



Intermodal rail transport in selected European countries

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Paper presents analysis of intermodal rail transport in selected loading units. The brief description of the loading units is presented. The volume of intermodal rail transport of load units in European countries in 2021 is shown, taking into account mass of transported goods, transport performance and average transport distance. Goods in the intermodal transport are carried out in container, swap bodies, semi-trailers and road sets. The most frequently used loading unit is the container. Semi-trailers is the most often used loading unit in road freight transport. However, semitrailers are rarely used in intermodal transport in most European countries. In the case of Poland, the share of intermodal transport of containers and swap bodies by rail constitutes a significant share in the European market, however, the transport of semi-trailers and road sets is still a rather unpopular form of transport compared to other European countries.

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1. Introduction

Intermodal transport is the transport of goods in which more than one means of transport is used [7]. An important assumption is also the use of the same loading unit during the entire transport process [13]. In intermodal transport, the most popular loading units are containers, swap bodies and semi-trailers.

Intermodal transport has gained in popularity, mainly due to the significant reduction in the costs of reloading goods. The use of unified loading units allowed for a significant reduction in the time of loading and unloading goods and limited the risk of its damage [6, 18]. In addition, a loading unit with standardized dimensions enables easier planning of the transport process [19, 21].

The most frequently used loading unit is the container, which is particularly common in sea shipping [5]. The standardization of its dimensions and technical parameters in 1968 by the International Organization for Standardization (ISO) contributed to the wide use of the container [11]. The use of the container has brought many positive aspects such as time and cost reduction. An example is the costs of reloading 1 ton of goods in the ports in 1956, where the conven-

tional methods costed \$5.86, and with the use of a container costed only \$0.16 [10].

Another type of the loading unit is swap body which is less popular than the container. It is a type of loading unit in the form of a box detachable from the chassis of a road vehicle, and is also transported by railway. Swap bodies equipped with four supporting legs are lighter than containers and are usually not suitable for multi-level storage [9].

An important loading unit in intermodal transport is semi-trailer. There are universal trailers and special trailers [17]. Universal units do not require changes in the construction. Due to the wide availability on the market, they are used especially in road transport [12, 15]. In the case of special trailers, they are appropriately adapted to rail transport. Units that require minor structural changes to enable appropriate reloading are used more often, such as semi-trailers for transport in pocket wagons [20]. There are also bimodal units on the transport market that require major structural changes. These units in the train composition, between the supports on the bogies, constitute the self load-bearing structure and transfer the longitudinal railway forces [14, 16].

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Fig. 1. Types of loading units used in railway intermodal transport

In intermodal transport accompanying for Rollende Landstrasse systems [8] and Flexiwaggon [2, 3] a complete road set is transported on the railway platform (a truck unit with a semi-trailer). However, in the intermodal transport accompanying the Modalohr system (where the wagon is equipped with two load-carrying platforms), when disconnecting the road set, the semi-trailer is loaded on one platform, while on the other platform, the truck unit is loaded with the truck from the next road set [4, 25].

These intermodal loading units (Fig. 1) are transported in European countries in different amounts. In some countries, only the transport of containers is used, in others, especially highly developed, thanks to appropriate subsidies, the use of semi-trailers is encouraged to relieve congested roads and protect the environment. The following article presents analyzes of intermodal transport in selected European countries by railway in 2021.

2. Analysis of the railway transport of intermodal loading units in Europe

2.1. Containers and swap bodies

Figure 2 shows the volume of intermodal rail transport of containers and swap bodies in European countries in 2021. The data was prepared on the basis of the Eurostat data [24]. On the basis of the diagram, it can be seen that most of the transport of containers and swap bodies in Europe by railway is made in Germany (72 million tons (t), 35.2 billion tonne kilometers (tkm)). The average distance for which this type of cargo was transported was 488.51 km. Containers and swap bodies are transported to a large extent in Poland (23.6 million t, 7.8 billion tkm), which in the ranking for 2021 this country took 3rd place in Europe in terms of the mass of the cargo transported and 4th place in terms of transport performance. The average distance for which the discussed type of loads



Fig. 2. The volume of intermodal transport of containers and swap bodies by railway in European countries in 2021. Mass, transport performance and average transport distance (own study according to Eurostat data [24])

were transported was 330.9 km. Poland, apart from Germany, was overtaken only by Italy (46.4 million t, 10.7 billion tkm) and taking into account the performance transport France – 12.2 billion tkm (21 million t and a relatively large average distance of 582.6 km). In the case of the average distance for which containers and swap bodies were transported in Europe by railway, Greece came first with 601.7 km for 2021.

The top ten also includes countries transporting containers and swap bodies at a level not much smaller than Poland, these are Switzerland (21.8 million t, 5 billion tkm, 229 km), the Netherlands (19.3 million t, 3 billion tkm, 157 km), Turkey (17.9 million t, 6.9 billion tkm, 384.6 km) and the Czech Republic (11.9 million t, 2.9 billion tkm, 242.6 km). Eurostat data from 2021 does not include transport in Great Britain, Belgium or Austria [20]. The United Kingdom left the European Union on January 31, 2020. Data recorded in 2019 by the Statistical Office of the European Union indicate that the United Kingdom was ranked high, 6th in Europe in container and swap body transport (15.6 million t, 8.9 billion tkm). Data recorded in 2013 show that Austria was ranked 3rd in the intermodal transport of containers and swap bodies by rail (14.4 million t, 2.8 billion tkm). Belgium is also making use of its potential, with a large number of containers being reloaded onto railway wagons at the

second largest port in Europe, Antwerp. Eurostat data from 2011 on the transport of containers and swap bodies by rail in Belgium indicate a weight of transported cargo of 15.6 million t and transport performance of 2.1 billion tkm.

The average values for a single country for 2021 in the case of intermodal rail transport of containers and swap bodies among the selected countries are as follows: mass of transported goods – 11,823 million t, performance transport – 4308 billion tkm and average distance 364.34 km.

2.2. Semi trailers

Figure 3 shows the volume of intermodal rail transport of semi-trailers in selected European countries in 2021. It can be seen that, similarly to the transport of containers and swap bodies, the largest number of intermodal rail transport of road semi-trailers in Europe takes place in Germany. Taking into account both the mass of the cargo transported and the transport performance (28.6 million t, 17.7 billion tkm).

The following places in terms of the mass of transported goods are followed by: Italy – 10.9 million tonnes (2.4 billion tkm, 216.7 km), Switzerland – 5.5 million tonnes (1.34 billion tkm, 244.5 km) and France – 3.7 million tonnes (1.2 billion tkm, 325.6 km).

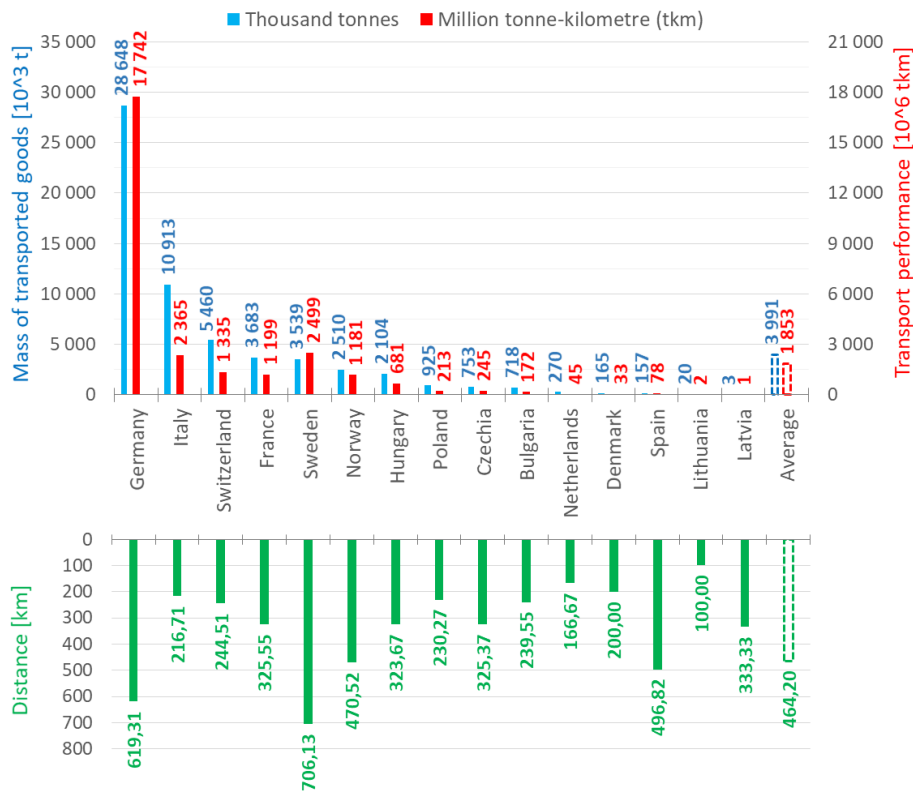


Fig. 3. The volume of intermodal transport of semi-trailers by railway in European countries in 2021. Mass, transport performance and average transport distance (own study according to Eurostat data [24])

km). Poland, with the result of 0.925 million t (0.213 billion tkm, 230.3 km), was placed 8th in the ranking.

In the case of transport performance, Sweden is in second place after Germany, where in 2021 the result was 2.5 billion tkm. It is caused by transports carried out over very long distances, where the average distance was 706.1 km. It is a distance longer by as much as 86.8 km compared to the second place in the list of Germany (619.3 km) and by 209 km longer than in the third Spain (496.8 km).

The average distance of semi-trailer transport in the case of Germany is longer by 26.8%, i.e. 130.8 km, compared to the transport of containers and swap bodies (488.51 km). In the case of the leader – Sweden – this difference is even more visible and amounts to 35.1%, i.e. 180.6 km. This may be associated with greater profitability of this type of transport over longer distances.

The average values for a single country for semi-trailer intermodal rail transport among the countries included in the list are as follows: mass of transported goods – 3991 million t, transport performance – 1853 billion tkm and the average distance of transported 464.20 km.

Based on the data presented in Fig. 2 and Fig. 3, it can be seen that the transport of containers and swap bodies in Germany, taking into account the transport performance in 2021, is only twice as large as the transport of semi-trailers. In the case of Poland, this difference is much greater. Based on the presented data, it can be noted that the transport of road semi-trailers in Poland, taking into account the transport performance in 2021, is 37 times smaller than the transport of containers and swap bodies.

Alpine and Scandinavian countries occupy a high position in the transport of semi-trailers. Taking the example of Switzerland, due to the upland or mountainous terrain, this country imposes numerous restrictions on road transport or even makes it impossible to transport cargo on selected routes. The regulations impose the obligation to transport semi-trailers by rail on specific sections. A frequent phenomenon is that in transit transport many trucks are loaded at the border and unloaded at the next border.

2.3. Road vehicles

Figure 4 shows the volume of rail transport of intermodal road sets (truck unit with a semi-trailer) in accompanying transport in European countries in 2021. The largest number of transports of road sets in Europe by rail, taking into account the mass of the transported cargo, takes place in Italy – 3.37 million tonnes (314 million tkm, 93.3 km) and taking into account transport performance in Switzerland – 479 million tkm (2.18 million t, 219.5 km). Significant

volumes of transport of semi-trailers with trucks are recorded in Germany (2.23 million t, 134 million tkm, 60.04 km). This country ranks second in Europe in terms of the transported mass of cargo and fourth in terms of transport performance. In terms of the mass of loads, the fourth place is taken by Slovenia (0.858 million t, 16 million tkm), with intermodal connections "RoLa" on the Wels (Austria)–Maribor (Slovenia) route.

Bulgaria and France had a slight share in intermodal accompanying transport, in which in 2021, where respectively 2 thousand tons and 1 thousand tons of cargo mass were transported in road sets by railway. In the case of transport performance, in these countries the values of the described index were much lower than for other countries and amounted to 1 million tkm in the case of Bulgaria, and in the case of France, the value was even below 1 million tkm.

Austria also plays an important role in transport of the road sets in Europe. Data recorded in 2013 by the Statistical Office of the European Union, last available, show that Austria had the largest transports in the transport of road sets (7.2 million tonnes, 1.1 billion tonne-kilometers).

Accompanying transports were also registered in Poland in 2021. During this period, a total of 636,000 tonnes of goods were transported using the discussed transport method. 147 million tkm were performed by this type of transport. The average distance for which the goods were transported was 231 km.

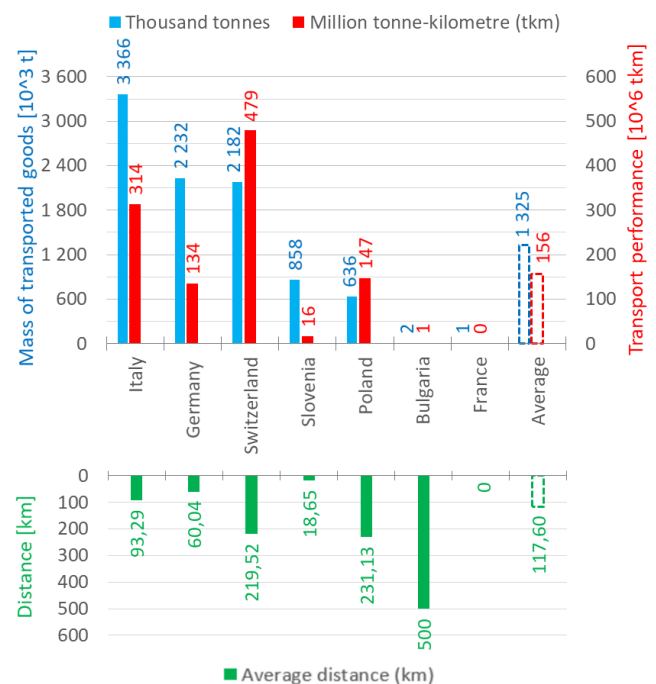


Fig. 4. The volume of intermodal transport of road sets (truck unit with a semi-trailer) by railway in European countries in 2021. Mass, transport performance and average transport distance. [Own study according to Eurostat data [24]]

To sum up, most road sets in Europe are transported by railway in the following countries: Italy, Switzerland and Germany, which actively support accompanying transport through appropriate programs that subsidize Ro-La transport. In 2021, for the described group of countries, the average values were: mass of transported goods – 1.325 million t, transport performance – 156 million tkm and the average transport distance – 117.6 km. An interesting fact is the very short average distance that the road sets were transported by railway. This value is almost 3 times lower than the average for containers and swap bodies and 4 times lower than for semi-trailers.

Conclusions

Based on the analysis of intermodal rail transport in Europe, it was concluded that selected loading units participation in the total number of all units is: containers and swap bodies (80% for the mass of transported goods, 78% for the transport performance), semi-trailers (17% for the mass of transported goods, 21 % for transport performance), road sets (3% for the mass of transported goods, 1% for transport performance). The conducted analysis confirms that the most frequently used units in intermodal rail transport are containers and swap bodies (the proportion of containers to swap bodies are 78% to 20% respectively [26]). The largest number of loads transported on

railway wagons with the use of semi-trailers and road sets occurs in highly developed countries, including Germany, Switzerland, Italy, which actively support intermodal transport through appropriate subsidy programmes.

The semi-trailer is the most frequently used unimodal road transport unit in Europe. The highest number of registered semi-trailers in Europe is in Denmark, Poland and Germany, respectively. However, semitrailers are rarely used in intermodal transport in most European countries (including Poland). This situation is due to the lack of appropriate technologies enabling the transport and reloading of these load units. A good example is the transport of road semi-trailers on railway wagons in Germany, where, including the transport performance in 2021, the transport of semi-trailers is only two times lower than the transport of containers. Comparing with Poland, including the transport performance in 2021, the transport of semi-trailers in intermodal transport is 37 times lower than the transport of containers.

Semi-trailers with docking sockets for vertical loading represent a small number of registered semi-trailers in Europe. Therefore, it is important to support the development of technologies enabling the transport and reloading of standard semi-trailers, as they constitute the majority of the rolling stock used on the roads.

Nomenclature

ISO	International Organization for Standardization	t	tons
TEU	Twenty-foot Equivalent Unit	tkm	tonne-kilometre

Bibliography

- [1] 3-axle platform semitrailer. Schwarzmüller. <https://www.schwarzmueller.com/en/vehicle/platform-vehicles/platform-trailers-centre-axle/> (accessed on 17.11.2022).
- [2] Auguściuk M, Pawelczyk N. Innowacyjne rozwiązania w branży TSL na przykładzie technologii przewozów w systemie Flexiwaggon. *Journal of TransLogistics*. 2019;5(1):119-130.
- [3] Brzeziński M, Pyza D. Designing of Transshipment Terminals for Selected Intermodal Transport Systems. In: Siergiejczyk M, Krzykowska K (eds). *Research Methods and Solutions to Current Transport Problems*. Advances in Intelligent Systems and Computing. Springer International Publishing; 2020;(1032): 52-62. https://doi.org/10.1007/978-3-030-27687-4_6
- [4] Cempírek V, Rathouský B, Jirsák P. The intermodal transportation of semitrailers. *Perner's Contacts*. 2020; 15(2). <https://doi.org/10.46585/pc.2020.2.1650>
- [5] Cudahy BJ. *Box Boats: How Container Ships Changed the World*. Fordham Univ Press. 2007.
- [6] Gharehgozli A, de Vries H, Decrauw S. The role of standardisation in European intermodal transportation. *Maritime Business Review*. 2019;4(2):151-168. <https://doi.org/10.1108/MABR-09-2018-0038>
- [7] Jacyna M, Jachimowski R, Szczepański E, Izdebski M. Road vehicle sequencing problem in a railroad intermodal terminal—simulation research. *B Pol Acad Sci-Tech*. 2020; 68(5):1135-1148. <https://doi.org/10.24425/bpasts.2020.134643>
- [8] Knauer U. Straßengüterfernverkehr oder Rollende Landstraße. In: Knauer U (ed.) *Mathematische Modellierung: Laster, Busse und Schweine im Mathematikstudium*. Vieweg+Teubner Verlag; 1992:31-87. https://doi.org/10.1007/978-3-322-87603-4_9
- [9] Kwaśniewski S, Nowakowski T, Zając M. *Transport Intermodalny w Sieciach Logistycznych*. Oficyna Wydawnicza Politechniki Wrocławskiej, 2008.
- [10] Levinson M. *The Box: How the Shipping Container Made the World Smaller and the World Economy*

- Bigger – Second Edition. Princeton University Press. 2016. <https://doi.org/10.1515/9781400880751>
- [11] Lewandowski K. Kontenerowe Systemy Transportowe. Geneza i Rozwój do 1914 r. Oficyna Wydawnicza Politechniki Wrocławskiej. 2015.
- [12] Madej J, Medwid M, Cichy R, Jakuszko W, Nowaczyk T. Modułowy system transportu naczep siodłowych na wózkach kolejowych w ruchu kombinowanym kolejowo-drogowym. Rail Vehicles/Pojazdy Szynowe. 2013;(2):6-10. <https://doi.org/10.53502/RAIL-139348>
- [13] Markowska K. Model of service realization on the intermodal transport market. Rail Vehicles/Pojazdy Szynowe. 2019;(2):44-49. <https://doi.org/10.53502/RAIL-138530>
- [14] Medwid M, Merkisz-Guranowska A, Strzemkowski J, Królikowski J. Bimodal transport system with horizontal, transverse transshipment of semi-trailers. Rail Vehicles/Pojazdy Szynowe. 2018;(3):1-10. <https://doi.org/10.53502/RAIL-138509>
- [15] Medwid M, Nowaczyk T, Jakuszko W. Technologia przeładunku poziomego na przykładzie modułowego systemu transportu kombinowanego. Rail Vehicles/Pojazdy Szynowe. 2013;(3):23-26. <https://doi.org/10.53502/RAIL-139365>
- [16] Medwid M, Stawecki W, Czerwiński J. Bimodal rolling stock as the economically justified alternative to the existing combined transport systems. Rail Vehicles/Pojazdy Szynowe. 2016;(2):1-8. <https://doi.org/10.53502/RAIL-138688>
- [17] Medwid M, Tomaszewski F, Nowaczyk T, Czerwiński J. The transport system of standard road semi-trailers providing for their horizontal-skew transshipment. Rail Vehicles/Pojazdy Szynowe. 2018;(2):7-16. <https://doi.org/10.53502/RAIL-138480>
- [18] Mielcarek A. Transport of containers by railway in Central Europe – Germany in the 1920s and 1930s. Rail Vehicles/Pojazdy Szynowe. 2019;(4):43-52. <https://doi.org/10.53502/RAIL-138544>
- [19] Nowaczyk T. Genesis of intermodal transport. Rail Vehicles/Pojazdy Szynowe. 2020;(1):42-48. <https://doi.org/10.53502/RAIL-138499>
- [20] Nowaczyk T, Orczyk M. Diagonal handling technology in the intermodal transport system. Rail Vehicles/Pojazdy Szynowe. 2021;(1):1-9. <https://doi.org/10.53502/RAIL-138485>
- [21] Nowaczyk T, Urbański P, Daszkiewicz P, Andrzejewski M, Orczyk M, Cichy R. Historia transportu intermodalnego w tle nowoczesnych rozwiązań. In book: Preservation and conservation of museum collections- Publisher: Poznańskie Towarzystwo Przyjaciół Nauk, Muzeum Narodowe Rolnictwa i Przemysłu Rolno-Spożywczego w Szreniawie. Poznań 2021.
- [22] Road transportation – D4Dxpress. <https://d4dexpress.com/road-transportation/> (accessed on 17.11.2022).
- [23] Sea Freight Container Types. AK Logistics and Supply Chain. <https://aklogisticsandsupplychain.com/2020/03/19/sea-freight-container-types/> (accessed on 17.11.2022).
- [24] Statistics. Eurostat. https://ec.europa.eu/eurostat/databrowser/view/rail_go_contwgt/default/bar?lang=en (accessed on 17.11.2022).
- [25] Stoilova S, Martinov S. Evaluation of semi-trailer rail transport technologies by using multi-criteria analysis. Engineering for Rural Development. 21st International Scientific Conference: Engineering for Rural Development. 25-27.05.2022 Jelgava. <https://doi.org/10.22616/ERDev.2022.21.TF219>
- [26] UIC and UIRR. 2020 Report on Combined Transport in Europe. Published online 2020.
- [27] What is a Container? Logistics Terms and Definitions. <https://www.saloodo.com/logistics-dictionary/container/> (accessed on 17.11.2022).