bulk transport market, rather than Combined Transport. In a 2009 study on the introduction of the 44 tonne general rule in France (Conseil National de Transport “Le 44 tonnes, Rapport de synthèse sous forme de compte-rendu des travaux du Groupe marchandises du CNT”), it was estimated that a modal shift of 1% (from rail to road) could occur, but this includes all rail, not just Combined Transport. This report also estimated that the decrease in total road transport volume due to the increased load capacity would outweigh modal shift and induced traffic (due to lower cost of road transport) by a factor 4.

In a study by Prognos, commissioned by UIRR in 2021, the potential effects of such an increase in general GVW to 44 tonnes was examined. It found that almost half of cross border Combined Transport was heavier than 24 tonnes and could thus potentially shift to road if this new rule would enter into force, with increases in CO_2 emissions of 244%. The study did not estimate the actual potential reverse modal shift.

Annex: remarks to weights and dimensions tables

Weights table

1. National traffic: 10 t.
2. Only with air suspension or similar, and ABS (Anti-lock Braking System).
3. National traffic: 24 t.
4. Above the authorised weight of 36 t, each additional tone is subject to a fine of AMD 55 (1 USD = 364 AMD) per km.
5. Vehicle engaged in Combined Transport: 44 t. Austria: initial and final road hauls in Combined Transport to/from the nearest technically suitable terminal in Austria.
6. (Flanders and Brussels Capital Region) The maximum authorised weight is increased by the added additional weight required for the alternative fuel technology with a maximum of 1 t.
7. (Flanders) Two-axle motor vehicle with one-axle trailer: 36 t.
8. (Flanders) Two-axle motor vehicle with two-axle trailer (with a tandem axle with axle spacing < 1.80 m): 36 t.
9. (Wallonia) Two-axle motor vehicle with a trailer with a tandem axle: 36 t.
10. (Brussel Capital Region) Mechanic suspension: 43 t.
11. (Flanders) Two-axle motor vehicle with three-axle trailer (with axle spacing < 1.80 m): 40 t.
12. (Flanders) Three-axle motor vehicle with two- or three-axle trailer (with axle spacing < 1.80 m and mechanical suspension): 42 t.
13. (Wallonia) Three-axle motor vehicle with trailer with a tandem or tridem axle with mechanic suspension: 42 t.
14. (Wallonia) 50 t in two cases: 1) articulated vehicles consisting of a three-axle tractor and a three axle semi-trailer; 2) trains of vehicles consisting of a motor vehicle with three or more axles and a trailer with three or more axles, subject to the following conditions: a) the set of axles is of the type air suspension or recognised as equivalent; b) the distance between the two axles is greater than or equal to 1.3 m; c) the maximum mass of any tridem is 25 t; d) the articulated vehicle or the vehicle train is equipped with an on-board sensor device indicating the laden mass of the vehicle and the load of axle to the driver; e) the trailer or semi-trailer tractor is in category N3, covered by a certificate of approval issued by a Member State of the European Union, and meets the minimum environmental class EURO VI, in accordance with the Royal Decree of 26 February 1981 implementing the European Communities' Directives on the type-approval of motor vehicles and their trailers, wheeled agricultural or forestry tractors, their components and safety accessories, or in accordance with Regulation (EEC) No 49 ECE; f) EBS (Electronic Braking System), AEB (Automatic Emergency Braking) and ESC (Electronic Stability Control) or RSC (Rolling Stability Control) systems are mandatory and the EBS calculator and modulators provide an immediate response based on the state of charge of the vehicle; g) the driver of a vehicle and train of vehicles shall maintain an interval of at least 50 m with other vehicles and vehicle trains with a maximum authorised mass exceeding 3.5 t; h) the special rules in point 1.4.2 art. 32bis of the Royal Decree laying down general regulations on the technical conditions to be met by motor vehicles and their trailers, their components and safety accessories cannot be applied.
15. Two-axle tractor with three-axle semi-trailer: mechanical suspension = 43 t; pneumatic suspension = 44 t.

16. Two-axle motor vehicle with three-axle semi-trailer carrying, in intermodal transport operations, one or more containers or swap bodies, up to a total maximum length of 45 ft.
17. Three-axle motor vehicle with two- or three-axle semi-trailer carrying, in intermodal transport operations, one or more containers or swap bodies, up to a total maximum length of 45 ft: 44 t.
18. The driving axle is fitted and pneumatic suspension or recognised as equivalent to EU level, or each driving axle is fitted with double tyres and the MMA on each axle does not exceed 9.5 t: 26 t.
19. Under specific conditions EMS (European Modular System) combinations may have a maximum length of 25.25 m and maximum weight of 60 t.
20. The driving axle is fitted with double tyres and pneumatic suspension: 26 t.
21. Six-axle: 50 t; seven-axle or more: 56 t.
22. Three-axle tractor with one-axle trailer: 35 t.
23. Three- and more axle tractor with three- and more axle trailer: 44 t.
24. Three-axle motor vehicle with two- or three-axle semi-trailer carrying a 40 ft ISO container as a Combined Transport operation: 44 t.
25. For vehicles registered in an EEA member country.
26. Five-axle: 44 t; six-axle: 56 t; seven-axle: 60 t; eight-axle: 64-68 t (restrictions for ADR), 69-76 t (not for ADR).
27. Lorry weighting less than 40 t: 13 t.
28. Four-axle (single unit) lorry: 32 t.
29. 44 t is applicable under special conditions concerning axle weight, tridem weight, euro-norm, suspension type (cf. https://www.ecologiquesolidaire.gouv.fr/sites/default/files/Plaquette%20 44%20tonnes.pdf).
30. Vehicle with three axles equipped with double mounted tyres on running axle and with pneumatic suspension or an equivalent system to EU level, or each running axle has double mounted tyres and axle load less than 9.5 t.
31. Vehicle with alternative drive systems: 19 t (two-axle lorry) or 27 t (three-axle lorry) [cf. Fünfundfünfzigste Verordnung über Ausnahmen von den Vorschriften der Straßenverkehrs-Zulassungs-Ordnung (55. Ausnahmeverordnung zur StVZO)].
32. Vehicle in intermodal transport: 44 t [cf. Dreiundfünfzigste Verordnung über Ausnahmen von den Vorschriften der Straßenverkehrs-ZulassungsOrdnung (53. Ausnahmeverordnung zur StVZO) and §34 StVZO Absatz 6 Nummer 6].
33. Three-axle tractor with one-axle trailer: 33 t.
34. Two-axle motor vehicle with two-axle semi-trailer carrying a container: 40 t.
35. Four-axle motor vehicle with one-axle trailer: 38 t. Three-axle motor vehicle with two-axle trailer: 38 t. Two-axle motor vehicle with three-axle trailer: 38 t.
36. +20% if the vehicle is fitted on the same axle with: a) four or more wheels at least 0.65 m distance from each other and two independent suspension; b) three or more wheels fitted with independent suspensions.
37. National traffic: 20 t.
38. Road friendly suspension: 26 t.
39. Towing vehicle with a semi-trailer where the towing vehicle has a road friendly suspension and the wheelbase of the semi-trailer is ≥ 1.8 m: 38 t.
40. Mechanical suspension (national traffic): 10.5 t.

41. Provided that the vehicle is equipped with twin tyres and an air suspension system or an equivalent system on each driving axle, or is equipped with twin tyres and two driving axles neither of which transmits to the surface of a road a weight in excess of 9.5 t. Distance measured from centre of front to centre of rearmost axle allowing 5.5 t per metre, subject to a maximum of 26 t for three-axle rigid.
42. Distance between the rearmost axle of the vehicle and the foremost axle of the trailer less than 3 m: 30 t.
43. Six- or more axle rigid truck and drawbar trailer combinations may operate at 46 t provided they are fitted with road friendly or equivalent suspension and Electronic Braking Systems (EBS). Rigid trucks (with not more than three axles) first registered from 1 June 2015 must also be equipped with Electronic Stability Control (ESC) for 46 t operation, with drawbar trailers first licensed from 1 June 2015 requiring Roll Stability Control (RSC))cf. http://www.rsa.ie/en/RSA/Your-Vehicle/Vehicle-Standards/Weights--Dimensions-/46-tonne-weight-limit-rigid-and-drawbar-trailer/).
44. Two-axle rigid towing a three-axle trailer: 40 t.
45. Mechanically propelled vehicle having at least three axles, air suspension or an equivalent suspension on each driving axle and ABS brakes: 46 t. The vehicle must also be fitted with a plate complying with the requirements of Statutory Instrument 224 of 2000.
46. Six- or more axle articulated vehicle combinations may operate at 46 t provided they are fitted with road friendly or equivalent suspension and Electronic Braking Systems (EBS). Tractor units first registered since 1 April 2013 must also be equipped with Electronic Stability Control (ESC) for 46 t operation, with semi-trailers first licensed since 1 April 2013 requiring Roll Stability Control (RSC) (cf. http://www.rsa.ie/en/RSA/YourVehicle/Vehicle-Standards/Weights--Dimensions-/46-tonne-weight-limit/).
47. Two-axle motor vehicle with three-axle semi-trailer carrying, in intermodal transport operations, one or more containers or swap bodies, up to a total maximum length of 45 ft can operate to 42 t (subject to 5.5 t per metre rule).
48. Three-axle appropriate motor vehicle with two-axle semi-trailer carrying, in intermodal transport operations, one or more containers or swap bodies, up to a total maximum length of 45 ft.
49. Two-axle motor vehicle with three-axle semi-trailer carrying a 40 ft ISO container as a Combined Transport operation: 42 t.
50. Vehicle using alternative fuels: 26 t.
51. The driving axle is fitted and pneumatic suspension or recognized equivalent to EU level, or where each driving axle is fitted with double tyres and the MMA on each axle does not exceed 9.5 t and used alternative fuels: 27 t.
52. Mechanical suspension: 11.5 t.
53. 40 ft long ISO containers: 44 t.
54. Only with air suspension or similar and double mounted tyres.
55. Depending on the distance between the axles, number of driven axles, type of suspension and single or double mounted tyres.
56. The Norwegian road network is divided into categories in terms of permitted weights and dimensions. The permitted weights listed here apply to roads with the Bk 10/50 classification.
57. The maximum authorised weight is increased by the added additional weight required for the alternative fuel technology with a maximum of 1 t.
58. Five-axle (3 + 2): 46 t; five-axle (2 + 3): 47 t.; six-axle: 50 t; timber transport between 19.5 m and 24 m with an overall wheelbase of at least 19 m: 60 t.

59. Five-axle [(2 + 3) fixed]: 43 t; five-axle (2 + 3 [with a tandem axle with axle spacing 1.30-1.79 m followed by a positive steering axle at a distance of more than 1.79 m, where at least the fixed axles has twin wheels]): 46 t; five-axle (3 + 2 [axle spacing 1.30-1.79 m]): 43 t; five-axle (3 + 2 [axle spacing ≥ 1.80 m]): 46 t; six-axle (3 + 3): 50 t.
60. Increased values are applicable for certain types of transport.
61. Tractor with semi-trailer, combination with four axles: 38 t.
62. 44 t is applicable for two 20 ft or one 40 ft ISO containers. 60 t is allowed under specific conditions: transportation of woody material, paper, wood paper and ceramic products.
63. Road sections constructed according to this norm: 11.5 t.
64. Three-axle road train: 28 t.
65. Six-axle and more: 44 t.
66. Two-axle alternatively fuelled motor vehicles other than buses: the maximum authorised weight is increased by the additional weight required for the alternative fuel technology with a maximum of 1 t.
67. Three-axle alternatively fuelled motor vehicles: the maximum authorised weight is increased by the additional weight required for the alternative fuel technology with a maximum of 1 t.
68. Articulated vehicles with four axles: 38 t in the following cases: a) the driving axle is fitted with twin tyres and pneumatic suspension or recognized as equivalent to EU level, the wheelbase of the semitrailer is > 1.8 m and the motor vehicle MMA is respected (18 t) and the MMA of the axle tandem of the semi-trailer (20 t); b) the semi-trailer (the wheelbase of the semitrailer is ≥ 1.8 m) is equipped with enhanced tipper body specifically for the use in construction or mining it will be 38 t, provided that the burden imposed on the coupling device is compatible with the maximum mass per axle.
69. 44 t is applicable for triaxle tractor with a two or triaxle trailer in Combined Transport transporting the container(s) or if the trailer has been strengthened for unattended transport service or if the trailer has been adapted for interchangeable load compartments, and on highway section A3 Terminal Sežana – Terminal Fernetiči, No. of section 0372.
70. On some roads the permissible maximum weight is 74 t. The permissible maximum weight of a vehicle is determined by the distance between the outermost axle of the vehicle or combined vehicle.
71. Only with twin tyres and air suspension or similar (otherwise only 25 t), and ABS (Anti-lock Braking System) (cf. EU regulation RL 96/53/EG).
72. With the conditions laid down in Regulation for type approval: 26 t.
73. Vehicle with four axles and axle group weight of 20 t of the semi-trailer: 38 t.
74. Three-axle motor vehicle with two- or three-axle semi-trailer carrying a 40 ft ISO container: 44 t.
75. Two-axle container truck: 18 t.
76. Three-axle container truck: 24 t.
77. Four-, five- and more axle road train and five and more axle articulated vehicle: 44 t. Container truck licenced by the state Motor Road service of Ukraine and State Traffic Inspection Department, five- and more axle road train and articulated vehicle: 46 t.
78. Only with air suspension or similar.
79. Four-axle articulated vehicle with air suspension or similar and above other requirements: 38 t.
80. For general operation at 44 t, at least six axles are required. The drive axle(s) must not exceed 10.5 t and have twin tyres/road friendly suspension. Vehicles not having road friendly suspension on the drive axle(s) must have twin tyres and a maximum axle weight not exceeding 8.5 t. Each part of the combination must have at least three axles and the trailer must have road friendly suspension.

Dimensions table

List of remarks:

1. Vehicle at controlled temperatures: 2.60 m.
2. Under specific conditions EMS (European Modular System) combinations may have a maximum length of 25.25 m and maximum weight of 60 t. Domestic transport of 45 ft containers is accepted with combinations of vehicles (tractor – trailer – container) of maximum length of 17.27 m (B) or 17.30 m (NL). The maximum overhang of the container to the rear of the semi-trailer shall not exceed 0.77 m (B).The maximum overhang of the container to the (rear) underrun protection shall not exceed 0.40 m (B) or 0.60 m (NL).
3. Road train specialised in the carriage of cars (loaded): 21 m.
4. Road train specialised in the carriage of cars: height = 4.20 m; length = 20.75 m.
5. For vehicles registered in an EEA member country.
6. Road train (total length over 22 m) as from 1 January 2010: 2.55 m. Road train (total length over 22 m) units and coaches fitted with a new vehicle body as from 1 October 2004: 2.55 m. Vehicles at controlled temperatures: 2.55 m.
7. Road train specialised in the carriage of cars (loaded): 20.35 m.
8. Vehicle specialised in the carriage of cars and vehicle specialised in the carriage of containers: 4.30 m.
9. Specialised road train: 20 m.
10. Vehicle in intermodal traffic: 16.65 m [cf. Fünfundfünfzigste Verordnung über Ausnahmen von den Vorschriften der Straßenverkehrs-ZulassungsOrdnung (55. Ausnahmeverordnung zur StVZO)].
11. Swap body transported by vehicles: 2.60 m.
12. Lorry with two trailers: 24 m.
13. Tow vehicle with two trailers: 2 2 m.
14. The 4.65 m limit does not apply to vehicles/combinations of vehicles and trailers transporting agricultural produce (i.e. hay, silage straw or other animal fodder) which is baled.
15. It may be allowed up to 22 m subject to certain restrictions.
16. Increased values are applicable for certain types of transport (i.e. containers, motorcars, etc.). [16a. Increased value: 4.10 m].
17. Container truck: 4.35 m.
18. Vehicle specialised in the carriage of cars (loaded) in which the length of the load must now exceed 0.5 m in front of the vehicle and 1.5 m behind it: 20.75 m.
19. Vehicle specialised in the carriage of cars and vehicle specialised in the carriage of containers: 21 m.
20. The Norwegian road network is divided into categories in terms of permitted weights and dimensions. The permitted weight listed here applied to roads with the 19.5 m classification.
21. Heavy goods vehicle specially designed for the transport of timber: 24 m.
22. EMS (European Modular System) combinations may have a maximum length of 25.25 m and maximum weight of 60 t on a designated road network.
23. When carrying a 45 ft container in intermodal transport: 17.65 m, 18.60 m with side loaders.
24. Class I coach: 4.20 m.
25. Vehicle specialised in the carriage of cars and vehicle specialised in the carriage of 45 ft containers: 4.60 m.
26. Vehicle carrying damaged motor vehicles: 4.50 m.

27. An extra 15 cm are allowed for vehicles carrying 45 ft container involved in intermodal operations.
28. Vehicle specialised in the carriage of cars: additional 3 m with the payment of the fee of EUR 2.3 per 100 km + EUR 10.
29. Vehicle type N, which has removable devices for road maintenance: 3.00 m.
30. Road train or articulated vehicle specialised in the carriage of containers or cars: 21.00 m.
31. Specialised road train in transporting vehicles (only on motorways, dual carriageways, major roads, regional and municipality roads regulated with the Traffic Regulations): 22.00 m.
32. Auto-transport specialised in transporting vehicles, cranes for removal of vehicles, vehicles transporting containers approved for Combined Transport: 4.50 m.
33. Road train specialised in the carriage of cars (loaded): 20.55 m.
34. Road train with two trailers: 22.00 m.

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