Modelling parameters of traffic flows in a traffic simulation model with the priority of public transport

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Abstract. The article defines the importance of simulation modeling of traffic flows for the development of both individual territories and the entire city. The object of the study is a transport artery connecting two major districts of the city of Moscow: Strogino and Shchukino. As part of the work, the key quantitative and qualitative parameters of the object are highlighted, allowing to determine the input parameters for the simulation model of the real object in order to implement a scenario of reducing the number of lanes for personal road transport and adding a dedicated lane for public transport.

1 Introduction

Traffic safety and increased capacity of arterial highways are determined by the quality of traffic management. The scope of such traffic organization includes the management of traffic and pedestrian flows. As Kuzin notes in his work, "to find effective strategies for managing traffic flows in a metropolis, optimal solutions for the design of the street and road network and traffic organization, it is necessary to consider a wide range of traffic flow characteristics, patterns of influence of external and internal factors on the dynamic characteristics of the combined traffic flow", Kuzin (2011). To solve this problem, it is necessary to build an adequate model of traffic flow. Such model is based on the input parameters. For example, in his study Logachev et al. (2022a) gives the argument that a detailed analysis of the problem area is required in order to highlight all its possible quantitative and qualitative characteristics. In addition, it is necessary to build a model to predict the consequences of any changes in the actual state of the object. As such a change, the study assumes the introduction of dedicated lanes for public transport. According to

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Belova (2014), it is "one of the effective ways to reduce the load on the streets and roads, improve the quality and efficiency of passenger transportation in cities".

Thus, the purpose of the study is to develop a methodology to justify the use of dedicated lanes for public transport on the case of a road network section in the districts of the city of Moscow.

The practical significance of the study lies in the organization of traffic using priority for certain types of transport with the possibility of reducing its downtime and increasing its attractiveness.

The theoretical significance of the study is to determine the quantitative and qualitative characteristics of the real object in order to create the rules of the formal model, which allows to simulate different scenarios of its behavior depending on external influences.

2 Objects and methods

1. The object of the study is a 4 km long section of road, which begins in the Strogino district and ends in the Shchukino district. This section is formed by Marshal Katukov Street (from house 22), Strogino highway, Strogino bridge and Novoshchukinskaya street.
2. The formal model of the object is built on the basis of its quantitative and qualitative characteristics, which are obtained by the combined use of the following methods:
3. Abstraction. Allocation of significant features of the object for further research. Allocation of features of the object for model building requires the use of step-by-step refinement method, Logachev et al. (2022b), Logachev et al. (2022c).
4. Observation. Allowed to isolate the quantitative values of the object characteristics with the help of the sensory organs.
5. Analysis. Evaluation of the significance of the obtained results in the course of using the methods of abstraction and observation.
6. Synthesis. Creating rules for the model based on the results of analysis.

3 Results

As a result of applying the methods to the object under study, the key characteristics that became the input parameters for the implementation of simulation modeling have been established.

The road section has three lanes in each direction for road transport and a dedicated lane for a tramway (a detailed diagram of the section is shown in Fig. 1). It should be noted that the tramway is elevated above the roadway.

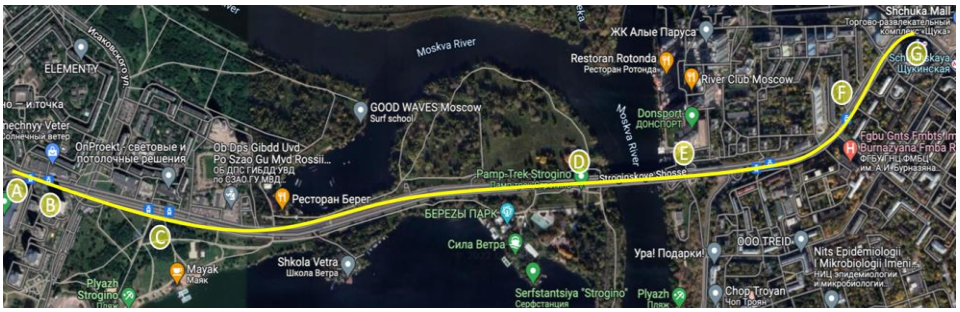
In the course of the study, it was found that this section serves as a connecting strip for two Moscow districts: Strogino (159 thousand people) and Shchukino (110 thousand people). Statistical data on the population were obtained by studying the report of the Federal State Statistics Service for the urban population of the city of Moscow on January 1, 2022 (https://showdata.gks.ru/report/278932). This section of the road allows to carry passengers to the metro stations of radial direction (Strogino and Shchukinskaya). Separately, it should be noted that Shchukinskaya station is a major transfer hub that combines the Moscow Central Diameter, subway, tram and bus routes.

In order to build a model that will allow to estimate the effect of implementing a dedicated lane for public transport, the intensity of public transport traffic, the duration of phases of traffic lights and the number of exits (or intersections) should be taken into account.

Fig. 2 shows a scheme of the location of traffic lights.

Traffic lights that are located on the site of the studied object can be classified into the following groups:

- traffic lights organizing the movement of pedestrians (located at tram stops and equipped with a traffic light button);
- traffic lights organizing the movement of transport and pedestrians (located at intersections).
- The intensity of public transport is high:
- four tram routes (2–5-minute traffic interval during peak traffic loads, 5-10 during off-peak intervals; the rolling stock includes trams of large and extra-large passenger capacity class);
- seven bus routes (5–10-minute traffic interval; the rolling stock includes cars of medium, large and extra-large passenger capacity class).



Road section: 22 Marshala Katukova Street (A) – Stroginskoe Highway (C-D) – Strogino Bridge (D-E) – Novoshchukinskaya Street (E-F-G) (Source of the background map: https://goo.gl/maps/7Lkq3F6AFYKbdE5p8).

Direction from C to B (Stroginskoye Highway and Marshala Katukova Street)

Direction from B to A (Marshala Katukova Street)

Direction from E to D (Strogino Bridge and Novoshchukinskaya Street)

Direction from E to D (Strogino Bridge and Stroginskoye Highway)

FE section (Novoshchukinskaya Street)

Direction from F to G (Novoshchukinskaya Street)

Fig. 1. Scheme of the traffic organization along the section from Marshala Katukova Street to Novoshchukinskaya Street in Moscow (source of the panoramas: Yandex https://yandex.ru/maps/-/CCUZ4LVrkA).

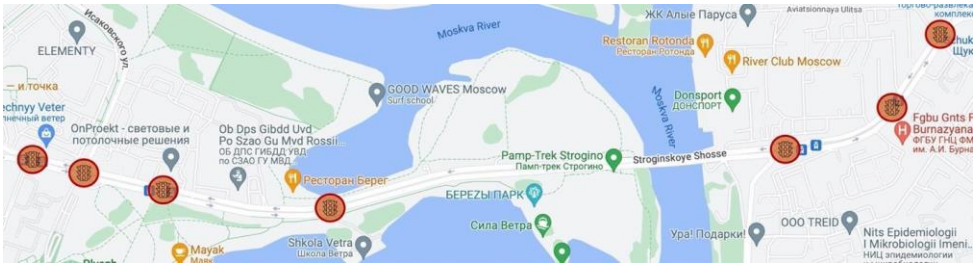


Fig. 2. Location of traffic lights along the section from Marshala Katukova Street to Novoshchukinskaya Street in Moscow (Source of the background map: https://goo.gl/maps/7Lkq3F6AFYKbdE5p8).

It should be noted that the tramway routes already run in physically separated lanes away from road transport, but their traffic has an impact on the organization of traffic along the dedicated bus lane being developed. The reason is that the organization of traffic uses a dedicated traffic light for tramways at all intersections, and also the frequency of passenger approach to (or from) the tramway stops.

The number of right turns along the traffic and exits to the study area should be taken into account when building the model, since all this traffic will be crossing the public transport lane. Fig. 3 shows the places where, depending on the direction of traffic along the studied section, motor transport will cross the public transport lane.

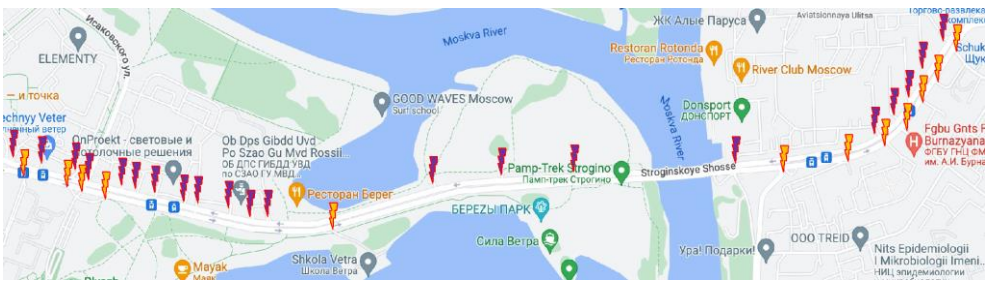


Fig. 3. Scheme of exits depending on the direction of traffic along the section from Marshala Katukova Street to Novoshchukinskaya Street in Moscow (background map source: https://goo.gl/maps/7Lkq3F6AFYKbdE5p8).

In addition, the model should take into account the intensity of motor traffic. The study revealed that on weekdays the congestion is distributed as follows:

- 7:30am-10:00am 7-8 points (towards Shchukinskaya metro station), 5 points (towards Strogino metro station);
- 5:00pm-9:00pm 7-8 points (Strogino metro station direction), 6 points (Shchukinskaya metro station direction);
- during the rest of the time, it varies from 3 to 4 points.

At weekends congestion intensity is 3-4 points, not taking seasonality into account. Congestion intensity is measured on a scale from 1 to 10, according to the Yandex Traffic system.

4 Discussion

The solution to a city's traffic problems depends on the role of public transport. As it is noted by a number of researchers, the popularity of studies aimed at developing techniques,

modeling and organizing the transport systems functioning has increased over the last decade, Somov (2015), Chen et al. (2019), Zhao and Hu (2019). Modeling and designing processes of varying complexity depend on the quality of the analysis of a problem domain, Logachev et al. (2022a), Logachev et al. (2022b), Ma et al. (2021). As Belova (2014) notes in her study, traffic flows with the allocation of public transport are a complex managed system, which relies on a variety of indicators. The general methodology for modeling such a system should be based on mathematical and system analysis, the implementation of which requires valid and reliable input data, Somov (2015), Ma et al. (2021). The methodology for obtaining such data correlates with the methodology for obtaining qualitative and quantitative data that was used by our author's team.

5 Conclusion

The modern software market often requires the development of operational decision support systems based on the results of simulation modeling of real processes. To develop such models, various methods are used to evaluate management decisions or reorganization of different systems, including transport systems. In this case, such modeling requires deep decomposition, gathering and analysis of all aspects or entities relevant to the object under study. Based on the results of such work, input parameters are formed, which reflect the quantitative and qualitative characteristics of the object, allowing to create an adequate model of the object for the implementation of various scenarios.

The results obtained during the study reflect all transport features of the allocated object and allow to build an appropriate simulation model to assess the possibility of implementing a dedicated lane for public transport.

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