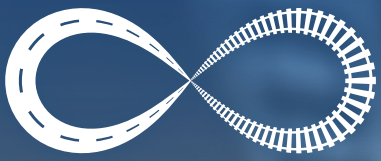

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5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR

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COMPARISON OF THE OPERATING INTERVALS ON THE RAILWAY LINE BETWEEN ŽILINA AND RAJEC AFTER THE APPLICATION OF A NEW DIRECTIVE BY THE SLOVAK RAILWAY INFRASTRUCTURE MANAGER

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Abstract

The operating intervals and the intervals of subsequent rides are among the basic (normative) elements of the train transport schedule. These intervals are designed to control train movements and ensure the smooth running of trains with regard to safety and other operating regulations. Run intervals are used for the construction of the train traffic diagram, for the control of train movements and for the design of the railway infrastructure. They are also used to calculate the permeability of railway lines according to a special regulation. The operating intervals must be determined as precisely as possible. Their correct determination, as well as their observance, is a basic prerequisite for ensuring smooth transport operation. The operating intervals are set for stations and, for their separate parts, such as personal, entrance, exit groups, etc. From 9th of December, 2017, a new rule for calculating slots has been applied to the ŽSR network. The rule gives the possibility to calculate and apply new service intervals since GVD 2019/2020. The direct application of these new operating intervals changes and adjusts work in individual stations. In the present article, new service intervals will be calculated with direct application on the Žilina – Rajec railway line. At present, some operating intervals are not taken into account in the construction of the GVD. Subsequently, stressful situations are being experienced by executive employees in everyday situations. Due to the width of the area surveyed, this paper will only mention the calculations of the operating intervals for the Bytčica railway station.

Keywords: operating interval, railway station, infrastructure modelling

1 Characteristics of operating intervals

The operating interval is the shortest time required to complete all the prescribed activities to run trains smoothly and ensure the safety of places of any possible mutual danger. It is the shortest time between arrival or departure or passing the first train and arriving or leaving or passing the second train [1]. The operating intervals are among the basic (normative) elements of the train transport schedule. They are designed to drive train movements and ensure smooth running of the train with regard to safety, operational rules and other internal documents of the Infrastructure Manager [2, 3]. The intervals are used in the construction of the train transport schedule, in the management of train runs and in the design of the railway infrastructure. The length of intervals and subsequent intervals depends on [4]:

- the type of station and track interlocking systems
- the method to control the switches,
- the layout of the station track lines,

- the spacing and layout of the individual locations that are decisive for the calculation of the service intervals and the subsequent intervals (the signalling device, the transport office, the warning point, etc.),
- the speed and length of the train
- work organization on arriving, departing and transiting trains, in particular in terms of the number and competence of the staff involved in the preparation and cancellation of the train path and the technology of their work.

1.1 Analysis of the operating intervals

Each operating interval is comprised of the time t_{ST} of station operations and the times of the dynamic component t_D. The general relationship to determining the station operating interval is as follows [5]:

$$\tau = t_{ST1} + t_{ST2} + t_{D1} + t_{D2}\,[\text{min}] \tag{1}$$

Where:

τ – the operating interval,
t_{ST1} – the station time to perform operations related to the first train,
t_{D1} – the dynamic component of the first train,
t_{ST2} – the station time to perform operations related to the second train,
t_{D2} – the dynamic component of the second train,

Indexes 1 and 2 in Eq. (1) express the relationship to the first or second train. The station timing period (t_{ST}) includes the duration of all necessary actions related to the safety of the train running in the station (e.g., tracking of the train path, handling of the equipment, walking, necessary reports, set up of the train) [4]. The time of the dynamic component (t_D) represents the train travel time required to pass the specified distance relative to the interval in question (e.g., to release the track, to arrive at an assigned place, to leave an assigned place) [4]. An important element in calculating the operating intervals is the determination of dynamic components. In the old methodology, this partial time was determined only linearly as a simple computation of the average speed on the specified path. Applying the new rule allows one to use evenly accelerated and slow motion attributes to calculate dynamic components. This methodology for calculating the dynamic drive of train components takes into account parabolic train movements (the theoretical simplified train tachograph) as well as the speed limitations of the track [6]. The following relationships can be used to calculate the partial time (t) [7]:

- for the linear movement of the train:

$$t = \frac{l}{v} \cdot 0{,}06\,[\text{min;m, km/h}^{-1}] \tag{2}$$

- for evenly accelerated (or decelerated) train movement:

$$t = \frac{v_2 - v_1}{216 \cdot a}\,[\text{min;km/h}^{-1}, \text{m/s}^{-2}] \tag{3}$$

For the calculation of the partial path (l) the following relationships can be used:

- for the linear movement of the train:

$$l = \frac{v \cdot t}{0{,}06}\,[\text{m;km/h}^{-1}, \text{min}] \tag{4}$$

• for evenly accelerated (or decelerated) train movement:

$$l = \frac{v_2 - v_1}{25{,}92 \cdot a} \left[m; km/h, m/s^2 \right] \quad (5)$$

Where:
v – train speed for linear movement,
v_1 – the beginning speed of train for relationship with evenly accelerated (decelerated) movement,
v_2 – the end speed of train for relationship with evenly accelerated (decelerated) movement,
l – travelled distance of the train,
t – travelled time of the train,
a – with "+" sign = medium acceleration, (with "–" sign = mean braking deceleration).

In the calculations, the following mean acceleration values are used, respectively. Mean braking deceleration "a":
• 0,55 m/s² for passenger trains and locomotive trains,
• 0,45 m/s² for freight trains and service trains with braking mode "P" (for speed to 120 km/h)
• 0,35 m/s² for freight trains and service trains with braking mode "G" (for speed to 80 km/h).

When calculating the dynamic components it is also necessary to count the visibility of the signalling devices. Surveillance is a distance equal to at least the path the vehicle is driving at the highest permissible speed in 7 s (0.12 min), this distance being not less than 100 m. Surveillance gives the driver enough time to be aware of the signal and to respond to it [8].

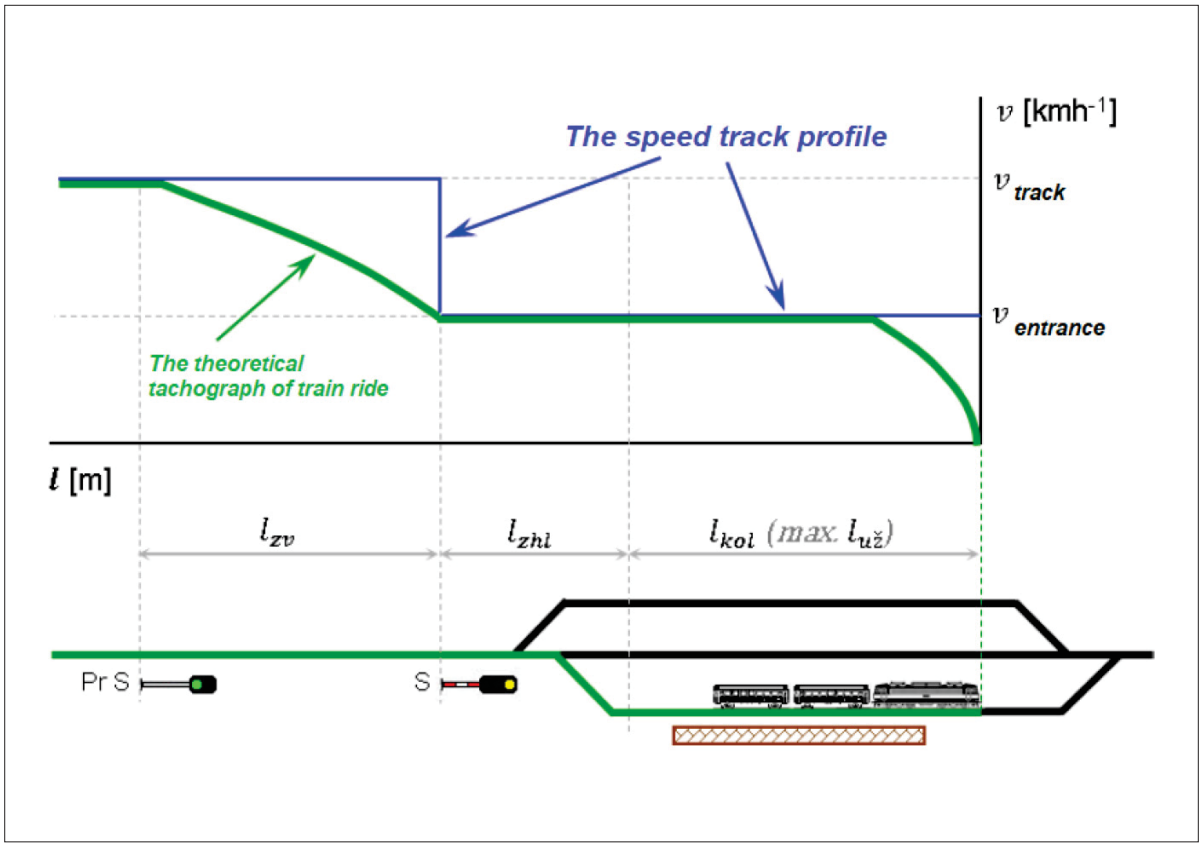

Figure 1 The course of a arriving train with a limitation of the entry speed

The operating intervals (τ) are broken down according to the decisive place for their determination to the station operating intervals and track operating intervals.

1.2 The stations operating intervals

a) The station operating intervals are divided according to [9]:
b) the interval of successive entrances – τ_{pv} – representing the shortest time between the moment of arrival (transition) of the first train and the moment of arrival (transition) of the second train at the station.
c) the interval of the successive entrance and departure – τ_{VO} – is the shortest time between the arrival of the first train and the moment when the second train passes the station.
d) the interval of successive departures – τ_{PO} – is the shortest time between the moment of the first train's departure (transition) and the moment of departure (transition) of the second train from the station.
e) the interval of successive departure and arrival –τ_{OV} – is the shortest time between the moment of the first train's departure and the moment of the second train's transition.

2 The basic characteristic of the line Žilina – Rajec and station Bytčica

The railway line Žilina – Rajec is a regional railway line 22 kilometres long with a maximum speed of 60 km/h. The stopping distance is 400 meters. On the track there are three stations, namely Bytčica, Lietavská Lúčka and Rajec. All stations are allocated by the ZST Žilina administration [10].
The railway station Bytčica lies is the first station of non-electrified single railway track Zilina – Rajec. At the station there are only two transport tracks designed for train journeys. Both station tracks have passenger platforms [11].
At the Bytčica station is an interlocking system of first category with independent signalling devices. There are manually handled switches with elementary switches locks.
Between the stations Žilina – Bytčica is a second category track interlocking system – relay approval for track freedom with track approval for the change of which only one station participates. Between the stations Bytčica – Lietavská Lúčka is a track interlocking system of the first category – telephonic communication – in both directions [11].
Simultaneous train drives are forbidden. If two trains in opposite directions approach the station, the first train will be allowed to enter, preferably from Žilina.
Schematic diagram of the Bytčica is in Figure 2 [10].

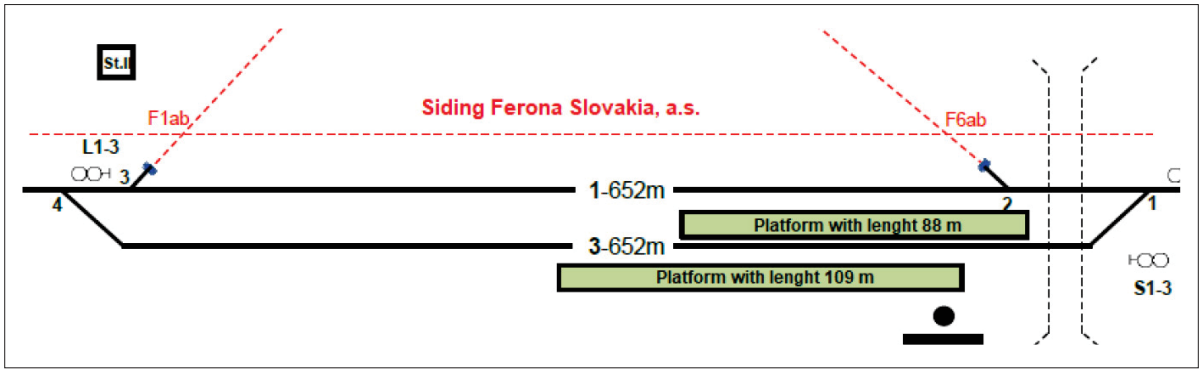

Figure 2 Schematic diagram of the railway station Bytčica

3 The stations operating intervals for station Bytčica and their comparison

For each railway station the operating interval currently in use is valid under the current Infrastructure Manager service regulations [12]. These are listed in the annexes to the station's operational instructions. When a new regulation comes into force, it will be necessary to recalculate the operating intervals and then apply it to the operation [13].

In the following section, the initial operating interval and subsequent values of the newly calculated intervals are shown with their mutual comparison. The red part of the tables indicate old operating intervals. The green part of the tables indicate new operating intervals. In the following tables 1 and 2 are the original operating intervals of successive entrances calculated with the new operating intervals. In tables 3 and 4 are the original operating intervals of successive entrances and departures calculated with the new operating intervals. Tables 5 and 6 show the original operating intervals of successive departures calculated with the new operating intervals. Tables 7 and 8 show the original operating intervals of successive departures and arrivals calculated with the new operating intervals. The shortcuts in tables mean:

- PT_A – the passenger trains arrival;
- PT_T – the passenger trains transiting;
- FT_A – the freight trains arrival;
- TF_F – the freight trains transiting.

Table 1 The operating interval of successive entrance where the firs train is coming from Žilina

	The second train is coming from Lietavska Lúčka							
The first train is coming from Žilina		PT_A	PT_T	FT_A	FT_T	PT_A	PT_T	FT_A	FT_T
	PT_A	3,5	6,5	3,5	6,5	3,0	5,5	3,0	5,5
	FT_A	3,5	6,5	3,5	6,5	3,0	5,5	3,0	5,5

Table 2 The operating interval of successive entrance where the first train is coming from Lientavska Lúčka

	The second train is coming from Žilina							
The first train is coming from Liet. Lucka		PT_A	PT_T	FT_A	FT_T	PT_A	PT_T	FT_A	FT_T
	PT_A	3,0	5,5	3,0	5,5	2,5	5,0	2,5	5,0
	FT_A	3,0	5,5	3,0	5,5	2,5	5,0	2,5	5,0

Table 3 The operating interval of successive entrance and departure where the firs train is coming from Žilina

	The second train is departing (transiting) to Žilina							
The first train is arriving (transiting) from Žilina		PT_A	FT_A	PT_T	FT_T	PT_A	FT_A	PT_T	FT_T
	PT_A	4,5	4,5	6,5	6,5	4,0	4,0	5,5	5,5
	PT_T	4,0	4,0	X	X	3,5	3,5	X	X
	FT_A	4,5	4,5	6,5	6,5	4,0	4,0	5,5	5,5
	FT_T	4,5	4,5	X	X	4,0	4,0	X	X

Table 4 The operating interval of successive entrance and departure where the firs train is coming from Lietavska Lúčka

	The second train is departing (transiting) to Lietavska Lúčka							
The first train is arriving (transiting) from Liet. Lúčka		PT_A	FT_A	PT_T	FT_T	PT_A	FT_A	PT_T	FT_T
	PT_A	3,5	5,5	5,5	5,5	3,0	5,0	5,0	5,0
	PT_T	3,0	5,0	X	X	3,0	5,0	X	X
	FT_A	3,5	5,5	5,5	5,5	3,0	5,0	5,0	5,0
	FT_T	3,5	5,5	X	X	3,0	5,0	X	X

Table 5 The operating intervals of successive departures where the firs train is coming from Žilina

	The second train is departing to Lietavska Lúčka			
The first train is departing to Žilina		PT_A	FT_A	PT_A	FT_A
	PT_A	0,5	2,0	0,5	2,0
	FT_A	0,5	2,0	0,5	2,0

Table 6 The operating intervals of successive departures where the firs train is coming from Lietavska Lúčka

	The second train is departing to Žilina			
The first train is departing to L. Lúčka		PT_A	FT_A	PT_A	FT_A
	PT_A	0,5	0,5	0,5	0,5
	FT_A	0,5	0,5	0,5	0,5

Table 7 The operating intervals of successive departure and arrivals where firs train is coming from Žilina

	The second train is arriving from Lietavska Lúčka			
The first train is departing to Žiina		PT_A	FT_A	PT_A	FT_A
	PT_A	3,5	3,5	3,0	3,0
	FT_A	4,0	4,0	4,0	4,0

Table 8 The operating intervals of successive departure and arrivals where firs train is coming from Lietavska Lúčka

	The second train is arriving from Žilina			
The first train is departing to L. Lúčka		PT_A	FT_A	PT_A	FT_A
	PT_A	3,0	3,0	3,0	3,0
	FT_A	3,5	3,5	3,5	3,5

4 Results

Railway transport is a continuous process that must be coordinated at all levels of management and determined by technological processes. In addition to the scope of train transport, it is necessary to know the timing norms, also referred to as time standards, for the construction of a quality train diagram [5, 9]. These are station and track operating intervals.
Based on the analysis and the realized calculations, the station intervals were compared after the new methodology was introduced to the Slovak Railways. The comparison was made on the Žilina – Rajec regional railway track with practical application for Bytčica station. The comparison of both methodologies proved the changes in operating intervals. The main reason for the changes were the approaches to calculating the dynamic components of the train ride. The second main reason was the calculation of the employees' walking time towards to the devices and their objectification.

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References

[1] Gašparík, J., Abramović, B., Halás M.: New graphical approach to railway infrastructure capacity analysis. In: Promet – Traffic & Transportation: scientific journal on traffic and transportation research. ISSN 0353-5320. Vol. 27, no. 4 (2015), pages 283-290.

[2] Zitricky, V., Cerna, L., Abramovic, B.: The proposal for the allocation of capacity for international railway transport In: Procedia Engineering. 12th International Scientific Conference of Young Scientists on Sustainable, Modern and Safe Transport High Tatras, Slovakia, May 31th – June 2nd. ISSN 1877-7058. Vol. 192, pages 994-999.The operations procedures in railway station Bytčica. 2013. Bratislava: ŽSR, 2013. 33 pages.

[3] Kampf, R., Stopka, O., Kubasakova, I., Zitrický, V.: Macroeconomic Evaluation of Projects Regarding the Traffic Constructions and Equipment, In: Procedia Engineering, ISSN 1877-7058, Vol. 161 (2016), pages 1538-1544.

[4] Regulation DP1: The determination of operating intervals and subsequent intervals. Bratislava: ŽSR, 2017. 170 pages

[5] Blaho, P., Gašparík, J., Šulko, P.: Modelling of rail infrastructure capacity dependencies. In: Horizons of railway transport: scientific papers. ISSN 1338-287X. Vol. 8, no. 1 (2017). pages 5-13.

[6] Čamaj, J., Mašek, J., Dolinayová, A., Daniš, J.: Possibilities to evaluation railway tracks in conditions of the Slovak railway. In: ICTTE 2016 = international conference on Traffic and transport engineering : November 24-25, 2016, Belgrade, Serbia. Belgrade: City Net Scientific Research Center, 2016. ISBN 978-86-916153-3-8. pages 955-963.

[7] Danis, J., Dolinayova, A., Camaj, J.: Prognosis of rail transport demand in the Slovak Republic. In: ESM 2016:The 2016 international conference on Engineering science and management : proceedings : August 13-14, 2016 Zhengzhou, Henan, China. – Paris: Atlantis Press, 2016. ISBN 978-94-6252-218-3. pages 187-190.

[8] Abramovič, B., Zitrický, V., Biškup, V.: Organisation of railway freight transport: case study CIM/SMGS between Slovakia and Ukraine. In: European Transport Research Review. ISSN 1867-0717. Volume 8. Issue 4 (2016). Article 27.

[9] Gašparík, J., Zitrický, V.: A new approach to estimating the occupation time of the railway infrastructure, In: Transport, Journal of Vilnius Gediminas Technical University and Lithuanian Academy of Sciences. ISSN 1648-4142. Vol. 25, No. 4 (2010), pages 387-393.

[10] The operations procedures in railway station Bytčica. Žilina: ZSR, 2013. 22 pages.

[11] The tables of track ratios from Žilina to Rajec.2005. Bratislava: ŽSR, 2005. 24 pages.

[12] Blaho, P., Javorka, R.: Operational Management – The Effective Management Tool for the Railway companies. In: Railway transport and logistic: the scientific and technical on-line journal. ISSN 1336-7943. Vol. 5, No. 2 (2009), pages 7-14.

[13] Šulko, P., Blaho, P.: Implementation of operational requirements for train paths beyond the current rail transport diagram. In: Railway transport and logistic: the scientific and technical on-line journal. ISSN 1336-7943. Vol. 9, No. 2 (2013). pages 31-35.