

METHODOLOGY FOR CAPACITY CALCULATION IN RAILWAY STATIONS USED IN IS KANGO

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Summary: This paper deals with design of methodology for railway station capacity assessment that is in an experimental stage within the information system KANGO. This methodology is slightly different from procedure that is defined in obsolete regulation D24. These days the new methodology is in test stage. The reason for changes in methodology consist of finished reworks in module that is responsible for technological times – this module is basis for occupancy time calculation for running tracks and gridiron.

Key words: capacity calculation, railway station, gridiron, running track, occupation period, change-over between station track and line track

INTRODUCTION

Performance and quality of railway transport is undoubtedly dependent on the capacity of the rail network or let's say on the capacity of individual segments that railway network consists of. Therefore we are mainly focused on the capacity of line tracks and the capacity of railway stations.

Methodology for the calculation is defined in regulation CD D24 that is valid since 1966. This regulation is still valid (but nowadays it is considered as an obsolete) and defines the procedure for the capacity calculation of line tracks as well as of a railway stations. On the basis of efforts to update the above mentioned regulation SZDC, staff proposed a new methodology to calculate crossing or overtaking section with an intermediate junction [5, 6] that seems to be, after generalization, suitable for calculating capacity of any crossing or overtaking section. A similar effort is also to amend the methodology to calculate capacity of railway station. One of the main objectives is the possibility of using an existing information system KANGO, use its database and minimize manual entry of input values.

Current graphical-analytical methodology to calculate the capacity of railway station is mainly based on a few basic facts:

- Correct definition of individual elements at the gridiron and correct definition of track groups. Elements definition depends on the topological scheme of the station, its technological equipment and another administrative constraints. Basically, it is about finding such groups of switches that you can use in parallel to build such train routes that don't interfere mutually. It is yet to find the maximum possible number of these elements.

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- Definition of track groups. Individual groups are formed by set of tracks that (depending on the topology and technology stations) cannot be used simultaneously for building more than one route. There is also the limit that the number of track groups must be greater than or equal to the number of elements.
- Definition of train flow that is created on the basis of typical train paths which are possible at the station. This is based on the current conflict-free train traffic diagram (TTD). The train flow is characterized by the direction of travel, by the outward line track or by outward non-line track direction, by the used track group, using certain gridiron elements, by the number of trains and the average usage time of the gridiron elements and station tracks.

1 MODIFICATION OF METHODOLOGY FOR USE IN IS KANGO

IS KANGO (originally SENA-JR-VT) was in its beginning primarily intended for the timetable construction and the production of another supporting tools for TTD. During the development of this tool it was rebuilt to large system that allows to work with created train traffic diagram on very detailed level. One of the system upgrades is also a module that calculates capacity of line tracks. In this module there is implemented modified capacity calculation for line tracks.

The next logical step was to add a new module to calculate the station capacity. Analysis of the existing methodology and its application in IS KANGO pointed to the lack of information in the data that are available in the information system. Generic database of the information system is very extensive (including detailed topology of railway stations), but it does not contain information about the switches groups whereas this is required by the existing methodology. Definition of track groups is also not available and it is required in the capacity calculation for railway stations.

Since the algorithm for automatic determination of elements and track groups from existing data is not a trivial problem, and in order to avoid difficult expansion and creation of new data structures (and their editing), it was necessary to modify the existing methodology for capacity calculation. The innovative methodology to calculate railway station capacity was already designed by Ing. Otakar Fiala, the worker SZDC. The above-mentioned methodology is using existing data structures available IS KANGO as much as possible.

To calculate capacity of gridiron there was replaced the previously used term element (in some way defined to be a group of switches) directly to individual switches. Track groups (also defined and created using certain rules) have been replaced by individual tracks. Outward direction is characterized as before - either by mouthed line track or outward non-line track outward direction (2).

Train route that was formerly defined using outward direction, using track group and using set of occupied elements, is newly redefined by so called transition.

Transition is a data structure that is used to define existing topological connection between two tracks using oriented sequence of switches. This way are defined tracks sections

between mouthed line track and station track (so called crossing line track - station, TSP) or between two station tracks (so called crossing station track - station track, SSP).

Train route is thus newly defined using TSP or SSP which directly determines the outward direction, station track or sequence of used switches.

The main change in the methodology is therefore a new way of defining bindings "external direction – crossing – track" and interrelationships of train routes that use them (2).

When using current approach for calculations of routes interference there are only considered interferences that occupy a crucial element when driving off the element. It is not considered likely to have interferences between routes that directly occupy this element. Under the new proposal it is being under consideration to calculate total probable mutual interference of all routes on the gridiron. Total interference is then divided for the need of further calculation according to index number.

The above described method of calculating the likelihood of interference on the gridiron can be also used in calculations running tracks. Current method for calculating interference (trains running direction 1 and 2) is then replaced with the sum of interferences generated at all gridirons and with the sum of interferences on individual tracks. There are also interferences between trains running the same direction whereas it is based on sojourn time on that particular track (2).

Another significant change to the new methodology is that average occupancy values for each train flows are not used anymore. Due to the connection of methodology on a specific timetable in KANGO system and its complete database, it is allowed to use specific data on each train route (time information on individual journeys in TTD). Consequently, the driving time and the sojourn stays are determined for each train exactly according to the designed routes. Also occupancy times that are determined using partial values for range departure-arrival-enter (or transit-transit, transit-arrival or departure-transit) are always calculated for a particular pair of trains. These technological calculations are performed with module for calculating intervals that is currently under significant upgrade on the base of innovative regulation SZDC 104.

2 CAPACITY CALCULATION OF STATION TRACKS

This calculation is in principle the same as is mentioned in regulation D24. Trains included in the calculation are divided according to the station track, line track, direction and driving characteristics. Let's denote trains as $V_{s,i}$, where index i represents the ordinal number of the train $i = 1..N$, index s reflects direction of the train with values $s = 1$ for trains going to odd direction and $s = 2$ for trains going to even direction. Number of station tracks is denoted as m_{skut} . For each train there is determined time of station track occupation $t_{obs_{s,i}}^k$ using the standard equation (1).

$$t_{obs_{s,i}}^k = t_{vj_i}^k + t_{pob_i}^k + t_{odj_i}^k \quad (1)$$

- $t_{obs_{s,i}}^k$ – occupation time of track k with train i that is going to direction s
- $t_{vj_i}^k$ – occupation time of track k with arrival of train i (occupation of entry gridiron)
- $t_{odj_i}^k$ – occupation time of track k with departure of train i (occupation of departure gridiron)
- $t_{pob_i}^k$ – occupation time of train i of track k

For occupation time for the train on station track is used the real value that is entered in TTD. For starting and terminating trains it is possible to increase this time (individually for each train) about the value that is needed for train apposition or train stabling.

Occupation of entry and departure gridiron is calculated on the basis of elementary technological times based on proper headway for a particular pair of trains.

At the current stage (the methodology is still in development) there is still question how to determine pairs of trains for the calculation of the technological times. One of the variants that might be used to calculate occupancy expects that it will be calculated for every train in isolation, i.e. regardless of the actual order of trains, or on the basis of real train order at the station or at the track. Another unresolved question remains in the processing of station tracks that are separated by a middle gridiron.

Then summarization of the occupancy times and the number of trains for each direction on each track is made as well as summarization of totals for each track, summarization for the whole station in each directions and overall for the entire station.

$$N_1^k, N_2^k \dots \text{number of trains for each direction individually on track } k \quad (2)$$

$$N_1, N_2 \dots \text{number of trains for each direction for entire station} \quad (3)$$

$$T_{obs}^k, T_{obs_1}^k, T_{obs_2}^k \dots \text{total occupancy times for track } k \text{ and for each direction} \quad (4)$$

$$T_{obs}, T_{obs_1}, T_{obs_2} \dots \text{total occupancy times for entire station and for each direction} \quad (5)$$

Furthermore the procedure for calculation is the same as with the methodology D24. There is calculated average occupancy time for each direction t_{obs_1} and t_{obs_2} , average occupancy time t_{obs} for entire railway station, then it is set reduced number of tracks m and after that it is calculated the total interference T_{rus} and average mutual interference $trus$.

At the conclusion standard calculations are performed for indicators: practical capacity n , practical capacity usage K , level of occupancy S_o , backup on a regular train and so on. It is not needed for above listed indicators.

3 CAPACITY CALCULATION FOR GRIDIRON AT RAILWAY STATION

This calculation is fundamentally different from a standard methodology that is specified in regulation D24 (see Chapter 1). The calculation is done on the basis of the occupancy times for each of the transitions and then it is converted to the occupancy of individual

switches. Calculation for the entire gridiron is based on the switch with highest occupancy time (2, 3).

When using current approach for calculations of routes interference there are only considered interferences that occupy a crucial element when driving off the element. It is not considered likely to have interferences between routes that directly occupy this element. Under the new proposal it is being under consideration to calculate total probable mutual interference of all routes on the gridiron. Total interference then divided for the need of further calculation according to index number (3).

Trains, that use gridiron that the capacity is calculated for, are divided according to individual directions and also according to individual transitions. Another actions are divided this way as well whereas these actions might be entered using input form.

On the basis of the interval module there is calculated occupancy time of individual transactions that are used with respective trains. Here again the question arises – how to create a pairs of trains for which the technological times calculation is carried out.

Gridiron occupancy with a train can be determined as the sum of preparing train route across the gridiron, train time over the gridiron and cancelation of train route. Specific details about the determination of these occupancy sub-periods of are beyond the scope of this text. All required values are obtained on the basis of technological calculations for partial times within given headway.

Then we summarize individual transitions. For every single transition p there is determined number of all actions $N_{\dot{u}}^p$ (or number of trains), total occupancy time T_{obs}^p and average occupancy time t_{obs}^p . Then we summarize all actions $N_{\dot{u}}$ or all trains N .

$$t_{obs}^p = \frac{T_{obs}^p}{N^p} \dots \text{average occupancy time for transition } p \quad (6)$$

These data about traffic at individual transitions represent "Routes overview at the gridiron" from regulation D24. This table is then modified so that the transitions are replaced by switches and then summarization of the individual switches is done. On the same principle as in the existing methodology (regulation D24) there is determined for each switch proportional number β^v based on the number of operations at the switch and on the base of the total number of actions. The average occupancy time t_{obs}^v and the ratio number β^v for each switch v determines the proportional occupation time τ^v .

$$\beta^v = \frac{N_{\dot{u}}^v}{N_{\dot{u}}} \dots \text{proportional number for switch } v \quad (7)$$

$$\tau^v = \frac{\beta^v}{t_{obs}^v} \dots \text{proportional occupation time for switch } v \quad (8)$$

Based on switch with a maximum occupancy time there is another calculation for the gridiron as a whole. The calculation should consider interference for individual traffic flows. Traffic flows interference occur mostly on the gridiron. On the tracks there is only interference of traffic flows that converge on one track (2). For each pair of traffic flow where an interference occurs we calculate the time of interference using following formulas:

$$T_{rus}^{j,k} = \frac{N^j N^k [(t^j)^2 + (t^k)^2]}{2T} \dots \text{mutual traffic flows interference } j \text{ a } k \quad (9)$$

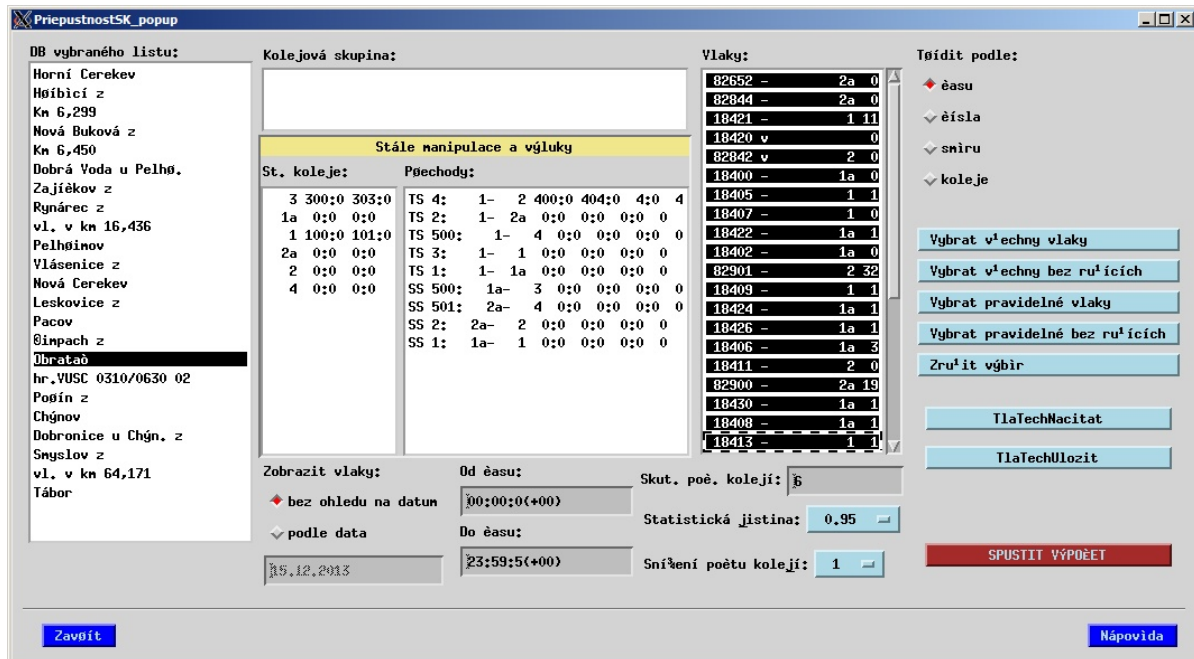
- N^j, N^k ... number of traffic flows actions j a k
- t^j, t^k ... average occupancy time for one action within traffic flow j a k

We summarize values for the gridiron, track and the whole yard and then we calculate the average value per one train (or action). To calculate capacity parameters the procedure is the same as in the existing methodology in regulation D24.

4 REALIZATION OF CALCULATIONS WITHIN IS KANGO

Calculation of the station's capacity is always realized for the selected railway station on the basis of constructed TTD. The basic premise is TTD without any conflicts. The calculation can be influenced by setting a few parameters.

The basic parameter is choice of group tracks. Track group contains a list of tracks for which the calculation is performed. If there is no track group for the station available, or no group is selected on the form, the calculation is performed for all station tracks.



Source: Author

Fig. 1: Entering parameters for calculation

For all individual station tracks and transitions it is possible to specify a manipulation, exclusions or shunting manipulations. These data are not included in the database but it is possible to save them locally and use them later for another calculations.

Other important parameters are: time interval for calculation, the parameter "real number of tracks", parameter "statistical principal" and the parameter "track number reduction".

On the base of entered time interval it is possible to select specific trains. The calculation includes only the required (or selected) trains. It is possible to select all trains, regular trains or ignore interference trains.

The calculation that is realized with respect to described methodology is divided into calculation capacity for station tracks and gridiron capacity. The resulting report contains in addition to the resulting capacity also huge number of partial values - mainly particular occupancy times for individual trains (actions) that divided to directions, tracks, transitions and switches. For future there is a plan to allow export to CSV format to be able to do further statistical processing or any other calculations.

CONCLUSION

The methodology for railway station capacity calculation has been created with regard to the existing data base that is available within information system IS KANGO. Given that during the development of the IS there were significant changes in the module that calculates the technological times there are also performed some adjustments in this methodology (these days). Some problems and issues that have been outlined in previous chapters remain unresolved. Currently the computational module and the methodology itself are tested on detail level.

REFERENCES

- (1) *Směrnice D24 pro zjišťování propustnosti železničních tratí*. Praha, 1966.
- (2) *Zadání propustnosti stanice. Interní materiál SŽDC*. 2000.
- (3) *Pracovní návrh aktualizace D24. Interní materiál SŽDC*. 2003
- (4) VESELÝ, Petr. *Modul výpočtu propustnosti IS SENA-JŘ-VT*. In Sborník příspěvků z mezinárodní konference - Informační technologie v dopravě a logistice INFOTRANS 2005. Pardubice: 2005. s. 313-319. ISBN 80-7194-792-X.
- (5) KRÝŽE, Pavel, AMCHA, René, VESELÝ, Petr. *Nová metodika výpočtu propustnosti mezistaničního úseku s odbočkou*. Perner's Contacts, 2008, roč. 3, č. 5, s. 183–189. ISSN 1801-674X.
- (6) VESELÝ, Petr, KRÝŽE, Pavel. *Development of methodology for capacity calculation in the sections with an intermediate junction*. Perner's Contacts, 2011, roč. 6, č. 5, s. 300–307. ISSN 1801-674X.