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NEW PROCESS OF DETERMINATION OF THE POTENTIAL AND SCOPE OF THE RAILWAY INFRASTRUCTURE

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Abstract

Currently, it is necessary to support railway transport as a key element of passenger and freight transport. Railway transport must be the backbone of transport services, which must be implemented in the context of the basic goal of EU transport policy, which is to ensure the efficient use of the railway infrastructure, and thus the quality of passenger and freight transport. Therefore, it is necessary to ensure the high-quality use of the railway infrastructure, its adequate development and the constant process of modernization. The management and operation of the infrastructure is carried out by the infrastructure manager, which is usually owned by the state. The railway infrastructure is influenced by several important factors, which ultimately affect the quality and stability of the train traffic diagram. The main goal of the contribution is to briefly describe the current procedures and methodologies for the capacity of the railway infrastructure determining and using, but especially the proposal of new procedures and options for determining the scope and potential of the railway infrastructure. These indicators are also important from the point of view of determining the theoretical and practical permeability of the track sections. Subsequently, specific parameters and a specific recommended range of transport service will be proposed for each range. Last but not least, a brief practical application will be developed on the selected railway lines in individual European countries. The main contribution of the article, as well as the entire research presented, will be a more effective determination of the capacity of the railway infrastructure and the planning of the traffic operations scope on it.

Keywords: railway infrastructure, determination, infrastructure parameters

1 Introduction

Railway transport occupies a significant position in Europe, offering the diversity of the infrastructure network. It provides sustainable and especially ecological way of transport of passengers and goods practically over various long distances. Railway passenger transport must by a key element of the public passenger transport. However, the mentioned processes largely depend on the quality and capacity of the railway infrastructure. In the process of train path capacity allocation to railway udertaking the infrastructure manager needs to be aware of infrastructure capacity [1]. It is relatively difficult to define railway infrastructure capacity and also the potential and scope of the railway infrastructure in the context of railway transport operation.

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2 The current state of the railway infrastructure capacity solution

There are lots of types of the railway capacity. Krueger in the publication [2] categorises railway capacity into different types and stresses that practical capacity is the most important one:
• theoretical capacity (upper bound of capacity),
• practical capacity (practical limit of traffic for a defined performance level),
• used capacity (actual traffic volume and its variations on the line),
• available capacity (the difference between used and practical capacity).

There are also lots of methods of railway capacity utilisation, which can be defined as “the amount of capacity used for a given timetable on a given infrastructure” [3] and there are various methods of estimating it. As described by [2] and [4], they can generally be placed into four categories:
• analytical methods such as graphical compression methods [5],
• parametric models such as the works by [2],
• optimisation such as the works reviewed by [6],
• simulation such as RailSys software.

However, currently there are certain bottlenecks of the mentioned issue solution through certain expert methods. Therefore, it is necessary to propose solutions to resolve the problem of railway infrastructure capacity in the mentioned way. Within the first phase, it is appropriate to focus on the potential and scope of the railway infrastructure. One of the most important parts of the proposed methodological procedure is the necessity to ensure the railway infrastructure in such quality that it is possible to provide the proposed range of railway transport operation on the railway line section in question while maintaining maximum reliability and safety. However, it is rather complicated to determine the exact scope or parameters of the railway infrastructure, when only the extent of passenger and freight transport is known.
The aim of the above proposal is not to establish a new throughput method, but to propose a methodology to define the different ranges of railway infrastructure and to establish their hierarchy. The inspiration for the methodology proposal is the International Union of Railways (UIC) Decree 406 entitled Capacity, adopted in 2004. Its aim was to unify the national methodologies used so far. It is not directive but recommendatory. For example, it also proposes recommended values of occupancy of a line section by trains when calculating the utilisation of railway infrastructure capacity. Individual values and parameters are listed in Table 1 [7, 8].

Table 1 Recommended values and parameters of the occupation of the track section according to the UIC 406 decree [7]

Type of transport in railway line	Rush hour	Full-day concept	Remarks
Railway lines reserved for suburban passenger transport	85%	70%	Possibility to cancel some scheduled services in case of delays.
Railway lines reserved for high-speed transport	75%	60%	
Railway lines with mixed traffic	75%	60%	Values can be higher if the number of trains is low (up to five per hour) and heterogeneous.

3 Methodology of the railway infrastructure scope determination

The mentioned methodology will consist of the parameters of the railway infrastructure defining and then assigning them to the selected scopes of the railway infrastructure. The recommended scope of the railway operation expressed by number of train connections will be assigned to infrastructure scopes in the next part. Specific outputs are presented in the following chapters.

3.1 Determination of the railway infrastructure parameters

In the context of the optimal determination of transport services, it is very important to consider the conditions and parameters of the railway infrastructure where the railway transport can be provided. To ensure the individual ranges of railway transport, it is essential that the railway infrastructure is adapted in such a way that the required range can be safely and smoothly provided on it. This involves adjusting its individual parameters. The most important parameters to be monitored include:
- the number of railway tracks, platforms in the railway station,
- average line speed,
- station and track safety device,
- length of the inter-station section or space section,
- electrification of the railway line.

The above parameters have a significant impact on the capacity of the railway infrastructure, i.e. the theoretical and practical throughput. In the case of ensuring optimal transport service on a certain transport route, or on a certain railway line section, it is necessary to monitor the capacity of that railway line section. It is very important to determine the exact number of trains that can 'fit' per day on the section under consideration [8, 9].

3.2 Determination of railway infrastructure and railway operation scope

Within the framework of determining the scope of the railway infrastructure and subsequently the scope of the railway operation, it is necessary to use certain scientific methods and professional knowledge. As mentioned in the second chapter, the mentioned problem was not sufficiently solved through expert methods. Within the input data available to us, it is an optimal solution, but it requires a detailed solution in several phases. In the case of this contribution, the first phase of the mentioned specific research was carried out, where the following universal scientific research methods were used:
- method of induction - induction is one of the basic forms of connecting ideas in reasoning; it is a type of reasoning in which general judgments and conclusions are derived from several unique or partial judgments,
- method of synthesis - it is connection of individual parts or components into a whole; merging, amalgamation; one of the basic methods and thought operations, consisting of connecting parts into a whole,
- Delphi method - procedure for establishing an expert estimate of future development or status using a group of experts; it uses the subjective opinions of the members of the expert group with the aim of obtaining a consensus; It is specific kind of brainstorming,
- the heuristic method - it discovers new ways of problems solutions including new contexts; it is a scientific activity based on a "discovery" process.

Specifically, these methods were used in the research, which consists of the fact that several railway lines and its sections, usually on the network of the Slovak Railways, were selected. All the mentioned parameters of the railway infrastructure were assessed, as well as the scope of railway operations on them. These railway line sections were selected in such a way that they represented lines with lower, medium, and higher railway operation scope (including passenger and freight transport) as well as with different parameters of the railway infrastructure. Subsequently, based on the findings, certain universal proposals are presented in tables 2 and 3. Moreover, within the proposal, a procedure has been chosen which modifies and extends the recommendations of UIC 406. It considers seven levels or seven possible scopes of railway infrastructure (indicated in Table 2 by the Arabic numerals 1-7). Within each level, certain recommended railway infrastructure parameters are proposed (number of tracks, station and track-side signalling equipment, average line speed, etc.). These parameters within each proposed level of railway infrastructure are shown in Table 2. Individual selected railway lines and sections are shown and marked in colour in Figure 1.

Table 2 Parameters and scopes of railway infrastructure

Railway infrastructure scope / railway infrastructure parameters	
1	- single-track railway line, - mechanical, possibly electromechanical station safety device, - railway line safety device of the first or second category, (telephone communication), possibly semi-automatic block, - lower average line speed sufficient (on average up to 60 km/h), - longer interstation sections or longer distances between operating posts with track branching.
2	- single-track railway line, - electromechanical station safety device in most of the stations (ideally relay or possibly electronical safety device), - railway line safety device at least category II, which is a semi-automatic block or ideally an automatic block signal, - higher average line speed (min. 60 km/h on average), - shorter inter-station sections, or shorter distances between branch lines.
3	- double-track railway line, - electromechanical or mechanical station safety device is sufficient in most of the operating posts, - railway line safety device of the first or second category, which means telephone communication, or semi-automatic block, - a lower average line speed is sufficient (on average generally up to 100 km/h), - longer interstation distances or longer distances between operating posts with track branching.
4	- sufficient double-track railway line, - at least relay station safety device in most of the transport, possibly electronical safety device, - railway line safety device is automatic block signal or in certain cases a semi-automatic block is sufficient, - recommended higher line speed (min. 80 km/h on average), - shorter interstation sections, or shorter distances between track-branching stations.
5	- double-track railway line, - modern station safety device – electronical safety device in most of the operating posts, - railway line safety device exclusively automatic block, - higher average line speed (min. 100 km/h), - if necessary, consider the possibility of building a third line track in the limiting section.
6	- three-track railway line, - modern electronical station safety device in most of the operating posts, - railway line safety device of at least second category, - higher average line speed (min. 120 km/h).
7	- a dedicated railway line for suburban and regional rail passenger transport and a dedicated railway line for long-distance transport, - modern station and railway line safety device (min. third category), - on the line for long-distance transport, an average line speed of at least 160 km/h.

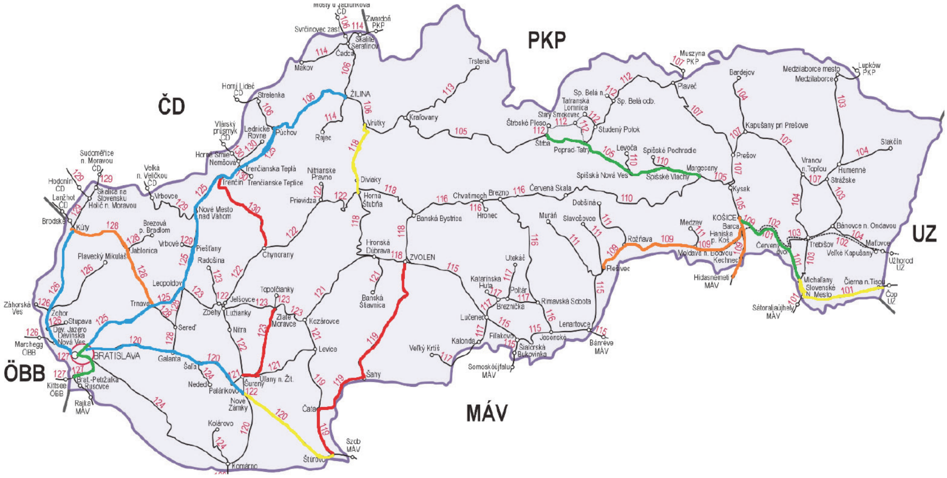

Figure 1 Selected and marked in colour railway line sections in the Slovak Railways

Concrete selected railway lines within the individual colour-marked infrastructure ranges are shown in Table 2. Railway infrastructure ranges 6 and 7 are not on the Slovak Railways network, so they are not even on the map. These ranges were assessed according to railway line sections in the Czech Republic (Prague - Kolín), in Austria (Vienna - St. Polten) and sections in German conurbations. Some Swiss examples are also interesting to by classified Loetschberg Base Tunnel, 2/3 single tracks, 110 trains per day.

Table 3 Selected railway lines on railway infrastructure scopes

Railway infrastructure scope / selected railway lines	
1	Šurany - Zlaté Moravce; Trenčín - Chynorany; Zvolen - Štúrovo
2	Trnava - Kúty; Košice - Hidasnémeti; Košice - Plešivec
3	Michaľany - Čierna n/T; Vrútky - Horná Štubňa; Nové Zámky - Štúrovo
4	Košice - Michaľany; Bratislava Petržalka – Brat. Rača; Margecany - Štrba
5	Bratislava - Nové Zámky; Bratislava - Kúty; Bratislava - Žilina

The further parameters are then proposed in each range, namely the interval of the number of trains per 24 hours in both directions, then the maximum number of trains per 24 hours in one direction, as well as the maximum number of trains within one hour in the peak hour, first in total in both directions and then per line track. It is the number of trains in the peak that is the limiting factor in the throughput performance of the railway infrastructure. When determining the maximum number of trains that can be operated on a given scale, it is necessary to consider a margin for freight traffic as well as a certain time reserve. The total recommended number of all trains in both directions was determined in turn, followed by the maximum recommended number of trains in peak periods in total and per one track line. As a paired timetable is considered, the number of trains in one direction is half the total number of trains. In determining the number of trains per hour in the peak period, it was assumed that most of all train services are generally evenly distributed over the period from 04.00/5.00 to 23.00/24.00, with double the number of trains in the morning (generally 05.00 - 08.00) and afternoon peak periods (generally 13.00 - 17.00, possibly 19.00) compared to the peak period.

A simple calculation shows that for any given hour during the peak period, even if no transport services were operated during the night peak (23.00/24.00 to 4.00/5.00), it is theoretically possible to operate 6-8% of the total number of all railway transport scope. In the case of determining the number of trains within an arbitrary hour during the peak period, an upper limit of 8% of the total number of trains in both directions as well as of the total number of trains in one direction was considered [9]. These proposed parameters within the individual scopes of railway infrastructure are shown in Table 3. The individual columns of the table, marked with capital letters A - D, represent in turn:

- A: interval of the recommended number of all train pairs per 24 hours,
- B: interval of the recommended number of trains in both directions per 24 hours,
- C: the maximum recommended approximate number of trains in the peak hour,
- D: the maximum recommended approximate number of trains in the peak hour on one track line.

Table 4 Other parameters of individual scopes of railway infrastructure

Scope	A	B	C	D
1	0 – 14	0 – 28	3	3
2	15 – 29	30 – 58	5	5
3	30 – 49	60 – 98	8	4
4	50 – 69	100 – 138	12	6
5	70 – 119	140 - 238	20	10
6	120 – 159	240 - 318	26	9
7	160 and more	320 and more	27 and more	7

The table 3 can be considered as a general all-purpose guide for planning railway operation at different levels of the railway infrastructure scope. However, in the case of solving the above-mentioned problem on a specific transport route or line section at a specific range of transport service, it is necessary to take into account also various objective circumstances or certain stochastic processes typical for a particular line section and also the specific concept of trains´ operation, train operation in the constrained section, during the peak hours, etc.

4 Conclusion

Railway transport must be a key element of both passenger and freight transport and, even in the context of the EU strategy, it must be a supporting transport system. To achieve the stated goals, it is necessary to fulfil several conditions. One of them is high-quality and modern railway infrastructure. This paper also dealt with the mentioned issue and its aim was to point out the current state of solving the railway infrastructure capacity, its scope and potential. In the third chapter, a new methodology is briefly proposed, which consists of determination of the railway infrastructure parameters and scope including railway operation scope. Seven specific levels of scope were proposed based on specific lines on the Slovak Railways network. The proposal and research part were solved mainly through certain expert methods, so the results may not always be completely relevant. As part of the authors' further scientific research activities, this issue will continue to be addressed, at a higher level and more comprehensively. For future research short blocks in ETCS Level 2 should be taken into account because they have a huge impact on capacity.

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