APPLICATION OF SOFTWARE SIMULATION AS A SUPPORTING TOOL FOR REDUCING OF TRAFFIC CONGESTIONS

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Summary

Question of traffic congestions analysed within the framework of a city logistics is such problem, which is caused due to various factors. There are applied different methodological approaches in order to eliminate the traffic congestions. These methods are distinguished each other with regard to their complexity and applied tools. Among these tools just the software simulation plays an irreplaceable role. The software simulation method is an efficient decision-making tool, which is suitable for solving of the traffic problems during the individual solution phases. There will be presented in the following paper application possibilities of the software simulation methods that are specified for solving of the traffic congestions.

Key words: transport, city logistics, simulation, traffic

1. Introduction

The traffic congestions are becoming to be a more and more serious problem during the last years within the framework of a wide spectrum of city agglomerations. The main cause of the traffic congestion occurrences is an increasing number of the transport vehicles, high intensity of the transport flows on the road communications as well as other secondary factors, such as urban conception of the aerial and functional arrangement of the individual parts in the city agglomerations, capacity of the road communications, level of industrialisation etc. All the above-mentioned tasks are analysed in terms of the City logistics.

The City logistics is defined as an application of the logistic principles concerning movement of consignments on metropolitan conditions. There is applied a large scale of the activities connected with transfer and grouping of the consignments, selection of the suitable transport vehicles, optimisation of the individual drives in order to reduce number of the vehicles required for realization of the given transport operations. It is

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possible in this way to improve exploitation of the vehicle capacities, to increase the operational efficiency and to reduce the negative environmental impacts caused by the transport activities. The proper realization of the City logistics requires a tripartite cooperation among the forwarders, carriers and haulers together with the competent municipal institutions.

The City logistics should not be oriented towards the freight transport only. The traffic and traffic problems has to be analysed and solved complexly, i.e. with regard to a fact that the traffic is one integrated complex, which fulfils an important task for correct functioning of the urban agglomeration as well as it enables progressive development with regard to a quality of life for all residents living in the central zone and suburb zones.

„Many cities have problems with traffic overloading and with degeneration of their urban centres. Capacities of the local communications are insufficient and there are occurring collisions among the individual kinds of transport, i.e. among the passenger traffic, freight transport and foot-passengers." [4] The final negative result of such collision situations are the traffic congestions with all negative impacts on the given area.

2. Traffic congestions

The traffic congestion is such kind of risk, which belongs into the category of the social risks. This categorisation is determined by a fact that the traffic congestions are influencing directly the life quality of people living in the affected area. Impacts of the congestions are concerning ecology of everyday life, time loses, psychological aspects, energy consumption as well as accessibility of the individual functional components in the affected area. The traffic congestions are categorised into a group of risks, which are caused by a human factor.

The main causes of the traffic congestions can be classified into the next categories:

a) weather conditions,
b) capacitive influences,
c) technological influences,
d) temporary restrictions,
e) influences of crisis situations,
f) others.

The weather conditions are able to induce the short-term congestions due to a sudden change of weather, rainfall intensity or temperature oscillations. The capacitive influences are causing the short- and medium-term congestions, which are occurring only during certain but almost periodical time intervals within a day and after them the transport is normalised again. The main reason of such kind of congestions is a limited capacity of the road infrastructure, crossroads etc. The technological influences are negative results of an improper control or organisation of the traffic process and they are developing the medium-term traffic congestions. Elimination of the technological influences is not only

a time demanding task, but it is also a material demanding process with regard to the requirement of modernisation or optimisation.

The temporary restrictions are causing the short-, middle- and long-term congestions as a result of the scheduled reconstructions, maintenance of technological equipment and temporary changes in traffic organisation. The crisis situations implicate the traffic congestions with a rapid start up, however they are short-term usually. These situations are unforeseeable and without any periodicity. There are also possible other kinds of factors causing crisis traffic situations as well as combinations of the above-mentioned factors.

3. Actual situation in development of the traffic congestions in slovak republic

Increase of the transport volume in Slovak Republic is also determined by a degree of urbanization, what is a ratio between the number of inhabitants living in the cities and the total number of inhabitants living in the country. The value of urbanization degree in Slovak Republic was 56,6% in the year 2000 and 55,35% in the year 2006. There is expected an increase of the urbanization degree up to the value 64,9% until the year 2030. More and more people are living in the suburban localities and just these "fragmented localities" are the main cause of an increasing utilisation of the passenger cars.

The level of motorisation in Slovakia reached the number 250 cars per 1000 inhabitants in the year 2005 and a prognosis estimates 342 cars per 1000 inhabitants till the year 2020, i.e. increase of 36%.

It is evident from the above-mentioned facts that road communications and transport nodal points in our country are overloaded as well as they are insufficient with regard to the real traffic capacity. Overloading of the roads causes negative economical, social, health and environmental impacts and in this way it reduces the life quality. From this reason it is necessary to reduce the negative influences of the traffic overloading, to minimise occurrences of the traffic congestions, together with a modern development of the municipal zones. [5]

4. Solution possibilities of the traffic congestions

Solution of the traffic congestion is a difficult transport-engineering task. Application of the modern technologies is often presented like only one solution possibility. However, it not has to be the best solution, because the modern technologies are efficient just when they are integrated into a more complex context within a solution of the analysed traffic problem. The modern technologies should be tailored to the given locality.

The traffic congestions can be reduced or eliminated using the traffic simulation tools and appropriate computer simulation.

5. Application of the simulation tools

Overloading of the road communications and creation of the traffic congestions is a phenomenon, which is typical not only for the larger cities, but also for the smaller Slovak towns, like Vranov nad Topľou. The town Vranov nad Topľou is a smaller district town, however with an everyday intensive input-output transport flows. (Fig.1) The critical traffic point is entry to the town through a street crossing. This critical traffic nodal point causes slowing-down of the traffic flow and creation of the motorcades. In addition, such unfavourable situation is multiplied by a near grade crossing, because in the case of a passing train the road traffic is almost blocked in the given locality. (Fig.2 and Fig.3)

The above-mentioned situation requires looking for a suitable solution in order to master this complicated situation. The first necessary step is realization of several traffic investigations and subsequently it is possible to elaborate the corresponding traffic-engineering studies.

Fig. 1 Illustration of the real traffic situation in the town Vranov nad Topľou

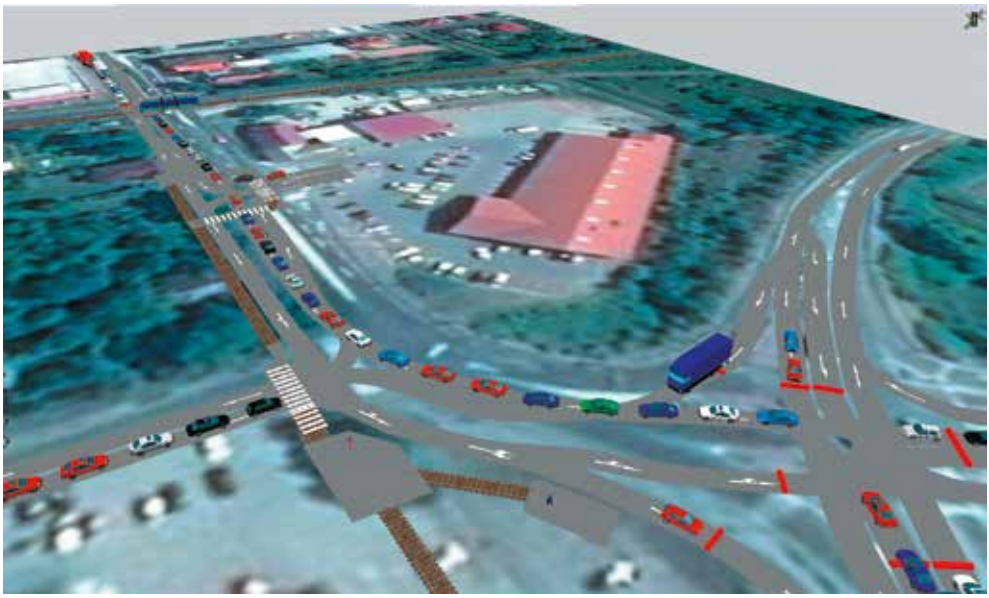

Fig. 2 Illustration of traffic situation in the town Vranov nad Topľou obtained from simulation of the present traffic status

Fig. 3 Illustration of traffic situation in the town Vranov nad Topľou obtained from simulation of the traffic status in case of the closed grade crossing

Fig. 4 Illustration of one of possible variants developed for solution of the traffic problem in the town Vranov nad Topľou

The main purpose of the elaborated studies was to look for such prosperous traffic solution, which could be able to eliminate the existing traffic problems or to minimise them. All the elaborated studies were considered with regard to the various criteria, such as feasibility of the individual variants, financial demands, time aspect, environmental impacts, difficultness of process realization and application of new technologies. One of the most relevant factors is conformity of the proposed solution with a long-term vision of the traffic development in the given town.

The evaluation process of the individual variants was performed using various approaches and decision methods, namely using the methods and tools of computer simulation and traffic simulation, i.e. by means of the general simulation tools applied together with the software products PTV Vissim - PTV Visum specified explicitly for the traffic simulation. Thanks to these software products there were obtained the most relevant information concerning the length of motorcades, speed of the traffic flows and amount of the passing vehicles.

The above-mentioned simulation tools enabled to perform a wide range of various simulation experiments in order to obtain information database built from the various data and indicators. (Fig. 5)

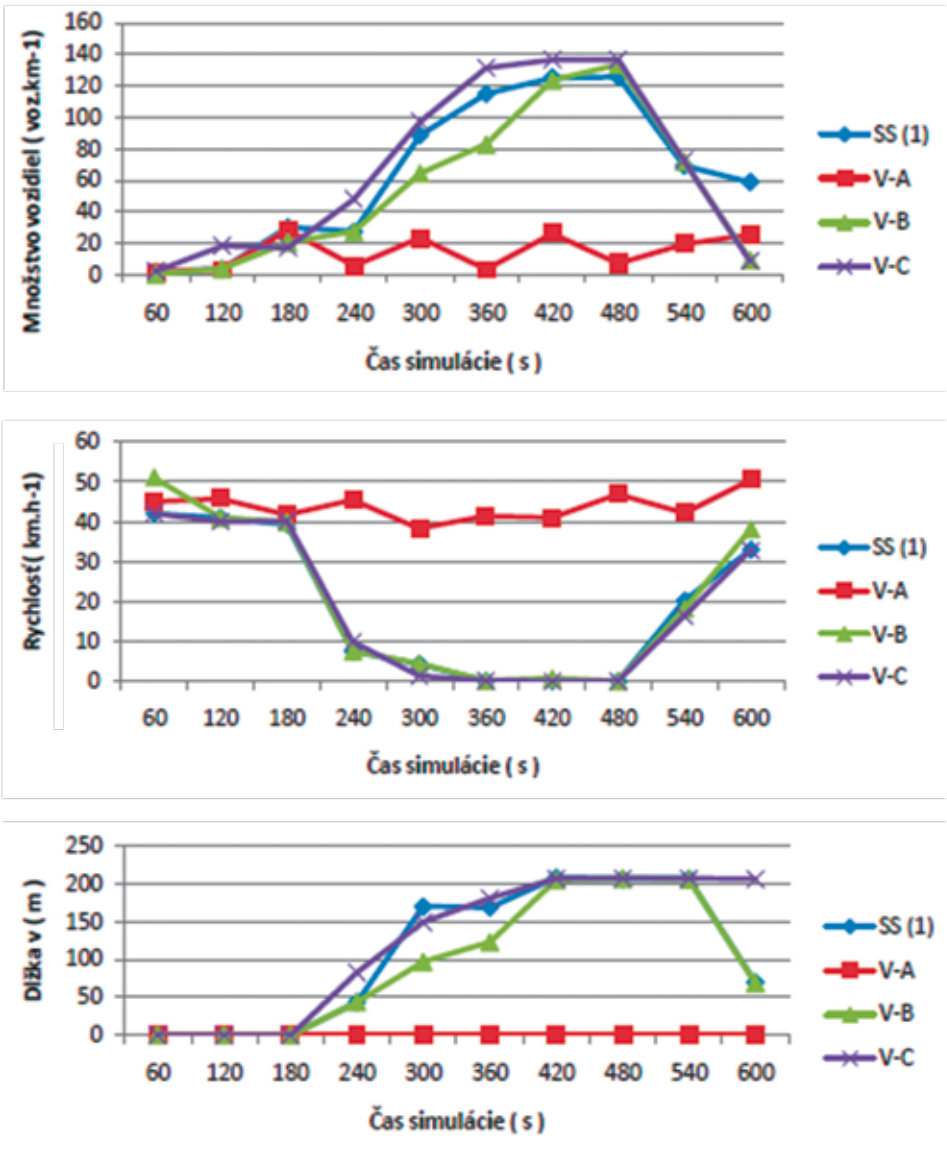

Fig. 5 Example of information obtained using traffic simulation – time behaviour of the number of vehicles, average speed of vehicles and lenght of motorcades

The individual simulation experiments were performed for various time intervals during day, week, months and season of the year. The simulation results were evaluated and processed by means of the graphs, 3D-visualisations and mathematical-statistic methods.

The optimal solution was chosen according to the processed simulation results and after a detailed analysis or communication with the responsible authorities in the town or district. One part of the chosen solution is presented in Fig. 4.

The traffic density belongs among the important analysed factors, as well. It is visible from the graph in Fig. 6 that the traffic density average value is approx. 20 vehicles per one kilometre (V-A). Closing of the grade crossing increases the traffic density up to the number 140 vehicles per one kilometre what is 7-times more (SS(1)); whereas it concerns only one train passing, which lasts 5 minutes. There are recorded two passing trains during the simulation process.

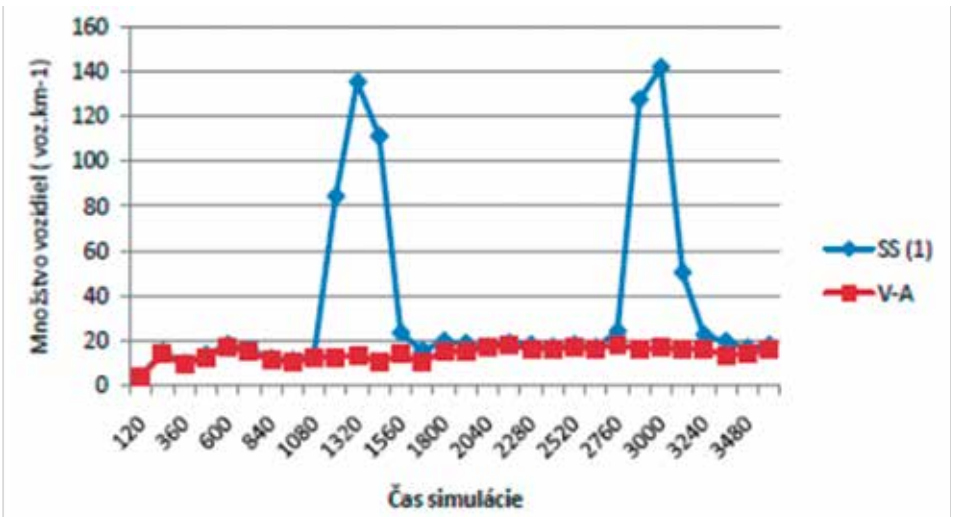

Fig. 6 Traffic density within application of the proposed solution if the grade crossing is closed due to a passing train

Another relevant factor, which was monitored during the traffic simulation process, is an average value of the traffic flow speed. The actual speed of the traffic flow is almost 40 km per hour (SS(1)) according to the graph in Fig. 7. The new variant V-A offers increasing of the average speed value about 5 km per hour, however more important is a fact that the chosen solution eliminates impact of the grade crossing closure. That is to say, if nowadays the grade crossing is closed, so the actual traffic flow speed descends to the zero level.

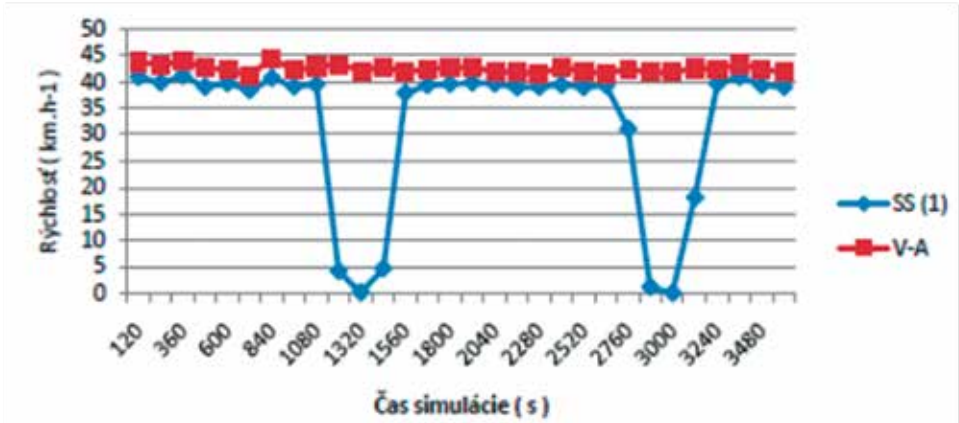

Fig. 7 Average traffic flow speed

The maximal length of the traffic congestions illustrates the graph in Fig.8. It is evident, according to this graph that the traffic congestions are not occurring till the moment of the grade crossing closure; however from this moment the motorcade length reaches more than 200 meters what is a distance to the nearest street crossing, which is blocked fully thereby. A new proposal of the traffic solution offers elimination of the above-mentioned negative fluctuations.

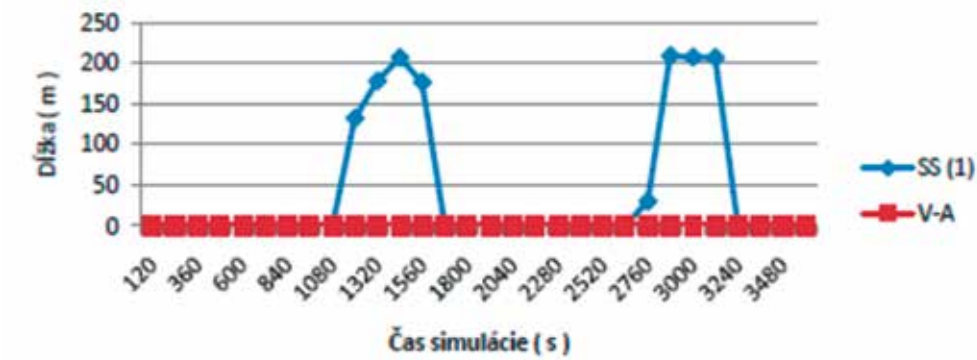

Fig. 8 Comparison of the motorcade length between the present situation (SS(1)) and the new proposal (V-A)

There were performed also another traffic simulations but they are not presented in this article. Finally, it was proposed and chosen the best traffic solution, which is able to improve significantly the traffic situation in the town, quality of travelling and living conditions. The decisive factor for a successful solution was the computer simulation using the suitable simulation tools.

6. Conclusion

The computer simulation plays a dominant role for solution of a wide range of the traffic tasks. The sophisticated simulation tools offer a huge information database, which supports the individual decisions and analytical processes. The developed traffic simulation models allow a better understanding of the occurring traffic problems as well as they enable to create various kinds of the traffic models suitable for usage in a wide range of the application levels.

The traffic simulation process is useful especially for solution of the traffic congestions because the traditional traffic investigation methods are insufficient in these cases with regard to the local specifications and details; however they are able to offer a lot of valuable primary information necessary for the following data processing using the simulation models.

The paper is a part of solved grant project VEGA 1/0922/12, VEGA 1/0258/14 and project APVV SK-CZ-2013-0169.

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