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Design of the City Logistics Simulation Model Using PTV VISSIM Software

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Abstract

Transport modelling and simulation have an irreplaceable role in transport infrastructure planning and in city logistics. Designing road networks and crossroads, analyzing traffic situations to eliminate congestion, reducing vehicle delays and increasing road safety are the subject of many scientific work. Most of them are based on the creation and analysis of microscopic models. PTV VISSIM microscopic traffic flow modelling software is mainly used to model traffic flows of a selected agglomeration to achieve a sustainable urban traffic system and a sustainable city logistics. It is possible with PTV VISSIM software to explore new management tools for logistics planning suitable for achieving the concept of the sustainable city logistics. PTV VISSIM software allows to simulate real city traffic, design efficient traffic management strategies, and test different constructions of all types of intersections. The aim of this paper is to design of the simulation model using PTV VISSIM software in the context of traffic infrastructure planning in a particular area of a significant intersection in the city of Pardubice in the Czech Republic. The possible impacts of the rebuilding of the intersection and the impact of these measures on road traffic flow in city logistics in the surrounding area will be discussed.

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Keywords: simulation model; traffic modelling; city logistics; PTV VISSIM software

1. Introduction

Currently, the following trends in the city logistics are typical according to Taniguchi et al. (2003), Crainic et al. (2004), Anderson et al. (2005), Behrends (2016), Kin et al. (2017) and Hu et al. (2019): the rapid increase in demand for distribution services and the resulting increase in freight transport performance due to changes in purchasing behavior and the rapid development of e-commerce and m-commerce (the increasing consumption in general), the increasing demands on parking spaces and increased mobility needs has placed a great burden to the urban mobility

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(congestion, low accessibility, inconvenience and inefficiency), the environment (visual intrusion, noise, vibration, greenhouse gas emission and resource waste), the social welfare (accidents and public health impacts), and the governance (land scarcity and uncontrolled sprawl). Katsela and Browne (2019) stated that many stakeholders (those that have a stake or an interest in the outcomes of city logistics initiatives) are directly and indirectly affected by the issue of the city logistics in agglomerations (e.g. residents of agglomerations, tourists, companies and entrepreneurs, transport operators, associations, state administration and local self-government). Other authors defined six categories of stakeholders in the city logistics: shippers, freight carriers, administrators, residents, non-governmental organizations and property owners and others (Taniguchi et al., 2001; Benjelloun et al., 2010; Pålsson and Katsela, 2016; Barceló, 2019). The use of simulation modelling opens up new possibilities in determining line capacity (Tischer et al., 2020).

The transport sector produces many air pollutants, for example carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_x), sulphur dioxide (SO_2) and particulate matter (PM) on the one hand, but on the other, it has a crucial importance to the economy of each state (Abou-Senna et al., 2013). The road transport is the main source of CO_2 emissions in all the developed countries and in many of the developing countries in the world, in this context the Intergovernmental Panel on Climate Change estimates that baseline global greenhouse gas emissions may increase 25 – 90% from 2000 to 2030, with carbon dioxide (CO_2) emissions growing 40 – 110% over the same period (Intergovernmental Panel on Climate Change, 2008; Abou-Senna and Radwan, 2013; Abou-Senna et al., 2013). Due to these facts, it is necessary to pay attention to the transport system in urban agglomerations as a whole and to use adequate software tools for their planning, analyzing and modification. Regarding to the city logistics in a given agglomeration is significantly influenced by the quality of the transport system, it is necessary to focus on the transport system from all possible perspectives (macroscopic, mesoscopic and microscopic) nevertheless the main focus must be on the individual elements of the transport infrastructure (intersections, roundabouts, pedestrian crossings, railway crossings, etc.), because their optimal setting is a condition for achieving an efficient transport system (Li et al., 2020; Mejokh et al., 2020). Sustainable development requires global thinking and such that those who are richer adopt a lifestyle within the ecological possibilities of the planet (World Commission on Environment and Development, 1987; Kučera, 2017).

The aim of this paper is to design of the simulation model using PTV VISSIM software in the context of traffic infrastructure planning in a particular area of a significant intersection in the city of Pardubice in the Czech Republic.

2. Theoretical Background of the PTV VISSIM Software

PTV VISSIM software is according to PTV Group (2020) the standard microscopic traffic and transport planning tool which is based on modelling and simulation. This software can be used in the following areas (PTV Group, 2020):

- Traffic Flow Simulation – software helps in the decision-making process for creating sustainable transport system (e.g. Muchlisin et al. (2019))
- Advanced Traffic Management Systems – software helps to reduce the negative impacts of transport system (e.g. Yang et al. (2013), Xing et al. (2014))
- Multimodal Systems – software helps to study of all transport modes including pedestrians (e.g. Wu et al. (2018))
- Autonomous Vehicles and New Mobility – software helps to model and to simulate the impacts of autonomous driving (e.g. Songchitruksa et al. (2017))
- Virtual Reality Traffic Simulation – software helps to create microscopic traffic simulation

The development of the number of VISSIM software-related articles in Web of Science and Scopus databases during 1994-2019 is presented in Figure 1. Articles were searched in Web of Science (2020) database in the field "topic" after entering keyword "VISSIM" (1 195 articles were found in total). Articles were searched in Scopus (2020) database in the all fields after entering keyword "VISSIM" (4 123 articles were found in total).

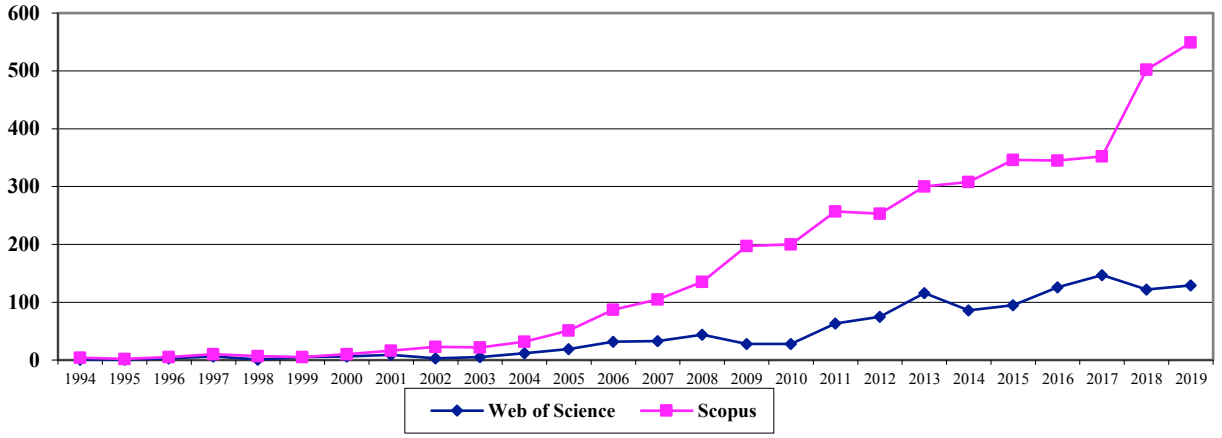

Fig. 1. The development of number of VISSIM software related articles in selected databases during 1994-2019 (Web of Science, 2020; Scopus, 2020).

A total of 5 318 VISSIM software-related articles were published between 1994 and 2019, but 82.72% of VISSIM software-related articles were published in the last ten years. The total number of articles in databases is growing from 1998 to 2019, except in 2014. The most articles were identified in 2019 (total 678, of which 129 in the Web of Science database and 549 in the Scopus database). It is generally assumed that given the importance of the transport sector and the increasing popularity of simulation software, the number of scientific articles in this area will increase in the coming years.

3. Results and Discussion

PTV VISSIM is the microscopic simulation program for modelling multimodal transport operations and belongs to the vision traffic suite software. PTV VISSIM creates the conditions for testing various operating scenarios before their implementation for realistic and accurate in every detail. PTV VISSIM is now used worldwide by the public sector, consulting firms and universities. The Figure 2 shows visual interface of the PTV VISSIM software.

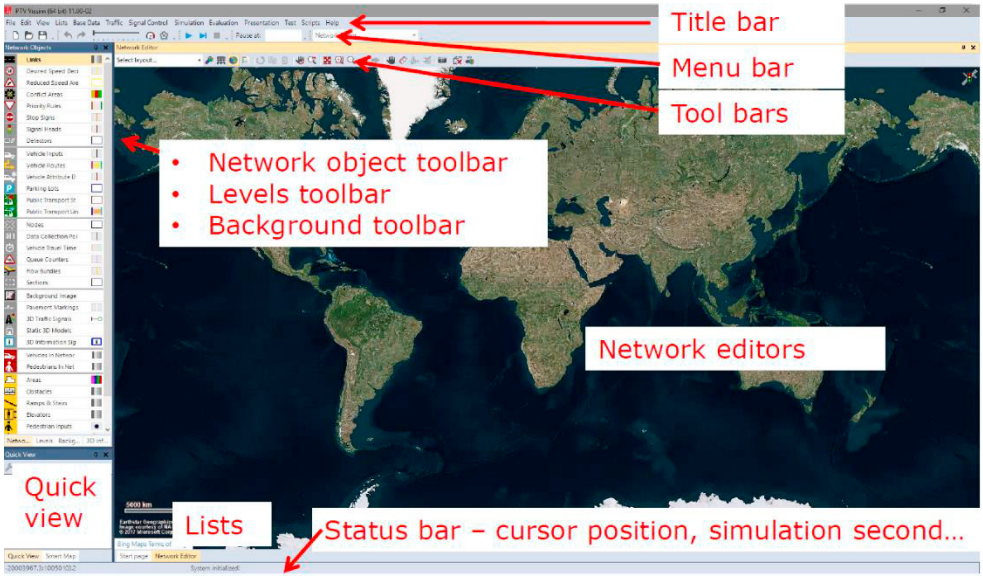

Fig. 2. Visual interface of the PTV VISSIM software.

Figure 3 shows the current situation at a selected intersection in Pardubice, which will be further addressed. This particular intersection was chosen based on the experience with the problems with this intersection and its great congestion. The map base was inserted directly into the PTV VISSIM software in Figure 3, and the problem of large congestion in this area will be further solved using PTV VISSIM software and its modelling functions.

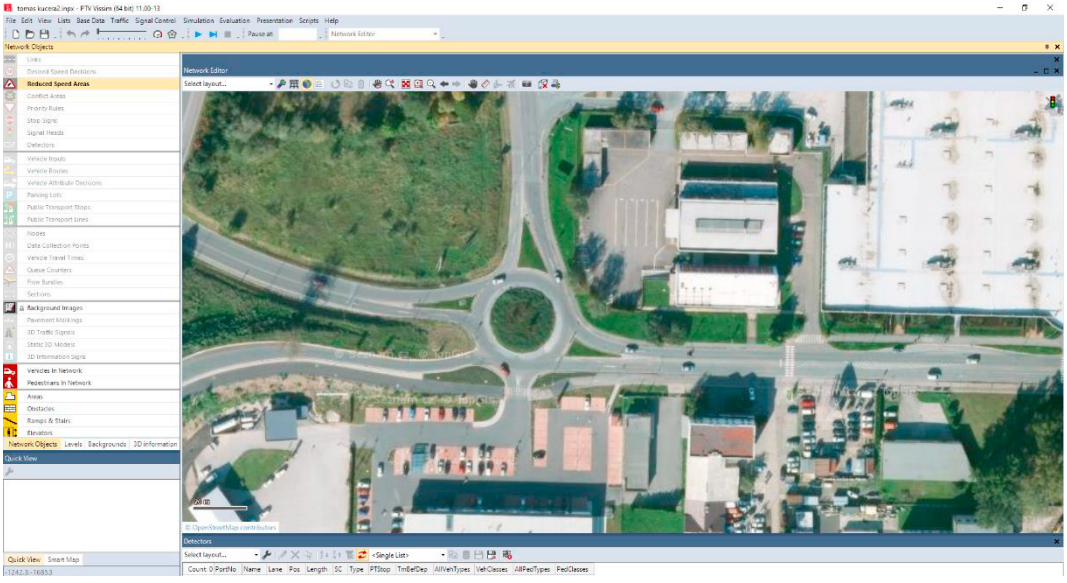

Fig. 3. Selected intersection in Pardubice for solving the traffic situation (map base).

Figure 4 shows the current situation at the roundabout and uses modelled roads, which allows the PTV VISSIM software to insert into the selected model. Also, the embedded currents of the vehicle inputs can already be seen in Figure 4. On the attached map, it can be seen that there are 2 shopping centers (yellow-highlighted circles) near

the roundabout, which have signs affect to the traffic situation in the area. The roundabout is also located at one of the main entrances to the city of Pardubice and is therefore very busy not only due to the 2 shopping centers.

Fig. 4. Use of the PTV VSSIM software with modelled lines (roads) and insertion of vehicle inputs.

Figure 5 shows the inserted inputs of vehicles into the traffic situation in Pardubice within the selected intersection based on modified and adjusted traffic flow data for this simulation model.

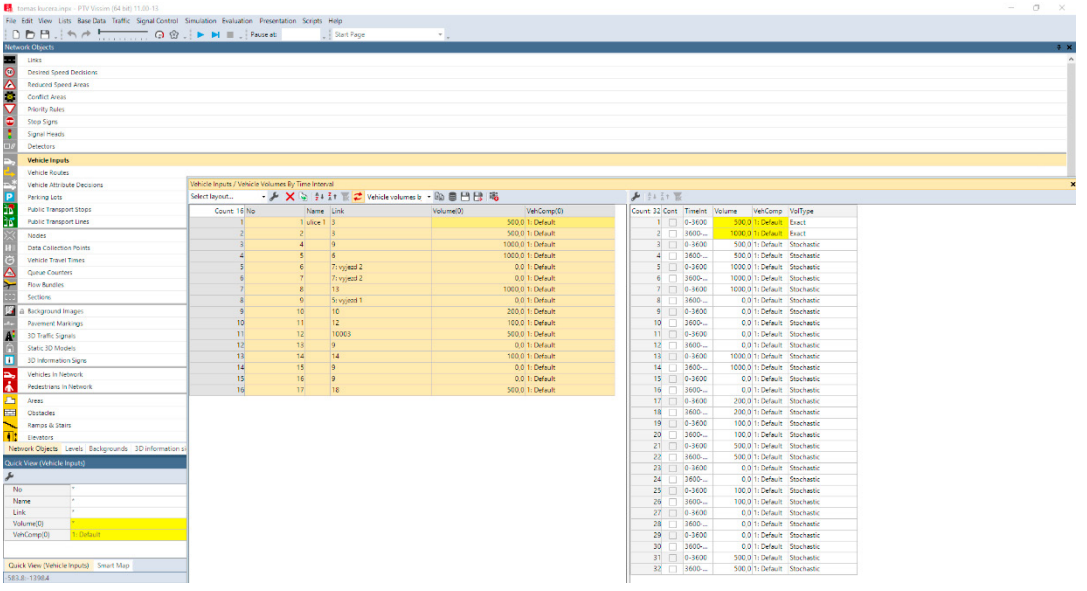

Fig. 5. Inserted orientation inputs of vehicles into the traffic situation in Pardubice within the selected intersection.

Figure 6 shows exactly the new solution to the traffic situation at the selected intersection in Pardubice. A possible bypass is created in the yellow-highlighted oval, which can be carried out for faster transit of vehicles that turn from

the direction of the center with the first exit towards the large neighboring regional city which is Hradec Králové. This releases the already occupied roundabout and facilitates the transit through this roundabout.

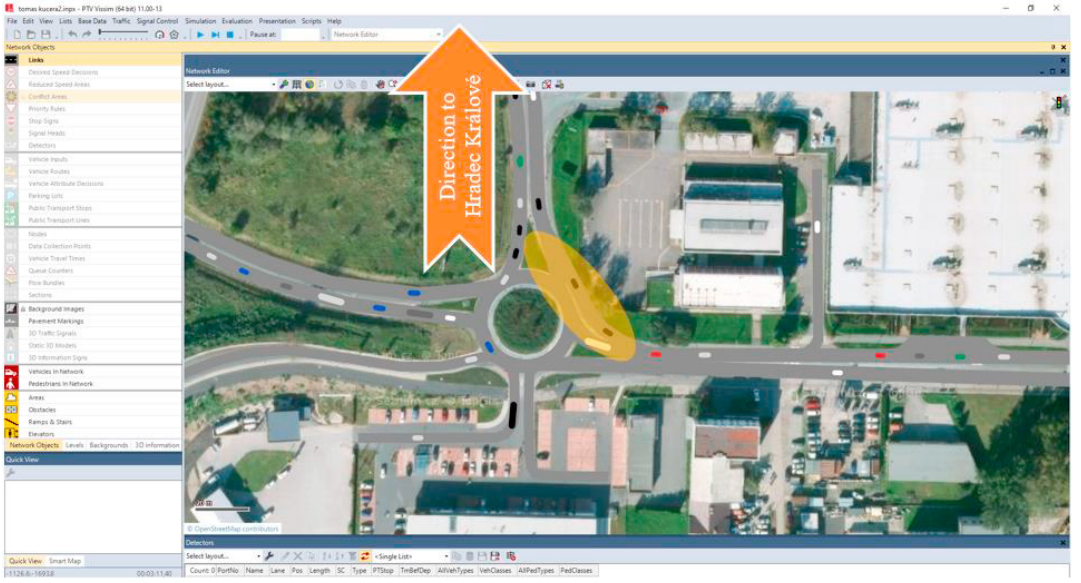

Fig. 6. New traffic solution for the selected intersection in Pardubice with insertion of vehicle inputs.

Figure 7 shows in detail the solution of the traffic situation using bypass at the roundabout in the 3D model. It is evident from Figure 7 that the vehicles that leave the roundabout on the first exit turn directly towards Hradec Králové and use the modelled bypass. This solution significantly relaxes the traffic situation directly at the roundabout and the roundabout can be fully used for other traffic directions.

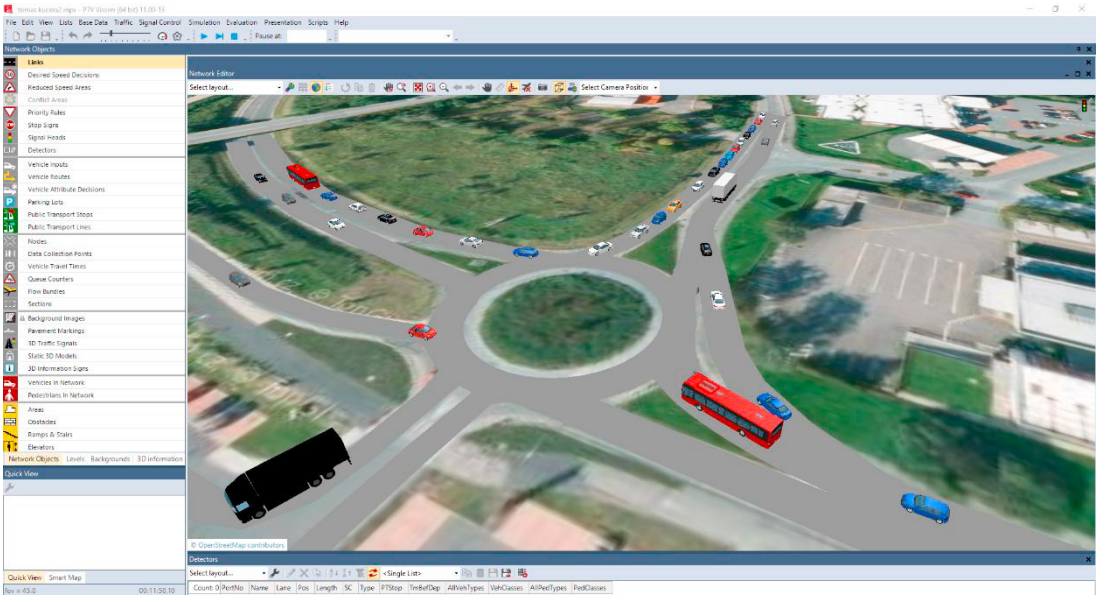

Fig. 7. 3D visualization of the new traffic solution for the selected intersection in Pardubice.

4. Conclusion

Traffic modelling has played an important role in all areas of transport infrastructure in recent decades and has an impact on all stakeholders. The growth of road traffic in cities gives more and more opportunity to apply software solutions to given traffic situations in the city logistics. With the help of the design of the city logistics simulation models, it is cheaper to put into context a possible new transport solution for a specific intersection than tradition access. The aim of this paper was to design the simulation model using PTV VISSIM software in the context of traffic infrastructure planning in the particular area of the significant intersection in the city of Pardubice in the Czech Republic. The specific solution to the traffic situation was with the use and possible reconstruction of the current roundabout with the addition of the bypass. Thanks to this solution, the other directional lines within the roundabout are released. The use of PTV VISSIM software has the possibility of other scientific publications such as various operating scenarios before their implementation for realistic life in other transport situation in the city logistics.

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