Ecological Impact of Changes in Transport Organisation in Martin with Using Transport-Planning Software

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Abstract Using motor vehicles, which uses fossil fuels, is connected with emissions. The main goal of cities, towns and also of the state is to keep these emissions as low as possible. Vehicles move on a traffic network where they are forced to accelerate and decelerate due to various impacts. Junctions and traffic jams are examples of these impacts. An important task is to build transport networks and junctions where vehicles can cross the junction as quickly as possible without unnecessary delay and a significant change in speed. This can contribute to lower vehicle fuel consumption and thus lower emissions.

Keywords circular junctions, traffic survey, emissions, simulation

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1. Introduction

Nowadays the traffic planning software is commonly used for finding the way how to change the organization of traffic at junctions or on the whole transport network. Such software can record not only traffic characteristics, but also vehicle consumption and emissions [1, 7].

The intersected crossing is located in the centre of Martin. It is one of the important roads connecting the city centre with the first class road no. I/65 and the housing estate Podháj - Stráne. The junction is uncontrolled with four arms and has only one level. Close to this junction there is an overpass which allows overcoming the altitude difference between this junction and next intersection on the first class road no. I/65. It also allows a smooth crossing over the railway track, which connects the towns of Martin and Vrútky. This results in a safer and more fluid traffic.

Close to the junction, there are residential apartments, department store LIDL, bus stop, overpass, Secondary Combined School in Martin, Development Company in Martin, district police department, restaurant and other smaller shops.

Figure number 1 shows important civilian objects which are located near the junction. Objects are marked with following colours:

- red – department store LIDL,
- yellow – Secondary Combined School in Martin,
- purple – Development Company in Martin,
- green – district police department,
- pink – restaurant and shops.

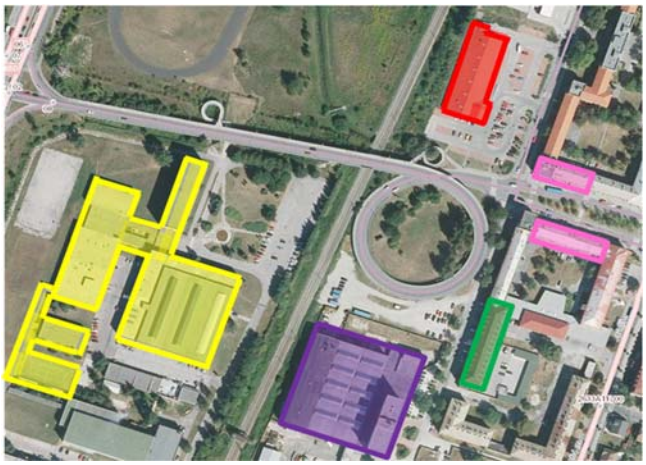

Figure 1. Junction and important buildings marked with colours.

2. Traffic survey

The traffic survey was performed on Wednesday, October 28, 2015. The temperature was 7 °C in the morning and around 15 °C around lunchtime. At the time of the survey there was semi-cloudy sky with a wind speed of 1 - 5 m/s.

The total time of traffic survey should be 8 hours. It can be divided into two 4-hour parts. We performed survey of total duration of 10 hours. Distribution of traffic during day is uneven, so the traffic survey was divided into two 5-hour parts [5, 6]. The first part of the survey lasted from 6:00 to 11:00 am and the second in the afternoon from 13:00 to 18:00 p.m. Traffic jams at the junction are shown in the following figure.

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Figure 2. Location of inputs and posts

Figure 3. Location of inputs and posts

After the survey, it was possible to start its evaluation. The information from survey is necessary for capacitive calculation, transport modelling and simulation. The least loaded input was number 2, where its load over the entire survey time reached 124 vehicles. Direction of individual vehicles across the intersection area during the peak hour between 7:30 and 8:30 a.m. is shown in the following table [9, 13].

Table 1. Direction of vehicles during the peak hour

Input	Left	Straight	Right	Total
1	2	219	72	293
2	6	1	15	22
3	153	296	8	457
4	116	2	35	153
Total	277	518	130	**925**

The total number of vehicles that crossed the intersection from all inputs during the survey was 6,834. The entry with the highest load was input 3, which was used by 3,170 vehicles during the whole time of survey.

3. Microsimulation of current state and future proposal

The transport simulation system - Aimsun was used for creating the transport model. It is software from the Spanish company and it is commonly used for traffic planning. In this case, it was used for creating of two transport models. These were constructed on the basis of technical conditions TP102 - Capacity Calculations. Traffic models are based on mapped data and real scale. They reflect reality as accurately as possible. Ten simulations were created for both transport models and then the average was constructed. The total length of each simulation was two hours, i.e. from 7:00 to 9:00 [2, 4].

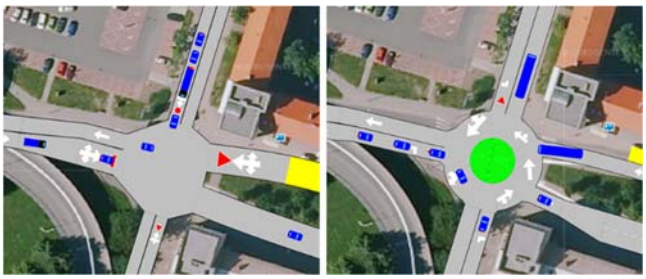

Figure 4. Creation of transport models for current and future state, source: author - processed in Aimsun software

An important recording parameter for each simulation was the residence time and its course over time. These data were then to be compared between each other [10].

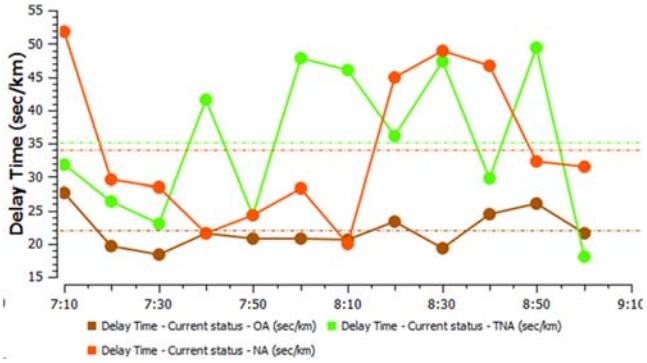

Figure 5. Delay time progress for uncontrolled junction

Progress of average delay time is shown in the figure number 6. For the each vehicle in simulation it has value of 23.15 seconds.

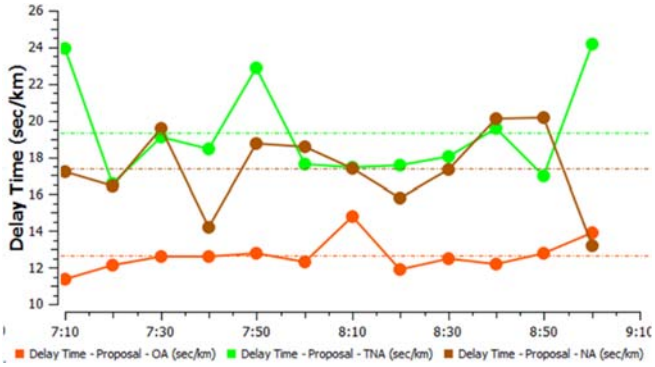

Figure 6. Delay time progress for circular junction

The average delay time for each vehicle is shown in the figure number 7. Its value is at a level of 13.17 seconds for the current state of junction. From the picture it is obvious that the circular junction achieves lower values than the uncontrolled junction. The difference between these two types of junctions is 9.98 s for each vehicle [2, 3]. Time savings are therefore at 43.11%. Additional simulated parameters are shown in the following table.

Table 2. Direction of vehicles during the peak hour

Parameter	Current status	Proposal	Units
Delay time	23.15	13.17	sec/km
Density	7.32	7.49	veh/km
Traffic flow	912.3	901.1	veh/h
Harmonic speed	25.84	29.38	km/h
Num. of all stops	1.44	0.72	#/veh/km
Stop time	21.4	3.6	sec/km
Travel time	139.35	122.55	sec/km

As can be seen from tab. 3, for most of the parameters recorded, the individual values decreased except for the incremental velocity and density that had increased. A very significant decrease was recorded at the time of the station and up to 17.80 sec/km. This difference represents a decrease of up to 83.18%. On the basis of the simulations performed, it can be stated that at the current traffic intensity, the circular junction can reduce the individual delays, not to a small extent. Simulated intensity and density are very similar. It is therefore possible to consider the given simulations as very objective [8, 13].

The reduction of the above-mentioned traffic characteristics also leads to a reduction of the individual types of emissions produced by vehicles at the junction. Traffic planning software TSS-Aimsun allowed to choose from two possible emission calculations: QUARTET, 1992 and Panis et al, 2006. The second option was the second option for calculating emissions according to the pre-set parameters from the traffic planning software. Choice of the option is in the figure number 7 [14, 15].

Figure 7. Choice of the emission calculation

Totally in traffic planning software 4 emission categories were recorded - IEM Emission CO2, NOx, PM and VOC. Recorded values are shown in the table number 4 [11, 12].

Table 3. Direction of vehicles during the peak hour

Characteristics	Current status	Proposal	Units	Decrease [%]
IEM Emission – CO2	600 040.7	480 014.35	g	20.00%
IEM Emission – NOx	4 300.2	3 800.29	g	11.63%
IEM Emission – PM	168.66	124.31	g	26.30%
IEM Emission – VOC	353.87	350.33	g	1.00%

The most significant decrease of 26.30% in emissions was recorded for IEM Emission – PM. On the contrary the smallest decrease reaching 1.00% and can be considered a non-changeable value in these microsimulations. All these indicators are related to previous recorded traffic characteristics. The drop in emission values is directly related to the reduction in vehicle consumption, as there are shorter delays and a smoother passage on a simulated junction, with fewer stops.

4. Conclusions

By changing the organization of traffic at chose junction in Martin, it is possible to improve some characteristics. The proposal of a new roundabout can reduce delay time, number of stops, total travel time and also stop time. The biggest decrease from all individual parameters has stop time. It decreased by 83.18% and delay time decreased by 43.11%. For these data, the segment speed was increased by 13.70% on individual sections of roads. Overall, we managed to reduce our average emissions by 14.73% on average.

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