National Logistics Network Design with Regard to Transport Co-Modality

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The article presents a general approach to logistics network design for logistics system of Poland in aspect of co-modality. The main tasks realized by this network and its functions in cargo flow were defined. Special attention was paid to transport co-modality. Starting from the concept of co-modality the main principles for a national logistics network were defined.
Keywords: logistics network, logistics system, transport co-modality.

1. INTRODUCTION

Development planning of transport sector must take into account the requirements for service quality and its impact on the volume of traffic tasks. The quality of transport services is derived from the quality of transport infrastructure, and in a broader sense also from the logistics infrastructure. Thus, the efficiency of the economy which depends on the quality of transport services will also depend on an investments in country's logistics infrastructure.

The efficient cargo flow in a given country is possible thanks to this country's logistics network efficiency which is measured by punctual and linear elements of the transportation infrastructure. However, national logistics network burden with cargo flow results from tasks that are the sum of the demand for logistics services.

The national logistics network must take into account the passengers flows as an aggravating factor, but in a further research this factor will be treated as a constant. The logistics system of the country, in addition to business and economic functions, fills the role of a factor stimulating economic growth and economic development of regions and cities. This task comes from mechanisms which indirectly control the logistics system of a country such as legislation and the decisions made by governments in matters relating to country's transport policy and the country's economics.

The role of political systems, in addition to the economics work out, is to foster the societies development. Transport and infrastructure policy are the tools which have a direct impact on the quality of citizens life. It has to ensure the possibility of people's free movement, infrastructure's land consumption, transport aspects and its impact on the environment. Above factors have to be considered together with economical factors. They are the basis for creation of the sustainable transport strategy and they can be a part of a set of evaluation criteria for the logistics system of a country.

The logistics system of a country is a structure which is physically limited by national borders. This system moves cargo within a country with the usage of different modes of transport and transshipment equipment. Moreover it provides the ability to cache, consolidate and distribute the cargo flows and also to modify their physical form. From the strategic point of view it is crucial to properly form the elements of this system, including transport co-modality. Co-modality is a feature of harmonious functioning (including the interaction) of all subsystems performing transportation tasks.

In 2006, the European Commission defined the co-modality as an efficient use of transport modes operating on their own or transport modes multimodally integrated in the European transport system to reach an optimal and sustainable utilization of resources. According to the EU policy, everywhere where it is possible, especially in long distance transport, urban areas transport and congested corridors transport, modes of transport should be changed for those which are more environmentally friendly.

In conclusion, the logistics system which sets tasks for the country's transport system has a significant impact on the scope and use of transport. Thus, in this perspective, the logistics system of a country is a part of a transport co-modality. Setting tasks for the transportation system, the logistics system of a country has to consider current conditions of transport operations (such as available transportation modes, transportation technologies, transportation vehicles capacities).

It can be concluded that the efficiency and the environmental performance of the transportation tasks depend on:

– **The design of the logistics system and principles of its operation -** the ability to generate reasonable transportation tasks and to eliminate the unnecessary transport
– **The degree of transport development and its economy –** transportation system adaptation for co-modality, efficient and environmentally friendly realization of transport tasks.

The influence of the logistics system and transportation system on transport co-modality is presented in fig. 1. It can be concluded that the transport co-modality cannot be achieved in isolation from the state of the national logistics network.

2. LOGISTICS NETWORK AND A SUPPLY CHAIN

In the literature, a logistics network is understood as a distribution network or a supply network or a supply chain [4], [9]. In a broader meaning, the supply network consists of two or more legally separated entities connected by the flow of materials, information and funds. These entities are generally manufacturers of parts, components or finished products, logistics service providers, and also customers. However, in a narrower meaning in relation to supply network, the supply chain term is used [1], [3].

The supply network term is used to define a flow of materials between suppliers and production companies and a flow of products between producers and final consumers (fig. 2) or is defined as a set of entities cooperating together (companies or institutions) [12]. In terms of functionality, the supply network is defined as the chain of subsequent links (companies and institutions) that are involved in products movement, and in organizational and managerial term, as an integrated set of processes that manage the flow of materials from suppliers up to final customers [2].

Taking the above into account, we can say that the supply network includes all necessary activities related to the flow of materials, beginning with raw materials and ending with the sale to the final customer [4], [10]. At every stage of the flow returns may occur, which are materials returned by the subsequent company or waste that needs recycling.

Thus, the logistics network constitutes *a system of interconnected punctual objects belonging to the logistics infrastructure which are involved in the materials delivery process from suppliers to manufacturers (manufacturer supply area), and in the finished goods delivery process from manufacturers to final customers (manufacturer distribution area)*

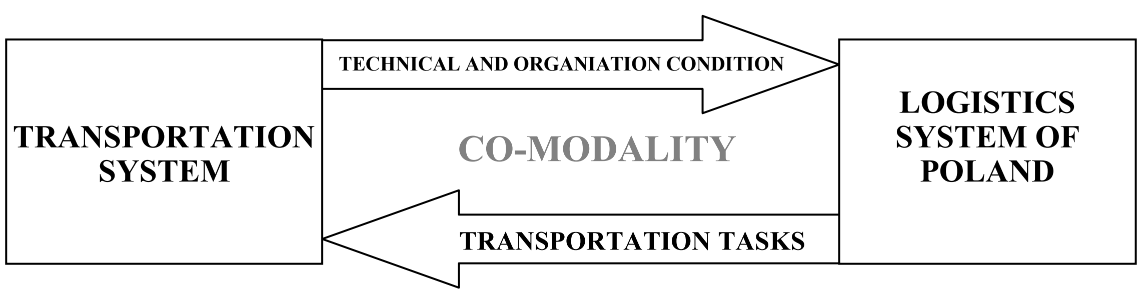

Fig. 1. Transportation system, logistics system and a transport co-modality

Source: own work

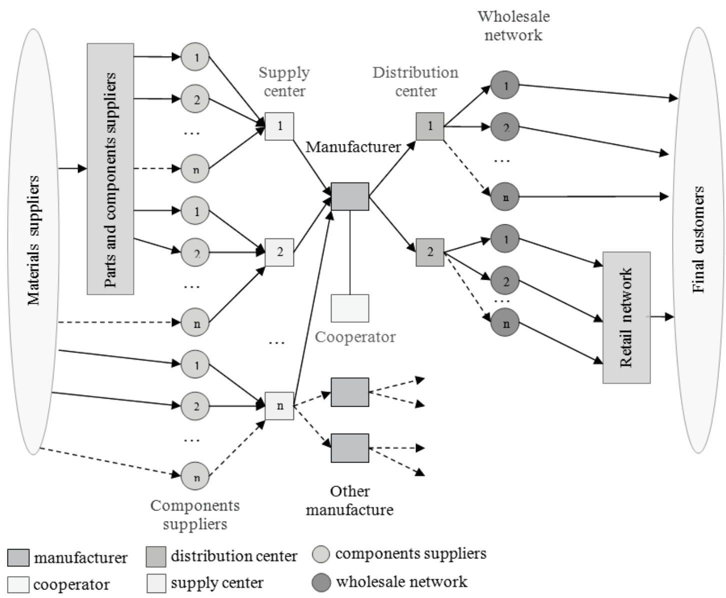

Fig. 2. Delivery network example

Source: [5]

The national logistics system is an integrator of all possible supply chains that reach the country, and connects these chains with the environment.

Due to the fact that supply chains are the strategic components of the business, and their goal is to develop a companies' profit, they are controlled to increase profits while ignoring issues related to the efficiency, effectiveness and ecology of the transportation network. The logistics network KSL, which is a supply chain integrator, should therefore be controlled (shaped) to increase the potential of these chains, while maintaining the principles of sustainable development.

One of the ways to shape this system is the implementation of the principles of co-modality, i.e., save time and money at the stages of the logistics process which can consolidate material streams generated by various supply chains.

3. LOGISTICS NETWORK TASKS IN ASPECT OF CARGO TRANSPORT

The national logistics system is a deliberately organized and connected within the country set of subsystems: production, transport and storage with the relations between them and the relations between their properties which determine the flow of cargo and the flow of related information.

The aim of each system, including the logistics system, is to identify its processes properly. The Model of the Logistics System of Poland should therefore reflect the complexity and interdependence of the phenomena occurring in the system and its relationship with the environment, the more that the realization of a cargo transportation process needs the engagement of many elements of the system. Here, the transportation system infrastructure, as a logistics system element, seems to be the most important when we think about a transportation duration.

The infrastructure which determines the logistics network is very important for the proper realization of logistics processes:

- linear infrastructure: existing transportation link (rail, road, air, maritime)
- punctual infrastructure: spatially separated points of origins and destination of cargo, and transshipment facilities (stations, warehouses, logistics centers, etc.)
- informatics infrastructure: which is determined by different types of communication and data exchange standards

The suprastructure instead of infrastructure is understood as the specified transportation vehicles. These vehicles are determined by the infrastructure parameters (size, capacity, speed) and economical parameters (unitary costs).

As the basic types of elements of the logistics system of Poland there should be distinguished [7], [8]:

- origin points,

- transshipment points were the cargo is handled (transshipped, consolidated, deconsolidated),
- destination points,
- transportation links between these points, as an existing linear transport infrastructure,
- organization and network communication.

Origins and destinations of the cargo flows tend to be points of gravity for the surrounding of logistics facilities such as transshipment points, logistics centers, intermodal transport terminals etc.

In contrast to origin and destination point, the transshipment points are the logistics system elements which can enable the change of transport mode, consolidation, deconsolidation, warehousing of the cargo transported from the supplier to customer. Depending on the size of the performed work and the level of the infrastructure development, different types of transshipment points such as transshipment terminals, logistics centers, etc. can be distinguished.

Cargo transport (cargo flow) between the origin, transshipment and destination points is possible only thanks to the transportation, informational and organizational links (existing linear transportation infrastructure).

The cargo movement in the national logistics system is realized by using a variety of transport modes. It means that the increase in the efficiency of the national logistics system can be achieved mainly through the rational use of transport infrastructure. This causes the decrease in the cost of logistics (transport, warehousing, etc.) and the increase in the quality of a performed work.

The ability to customize various elements of the infrastructure for the tasks realization is determined by the characteristics of these elements, for example vehicles capacity, transportation costs per mode of transport or intermodal and traditional terminals operating capacities.

The logistics task in case of KSL arise from both: the specificity of logistics area, its various aspects and from the necessity to meet the needs of those involved in the cargo flow. That is why the logistics task consists of a number of tasks related to the transformation of the partial flows (flow of materials, information) occurring in the relationship between the various functional blocks of the system and the environment.

It is important to organize transport in logistics chain in order to effectively control cargo flows within the country, and to endeavor for integration and coordination of the cargo flows in order to fulfill the expectations of the logistics system users at a fixed level [8].

In accordance to the essence of the logistics task, it is necessary to characterize the origin and destination point for the cargo flow. The origin and destination point for the cargo flow in terms of the national logistics network design include: manufacturing and service companies, mining companies, import, export, and companies involved in recycling.

4. LOGISTICS NETWORK IN ASPECT OF TRANSPORT CO-MODALITY

Every new logistics network design project (or analysis of an existing one) starts with the identification of suppliers, customers, origin and destination point for cargo flows and with the structure of time and quality of these flows. It is about getting answers to question such as: what?, how?, where? and when? the cargo has to be transported, stored, consolidated, deconsolidated, etc. Identification of suppliers and customers is a result of the system's area analysis and allows to set the conditions for the task realization.

The correct realization of the designing work is based mainly on the different cases of the network analysis, which means setting designing variants.

Starting the analysis of the given designing options, it is necessary to consider future customer needs and the ability to use different technologies for cargo and information flow [2,4].

Logistics network design is based on three basic stages (fig. 3):

1. development of the technological and organizational conception (formation)
2. determination of the numerical values of the technical characteristics and economically solving the logistics task (dimensioning)
3. evaluation of the results.

Although the stages of designing and dimensioning give an answer to the fundamental question: "how?" to accomplish the logistics task and how much it will cost, it is the most laborious stage to formulate the logistics tasks. This task formulation stage involves much effort related to the analysis of the available design data and data preparation, so it could be then used in the designing process.

When designing logistics networks, it is necessary to include a few alternative solutions' variants to make it then possible to compare and choose the most effective solution in terms of the evaluation criteria. It the stages of designing and dimensioning the answers to the questions about vehicles' types, their number and technology that should be used are obtained. Additionally, it has to be determined what spaces for their operation must be provided and what the cost of the process will be. The results obtained at the designing and dimensioning steps have to ensure the logistics task realization (this task involves the cargo flow transformation in terms of space, form and time).

The final stage of the design is to choose the variant which is most efficient from the criteria point of view. Optimal variant selection is done on the basis of multi-criteria evaluation. The problem of transport modality can be considered as a multi-criteria optimization problem in which objectives like these are included in the sub-critical evaluation of the transportation system functioning. The criteria of transport co-modality evaluation in aspect of logistics are:

- the average utilization of logistical infrastructure elements,
- the minimum utilization of logistical infrastructure element
- the maximum utilization of logistical infrastructure element

Considering the efficiency problem, it is worth to remember that costs minimization and benefits maximization usually provide different solutions. With low costs as well as with high costs, the benefits scale is small or losses occur.

Another approach which guarantees the effectiveness of the solution is to directly take into account the performance indicators as a criteria evaluation. In scientific publications the efficiency is defined as a result of taken actions, described by the relationship between results and expenditures. From the economical point of view, the scale of the obtained results (economical results) is determined by the profit, and the efficiency (in economic terms) is expressed by the indicator of sales profitability.

Important from the co-modality point of view is the indicator of unitary operating profit from the transportation task realization by the unitary external cost of tasks realization

In addition, it is necessary to design an infrastructure which will allow to perform transshipment between different modes of transport. Special attention is paid to transshipment terminals such as cross-docking, road-rail terminals, seaports, river ports and logistics centers which are the basis of national logistics system.

The development of multimodal transport modes (especially intermodal) in KSL should be given a priority, because this type of transport allows to connect advantages of different modes of transport and is much more environmentally friendly then just a road transport.

Consideration of the external transport, taking into account the above aspects is necessary to establish the modal distribution of various modes of transport. In this aspect, from a logistical point of view the factor which characterizes the transport activities in logistic systems is the relationship between the transportation cost and logistics service level. Most often the choice of transport depends on the size of cargo and transportation distance.

The important aspect of the national logistics network design is to identify all the necessary features of the elements of network structure and characteristics of element of the transport infrastructure.

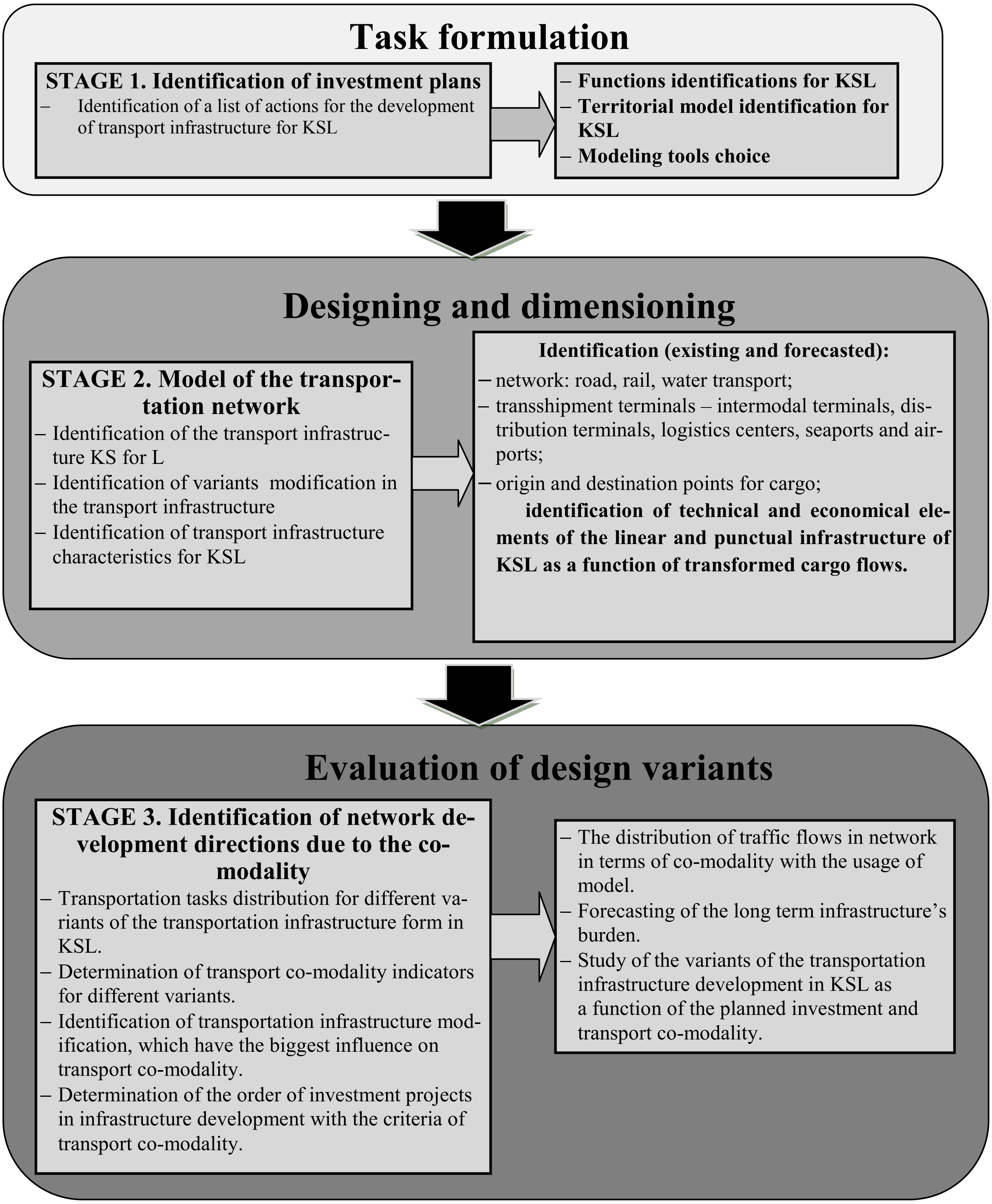

Fig. 3. Logistics network design procedure in KSL.
Source: own work based on [7].

5. CONCLUSIONS

The issue of the national logistics network design comes from the forecasts of logistics tasks (transportation needs), as well as from the adaptation of the transportation system infrastructure to the standards and requirements of the European Union. Logistics network design is a complex multi-aspect decision-making process associated with making decisions in conditions of limited financial resources, as well as limited technical equipment.

Analyzing the determinants of the costs level, it is easy to notice that the level of external costs of logistics tasks realization depends on the impact of transport on the environment. The level of unitary fixed operating costs of logistics tasks realization is dependent on the degree of the transportation system resources usage. Whereas the level of unitary fixed and variable operating costs of logistics tasks realization is understood as a transport efficiency.

Thus, by minimizing the total unitary costs of logistics tasks realization, including the ones listed above, the transport co-modality is assured.

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