RESEARCH JOURNAL OF THE UNIVERSITY OF GDAŃSK

Transport Economics and Logistics Vol. 76 (2018)
http://dx.doi.org/10.26881/etil.2018.76.07

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RATIONAL DISTRIBUTION OF THE HIGH-SPEED RAILWAY CAPACITY BETWEEN TRAINS OF VARIOUS CATEGORIES

Abstract

The article presents a methodology for the distribution of available capacity of high-speed railways, in the conditions of equal access to the railway infrastructure of different participants of the transport market. This will allow maximizing the efficiency of using available capacity of high-speed railways, while simultaneously organizing freight and passenger transportation.

Keywords: high-speed railways, organization of high-speed passenger and freight transportation, dedicated capacity

Introduction

Rail transport is able to provide relatively low capacity (in terms of, for example, road transport). But each "path" of the traffic schedule makes it possible to transport a significant amount of cargo and provide high freight capacity of transport lines. Along with freight traffic, the infrastructure of railways is used for passenger and other transportation. In the conditions of intensive traffic schedule, passage of a passenger train is an unused possibility of passing a freight train. The task of rational use of the traffic capacity has always been and is relevant, especially in the current conditions of Ukraine's transition to the European principles of infrastructure and transportation activities delineation in the railway transport operation. Even more importance, this issue gets under conditions of high-speed traffic, because high speeds require an increase of inter-zone intervals and lead to an even greater "removal" of trains.

1. Analysis of previous researches

A lot of scientific works are devoted to the railway lines and sections capacity. Sufficient techniques have been developed that allow different criteria to establish the most rational scheme for passing trains of various categories (But'ko, Prohorchenko, 2015), including the criterion of technological failure (Matsiuk, 2017). At the same time, attention is paid to the commercial use of the capacity and the formation of a "fair price" in the conditions of equal access to the railway infrastructure (Myronenko, Matsiuk, Rodkevich, 2015). The effectiveness of the interaction of transport market participants – infrastructure and rolling stock operators, carriers and cargo owners – may be determined by the actual demand for rail transport infrastructure. Along with the influence of other important factors (commercial benefit, commodity market structure, transportation tariffs, delivery rates, etc.), it is possible with a high level of reliability to predict the volume of transit traffic within the existing transit routes (Myronenko et al., 2012). Volumes and capacity of passenger and freight traffic is a decisive factor in the formation of demand for available capacity (Kerner, 2009).

However, it should be noted that most of the existing techniques are effectively implemented under normal (up to 120 km/h) running speeds. In conditions of high-speed connections organization, along with running speed, minimum train intervals increase (Nikitin, Boltaev, Glybovskij, 2016). The organization of high-speed and conventional trains in one railway direction is rather complicated, from a technical point of view. Therefore, most of the existing high-speed lines in the world are specialized for one type of connection – namely passenger (Boravskaja, Shapilov, 2001).

Nevertheless, today the world tends to diversify into the use of high-speed lines, mainly due to the organization of high-speed freight trains (Rail Turkey English, 2018; Waters, 2017), even with predicted speeds of 350 km/h (Vedomosti.ru, 2017; Portal of the city of Verkhnyaya Pyshma, 2017).

One of the main reasons for such a sharp increase of interest in high-speed freight trains is the large-scale plan of China to build new routes for the delivery of its own products to European countries within the framework of the New Silk Road (Khanna, 2017; Dehghan, 2017). Within the framework of this project Ukraine is defined as a promising and important partner (Me.gov.ua, 2017). However, only from Ukraine successful implementation of new perspectives depends on.

2. Main material

Historically, modern railways of Ukraine were formed in a centralized planned economy. The whole organization of goods and passengers delivery, especially in its technical part, that is, internal, operation was a centralized system of managing the transportation process – from the planning of train formation and organization of operational processes of railway stations to the allocation of railway lines available capacity for development of train schedules. This aspect remains connected with

the centralized principle of infrastructure management and railroad and locomotive parks, as well as with the standard length of the control "circle" – part of the lines network that corresponds to a separate train dispatcher. The specified polygon, as a rule, does not exceed the length of one section.

Methods for assessing the available (technical) capacity of transit routes (from the border to the border) will differ somewhat from classical approaches to assessing the technological capacity of lines sections or races. For determining the available capacity of railway line section, the inter-passage interval (on double-track sections) or the period of the schedule for which a pair of trains is traversed (for single-track directions) are used. In order to evaluate the possibilities of the railway transit routes (from the border to the border), it is advisable to take into account the total time of trains occurrence within the direction, that is, the time applications service in a single system of transport services. Since the capacity of the transit route can be limited not only by the technological capabilities of lines sections, but also by the entrance or exit border crossings.

In this case, the key is the question of determining the priorities of different categories of trains moving on the same infrastructure, requiring the allocation of certain shares of its capability. Obviously, the higher the priority of the train, the greater the advantage it have in the allocation of capacity and the more precise must be the schedule of its movement. It is known, but not yet reflected in the relevant regulatory documents, that the accuracy of the train schedule execution is of a stochastic, probabilistic nature depending on a large number of factors, such as technical, organizational, technological and well-known "human" factors.

It should be noted that under conditions of high-speed lines operation, the organization of trains with low speed (local cargo and passenger at speeds 45–75 km/h) along with high-speed (200 km/h or more) is complicated by technical means and may not be sufficiently safe and reliable due to significant delimitation of moving periods on sections lines and block areas. In the conditions of equal access of all participants of the transport market (in particular freight operators and high-speed passenger transport), this will result in low efficiency due to the significant increase in the organization of "slow" trains on high-speed routes. Therefore, in terms of the railway connections organization, the movement of trains should be provided close to the value of running speeds. As far as the high-speed connection is concerned, this is true for the categories of trains (freight and passenger) with average speeds per section in the range of 200–250, and in the future 300–350 km/h.

In Ukraine, there is no alternative to the combined use of the high-speed routes (for passenger and freight traffic), since we do not have and will never have such powerful passenger flows as, for instance, in China. But China is already building high-speed freight trains to increase the commercial efficiency of its high-speed routes. They are built on the basis of passenger trains, but are designed at a speed of 250 km/h. Market requires a rapid delivery. Thus, in 2014, the mass transportation of goods in China decreased by 11.4%, while others, non-mass, grew by 12.2%.

This is the way that Russia has also used. Together with the Chinese, it designs a cargo train at a speed of 350 km/h. It is even identified who will produce freight trains for the high-speed routes. Freight trains for the high-speed Moscow-Kazan highway will be built in Verkhnyaya Pyshma plant.

Another key issue is the introducing of the "dedicated capacity" concept into professional usage and in the organization of transportation. Dedicated capacity is a new term in the organization of rail transportation. Unlike traditional concepts – available capacity, the dedicated capacity should be determined to provide access to the infrastructure, which should be, on the one hand, equal, non-discriminatory, and on the other hand – economically justified for both the carrier and the owner (operator) of the railway infrastructure. At the same time, this access must have a physical, technological and economic dimension – a certain route, at a certain time of the day, which has a certain price. Therefore, the following understanding and definition is proposed.

The dedicated capacity is the part of the maximum available capacity for the period of time ($0 < T \leq 24$hours) that remains for trains of i-priority to pass after passing all of the trains of higher priorities. Special trains, transportation (for example, recovery trains for disaster, accidents, military transports) have a priority i=0 and if they are to be taken into account, then this is done separately.

A graphic model that explains the concept of "dedicated capacity" is shown below. It shows the conventional rail line with length L having different priorities i and, accordingly, different speeds $V_i > V_{i+1}$ and duration of movement in the direction equal to $t_{Xi} = l/V_i$. The minimum interval of passing by train of the highest priority J_i, have a value that depends on the ratio of train speeds and the specific conditions for their movement (Figure 1).

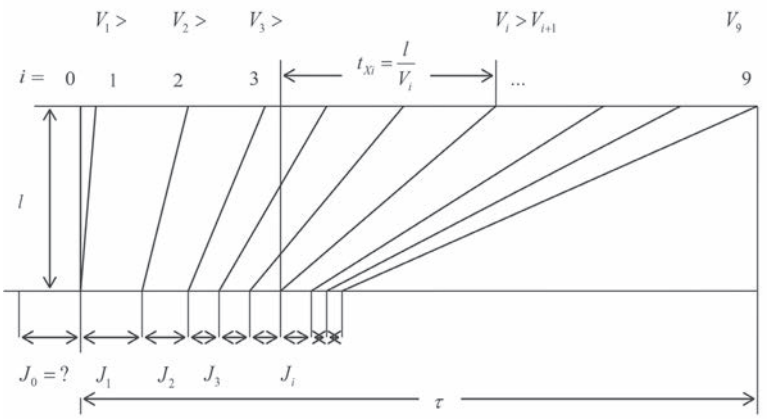

Figure 1. Graphical model for calculating the dedicated capacity
Source: (own elaboration)

Conclusions

The introduction of high-speed rail transport is a new and very important stage in the development of Ukraine's railways. Particular importance is given to this process during the period of in-depth reforms and modernization of various spheres of economic development.

The high-speed railways development depends on further plans to ensure the effectiveness of their usage. In practice, this will be reflected in the efficiency of using the dedicated capacity.

The methodology of the distribution of high-speed railways available capacity presented by the authors will provide maximum efficiency in organizing the movement of various categories of trains in the conditions of non-parallel train schedules and equal access to the railway infrastructure of all transport market participants.

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