

SWITCH AREA CAPACITY ASSESSMENT USING UIC 406 – THE PROCEDURE AND SOFTWARE TOOL

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Summary: This article deals about modified way of switch area capacity assessment in a railway station and about the software tool that realize the calculation. The procedure of calculation originates from the leaflet UIC 406. Original methodology that is described in the leaflet is based on the knowledge of a switch area (only some parts of it) exclusion times because of occupancy by individual trains. In some cases it might be problem to get input data in needed format. There are some simulation tools that provide occupancy times it different format and to convert the data to a needed format is not easy to do. Due to this reason there was designed alternative way how to assess capacity of switch area that use data from simulation tools. To assess the capacity there was developed software tool that follow rules from the leaflet UIC 406 so the results that it provides are equal to original methodology.

Key words: leaflet UIC 406, capacity, railway station, switch area, railway switch, occupancy times

1 INTRODUCTION TO CAPACITY ASSESSMENT ACCORDING TO LEAFLET UIC 406

For a railway station we can assess capacity of an individual switch area and also individual station tracks. The capacity is assessed for each switch area and also for each track individually. Basic index is occupancy time rate (OTR) that provide ratio metric usage of a certain part of the railway station.

Utilization rate is calculated as a proportion of occupancy time and defined time period.

$$OTR [\%] = \frac{\text{Occupancy Time}}{\text{Defined Time Period}} \cdot 100 \quad (1)$$

Other values that are assessed is number of concatenations K and concatenation rate φ .

$$\varphi [\%] = \frac{\text{Number of Concatenations}}{\text{Total Number of Trips}} \cdot 100 \quad (2)$$

Occupancy time for switch area is calculated as one value whereas individual times of occupancy are included as well as times between occupancies that might be used also for oth-

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er task at switch area. Occupancy time for switch area is calculated as minimum time at which it is possible to realize all tasks according to given timetable.

To calculate capacity properly it is needed to have template for timetable that does not include any conflicts. Timetable includes individual tasks and also order of the tasks. Basic principle is to change time stamps for individual tasks so that they follow each other in the shortest possible time. The first task is consider with its original time stamp and all other task's time stamps are changed so that they immediately follow previous task when taking into account correct technological times. It is needed to consider that individual tasks occupy infrastructure elements (tracks, switches) at switch area. Every switch can be serve only one task at a time. Element can be occupied by another task only when the element is released.

When the time stamps of tasks are changed we call it compression – it means reduction of total time that is needed to serve all tasks.

During compression it is needed to follow these rules:

- All planned tasks must be served.
- During compression the task is moved (it's time stamp) as a whole part on time axis.
- Original order of tasks that use the same elements must be kept.
- Technological times must be kept – occupancy of element by next task can start when it was already released.
- Two tasks (that do not use any common element and their parallel execution is not excluded due to any other reason) can be executed in parallel or can be executed in opposite sequence.

2 ORIGINAL METHODOLOGY

UIC 406 establishes exemplary methodology to calculate occupancy time of switch area. It is based on the fact that each individual task represent movement of so called typical trains. There is only limited amount of these typical trains and there is also information about critical element – the element that determines minimal duration (interval) when the second of the two trains can start its trip across switch area after the first train.

In practice it means that it is needed to create for every single typical train set of time intervals that represent times when other trains are eliminated from their trip. When determining the intervals it is needed to take into account occupancy times of elements at switch area by every single train and also take into account topology of the switch area.

On top of all these data matrix of minimum intervals between couples of trains is created.

To calculate occupancy times it is needed to start with first planned task (train movement) and then for each other task (train) it is determined its earliest possible time to start.

During realization of the methodology there has been found some negatives. There is problem to get input data and then to transfer them into matrix of minimal intervals between

trains. This task means huge amount of manual calculations and it is not easy to automate them. Next problem consists in working with real timetable where there is nothing like typical train. So it might be quite hard to create a few typical trains on top of real trains and then use these typical trains in calculation. In extreme situation every single real train can be considered as typical train – in such a situation it can lead to a matrix where number of rows and number of columns correspond to number of trains in real timetable. And the last problem is the compression itself. Even using spreadsheet it might be time consuming process. When the aim is to minimize manual work it leads to programming of complicated macros.

3 ALTERNATIVE PROCEDURE OF CALCULATION

When designing alternative procedure of calculation it was needed to take into account principles of leaflet UIC 406. The aim was to remove disadvantages of original procedure (see chapter 2). The methodology was adjusted to be able to work with data that are available as output from some simulation tools, e.g. Villon. Villon (on top of deterministic simulation experiments) provides output statistics that contain information about trains running times, occupancy times for every single element etc.

Alternative compression method (assessment of minimum occupancy time) include list of occupancy for every single element of switch area. Starting time for compression is based on time when the first train (task) occupy concrete path across given switch area. Then other trains are subsequently added to compressed plan from original timetable. For every train there is evaluated earliest possible time when basement for this is:

- list of elements that are occupied by the train movement
- occupancy times of the same elements by previous trains that are already in compressed plan

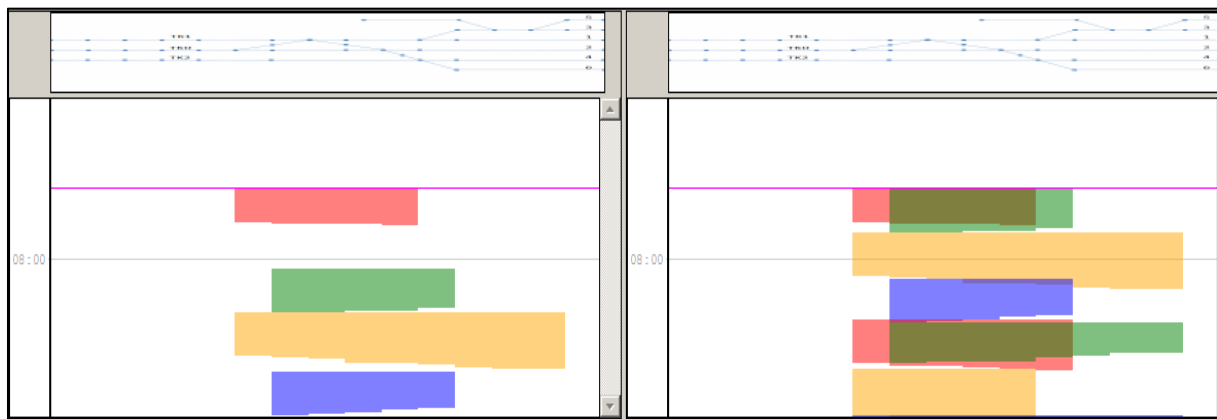
To determine place in compressed plan we must follow rules that are listed above. The earliest possible time of a train is determined so that occupancy of each elements starts after each element is released by previous train.

All principles of compression method have been followed in this alternative method as well so results are in principle the same as using original methodology.

4 TOOL FOR SWITCH AREA CAPACITY CALCULATION

A new specialized software tool for switch area capacity calculation was developed. The modified methodology has been implemented into this tool. The tool is able to process input data and calculate the capacity indicators completely without user interaction. Beside resulting values there is also the graphical representation of the situation before and after compression in two separate panels (Figure 1 and Figure 4). All results (including the occupation time of each element after compression) can be exported in tabular form in output file.

The form of the visualization of the occupation time fully corresponds to examples specified in leaflet UIC 406. Vertical axis shows the time. Horizontal axis represents relevant metric distances in this part of the railway station. Horizontal axis scale is adjusted to the image of a switch area which is displayed in the header part of the panel. The occupation time of each element is shown by colored rectangles (blocks). Blocks that relate to a single train are linked together. The upper edge of the rectangle represents start occupation time and the bottom edge represents end time for this occupation. The horizontal position and size of the rectangle corresponds to the position of the element in the layout of the station. Different colors are used to distinguish individual trains (Figure 1).



Source: Authors

Fig. 1 – Detailed view of the visualization of the results

Input data is stored in four files for each switch area. These files are located in a common directory. Particular files contain the following data:

1. Layout of the switch area. Layout is stored as an image format. This image is used for display in the header part of both graphic panels.
2. List of trains that are used for the calculation on the switch area. The order of trains corresponds to a given timetable. The order is determined by occupation time of train paths on the switch area. The file is in CSV format.
3. List of displayed elements. The elements are switches, station tracks and line track sections. The calculation is always performed only on the basis of occupancy of switches. Occupancy of the other elements can be optionally displayed. The file is in CSV format.
4. List of the occupation time for each element of each train. This file contains the following information for each occupancy: train number, label of the element, start time and end time for this occupation. The file is in CSV format.

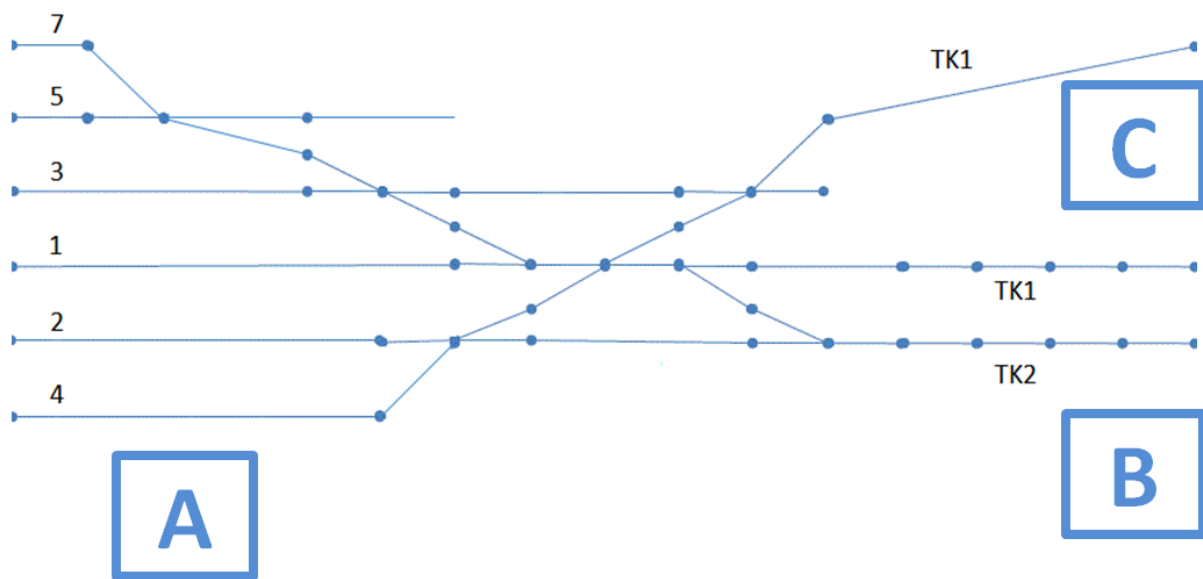
Compression and output values calculation is performed automatically when the directory that contains the input data is selected. The result of compression is then visualized. The user has the option to choose and change the observed time period.

5 TESTING ALTERNATIVE METHODOLOGY

It was assumed that the alternative methods will produce results identical to the original methodology due to the fact that the alternative methodology follows the principles specified in Leaflet UIC 406. Several comparative calculations were made to confirm and verify this assumption

The following text briefly describes one specific comparative calculation using both methodologies and compares their results.

The calculation of switch area capacity was performed on a sample railway station. Two interstation sections are connected through the examined switch area to the station (Figure 2). Section A-B contains two line tracks and section A-C contains one line track.



Source: Authors

Fig. 2 – Layout of the tested switch area

A deterministic simulation experiment of the traffic at the railway station was made according to the sample timetable. Output statistics was obtained from the simulation tool Vil-lon as described in the previous chapter. The obtained data was used for capacity calculation using the original methodology UIC 406 and also using modified methodology.

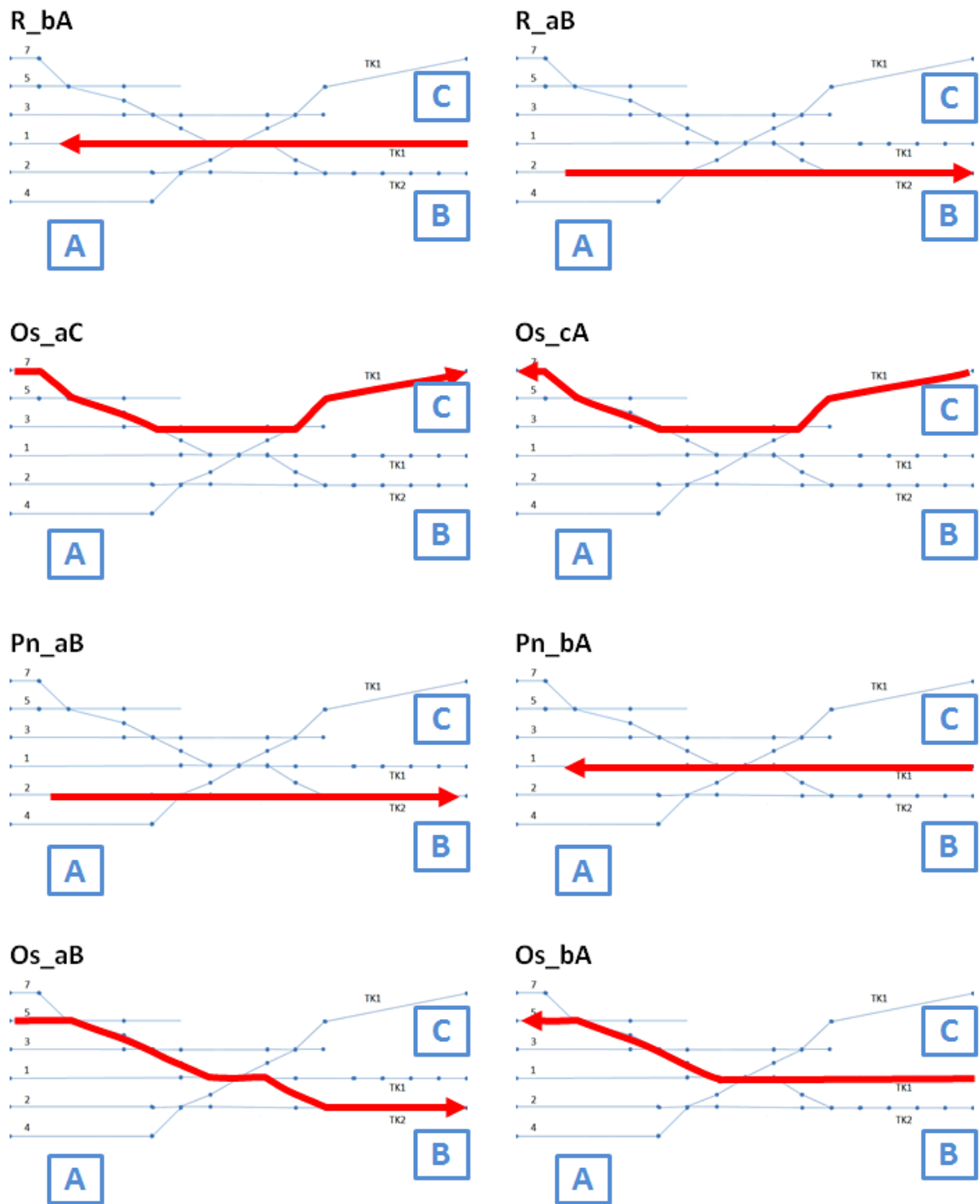
The calculation was carried out for the selected time period of 120 minutes. It included 34 trains from the sample timetable in the calculation. It determined 8 template trains for the purposes of original methodology. Template trains are listed below: R_bA, R_aB, Os_aC, Os_cA, Pn_aB, Pn_bA, Os_aB, Os_bA. The label includes the type of train (R: fast train, Os: passenger train, Pn: freight train). A pair of letters (A, a, B, b, C, c) behind an underscore indicates the direction of trip (e.g. „R_bA“ indicates fast train from station B to station A). Figure 3 shows all trips of each template trains through the tested switch area.

The matrix of minimum follow-up-times between the possible trips was created based on the above occupancy time data for each element, trips of template trains through the switch area, and knowledge of the topology of the switch area.

Tab. 1 – Minimum follow-up-times between the possible routes

		Excluded Trip (k)							
		R_bA	R_aB	Os_aC	Os_cA	Pn_aB	Pn_bA	Os_aB	Os_bA
Actual Trip (i)	R_bA	1,57	-	-	-	-	1,57	1,57	1,57
	R_aB	-	1,75	-	-	1,75	-	1,75	-
	Os_aC	-	-	1,47	1,47	-	-	1,17	1,17
	Os_cA	-	-	2,18	2,18	-	-	2,18	2,18
	Pn_aB	-	1,87	-	-	1,87	-	1,87	-
	Pn_bA	1,92	-	-	-	-	1,92	1,92	1,92
	Os_aB	1,6	1,6	1,38	1,38	1,6	-	1,6	1,6
	Os_bA	1,93	-	2,13	2,13	-	1,93	2,13	2,13

Source: Authors



Source: Authors

Fig. 3 – Schematic representation of routes through the tested switch area

Finally, the calculation of the total occupancy time and determination of the occupancy time rate was performed. The resulting values are shown in table 2. The total occupancy time is 43,82 minutes (0:43:49). The occupancy time rate is 36,52 %. These results were obtained for the defined time period of 120 minutes.

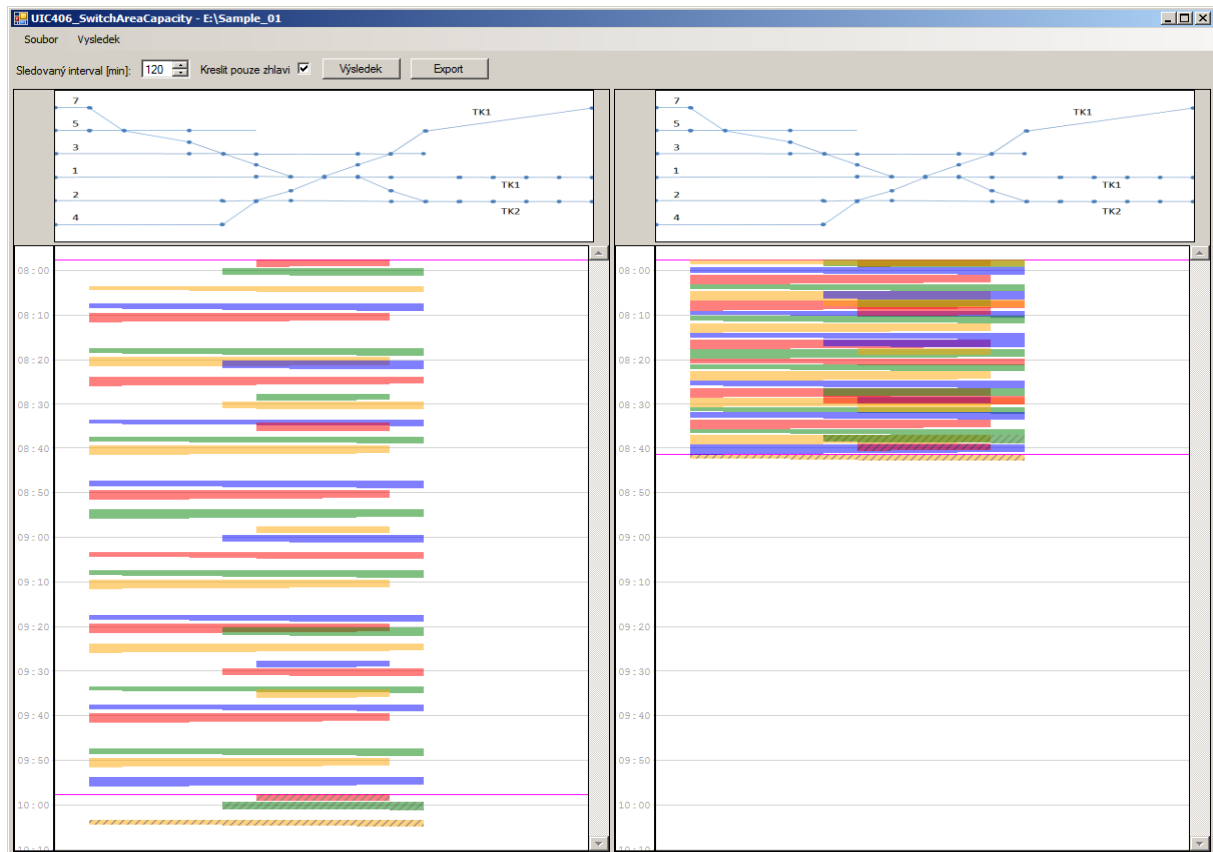
Trip	Begin of occupation [min]	End of Occupation/Exclusion [min]							
		R_bA	R_aB	Os_aC	Os_cA	Pn_aB	Pn_bA	Os_aB	Os_bA
R_bA	0,00	1,57	*	*	*	*	1,57	1,57	1,57
R_aB	0,00	*	1,75	*	*	1,75	*	1,75	*
Os_aC	0,00	*	*	1,47	1,47	*	*	1,75	1,57
Os_aB	1,75	3,35	3,35	3,13	3,13	3,35	*	3,35	3,35
Os_bA	3,35	5,28	*	5,48	5,48	*	5,28	5,48	5,48
Os_aB	5,48	7,08	7,08	6,86	6,86	7,08	*	7,08	7,08
Os_bA	7,08	9,01	*	9,21	9,21	*	9,01	9,21	9,21
Pn_aB	7,08	*	8,95	*	*	8,95	*	9,21	*
Os_cA	9,21	*	*	11,39	11,39	*	*	11,39	11,39
R_bA	9,01	10,58	*	*	*	*	10,58	11,39	11,39
R_aB	8,95	*	10,7	*	*	10,7	*	11,39	*
Os_aC	11,39	*	*	12,86	12,86	*	*	12,56	12,56
Pn_bA	10,58	12,5	*	*	*	*	12,5	12,56	12,56
Os_aB	12,56	14,16	14,16	13,94	13,94	14,16	*	14,16	14,16
Os_bA	14,16	16,09	*	16,29	16,29	*	16,09	16,29	16,29
Os_aB	16,29	17,89	17,89	17,67	17,67	17,89	*	17,89	17,89
Os_bA	17,89	19,82	*	20,02	20,02	*	19,82	20,02	20,02
Os_cA	20,02	*	*	22,2	22,2	*	*	22,2	22,2
R_bA	19,82	21,39	*	*	*	*	21,39	22,2	22,2
R_aB	17,89	*	19,64	*	*	19,64	*	22,2	*
Os_aC	22,20	*	*	23,67	23,67	*	*	23,37	23,37
Os_aB	23,37	24,97	24,97	24,75	24,75	24,97	*	24,97	24,97
Os_bA	24,97	26,9	*	27,1	27,1	*	26,9	27,1	27,1
Os_aB	27,10	28,7	28,7	28,48	28,48	28,7	*	28,7	28,7
Os_bA	28,70	30,63	*	30,83	30,83	*	30,63	30,83	30,83
Pn_aB	28,70	*	30,57	*	*	30,57	*	30,83	*
Os_cA	30,83	*	*	33,01	33,01	*	*	33,01	33,01
R_bA	30,63	32,2	*	*	*	*	32,2	33,01	33,01
R_aB	30,57	*	32,32	*	*	32,32	*	33,01	*
Os_aC	33,01	*	*	34,48	34,48	*	*	34,18	34,18
Pn_bA	32,20	34,12	*	*	*	*	34,12	34,18	34,18
Os_aB	34,18	35,78	35,78	35,56	35,56	35,78	*	35,78	35,78
Os_bA	35,78	37,71	*	37,91	37,91	*	37,71	37,91	37,91
Os_aB	37,91	39,51	39,51	39,29	39,29	39,51	*	39,51	39,51
Os_bA	39,51	41,44	*	41,64	41,64	*	41,44	41,64	41,64
Os_cA	41,64	*	*	43,82	43,82	*	*	43,82	43,82
(R_bA)	41,44	43,01	*	*	*	*	43,01	43,82	43,82
(R_aB)	39,51	*	41,26	*	*	41,26	*	43,82	*
(Os_aC)	43,82	*	*	45,29	45,29	*	*	44,99	44,99

Source: Authors

Tab. 2 – Switch area capacity calculation

The same data was used in the calculation using an alternative methodology. The data was processed with the above mentioned tool. The calculation was performed automatically. Figure 4 shows the graphical representation of the situation prior to compression and after compression.

The resulting total occupancy time is 43,85 minutes (0:43:51). Occupancy time rate is 36,54 %. These results were obtained for the defined time period of 120 minutes.



Source: Authors

Fig. 4 – Display window with the examined switch area capacity calculation

The results of the both methodologies are practically identical, as expected. The difference between the values corresponds to an error when working with real values.

CONCLUSION

This paper mentioned the modified procedure of switch area capacity calculation, which has been created with regard to the data format of the output data that is available within some simulation tools, e.g. software simulation tool Villon.

The main objective of the modified methodology was to speed up and automate the process of capacity calculation. Hence the modified methodology has been successfully implemented into the new specialized software tool for switch area capacity calculation.

The basic principle of calculation, as defined in the leaflet UIC 406, was fully respected.

The new methodology and software tool for switch area capacity calculation has been tested on several examples. The results of the original methodology and modified methodologies are practically identical.

REFERENCES

- (1) *UIC CODE 406, Capacity. 2nd edition, June 2013. International Union of Railways.*