MODELLING OF NATIONAL MULTIMODAL TRANSPORT NETWORK

Aidas Vasilis Vasiliauskas

Vilnius Gediminas Technical University, Transport Research Institute,
Plytinės 27, LT-2040 Vilnius, Lithuania,
Tel. +370 52699694. E-mail: aidasv@ti.vtu..lt

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It is realized long time ago, that one of the main factors for country steady grooving economic is a properly working transport system, in which not last place takes a mean of cargo transportation, so-called multimodal transport. But like all other means of transport it experiences problems related to the development and optimization of proper infrastructure (network of roads and terminals).

In the article there is made an attempt to simulate a national multimodal transport network.

The basis for such model lies in the investigation of freight flows, during which we identify the possible routs for freight transportation (as well as places where such freight is shifted from one mode of transport to another), extend the existing statistic database on modal transport carriages and start to develop a new database on multimodal freight carriages. With the help of the last one, we can start to create the model of national multimodal transport network.

1. Introduction

In recent decades, the transportation of goods has been growing in Europe, thus making the efficient freight transportation system a major component of highly developed national economy. In this respect, the efficiency of multimodal transportation is often mentioned. Multimodal transportation is usually referred to as a transportation of a particular cargo by different transport facilities without transfer. In Lithuania, this type of transportation could be associated with the transporting of goods by combining railroad – road, road – sea and railroad – sea transport as well as the networks of respective modal infrastructures and cargo transfer terminals.

The novel types of transport facilities, freight containers and their handling technologies widely extend the potentialities of multimodal transportation, thus making the multimodal network modeling a basic element of further development in this area.

A major goal of this paper is to provide one of the possible variants of developing national multimodal freight transport network.

2. Investigation of Freight Flows

The network considered should embrace the modal freight transportation infrastructure from the origin and destination points (having some indices) in Lithuania and abroad. For this purpose, freight flows should be investigated, in order to establish how many operators and in what way use the multimodal transportation in the country and for exporting goods. A survey would require the data from operators on :

a) the points of origin and destination of the trip ;
b) the types of goods transported, their tonnage and value ;
c) the sequence of using various transport facilities.

The results of the research would make the basis for freight transportation map plotting, showing the routes of multimodal transportation and the places of transport facilities changing. To achieve this, a computer – aided program for the research data processing and presentation in the form available for the user should be developed. However, this is not the issue discussed in the present paper. The problem of developing the national multimodal transportation network showing the routes in compliance with those obtained in the reports on freight flows investigation is considered. The relevance of freight flows research is primarily for storing the data on multimodal freight transportation between the origin and destination points. It is important, because the data at the disposal of the authorities are based only on the transportation performed by modal transport facilities between departure and destination points. This means that the geography and multimodality of freight transportation are not taken into account. The study of freight flows would fill the gap, as well as providing the information about the modal freight transportation. Therefore, the research considered could provide the basis for solving the problems of developing and presenting the multimodal freight transportation network as follows:

a) development of multimodal network by investigating various modal networks ;

b) finding the terminals closest to the origin and destination points, allowing the multimodal network optimization ;

c) assessing terminal operation in the context of the whole network, in order to obtain most adequate view of the multimodal freight transportation network.

3. The Development of Multimodal Transportation Network

The development of a general network would include the integration of the separate modal networks into a unified system, ensuring the multimodal transportation between any two network points denoted by certain indices. Thus, an integral network will be developed allowing any combination of modal routes sequences. All the links of the network represent actual roads at certain geographical location specified in freight flows investigation reports. A general network will be created by connecting the networks of particular transport facilities via a number of road – railroad (RR), road – waterway (RW), and railroad – waterway (RRW) transport terminals. This concept is illustrated in Fig. 1 for the interaction of road and railroad transport networks.

The network development proceeds with connecting the first road transport network and the network of railroad transport via the first RR terminal, and then back to the second road transport network through the second RR terminal.

The use of the required transport facilities at a particular stage of transportation will be provided in the following way. At the beginning, all the components of the general network are “turned off”. It is assumed that any transport facility is used in its turn, at the moment required. Then the first part of the general network is “activated”, which is 1 – st road transport network with RR terminal closest to the starting point denoted by a particular index. In a similar way, the terminal for getting to 2 – nd road transportation network is found. The part of the route for railroad transportation is inserted between the first and the last road transport networks via the corresponding RR terminals. Thus, the terminals located along a particular route close to particular indexed departure and destination points ensure the proper sequence of using the available transport facilities.

By the way, in cargo transfer at the terminals, some additional entrance/ exit links, not belonging to any of the modal networks but forming a general network, should be taken into account. This is shown in Fig. 1 and will be discussed in the following chapters.

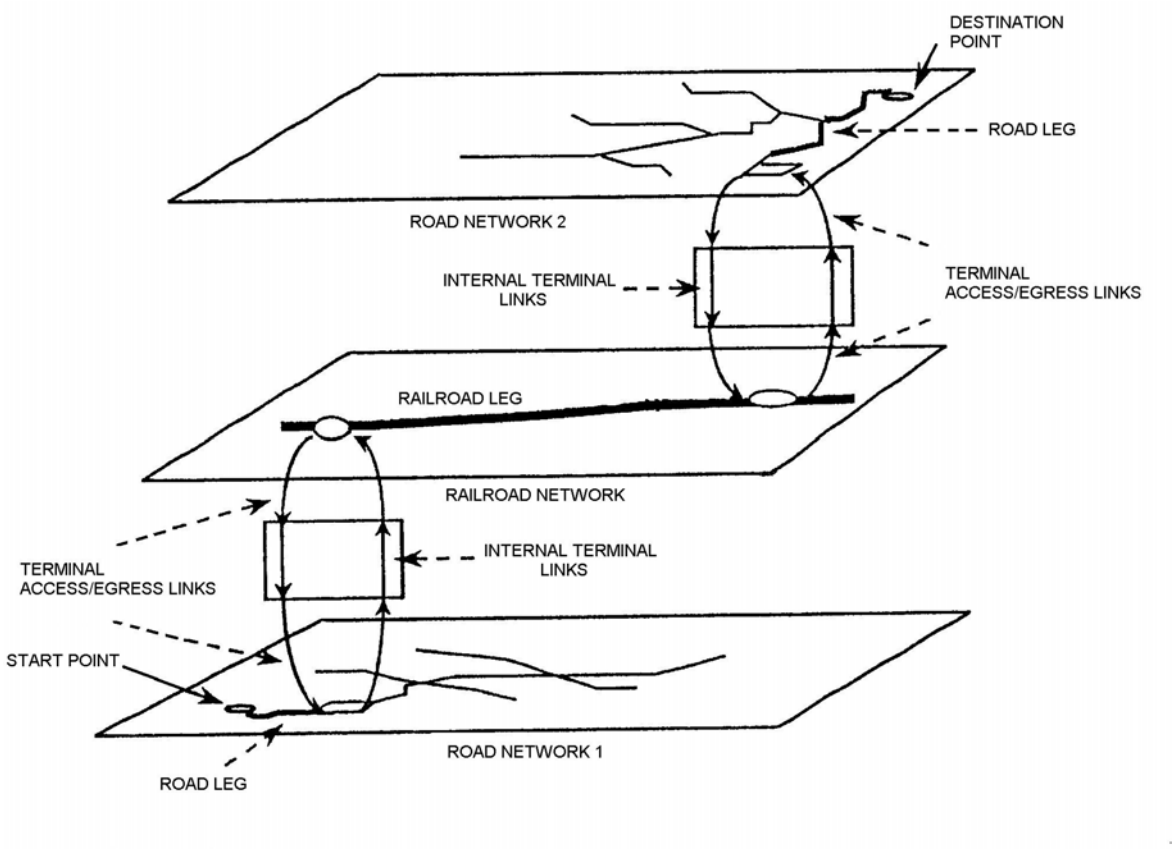

Fig. 1 Integration of the particular modal networks into a general multimodal network

For now, it can be stated that when individual modal networks and terminals connecting them, which have their own entrance/exit links with a particular modal network, have been taken into consideration, we obtain a general geographical view of multimodal network.

The problems which may arise with respect to the above visual network presentation are as follows :

a) a large number of links may appear to be of zero – length, since they represent a process taking place at a point (i.e. cargo transfer at a terminal),

b) some objects may overlap (i.e. terminals for freight handling located at the same geographical area).

To avoid these problems, a possibility should be provided in developing a network to slightly alter the location of the points in such a way as to avoid placing two objects in the same geographical area. This could provide a certain length for the link as well as avoiding overlapping of the objects.

4. Determining the terminals nearest to starting and destination points in transportation

In order to begin working out the routes for freight transportation, every individual modal network should be slightly modified to be integrated into a general network. In addition, the inclusion of such specific links as railroad access tracks and approaches to terminals, the information of which is not provided anywhere, requires some modification. The networks of particular transport facilities should be modified in the following way:

1. In representing road transport networks, the corresponding road transport terminals, acting as the ways of intermediate stops in the route, should be taken into account. The approaches to such terminals should be handled as some additional links in a network.

2. Water transport network should be divided into two smaller, but closely related subsets. They are the network of the inland water transport and sea transport, in which different types of ships are used. It is important to identify the locations of cargo transfer from the ships of various types, adding special links to a general network in these places.

3. In railroad transport, the fact that various railroad operators can operate on particular railroad lines should be taken into account. This is important, because the operators transporting cargoes to various countries greatly extend the geographical database of transportation as well as increasing the number of additional links.

In addition, railroad and road transport networks should be extended to embrace major roads of the neighbouring countries by connecting them to Lithuanian internal transportation networks. This should be achieved by adding new links at the points of crossing the border.

Having made the appropriate modifications, a rather accurate view of an multimodal transportation network would be obtained. However, to make it optimal, one or more terminals nearest to a departure or destination points of the route, provided with the particular indices, should be determined. For this purpose, a formula is used to find a radius, at the range of which with respect to the indexed departure point of the trip the required area could be found, with the terminals on it to be used as entrance/exit points to/from the multimodal network:

$$R_{\max} = R_z + (2e) + p\,; \qquad (1)$$

here,

R_{max} – radius of searching for the network entrance/exit points (terminals);
Rz – the shortest distance from the point having a particular index to an arc of a circle described by a search radius;
e – the least root – mean – square error in determining the location;
p – maximum length of entrance/exit links to/from the network, not entered into modal infrastructure data base of a particular transport facility.

It should be noted, that ***e*** and ***p*** values for the particular transport facilities should be obtained experimentally.

By applying the formula (1), maximum search radius from an indexed departure or destination point of the trip could be found for any transport facility, with all the terminals in the range of this radius being the potential entrance/exit points to/from the multimodal network. How it works, is shown in the Fig. 2. But once again it should be noted, that the search for the terminal varies slightly, depending on the type of transport facility.

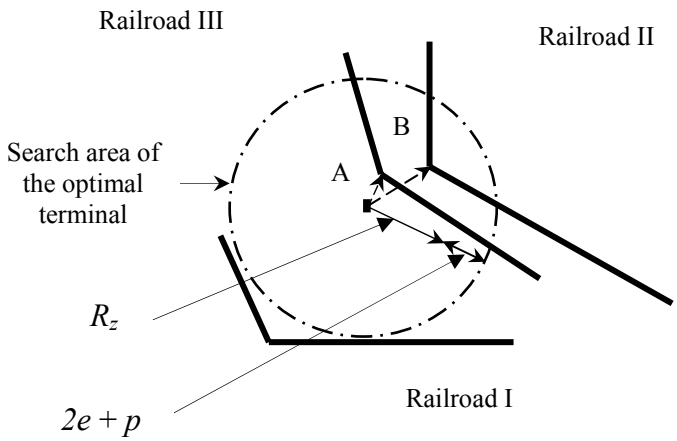

Fig. 2. The search for the optimal terminal in transport network

5. Assessment of terminal operations in detailed presentation of multimodal network

In section 3 it was mentioned that, developing an multimodal network out of individual modal networks, the areas for linking the above network where cargo transfer would take place should be provided. To obtain more detailed view of the network, a terminal should be presented (and assessed) as a separate link. In Fig. 3, two possible variants of terminal presentation and evaluation in a general network are given.

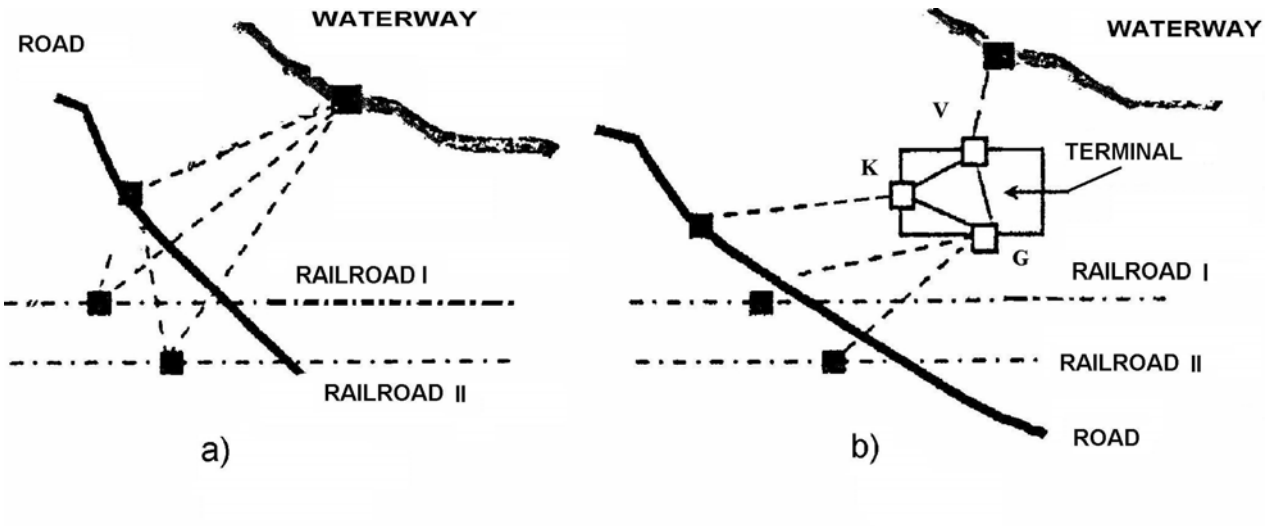

Fig. 3. Two ways available for terminal operation modeling

One of them (Fig. 3a) may be referred to as a bimodal link method, because each cargo transfer operation is represented as the only additional link between two different transport facilities (they are shown by a dotted line in the picture). This would be the easiest solution, allowing a number of links of a particular direction to be related to a separate modal network of transport facility.

Another approach to considering and representing terminal operations is shown in Fig. 3b. In this case, a transport terminal located in a certain geographical area is considered together with the actual entrance/exit links to/from the corresponding modal network (they are shown by single dotted – lines leading to the entrance gate of the terminal, denoting V – water, K – road, and G – railroad transport, respectively). It should be noted, that for the 1 – st type of transport more than one entrance gate may exist. This more complex variant is particularly effective for the situation when modal networks are rather rare, requiring sufficiently long entrance links to integrate the terminals into a general network. It is also important in areas, where the gates face various directions.

6. Conclusions

1. One of the available models of developing national multimodal freight transportation network has been considered. It is based on the analysis of freight flows, providing the initial

data for model development. Currently available statistical data on modal freight transportation has been extended and some data for a new database on multimodal freight flows have been stored.

2. Based on the data of the present research, a model of Lithuania multimodal freight transportation network may be developed and applied to practical needs.

3. Due to universal character of the data collected and the use of simple algorithms, modeling may be performed in three stages aimed:

- to develop an intermodal network by connecting individual modal networks into an integral system ;
- to optimise the network, identifying optimal freight handling terminals for any origin or destination point of the trip mentioned in freight flows survey ;
- to evaluate the processes taking place in the terminal, thereby optimising the operations performed as well as presenting most adequate and detailed view of the multimodal network.

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