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Managing traffic and pedestrian flows at an intersection: simulation model parameters

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Abstract. The article highlights and justifies the input parameters for the simulation model of an intersection. The purpose of building the model is to predict and evaluate the results for reducing traffic and pedestrian downtime. The object of the study is an intersection located in the Pokrovskoe-Streshnevo area of the Northwest District of Moscow (55°49'35.9 "N 37°27'08.0 "E). The authors structured and analyzed traffic flows passing through the intersection. The frequency of public transport, the location of nearby stops of such transport, and the phases of traffic lights were determined. Also, the parameters for the simulation scenarios are defined.

1 Introduction

A modern city is a complex network consisting of many segments (sociocultural, economic, transport and logistics, etc.). As Seliverstov (2015) points out in his research: "solving the transportation problems of urban agglomerations requires the increased use of global radio-navigation systems, high-performance info-telecommunication technologies, software and algorithmic information processing tools to create intelligent urban transportation systems on their basis".

Russian cities are characterized by the growth rate of motor transport, which significantly outstrips the pace of development of the street and road network. All this contributes to a number of problems related to the organization and management of traffic: traffic congestion, environmental pollution, etc. In Moscow, all of this is aggravated by the historically established radial-ring layout of the city, significant growth and densification of the urban environment, considerable influence of suburban traffic flows and the separation of places of work and living, Mogoras (2010). One of the ways to effectively organize traffic and pedestrian flows is simulation modeling, which allows to simulate real objects of the urban environment, taking into account all the existing processes and implement different scenarios for modernization. All this allows to reveal patterns of influence of different factors and formalize knowledge about dynamic properties of the problem area.

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Thus, *the aim of the study* is to modernize traffic and pedestrian flows at an intersection within the same neighborhood.

The theoretical significance of the study is the design of a simulation model, which is a module of the intelligent transport system of the city for the prediction of the dynamic states of traffic and pedestrian flows.

The practical significance of the study lies in the possibility of controlling the flows when crossing an intersection according to the given parameters of the implementing scenario.

2 Objects and methods

The object of the study is an intersection located in the Pokrovskoe-Streshnevo area of the Northwest District of Moscow. The intersection is formed with Tushinskaya Street (marked in red in Fig. 1) and Svoboda Street (marked in yellow in Fig. 1). Tushinskaya street provides transport connection within the district and links main streets of municipal significance. One of such streets is Svoboda Street. It provides connection of district residents with the major transport artery Volokolamskoe Highway, which represents a high-speed transport connection between the major districts of Moscow.

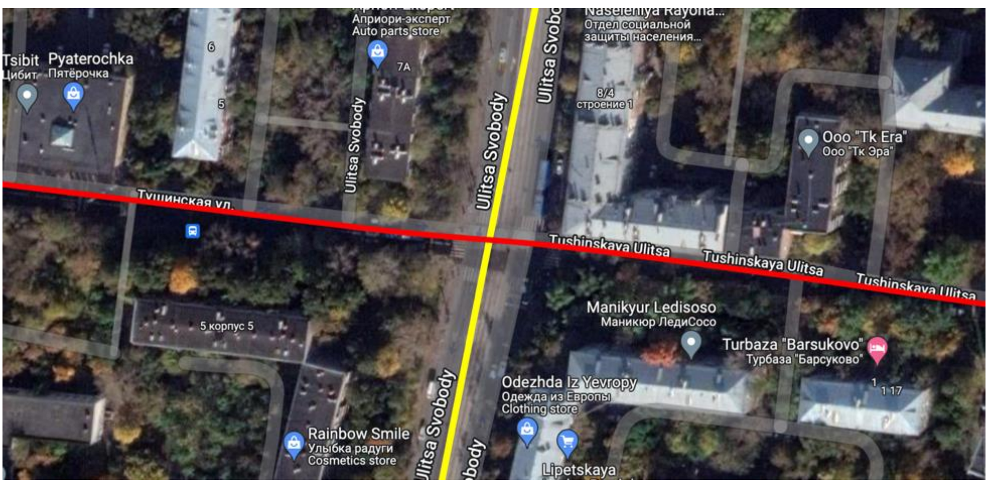


Fig. 1. Satellite imagery of Tushinskaya Street and Svoboda Street intersection in the Pokrovskoe-Streshnevo district of Moscow.

In order to obtain the characteristics of the object for the purpose of building a simulation model, our team used the following commonly used methods:

- analysis
- observation
- structuring
- synthesis

As noted in the studies of processes within ecosystems of various organizational structures, the use of the structurization method makes it possible to highlight the features of processes and objects that meet the goals and objectives of the study, Logachev et al. (2022b), Logachev et al. (2022c). The observation method makes it possible to obtain quantitative and qualitative characteristics of structured objects in real time with dynamically changing indicators of the system. The data obtained as a result of using structurization and observation methods is processed, studied and using the method of analysis the dependencies of these indicators between themselves, on surrounding events, etc. are determined. In this case, the method of synthesis allows to establish new characteristics of objects, which are obtained on the basis of the analyzed data, Logachev et al. (2022c), Nikitina et al, 2017. These are the input parameters for simulation modeling scenarios in the model, Yao et al. (2018).

3 Results

The results obtained by our team of authors are divided into the following groups:

1. The results obtained by structuring data from open sources. This group should include quantitative and qualitative characteristics of the object:

- related to the organization of personal vehicle traffic in the specified area (determined by Google Maps and Google Panoramas, which are in the public domain: https://goo.gl/maps/eRRFjJP2iuzdAxEw8);
- related to the organization of public transport traffic (determined by Yandex maps: https://yandex.ru/maps/-/CCUZm8VI9B);
- related to the intensity of public transport traffic (determined by the official schedule posted on the website of the Moscow Transport Portal: https://transport.mos.ru).

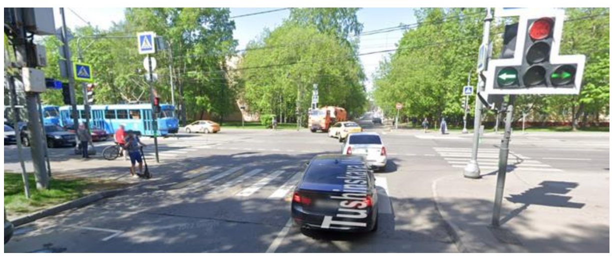
The results obtained during the field study of the site. At this stage the researchers determined the intensity of traffic, the phases of traffic lights, and typical scenarios of pedestrian behavior.

Let us consider the results obtained in order.

The characteristic of the traffic organization is presented in Table 1. For the convenience of comparing the obtained results, the authors adhered to the letter designation of the road sections presented in Fig. 2.

Fig. 2. Letter designation of sections of Tushinskaya Street and Svoboda Street.

Table 1. Traffic management at the Tushinskaya Street and Svoboda Street intersection.

<table>
<tr><th>No.</th><th>Street</th><th>Characteristics</th></tr>
<tr><td>1</td><td>Tushinskaya Street AB</td><td>Two-lane one-way traffic in the direction towards point B. There is a dedicated parking lane. Traffic is allowed towards D, E and F</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>2</td><td>Tushinskaya Street CD</td><td>One lane in each direction of traffic. There is a dedicated parking lane. Traffic is allowed towards E and F</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>3</td><td>Svoboda Street EG</td><td>Two lanes in each direction of traffic. Separated by dedicated lanes for tramway in oncoming directions. At point G there are dividers between tramway and car lane in order to prohibit cars from entering the tramway while waiting to make a turn</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>4</td><td>Svoboda Street GF</td><td>Similar to EG</td></tr>
<tr><td colspan="3">
</td></tr>
</table>

The characteristic of the organization of public transport at the studied intersection is presented in Table 2.

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Table 2. Traffic management of public transport at the Tushinskaya Street and Svoboda Street intersection.

№	Section	Characteristics
1	EF	Two-way tram traffic, no priority intersection crossing, no drop-off and pick-up of passengers, no technical stop. A single route with an interval of 5 to 10 minutes
		Bus traffic in two directions. Two daytime routes with an interval of 5 to 10 minutes, and one night route with an interval of 30 minutes
2	AB	Bus traffic. Five routes at 5 to 10 minute intervals. At the intersection all routes keep going towards the F. The nearest stop is 90 meters away from the intersection
3	CD	There is no public transport traffic

The field study made it possible to determine the phases of the traffic lights that regulate traffic at the intersection for road transport (a schematic representation is shown in Fig. 3).

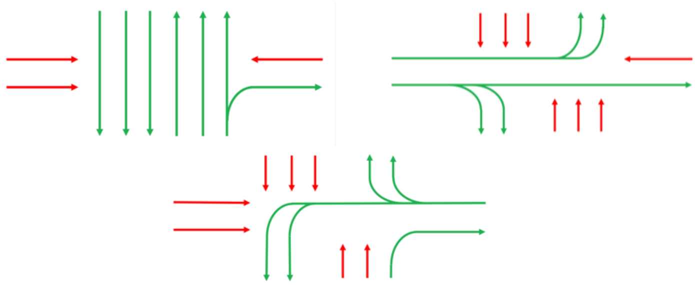

Fig. 3. Phases of traffic lights for motor transport at the Tushinskaya Street and Svoboda Street intersection.

In Fig. 3 the traffic flows that are prohibited to move are marked in red, and the traffic flows that are allowed to move are marked in green. The tram traffic is not marked separately, as it has no priority on this section.

Pedestrian flows are shown in Fig. 4. It should be noted that the scheme does not respect the distance of crosswalks from the intersection with natural metrics.

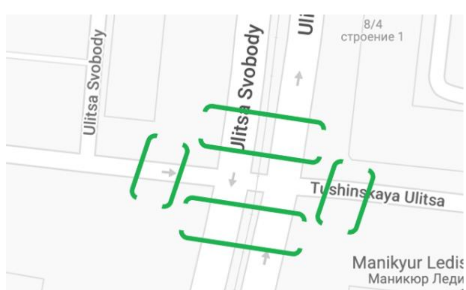

Fig. 4. Scheme of pedestrian flows at the Tushinskaya Street and Svoboda Street intersection.

All listed parameters and their characteristics are basic for the simulation model. The option shown in Fig. 5 is considered as the main scenario to be implemented in the simulation model.

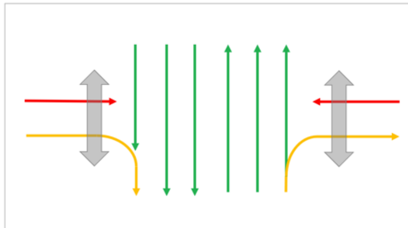

Fig. 5. Traffic pattern with changing parameters in the simulation model of the intersection.

The grey arrows in Fig. 5 indicate the pedestrian movement during vehicular traffic on Svoboda Street. At the same time, motor traffic will be executed along the yellow arrows (turning from Svoboda Street to Tushinskaya Street (ABE) and from Tushinskaya Street to Svoboda Street (ECD)). The organization of such turns should be carried out by traffic lights with combined phase (simultaneous movement of pedestrians and vehicles making a right turn). The second part of this scenario is diagonal movement of pedestrians along the intersection with the traffic lights prohibiting all traffic.

4 Discussion

Management of the transport system of large cities using information technology is widely used in global and national road traffic organization practice, Seliverstov (2015). The building of simulation models is one of the ways to implement scenarios that allow evaluating potential changes in the transport system of certain areas at different time intervals. Our team of authors obtained the basic parameters of the simulation model, allowing to build mathematical and software-algorithmic models. In their works Logachev et al. (2022a) and Alajali et al. (2018) note the importance of obtaining such parameters, on the basis of which mathematical models describing certain processes of the problem area are developed. It should be noted that in the works of Nikitina [5], the regulation of traffic and pedestrian flows in order to reduce the downtime of transport within the simulation model allows to estimate the levels of environmental pollution. The work performed by our team does not contradict such studies as Buneev (2018), Zeng (2018), but complements and allows the simulation of different environmental scenarios in the area. The results obtained as part of the work are reliable and reflect the real characteristics of the problem area. Reliability of the obtained results is confirmed by the use of common methods for conducting appropriate research.

5 Conclusion

The building of simulation models is one of the main tools for assessing the efficiency of transport construction or traffic management in the existing development. Such models are not only illustrative, but also flexible, allowing to simulate different states according to a certain scenario (for example, changing the number of road lanes). By the results of the analysis of the obtained simulation an appropriate decision is made whether it is possible to implement the scenario parameters or not. An important feature of such models are the input parameters, which reflect the quantitative and qualitative indicators of the real object.

To summarize, we note that the input parameters obtained for the simulation modeling of flows crossing an intersection are reliable. This is ensured by the proper use of methods, the application of a systematic approach in the analysis, structuring of the subject area and the consistency of the obtained results with the results of the other researchers' studies.

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