THE TRANSPORT MODEL TO IMPROVE CITY LOGISTICS IN VISSIM PROGRAM

[1]Jana FABIANOVA, [1]Nikoleta MIKUSOVA, [2]Peter MICHALIK

[1]Technical University of Kosice, Faculty of Mining, Ecology, Process Control and Geotechnologies, Kosice, Slovakia, EU, jana.fabianova@tuke.sk, nikoleta.mikusova@tuke.sk

[2]Technical University of Kosice, Faculty of Manufacturing Technologies, Presov, Slovakia, EU, peter.michalik@tuke.sk

https://doi.org/10.37904/clc.2022.4558

Abstract

Individual car transport in large cities causes congestion, parking problems, and overall difficulty in urban logistics. There is a big problem finding a parking space in city centres, especially near offices and institutions. One of the possible solutions is to build parking lots on the outskirts of cities and thus reduce car traffic in the city. This article presents a proposal to improve the city logistics in the city of Kosice by creating a parking lot at the northern entrance and providing an alternative form of transport. The impact of the proposal on the traffic is experimentally verified by simulations in the VISSIM program.

Keywords: Traffic, parking lot, simulations, VISSIM

1. INTRODUCTION

The growing individual car traffic is causing several problems in cities, e.g. congestion, parking problems, and also pollution with emissions, dust, and excessive noise. Addressing these transport externalities is the subject of research in many scientific papers. One of them, Bindzar et al. [1] compared the current transport organization with the proposed change in transport organization in terms of traffic intensity. The authors evaluated changes brought by their proposal for the traffic organization in Kosice city using OmniTRANS program. Design of the significant intersection using PTV VISSIM in the context of traffic infrastructure planning was the aim of the paper by Kučera et al. [2]. Cattaruzza et al. [3] surveyed the vehicle routing problems for good distribution in the city. Guo et al. [4] proposed traffic management strategies based on hospital traffic characteristics and the estimated traffic volume through a model developed based on the queueing theory. The paper by [5] presented the architecture and the development of a decision tool for simulating and optimizing alternative solutions to road transportation. Yao et al. [6] proposed a bi-level model to optimize urban transportation demand management strategies based on simulation in VISSIM program. Barceló et al. [7] created the modelling framework that consists of a Decision Support System. The system includes an underlying dynamic traffic simulation model that can track the fleet vehicles individually, emulating the monitoring of fleet vehicles in a real-time fleet management system. Some papers dealt with parking demand challenges and sustainable city logistics. Research by Yaliniz et al. [8] aimed to support the development of the "Park-and-Ride" (P&R) system by applying the methodical approach adopted by the authors for the study to make it relevant for cities. Similarly, the authors of [9] provided a general review of the policy debate around the provision of formal Park-and-Ride facilities. Their finding was, that P&R implementations are generally successful where they provide more parking for economic growth reasons, rather than to enhance sustainable mobility. The authors of [10] discussed intercepting parking as the possible ways to solve the problem with the parking of out-of-town drivers in parking lots of large shopping centers. The problem with parking in large cities is also the topic of [11]. The authors applied a serious game – PARKGAME – to understand and model drivers' two intertwined instantaneous parking choices. Further sustainable city logistics solutions were presented in [12,13]. However, smart city technologies have a high impact on city logistics. The analysis of practical solutions in the field of smart mobility solutions in European urban areas was carried out by [14]. Niculescu et al. developed a smart parking assistant whose evaluation presented in [15].

This paper aims to present the proposal to improve the traffic situation at the northern entrance to the city Kosice by creating a parking lot and providing an alternative transport to the city. The proposed road model and experimental verification of the traffic situation is made in the VISSIM simulation program.

2. MATERIALS AND METHOD

2.1. Current traffic situation and problem description

Traffic at the northern entrance to the city of Kosice has long been problematic, especially during rush hours in the morning and afternoon. Cars coming to the city usually stand in traffic jams, forming long columns, even a few hundred meters. Also, the latest traffic survey conducted in 2015 indicates traffic intensity [16]. According to the traffic survey, around 23,000 vehicles come to Kosice every day on working days (**Figure 1**). Currently, there are mostly passenger vehicles transporting people outside the city to work or school. Freight traffic is minimized and consists of vehicles supplying and transporting goods to the city. Transit vehicles use the new motorway bypass and do not burden the city's road network. But cars entering the town significantly burden the road network. The road network in this part of the city connects the traffic flow of vehicles coming from the north and the settlements of Tahanovce and Furca.

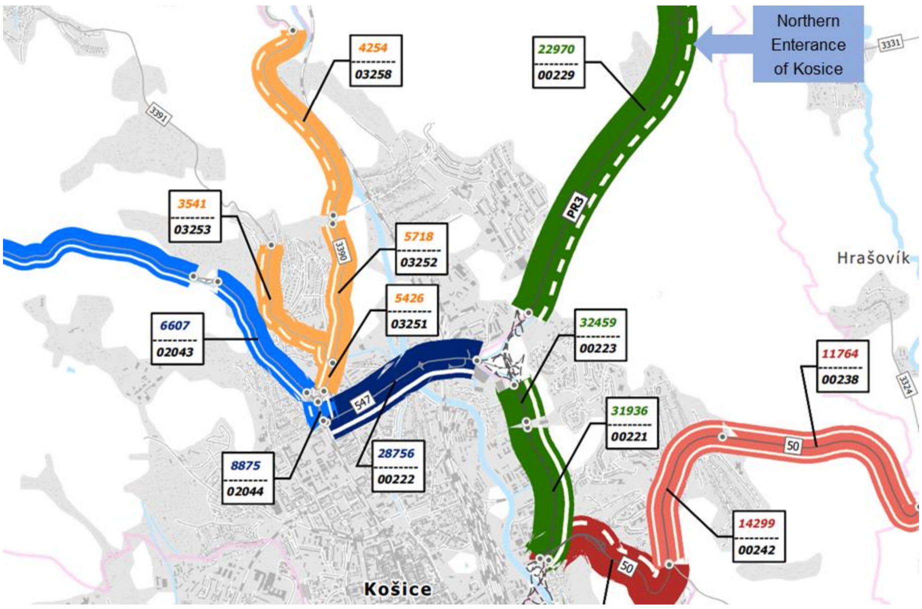

Figure 1 Traffic survey in 2015 [16]

The proposed change is to regulate the organization of transport in the city by building a car park at the entrance to the city for cars and introducing public bus transport from the car park towards the city centre. The aim of the research is to experimentally examine the proposed modification for different levels of traffic flow reduction of incoming vehicles. Parking near the entrance to the city will allow the parking of vehicles, and the P&R system would provide public passenger transport to the city. The provision of shared bicycles and scooters may be an alternative mode of transportation.

2.2. Input data and traffic simulation settings

The traffic model is made on survey data and estimates of traffic flow intensity for the peak hour. The vehicles are generated from three entrances: the Tahanovce housing estate, the northern entrance to the town, and the Furca housing estate. Driving directions of vehicles are considered only those that relate to the section of the road network we are dealing with. The simulation time is set to the maximum that can be simulated, 3600 seconds. The composition of the traffic flow is determined by estimation, and the traffic flow is formed by passenger cars and buses. The parameters of the traffic model and simulation are presented in **Table1**.

Table 1 Traffic parameters and simulation settings

Traffic Parameters	**Vehicle input**	**Value/Settings**
Traffic flow	Northern Entrance	1200 car/h
	Furca	600 car/h
	Tahanovce	600 car/h
Traffic composition	Northern Entrance	90 % cars, 10 % buses
	Furca	90 % cars, 10 % buses
	Tahanovce	90 % cars, 10 % buess
Vehicle routes	Northern Entrance	straight: city bypass direction, right: city centre direction
	Furca	straight: city centre direction
	Tahanovce	left: city bypass direction, right: city centre direction
Relative flow rate	Northern Entrance	straight 50 %, right 50 %
	Furca	straight 100 %
	Tahanovce	left 30 %, right 70 %
Vehicle speed		40 km. h^{-1}
Simulation time		3600 s

2.3. Traffic model creation

When creating the model, we start from the measured values of traffic intensity according to the mentioned survey, while the flow intensity during peak hours is estimated. The simulation model is created in the VISSIM program. The road network at the northern entrance to the city is modelled on the background of a scaled satellite image of the intersection (**Figure 2**). Vehicle composition and relative traffic flow in individual directions were estimated and can be seen in **Table1**. By simulation outputs parameters setting and entering the measurement points in the model, the model is ready for simulation. In our case, the parameters we check and evaluate by simulation are the time of the vehicle passing through the defined section of the road, the number of vehicles stops in the traffic jam, and the length of the queue (average and maximum). The monitored road network ends with a light signal, which can also affect the occurrence of traffic jams, and its light mode has been set according to the program at peak times.

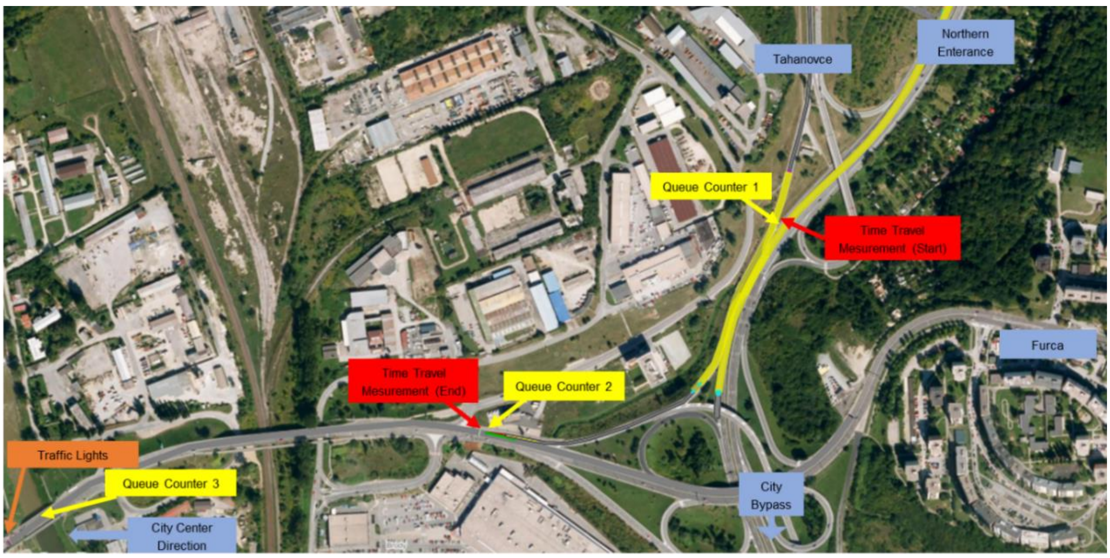

Figure 2 Road model in VISSIM

In places where individual traffic flows intersect, that means in conflict zones. It is necessary to define the traffic rules based on reality in the model. Three conflict zones are relevant in our case. Two of them are in the place where the flow from the Tahanovce estate and the northern entrance to the town join. One is at the point of joining vehicle flow from Furca and Tahanovce. Also, in conflict zones, the speed is reduced to 12 km.h^{-1}.

3. SIMULATION RESULTS

The traffic simulation for the current situation showed that the traffic situation is as we can see in reality. After a simulation time of 1 hour, congestion formed from vehicle entrances from the north and from the Tahanovce estate. The road on which the vehicles come from Furca was freely passable (**Figure 3**), which is the most common situation in reality.

Figure 3 Traffic situation in peak time- current state

The traffic situation with the proposed modification to reduce traffic coming to the city in the interception parking lot was the subject of further simulations. The model of the interception car park and its allocation is presented in **Figure 4a**. The car park is dimensioned for 500 parking spaces, and public transport by bus is provided from the car park (**Figure 4b**). Bus departures are at 3-minute intervals.

a b

Figure 4 Allocation of the interception car park and detail of the parking lot with a public transport line

In the current state, the measuring points showed that the longest queues formed before queue counters (QC) 1 and 2. The queue length is about 500 m. Before QC3, the range was minimal (see **Figure 5a**). By reducing the traffic from the northern entrance, the situation at this measuring point practically does not change (see **Figures 5 b-d**). The traffic situation near QC3 is stable. It is influenced by different factors, not by traffic flow reduced by the parking lot. Everything is caught in the funnel near QC1 and QC2, and the traffic is further moved already adjusted.

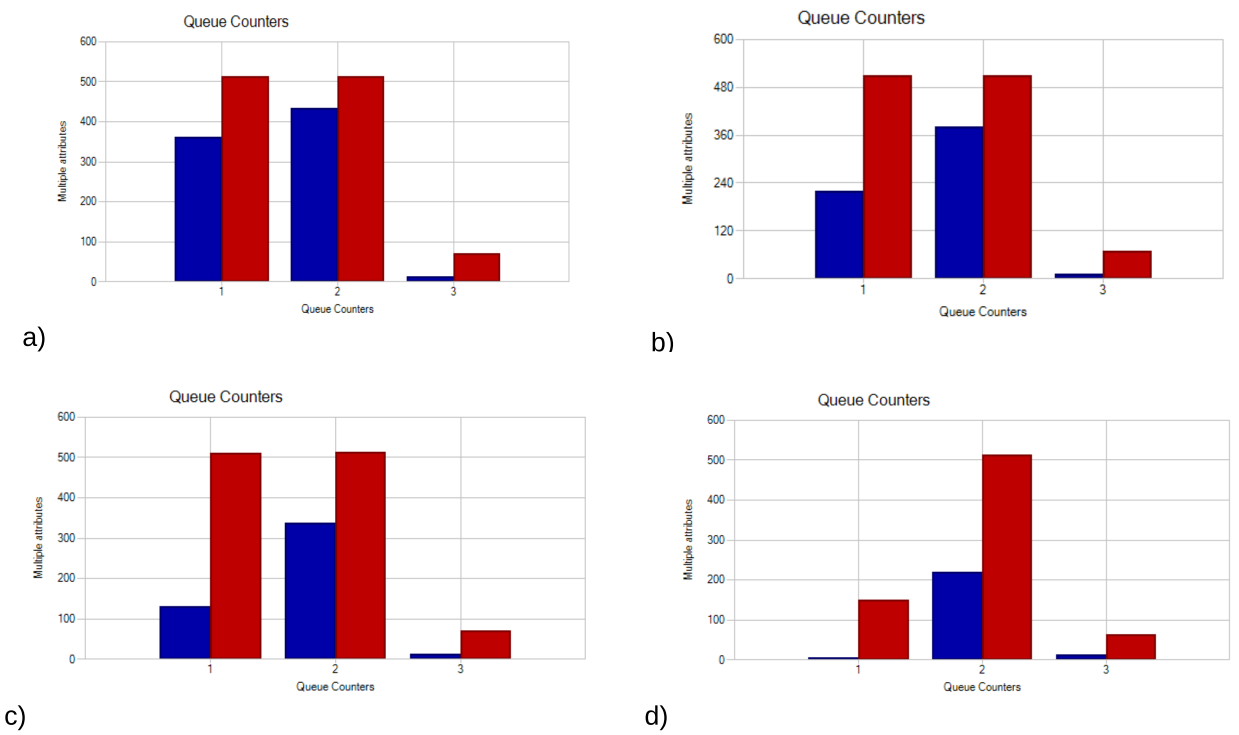

Figure 5 Results: Queue length. Average length (blue), Max. length (red)

Another monitored parameter is the vehicle travel time between the points Travel Time Measurement Start and End (**Figure 2**). The simulation results are in **Figure 6a**. According to the simulation results, vehicle travel times decreased from 255 s to 125 s, while the traffic flow through parking was reduced by 60 % (**Figure 6a**).

The third monitored parameter is the number of vehicle stops in the queue. From **Figure 6a**, we can see that although the length of the queue is the same in front of QC1 and QC2 (500 m on average), vehicles are not really standing but are moving slowly. The most vehicle stop is at QC2, where the situation seems the most complicated overall. The length of the queue and the number of stopped vehicles on QC3 are approximately the same for all levels of traffic flow reduction (**Figure 6**) and appear to be independent of the level of flow reduction through the parking lot.

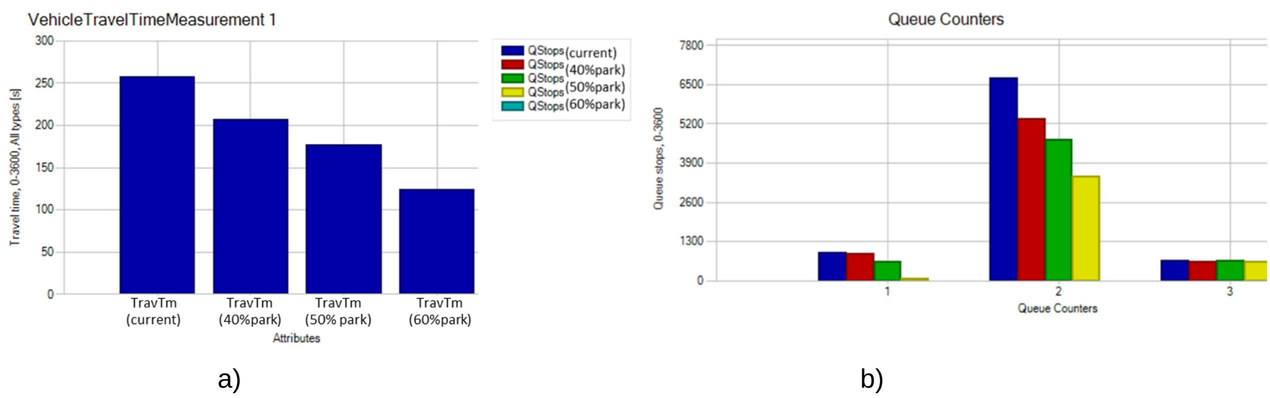

Figure 6 Results: Vehicle Time (a). Number of Stops in Queue (b)

4. CONCLUSION

The article aimed to present a solution to the traffic situation on the road behind the northern entrance to the city of Kosice by building a parking lot. The selected road network transport model was in the VISSIM program. The input data for the simulation were based on the traffic survey 2015, and the other parameters were estimated. The simulation of the current situation confirmed the existence of congestion at the peak time, with the vehicle queue length on average around 500 cars. By reducing the traffic flow intensity from the north to 40, 50, and 60 %, the length of the queue, the transit time, and the number of vehicle stops were significantly reduced. At the parameter "queue length" the situation changed the most at the QC2. The number of vehicles stops decreased up to 50 % (60 % of the vehicles were parked). On the other hand, the number of vehicles stops in front of QC1 and QC3 was not significantly affected by the car park. The travel time of the measured section decreased proportionally, according to the percentage of vehicles parked.

In conclusion, it is necessary to state the limits of the presented research. The transport model does not reflect reality reliably because model creation is not based on the measured transport parameters. Specifically, the intensity of traffic flows was only a rough estimate. Also, the applicability of the proposed solution is just hypothetical due to the need to solve many other aspects. E.g., material aspects (infrastructure construction, connection with public transport, bus route tracing, and others) and intangible issues of the proposed solution (e.g., drivers' motivation to use the parking lot). We consider the results indicative of outlining one of the variants of solving the problems that the growing car traffic brings to Kosice.

ACKNOWLEDGEMENTS

This work has been supported by grant projects VEGA 1/0638/19, VEGA 1/0600/20, KEGA 049TUKE-4/2020.

REFERENCES

[1] BINDZAR, P., SADEROVA, J., SOFRANKO, M., et al. A Case Study: Simulation Traffic Model as a Tool to Assess One-Way vs. Two-Way Traffic on Urban Roads around the City Center. *Appl Sci* 2021, vol. 11, pp 5018 2021.

[2] KUČERA, T., CHOCHOLÁČ, J. Design of the City Logistics Simulation Model Using PTV VISSIM Software. *Transp Res Procedia.* 2021; vol. 53, pp 258–265.

[3] CATTARUZZA, D., ABSI, N., FEILLET, D., et al. Vehicle routing problems for city logistics. *EURO J Transp Logist.* 2017; vol. 6: pp. 51–79.

[4] GUO, Y., ZHANG, Y., ZHAO, Y., et al. Traffic Congestion Evaluation and Management Optimization Based on Queueing Model and VISSIM Simulation. In: *Proc 2018 IEEE 22nd Int Conf Comput Support Coop Work Des CSCWD. 2018* 2018; pp. 636–641.

[5] DOSSOU, P.E., VERMERSCH, A. Development of a decision support tool for sustainable urban logistics optimization. *Procedia Comput Sci.* 2021; vol. 18, pp. 476–483.

[6] YAO, B., YAN, Q., CHEN, Q., et al. Simulation-based optimization for urban transportation demand management strategy. *Simulation*. vol. 94:7, pp. 637–647. Available from: https://doi.org/101177/0037549718761189 2018

[7] BARCELÓ, J., GRZYBOWSKA, H., PARDO, S. Vehicle Routing And Scheduling Models, Simulation And City Logistics. *Oper Res Comput Sci Interfaces Ser.* 2007; vol. 38, pp. 163–195.

[8] YALINIZ, P., USTUN, O.., BILGIÇ, S., et al. Development of «Park-and-Ride» system as a tool for sustainable access control managing. *IOP Conf Ser Earth Environ Sci.* 2017; vol. 90:1, pp. 012214.

[9] PARKHURST, G., MEEK, S. The effectiveness of park-and-ride as a policy measure for more sustainable mobility. *Transp Sustain* 2014; vol. 5, pp. 185–211.

[10] SOROKINA, D.N. Research Into Demand for Intercepting Parking in the City of Rostov-On-Don. IOP Conf Ser *Earth Environ Sci.* 2022; vol. 988, no. 2, p. 022065.

[11] FULMAN, N., BENENSON, I., BEN ELIA, E. Modeling parking search behavior in the city center: A game-based approach. *Transp Res Part C Emerg Technol.* 2020, vol. 120, p.102800.

[12] KJAERSGAARD, S., ENSLEVJENSEN, H. Sustainable city logistic solutions. In: *Logistics Systems for Sustainable Citie:* Elsevier. 2004, pp. 441–448.

[13] SAMUEL, L., SHIBIL, M., NASSER, M., et al. Sustainable Planning of Urban Transportation Using PTV VISSIM. *Lect Notes Civ Eng.* 2022; vol. 171, pp. 889–904.

[14] RZEŚNY CIEPLIŃSKA, J. Transport organizers' integrating role in city logistics. *Int J Transp Dev Integr* .2018; vol. 2, no. 1, pp. 30–38.

[15] NICULESCU, A., NICULESCU, A.I., WADHWA, B., et al. Smart City Technologies: Design and Evaluation of An Intelligent Driving Assistant for Smart Parking. *Int J Adv Sci Eng Inf Technol.* 2016; vol. 6, no. 6, pp. 1096–1102.

[16] Slovak Road Administration. *Kosice Traffic Survey*. [online]. 2015. [viewed: 2022-05-25]. Available from: https://www.ssc.sk/files/documents/dopravne-inzinierstvo/csd_2015/ke/scitanie_kosice_2015.pdf