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Combined freight transport terminals in Germany – current state and development prospects

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The article presents current issues regarding combined freight transport terminals (CFT terminals) in Germany, with particular attention to road/rail transport and the implementation of the latest technologies of rail/road handling of rolling stock in terminals. The brief description of the state of current knowledge about combined freight transport terminals in both organizational and technological aspects are introduced. Considerations are focused on the description of the development of selected facilities and trends in the field of terminal operations. Examples of currently implemented projects and best practices, especially the implementation of digital solutions, are presented.

1. Introduction

The development of intermodal transport in Europe over the last two decades and the predicted increase of cargo flows make it necessary to build new and expand existing intermodal terminals serving loading units moved by various means of transport [13, 20]. On the other hand, terminals are also an attractive place for the implementation of innovations, in particular railways [1–4]. The ecological benefits are also unquestionable advantage of combined transport of combined transport, obtained by covering longer sections of the route using rail transport [19]. According to the Transport Emission Model (TREMOD), developed by the IFEU Institute in Heidelberg, transferring the load transported by one truck to the rail reduces CO_2 emissions by 60 g per tonne-kilometre compared to transport using only road transport, which means a reduction in CO_2 emissions by as much as 80% [25].

In the case of Germany, insufficient needs to handle the growth of freight flows forecast for the coming years prompt transport operators, manufacturers of terminal and railway equipment and infrastructure managers to look for new solutions that would streamline terminal operations and create the possibility of implementing large-scale projects increasingly using digital solutions.

2. The nature of combined transport and the characteristics of the combined transport terminal

The authors of most studies on combined transport and combined transport terminals point to the essential feature of the ability to transfer a loading unit (container/swap body) from one mode of transport to another, while stressing that a longer part of the journey should be by train or inland waterway vessel [5, 6]. The multifunctionality of terminals as important intermediate nodes in logistics networks is also highlighted.

The article adopts definitions of combined transport and combined transport terminal, developed by the Federal Ministry of Digital Affairs and Transport [11].

Combined transport

Combined transport is a special form of intermodal freight transport that involves moving loading units such as containers or swap bodies or HGV semi-trailers by rail or waterway over long distances.

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HGVs are only used for short distances on roads, to move the containers or the swap bodies to the terminals where they are transshipped to trains or inland waterway vessels, or to collect them at their place of unloading and move them to their final destination.

Terminal

The terminals are the interfaces of combined transport. Using suitable cranes or other loading equipment, the loading units are transferred from HGVs to trains or inland waterway vessels. At the place of unloading, another intermodal terminal, the loading units are unloaded and moved to their destination by HGV.

3. Development of intermodal transport and terminals in Germany

Originally, the development of intermodal transport and terminals in Germany was closely linked to the dynamic development of logistics centres (GVZ), large infrastructure facilities in which the intermodal terminal is a key element.

A factor of support and at the same time a stimulus for the development of terminals are preferences for entities working for the development of sustainable transport, resulting from Germany's pro-ecological transport policy, which for many years has been promoting the transfer of an increasing mass of cargo from road transport to rail and inland waterway transport [9].

Current German regulations [8, 15, 22] guarantee transport companies handling at terminals, i.e. the following preferences:

1. Increasing the maximum permissible weight limit from 40 t to 44 t for trucks performing feeder transport to the terminal and drop-off from the terminal.
2. Exemption from road tax.
3. Lower toll rates.
4. No driving ban for trucks providing feeder transport (to the terminal) and drop-off (from the terminal) on weekends and holidays.
5. Non-returnable subsidies from the Federation funds up to 80% for non-state enterprises installing terminal equipment (in the case of investments related to the construction or expansion of terminals).

As a result of the actions taken to support the development of combined transport, its dynamics in the last decade have been clearly visible. By weight of transported cargo by combined transport in the years 2011-2021 they recorded an increase from 98 million t to 129.9 million t (+26%), while by transport performance they recorded an increase of 5.77 million km (+7.43%) [21].

Table 1 presents the state and short-term forecast of total rail transport and the share of combined transport, which assumes an increase compared to 2021 – by 2.1% and 6.5% and 4.1% and 8.1% respectively [21].

Table 1. Status and short-term forecast of total rail services and share of combined transport [21]

Rail transport by weight of transported cargo (million tonnes)	2021	2022	2024	2021–2024
Total, including combined transport	378.9 111.2	378.8 112.0	386.8 118.5	+2.1% +6.6%
Rail transport by transport performance (million km)	**2021**	**2022**	**2024**	**2021–2024**
Total, including combined transport	129.9 59.00	130.5 59.8	135.2 63.8	+4.1% +8.1 %

The current activities of the federal government are aimed at implementing technological solutions corresponding to the size and scale of commodity flows in the context of this time perspective, while the investment needs related to the co-financing of these facilities (expansion, equipment) until 2031 are estimated at EUR 1 billion [21].

Deutsche Bahn Netze plays an important role in the development, having 26 terminals in Germany in 2022. They are operated by Deutsche Umschlaggesellschaft Schiene-Strasse (DUSS), which has a total of 59 gantry cranes and 10 to 15 front vehicles. The annual transshipment capacity of the terminals is 2 million loading units (approx. 4 million TEU) [12].

An example of one of the priority projects in the area of terminals in Germany is the planned (approved in 2022 by BMDV) expansion of the Deutsche Bahn terminal in Regensburg (Regensburg-Burgwainting) [12].

Fig. 1. Visualization of the Deutsche Bahn terminal Regensburg-Burgwainting

The terminal will handle cargo flows primarily from the automotive, machinery and seaport indus-

tries. Its choice was determined by location factors (convenient location and good access to the road and rail network, existing railway connections with domestic and foreign logistics centers and distribution centers) and environmental benefits (reduction of road transport by 48.7 thousand kilometers), which translates into a reduction in the annual environmental burden by 360 thousand tons of CO_2) [12]. The completion of the investment is planned for 2029.

4. Development of innovations in the field of terminal technology

The first innovative solutions in the field of combined transport in the USA and Western Europe, especially in Germany, date back to the turn of the 60s and 70s of the last century. During this period, the most important issue was to solve the problem of container transshipment. The equipment with track gantry cranes enabling fast reloading was the biggest innovation at the terminals.

With the growing interest in combined transport at the turn of the 80s and 90s of the twentieth century, many innovative concepts – combined transport technologies – were developed in Germany – which can be classified in three categories [10]:

1. Trains with bimodal semi-trailers (e.g. Road-Railer).
2. New train forms (e.g. CargoSprinter).
3. Handling systems (e.g. ACTS, Kombilifter).

The last two decades have brought further improvements to both vertical and horizontal loading systems for semi-trailers on railway platforms. This is because more and more of them are not suitable for lifting using cranes (according to some sources, even 80 percent [21].

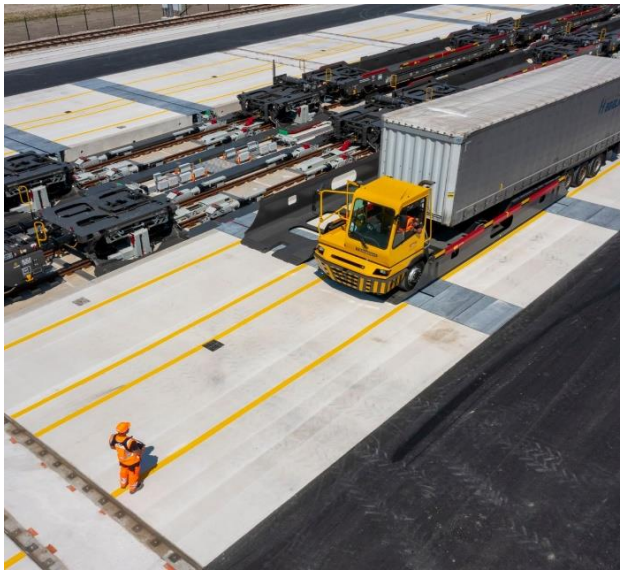

Fig. 2. Cargo Beamer System [16]

An innovative solution from the early 2000s is the Cargo Beamer [16, 18], developed by a German company under the same name. The system, which has undergone many implementations, enables fully automated handling of 120 swap bodies per hour (from one track) from car to train and is adapted to simultaneously lift semi-trailers and swap bodies without the need for a crane.

The following benefits [16] of this system are worth noting:

– The CargoBeamer system needs less than 20 minutes to load and unload a whole 700-metre-long train with 36 wagons and up to 72 semi-trailers in parallel.
– Depending on the lane, CargoBeamer reduces CO_2 emissions by around 75%, that's more than half as opposed to road transport. Using one train and one year as the basis for calculation, CargoBeamer prevents around 3500 tonnes CO_2 from polluting nature.
– CargoBeamer saves approximately 66% energy as opposed to road transport.

In turn, a current example in the area of vertical transshipment is the NiKRASA system developed in 2014 by TX Logistics [23], which third generation (NiKRASA 3.0) was presented at the International Railway Fair INNOTRANS 2022 in Berlin. Handling this system does not require a typical terminal ramp, which has been replaced by a loading frame laid on the yard. Previous experience shows above all the simplicity of handling operations and low operating costs. Another advantage is the versatility of the platform, which allows handling most used semi-trailers [8].

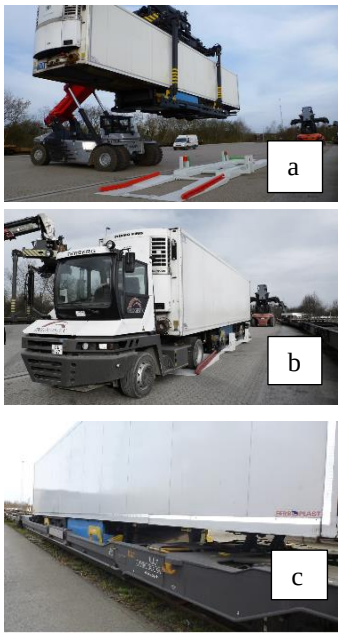

Fig. 3. Stages of vertical transshipment in the NiKRASA system: a) entry of the semi-trailer on a special loading frame, b) lifting of the semi-trailer, c) foundation of the semi-trailer on the railway platform [23]

As can be seen from the brief characteristics of innovations, the evolution of transshipment systems was associated with the pursuit of maximum automation of terminal operations. Gerken [5], analyzing current intermodal solutions, mentions the following important innovations in the area of transshipment systems, which in the future will have an impact on rail freight transport and thus on terminal operations.

1. New drive systems.
2. Automatic Train Operation (ATO).
3. New concepts for railway wagons (optimal use of cargo space).
4. Optimization of loading units according to size and target market.
5. Automatic train connection.

5. Terminal of the future

5.1. Examples of solutions from the German market

In 2019, experts from the Center for Applied Research on Supply Chain Services at Fraunhofer IIS developed the concept of the digital terminal of the future [14]. Following 19 terminal elements were assessed and evaluated, which are then to be integrated with each other:

1. ETA forecast for trucks.
2. Automatic control system for incoming flows.
3. Automated check in for trucks.
4. Driver app.
5. Automatic location addressing.
6. Process control.
7. Optimized crane allocation.
8. Automatic handling.
9. Monitoring of transshipment operations.
10. Predictive Maintenance.
11. Automatic damage detection.
12. Digital assistant systems.
13. ETA forecast for trains.
14. Tracking and interfaces.
15. Automatic track allocation.
16. Automated transport of loading units.
17. Sequence control for trains and inland waterway vessels.
18. Digital yard for empty containers.
19. Automated check-out for trucks.

The visualization of the digital terminal of the future is shown in Fig. 4.

In the area of innovations in the digital trend, many hopes are associated with the government program of the Federal Ministry of Infrastructure and Transport "Artificial Intelligence and Discrete Loading Optimization Models for Increasing Capacity Utilization in Combined Transport" (KIBA) [7]. The implementation of the three-year project, which began in November 2022, is to contribute to solving – using artificial intelligence – the problem of assigning the right wagon to carry specific loads. The partners are well-known companies: Deutsche Umschlaggesellschaft Schiene-Straße (DUSS) mbH, VTG Rail Europe GmbH, INFORM GmbH, KombiConsult GmbH, Kombiverkehr and prestigious universities: TU Darmstadt and Goethe University Frankfurt.

Fig. 4. Visualizing the digital terminal of the future [14]

Measurable benefits, in particular for small and medium-sized enterprises interested in cooperation with terminals, can be brought by the implementation of the "Truck2train" project, launched in 2021, implemented by Allianz pro Schiene in cooperation with the Bundesverband für Güterkraftverkehr Logistik und Entsorgung (BGL), an organization associating carriers. The essence of the proposed solution is to eliminate barriers to market entry and facilitate SMEs' access to intermodal transport offers by creating a digital solution in the form of a booking portal functioning as a broker [17].

Identified barriers:

- insufficient knowledge of enterprises about the market
- using of non-craneable loading units
- high planning costs
- lack of confidence in combined transport.

As a result of the simulations, it was shown that the brokerage system can provide:

- quick overview of the services offered thanks to access to the e-platform
- selection of rental options and transshipment system
- booking a comprehensive offer
- quality guarantee and insurance.

Conclusions

Striving to expand the combined transport infrastructure, especially rail-road, is associated with the forecasted increase in cargo flows, limited transshipment capacity of terminals, as well as ecological fac-

tors. The innovative infrastructure projects currently being implemented in Germany can contribute to increasing the competitiveness of railways, making terminal operations more efficient and encouraging companies (shippers) to make greater use of the combined transport offer. A characteristic phenomenon in the area of current innovations is the implementation of projects/models aimed at implementing digital solutions and creating brokerage solutions.

The presented analyses show that combined transport itself in Germany, including terminals as its nodal points and important components of logistics infrastructure, has developed thanks to significant state support, consisting in granting measurable preferences to the entities taking part, but also co-financing large-scale projects. This approach can be a good example for other countries where combined transport is not yet as well developed as in Germany.

Based on the analysis of the prospects for the development of combined transport terminals, it can be said that the increasing modernization and implementation of digital solutions in terminals in Germany has a chance – from the point of view of cross-border logistics – also to contribute to faster and more effective handling of cargo flows in the exchange of goods Poland, Germany/Germany–Poland, as indicated by the development plans of the terminal in Frankfurt (Oder). In this context, further research should focus on the diagnosis of the possibilities of cooperation between railway companies and terminal operators in both countries in implementing of innovations (e.g., freight brokerage platforms), building connections and better exploiting the potential of infrastructure.

Nomenclature

ACTS	Abroll Container Transportation System	ETA	estimated time of arrival
ATO	automatic train operation	HGV	heavy goods vehicle
CFT terminal	combined freight transport terminal		

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