Modelling traffic conditions in the cadaster of Veľká Lomnica

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Abstract This article is focused on the analysis of the current traffic situation in the cadaster of Veľká Lomnica and suggestions for its improvement. The most important intersection of the road I/67 and II/540 is problematic where is also located the railway crossing with a light signalling device. As a basis for the traffic analysis was performed traffic survey at the four positions in the cadastral territory. Its analysis provides information about the current traffic intensity and is also the basis for the simulation of traffic in traffic - planning software AIMSUN. The article contains an evaluation of various proposed solutions on the basis of the results from AIMSUN software and the selection of the appropriate variant.

Keywords intersection, traffic survey, simulation, OmniTRANS

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1. Introduction

The aim of this article is the analysis of the current condition of transport in the cadaster of Veľká Lomnica and the proposal of possible solutions for its improvement. Especially, the problematic section in the village is the main traffic flow in the direction of Poprad – Kežmarok and its intersection of the road I/67 and II/540 on which is at the same time located the railway crossing with a light signalling device where collisions and congestions arise during the traffic peak and passing of train.[1]

2. Traffic Analysis of current situation at the intersection of the road I/67 and II/540

The intersection is located in the village of Veľká Lomnica. Road I/67 represents the connection between the Hungary and Poland. Road II/540 begins at the intersection with the road number I/67 in Veľká Lomnica and heads to Tatranská Lomnica, where its end is with junction of the road number II/537. Solved intersection is a unguided level junction. On the Popradská Street, there are two bus stops and a railway station called Studený Potok. [1]

Currently, the bulk of traffic is transit in the direction of Poprad – Kežmarok and in reverse, the most overloaded is road number I/67. Figure 1 represents the intersection scheme (current situation). [1]

Figure 1 Scheme of intersection showing the streets and individual inputs [3]

At the time of traffic peak it leads to formation of congestions, mainly in the direction of Poprad. Vehicles entering the intersection along the road II/540 must stop in front of the railway crossing. Left turning complicates the impaired visibility, which is especially impeded by the crossing house, which is located close to the railway crossing and therefore the vehicles stop either in close proximity to the barrier or even directly on the railroad when they endanger themselves and also operation on the railway track. At the time of the passing train, vehicles turning to the left from the road I/67 from the direction of Poprad must stop at the border crossings and this stops the

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entire traffic flow. To formation of congestions also contributes time, when it is turned on the light signalisation on railway crossings. During the one hour are passing through this zone usually two passenger trains. Light signalisation is turned on during one hour approximately 4 and a half minute. Figure 2 shows the situation on the intersection at the time of afternoon traffic peak. [1]

Figure 2 Situation near the junction during traffic peak [1]

Congestion arises when demand levels approach the capacity of a facility and the time required to use it (travel through it) increases well above the average under low demand conditions. In the case of transport infrastructure the inclusion of an additional vehicle generates supplementary delay to all other users as well, see for example Figure 3. Note that the contribution an additional car makes to the delay of all users is greater at high flows than at low flow levels. [2]

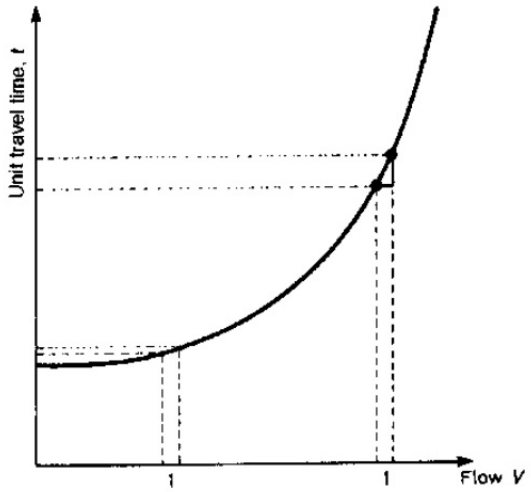


Figure 3 Congestion and its external effects [2]

2.1 Traffic survey in the intersections

Crossroad surveys were performed on Thursday 15th of October 2015 in the time range of 8 hours, from 6 am to 10 am and from 1 pm to 5 pm.

The minimum period for determination the traffic intensity are four hours in the morning and four hours in the afternoon. [3]

We made three crossroad surveys on the intersections of the streets:

- I67 and II/540,
- Popradská and Jilemnického Street,
- Tatranská, Skalnatá and Železničná Street.

The load of individual intersections was processed in traffic – planning software OmniTRAN. The results of traffic surveys at traffic peak hours are shown in Figures 4, 5 and 6.

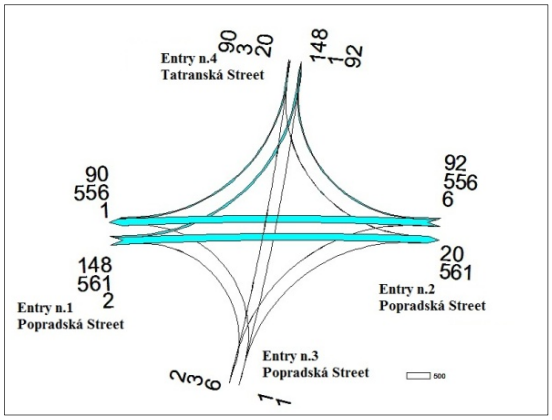


Figure 4 Load cartogram for intersection I/67 – II/540 processed in OmniTRANS software **[1]**

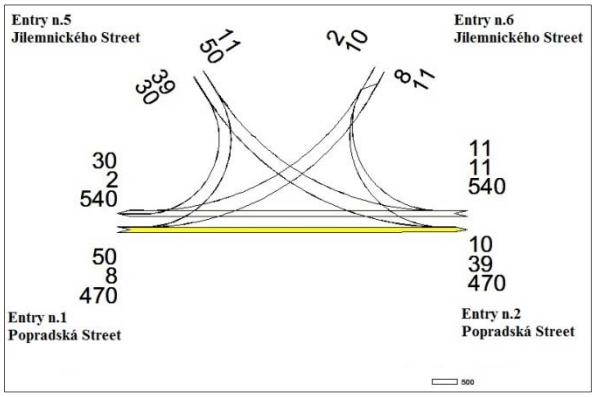


Figure 5 Load cartogram for intersection I/67 – Jilemnického Street processed in OmniTRANS software

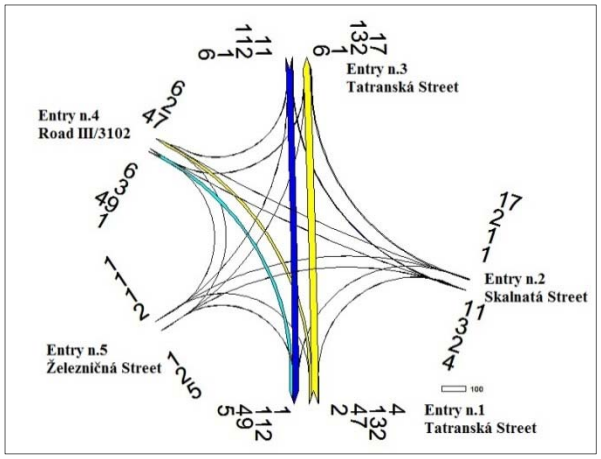


Figure 6 Load cartogram for intersection II/540 – Železničná Street – Skalnatá Street processed in OmniTRANS software

Subsequently we conducted a traffic survey, therefore survey intensity. This was carried out near the gas station, BIO – plus on the road I/67. T here were recorded vehicles passing in the direction from Poprad to the village and in reverse. The intensity survey was carried out simultaneously with other traffic surveys in the cadaster of the village. **[1]**

3. Proposals for improving traffic situation based on simulation

3.1 First draft – Separate left turn lane

First proposal for improving the traffic situation at the intersection of roads I/67 and II/540 consists in the addition of a road lane for the left - hand branch at entry from Poprad, see Figure 7. [1]

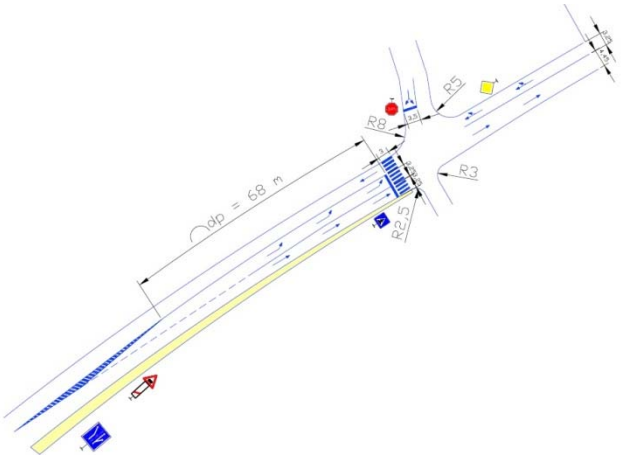


Figure 7 Proposal of traffic organisation at intersection [1]

3.2 Second draft – By-pass road of Veľká Lomnica in direction to High Tatras

After consulting with the Mayor of village about the current traffic problems in the cadaster of the village and on the future perspective, it was decided that a suitable solution for reducing the intensity of vehicles passing through the village was the proposal to bypass the village in the direction to High Tatras. This solution diverts the high intensity of vehicles passing through the village, especially in the winter, when many vehicles are heading to the High Tatras and their aim is the ski resort in Tatranská Lomnica, where the grow in following years is expected.

Proposed by – pass road is shown in Figure 8.

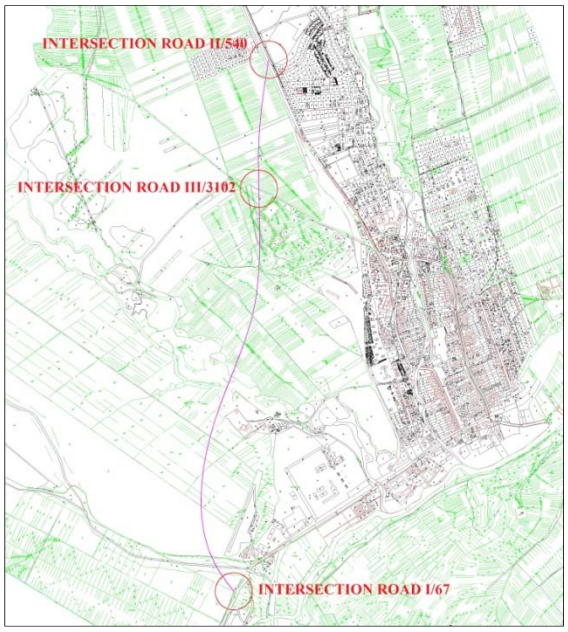
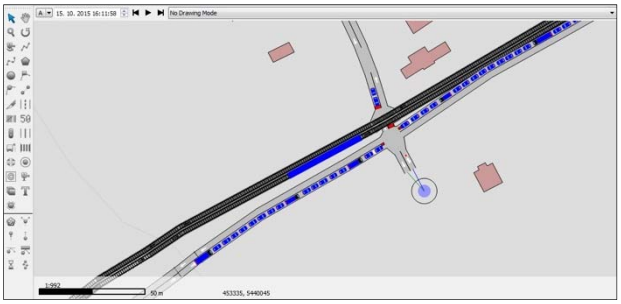


Figure 8 Proposed By-pass road of Veľká Lomnica [1]

3.3 Simulation and evaluation of proposed solutions

In this chapter, we have devoted ourselves to individual



simulations in AIMSUN. For each one proposal, we performed a total of 10 simulations. The tables also show the differences between the individual variables. Consequently, we compared the proposed solutions, especially in terms of simulation results, which should confirm the importance of creating a separate left turn lane at the intersection of roads I/67 and II/540, or the suitability of creating a by - pass road of the village in the direction to High Tatras. In the Figure 9, we can see the situation in the afternoon traffic peak.

Figure 9 View of 2D simulation in AIMSUN software during afternoon traffic peak and passing train **[1]**

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In the first variant, we designed separate lane for the left turn at I/67 and II/540. Table 1 lists the average values of ten simulations.

Table 1 The average values of the simulation in AIMSUN software for the current and proposed status

	Unit	Average current status (1.)	Average proposed status (separate line) (2.)	Difference between 1st and 2nd status
Delay time - all vehicles	[sec/km]	13,12	9,04	-4,08
Density - all vehicles	[veh/km]	2,92	2,79	-0,13
Fuel consumption - all vehicles	[l/100 km]	5,27	4,97	-0,30
Track speed - all vehicles	[km/h]	45,32	47,80	2,48
IEM Emissions CO2 - all vehicles	[g/100 km]	72388,06	72348,69	-39,37
Maximum virtual queue - all vehicles	[veh]	3,40	3,40	0,00
Average queue - all vehicles	[veh]	6,37	2,99	-3,38
Speed - all vehicles	[km/h]	47,54	49,21	1,67
Stop time - all vehicles	[sek/km]	7,56	4,31	-3,25
Total travel time - all vehicles	[hour]	74,27	70,31	-3,96
Travel time - all vehicles	[sec/km]	79,45	75,32	-4,13

From the simulation results for the first variant it follows that by creating a separate lane for the left branch the values of the individual variables have changed. In all cases, improvements have been made. Adding the separate lane would therefore have a positive effect on the traffic flow in this section.

In the case where we designed the by – pass road of the village and separate lane for the left turn, the result simulation values were again better than in the current state. However, there has been an increase in fuel consumption of all vehicles that have passed through the system, as well as an increase in CO_2 emissions. The resulting values are shown in Table 2.

Table 2 The average values of the simulation in AIMSUN software for the current and proposed status

	Unit	Average current status (1.)	Average proposed status (separate line + by - pass road) (3.)	Difference between 1st and 3rd status
Delay time - all vehicles	[sec/km]	13,12	8,59	-4,53
Density - all vehicles	[veh/km]	2,92	2,08	-0,84
Fuel consumption - all vehicles	[l/100 km]	5,27	6,98	1,71
Track speed - all vehicles	[km/h]	45,32	49,70	4,38
IEM Emissions CO_2 - all vehicles	[g/100 km]	72388,06	82432,89	10044,82
Maximum virtual queue - all vehicles	[veh.]	3,40	3,25	-0,15
Average queue - all vehicles	[veh]	6,37	1,64	-4,73
Speed - all vehicles	[km/h]	47,54	51,01	3,47
Stop time - all vehicles	[sec/km]	7,56	2,31	-5,25
Total travel time - all vehicles	[hour]	74,27	67,62	-6,65
Travel time - all vehicles	[sec/km]	79,45	72,44	-7,01

Figure 10 shows a graphical comparison from simulation results for the comparison states (up - current state, down - state proposed).

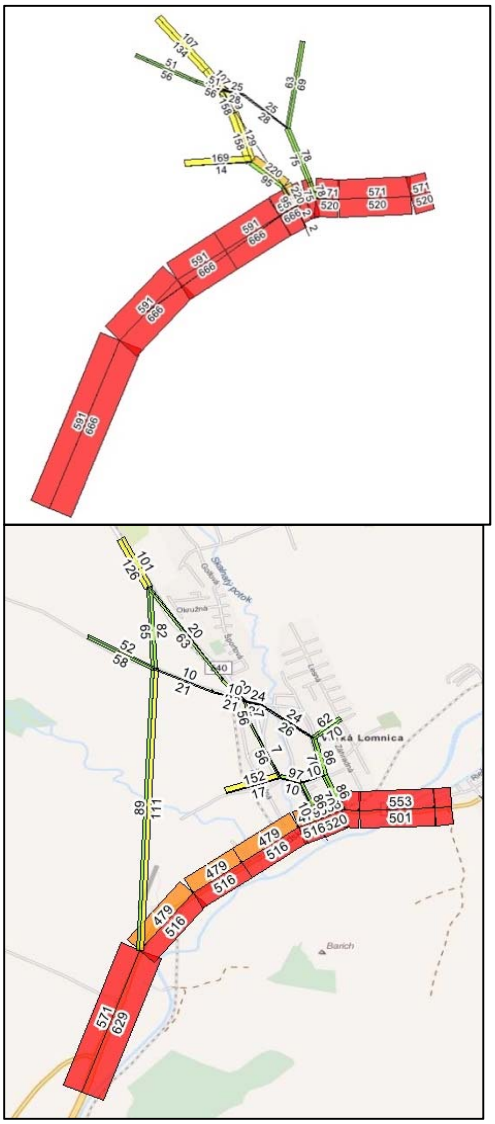

Figure 10 Comparison of current and proposed status load results

Third variant includes a planned by-pass road of Veľká Lomnica in the direction of Kežmarok, which construction should begin in the next few years. The resulting figures have changed significantly against the current situation.

If the traffic in the area will be solved by by - passes and the separate left turn lane proposed by us, first of all, there would be a significant relieving of the village by transit traffic, where all the transit is carried out over capacity roads, and consequently a significant increase in the speed and reduction of delay time also within the village). Average values and comparison among the individual states are shown in Table 4.

Table 4 The average values of the simulation in AIMSUN for the current and proposed status

	Unit	Average current status (1.)	Average proposed status (separate line + by - pass road to High Tatras + by - pass road to Kežmarok) (4.)	Difference between 1st and 4th status
Delay time - all vehicles	[sec/km]	13,12	3,53	-9,59
Density - all vehicles	[veh/km]	2,92	2,08	-0,84
Fuel consumption - all vehicles	[l/100 km]	5,27	8,58	3,31
Track speed - all vehicles	[km/h]	45,32	71,77	26,45
IEM Emissions CO_2 - all vehicles	[g/100 km]	72388,06	89713,88	17325,82
Maximum virtual queue - all vehicles	[veh]	3,40	2,00	-1,40
Average queue - all vehicles	[veh]	6,37	0,60	-5,77
Speed - all vehicles	[km/h]	47,54	77,98	30,44
Stop time - all vehicles	[sec/km]	7,56	0,96	-6,59
Total travel time - all vehicles	[hour]	74,27	47,20	-27,07
Travel time - all vehicles	[sec/km]	79,45	50,17	-29,28

Figure 11 shows a graphical comparison of the simulation results for the comparison states (up - current state, down - state proposed).

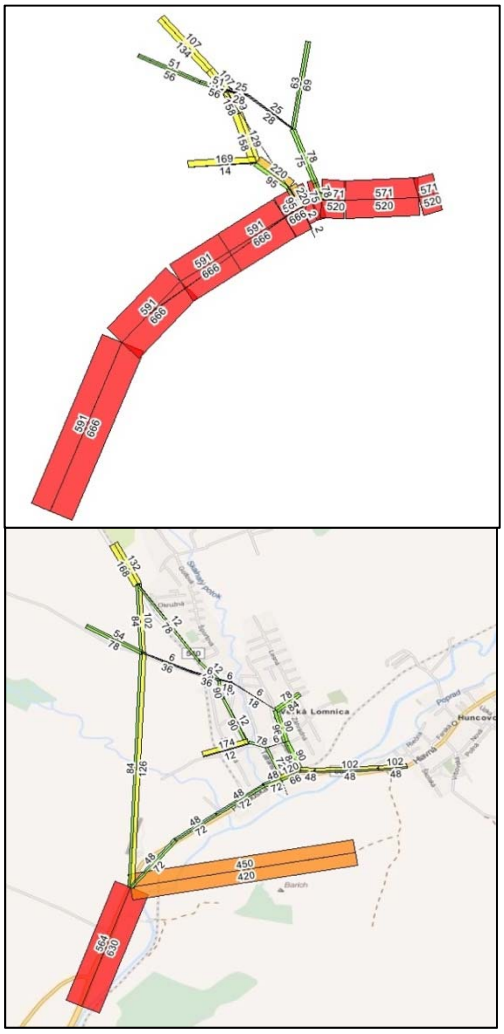

Figure 11 Comparison of current and proposed status load results

Table 5 compares the differences between the proposed solutions. Each solution produces positive results in the form of acceleration of traffic in the area, i.e., speeding up all vehicles, reducing travel time, reducing downtime, resulting in a reduction in total travel time.

Table 5 The difference in the values of the variables between the individual proposed status

	Unit	Difference between 2nd and 3rd status	Difference between 2nd and 4th status	Difference between 3rd and 4th status
Delay time - all vehicles	[sec/km]	0,45	-5,51	-5,06
Dentisy - all vehicles	[veh/km]	0,71	-0,71	0,00
Fuel consumption - all vehicles	[l/100 km]	-2,01	3,61	1,60
Track speed - all vehicles	[km/h]	-1,90	23,97	22,07
IEM Emissions CO_2 - all vehicles	[g/100 km]	-11848,29	19129,29	7280,99
Maximum virtual queue - all vehicles	[veh]	0,15	-1,40	-1,25
Average queue - all vehicles	[veh]	1,35	-2,39	-1,04
Speed - all vehicles	[km/h]	-1,80	28,77	26,98
Stop time - all vehicles	[sec/km]	2,00	-3,34	-1,35
Total travel time - all vehicles	[hour]	2,68	-23,11	-20,42
Travel time - all vehicles	[sec/km]	2,88	-25,15	-22,27

4. Conclusion

Based on the results of traffic survey and simulations in the AIMSUN software, we considered proposal 1 and design 2. It was still compared with the zero variation - the current state. We can say that each of the proposed solutions has a positive impact on the transport situation in the area. Although Veľká Lomnica is a small village, transport is very complicated, and these proposals can not only improve the quality of life of the population but also the development of tourism, thanks to the better accessibility of the High Tatras.

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