Modelling As A Means Of Improving The Organization Of Movement Of The City Traffic

PAVEL STOYANOV, ASEN ASENOV
Department of Transport
Ruse University "Angel Kanchev"
Ruse, 7017, Studentska Str. 8
BULGARIA
pstoyanov@uni-ruse.bg, asasenov@uni-ruse.bg

Abstract: - The paper show the results of an application of system Vissim to the microscopic simulation of traffic flow for a fragment of a real urban road network. First, the problem of traffic flow modelling and simulation was described, and the selected system is introduced. A crossroad on one of the main boulevards in the city of Ruse was chosen to be explored through a simulation model. The model examine the impact of traffic light cycle on the queue, the transport delay and the number of vehicles that have passed.

Key-Words: - traffic flow, urban, simulation, traffic jams, microscopic simulation modelling, vissim

1 Introduction

The magnitude of transport flows and city streets, frequency of bus stops and ways of organizing traffic increasingly lead to a mismatch between the technical capabilities of the means of transport and the conditions of their operation. As the urbanization of cities increases, the disproportion between the traffic volume and the streets also increases. The contradiction between the need to increase the speed of traffic and the growth of transport flows is becoming increasingly irresolvable.

The large intensity of the transport and the traffic jams are the two external factors affecting the transport expenses, that's why reducing their influence often is one of the main aims of the optimization of the transport organization. It is suggested that there may be a feedback between the traffic jam on the roads and the incidents, many authors are trying to confirm or reject this hypothesis [1,2,3,4,5,6,7,8]. The traffic jams may influence human's health by the different types of pollution generated, and that pollution can be exhaust or noise. [9]. The question whether the traffic jams are dangerous or not is important for the society as much as the influence of the congestion to the cities' and states' economy. Many research studies done in this connection prove this influence [10,11,12]. Finding the right balance of the above considerations in organization modelling of the traffic in the cities is of particular importance for creating of the good living environment.

2 Examine traffic organization

The carrying capacity of the crossroad is determined mainly by its size and type of control that cause the traffic jam. The parameters connected with vehicles' and pedestrians' flow, carrying capacity and the traffic jams are most important for the organisation and management of the traffic flow.

The parameters may be divided on three groups:

-outgoing - these are the parameters of the transport flows over the values that can't be affected and as well the parameters of the existing road junctions and sections.

-working – parameters and subjects describing the processes like lengths of queues, time for crossing, duration of the light signals, etc.

-evaluating-give an opportunity for evaluation of the decisions made as waiting time, lengths of the queues, the amount of the harmful emissions released by the transport vehicles, fuel expenses and others.

The traffic flows are characterised by the following parameters-intensity, speed, density and composition.

The intensity of the transport flow I_a^f is determined for the roadway, lane or direction as a ratio of the number of the vehicles passed A_m for a period of time t, estimated by the following formula:

$$I_a^f = \frac{A_m}{t} \text{ , N/h.} \qquad (1)$$

With given transport conditions the speed and density of the transport flow depend directly from its intensity. The continuous measuring of the speed is technically possible, but its use as an incoming parameter for modelling and optimization is unpractical for the different conditions on the road. The density of the transport flow requires examination over the large parts of the roadway but that needs great technological resource. The main thing in the modelling of the traffic flow is to determine or accepting of a rule that reflects the passing of the vehicles. This can be done by evaluating of the time intervals between the vehicles. It is measured from the point of crossing of the front bumper of the vehicle through a line drawn until crossing of the front bumper on the next car. Modern conditions of traffic in most cases do not allow the establishment of a law for the distribution of the time intervals between the cars. This is due to the fact that the traffic in urban conditions is subject to numerous factors, such as: distance to front traffic lights controlled intersections; condition of the road surface; limiting the speed on certain sections of the road network; weather conditions and others. Furthermore, the demand of the law of distribution does not always lead to a positive result, aggravates the use of algorithms for modelling of the road traffic. The following reasons as the parameter for testing intensity of traffic flow, which can be determined by the observers and as well by technical means such as video surveillance and other transport detectors. This is of significant importance of the realization of the adaptive signal regulation which, on the other side is a base of improvement of the organisation of the traffic in urban areas.

The parameters of the travel units and divisions such as dimensions, the type of flooring, number of lanes, etc. affect the carrying capacity of road intersections, but the physical change of the road section is not always possible. In practice, the only changes that could be made at intersections in the cities are the modification of the parameters related to the times at the light regulated intersections, as the times duration of the cycle of the traffic lights, duration and type of phases of the passing streams and etc. In individual cases the limits of change of these parameters are standardly defined. The effectiveness of the decisions taken, related to the organisation of traffic is evaluated mainly with the waiting time for vehicles. It can be defined for each vehicle, for all vehicles from a certain stream or for all streams. In some cases the carrying capacity of the road intersection can be estimated by the parameter waiting time, in other cases- the organisation of the traffic through the road parts and junctions. The composition of the traffic flow and the waiting time of the vehicles are connected with the released pollution emissions by the movement of the city transport.

The traditional methods for testing the parameters of traffic flow are complex and require significant resources, such as embedding of special technical means for traffic accounting, multiple observers that must be trained in the specifics of the activity that will be carried out. This process can be optimized using the video-recording, in which the necessary installation of multiple cameras for the studied areas of the roadway and others, as well as of the installation in the roadway sensors collecting the necessary information. Post-processing of the information is collected is associated with carrying out a series of equations through the use of different models. Using simulations may accelerate the research process and as well to achieve flexibility. Via simulation it is possible to look for a short time for different solutions to improve of the road traffic parameters. Another convenience of the simulation is that by its use the information gathered automatically can be processed easily. In the present research the product Vissim is used, which is a new thing for similar kind of studies in Bulgaria.

The aim of this work is to evaluate the possibility of the improvement of the organisation of the traffic light controlled crossroad via simulation.

2.1. Crossroad

The city of Ruse is the biggest inhabited place on the river Danube. The population of Ruse is 147 850 people which is making it the fifth biggest city in Bulgaria [14]. The urban traffic is maintained via 9 main boulevards, connecting the living city neighborhoods with its central part and the two industrial zones. One of those boulevards is ‘’Lipnik’’. Its length is 3.73 km, and there are 5 built traffic lights regulated crossroads. In the section of the crossroad between ‘’Lipnik’’(A1,A2) boulevard and the streets ‘’Ivan Vedar’’(A3) and ‘’Rayna Knyaginya’’(A4) (see fig. 1) which will be marked as ‘’C1’’ was found forming of the traffic jams with large duration. As a result of this problem, the time for travelling is longer for that part of road. The boulevard explored is a main road artery which connects the eastern living neighborhoods with the central part of the city. Street ‘’Lozen planina’’ is newly built and is a direct road from ‘’Rodina’’ living complex, ‘’Tcharodeika’’ and ‘’Druzhba’’ to the central city part and the commercial objects described in the sentence above. During the peak hour of the day the intensity of the traffic on the crossroad between these three streets and the organization of the traffic control create favorable conditions for traffic jams. In the present work the possibility of improvement of the organization of the traffic controlled crossroad with a simulation will be explored.

Fig. 1. Crossroad “C1”

2.2. Methodology of the study

The traffic intensity survey was conducted in June 2018 within one week through observation.

2.3. Building of the simulation model of a crossroad

Vissim software was used. The program can analyze private and public transport operations under constraints such as lane configuration, vehicle composition, traffic signals, PT stops, etc., thus making it a useful tool for the evaluation of various alternatives based on transportation engineering and planning measures of effectiveness. Accordingly, also pedestrian flows can be modelled, either exclusively or combined with private traffic and/or public transport [13].

The road network model consists of the boulevard and surrounding streets which are mentioned above. The Building of the model consists of the following steps:

- Building of streets and connections between them;
- Introduction of the actual organization of the traffic signalization.
- Introduction of the vehicle composition, intensity and direction of the traffic.

In this model the possible road incidents are ignored. The crossroad explored is presented on (Fig. 2).

The criteria by which the intersection organisation will be evaluated are the estimation and working parameters:

- Time of the traffic;
- Maximum length of the queue;
- Number of the passing vehicles on that section of the road.

The queue length Q_{av} may be determined continuously if the information for the arriving and departing vehicles is available. When there is no such possibility, it is determined experimentally by the following formula:

$$Q_{av} = \sum_{i=0}^{n} q_i. \qquad (2)$$

where: q_i is the queue length for every measurement (every cycle of estimated periods or defined period of time), vehicle number.

n – number of measurements in the estimated period.

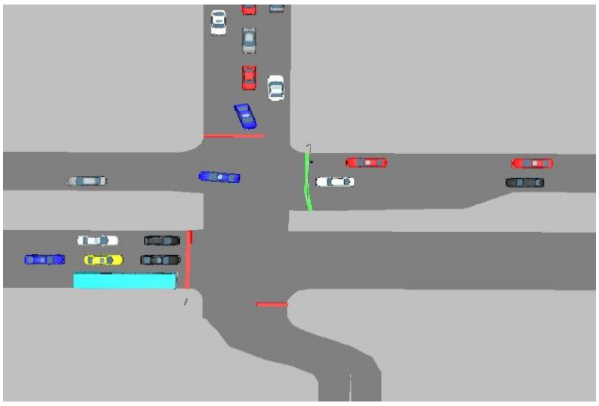
Fig. 2. Crossroad “C1” - model in Vissim

The entered intensity of the traffic is experimentally established via direct observation of the crossroad during the peak time of the day. The explicit information, entered in the simulation for the traffic lights control is estimated by the measurement of the distance (Fig. 3).

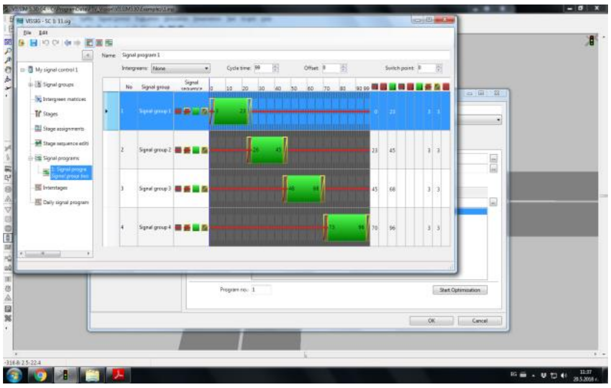
Fig. 3. Graphic of the traffic light control

3 Results from the study

Traffic simulation data at the intersection "C1" shows a total intensity of 2373 E/h. Of these, 97.35% of the cars crossed by the intersection, 1,47% HGV and 1,18% is buses from urban passenger transport.

The average running speed of city passenger buses in "C1" peak is 9.83 km / h, which is 44.7% lower than that of cars.

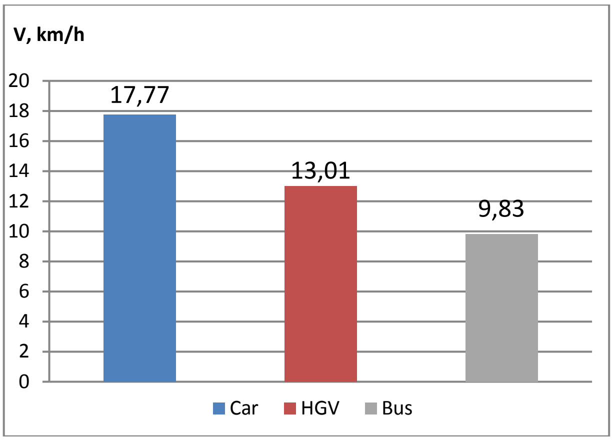

Fig. 4. Average traffic speed of vehicle types

This difference is due to the passengers' embarkation and disembarkation, as well as to the lower acceleration values when starting at the junction or the bus stop related to the comfort of travel.

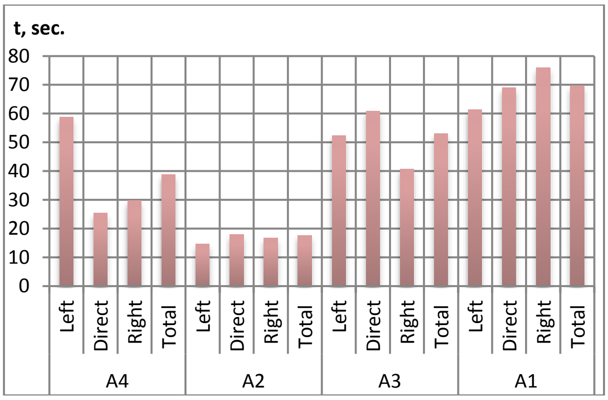

Fig. 5. Average time inhibitions for passing through “C1” in different directions

As can be seen from the diagram, the most significant is the delay due to crossing the junction for the A 1 transport stream. Because of the resulting detention, vehicles fail to cross the intersection during the permissive alert, and an extra wait is required. The average length of the tails forming in this direction is 64,4 m., reaching at or even exceeding 100 m. Largest decelerations have vehicles running right to A3 – 75,9s. This delay is a consequence of many factors stemming from the presence of traffic light traffic at the crossroad. In two of the A2 and A4 directions, almost no queues are formed, and therefore the average queue length is bent to 0.

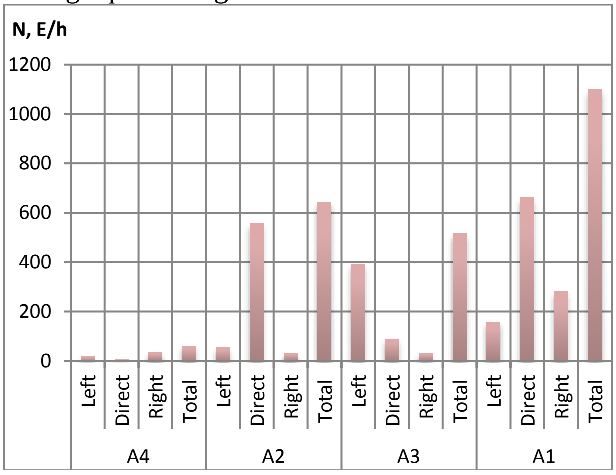

Fig. 6. Distribution of traffic intensity by directions

As seen above, the main transport flow in the period 17:00 - 18:00 is the one on Lipnik Blvd. Driving vehicles from A 2 to C1 are a total of 644 units and A 1 to 1099 units. In total, the two flows generate just over 73% of the total traffic intensity at the crossroad. Relatively low is the transport flow of A4. It represents only 2.6% of the workload at the crossroad.

4 Conclusion

Due to the low average traffic speed of 9.81 km / h and the length of individual vehicle types between 11 and 13 m, along with the limited time to cross the junction during the green signal 18 sec. Interaction between public transport vehicles and other vehicles, as well as the large number of A1 vehicles, worsens the crossing capacity of the junctions and leads to the formation and extension of queues to pass through it. It is therefore necessary to make a new cyclogram in order to optimize the times for crossing the junction.

The use of "Vissim" software products to simulate transport processes in the construction, maintenance and optimization of the urban road network can offer appropriate optimization of crossing times to reduce vehicle downtimes or it is proven that the applied model is the most appropriate and it is necessary to look for other optimization solutions.

Using computer simulation. allows multiple attempts to be made in a different arrangement of traffic light signaling to select the most appropriate option before it is actually implemented. This makes it possible to avoid errors at the stage before making definitive changes.

Acknowledgement

The study was supported by contract of University of Ruse “Angel Kanchev”, № BG05M2OP001-2.009-0011-C01, " Support for the development of human resources for research and innovation at the University of Ruse “Angel Kanchev”. The project is funded with support from the Operational Program " Science and Education for Smart Growth 2014 - 2020" financed by the European Social Fund of the European Union.

The report reflects the results of the work on the project no 2019-FT-02, funded by the National Science Fund of The University.

References:

[1] Chao Wang Mohammed, A. Quddus Stephen, G. Ison, Impact of traffic congestion on road accidents: A spatial analysis of the M25 motorway in England. Accident Analysis & Prevention Volume 41, Issue 4, July 2009, Pages 798-808

[2] D. M. Belmont, T. W. Forbes, Effect of average speed and volume on motor-vehicle accidents on two-lane tangents, Proceedings of the Highway Research Board, 32 (1953), pp. 383-395

[3] A. Ceder, M. Livneh, Relationships between road accidents and hourly traffic flow. I. Analyses and interpretation. Accident Analysis and Prevention, 14 (1) (1982), pp. 19-34

[4] T. F. Golob, W. W. Recker, Relationships among urban freeway accidents, traffic flow, weather, and lighting conditions. Journal of Transportation Engineering, 129 (4) (2003), pp. 342-353

[5] Yurshevich, E., Yatskiv, I., Modelling as a means of solving the problem of city traffic, September 2004

[6] Yatskiv, I., Yurshevich, E., Savrasov, M., Investigation of riga transport node capacity on the basis of microscopic simulation

[7] Soo, H. Y.; Teodorovic, D.; Collura, J. 2006. A DSS Framework For Advanced Traffic Signal Control System Investment Planning

[8] Lyubenov D. „Изследване на някой от основните характеристики на транспортния поток по ул. “Плиска”, гр. Русе”. Trans & MOTAUTO 2011. с. 8–10. ISBN: 1310-3946.

[9] Journal of Public Transportation 9(4): 87–106.

[10] Mats Wilhelmsson, The Impact of Traffic Noise on the Values of Single-family Houses. Journal of Environmental Planning and Management, Volume 43, 2000 - Issue 6, pp. 799-815

[11] Richard Arnott, Kenneth Small, The Economics of Traffic Congestion. American Scientist, Vol. 82, No. 5 (September-October 1994), pp. 446-455

[12] Phil Goodwin , Joyce Dargay, Mark Hanly, Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review. Transport Reviews, Volume 24, 2004 - Issue 3, pp 275-292

[13] Vissim 5.30 manual: https://www.et.byu.edu/~msaito/CE662MS/Labs/VISSIM_530_e.pdf

[14] National statistical institute of republic of Bulgaria, statistical yearbook 2014, Sofia, 2015, pp. 62