TRAIN PATHS ALLOCATION AS A PART OF RAIL INFRASTRUCTURE CAPACITY RESEARCH

doc. Ing. Jozef Gašparík, PhD.[1] – Ing. Lumír Pečený, PhD. – Ing. Veronika Gáborová
Faculty of Operation and Economics of Transport and Communications, Department of Railway Transport - University of Žilina, the Slovak Republic[1]
jozef.gasparik@fpedas.uniza.sk

Abstract: *The paper is focused to relationship between rail infrastructure manager and railway undertaking as a subject in railway market. The rail capacity research offers response to questions about possibilities how to satisfy the railway undertaking requirements. The train path allocation is continuous process that is organised by European law in liberalised railway sector. This contribution provides a new look at the issue of rail capacity, its identification and provision for railway transport undertakings. The paper introduces the selected methodologies for railway infrastructure capacity calculation shortly and its importance for non-discriminatory capacity allocation.*

Keywords: UIC METHODOLOGY, RAILWAY INFRASTRUCTURE, THEORETICAL CAPACITY, PRACTICAL CAPACITY

1. Introduction

Allowing undertakings to access to the railway infrastructure is one of the preconditions for achieving a competitive railway services market. The direction of infrastructure development refers to the two key subjects generally: the state that creates transport policy at national level and railway infrastructure manager (IM). IM operates infrastructure under the permission and also offers it to the undertakings with a valid license for transport operation. Third subject can be a union of states with interest to create a transnational transport market with non-discriminatory terms. Thus determines the basic transport policy that is superior to transport policy at national level.

The key issue for IM is capacity management. There is need to know the infrastructure capacity. The capacity expresses the infrastructure manager's business offered by the allocating of the train paths to the railway undertakings.

2. Guiding principles in determining the capacity in Slovakia compared to Croatia

The methodology including the detection procedures for capacity of infrastructure facilities was contained in prescription D 24 ČSD (Czechoslovakian railways). ŽSR (Railways of Slovak republic) as its successor took over the methodology in Regulation D24 ŽSR.

The theoretical and practical capacity

The capacity can be in principle divided into:

- theoretical (maximum),
- practical.

When calculating the maximum capacity any loss of time is not considering and it is assumed that the device capacity we determine is used exclusively for activities, for which it is intended and necessary technological blocking times follow up tightly and immediately without any loss of time.

When calculating the practical capacity we consider not only the need for maintenance of equipment or the fact that the equipment is also used for other purposes than for which it is primarily designed and used, but also time to eliminate the backup for possible defects or irregularities in traffic.

The capacity of equipment

The capacity can be determined for these railway equipments:

- track line,
- station gridiron,
- station line.

For determining capacity of track lines can be used graphically methodology, analytically methodology as well as combination of both.

Maximum capacity can be expressed by a formula:

$$N_{\max} = \frac{T}{t_{obs}}$$ [technological operations/calculation period]

where:

T calculated time (peak time or all the day) [min],

t_{obs} average time for realization of the following technological operation (train drive, shunting operation etc.) [min].

If there is calculated a practical capacity, we could take into consideration the time for maintenance as well as the reserve time for elimination of delays, in which are primary traffic operations not possible. Practical capacity is expressed by a formula:

$$n = \frac{T - (T_{výl} + T_{stál})}{t_{obs} + t_{dod} + t_{ruš}}$$ [technological operations per period]

where:

$T_{výl}$ total time, in which is the facility out of order because of maintenance, inspection or revision [min],

$T_{stál}$ total time, in which is the facility occupied by another operations, that are not primary intended for this facility [min],

t_{obs} technological time of facility occupation by one technological operation [min],

$t_{ruš}$ average time of probable mutual distortion of two operations (trains) in the places of potential threats (simultaneous drives impossible) accrued at one technical operation (train) [min].

The capacity is defined as a value of calculated trains of basic parallel train diagram (mostly represented by middle-distance freight trains or by the most frequent train category) or in an average trains (average value of time occupation – train sequence time).

To compare the analytical methods, the Faculty of Transport and Traffic Science of the University of Zagreb presented a quite similar methodology, that we can mention from this point of view. For the calculation of particular capacity is used a coefficient of elimination. There are used two different methods for capacity calculation. The first method deals with the maximum capacity in the number of trains or train pairs (the differentness), that are the most frequent on the line and these are used as a base. By using equivalents they transfer other train categories to this basic trains and the capacity is calculated such for parallel train diagram as for non-parallel train diagram. Other method determines the capacity without isolating the category of trains and takes into consideration the probability of the influence of mutual relations of certain types of trains.

For example, the capacity of the line section (both directional one track line) is presented in the following formula:

$$N = \frac{1440 - T_{pr}}{T_{pg}} \alpha_{ps} \quad \text{[train pairs / day]}$$

where:

T_{pr} time of technological downtime [min],

T_{pg} graph period (means for both directional train pair) [min],

α_{ps} coefficient of operation reliability [-].

That means, that capacity is detected for train pairs (supposition for only mutual trains) and the other circumstances that decrease the value of capacity are expressed by the coefficient in comparing with Slovak method that uses marginal amount of exact values in formula. But the whole issue is quite difficult and highly professional and slickly elaborated in detail.

3. Contemporary trends in the determination of the capacity worldwide

In the world are currently using many methodologies for detection of railway infrastructure capacity. In the Europe, the International Union of Railways (UIC) draw up regulations for capacity, which aims to unify previously used national methodologies of each European railway networks, so that the results of the assessment of the individual parts of the corridors are mutually comparable. Leaflet UIC 406 is not mandatory also allows infrastructure managers to use also the national methodology.

UIC methodology

Leaflet UIC 406 was adopted in 2004. It admits that capacity qua doesn't exist, because it depends on the exploitation of infrastructure. Basic parameters from which depends the infrastructure capacity depends are the number of trains, average speed, stability and heterogeneity of timetable. Like the D24 methodology so the UIC methodology uses in determining the track section capacity a method of inserting an additional train paths to advance designed timetable. Calculation of total capacity must be applied by compression of train paths at restrictive track section. The compression of paths is performed regardless to the downstream of the track sections in so-called representative day and in a maximum (peak) operation (minimum 120 minutes).

There is space for research continuance. At first, the compression of train paths is well to apply for and double-track line or for every track of one direction traffic. There is not exactly done how could we proceed it to the compression of a both directional train paths. On the other hand, the idea of relative capacity which depends at various aspects is one of the most important notions that we can follow as a hypothesis and based on that we can involve our ideas. That is the reason continuing research in this direction.

Simulation as a capacity exploitation planning tool

Due to different scientific theories we know several different types of railway simulations. Railway simulation models can be classified generally to:

- scope (macroscopic, microscopic),
- analytical approach (stochastic, deterministic),
- processing technique (synchronous/ parallel/ contemporary, asynchronous).

Many of the models used in practice are based on the theory of synchronous simulation, but we can deal with asynchronous simulation method as well. Some selected synchronous simulation tools are RailSys, RailPlan, VISION, OpenTrack, SIMONE, FALCO, TRANSIT, RAILSIM, SENA JŘ VT / ZONA CP VT.

After the first experience with the good-known simulation software OpenTrack we have got an unique opportunity to work with the RailSys as well as the OpenTrack at the University of Zagreb and thus evolve new ideas in this field by proceeding a simulation tests and make partial conclusions about the direction of new ideas. The research now is in progress by working in an infrastructure manager of RailSys and the first results are coming soon.

As example, the representatives of asynchronous simulation tools BABSI a STRESI are developed by German university RWTH Aachen.

3.1. Transcript of a new methodology design

While so far it´s been the trend in detection of railway infrastructure capacity to simplify and average many of inputs, such as the relating calculations to the "average" trains, respectively simplifying the elements of time, so in terms of technological progress it is not a big deal today to create a comprehensive system that would be as far as possible considering a diversity of these parameters and that would provide a space for detailed and transparent detection of capacity with identifying the bottlenecks as a problem of railway infrastructure. Such a system could make an interactive platform and could quick operational respond to an incident caused by the operation, respectively to more and new assigned paths. Another focus area is based on the fact that the infrastructure capacity analysis takes into account the integrity of the train path from the initial point to the end pint of the track section of a line and thus the capacity of railway section is detecting by searching a limiting partial section. Methodology does not taking into account the possibility ordering the requirement for train path using a part of the track section only. That is reason the path not always goes through the limiting partial section. The result is a distortion of the actual infrastructure capacity which may in some cases hinder to respond flexibly to supply the demand for transport paths and degrade the procedure to increase the competitiveness of railway transport to another modal transport.

3.2. Determination of the basic principles of capacity calculation in research

Tackling the issue of capacity of oven systems (infrastructure equipment, etc.) is a complex process in which basic rules of traffic operations must be followed while safeguarding the diversity that exists in this field in different countries. The basic premise is that practical capacity and required reliability of transport operations are consistent and as much as possible optimized.

The purpose of the new methodology proposal for capacity detection, respectively providing appropriate information, is the determination and the establishment of a procedure that can flexibly respond to immediate changes in traffic management and will be so full auxiliary tool for traffic planning that can be useful in relation to the railway infrastructure managers and railway undertakings. The basic scheme of the proposed methodology in which the undertaking enters into the process of selecting a suitable free train path is based on the following steps (Figure 2):

- *route choice* – customer (operator) in the interactive software application pre-selects train path, which may contain several lines,
- *basic state of capacity view* – the maximum capacity for the selected line and its status from preliminary timetable is shown (Figure 2),
- *track section choice* – in case of non route-long paths,
- *specifications for allocation of path* – detailed specification of the requirements for the allocation of such path, as a date and approximate time position of the path, train type (weight,

length, rolling resistance, traction, etc.), the base of which is recalculated into time elements needed for upgrade the capacity, along the number of paths (one, more or two-way path), use of station lines with a boarding platform edge or stops, the possibility (accepting) of staying on the journey (crossing over, prevention, traffic sequence), it means priority paths and so on.,

- *current and planned state view* – appears updated capacity on the selected track, which can then be confirmed by customer, respectively it will not be available and customer will be offered to change the planned route due to insufficient capacity of this option,
- *confirmation and incorporation of requirements* – after successful completion of a route selection for the request for capacity is incorporated as requirement into the system and appears as increased used capacity, respectively reduced free capacity in all the track sections of chosen route (in several lines). Output requirement then becomes the input for the infrastructure manager to be further processed in the process of allocation of railway infrastructure capacity.
-

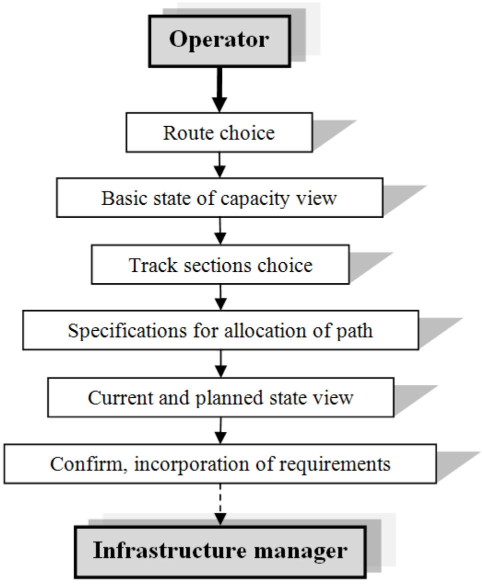

***Fig. 1** Flow diagram of selection of a suitable route for planning of shipment*

4. Next steps research

For the further steps in the research is used a graphic method, is similar to the UIC methodology. This is based on following:

- hypothesis that the capacity is relative, depending on a lot of aspects,
- obscure steps of using train path compression for one-track lines,
- each line section can be occupied by different amount of trains.

As we are trying to focus on a graphic method (geometrical relations), at first we need to solve a problem of the value, in which can we express a blocking space (or blocking stairs) of a train in the time-distance dimension. We are tending several forthcoming issues:

- to test the idea of Figure 2 in a simulation software (timetable stability),
- to propose the model of a new method for graphic detection of capacity,
- to draft an absolute addressing of blocked sections for this case,
- to make this usable for manual calculation as well as simulation outputs,
- to continue in the research by evolving next ideas.

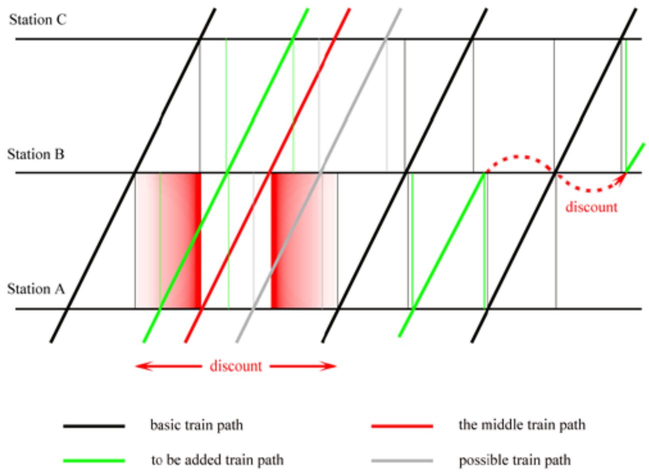

***Fig. 2** Events of discount provision in terms of train path marketing*

Figure 2 shows the basic states for supply of discount for railway undertakings based on their previous optional choice of the train path they would like to use. Basic train paths (black) are previously added in yearly timetable construction process or they are “ad hoc” paths, that are confirmed (or later paid) by railway undertakings and broke in by infrastructure manager. Red path means the theoretical middle distance path in the free space of time-distance traffic diagram. There are two basic situations that can be brightly used in marketing of infrastructure manager. If in that free space is possible to add more than one path (grey vs. green), than it is better to add the demanding path (green) as close to the basic path as possible and do not block the free space by only one inappropriate path in the middle. This can be achieved by offering discounts from the train path fees. Similar situation can relieve a timetable construction by using latitude setting for adding train paths. That means, that this paths are interrupted because of non-moving basic paths (cruising, preceding, etc.) and that is why this paths are easier inserted. Of course, this means longer and energy inefficient train drive that should be eliminated by discount again.

5. Conclusion

In the chain of transport services, especially in freight transport is increasingly coming to the fore system of "the pull" when determining and significant entity in the development of the transport market is the shipper, so the final element of the chain that determines the mode of its transport operations in the form of specified requirements for transport and by this basis is the requirement for transportation transmitted through the undertakings to the primary transport market and thus the infrastructure manager in the form of demand for railway infrastructure capacity. The common space of business is therefore railway infrastructure, which is provided to them based on their current license for operating on that infrastructure. However, to be fully maintained the principle of non-discriminatory access to the infrastructure for customers, the capacity (and its information) has to be properly identified and published by infrastructure manager, which is in its administration and for which is fully responsible. It is necessary to find a simple and transparent way to organize the resulting values into a usable format for marketing activities of infrastructure managers. This method may be used to:

- a detailed determination of railway infrastructure capacity,
- accurate allocation bottlenecks that reduce the capacity of rail infrastructure,
- continuous calculation of available capacity in the allocation of "ad hoc" paths,

- operational management and decision making at operational incidents,
- educational and research purposes.

Acknowledgement

The paper is supported by the VEGA Agency by the Project 1/0095/16 "Assessment of the quality of connections on the transport network as a tool to enhance the competitiveness of public passenger transport system", that is solved at Faculty of Operations and Economics of Transport and Communication, University of Žilina.

Literature

Pečený, L. et al. Connection evaluation in public passenger transport, internal research, Faculty PEDAS, University of Žilina, 2016

Čičak, M., Mlinarič, T. J., Abramovič, B.: Methods for determining throughput capacity of railway lines using coefficient of elimination. In: Promet – Traffic - Traffico, Vol. 16, No.2, 2004, pages 63-69, ISSN 0353-5320

D 24 - Predpisy pre zisťovanie priepustnosti železničných tratí. Nadas, Praha 1965

Gašparík, J., Halás, M., Schoebel, A.: The first experience with the tool OpenTRACK at the University of Žilina. In: Euro-Žel 2012, Proccedings of The 20th International symposium, Tribun EU 2012, Univerity of Žilina 2012, ISBN 978-80-263-0242-1

Gašparík, J.; Zitrický, V.: Manažment kapacity železničnej infraštruktúry. EDIS, Žilinská univerzita v Žiline 2010, 1.vyd., 130 s., ISBN 978-80-5540-241-3

Halás, M.; Zitrický, V.; Blaho, P.: Möglichkeiten der Effizienzsteigerung im Eisenbahnverkehr. In: Zeitschrift der OSShD, Jahrg. 56, Nr. 1-2 (2013), p. 16-20.ISSN 0208-8691

Hansen, I., Pachl, J.: Railway timetable and traffic. University of Technology Delft, Technische Universität Braunschweig 2008, 1. vyd., 228 s., ISBN 978-3-7771-0371-6

Leaflet UIC 406 - Capacity. 2nd edition, International Union of Railways (UIC). Paris 2013, ISBN 2-7461-0802-X

Šotek, K.; Bachratý, H.: Koncepce směrující k inovaci tvorby jízdního řádu v železniční dopravě. In: Infotrans 2009 : Pardubice, zborník z konferencie, Univerzita Pardubice, 2009. s. 117-125, ISBN 978-80-7395-171-9

Zitrický, V.; Šulko, P.: Capacity management of train paths in rail freight transport. In: LOGI 2014 : conference proceedings - Brno: Tribun EU, 2014 - ISBN 978-80-263-0860-7 - p. 377-384