Socio-economic development of territories in the project of upgrading the infrastructure of the transport corridor “China-Mongolia-Russia”

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Abstract. The article presents the importance of creating transport corridors in the New Silk Road project and modernizing sections of existing highways. The use of methods of structurization, analysis, synthesis, systematization, and agent-based modeling allowed us to develop a simulation model of local transport hubs of the highway section in the Republic of Buryatia (Russia) to the border with Mongolia. The concept of such hubs is to justify the design of infrastructure facilities that provide short-term parking of vehicles for their rapid maintenance and recreation of drivers or passengers. All entities involved in traffic flows are identified and their characteristics are defined. Based on the rules of their conduct individually and collectively are established. The resulting rules are used to create models of the behavior of entities in the simulation model and presented its corresponding 3d fragments.

1 Introduction

In 2013, Chinese President Xi Jinping put forward a proposal to create a transport corridor linking Asia and Europe, calling it the New Silk Road by analogy with the caravan road used to transport goods from China to the Mediterranean in ancient and medieval times [1]. The development vectors of this project with the involvement of other countries allowed the motto “One Belt, One Road” to be formulated. Thus, the transport corridor was to become a belt of economic development along the entire length of the route [1].

Among the main transport projects between Russia and China in the New Silk Road Initiative is the China-Mongolia-Russia transport corridor [2]. It includes projects in the development and comprehensive modernization of the Central Railway Corridor, the use of Asian highways in transit traffic, the modernization of border checkpoints in the three countries, and other projects. The Russian section of such a transport corridor includes a road in the Republic of Buryatia that connects the cities of Ulan-Ude and Kyakhta.

To ensure traffic safety, reduce the number of accidents, preserve road shoulders and pavement, and increase the speed of traffic flow certain road infrastructure facilities are required [3]. Such facilities may include transport and service enterprises (e.g., parking lots

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or parking lots for different types of vehicles, places for maintenance and repair of vehicles), facilities for control and monitoring of road traffic, public catering facilities, and places for recreation.

Parking lots must meet the different needs of road users and are divided into separate groups (e.g., short-term, sightseeing, parking for trucks or buses, near memorials). The duration of the user’s stay depends on the type of parking, which makes significant adjustments to the location and design features of the sites. It is possible to assess the demand, the degree of workload, and the impact on the environment of such sites at the stage of its design through the implementation of different scenarios in a simulation model.

Thus, the study aims to justify the location of road infrastructure facilities for drivers of road transport using simulation modeling techniques.

The theoretical implication of the study lies in the creation of a formal model of the road section considering all qualitative and quantitative characteristics.

The practical implications of the study lie in the use of a formal model to justify solutions to modernize road infrastructure, increase capacity, reduce traffic accidents, increase traffic comfort, assess the degree of negative impact on the environmental situation in the areas adjacent to the road, etc.

2 Materials and methods

The object of the study is a 233 km section of the highway connecting the cities of Ulan-Ude and Kyahta in the Republic of Buryatia (Russia). The road is a road of federal importance, connecting Russia with Mongolia (the scheme of this section is highlighted in blue in Figure 1).

Fig. 1. Ulan-Ude–Kyahta road in the Republic of Buryatia (Russia) (Google Maps source https://goo.gl/maps/RukPa2tPVhVzNf3BA)

The study of the works of researchers in the field of simulation modeling of transport objects has shown that it is necessary to consistently use the following methods:

1. Structuring, analysis, and synthesis methods. The integrated use of the above methods allowed forming the study design. The purpose of the study was defined, the tasks to be performed, to establish all the key objects involved in the transport processes of the study object. As Logachev [4-6], Krasnikov [7, 8], and Chetverushkin [9] note in their works, the determination of the key objects of the problem domain is an important research stage, as it allows forming a list of input parameters for the simulation model.
2. **Systematization method.** The use of such a method allowed to classify the input parameters according to the nature of their behavior and the degree of influence on the formation of transport processes of the research object. The need for such a method is justified in the works of Voronin [10], Logachev [11], and Serbian [12].

3. **Agent-based modeling method.** The method allows simulating the behavior of each participant of the object of research [6, 13, 14]. The obtained results sufficiently reflect the behavior of transport systems when their different parameters change [4, 7].

4. **Graphical method.** The graphical method is used to demonstrate the obtained results. It is possible to show the important aspects of any complexity of the system in an accessible form [15].

## 3 Result

The study object is located in the Republic of Buryatia (Russia) in a zone of sharply continental climate. This makes it difficult to travel from south to northeast in late winter due to strong northwest winds and the formation of local snow drifts. The route mostly runs along the upper sides of river valleys, so river floods and heavy summer rains do not significantly affect the roadway. The highway is located in an area of treeless valleys, which are interspersed with lingering passes and pine forests. It should be noted that the studied road section is the northern element of the Asian route AN3 of the international transport corridor Russia-Mongolia-China. It connects the Mongolian cities of Sukhbaatar and Ulaanbaatar, then goes to Inner Mongolia and the eastern provinces of China.

Analyzing traffic flows, the study identified the following main agents:

- passenger cars (general purpose, special, equipped with various types of trailers);
- trucks (general purpose, special, equipped with various types of trailers);
- buses (minibusses, special, general purpose);
- specialized vehicles servicing the highway.

Given the specifics of the highway and compliance with traffic safety and comfort requirements, the placement of specialized infrastructure facilities on the entire road section is required. Such facilities include parking lots or bus stops for drivers and passengers to rest, check the technical condition of vehicles, fix individual malfunctions, and meet other needs. The presence of such sites contributes to traffic safety, as it eliminates the “wild” parking, allowing to maintain the quality of the road surface (eliminating the entry of dirt when leaving the curb or ground); to exclude sudden departures due to lack of visibility; to save the roadsides. In addition, the speed of traffic flow is increased by excluding faulty vehicles, tired drivers, and potential contact with vehicles standing on the roadsides.

The use of simulation methods allowed to determine road sections where parking lots with certain infrastructure facilities (gas station, service station, recreation, and catering points) should be located.

Figures 2-5 show fragments of the 3D model simulation, demonstrating stopping places for vehicles.
Fig. 2. General view of the study object in the 3D model simulation.

Fig. 3. Location of the gas station and the place of short-term parking of vehicles in the 3D model simulation.

Fig. 4. Location of long-term parking of vehicles for recreation and maintenance in the 3D model simulation.

Fig. 5. Location of combined vehicle parking

Combined parking means the combination of a gas station, a place of maintenance of vehicles, a place of rest, and meals for drivers and passengers. The location of such a parking lot is most successful from the viewpoint of the route. At the same time should have a minimal negative impact on the environment [16].

Here is a graphical representation of the parametric equations describing the emerging traffic flows on the highway in the areas of the planned placement of infrastructure facilities (Figure 6-7).
Here are the locations on the highway where the simulation objects were located:
- Sredny Ubukun (69 km);
- Tohoi (89 km);
- Novoselenginsk (119 km);
- Subuktui (189 km).

4 Discussion

Policy in the field of transport in general, road transport and road economy in particular is designed to solve economic and social problems of a national scale, so the development of these industries is one of the key problems [3]. When designing a highway or upgrading it, you should consider the availability of parking spaces for vehicles with certain infrastructure. Such infrastructure must minimally meet the requirements for at least a short rest for drivers and maintenance of vehicles. Appropriate infrastructure in Russia is underdeveloped or absent for many hundreds of kilometers on some highways.

The use of simulation modeling techniques allowed us to assess the degree of impact on traffic flows of infrastructure facilities that provide a traffic stop. As noted in the simulation model, taking into account all the quantitative and qualitative characteristics of the study object, it allows predicting the degree of use and workload of projected objects, modeling and evaluating the development of the territory over time, to develop an ecological concept of the territory to minimize damage to its condition [3-5].

5 Conclusion

The obtained results correspond to small-scale simulation modeling of traffic flows, which allows evaluation of the functioning of local transport nodes on limited sections of the highway. The developed model can be used as part of complex simulation models, allowing to carry out comprehensive measures for the design and modernization of the entire length of the transport artery.

All of this contributes to the development and expansion of the transport corridor, allowing for the accelerated economic development of the regions in Eurasia and the strengthening of political stability. Infrastructure projects implemented as part of the “New
Silk Road” are a major incentive for the development and technological modernization of the Russian construction industry and the Russian economy as a whole and increase its balance between East and West.

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