THE CUBOID CAPACITY METHODOLOGY – TIMETABLE CONVENIENCE VALUE COUNTING

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Abstract: The main goal of this article is to determine new way of capacity counting. On the previous research basis it was created the cuboid capacity methodology, which counts timetable convenience value. This value includes chosen parameters and provides the possibility of timetable comparison based on one value, only.

Keywords: Capacity, methodology, periodicity rate, timetable.

1 Introduction

There is great amount of capacity methodologies to evaluate and determine capacity in the world. The UIC 406 capacity methodology is widespread, but quite every country has its own capacity counting prescription. To determine the capacity range or to evaluate timetable variants is quite a lot difficult – therefore it is necessary to think over this problematic more and to determine some new capacity evaluating methodology, which would be easier and more user friendly.

2 Materials and methods

There are mentioned some information about periodicity rate, average delay increment (ADI) calculation and new capacity methodology suggestion.

2.1 Periodicity rate

Periodicity rate is defined as the share of amount of all trains constructed in periodic timetable and the number of all trains on a line (or closed network). It is displayed in Formula 1 (1).

$$R_p = \frac{N_p}{N_w} \tag{1}$$

Where:

R_p periodicity rate,
N_p number of trains with periodic routing,
N_W the whole number of trains on a line (on a closed network).

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2.2 Average delay increment calculation

The average delay increment (ADI) – it is calculated by dividing the difference between total output and total input delay and the total number of trains. As part of the simulation it is set for all simulation runs random input delay based on the exponential probability distribution. It is displayed in Formula 2.

$$ADI = \frac{total\ output\ delay - total\ input\ delay}{number\ of\ trains} \quad (2)$$

For ADI calculation is appropriate to use some simulation tool (1).

2.3 The cuboid capacity methodology

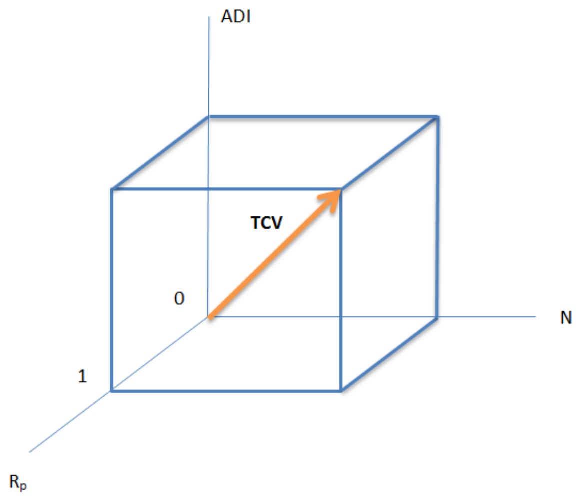
All required values could be expressed through a cuboid capacity methodology (CCM), where there are on 3 axes displayed the periodicity rate value (or other parameter), the quality value (ADI) and the quantity value (number of trains). These parameters have limitations:

- Periodicity rate <0;1>,
- ADI (-∞, +∞),
- number of trains <1; +∞).

The result of CCM is timetable convenience value (TCV). In the Formula 3 is displayed the calculation way of timetable convenience value (TCV):

$$TCV = \sqrt{ADI^2 + N^2 + R_p^2} \quad (3)$$

On the figure 1 is displayed an outline of TCV.



Source: Authors

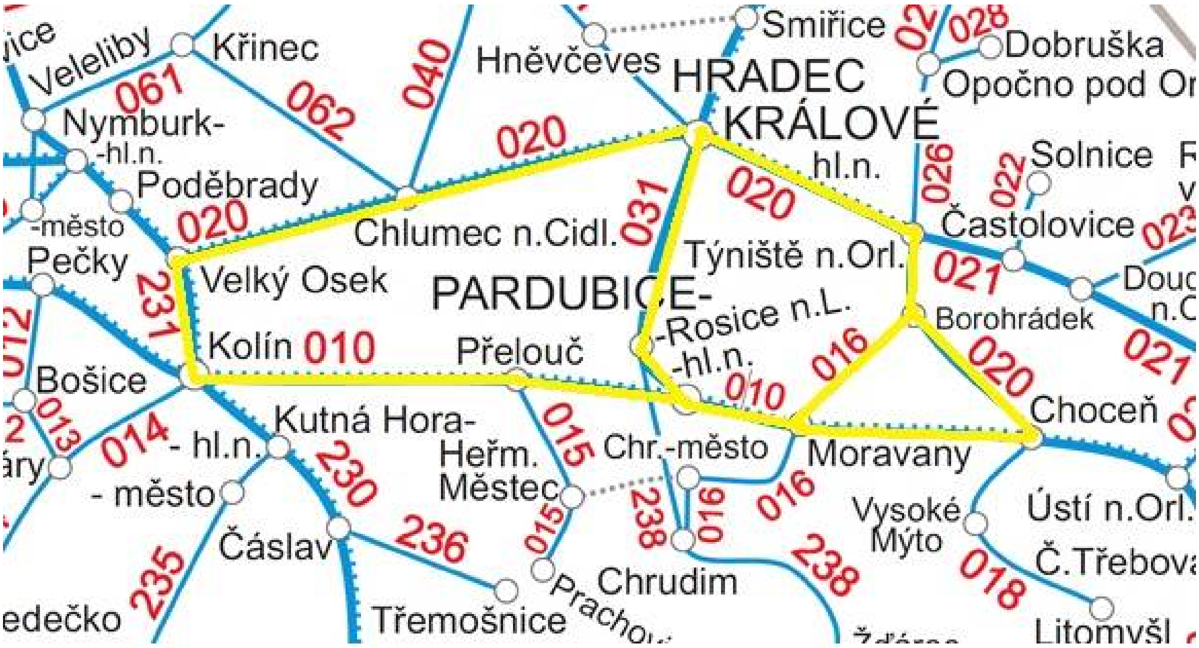
Fig. - The timetable convenience value outline

The timetable convenience value is determining timetable parameter in the terms of quality, quantity and other (in this case it is periodicity, but it could be replaced). Because of CCM is possible to get only one determining value for timetable evaluation.

2.4 Timetables for evaluation

It was chosen a closed railway network in the Czech Republic consisting of various lines (different number of tracks, different security equipment e. t. c.), among others of overlapping section of Rail Freight Corridors RFC 7 and RFC 9 (namely section Kolín – Choceň). The whole chosen closed railway network is yellow marked on Figure 2 (2).

In the chosen closed railway network there are a total amount of 29 railway stations, in which it is possible overtaking trains (double track line) or crossing trains (single track line). The amount of trains, ADI and periodicity rate on whole closed network are displayed in the Table 1. It is displayed for the real operation in the timetable 2016 (TT 2016), constructed periodic timetable (PTT) and constructed periodic timetable with periodic freight train paths (PFTP, rescheduling of freight expresses) (2).



Source: Timetable 2017/18, Authors

Fig. 2 - The chosen closed railway network

Tab. 1 - The parameters for whole closed network

TT	Amount of trains	ADI (min/train)	Periodicity rate (%)
2016	956	0,21	44,04
PTT	901	-0,49	98,34
PFTP	907	-0,62	98,57

Source: Authors

To be more concrete, in Table 2, Table 3 and Table 4 are displayed the same parameters for each line (1).

Tab. 2 - The section parameters, timetable 2016

Line section	Amount of trains	ADI (min/train)	Periodicity rate (%)
Kolín - Choceň	384	1,05	47,40
Choceň – HK – VO	174	- 1,26	44,83
Pardubice hl. n. – HK hl. n.	137	- 0,20	38,69
Kolín – VO	213	0,27	37,09
Moravany - Borohrádek	48	- 0,29	60,42

Source: Authors

Tab. 3 - The section parameters, periodic timetable

Line section	Amount of trains	ADI (min/train)	Periodicity rate (%)
Kolín - Choceň	336	- 1,03	100
Choceň – HK – VO	108	- 2,21	86,11
Pardubice hl. n. – HK hl. n.	179	0,76	100
Kolín – VO	221	0,26	100
Moravany - Borohrádek	57	- 0,88	100

Source: Authors

Tab. 4 - The section parameters, periodic timetable with periodic freight train paths

Line section	Amount of trains	ADI (min/train)	Periodicity rate (%)
Kolín - Choceň	336	-1,03	100
Choceň – HK – VO	114	-3,14	88,60
Pardubice hl. n. – HK hl. n.	179	0,76	100
Kolín – VO	221	0,26	100
Moravany - Borohrádek	57	-0,88	100

Source: Authors

In these tables there are found all parameters for TCV calculation.

3 Results and Discussion

First, it is necessary to modify the parameters: the ADI parameter could be in same form, but the periodicity rate could not be in percent – it is appropriate to write it like dimensionless parameter. The amount of trains is then necessary to indicate like one thousandth of the amount due to corresponding value of TCV. In the following tables there are displayed modified parameters with TCV (calculated according to Formula 3).

Tab. 5 - The modified parameters for whole closed network with TCV

TT	N	ADI (min/train)	R_p	TCV
2016	0,956	0,21	0,4404	1,073
PTT	0,901	-0,49	0,9834	1,421
PFTP	0,907	-0,62	0,9857	1,476

Source: Authors

According to TCV it seems the most convenient timetable is the PFTP – it corresponds to previous research and it is its validation. However, it must be said, the main corrective parameter is ADI – it is due to the second power in Formula 3. The TCV is generally valid especially for ADI (-∞, 0>.

Tab. 6 - The section modified parameters with TCV, timetable 2016

Line section	N	ADI (min/train)	R_p	TCV
Kolín - Choceň	0,384	1,05	0,4740	1,214
Choceň – HK – VO	0,174	- 1,26	0,4483	1,349
Pardubice hl. n. – HK hl. n.	0,137	- 0,20	0,3869	0,456
Kolín – VO	0,213	0,27	0,3709	0,506
Moravany - Borohrádek	0,048	- 0,29	0,6042	0,672

Source: Authors

The TCV is highest in sections Kolín – Choceň and Choceň – Hradec Králové – Velký Osek. In this case it must be used the corrective function of ADI, when it is possible to say, the section Choceň – Hradec Králové – Velký Osek is correct, but the in section Kolín – Choceň there could be the timetable better in its stability (quality).

Tab. 7 - The section modified parameters with TCV, periodic timetable

Line section	N	ADI (min/train)	R_p	TCV
Kolín - Choceň	0,336	- 1,03	1	1,474
Choceň – HK – VO	0,108	- 2,21	0,8611	2,374
Pardubice hl. n. – HK hl. n.	0,179	0,76	1	1,269
Kolín – VO	0,221	0,26	1	1,056
Moravany - Borohrádek	0,057	- 0,88	1	1,333

Source: Authors

In this table, there is displayed really good improvement in section Choceň – Hradec Králové – Velký Osek, where in the terms of negative ADI is TCV quite twice higher.

Tab. 8 - The section modified parameters with TCV, periodic timetable with periodic freight train paths

Line section	N	ADI (min/train)	R_p	TCV
Kolín - Choceň	0,336	- 1,03	1	1,474
Choceň – HK – VO	0,114	- 3,14	0,8860	3,265
Pardubice hl. n. – HK hl. n.	0,179	0,76	1	1,269
Kolín – VO	0,221	0,26	1	1,056
Moravany - Borohrádek	0,057	- 0,88	1	1,333

Source: Authors

The main improvement of TCV is again in section Choceň – Hradec Králové – Velký Osek due to decreasing ADI.

However, to get only one determining value for timetable evaluation is necessary to get to the TCV the ADI limitation, because TCV is generally counted like vector size and therefore is generally valid especially for ADI $(-\infty, 0>$. In this range is valid, that the higher TCV, the better is the timetable. But in the ADI range $(0, +\infty)$ is this postulate invalid, because higher TCV caused by increasing ADI is not the evidence of better timetable. To solve this contradiction and to distinguish TCV by ADI range would be appropriate to add the sign before the TCV value. Because TCV like vector size is always affirmative, in the case of negative ADI is added before TCV the minus sign. In the case of positive ADI remains TCV without sign and it means, it is necessary to improve the timetable quality (to increase timetable stability). The TCV modified by this postulate are displayed in Table 9.

Tab. 9 - The modified TCV for ADI range

Line section	TCV TT 2016	TCV PTT	TCV PFTP
Whole network	1,073	-1,421	-1,476
Kolín - Choceň	1,214	-1,474	-1,474
Choceň – HK – VO	-1,349	-2,374	-3,265
Pardubice hl. n. – HK hl. n.	-0,456	1,269	1,269
Kolín – VO	0,506	1,056	1,056
Moravany - Borohrádek	-0,672	-1,333	-1,333

Source: Authors

After this adjustment is generally valid, the lower TCV, the better is the constructed timetable. In Table 9 there is apparent, in sections Kolín – Velký Osek and Pardubice hl. n. –

Hradec Králové hl. n. is the constructed timetable (PTT, PFTP) worse than real timetable 2016. It is due to the change of frequency of train type, when it was changed the conception of train operation and train routing and ADI is affirmative.

4 Conclusion

In this article there was described the cuboid capacity methodology (CCM), whose result is timetable convenience value. The TCV was counted for different timetables and the measures were taken to get maximal validity of TCV. It could be generally said, the lower TCV, the better is the constructed timetable. Nevertheless, for conceptual timetable changes is TCV not so exact and it could be further improved.

References

(1) ŠRÁMEK, P., 2017.: *Vliv periodických jízdních řádů na kapacitu trati*. Dizertační práce. Pardubice: Univerzita Pardubice.

(2) ŠRÁMEK, P., MOLKOVÁ, T.: Utilization of Train Routes in Relation to the Implementation of Periodic Timetable. Proceedings of the Third International Conference on Traffic and Transport Engineering (ICTTE Belgrade 2016), s. 949 – 954. ISBN 978-86-916153-3-8.

(3) ŠIROKÝ, J. et al. Transport Technology and Control. Tribun EU. Brno. pp. 238. (2014).

(4) GAŠPARÍK, J., MAJERČÁK, J., ŠIROKÝ, J., ABRAMOVIC, B., MEŠKO, P., NACHTIGALL, P., ZITRICKÝ, V. 2017. Railway Traffic Operation. Žilina: Žilinská univerzita, 292 p.

(5) GAŠPARÍK, J., ŠIROKÝ, J., PEČENY, L., HALÁS, M. 2014. Methodology for assessing the quality of rail connections on the network, In: Communications: scientific letters of the University of Zilina, Vol. 2: p. 25-30.

(6) ŠRÁMEK P., MOLKOVÁ, T. 2016. Utilization of Train Routes in Relation to the Implementation of Periodic Timetable. Proceedings of the Third International Conference on Traffic and Transport Engineering (ICTTE), p. 949 – 954.