Analysis of traffic flow in an urban environment based on simulation

O A Lebedeva* and J O Poltavskaya
Angarsk State Technical University, Russian Federation, 665835, Angarsk

* kravhome@mail.ru

Abstract. The article deals with the topic of simulation. The transport system is an important factor in the economic development of the urban environment. Its development is influenced by the condition of the roads, the intensity of road traffic, and the time costs of moving. Traffic closures have a negative impact on the quality of traffic management. To improve the efficiency of the transport system, we suggest using simulation modeling to analyze and optimize the duration of traffic. Research in the field of optimization of traffic flow Angarsk. You get that by increasing the speed by 50% the transport network does not cope with the load. The functional relationship between traffic intensity is established.

1. Introduction
Urban transport infrastructure is an important component of effective city development. The optimal functioning of the urban transport system has a positive effect on the population, development and economic condition of the city [1, 2].

Modelling the transport system is closely related to the definition of "mobility" - that is, increasing the speed of vehicles and reducing time costs. Analysing the state of the urban transport environment, many elements of the road network are taken into account, such as streets, traffic lights, road markings, road signs, pedestrian and bicycle lanes, stopping points, public transport lines. Forecasting transport demand is crucial for effective planning of urban transport operations.

Planning models are becoming increasingly important for assessing the functioning of the urban environment and are used globally to solve problems of different levels of complexity. Imitation modelling makes it possible to reproduce the real picture of the organization of traffic, taking into account the geographical location of the area and to predict traffic flows [3, 4, 5]. Simulation is a reliable tool that experts can use to evaluate options for the development of the transport network. The modelling process for the purpose of analysis and optimization is difficult to implement using conventional methods due to the complexity of the structure of the transport system and the interaction of its elements. The practical application of strategic modelling provides a high degree of abstraction of solving tasks.

2. Theoretical basis
The project of optimization of traffic flows was carried out on the example of the city of Angarsk. The methodology includes a detailed analysis of the city’s transport network, with the identification of sections of the road network requiring measures aimed at eliminating congestion during peak hours.

For the simulation, a satellite image of the road network at the intersection of Glinka and Voroshilov streets was chosen. Field surveys of traffic intensity revealed congestion during peak hours at this site, which leads to a change in the mobility of the urban transport system due to an increase in
the number of vehicles and road users. The site under consideration connects the central part of the city with residential neighborhoods. The junction is T-shaped, unregulated. The scheme of the organization of traffic at the intersection under study is shown in Figure 1.

**Figure 1.** Traffic organization scheme at the intersection of Glinka and Voroshilov streets.

Along Voroshilov Street, the movement is carried out in two directions - straight ahead, to the left (driving directions 1 and 2). When driving along Glinka Street - to the right, to the left (direction of movement 3). Maneuver "turn" is possible in all directions. There are footpaths on the site under consideration. Their presence is due to the following places: the stadium and swimming pool "Angara", the city court, music and secondary schools, the university, residential area.

A field survey of traffic intensity was conducted during the peak period of the day (from 8.00 to 9.00, from 17.00 to 18.00). Figures 2 and 3 shows the change in the intensity of movement of traffic and pedestrian flows by days of the week.

**Figure 2.** Traffic flow intensity by day of the week.

A full-scale survey showed that the greatest intensity was observed on weekdays and was about 1,400 vehicles per hour, on weekends a decrease in intensity to 500 units was observed. The intersection to be examined is located on the loaded section of the road network, therefore it is
necessary to optimize the movement of traffic flows in order to reduce travel time and minimize the number of traffic jams (Figure 2).

To analyze the urban transport network, it is necessary to evaluate pedestrian flows, which allows you to effectively plan the organization of the pedestrian area (Figure 3). Evaluation of solutions to the “narrow” traffic areas of pedestrian flows should include the location of: objects of venue (areas of shopping and entertainment and business centers, stadiums, stations), parking space, loading and unloading areas of freight transport, visualization of a promising transportation situation [6].

The analysis allows us to evaluate the planning decisions of the organization of the movement of pedestrian flows in terms of the level of service and comfort of moving pedestrians as close to reality as possible. At the same time, any possible characteristics of the movement of pedestrians should be taken into account: ignoring the red signal of a traffic light, crossing the street in the wrong place, changing behavior depending on time and space, and much more.

3. **Traffic flow simulation**

To solve the problem of optimizing the movement of traffic flows, the software PTV Vissim v.10 was used [7]. For this, the following method was developed.

Step 1. Preparatory stage. The creation of a simulation model begins with the selection of a satellite image from a Google map associated with the specified intersection, which was selected for analysis and optimization. To obtain reliable results, the created model is scaled based on the satellite image (the scale was 50 meters).

Step 2. Creating segments of the road network and intersection, taking into account the number of lanes and possible options for movement (turn, turn).

Step 3. Establish conflict zones at the intersection of the existing segments (Figure 4).
Step 4. Determination of traffic and pedestrian traffic intensity on the basis of previously conducted field surveys with an indication of the percentage composition of traffic flow by type (cars, trucks, buses, motorcycles) (Figure 5).

Step 5. Setting up the traffic light regulation. After building the traffic flow model, traffic light regulation is introduced taking into account the duration of the phases. Further, it is possible to optimize the work of a traffic light object. This stage is carried out in case the intersection is adjustable.

The change in traffic on the road network was assessed by increasing traffic intensity by 25 and 50%. To assess the effectiveness of the existing traffic organization, a variant was modeled that would allow predicting the reliability of the transport system. With an increase in traffic intensity by 50%, congestion occurs from the side of Voroshilov and st. Glinka in the case of turning left (the need to pass cars in two directions). A solution to the task is to install a traffic light object, and / or to differentiate the movement of traffic and pedestrian flows in space.

The functional relationship between traffic intensities in directions 1 and 2 has been established (Figure 6).
The high quality of a second-degree polynomial regression model, for which the coefficient of determination \( R^2 \) is calculated and its value is 0.8096, has been experimentally confirmed.

The obtained equation for the dependence of the intensity of movement in directions has a high quality of approximation, since the coefficient of determination \( R^2 > 0.8 \) (Figure 6).

4. Conclusion

At present, traffic flow analysis based on simulation modeling is an important step in assessing the organization of traffic in an urban environment, since the transport system must function effectively. The software used allows you to simulate traffic situations with a large number of road users. The duration of the iterative modeling process depends on the goals, objectives and limitations of the system. Simulation is influenced by the location of transport infrastructure elements: bus stations, bus stations, stopping points of the route network; types of vehicles are additionally specified, the intensity of movement of pedestrian flows.

Simulation modeling allows us to predict the efficiency of the transport network in a changing load for a long period.

References

[1] Vetrogon A A and Kripak M N 2018 Modern technologies. System analysis. Modeling Transport modeling as a tool for efficient solutions of the traffic flow management problems Vol 59 No 3 pp 82-91

[2] Poltavskaya Y O, Kripak M N and Gozbenko V E 2016 Modern technologies. System analysis. Modeling Assessment of the traffic flow with using GPS-technology No 1 (46) (Irkutsk) pp 155-161

[3] Kripak M N and Lebedeva O A 2016 Modern technologies. System analysis. Modeling Evaluation of the road network on the example of Angarsk streets No 3 (51) (Irkutsk) pp 171-174

[4] Macal C M and North M J 2009 Proceedings of the 2009 Winter Simulation Conference Agent-based modeling and simulation (Texas, USA)

[5] Coman M-M and Badea D 2017 Revista academiei forțelor terestre The vehicles traffic flow optimization in an urban transportation system by using simulation modeling nr 3 (87) pp 190-197

[6] Huynh N, Cao V L, Wickramasuriya R, Berryman M, Perez P and Barthelemy J 2015 Infrastructure and the City An Agent Based Model for the Simulation of Transport Demand and Land Use, http://discovery.ucl.ac.uk/1469210/1/67-72.pdf

[7] PTV PARTNER, http://ptv-vision.ru/