Harmonization of resources and technologies of transport modes at the terminal level in a logistics network

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Abstract. In the widest sense, networks provide, in the safest and easiest way, through the equipment and related facilities, connections between the different components of the transport system. The analysis of networks should take into account both their division according to geographic layout and their functions, but also taking into consideration three basic criteria: transport, control and management. Thus, it can be easily stated that networks represent basic elements of our society, which allow the study and optimization of some key issues for modern society. In a transport network, interactions between modes of transport are recorded in terminals or junction points. It should be noted that in transport modes, the heterogeneous components of the transport infrastructure interact with the flow of traffic entities. Thus, in order to determine the optimal correlation between the resources and technologies of transport modes at terminals, it is necessary to analyse multiple variants. The differences between the loading capacities of means of transport and the impossibility of achieving perfect coordination between the different transportation modes of junction points determine additional stops. Terminal transhipment is often inevitable. Taking into consideration the importance of traffic flow in the network as well as the relations developed in the logistics network, in this paper we will analyse the transport systems with two transhipments specific to two intermodal routes (Shanghai-Koper-Budapest and Shanghai-Constanta-Budapest) of the Shanghai-Budapest transport network.

1. Introduction

The world economy of the beginning of the 21st century relies essentially and decisively on the existence and performance of transport networks. As a distinct and increasingly significant branch of this globalized economy, transport nowadays fulfils both its traditional role of providing access to natural resources and the new tasks generated by the permanent exchange of finished products between the productive industrial sector, markets and consumers.

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Nowadays, in the planning of territories, there are multiple networks, which require a research of their fundamental role within the territories served, in terms of territorial organization and synchronization, and especially in terms of transport techniques, [3].
The world transport network involves the co-operation of independent transport networks, which require very high investments due to their long lifespan. These transport networks are interconnected and analyzed in order to determine their overall performance by studying the characteristics of traffic flows, means of transport, infrastructure or the way in which they are operated. The transport of goods at the level of a logistics chain involves a large number of different actors who are involved and interact. The logistics network requires the analysis of the dynamic network of actors or the services network (developed by the interactions between them) that determine the information flow from its level and the analysis of the physical network made up by the nodal and the linear infrastructure, [4].

The need to reduce time and transport costs has generated a continuous refinement and development of the modalities of crossing the transport network nodes and modes of transport as such. Global competition and the need to increase the efficiency of the transport chain have led to an increased attention to the complexity of the intermodal transport system.

The introduction of intermodal transport units was a very important step for the international trade, triggering changes both in the means of transport and in the handling equipment and facilities, as well as in the transport network nodes, i.e. in the transport terminals. Therefore, the problem analysis aimed at improving the performance of handling equipment and transport terminals is necessary and essential for the smooth operation of transport networks.

2. Transport terminals as nodes of a logistics network
One of the basic elements of the transport system in general and of a logistics network in particular, which contributes decisively to the efficiency of the whole transport process, is the transport terminal. The transport terminal ensures connectivity within a logistics network, having the role of connecting nodes for two or more modes of transport, thus making the interface function between them.

The difference in capacity and frequency between two modes of transport is also regulated at the level of transport terminals, which act as a buffer between these differences. At the level of the region where the terminal operates, it has a number of advantages for regional development, by contributing to the economy but also by creating jobs [5].

The efficient use of the handling facilities for cargo units within a terminal is of utmost importance, because their number and performance influence both the operations carried out and the organization of the terminals [6]. The performance of the transhipments equipment contributes to the optimization of the logistics process, as it allows continuous flow without unnecessary delays within the intermodal transport system.

The development of the means of transport and manipulation specific to the loading units, by increasing the transport/handling capacity, require a major evolution of terminals that have to adapt permanently to the evolution of the world market.

Thus, in order to increase their efficiency, a series of measures can be taken in order to meet the technological requirements imposed on the world, [7] like: the use of efficient handling equipment, ensuring the transition from traditional to automated terminals; efficient coordination of the operations carried out in the terminals; the use of automated systems to enable efficient and rapid data transfer; the design of integrated logistics chains etc.

3. Case study
The Analysing the flow of goods between the Far East and Europe, this case study has studied the intermodal transport of 100 TEUs on the Shanghai-Budapest transport network, as seen in figure 1. The two intermodal routes of the transport network compared in this study for import and export are:
- Shanghai-Port of Koper-Budapest with a distance of 16,277.31 km;
- Shanghai-Port of Constanta-Budapest with a distance of 16,544.66 km.
Taking into account the flow of goods between the nodes of the transport network, the following container shipments were established:
- the Shanghai-Budapest export calculated for 100 TEU containers carrying textile products, each container weighing 10 tons;
- the Shanghai-Budapest import calculated for 100 TEU containers carrying 17 tonnes of metal products.

![Diagram of Shanghai-Budapest transport network](image)

**Figure 1.** Shanghai-Budapest transport network.

### 4. The harmonization of resources and technologies of transport modes at the terminal level

In a transport network, interactions between modes of transport are recorded in terminals or junction points. The differences between the loading capacities of means of transport and the impossibility of achieving perfect coordination between the different transportation modes of junction points determine additional stops, [3].

Taking into consideration the importance of traffic flow in the network as well as the relations developed in the logistics network, we have analyzed transport systems with two transhipments specific to the two intermodal routes of the Shanghai-Budapest transport network.

#### 4.1. For the two-transshipment transport system on the Shanghai-Koper-Budapest route

The transport system on the Shanghai-Koper-Budapest route requires, as shown in figure 2, two transhipments. We have determined the calculation elements specific to the situation where the containers arrive at the port of Shanghai using the rail transport, then use the maritime and rail transport, requiring additional transhipment in terminal 1 for delivery to destination.

![Diagram of transport system on the Shanghai-Koper-Budapest route](image)

**Figure 2.** Scheme of transport system on the Shanghai-Koper-Budapest route.
The maximum capacity of the system is equal to the maximum capacity of subsystem 2. The length of transhipment operations depends, not only on the capacity of the means of transport or the type of cargo, but also on the handling facilities specific to the terminals used and the productivity of the workforce.

Subsystem 2 (rail transport) limits the transport capacity of the entire system and therefore, in order to increase the system’s transport capacity we have increased the number of trains \(n_2\) to the maximum value of trains \(\bar{n}_2\) of 5.8 trains, from 5 trains. As far as the transhipment times are concerned, we have reduced the transhipment operations in subsystem 2 at terminal 1 \(t_{12}\) from 5 hours to 4 hours. Thus, \(T_2\) will be reduced from 29 to 28 hours, and the value \(\bar{n}_2\) from 5.8 to 7. These improvements have ensured a capacity increase for Subsystem 2, as can be seen in figure 3.

![Figure 3. Representation of transport capacities for the two systems (maritime and rail) after the decrease of the transhipment time.](image)

4.2. For the two-transshipment transport system on the Shanghai-Constanta-Budapest route

The transport system on the Shanghai-Constanta-Budapest route requires, also two transshipments, as shown in figure 4. As in the previously analyzed situation, the containers arrive at the Shanghai maritime port using the rail transport, using after that maritime and river transport. The cycles of the two transport systems used will also be \(T_1\) and \(T_2\).

![Figure 4. Scheme of transport system on the Shanghai-Constanta-Budapest route.](image)
The transport system on the Shanghai-Constanta-Budapest route also requires two transhipments. In this case, the maximum system capacity is equal to the maximum capacity of subsystem 2 (river transport). To increase the transport capacity of the system, we have increased the number of barges used ($n_2$) to the maximum value of 40 barges ($\bar{n}_2$). As far as the transhipment times are concerned, we have reduced the transsshipment operations at Terminal 1 ($t_{12}$) to 4 hours, resulting in a capacity increase of up to 250 t/h through the use of 50 barges for subsystem 2, see figure 5.

![Figure 5. Representation of transport capacities for the two systems (maritime and river) after the decrease of the transhipment time.](image)

5. Conclusions
In order to increase the maximum capacity of the transport system on the two routes, measures are needed to ensure the maximum capacity of the subsystem 2 (represented by rail transport and river transport). One of the measures that can be taken is to increase the capacity of the means of transport. Most of the time, the increase in the capacity of the means of transport does not lead to improvement beyond a certain point, the means of transport becoming non-operational. In this case, the bottleneck phenomenon is often due to the insufficiency of the means of transport but to the transhipment operations. Another important measure concerns the transhipment times that can be reduced by automating manipulation operations, organizing the workforce, replacing inefficient technologies, etc.

Solving the problem of the cargo break (as a prerequisite for intermodal transport), coupled with the development of the handling facilities and the means of transport, have led to the emergence of productive activities at the points of interaction between transport modes that add value to a commodity.

The dissociation of non-autonomous means of transport, the emergence of intermodal transport units for the autonomous means, as well as the development of loading/unloading equipment have triggered the cooperation of transport modes.

Transport terminals are basic elements of a logistics network which contribute decisively to the efficiency of the entire transport process. The harmonization of resources and technologies of transport modes at the terminal level, highlighted in this paper, aim to ensure the fulfilment of the requirements of the transport system.

Connections between different modes of transport at junction points that condition co-operation at the network level require careful analysis.
We can conclude that the efficiency of the transfer system on the level of a logistics network depends on two important factors: the duration of the transhipment operations taking place at the terminal and the extent of use of the means of transport.

In order to coordinate the port system with that of the inland transport system it is necessary to take into consideration the time span between the means of transport, the time cycle specific to the means of transport and the duration of the handling operations in the terminals, taking also into account that the port and inland transport specific activities influence each other.

6. References

[1] Ellanti M N, Gorshe S S, Raman L G and Grover W D 2005 Next generation transport networks: Data, Management, and Control Planes (USA: Springer Science) 710
[2] Barthelemy M 2011 Spatial networks Physics Reports 499(1) 1-101
[3] Raicu S 2007 Transport systems (Bucharest, Romania: AGIR) 484
[4] Demare T, Bertelle C, Dutot A and Leveque L 2013 Interface maritime et interface metropolitaine: vers la modelisation de l’axe Seine par les reseaux, in Les réseaux dans le temps et dans l’espace Paris 249-263
[5] Rodrigue J P, Comtois C and Slack B 2013 The Geography of Transport Systems Third Edition (New York, USA: Routledge) 432
[6] Saanen Y A 2004 An approach for designing robotized marine container terminals PhD thesis Delft University of Technology
[7] Rosca E and Raicu S 2006 Optimizing container handling in transport terminals in Intermodal concepts in transport (Bucharest, Romania: AGIR) 227-232