



EVALUATION OF TRAIN TIMETABLE USING INDICATORS

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Abstract

The article describes one of the evaluation tools of an application used for ordering train paths by railway undertakings in the Czech Republic. The tool allows calculating many indicators for the needs of freight and passenger transport. The calculation can be performed for selected lines, areas, tractions and periods. The areas can be standard (the Czech Republic and its regions) as well as user-defined (an arbitrary set of transport points and sections). After the calculation is done, selected paths of trains can be excluded or additionally included, which results in an immediate recalculation of the results.

Keywords

timetable, train, transport indicator, information system

1 INTRODUCTION

The annual train timetable in the Czech Republic is designed using the KANGO and KASO information system [1]. One of its components is the KANGO-Vlak and KASO-Vlak application [2] (hereinafter KANGO-Vlak), which primarily serves to acquire train paths required by a railway undertaking from an infrastructure manager.

The KANGO-Vlak program also provides several analytical tools. One of them is a module to calculate transport indicators, which is the content of this article.

2 SELECTING AND FILTERING TRAINS

Indicators are calculated for selected trains. Selection of trains can be done manually in the list of trains or automatically according to specified criteria. The tool to select trains offers a large number of criteria covering most of the train data, such as the interval of train numbers, a calendar, an engine of the train, and others. The user may specify any combination of the offered criteria. A train is chosen if it meets all the entered criteria. The tool also offers an option to maintain the current selection of trains. This allows adding more trains matching the criteria to the current set of selected trains (selected manually or using the tool to select trains).

In addition to the tool to select trains, the application provides a tool to filter trains, which offers the same criteria as in selecting trains. After they are entered in the list of trains, only such trains are displayed that meet all specified criteria. It is an active filter that is automatically performed with any change received from the application server. The filtered list can be created from selected trains.

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3 USER AREAS

Calculation of the indicators can be done not only for the standard areas (the Czech Republic and its regions), but also for the user areas. User area is an arbitrary set of transport points and sections. An area may contain a name and comment.

To prevent anyone from modifying or deleting a given area, the user may lock it. In this case, it can be modified or deleted only by the user who locked it or the administrator. Other users may view it and use it.

Transport points of the user area can be of the following types:

- Normal – common points of the area.
- Facultative – a train that runs within the area through the facultative points, facultative stopping points, and facultative sections:
 - and goes on through points or segments not belonging to the area is not included in the area,
 - and does not run through other points and segments not belonging to the area is included in the area.
- Normal stopping – if a train runs through normal stopping points, it has to stop in all these points in order to be included in the area.
- Facultative stopping – if a train goes through the facultative stopping points, it has to stop in all these points in order to be included in the area. Furthermore, if the train goes only through the facultative points, facultative stopping points and facultative sections:
 - then goes on through points or segments not belonging to the area, it is not included in the area,
 - does not go through other points and segments not belonging to the area, it is included in the area.

A train stopping point means the starting and destination point and also a track point where the train stops.

User area transport sections can be of the following types:

- Normal – common sections of the area.
- Facultative – see facultative points.
- Prohibited – a train that goes through some of the prohibited sections is not included in the area.

Facultative points, facultative sections and prohibited sections are used mainly in defining tracks of a book timetable, where there are points and segments that are part of several tracks.

Fig. 1 shows two fictitious lines: A – E and A – G. Track A – E represents a user-defined area. It contains the points A and B and the section between them, which are part of both lines. In order to avoid including the trains running along A – E track were not included in the A – G track, the points A, B and the section between them are marked as facultative. Endpoints of the track A – E must be marked as facultative because they are also part of other tracks. If there was a train that would only go from point A to point B or vice versa, it would be included in the track A – E.

Stopping points have been introduced to define the book timetable lines, which form a subset of a longer line and do not include trains that pass through certain points of this line.

Transport points and sections can be added/removed to/from the area in the dialog box, in a tabular or graphical form in the window of the railway network.

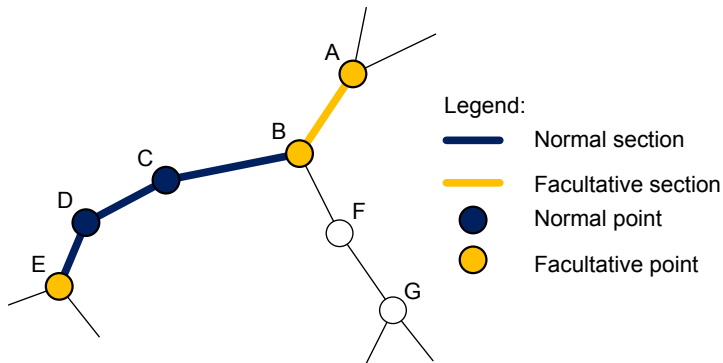


Fig. 1 User area of fictitious line A – E

An uninhibited section can be included in the area only partly. The portion of the inclusion of a section in the area can be defined by a coefficient, e.g. 0.25 of the length of the section. This functionality is used in calculating transport indicators for a track section, whose borderline can be within of the transport section.

4 CALCULATING INDICATORS

Indicators are calculated for selected areas, tractions and the specified period within the validity of the annual timetable. The selected indicators are calculated for each combination of the selected areas and tractions separately.

The areas include the following:

- the Czech Republic,
- regions of the Czech Republic,
- user areas.

The traction is determined by the decisive engine in the given section of the path of the train. On the train, engines are entered with a section, validity calendar and functions on the train (train, pusher etc.). The decisive engine is the engine with the train function.

The calculation can be done for the following tractions:

- electric locomotives,
- electric units,
- electric – electric locomotives and multiple units,
- diesel locomotives,
- railcars,
- motorized – diesel locomotives and railcars,
- all – regardless of traction.

For a given area and traction, only such sections are taken into account (further on referred to as the compliant sections) that meet all the following conditions:

- the section belongs to the relevant area,
- in the section, the decisive engine of the relevant traction is indicated on the train,
- the train runs in the section in the specified period,
- in the section, some of the selected transport types of trains is indicated on the train (such as passenger, InterCity),
- in the section, a selected general note is indicated on the train,
- in the section, the selected party to have ordered the train (Ministry of Transport, the regional authority or municipality) is indicated on the train,

- in the section, the selected integrated transport system is indicated on the train.

General notes are notes that appear in the timetable for passengers, for example, "seat reservation can be bought for marked passenger cars".

Transport types, general notes, ordering parties and integrated transport systems are entered on the train similarly to engines, i.e. with a section and validity calendar.

These conditions must be met also in terms of calendars. For a given traction and train path section, A set of days is calculated resulting from intersection of these sets:

- a set of all days in the specified period,
- union of sets of calendar days of the decisive engines of the given traction,
- union of sets of calendar days of selected transport types of trains,
- a set of calendar days of selected general notes,
- a set of calendar days of the party to have ordered the train,
- a set of calendar days of selected integrated transport system.

If set A is empty, the given section of the train is excluded from the calculation for the given area and traction.

Some indicators are calculated with data of the parameters of the train. The parameters of the train include weight, length, number of cars, rolling resistance, maximum speed, etc. On the train, they are entered with the section and the validity calendar.

The following examples of calendars make use of the numbers 1 to 7 representing the day of the week Monday to Sunday in the given period. The term the number of days the train runs, which is also used, means the number of days of the set A in the given compliant section.

The module offers calculation of the following indicators.

Total number of trains – the number of trains running at least in one compliant section multiplied by the number of days the trains run. For example, the train runs in the first compliant section on 1–4 and in the second compliant section on 4–6. The value of days 1–6 is added to the indicator for this train.

Daily number of trains – the number of trains running at least sometime in one compliant section. If the train runs at least sometime in one compliant segment, the value 1 is added to the indicator for this train.

Reduced number of trains – the number of trains calculated as a quotient of the indicator "total number of trains" and the number of days of the specified period.

Total train kilometres – the sum of multiples of lengths of compliant sections and the number of days the trains run. For example, a train in the first compliant section 10 km long runs in 1–4 and in the second compliant section 20 km long it runs in 4–6. The value

$$10a + 20b \quad (1)$$

is added to the indicator for this train where *a* is the number of days 1–4 and *b* is the number of days 4–6.

Daily train km – the sum of the lengths of the compliant sections of the trains.

Reduced train kilometres – the quotient of the indicator "total train kilometres" and the number of days of the specified period.

Total gross ton kilometres – the sum of the multiples of the weights of the parameters of the trains, the lengths of the compliant sections and the number of days the trains run. If there are multiple variants of parameters of trains in a section on the train, the weight of the train is calculated by the weighted average with regard to the number of days of the validity of individual variants of the parameters of the trains.

Daily gross ton kilometres – the sum of the multiples of the weights of the parameters of the trains and the lengths of the compliant sections. If there are multiple variants of the parameters of the trains in a section on the train, the weight of the train is calculated by the weighted average with regard to the number of days of the individual variants of the parameters of the trains run.

Reduced gross ton kilometres – the quotient of the indicator "total gross ton kilometres" and the number of days of the specified period.

Average weight of the train – the quotient of the indicator "total gross ton kilometres" and "total train kilometres".

Total, daily and reduced vehicle kilometres – are calculated the same way as the gross ton kilometres, except that instead of the weight of the parameters of the trains is used the number of cars.

Total, daily and reduced axle kilometres – are calculated the same way as the gross ton kilometres, except that instead of the weight of the parameters of the trains is used the number of axles.

Travel speed – the quotient of daily train km and total travel time of individual trains in compliant sections including the actual travel time and the duration of stay at intermediate transport points of the path of the train.

Sectional speed – the quotient of daily train km and total travel time of individual trains in compliant sections including the actual travel time and the duration of stay at intermediate points of the path of the train where a departure or intermediate technical inspection is not performed and neither is customs clearance and passport control.

Technical speed – the quotient of daily train km and the sum of journey time of individual trains in compliant sections not including the stay in the intermediate transport points of the path of the train.

During the calculation of indicators, completion and accuracy is checked of the information needed for the selected indicators. The calculation will take place even if errors have been found in some sections or points of train paths. These sections and points are not, however, included in the calculation. The errors detected are recorded in a protocol file.

The result is a window containing a list of indicators calculated for the selected area and tractions and, if need be, a list of trains, from which the indicators for each area and traction have been calculated. Fig. 2 shows an example of such a window containing the indicator of the reduced and total number of trains (CVI and RVI columns), total and reduced train km (CVIkm and RVIkm columns) in two regions and on one track of the book timetable for passengers for the entire 2017/2018 season of the timetable. The bottom of the window contains a list of trains for the selected line at the top of the window. For each train is given its starting point and destination, path section, which belong to the area and traction and partial values of the calculated indicators (PDJ column represents the number of the days the train runs). The train or the section of its path can be excluded from the calculation, which will automatically recalculate the total values of the indicators. The excluded trains are shown in the Figure with a crossed grey lettering.

The list of indicators, including the list of trains, can be saved to a text file and subsequently loaded into a spreadsheet or word processor for further processing.

KANGO-Vlak - [spravce : : gvd18_szdc : Ukazatele]

Soubor Zobrazit Seznam Nástroje Data Okno Náhověda

Oblast*	Trakce	CV	RV	CVkm	RVkm
280	elektrická	29 591	81,3	1 483 652,2	4 076,0
280	motorová	11 596	31,9	228 554,6	627,9
280	všechny	41 117	113,0	1 712 206,8	4 703,9
Pardubický	elektrická	170 525	468,5	12 716 93	34 936,6
Pardubický	motorová	158 742	436,1	3 721 394,4	10 223,6
Pardubický	všechny	328 369	902,1	16 423 86	45 120,5

Vlak*	Výchozí bod	Cílový bod	Z	Do	PDJ	km	CVkm	RVkm	Zákaz
54-5032/2	Česká Třebová	Pardubice hl.n.	Česká Třebová	Pardubice hl.n.	57	59,8	3 408,6	9,4	
54-5033/3	Pardubice hl.n.	Česká Třebová	Pardubice hl.n.	Česká Třebová	60	59,8	3 588,0	9,9	
54-5034/4	Králíky	Pardubice hl.n.	Králíky	Ústí nad Orlicí	304	42,4	12 889,6	35,4	*
54-5034/4	Králíky	Pardubice hl.n.	Ústí nad Orlicí	Pardubice hl.n.	54	49,1	2 651,4	7,3	*
54-5040/0	Česká Třebová	Choceň	Česká Třebová	Choceň	53	25,1	1 330,3	3,7	
54-5041/1	Choceň	Česká Třebová	Choceň	Česká Třebová	247	25,1	6 199,7	17,0	
54-5042/2	Česká Třebová	Choceň	Česká Třebová	Choceň	307	25,1	7 705,7	21,2	
54-5043/3	Pardubice hl.n.	Česká Třebová	Pardubice hl.n.	Choceň	54	34,7	1 873,8	5,1	
54-5043/3	Pardubice hl.n.	Česká Třebová	Choceň	Česká Třebová	250	25,1	6 275,0	17,2	
54-5044/4	Česká Třebová	Choceň	Česká Třebová	Choceň	58	25,1	1 455,8	4,0	

1 z 1403

Fig. 2 Window of the calculated indicators

5 CONCLUSION

The application KANGO-Vlak along with other applications of the KANGO and KASO systems were deployed in routine operation at the end of 2010. Their introduction resulted in improving and accelerating the work on the design of the annual timetable.

The module of calculation of the indicators provides a basic set of indicators for planning and evaluating a designed timetable. The calculation can be influenced by set of the parameters.

Indicators are calculated for selected trains and or geographical areas. Selection of trains is possible effectuate manually in the trains list or automatically according to pre-set criterions. The area can be predefined (Czech Republic and its regions) or defined by user. User area represents arbitrary set of transport points and sections of required type (e.g. stopping point, prohibited section). Type of transport point and section determines including/excluding of the train path in the appropriate area.



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