Input parameters for simulation modeling of traffic capacity at intra-district intersection

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Abstract. The results of structuring, analysis and synthesis of objects and processes of the road network section in the northeastern part of Shchukino District in Moscow are presented in the article. The purpose of this study is to identify the key quantitative and qualitative indicators necessary to create a simulation model of the corresponding area. The features of transport and pedestrian flows of the road network section are distinguished.

1 Introduction

The need to create simulation models is due to increasing pedestrian and traffic flows, an increase in the pace of construction of housing and social facilities, the modernization of the infrastructure of the road network and pedestrian zones in any area of the city, Gharehbaghi et al. (2020), Borisova (2020). With the help of such models, one can explore all the flows and processes of both individual sections of the city and districts, Mikhailov and Shesterov (2020). It should be noted that the main problem of managing any traffic is local in nature and in most cases is caused by the desynchronization of traffic light regulation. Thus, it is relevant to solve problems in individual sections of the region with an analysis of the general situation of the nearby territory.

Simulation models are created by various methods and are flexible (allow to implement many scenarios for the behavior of system objects) and visual (creation of both two-dimensional and three-dimensional models) Malykhanov (2011), Ramirez-Polo et al. (2021). According to Malykhanov (2011), high-level simulation models operate on the aggregate characteristics of transport infrastructure facilities, while low-level ones reflect only the behavior of each traffic participant.

To create a simulation model, it is necessary to develop a thorough design of the study **with the aim to** obtain accurate statistical data that allow a quantitative and qualitative assessment of existing objects and processes implemented in a selected area.

The theoretical significance of the study is the identification of key indicators and patterns of the traffic area, which can be used to create models that visualize various real traffic scenarios (for example, peak loads, failure of a traffic light, accidents, etc.).

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The practical significance is the ability to accurately and quickly change the state of road objects with an increase in the level of traffic safety, a decrease in the load on the road transport infrastructure, etc.

2 Methods

The research object is the intersection of Pekhotnaya Street and Aviatsionnaya Street in the Shchukino District of Moscow. It has the following coordinates: 55.810606, 37.483711 (coordinates determined from Google maps).

The following methods were used to develop the study design:

2.1 Method of structuring

This method provides for quantitative and qualitative descriptions, hierarchical distribution of all objects and relationships between them related to the selected problem area. According to Logachev et al. (2022a), Logachev et al. (2022b) in order to achieve the best results in the analysis of the subject area, one should use the method of step-by-step refinement or division of a complex object into simpler ones. Therefore, to highlight such features, this method was applied.

2.2 Method of analysis

The use of this method made it possible to identify the features of each object, to establish its compliance with the goals and features of use in the framework of the study Kuzin (2011), Sandhyavitri et al. (2021). It should be noted that the method of analysis used was direct, i.e. from the current state of objects to the ultimate goal of their use.

2.3 Method of synthesis

This method was used after applying the analysis method in order to combine the obtained parts into a single whole. As a result, clear requirements are formulated for the implementation of the next stage of the development life cycle, namely, the modeling of processes with given options for parameters, Savvin and Belyaev (2015).

3 Results

The use of the methods listed in the previous section enabled to determine all the features of the research object necessary for the modeling process.

As a result of the structuring of the object of study, the following features of the intersection were identified:

1. Pekhotnaya Street connects a part of the Shchukino residential area with the Volokolamskoye Highway “outbound” highway of the city (Figure 1 shows a map of a fragment of the area). Is a street with one-way traffic without public transport at the specified intersection, has parking pockets (Figure 2 shows the image of the street in both directions).

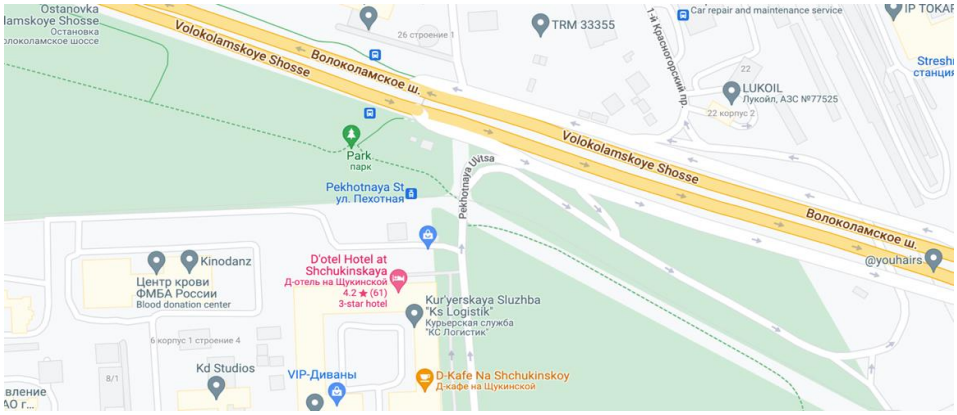

Fig. 1. Map of the northeastern part of the Shchukino region. Moscow city (Google Maps source).

Fig. 2. Current state of Pekhodnaya Street in Moscow (source: Yandex panoramas, https://yandex.ru/maps/-/CCUZI6CO1B).

1. Aviation street is designed for tram traffic in both directions (Figure 3). The rail track is tiled.

Fig. 3. The state of Aviation Street in the Shchukino District of Moscow (source: Yandex panoramas, https://yandex.ru/maps/-/CCUZI6CEGB).

2. There are two regulated pedestrian crossings:

- along Pekhotnaya Street in front of the tram lines (95 seconds of waiting, 30 seconds of movement);
- along Aviatsionnaya Street before the tram stop (95 seconds of movement, 30 seconds of waiting).

3. Tram traffic has no priority: a traffic light with a fixed switching interval is installed (does not react to the presence of a tram in front of the intersection).

An analysis of tram traffic along Aviatsionnaya Street showed the presence of high traffic. The results of structuring and analysis of movement are presented in Table 1 (at the stop "Pekhotnaya Street", location: https://yandex.ru/maps/-/CCUZI6WmsA).

Table 1. Tram traffic at the stop "Pekhotnaya Street" in the Shchukino District of Moscow.

No.	Route number	Main route	Traffic schedule	Number of wagons in 60 minutes (07:00–22:00
1	6	· Bratsevo – Sokol metro station, · Sokol – Bratsevo Metro station	· 05:38 – 01:00 · 05:53 – 00:45	10–13
2	15	· Tallinnskaya st. – Sokol metro station · Sokol metro station – Tallinnskaya Street	· 06:55 – 01:23 · 05:57 – 00:27	6–8 (peak interval: 9)
3	28	· Marshal Zhukov Avenue – Sokol metro station · Sokol metro station – Marshal Zhukov Avenue	· 05:36 – 23:04 · 05:26 – 23:20	7 (peak interval: 8)
4	30	· Tallinn Street – Mikhalkovo · Mikhalkovo – Tallinn Street	· 06:39 – 00:53 · 05:47 – 00:02	6
5	31	· Marshal Zhukov Avenue – Voikovskaya metro station · Voikovskaya metro station – Marshal Zhukov Avenue	· 06:02 – 01:25 · 05:49 – 01:22	6–8

Table 1 was compiled based on the source of the Department of Transport of the City of Moscow (https://transport.mos.ru/transport/schedule).

Pedestrian traffic at this intersection is intense at peak times, since this place is located not far from the Streshnevo interchange hub (Moscow Central Ring and Second Moscow Central Diameter). In addition, during the daytime, the centers of attraction for pedestrians are nearby public facilities: eight large city hospitals and hospitals, five educational organizations. Vehicle traffic is heavy: an average of 53 units per hour during the off-peak day and evening periods, 67 during the peak period, and 15 at night. Traffic is affected by seasonality: from July to September it decreases significantly.

4 Discussion

The listed indicators are important for the organization of the urban environment, as they determine pedestrian traffic pattern, the possibility of arranging street infrastructure, locating dedicated paths (for example, for cyclists), setting traffic light intervals, etc. According to the researchers Dryuchin and Yanuchkov (2019), modeling of different situations and assessing their suitability is possible only with the use of simulation modeling. For the correct compilation of the model, the presence of input parameters that are valid in the real

environment is required. As Logachev et al. (2022), Lebedeva (2020) and Yun et al. (2020) note in their studies, the input parameters should be evaluated for the possibility of their use in the mathematical model of the corresponding processes. The design of the study made it possible to collect and evaluate all the parameters that are key to the model to be developed in the next phase of the project.

5 Conclusion

Traffic management in any city is a complex process. It must take into account a wide range of characteristics, patterns, external and internal factors affecting the traffic flow. The use of modeling and creating a simulation model of a traffic flow is a key attribute in the processes of organizing and managing traffic.

The use of reliable, correct and non-redundant input data is an important feature of the functioning of the simulation model. As a result, a study design that fully characterizes all the objects of the selected area was developed. The features of each street forming the intersection were identified; phases of traffic lights were installed; pedestrian flows, frequency of automobile and public transport were determined. The stated methods were correctly used to obtain the data.

References

1. E.V. Borisova, Theory and practice of project education **2.14**, 21–23 (2020)
2. D.A. Dryuchin M.R. Yanuchkov, Intelligence. Innovation. Investments **4**, 90–97 (2019) https://doi.org/10.25198/2077-7175-2019-4-90
3. K. Gharehbaghi, K. Robson, F. Rahmani, Transportation Research Procedia **48**, 3996–4002 (2020) https://doi.org/10.1016/j.trpro.2021.04.001
4. M.V. Kuzin, Simulation modeling of traffic flows in a coordinated control mode. PhD Thesis (Omsk, 2011)
5. O.A. Lebedeva, Modern technologies and scientific and technical progress **1.7**, 165–166 (2020) https://doi.org/10.36629/2686-9896-2020-1-165–165
6. M. Logachev, V. Bugrimov, A. Kondratiev, Transportation Research Procedia **63**, 2335–2340 (2022) https://doi.org/10.1016/j.trpro.2022.06.267
7. M. Logachev, V. Chernova, Y. Laamarti, T. Makhamatov, V. Ivlev, L. Giulodori, I. Tutkova, International Journal of Instruction **15.3**, 153–170 (2022) https://doi.org/10.29333/iji.2022.1539a
8. M.S. Logachev, Y.A. Laamarti, S.E. Rudneva, A.I. Ekimov, D.N. Zemlyakov, A. Barkov, International Journal of Instruction **15.3**, 429–450 (2022) https://doi.org/10.29333/iji.2022.15324a.
9. A.A. Malykhanov, Agent simulation model for low-level research of transport systems. PhD Thesis (Ulyanovsk, 2011)
10. A. Mikhailov, E. Shesterov, Transportation Research Procedia **50**, 458–465 (2020) https://doi.org/10.1016/j.trpro.2020.10.054
11. L. Ramirez-Polo, M.A. Jimenez-Barros, V.V. Narváez, C.P. Daza, Procedia Computer Science **198**, 548–553 (2021) https://doi.org/10.1016/j.procs.2021.12.284
12. A. Sandhyavitri, A. Maulana, M. Ikhsan, A.I. Putra, R.R. Husaini, F. Restuhadi, Journal of Physics: Conference Series **2049.1**, 012096 (2021) https://doi.org/10.1088/1742-6596/2049/1/012096

13. S.V. Savvin, A.S. Belyaev, Simulation modeling of the street and road network. Collection of student scientific works of the Faculty of Computer Science (Voronezh State University, Voronezh, 2015)
14. T. Yun, I. Moon, Y. Kim, K. Jin, Winter Simulation Conference **December**, 620–631 (2020) https://doi.org/10.1109/WSC48552.2020.9383874&