Microscopic Simulation of New Traffic Organisation in the City of Lučenec

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Abstract. Sustainable development of road infrastructure has been the most discussed issue in Slovakia in few last years. Mainly in bigger cities road infrastructure is overloaded and ceases to satisfy the needs of road users. There is many possibilities how to solve this issue. We can build new roads and connections between points of interest (origin and destination) but this solution is not acceptable in every area of Slovakia because of lack of space and environment protection as well as financing. Solution, that is more suitable, is to use intelligent transport systems and try to reorganizing some transport routes in the most overloaded sections. We have used software Aimsun to simulate new traffic conditions and evaluate their effects on traffic situation. In our contribution, we focused on difficult traffic situation in the city of Lučenec. We made a microscopic simulation and compared a current state and a new traffic organization using software Aimsun.

Keywords: Microscopic simulation · Intersection · Traffic model
Accident section

1 Introduction

Transportation mobility is very often discussed issue in Slovakia. Road infrastructure, mostly in big cities, ceases to satisfy in terms of capacity and permeability. Cities have tried to solve this problem but firstly it is necessary to change human thinking. Nowadays, every second person owns motor vehicle. The intensity of vehicles on roads is unsustainable. Traffic accidents rate is closely related on vehicles intensity. The ambitious objective of Slovakia's commitment under the European Road Safety Charter to reduce the number of fatalities in road accidents to half by 2010 in comparison with 2002, when 610 people were killed on our roads, was not fulfilled. We managed to lower the number to 345 fatalities, what represents a 43% decrease. Even though we failed to meet the commitment mentioned above, subsequent statistical indicators of accident rates in the Slovak Republic, which show a downward trend, are positively perceived in Slovakia as well as in the European Union [1].

In connection with traffic accidents, traffic police regularly identifies critical sections and intersections where serious traffic accidents mostly occurred. Regional police

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headquarters make a list of accidental sections for summer and winter seasons every six months. Winter season is taken from October to March and summer season from April to September. According to intern documents of police, accident spot is a section with minimum hundred meters (intersections, pedestrian crossing, entrance or exit of objects, etc.) where the minimum of five accidents have occurred during six months. An accident section represents section of a kilometer length where the minimum of five accidents have occurred during six months. In the last evaluation of winter season, the section in urban area of the Lučenec city was evaluated as an accident section from 193,100 to 194,070 km (total length 970 m). Mentioned section has been regularly marked as accidental in last six years [1, 2].

This accident section begins in Haličská cesta Street at the intersection of J. Szabó Street and Dukelských hrdinov Street and ends in Masarykova Street at the intersection of I/75 - Karmána Street and II/585 - Vajanského Street (See Fig. 1). A carriageway has two lanes and in some parts four lanes and it is directionally divided by continuous white line. In this section, there are six intersections one of them is managed by traffic lights, six pedestrian crossings, reserved bus stops at driving lane and stopping lane for parking. There have been recorded seven traffic accidents during the chosen period. The causes of accidents were as follows: breach of driver obligations, wrong driving in lanes, and improper driving through intersections. In this section, there is no marking to warn drivers that it is an accident section.

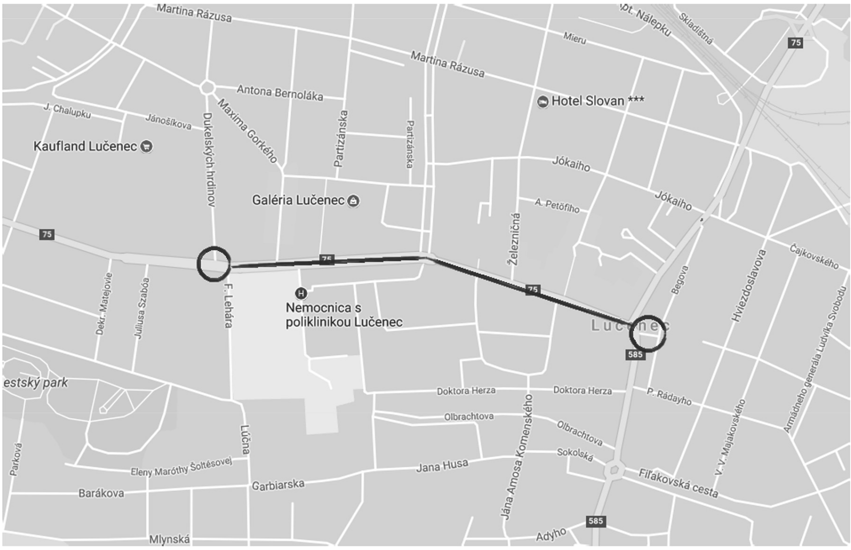

Fig. 1. The accident section in the city of Lučenec [own study using google maps].

In the city of Lučenec there is a high intensity of motor vehicles. The accident rate is related on intensity as we mentioned before, therefor we have tried to simulate a current state of traffic situation in this city and then implement some changes in our traffic model to improve bad traffic situation [2, 3].

2 Traffic Modelling in the City of Lučenec

First, we have chosen the accident section which would be simulated. The section was chosen because of the highest intensity of motor vehicles in the city and high prognosis of traffic accident occurrence (see Fig. 1). Then, we have made a traffic model using software Aimsun. This software allows making microscopic and macroscopic simulations. As input data, we used traffic volume and routing from traffic survey, which was made by the University of Žilina on 15th of October 2016 and junction signal plans. We have simulated a current state of traffic, obtained results and modified model with new parameters and traffic conditions. Comparison and evaluation between these two states were made and the results are described below [3].

2.1 Modelling of Current State

First step of our simulation was to draw the chosen city infrastructure network and create a traffic model. We defined the layout, length and wide of lanes, signal plans on intersections managed by traffic lights, speed limits, restrictions and traffic rules. The traffic volume and routing of vehicles were set up according the transport survey using origin/destination matrices. Figure 2 represents the proportion of origin and destination transport also with dividing according to modes of transport. Origin transportation is transport that starts in the city center and its destination is outside the city. On the other hand, destination transportation is transport that an origin is outside the city and a destination is in the city center, and transit transportation is transport that an origin as well as a destination is outside the city and just passes through the city [4].

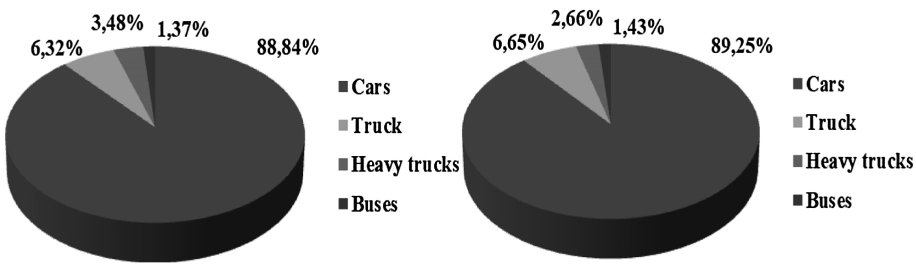

Fig. 2. Proportion of origin (left) and destination (right) transportation [own study].

These values were used to create an origin/destination matrices including transit transportation (see Fig. 3). Model was also calibrated according to values from transport survey. The simulation time was set up on 4 h including traffic peak hour.

After road network and origin/destination matrices defining, we implemented signal plans. As we mentioned before there are six intersections at our chosen accident section but only one is managed by traffic light signalization. We input times of several signal groups and their succession and related traffic movements. In Fig. 4 you can see the signal plan of junction and traffic movements' definitions [2, 5].

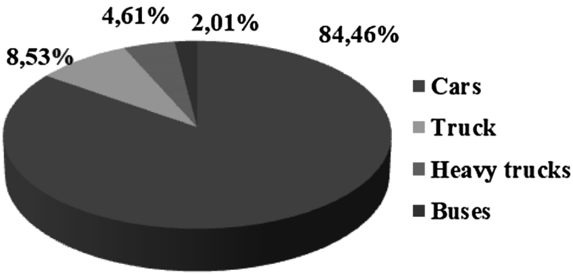

Fig. 3. Transit transportation with dividing according modes of transport [own study].

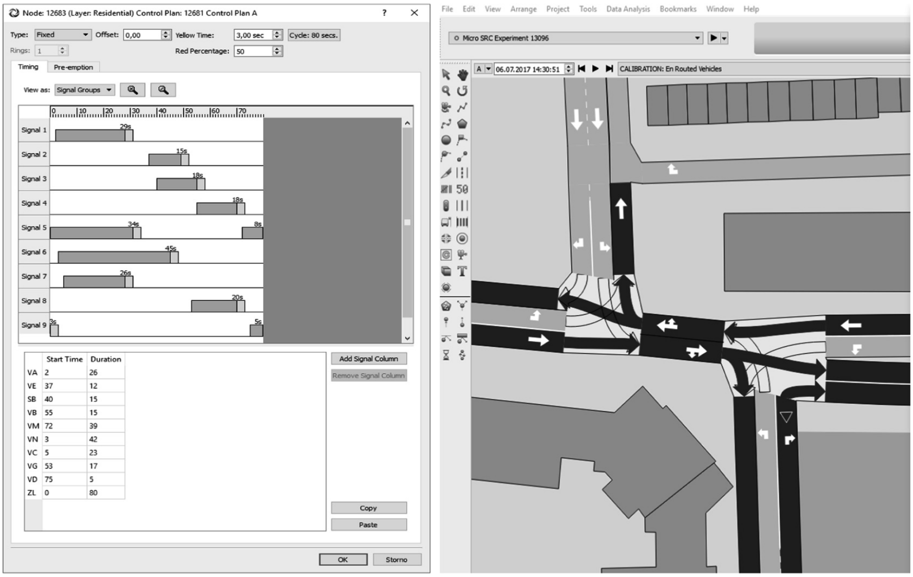

Fig. 4. Signal plan of junction managed by traffic light siganlization and related traffic movements [own study using Aimsun].

When everything was set up, we started simulations. Many simulations of current state were running and the results were averaged (Fig. 5).

Aimsun allows obtaining many characteristics of whole network as well as characteristics of a chosen section. For our needs, we focused and gathered only characteristics as follows: delay time, speed, number of stops and travel time [6, 7].

We have simulated four hours from 2 p.m. to 6 p.m. including traffic peak hour from 3:45 p.m. to 4:45 p.m. In Table 1, there are simulation outputs of a current state for the whole network. Standard deviations of the chosen parameters are also included. We have used a simplification where we put trucks and heavy trucks into the same category as Trucks.

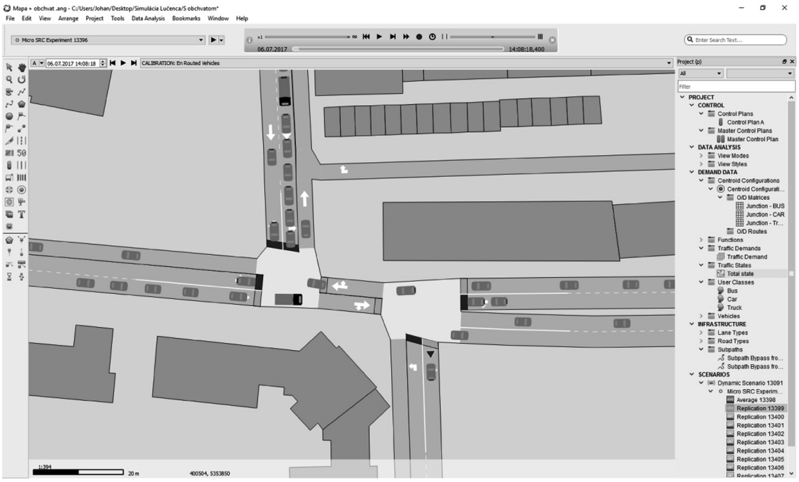

Fig. 5. Microscopic simulation in Aimsun [own study using Aimsun].

Table 1. Simulation outputs of the chosen characteristics of the whole network [own study].

	Cars		Trucks		Buses		All	
	Value	SD[a]	Value	SD	Value	SD	Value	SD
Delay time [sec/km]	99,9	9,01	70,34	9,67	137,43	29,28	99,2	9,01
Number of stops [#/veh/km]	0,01	0,00	0,01	0,00	0,00	0,00	0,01	0,00
Speed [km/h]	40,02	0,26	38,64	0,65	37,46	1,08	39,94	0,27
Stop time [sec/km]	90,86	8,99	58,64	9,20	127,23	28,84	90,05	8,81
Travel time [sec/km]	166,66	9,18	139,65	9,69	210,44	29,18	166,12	9,01

[a]Standard Deviation

As you can see in Table 1, buses recorded the highest delay time. It is necessary to say that this delay time could be affected by time spent on bus stops. These values are obtained for whole network. Higher values of the chosen characteristics may seem to be insignificant for whole network but for some sections may be notable. The next Table 2 represents values obtained only of the chosen accident section [8, 9].

This section is divided by direction on two parts. The first one is the direction from Haličská cesta Street at the intersection of J.Szabó Street and Dukelských hrdinov Street to the intersection of I/75 - Karmána Street and II/585 - Vajanského Street (Table 2-left). The second one is opposite direction from the intersection of I/75 - Karmána Street and II/585 - Vajanského Street to the Haličská cesta Street at the intersection of J.Szabó Street and Dukelských hrdinov Street (Table 2-right). We have divided this section because of better and detailed evaluation of the accident section in the city. Values shown in this table are obtained and evaluated for all modes of transport together and recorded in ten minutes intervals. The traffic peak hour is highlighted in square.

Table 2. Simulation outputs for all categories of vehicles at the chosen accident section in each direction [own study].

	Direction from Haličska cesta Street				Direction from Karmána Street			
Intervals	Delay time [sec/km]	Number of stops [#/veh/km]	Speed [km/h]	Travel time [sec/km]	Delay time [sec/km]	Number of stops [#/veh/km]	Speed [km/h]	Travel time [sec/km]
14:10:00	66,19	1,86	48,04	429,36	37,40	0,86	50,21	408,63
14:20:00	57,83	1,76	48,23	427,05	37,41	0,83	51,93	393,45
14:30:00	70,48	2,28	48,47	425,11	49,72	1,07	49,19	420,35
14:40:00	77,79	2,20	45,94	449,64	50,40	0,94	51,14	404,34
14:50:00	83,97	2,33	44,64	461,56	33,66	0,75	51,68	397,98
15:00:00	68,21	2,14	48,37	425,01	41,50	1,00	51,92	395,72
15:10:00	56,40	1,79	48,67	422,05	38,35	0,78	49,82	411,15
15:20:00	62,22	1,85	48,99	421,26	35,61	0,88	53,40	384,93
15:30:00	71,69	2,17	48,08	431,87	32,92	0,86	51,28	400,03
15:40:00	50,78	1,76	48,70	424,10	42,90	0,83	52,00	396,48
15:50:00	73,93	2,07	47,91	430,05	35,25	1,00	51,02	401,49
16:00:00	59,56	1,97	48,33	426,85	38,18	0,81	52,00	393,55
16:10:00	58,53	1,62	49,22	420,87	40,33	0,80	50,30	406,31
16:20:00	70,61	1,96	46,68	441,98	47,86	1,15	49,69	411,60
16:30:00	82,61	2,38	45,15	456,47	32,06	0,62	49,12	419,29
16:40:00	54,77	1,75	48,33	424,76	41,33	0,87	50,27	408,74
16:50:00	53,83	1,83	48,36	425,26	43,50	1,00	50,43	407,27
17:00:00	69,07	2,00	48,45	426,52	47,61	0,94	51,47	399,40
17:10:00	65,44	2,00	47,09	436,52	32,25	0,73	51,80	396,41
17:20:00	62,43	1,83	49,26	418,91	37,66	0,92	51,61	397,04
17:30:00	52,56	1,93	48,22	428,42	33,51	0,75	51,66	396,90
17:40:00	66,92	2,13	47,08	437,33	31,28	0,56	53,01	385,76
17:50:00	65,96	2,04	48,52	426,50	36,12	0,92	50,86	402,16
18:00:00	85,11	2,22	46,56	445,46	35,49	0,93	53,31	385,17

Table 2 shows that traffic situation affects permeability and fluency of traffic in both directions differently. The simulated accident section has 5660 m of length and the highest delay time was recorded in interval from 4:30 p.m. to 4:40 p.m. of value 82,61 sec/km in direction from Haličská cesta Street. This is relatively a high value. If our route has 5660 m of length, the total delay time will be about seven minutes. In opposite direction the highest value of delay time is 47,86 sec/km. It is a half of delay time in direction from Haličská cesta Street.

Users of transport who drive through this section regularly complain to traffic situation which getting worse every day. Therefore, we have proposed a city bypass, made a simulation of traffic situation with modifications and evaluated gathered outputs [9–11].

2.2 Modelling of a City Bypass

A proposal of city bypass we designed at the beginning of the city as the Fig. 6 shows. The bypass is highlighted by darker dashed line in the upper part of the figure. This communication should ensure that the intensity in the city center would be reduced at least by intensity of transit transport. We have also expected that other drivers may want to get a destination, using bypass because of less travel time and delay time due to higher speed and lower intensity of traffic [8].

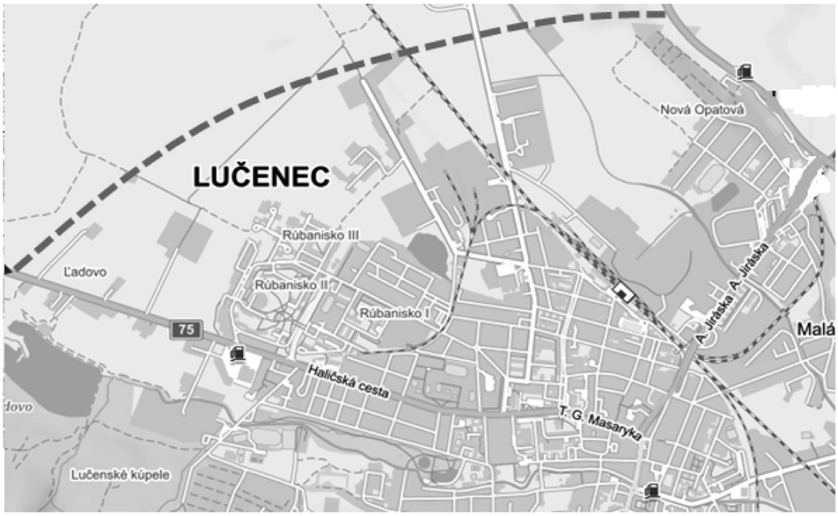

Fig. 6. The proposal of bypass in the city of Lučenec [own study using google maps].

Traffic conditions were set up the same as in current state. Some modifications were also set up, design of bypass, speed limit and redistribution of traffic flow. We made a simulation in duration of 4 h from 2 p.m. to 6 p.m. The characteristics for whole network were obtained as well as for the chosen accident section. After that, we evaluated and compared the chosen characteristics of current state to characteristics of modified traffic state. We recorded characteristics in the same way as in current state so in the form of table. However, we present our results in graphical form for better understanding and easier comparison. In this paper, we have decided to compare only the most significant characteristics as delay time and travel time. According to our transport-sociological survey, which has been made by University of Žilina in region of Žilina, drivers are most interested in these two characteristics which are the most important when making decision of travel from origin to destination. Figure 7 represents a comparison of delay time in current state and after bypass proposal. On the left, there is direction from Karmána Street to the city centre, on the right is opposite direction from Haličská cesta Street to the city centre [9, 11, 12].

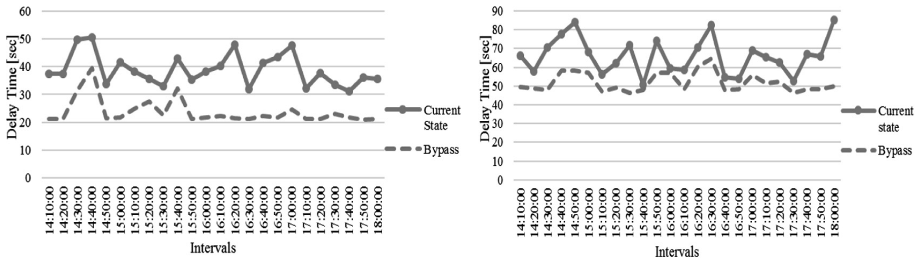

Fig. 7. Delay time running during simulation on each direction of the chosen accident section [own study using Aimsun].

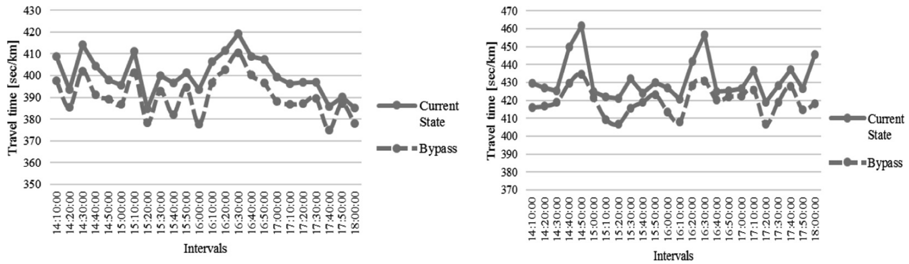

Fig. 8. Travel time running during simulation on each direction of the chosen accident section [own study using Aimsun].

Figure 8 shows running of travel time during simulations also on each direction of the chosen accident section. On the left, there is direction from Karmána Street to the city centre, on the right is opposite direction from Haličská cesta Street to the city centre.

As you can see, delay time is reduced about 15 s in average for traffic situation using bypass. Bypass also reduces travel time about 11 s in average. Except delay time and travel time reducing, this modification improves traffic safety in terms of intensity dividing to bypass and road that leads through the city centre. With lower intensity on accident section there is lower probability of traffic accident occurrence.

3 Conclusion

In the city of Lučenec there is a high intensity of motor vehicles. In our paper we have made simulations of a current state of traffic situation in this city and then implemented a bypass in our traffic model to improve bad traffic situation. According transport survey made by University of Žilina we set up traffic volume and its routing using origin/destination matrices. Due to simulations we obtained some important characteristics as delay time and travel time and we were able to obtain final results of traffic situation in current state and design a suitable solution including bypass to improve the situation in the city centre of Lučenec city [3, 13]. Simulation results have shown that bypass reduce delay time as well as travel time which would have a positive effect to traffic safety and contribute to transport users' satisfaction.

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