THE SOLUTION TO THE TRAFFIC SITUATION ON THE SELECTED ROAD SECTION IN THE PROGRAM PTV VISTRO

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Abstract

The article discusses the solution to the traffic situation on the selected traffic section of road II/552 in the city of Košice using simulations in the PTV Vistro program. The current state of the traffic section does not meet the requirements for the flow of traffic for a long time, and it is necessary to take measures to increase its throughput. From the data obtained during the survey, a simulation model is created that reflects the current state of the entire section, and an analysis of the traffic situation is carried out. The research aims to propose alternative solutions and select the optimal option for the reconstruction of the section. The proposal considers that traffic volume increase with the increasing level of passenger car use.

Keywords: Simulation, road traffic, PTV Vistro, optimisation

1. INTRODUCTION

Transport is a significant part of urban logistics. When urban road capacity is insufficient or traffic is poorly managed, the negative impacts are borne by the travelling public and businesses alike. Modelling and simulations in transport are important elements in dealing with problematic traffic situations. Designers of traffic systems might take advantage of the simulation-before-construction approach that allows them to study the system behaviour using simulation models [1]. Several papers dealt with the issue of intersections and traffic signal optimization. The main goal of the study by [2] was to improve traffic light management at a specific intersection. Similarly, the paper by [3] proposed a traffic signal control system to maximize the number of vehicles crossing an intersection and balance the signals between roads. In another study [4], a fuzzy-based model for controlling congestion at the crossroad covering the demands of real-time traffic conditions was designed. Authors of [5] formulated a microscopic model for the modern tram system integrated with a road traffic simulation. The next group of works is research focused on the problem of the reliability of a traffic model, which should obtain the real-world traffic on the roads as accurately as possible. The authors of the research [6] argue that ideal traffic-light programs should not only have an optimized fitness but also a high reliability, i.e., low fitness variance, against the uncertainties of the real world. Likewise, the authors of the paper [7] concluded that traffic microsimulations cannot be relied upon to evaluate macroscopically optimized signal timings. According to their research, when macroscopically optimized signal timings were evaluated through microsimulation, their efficiency was inconsistent. As mentioned, computer simulations are crucial for the designers of traffic systems. Models and traffic analysis can be made using various simulation tools. For instance, [8] evaluated and compared the performance of the optimal signal timing plans by Highway Capacity Software, Tru-Traffic, Vistro, and Vissim. The research by [9] proposed a simulation model evaluating action plans to reduce traffic jams and conflicts using the VISSIMTM simulation program. Similarly, [10] solved the problem of traffic congestion with the help of PTV Vissim, and Vissim was also used by [11] in optimizing urban transportation demand management.

The aim of this paper is to present an optimization of road transportation using the Vistro simulation program. The procedure is demonstrated on the case study of road II/552 reconstruction in the city of Košice.

2. MATERIALS AND METHODS

2.1 Characteristics of the selected road section and problem definition

The selected section of road II/552 is located in the city of Košice (**Figure 1**). The section is part of the main route to Košice, and at the same time, it is the only link between the city and the Košice - Nad jazerom district. The traffic situation in the selected section is characterized by significant traffic congestion, especially in the morning and afternoon rush hours. The goal and research methods are focused on this problem. The solution requires carrying out a traffic survey, creating a traffic model in the Vistro program, proposing a new solution for individual intersections, and checking the effects of the solution through simulation. Crossroads are marked in **Figure 1** as follows: 1-Entrance to road II/552, 2-Textilná, 3-Dneperská, 4-Napájadlá.

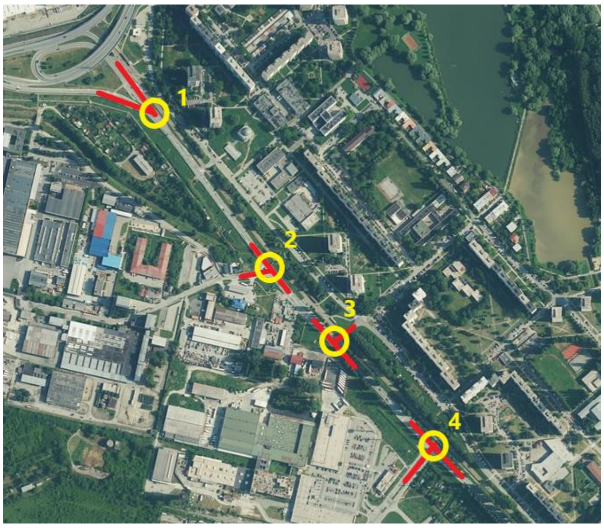

Figure 1 Analysed road section II/552

2.2 Results of the traffic survey

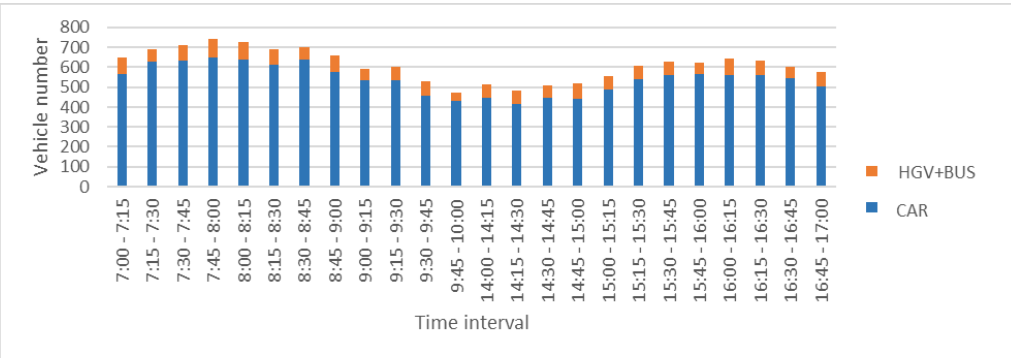

Figure 2 Traffic load of the monitored section

The traffic survey was conducted on the section during weekdays during March 2023. For the purposes of the traffic survey, a freely available online traffic camera of the company ANTIK Telecom was used. For the traffic survey, two intervals were determined during peak traffic times. The first interval was from 7:00 to 10:00. The second interval was between 14:00 and 17:00. The individual intervals were separated by 15 minutes. The evaluation of the traffic survey of road II/552 is presented in **Figure 2**. The traffic forecast calculated for the maximum intensity per hour is in **Table 1**.

2.3 Forecast of increase in traffic intensity

The traffic growth factor method was used to calculate the increase in traffic volume on the monitored section for the year 2040. The determination of traffic growth coefficients was based on TP 07/2013. These are the technical conditions for forecasting future intensities on road networks until 2040. Coefficients for 2nd class roads for the year 2040 and traffic forecasts are shown in **Table 1**.

Table 1 Traffic growth forecast

Time of the morning traffic rush	**Type of vehicle**	
	Light vehicles	**Heavy vehicles**
7:15 - 7:30	630	62
7:30 - 7:45	632	80
7:45 - 8:00	648	93
8:00 - 8:15	641	88
Together for the present	**2551**	**323**
Coefficient of growth	1.15	1.13
Together for 2040	**2934**	**365**

2.4 Assessment of the quality of traffic flows and the quality of transport

To differentiate the quality levels of traffic flows (QSV) according to TP 16/2015, the tolerance limit of density determined according to **Table 2** applies. The level of quality of traffic (LOS) is a qualitative measure used to compare the quality of traffic service by motor vehicles. According to TP 16/2015, we divide the levels of transport quality into individual classes. **Table 2** shows the individual levels of traffic quality (LOS).

Table 2 Tolerant traffic flow densities according to QSV and permissible values of waiting time for individual levels of transport quality (LOS).

Quality level of traffic streams (QSV)		**Level of Service (LOS)**		
QSV	**Traffic flow density [veh/km]**	**LOS**	**Characteristics of waiting time**	**Average waiting time [s]**
A	≤ 5	A	The waiting time is very short	≤ 10
B	≤ 12	B	Short waiting time with no queues	≤ 20
C	≤ 20	C	Acceptable waiting time and rarely short queues	≤ 30
D	≤ 30	D	Stable state with high time losses	≤ 45
E	≤ 40	E	Unstable state	> 45
F	> 40	F	Exceeded capacity	-

3. RESULTS

3.1 Proposal for the solution of the first monitored section

PTV Vistro software was used to simulate the entire monitored section of road II/552. From the simulation results (**Table 3**), we found that the monitored section reaches the traffic quality level of level F. Level F signals the breakdown of the smooth movement of vehicles the traffic collapses, which leads to a stop and the formation of vehicle columns.

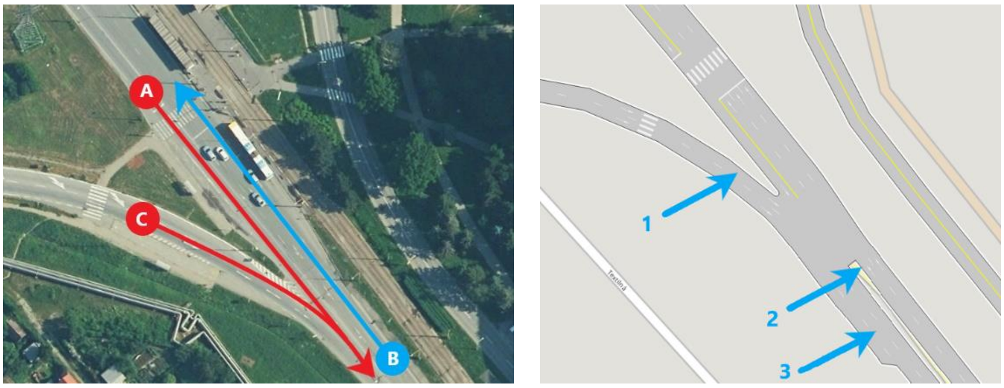

Figure 3 The original state (left) and the proposed modification of the of the first section (right)

Table 3 Simulation results of the first monitored section

Parameter	Stream B	Stream A	Stream C
Delay [s/veh]		24.37	74.45
LOS - entrance		C	F
Delay on the section [s/veh]		49.41	
LOS - section		F	

Due to the insufficient permeability of this section, several modifications were proposed on this section (see **Figure 3 right**):

1. Expansion of the number of driving lanes to the number of two driving lanes in both directions along the entire length of the section.
2. Addition of a dividing centre strip to separate the driving directions for traffic safety.
3. Addition of a feeder lane for smooth shifting of vehicles on the section.

Table 4 presents the grade of traffic flow quality for the original and proposed road conditions. The implementation of individual modifications would lead to a slight improvement in traffic flow on the monitored section from grade F to D. Quality grade D represents a situation where the free speed of the traffic flow decreases, and that significantly limits the possibilities of maneuvering vehicles within this flow.

Table 4 Transport parameters for the original and proposed state

Parameter	Present state	Proposed state
Traffic intensity [veh/h]	2874	1437
Traffic density [veh/km]	57.48	28.74
QSV	F	D

3.2 Proposal for the solution of the Textilná intersection

The following **Figure 4** shows the original state of the Textilná intersection (on the left) and the proposal for modification. The proposal consists of converting the original intersection into a three-arm roundabout with two lanes. Since entrance A is on the main road and has the right-of-way for going straight or turning right, it does not create a delay in its original state. It is similar at entrance B, where there are no delays when going straight, only when turning left. **Table 5** shows the degree of traffic quality for both the original and the proposed state of the intersection.

Figure 4 The original state (left) and the proposed state of the intersection Textilná (right)

Table 5 Simulation of the original and proposed state of the Textilná intersection

	Parameter	**Entrance A**		**Entrance B**		**Entrance C**	
Original state	Direction	Straight	Right	Left	Straight	Left	Right
	LOS - entrance			C		F	C
	Delay on the section [s/veh]	32.11					
	LOS - section	D					
Proposed state	Delay [s/veh]	8.27	9.45	7.91	9.03	12.97	
	LOS - entrance	A	A	A	A	B	
	Delay on the section [s/veh]	7.94					
	LOS - section	A					

Compared to the original state of the intersection, this proposal contributed to the reduction of delays caused by entrances B towards Textilná Street and entrance C in both directions.

3.3 Proposal for a solution of the Dneperská intersection

With the original traffic solution on this road section, we can observe similar problems as with the previous one, the Textilná intersection. Compared to that intersection, a side road from the northeast joins this section. A significant problem in this section was that the entrance E of the original intersection consisted of a single lane for both the right and left directions (**Figure 5**).

Figure 5 Model of the original state (left) and the proposed state of the Dneperská intersection with traffic lights (right)

As a result, if left-turning vehicles were waiting to pass, they directly influenced the following vehicles waiting behind them, intending to turn right. **Figure 5** shows the original state of the Dneperská intersection (left). It was proposed to change the organization to a four-lane road, change the intersection to be controlled by light signalling, and add a pedestrian crossing. For signals, the cycle was set at 90 seconds. The expected consequence of the addition of light signalling should be an increase in safety and the level of traffic quality in the section. **Table 6** presents the simulation results obtained after the implementation of all proposed solutions in the model.

Table 6 Simulation of the original and proposed state of the Dneperská intersection

	Parameter	**Entrance D**		**Entrance E**		**Entrance F**	
Original state	Direction	Straight	Right	Left	Straight	Left	Right
	LOS - entrance	B		E	D		
	Delay on the section [s/veh]	24.35					
	LOS - section	C					
Proposed state	Delay [s/veh]	8.27	9.45	7.91	9.03	12.97	
	LOS - entrance	B	A	C	B	B	
	Delay on the section [s/veh]	15.02					
	LOS - section	B					

3.4 Proposal for a solution for the section of the Napájadla intersection

Originally, this intersection was controlled by light signalling. It is currently in the process of long-term reconstruction, and it was not possible to find out the former light signal cycle. For this reason, in the original condition of the intersection, the optimal setting of the light signalling was used given the traffic intensity found during the survey. **Figure 6** shows the original and proposed state of the Nápájadlá intersection. For the final section, the Napájadlá intersection, the creation of a three-arm roundabout was proposed. An alternative solution for the Napájadlá intersection is shown in the following **Figure 6**.

Figure 6 Model of the original state (left) and the proposed state of the Napájadlá intersection (right)

Table 7 Simulation of the original and proposed state of the Napájadlá intersection

	Parameter	**Entrance G**		**Entrance H**		**Entrance I**	
Original state	Direction	Straight	Right	Left	Straight	Left	Right
	LOS - entrance	A	A	B	B	C	C
	Delay on the section [s/veh]	16.31					
	LOS - section	B					

Proposed state	Delay [s/veh]	8.20	3.55	9.70	11.43	13.64	9.26
	LOS - entrance	A	A	A	B	B	A
	Delay on the section [s/veh]	9.30					
	LOS - section	A					

As can be seen from the simulation results in **Table 7**, the modification of the intersection improved the overall quality of traffic from B to A.

3.5 Evaluation of proposed solutions

The results of simulations of the original state and proposed solutions for the entire monitored section are focused on the average delay time of the movement of vehicles at all entrances of the given road section.

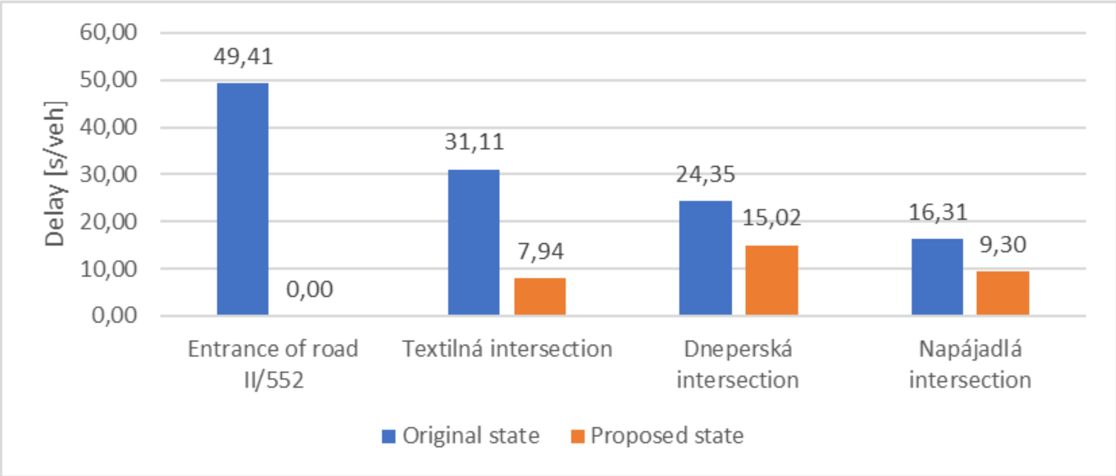

Figure 7 Comparison of the average delay of vehicles on the entire road section

As part of the implementation of the individual proposals on the first monitored section, at the entrance to road II/552, it is assumed that there will be a significant improvement and the complete elimination of vehicle movement delays, as there will be no crossing of traffic streams on the section after the changes. In the case of the Textilná and Napájádla intersections, roundabouts appear to be optimal. In both cases, there was a significant decrease in the average delays of vehicles passing through. At the Dneperská intersection, the state is improved to a smoother passage for all directions, using light signalling with an appropriate cycle. Based on the average delays achieved for the original and the proposed state, we can state an improvement (**Figure 7**). After the modifications, the total delay in the movement of vehicles is 26.36 s/veh. The improvement over the entire monitored section is 57 seconds.

4. CONCLUSION

The section of road II/552 is a crucial traffic route in the city of Košice. But the traffic situation in this section is problematic, with significant congestion, especially during rush hour. The main goal of the research was to improve traffic flow and reduce average vehicle delays in this section. The study included the traffic survey, traffic model creation, design of solutions for intersections, and simulation of the impacts of these solutions. During the implementation of the proposals on the first monitored section, the complete elimination of vehicle delays was achieved. In the case of the Textilná and Napájadla intersections, roundabouts proved to be the optimal solution, as they significantly reduced average vehicle delays. At the Dneperská intersection, light signalling with an appropriate cycle was designed that contribute to a smoother passage of vehicles in all directions. The overall improvement in the monitored section is significant. The improvement in vehicle delay over the entire monitored section reached 57 seconds. The presented research contributes to the improvement of the transport infrastructure in the city of Košice and the provision of more efficient and safer transport for the residents of this region.

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