

Road Network Research Towards Sustainable Development of the Metropolitan Area

Olga Gorlova^{1,*}, *Aidana Laiyk*², *Asel Sakatai*³, *Ekaterina Stativa*⁴, *Anatoly Denikin*⁵
and *Zoya Denikina*⁵

¹Moscow Polytechnic University, Moscow, Russia

²Satbayev University, Almaty, Kazakhstan

³Almaty University of Energy and Communications named after Gumarbek Daukeev, Almaty, Kazakhstan

⁴Moscow State University of Civil Engineering, Moscow, Russia

⁵Financial University under the Government of the Russian Federation, Moscow, Russia

Abstract. The article presents the analysis of a road network section located in Timiryazevsky District of Northern Administrative District of Moscow. Following the survey, traffic organisation characteristics were obtained, as well as the data on pedestrian flows, traffic density, operational features of public transport and zoning of the area adjacent to the object of study in terms of its use. The obtained results represent the main input parameters for simulation modelling that allows assessing different scenarios for sustainable development of the territory.

1 Introduction

The organisation and realisation of a set of measures aimed at creating safe and comfortable environment for people is a common practice for sustainable development of any territory, reducing the negative impact on ecosystems and securing the rational use of natural resources. This approach to the development of cities and human settlements is one of the goals of the United Nations Organisation.

The scientists deem the development of transport system, along with environmentally sustainable urbanisation, to be major criteria for human dwelling development [1, 2]. The concerned specialists develop respective international standards, which include, for instance, ISO 37120 “Sustainable development of communities – Indicators for city services and quality of life”, ISO 37122 “Sustainable cities and communities – Indicators for smart cities”. In 2021, Moscow became the first Russian region to meet the sustainable development goals.

The improvement of performance indicators and the development of urban areas requires addressing traffic management problems, with the view, among other aspects, to make it safer. As Ryzhkov points out in his study, reduced highway rates, acute shortage of urban areas in terms of parking organisation, environmental pollution, poor organisation of

* Corresponding author: business007@bk.ru

traffic flow, traffic noise and increased traffic accidents are the main negative factors for urban development [3].

The solution of the above problems requires a comprehensive study of all characteristics of the area in order to develop due methods, mathematical models and algorithms for the regulation of traffic and pedestrian flows; to elaborate a decision-making quality assessment model and the ways to assess the performance of the developed methods and models [4]. Thus, *the aim of the study* is to derive qualitative characteristics of a chosen road network section in order to create due models of sustainable development of the territory.

The theoretical significance of the study lies in the identification of interdependence of specific road network objects and the internal inherent processes, as well as assessing the significance of these objects and processes.

The practical significance of the research lies in the possibility to use the obtained results for modelling the processes that would make it possible to assess the quality of road network changes towards sustainable development of the territory.

2 Objects and methods

The object of the study is represented by a section of road network located in Timiryazevsky District of Northern Administrative District in Moscow. The object of the research includes a seven-hundred-metre stretch of Pryanishnikov Street from its intersection with Bolshaya Akademicheskaya Street in the northwest and Timiryazevskaya Street in the east (Fig. 1).

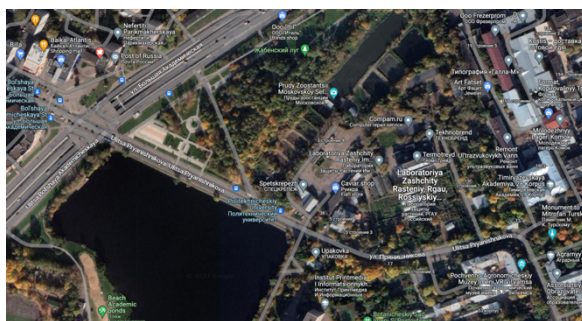


Fig. 1. Satellite image of Pryanishnikov street in Moscow
(source <https://goo.gl/maps/BoZWnwUpAY2ZOsa6>)

The main feature of this road section is two-way tram traffic in the central part of the street (Fig. 2).



Fig. 2. Panoramic image of Pryanishnikov street in Moscow
(source Yandex.Panoramas <https://yandex.ru/maps/213/moscow/panorama>)

As noted by the researchers [5, 6, 7], the following methods are required to obtain the characteristics of the object under investigation:

1. *The method of structuring* making it possible to break a complex object into smaller, independent components for detailed study.
2. *The method of analysis* which enabled the researchers to obtain different characteristics and aspects of the object under investigation (causes of emergence or change of its states, links with other objects or its constituent parts).
3. *The method of graphics* which makes it possible to visualise the structuring and analysis results for the purpose of visual demonstration of the given object’s features.

3 **Results**

The use of the stated methods made it possible to obtain the characteristics of the area adjacent to the object of study. These characteristics include:

1. *Functional characteristic* showing the area zoning according to the principle of its use (Fig. 3).

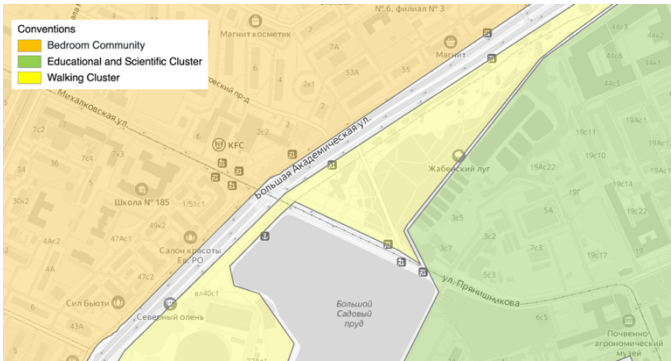


Fig. 3. Zoning of the area adjacent to Pryanishnikov street in Moscow

Three territorial zones are adjacent to the investigated object:

- A bedroom community in Moscow (Koptevo) which includes, in addition to residential development, social infrastructure objects (shops, catering facilities, etc.);
 - A park area with green space, walking or cycling lanes, sports facilities (stadium, volleyball court, etc.);
 - An academic and research territory housing university campus buildings, fish farming laboratories, plant cultivation sections.
2. *Characterisation of public transport accessibility.* All structures located in any of the areas covered by the research can be accessed by both private and public transport. Pryanishnikov street in its central part has two-way tram traffic, with two routes served at the interval of 5–10 minutes. Passengers are dropped off on demand; the stop area is not duly equipped (i.e. there is no boarding platform adjacent to the track, no elevated roadway to access the tram floor level). In addition to the rail transport, four two-way bus routes for passengers operate at the interval from 5 to 10 minutes. It should be noted that the bus stops are not opposite each other on the street sides, being located at a distance from each other (Fig. 4).



Fig. 4. Location of public transport stops in Pryanishnikov street in Moscow

It should be noted that while passengers are disembarking or boarding the bus, the traffic in the lane is stopped. Undoubtedly, this affects the traffic density in the studied area section.

3. *Characterisation of traffic density.* The traffic movement across the study area can be regarded as pendular, being formed by a shuttle pattern – from home to place of work (or study) and back. Figure 5 shows the traffic density across the studied site and the adjacent roads.

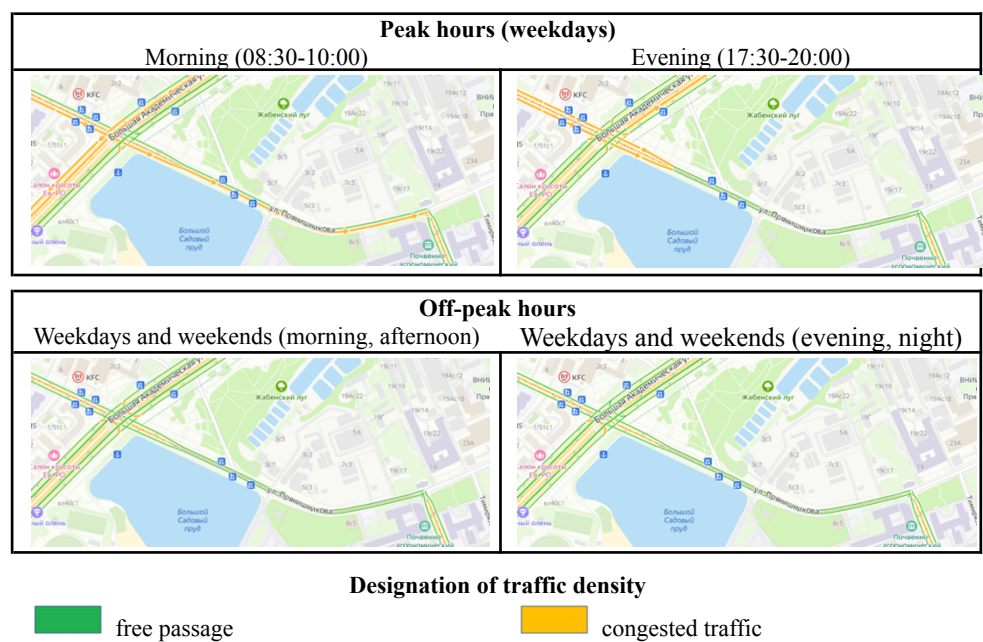


Fig. 5. Traffic density by day of the week and time of the day in Pryanishnikov street in Moscow (source of images and data – Yandex.Traffic Jams: <https://yandex.ru/maps/213/moscow/probki>)

It should be noted that the traffic in the considered road section is uncongested, but in some places one may face difficulties due to some objective reasons: traffic lights, letting public transport through, etc.

- 4. *Characterisation of traffic stop situations* which increase traffic density due to permanent external influence. Such external influence can include, as suggested by the authors team, controlled and uncontrolled street intersections, regulated and unregulated pedestrian crossings, interchange ramps, parking areas, passenger boarding and drop-off areas. Fig. 6 shows interchange ramps and transport stopping places.

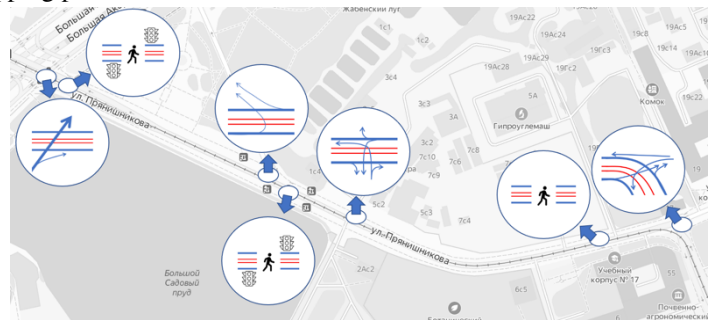


Fig. 6. Scheme of turns, interchange ramps and transport stops in Pryanishnikov street in Moscow

All of the above characteristics undoubtedly contribute to the increased traffic density on the extremely short stretch of the road network.

4 Discussion

Sustainable development of urban environment is impossible without comprehensive assessment of such indicators as street infrastructure location, density and traffic pattern (including that of public transport) or pedestrian flows, accessibility of infrastructural facilities, etc. As noted by [1, 8, 9], such characteristics are essential for the creation of simulation models and information systems that provide simulation of real situations for the purpose of, for instance, assessing the road network load, service life of infrastructure facilities, response to external (including aggressive) impact on infrastructure, etc. [10].

5 Conclusion

The implemented research made it possible to obtain a set of qualitative characteristics of a real-world object – a road section with an adjacent area. As a result of the study, a number of objects involved in different processes related to the road network were identified. The interconnection of these objects was established, as well as the extent of their reciprocal influence and the impact on external facilities adjacent to the area of investigation.

The obtained results are reliable, accurate and consistent. This was possible due to the correct use of the generally accepted research methods in the sphere of sustainable development of residential settlements, simulation modelling and research design. The qualitative characteristics can be used by traffic management specialists exploring the issues of both personal and public transport; experts in improvement of urban areas; professionals engaged in computer modelling of objects and processes of urban economy.

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