The Concept of the Development of Intermodal Transport Network Illustrated by Polish Market

Koncept razvoja mreže intermodalnog transporta oslikan tržištem Poljske

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DOI 10.17818/NM/2017/1.6
UDK 656.02 (438)
Preliminary communication / *Prethodno priopćenje*
Paper accepted / *Rukopis primljen:* 23. 2. 2016.

Summary

The presented research focuses on the development of an intermodal transport system in Europe. The model for a national intermodal transport network is presented based on conditioning of Poland. It proposes the location of intermodal terminals including port, regional, local and transit terminals. It also gives the forecast of intermodal units transhipments by the year 2030. Organizational solutions that provide for significant improvement to the quality of intermodal transport are suggested. The paper ends with the Authors' conclusions of a specific and strategic nature.

KEY WORDS

intermodal transport
transhipment points
transport efficiency

Sažetak

Ovo se istraživanje usredotočuje na online razvoj intermodalnog transportnog sustava u Europi. Model za nacionalnu intermodalnu transportnu mrežu je prezentiran na temelju uvjeta u Poljskoj. Predlaže lokaciju intermodalnih terminala uključujući luku, regionalne, lokalne i tranzitne terminale. Također, daje prognozu intermodalnih prekrcajnih jedinica i tranzitnih terminala do 2030. godine. Predlažu se organizacijska rješenja koja osiguravaju značajan napredak prema kakvoći intermodalnog transporta. Članak završava autorovim zaključcima specifične i strateške prirode.

KLJUČNE RIJEČI

intermodalni transport
točke prekrcaja
djelotvornost transporta

1. INTRODUCTION/*Uvod*

Intermodal transport, understood as the transport of intermodal loading units with a minimum of two different modes of transport, is one of the transport policy priorities for European countries. The developmental strategy for intermodal technologies and transport systems started in the last decade of the 20th century. The strategy aims to slow down the expansion of road based transport and to increase the market share of rail and water transport i.e. the so-called eco-friendly transport modes. In the meantime, there were changes in the detailed objectives, areas of the support, and tools used by politicians aiming to change the market preferences of shippers and logistic operators. Even the idea fo rthe intermodal transport system was repeatedly clarified by implementing related notions in regulations or official papers, i.e. combined transport, co-modal transport, or sustainable transport[1]. The last term seems to be the most up-to-date from a point of view of the binding developmental strategy for the European Union. Unfortunately, in spite of implementing many intermodal transport support programs and spending considerable funds a tboth the European and domestic level, the continued dominance of road transport in Europe is increasingly harmful to the society. This ineffectiveness of European transport policy will result in a growing negative environmental impact, measured in external transport costs.

In literature,the researches already pointed out the causes of the current state of European transport market (Łukasik Z., Kuśmińska-Fijałkowska A., 2012). These causes have a political, legal, market, and technical character. The great role in the expansion of the intermodal transport is usually being assigned to political factors, justifying the need for the state support. Without a doubt the transport policy has considerable influence on the market structure of transport services. Authors are of the opinion that solutions which are more effective, allow significant improvementsto the intermodal transport services without the need for change of political or legal surroundings. Therefore, the following analysis focuses rather on existing infrastructure and organizational issues. The research objective is to propose the integrated system of intermodal transport which can come

[1] The definitions of the given terms can be found in the EU Commission Directives and other European transport policy documents.

into existence on the basis of the existing infrastructure, and the forecasted demand. The scope of analysis is the Polish market which is biggest in the Central-Eastern Europe, and which has a great developmental potential. The analysis is concerned withrail-road combined transport technologies.

Application of verified research models describing complex transport systems is an important research assumption made by the authors. The following literature review is focused on scientific models so far applied in research on the intermodal transport.

2. LITERATURE REVIEW / *Pregled literature*

Models of intermodal transport described in scientific publications are diverse in terms of scope, goals, and the types of users. The goals of building models, however, are not always entirely clear. Some models are designed as decision-making tools; others are research tools to study the impact of various factors on the efficiency of intermodal transport. Often, external costs are used as one of the criteria (Chybowski L., Gawdzińska K. 2016a). Companies do not include external costs in their calculations unless they are forced to do so or it is due to their own strategy (Kulczyk J., Kolanek Cz., Skupień E., 2014). However, these are specific situations that should be presented in the description of the model.

A large part of a model deals with the problem of designing intermodal terminals, including the planning for their location. Even with regard to the problem of optimizing the location, there are many different models using different methods (Mayer G., Wagner B., 2002) (Ou C.-W., Chou S.-Y., 2009) (Vinh Van T., Devinder G., 2005) (Wang S., Liu P., 2007).These models, however, seem to be very general and universal. On the one hand, it seems to be right as that model should be of very general character. However, it seems dubious that one should not take into account practical considerations including regional specificity.

Some authors propose interesting ideas. For example, there are proposals for solving the problem of too small a share of intermodal transport in the transport system Europe. Racunica and Wynter (Racunica I., Wynter L., 2005), propose to increase the flexibility of intermodal transport through the creation of dedicated intermodal or semi-dedicated rail networks. This concept makes use of the technology used in the transport of Less-Than-Truckload (LTL) cargo. Finding such compromise solutions that are feasible and realistic to implement in present conditions seems to be the correct approach in the opinion of the authors.

Another very common problem, probably because it is a big challenge from a mathematical point of view is the optimization of a network (Yamada T., Russ B. F., Castro J., Taniguchi E., 2009). The problem of the optimal level of investment in the terminal has been the subject of research of Parola and Sciomachen (Parola F., Sciomachen A., 2005). The model takes into account the trade-offs between the costs and the level of customer service. A similar problem also relates to the model of Pedersen's (Pedersen M.B., 2005) whose goal is also to find the optimum between the level of customer service and costs (Chybowski L., Gawdzińska K. 2016b).

The PLATFORM model is intended to enable evaluation of the impact of using different technologies and management policies in order to increase the efficiency of intermodal terminals. Simulations using this model are intend to help in finding shipping pathways, so that the combined transport can compete with road transport (Rizzoli A.E., Fornara N., Gambardella L.M., 2002). The model can also show how increased intermodal traffic affects the efficiency of intermodal terminals.

The Heuristics Intermodal Transport Model (HIT-model) (Flodén J., 2007), is a strategic system model which allows one to determine the potential of intermodal transport, in terms of its competitiveness with road transport. The model is intended as a tool to calculate the costs and environmental impacts of the transport system. Another system model was developed by Groothedde et al. (Groothedde B., Ruijgrok, C., Tavasszy L., 2005), in which the authors propose the concept of a hubs-network shared by manufacturers and retailers.

Intermodal transport is characterized by a high degree of process complexity and, consequently, the complexity of decision making problems and their multiplicity. Therefore, state-of-the-art models are complex and require a large research effort. As a result, their practical use is very limited.

The modelling process, however, should be close to actual problems associated with intermodal transport, the problems which occur in practice. Relevant core problems for decision-makers in their business practice include the design of intermodal terminals (size, equipment, location, organization of work), and the optimization of the network for intermodal transport connections (including the elimination of bottlenecks). Despite a number of already developed models, there is a strong need for further work in this area. The first and foremost being their versatility with regard to problem solving and a greater connection with the transport business environment.

3. CONDITIONS FOR THE DEVELOPMENT OF THE INTERMODAL TRANSPORT IN POLAND / *Uvjeti za razvoj intermodalnog transporta u Poljskoj*

From the point of view of development of transport modes as an alternative to the road transport, the key role is played by the transport accessibility. In searching for an effective rail connection, the distance to the nearest reloading terminal is a key factor. As a result, the subject of the analysis will be the number and deployment of intermodal terminals in Poland and intermodal transport connections between them.

Poland is still in the early stages in the development of a network of intermodal connections. According to data from the Office for Railway Transport share of intermodal transport by transport work in total in Poland was 6.8% in 2014, while the EU's average was 17%. This share is gradually and steadily increasing, although its growth rate is variable and depends largely on the economic situation in Europe.

Intermodal technologies in practice are limited to rail transport of containers between sea ports and the interior. This applies to both ports of Gdańsk-Gdynia and ports of North-West Europe (Hamburg, Bremerhaven, Rotterdam, and Antwerp). There is a lack of swap bodies, and transport semi-trailers are limited to a very small turnovers in international relations. In 20151.15 million TEU (10.4 million tonnes) were transported by rail (Jaworski M., 2016).

We distinguish in Poland: inland and port terminals. Standard inland terminals are railway transhipment hubs located in the nodes of the railway networks, which are transfer points between different means of transport. Special inland terminals are located on the eastern Polish border, where rail lines with two different

track gauges meet[2]. These terminals offer mainly wagon-wagon transhipment operations. The complement to the inland terminals network are port terminals, located in the main Polish seaports where containers and ro-ro units are handled using a ship-storage yard-wagon relationship.

At the end of 2015, Poland had 6 independent intermodal port terminals and 25 inland terminals, supported by twelve different logistics operators. Most of land terminals are concentrated around the ports of Gdańsk/Gdynia, in the Lower and Upper Silesia, and in Central Poland (fig. 1). The large number of terminals reflects the inefficiency of their operation: The terminals are mostly small, and have a character of single-track sidings offering handling services. The largest agglomerations: Poznań, Warszawa and Wrocław, are served by several terminals in mutual competition with each other.

Source: JaworskiM., 2016

Figure 1 The location of intermodal terminals in Poland

Slika 1. Lokacija intermodalnih terminal u Poljskoj

Many mistakes were committed in building a coherent network of terminals and connections between them. At present we can discuss 2-3 large terminals that boast proper quality of service, and plenty of transhipment points without the possibility of developing and offering additional logistics services. Private ownership of terminals and limited transport network blocks development based on the so-called economies of scale. Both operators and their customers do not have a sense of market stability and guide themselves by long-term savings policy. This lack of investment, or its limited nature, results in the in low quality of intermodal transport offer.

Presently, investment carried out in Poland in the scope of long term development of railway infrastructure, will improve the speed of commerce, and reduce the cost of access to linear infrastructure (Ministry of Infrastructure, 2008). The minimum technical parameters of the infrastructure will be in accordance with guidelines of AGTC (European Commission, 1991). The daily capacity of railway lines will eventually be adapted so that freight and passenger are independent of each other and do not adversely affect their mileage.

These conditions are very important for the development of the network of intermodal transport in Poland. Poland is considered to be the largest and economically strongest country of Central and Eastern Europe. The large surface area and a relatively even distribution of urban areas (the average distance between large cities does not exceed 200 km) help with the efficient location of terminals. Stable economic development, one of the important pillars of the rapidly growing trade, provide for the efficiency of intermodal connections.

4. MODEL OF INTERMODAL TRANSPORT NETWORK IN POLAND / *Model intermodalne transportne mreže u Poljskoj*

The authors proposed the concept of a national system of intermodal transport. This system is assumed to serve both domestic and international trade (import and export). In the case of international transport, the key role is played by terminals located in seaports.

The key components of the proposed model fornetwork connections are listed below (Wiśnicki B., Chybowski L., Krukowski D., 2014).

1. Transport infrastructure
2. Transport technology
3. Distance from the terminal in getting way and delivered
4. Location of terminals
5. Terminal equipment and their potential transhipment
6. System management

Identified factors affecting the design and operation of the system:

1. Global demand
2. Demand in individual areas
3. Existing network of connections
4. National transport policy

As an example of the practical application of the model of intermodal system,we present the concept of an integrated intermodal transport system in Poland, which can be developed on the basis of existing infrastructure, taking into account the projected demand.

Analysis was conducted, which included two issues of strategic importance for the development of the system:

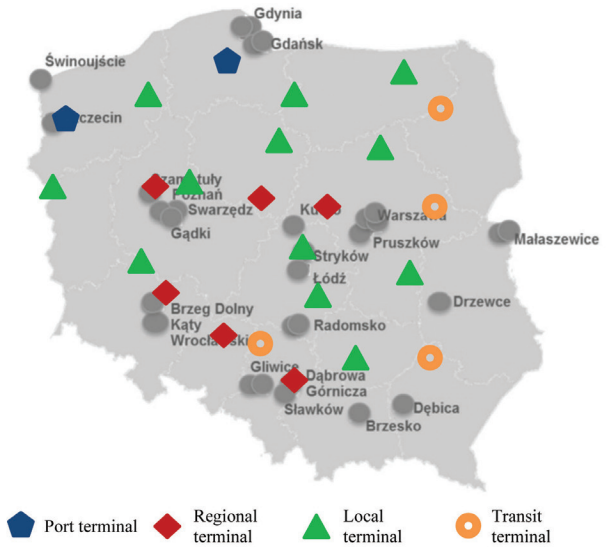
1. Designation of areas based on existing intermodal terminals,and proposals for new locations
2. Determination of the network of effective intermodal connections, including changing the potential of transport infrastructure.

When planning the location of terminals, it is essential to identify trade and transports needs of the studied area of the country. In the case of rail-road transport terminals, services should cover up to 150 km using the road transport means. From a practical point of view, one should select a location in such place that the area of operation of all the terminal covers the largest possible area of the country, and optionally, an area outside the country. Among the above-designated terminals it is proposed to adopt their functional division into four categories:

1. Port terminals: Located in the direct hinterland of seaports, fulfilling the functions of distribution and logistics services for the port terminals (container ones and ro-ro);
2. Regional terminals: Having regional importance, offering handling services and logistical services; tend to serve as logistics centres situated near large urban agglomerations;

[2] In addition to the state border terminals,there is the same type terminal situated at the end of broad-gauge railway line linking Ukraine with the Upper Silesia in Poland.

3. Local terminals: small terminals of local importance, fulfilling mainly handling functions; Their task is to focus mass cargo which is directed to regional terminals, but also service of direct links especially within the framework domestic transport; These terminals generally are located near large manufacturing companies or some medium-sized cities;
4. Transit terminals: Located mainly on the eastern border of the country.



Source: own elaboration(Jaworski M., 2016)

Figure 2 The project of network of intermodal terminals in Poland

Slika 2. Projekt mreže intermodalnih terminal u Poljskoj

Figure 2 shows the proposed network of intermodal terminals in Poland. The project involves the determination of two port terminals, 6 regional terminals on the basis of existing terminals ,and expansion of new locations for other local terminals. Regional terminals should ultimately serve as a major logistics centres with a line or satellite service for local terminals. In order for a regional terminal to fulfil its functions, specific technical assumptions must be fulfilled, e.g. multi-track system with a minimum working length 750 m, storage yards area of minimum 3000 TEU capacity (regional terminals) and an adequate number of power plugs for refrigerated containers (European Commission, 1991).

Based on the analysis of existing organization of the rail UIC carriers and the existing national strategies, the forecast for intermodal transhipments for Poland has been developed (UIC, 2012) (Ministry of Infrastructure, 2008) (Ministry of Infrastructure, 2011). Assuming a more than fivefold increase in the volume of transport by 2030, from which 30% will constitute domestic transportation, an annual number transhipments has on the level

Table 1 The amount of handling of intermodal terminals in the years 2020-30 [thous. TEU]

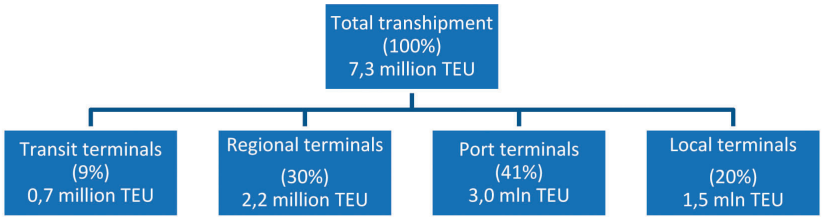
Tablica1. Iznos obrtaja tereta u intermodalnim terminalima u godinama 2020.-2030. (tisuće TEU)

Type of container terminals	Location	Up to 2020	Up to 2025	Up to 2030
Port terminals	Szczecin	330	660	990
	Tczew	1200	1600	2000
Transit terminals	Małaszewicze	90	180	270
	Medyka	40	80	120
	Sławków	40	80	120
	Trakiszki	50	100	150
Main terminals	Gliwice	140	280	400
	Kraków	30	150	270
	Kutno	120	240	360
	Poznań	120	240	340
	Warszawa	140	280	420
	Wrocław	130	260	370
Local terminals	Dąbrowa Górnicza	70	150	250
	Brzeg	70	150	230
	Mława	40	70	90
	Kielce	30	50	60
	Koluszki	30	50	60
	Lublin	40	70	90
	Małkinia	40	70	90
	Suwałki	40	70	90
	Swarzędz	80	190	270
	Szczecinek	40	70	90
	Świecie	20	35	50
	Tarnów	20	35	50
	Rzepin	40	70	90
	SUMA	3060	5280	7300

Source: own calculations (UIC, 2012) (Ministry of Infrastructure, 2008)

of 7.3 million TEU to be expected (fig. 3). The projected amount of freight should be reflected in the handling capacity of individual terminals. Properly selected handling and storage potential of terminals limits the risk of distorting of liquidity of the entire system of intermodal transport.

The forecasted amount of cargo handled in the various terminals is included in Table 1. Distribution of handled mass cargo was made taking into account the population in each region, which has the greatest impact on the forecasted demand for transport. Then, to estimate the size of transhipment in the future, an extrapolation method has been used. Comparing the results to the current handling capacity, e.g. terminal in Sławków or in Kutno, which amount to 120 000 TEU and 100 000 TEU respectively, it can be stated that they require a gradual extension. However, the expansion of terminals should be done in stages, for example in the five-year periods and thereby adapting to the changing market conditions.



Source: own elaboration

Figure 3 Transhipment in particular groups of terminals in 2030.

Slika 3. Prekrcaj u posebne grupe terminal u 2030.

At present only 30% of all containers leave the Polish port container terminals by rail (Czermański E. et al., 2014). One of the assumptions for further development of container terminals, both in Gdańsk and Szczecin, is to enable the distribution of a larger number of containers i.e. increase the share of rail to a minimum of 50%. Furthermore, service at ports should be based on the use of two large distribution terminals on hinterland of Szczecin and Gdańsk-Gdynia, which will be communicated with the container and ro-ro terminals using the fast and frequent rail shuttle connections. Another desirable solution is to enable stacking of containers, as it is the case in the US, which will significantly increase the capacity of these connections.

Connections to and from terminals should be implemented by means of shuttle and line railway trains. The shuttle train is defined as a train of fixed length that goes without shunting between the two terminals at fixed times. Such a train can be used to handle large, fixed flows of cargo. Regular shuttle connections are to be performed between the port terminals and the main terminals.

5. CONCLUSIONS/*Zaključci*

In the analysis, the model concept of effective intermodal transport network has been shown. In the presented case, terminals located in the most important nodes of the railway network and their target transhipment capacity up to 2030 were determined. A proposed network of domestic and international connections between terminals has been adapted to the current demand,and takes into account the macroeconomic forecasts.

It should be emphasized that the implementation of the proposed network of intermodal connections allows one to achieve the measurable social benefits. From the point of view of road users,it seems to be most important to reduce congestion and improve safety on roads. Also, a plan to reduce the negative impact of transport on the environment is increasingly gaining greater market value, even in the countries of Eastern Europe. From the economic point of view, the most important are benefits from the increased scale of transport in intermodal terminal-to-terminal corridors. Therefore, we can speak of correlated benefits for many groups of participants of the transport market.

There are opportunities to develop intermodal transport and to compete effectively with road transport. However, one should deal with the actual market conditions and take into account the existing technical, legal, or financial constraints. In the near and even distant future, we cannot expect a radical change in these constraints. Therefore, one should look for solutions that require as little as possible change to the existing system, especially with respect to transport infrastructure. The proposed model assumes minimal expenses to the development integrated intermodal transport network, and emphasizes the better utilizationof existing infrastructure. Of course, the presented intermodal transport development model has a general nature and should be treated as such. Many of the issues are to refine and resolve at a later stage in the implementation of this developmental plan.

Acknowledgment/*Zahvala*

The author's research presented in this article was carried out under research two grants of the Ministry of Science and Higher Education of Poland: "Diagnostics methods and efficient operation of complex technical systems in terms of failure prevention and environmental protection" (4/S/IESO/14), "Increasing operational effectiveness of complex technical systems by systematic development and implementation of innovations using novel materials and modifying the object's structure" (1/S/IESO/17) and "Analysis of the technology and economic efficiency of the intermodal transport connections in the Central and Eastern Europe" (8/S/IIT/2014).

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