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SIMULATION SOFTWARE AS A CALCULATION TOOL FOR TRAFFIC CAPACITY ASSESSMENT

Every town faces many problems one of which is ensuring good traffic situation in its territory. Road network in towns is limited by density of existing buildings and every traffic increase can lead to road network overcrowding. Therefore towns have to plan the future traffic in the way the roads are prevented from occurring traffic problems. In order to prevent traffic problems within the city every larger investment plan which may have impact on traffic has to come under the traffic capacity assessment before is approved by city. This paper is focused on various tools that may be used in traffic capacity assessment of every greater investment plan. You can find comparison of Aimsun simulation outputs, OmniTrans simulation outputs, and outputs of analytical calculation according to technical regulations valid in Slovakia in this paper.

Keywords: Delay times, traffic capacity assessment, aimsun, technical regulations, omnitrans.

1. Introduction

Good traffic situation is one of the objectives of every town. Road network in towns is limited by density of existing buildings and every traffic increase can lead to road network overcrowding, which may result in undesirable external costs such as traffic congestions, increased fuel consumption, and higher production of greenhouse gases and noise. This all ultimately reduces the attractiveness of the area. In order to achieve traffic sustainability all greater investment projects of developers that may have impact on the traffic have to come under traffic-capacity assessment, which is standard part of the preparatory or project documentation at present. Good traffic situation is important for both sides –for the town and its inhabitants and for the developers. But methods relating to traffic-capacity assessment used in approval process of investment plans may be processed non-uniformly, they may differ in the range of processing and may reflect a subjective approach of their processors [1, 2, 3 and 4]. Therefore, there is effort of the competent authorities to establish a uniform methodology for assessing the project documentation. Bratislava gave to create the methodology with uniform traffic engineering methods in order to avoid differences in approaches to the traffic-capacity assessments of great investment projects in its territory. Similar methodology is also applied in Presov. This methodology was based on the methodology of Bratislava, but it was modified in order to suit the conditions of the town Presov.

According to these methodologies the traffic-capacity calculations are carried out with the help of analytical methods and there are 3 basic junction types [5]:

- Uncontrolled junctions, where analytical calculations are set in Slovak standard STN 73 6102 [6] and in Technical regulations TP 10/2010 [7];
- Signal controlled junctions, where analytical calculations are set in Technical regulations TP 10/2010 ;
- Roundabouts, where analytical calculations are set in Technical regulations TP 10/2010 and in Technical regulations TP 04/2004 [8].

But there is an interesting part in these methodologies, which says that traffic-capacity calculation may be supplemented or even replaced by the virtual simulation of the assumed traffic on the communication network at the solved area or affected junctions. [5] Virtual simulation can be helpful in many traffic research areas such as in public transport priority investigation [9 and 10], traffic light coordination investigation [11], or in finding optimal use of communication network [12 and 13]. Also virtual simulation has an advantage over analytical calculations mainly because of its exceptional features such as clarity, versatility, ability to implement into calculation influence of the surroundings etc. [14].

Here, we can put the question: How much do the simulation outputs correspond (are simulation outputs comparable) to the analytical methods outputs? There is outputs comparison of the analytical traffic-capacity calculation - calculation according to TP

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10/2010 and simulation methods – simulation in Aimsun [15] and simulation in OmniTrans [16] in the following part of the paper.

2. Investigation procedure

In order to compare calculation outputs and simulation outputs there were carried out calculations and simulations at the two junctions in the town of Zilina, where traffic load data were available. The junctions and traffic flows are shown in Figs. 1 and 7. The First one was used for the assessment of uncontrolled and signal controlled junctions, the second one for the assessment of roundabouts. The examination procedure was as follows:

1. Delay time calculation according to TP 10/2010 [7];
2. Model creation and simulation in Aimsun [15];
3. Model creation and simulation in OmniTrans [16];
4. All the calculations and simulations were carried out for the traffic flows:
 - a. according to traffic surveys uniformly reduced by 20% (-20%);
 - b. according to traffic surveys uniformly reduced by 10% (-10%);
 - c. according to traffic surveys (basic state - BS);
 - d. according to traffic surveys uniformly increased by 10% (+10%);
 - e. according to traffic surveys uniformly increased by 20% (+20%);
5. Calculations and simulation outputs comparison.

The delay time was chosen as a comparative unit, because the delay time is obtained as an output of calculation according to TP10/2010 and of both simulation software tools.

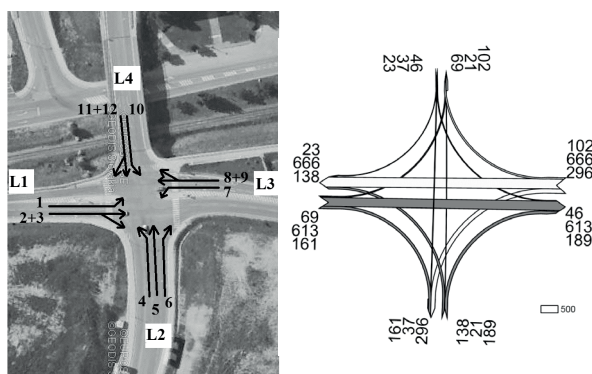


Fig. 1 Junction legs (L1-4) and traffic flows labelling according to TP 10/2010 rules (on left), traffic volume (pcu/h) during traffic peak (on right) [source: authors]

3. Results

Uncontrolled junctions

There are particular traffic flows at the uncontrolled junction, which are not obligated to give way to any other traffic flow, therefore it can be assumed that these traffic flows reach no delay times at uncontrolled junctions and it is not necessary to calculate them during assessment. These flows are represented by traffic flows No. 2, No.8 (straight movement on the main road), No.3, and No. 9 (right turnings from the main road). Other traffic flows are obligated to give way to 1 traffic flow (degree 2), to 2 traffic flows (degree 3), or to 3 traffic flows (degree 4).

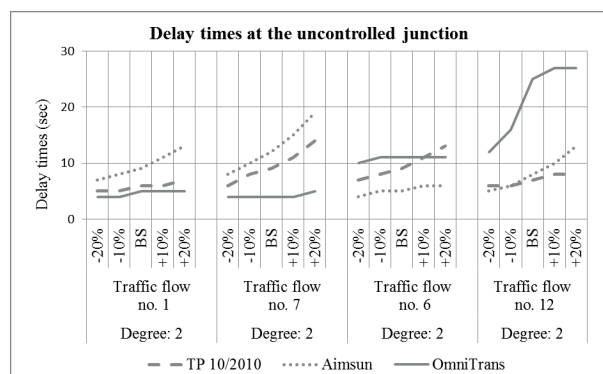


Fig. 2 Simulation and calculation outputs for the uncontrolled junction (traffic flows degree: 2) [source: authors]

Looking at the traffic flows which are obligated to give way to 1 traffic flow (Fig. 2) it is possible to see slight differences between analytical calculation outputs and simulations outputs, but there are also differences when outputs of 2 simulation tools are compared. The average difference between outputs of TP and Aimsun is about 3.3 sec (maximum of 7 sec), between TP and OmniTrans about 5.75 s (maximum of 19 sec), and between Aimsun and OmniTrans about 8.05 s (maximum of 17 sec).

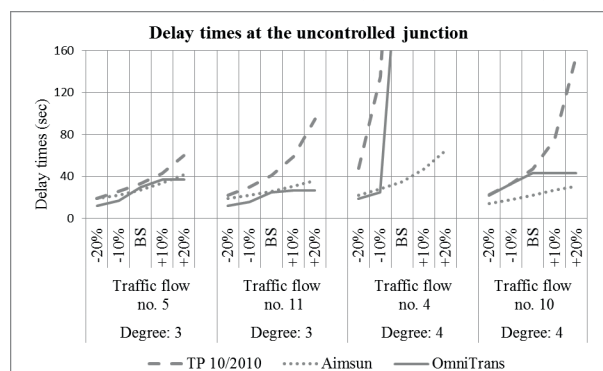


Fig. 3 Simulation and calculation outputs for the uncontrolled junction (traffic flows degree: 3 and 4) [source: authors]

Looking at the traffic flows that are obligated to give way to 2 traffic flows (Fig. 3, degree: 3, traffic flows No. 5 and No.11)

it can be seen that increase in delay times according to TP is noticeably higher than increase in delay times according to Aimsun or OmniTrans. The difference in delay times between TP and OmniTrans for the traffic flows increased by 20% is up to 68 sec. But when we take into account the fact that delay times according to Aimsun (OmniTrans) are also higher (40 sec), relative difference between TP and Aimsun is 27.1%, between TP and OmniTrans is 63.3%, and between Aimsun and OmniTrans is equal to 26.7%.

Traffic flows which are obligated to give way to 3 traffic flows (Fig. 3, degree: 4, traffic flow No. 4 and No. 10) are the traffic flows with the highest delay times. Moreover, there are highest differences between calculation and simulation outputs. Calculation outputs according TP show extremely high delay times for the traffic flow No. 4 (up to 2012 sec when the traffic flow is increased by 20%). The outputs according to OmniTrans also show high delay times already at the basic traffic volume, but with the maximum value up to 300 sec, but the delay time 300 sec is the maximum delay time that OmniTrans can simulate. Therefore, it is possible to assume that there would be even higher delay times if the traffic flow was higher. In contrast, calculation according to Aimsun showed only slightly increased delay times – only up to the value of 65 sec. From these findings it is possible to come to the conclusion that at uncontrolled junctions:

- The more the traffic flows to which the assessed traffic flow is obligated to give way, the huger the differences between calculations and simulations outputs are;
- Aimsun gives us the lowest delay times compared to other tools;

Signal controlled junctions

These calculation and simulation outputs were supplemented with calculation according to Webster method [17] in order to put more objective view into comparison. According to the outputs (see Figs. 2 and 3), there are more significant differences between average delay times of vehicles entering the junction from the main road (Fig. 4), where delay times are lower (around 10 sec), and vehicles entering from the side roads (Fig. 5), where delay times are around 40 sec and higher. This may be caused mainly by different green, which is much longer for the main road in comparison to side roads (56 sec and 69 sec in comparison to 13 sec and 11 sec).

Delay time calculation according to Webster gives us the lowest delay time values. Also there are not significant changes in delay time in the case that traffic load decreases/increases by 20% in any traffic flow. Even traffic flows turning left have not increased delay times values. According to this calculation it would be possible to declare that there are nearly no problems at this junction. The cars can pass through this junction with the acceptable delay also in the case that traffic load during traffic peak will increase by 20%.

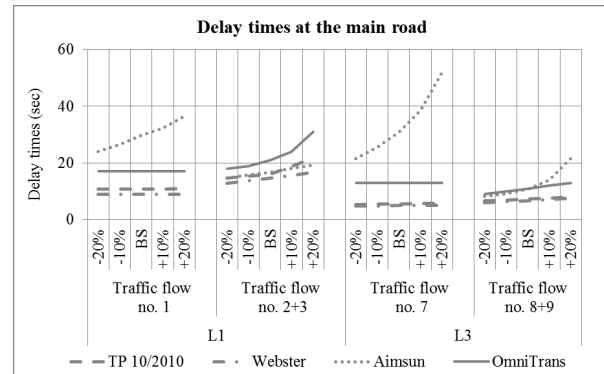


Fig. 4 Simulation and calculation outputs for the signal controlled junction (main road) [source: authors]

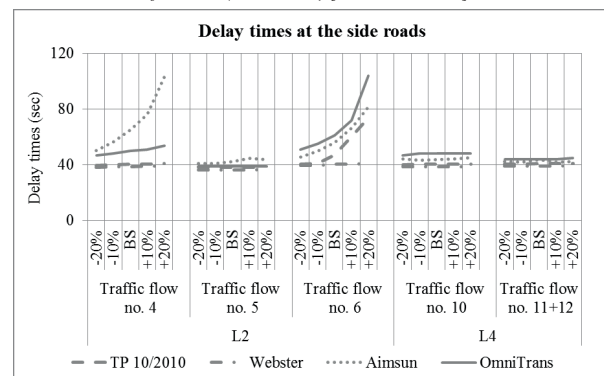


Fig. 5 Simulation and calculation outputs for the signal controlled junction (side roads) [source: authors]

Calculations according to technical regulations TP 10/2010 give us delay time values very similar to Webster's outputs. The total average difference is only about 10%. And also slight decrease/increase in delay time can be seen when traffic load changes and this decrease/increase is very similar to Webster's outputs. The only significant increase compared to Webster can be seen in the delay times of the traffic flow No. 6 (see Fig. 5). According to this calculation it would be possible to point out potential problems at the junction leg L2, where right turning of the traffic flow No. 6 is expected to be problematic. Other traffic flows are expected to have no problems even when the traffic flow increases by 20%.

Simulation in Aimsun can show us significant difference in delay times at particular traffic flows in comparison to Webster and to TP 10/2010. The differences are visible mainly at the left turning traffic flows No. 1, No. 7, and No. 4, but not at the left turning no. 10 (see Figs. 4 and 5). For instance, the traffic flow No. 7 has according to Aimsun the delay time nearly 6 times higher than according to Webster calculations. At the same time, increased delay time is shown at the traffic flow No. 6, which is also problematic according to TP 10/2010. Simulation outputs for other traffic flows are similar to the outputs of other methods. According to Aimsun it would be possible to point out

problematic left turnings of abovementioned traffic flows (No. 1, No. 7, No. 4) and problematic right turning No. 6.

Simulation in OmniTrans shows slightly higher delay times for nearly all traffic flows in comparison to other methods, but looking at Figs. 4 and 5, the only problematic traffic flow seems to be traffic flow No. 6, where increase in delay time is significant when traffic load is increased. Increased delay times can be also seen at other traffic flows (No. 2+3, and No. 4), but this increase is not very significant.

Roundabouts

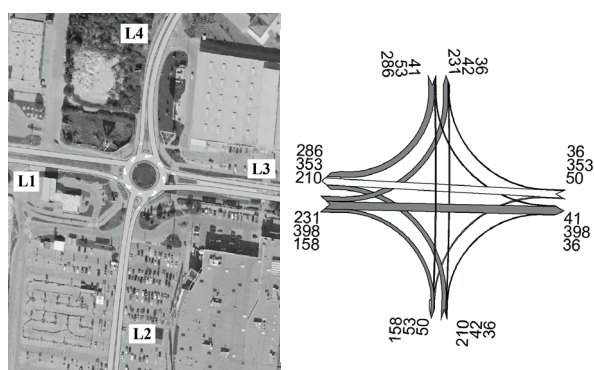


Fig. 6 Assessed roundabout (on left), traffic volume (pcu/h) during traffic peak (on right) [source: authors]

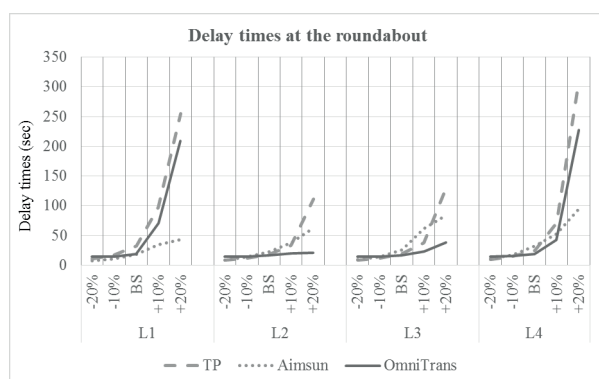


Fig. 7 Simulation and calculation outputs for the roundabout (main road) [source: authors]

Looking at the calculation and simulations outputs for roundabouts (Fig. 6) it can be stated that outputs of all tools are quite comparable when the traffic flow is low. If the traffic flow is decreased by 20%, the output values of all tools show the delay time values between 8 sec and 15 sec and the maximum difference in values between various tools is equal to 6 sec – between TP10/2010 and OmniTrans. But the differences in outputs increase when the traffic flow increases. For the basic state (present traffic volume) the differences in outputs increase to 13 sec (between TP 10/2010 and Aimsun), but for the traffic flow increased by 20% the differences in outputs increased to 211

sec (between TP10/2010 and Aimsun at the junction legs 1 and 2). You can also see in Fig. 7 that analytical calculation outputs show the highest delay time values at the all junction legs. Aimsun outputs show lower delay times than Omnitrans shows at the junction legs L1 and L4, which are the junction legs where the traffic load is relatively high, and Aimsun shows higher delay times than OmniTrans shows at the junction legs L2 and L4, where the traffic load is relatively low.

3. Conclusion

The aim of this paper was to show possibility of using the simulation tools in traffic capacity assessment. These simulation tools were compared to classical analytical calculations and to each other in this paper. Although simulation and analytical calculation were carried out for the same junctions and for the same traffic volumes the outputs of particular tools differed from each other. There were significant differences in outputs at some traffic flows and this might make contrary proposals when two different tools are used at the assessment or might create the space to influence the traffic capacity assessment outputs according to customers' (developers') needs. Therefore, it is possible to recommend further studies that would be focused on verification of particulars methods (e.g. delay times surveys at junctions) and which would clearly confirm the correctness or deviation of outputs from the real situation. Another recommendation is that towns (which will create methodology for traffic-capacity assessment) should pay attention on setting rules for approval/modification/rejection of the investment plan.

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