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Intermodal Transport Subsystems – Current State and Future

Abstract: The article presents the intermodal transport subsystems that are commonly operated at present and a selection of new subsystems that have been in operation for several years. Based on the analysis of the subsystems in operation, requirements for future subsystems were defined. The new subsystems will allow increase role of intermodal transport, in particular in the carriage of semi-trailers in Poland and Europe.

Key words: Intermodal transport; Railway infrastructure

Introduction

The increasing role of intermodal transport, especially in the transportation of semi-trailers within Europe, requires the search for new technical solutions that would enable the wider adoption of rail transport for semi-trailers. This is particularly important in the current context, where efforts are being made to reduce greenhouse gas emissions, primarily CO_2.

Currently, electric-powered semi-trucks, according to their manufacturers, have a range of up to 300 km on a fully charged battery. This makes their use in long-distance road transport problematic. A possible solution is intermodal transport, based on rail transport of semi-trailers, using electric semi-trucks for delivery and pickup from terminals, as they are suitable for this role. However, a major challenge is the transshipment at the road–rail–road interface.

Currently Operated Intermodal Transport Subsystems

Over the years of intermodal transport development, various subsystems have emerged, such as the transport of semi-trailers on "kangaroo" wagons or bimodal transport (semi-trailer on railway bogies) [1]. However, in European and Polish intermodal rail transport, two subsystems dominate:

- Transport of containers and swap bodies on platform wagons,
- Transport of containers, swap bodies, and semi-trailers on pocket wagons.

Due to the characteristics of intermodal transport in Poland (dominated by transport to and from seaports and freight traffic to and from China), the predominant loading unit is the container, both 20' and 40' (over 90% of intermodal transport in Poland). Swap bodies and semi-trailers are transported in significantly smaller numbers.

In other countries (especially Alpine countries), the "Ro-La" system is also used, where entire road vehicle sets (semi-truck with a trailer or a truck with a trailer) are transported on low-floor freight wagons.

It can be concluded that these three intermodal transport subsystems have dominated intermodal transport in Europe.

Tables **1-3** present an original SWOT analysis for the aforementioned subsystems.

Tab. 1. SWOT Analysis for the Transport of Containers and Swap Bodies on Platform Wagons

Strengths	**Weaknesses**
• "Standard" railcar design	• Vertical reloading • Reloading time (reloading of single units on the loading front)
Opportunities	**Threats**
• "Compatibility" with maritime transport in the case of container transport • Net cargo weight ratio (inside the unit) to gross train weight • Low costs of purchasing, maintaining and operating the wagon fleet	• High costs of construction, maintenance and operation of transshipment terminals

Source: Own study

Tab. 2. SWOT analysis for the transport of containers, swap bodies and semi-trailers on pocket wagons

Strengths	**Weaknesses**
• "Standard" railcar design	• Vertical reloading • Specially designed semi-trailer (reinforced chassis construction adapted for vertical reloading) • Reloading time (reloading of individual units on the loading front)
Opportunities	**Threats**
• "Compatibility" with maritime transport in the case of container transport • Net cargo weight ratio (inside the unit) to gross train weight • Low costs of purchasing, maintaining and operating the wagon fleet	• High costs of construction, maintenance and operation of transshipment terminals

Source: Own study

Tab. 3. SWOT analysis for the "Ro - La" subsystem

Strengths	**Weaknesses**
• Horizontal transshipment • Transport of entire road servos	• "Special" design of railway wagons (running gear with wheel sets of 330 – 380 mm in diameter, braking system), • Possibility of operation only in compact trains
Opportunities	**Threats**
• Low costs of construction, maintenance and operation of transshipment terminals	• High costs of purchasing, maintaining and operating a rolling stock

Source: Own study

The analysis indicates that in the case of vertical transshipment, a special design of semi-trailers is required to ensure safe lifting and lowering during handling. Additionally, a notable pattern can be observed: railway rolling stock with low construction, maintenance, and operational costs is typically associated with terminals that have high construction, maintenance, and operational costs, and vice versa.

New Subsystems Entering the Intermodal Transport Market

In recent years, we have observed the development of several new intermodal transport subsystems [1]. Some of these are already in operation; however, the scale of freight transport using these subsystems remains limited. The new subsystems focus on transporting semi-trailers that are not adapted for vertical transshipment. Most of these systems favor horizontal transshipment and aim to reduce the overall train handling time by, among other things, enabling the simultaneous transshipment of multiple semi-trailers.

Below is a brief description of three such subsystems:

- NiKRASA – A transport platform enabling the transshipment of semi-trailers not adapted for vertical handling onto and from pocket wagons.
- Modalohr **–** Allows the transshipment of a semi-trailer onto and from a wagon with a rotating frame using a semi-truck.
- CargoBeamer – Enables the horizontal transshipment of semi-trailers onto mobile platforms and into wagons with tilting side panels, utilizing terminals built from modular handling units.

The NiKRASA system facilitates the transshipment of a special "basket" platform with a semi-trailer placed on it. This system can utilize both standard pocket wagons and intermodal terminals.

The advantage of this system is its ability to use existing transshipment infrastructure and to handle semi-trailers that are not adapted for vertical lifting, which positively affects trailer load capacity. It is worth noting that semi-trailers designed for vertical transshipment have a reinforced structure, which results in a higher tare weight.

1. Semi-trailer on the NiKRASA platform (Source: [2])

2. NiKRASA semi-trailer with platform on a pocket wagon (Source: [2])

The Modalohr subsystem is a system that uses semi-trailer tractors to reload semi-trailers, which were used to transport these semi-trailers (in the case of loading) or to transport them (in the case of unloading) from the terminal.

3. Semi-trailer on the loading front of the Modalohr subsystem (Source:[3])

4. Semi-trailers on wagons of the Modalohr subsystem (Source:[3])

The rotating frame of the wagon allows a semi-trailer with a semi-truck to drive onto or off the wagon via an appropriate ramp at the transshipment front. The key advantages of this system include:

- The ability to perform horizontal transshipment using a semi-truck,
- Simultaneous transshipment of multiple semi-trailers, with the number limited by the number of ramps at the loading front.

However, this subsystem has certain drawbacks:

- The wagon's rotating frame construction can lead to higher purchase, operation, and maintenance costs**.**
- The terminal must be equipped with devices to enable the rotation of the wagon's frame.
- A critical limitation of this subsystem is the requirement for precise alignment of the wagon with its designated ramp at the transshipment front.

The CargoBeamer subsystem also enables horizontal transshipment of semi-trailers. In this system, the semi-trailer is loaded onto a special frame, which is then slid out of the wagon, loaded, and slid back in.

Both the wagon and the unloading ramp must be equipped with devices that allow the transverse movement of loading frames in relation to the longitudinal axis of the transshipment front. Additionally, the wagons in this system have lowerable and liftable side panels, which require appropriate mechanisms.

In this subsystem, the sequence of semi-trailer transshipments across the two adjacent ramps at the loading front is crucial to ensure smooth and efficient handling.

5. CargoBeamer system loading frame (Source: [4])

6. CargoBeamer system loading front (Source: [4])

In Poland, two new intermodal transport solutions are currently being developed, as described in [1]. However, these projects have not yet moved beyond the design phase.

Future Intermodal Transport Subsystems

As previously mentioned, several new intermodal transport subsystems have been in operation for a few years. However, their use remains limited and is primarily driven by the creators of these technical solutions. Despite years of operation, none of these new subsystems have gained widespread commercial adoption.

A reasonable conclusion is that none of the new subsystems fully meet the future requirements of intermodal transport. These requirements can be defined as follows:

- The ability to transport "standard-design" semi-trailers (those used in road transport without modifications required by a specific intermodal subsystem),
- Low costs of purchasing, operating, and maintaining rail wagons,
- Low costs of building, operating, and maintaining intermodal terminals,
- Reduced train transshipment times,
- A preference for horizontal transshipment.

It is important to note that future intermodal subsystems will primarily focus on intra-European transport. In contrast, intercontinental intermodal transport, which relies on maritime shipping, will continue to utilize 20' and 40' containers, transported by rail on platform wagons. The container remains the optimal cargo unit for maritime transport.

It can be observed that the subsystems described in Sections 2 and 3 do not fully meet all the requirements outlined above. Moreover, new subsystems are currently operated mainly by their creators and manufacturers, which limits their adoption to niche applications for semi-trailer transport.

For future intermodal transport subsystems to become widely used, they must meet most of the defined requirements and achieve mass commercial adoption. Only economies of scale can reduce the overall costs of intermodal transport within a given subsystem.

A business model in which a single entity controls the technology, production, and operation of transport services has hindered the widespread adoption of new intermodal subsystems. A potential solution to this problem is making the technology available free of charge to other entities, which could lead to broader adoption and mass usage of a specific subsystem, outpacing other competing technologies.

Examples from other fields of technology demonstrate that open-access specifications facilitate widespread adoption (for instance, the IBM PC, whose specifications were made publicly available). The alternative scenario is the existence of multiple intermodal subsystems, none of which achieve a dominant market position, instead forming niche markets or remaining technical curiosities. However, such an approach could lead to a situation where economic factors, rather than technical superiority, determine the adoption of a given subsystem.

Conclusion

Intermodal transport in Poland and Europe will continue to rely on:

- The transport of containers and swap bodies on platform wagons,
- The transport of containers, swap bodies, and semi-trailers on pocket wagons. In maritime intermodal transport, container transport will remain dominant.

Increasing the volume of semi-trailer transport in Europe will depend on the widespread adoption of a new or multiple new subsystems that prioritize handling semi-trailers not adapted for vertical transshipment.

However, for these systems to be widely used in commercial operations, their technical specifications must be openly available without restrictions related to intellectual property rights.

Source materials

[1] Janusz Poliński, Rola kolei w transporcie intermodalnym, Instytut Kolejnictwa, Warszawa,2015, ISBN 987-93-930070-2-8
[2] https://www.txlogistik.eu/en/services/nikrasa-2/, dostęp 21.03.2023 r.
[3] https://lohr.fr/lohr-railway-system/the-lohr-uic-wagons/, dostęp 21.03.2023 r.
[4] https://www.cargobeamer.de/was-wir-tun.html, dostęp 21.03.2023 r.