Project for the development of the Eurasian transport framework in the countries of Central Asia

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Abstract. The paper puts the importance of an international transport corridor for the Republic of Kazakhstan. Two directions of railway communication within the latitudinal Central Eurasian Corridor have been identified. A technique has been developed for applying simulation modeling to identify the bottlenecks on the way of railway flows. Bottlenecks include the intersections of vehicular and pedestrian traffic with rail traffic. In such places, conflicting flows are formed, which may be accompanied by a merger of individual flows. Using the methods of structural analysis, synthesis, system analysis and step-by-step inclusion (or exclusion), the input parameters of simulation models of objects and processes have been established for the case study of Aktobe city in the Republic of Kazakhstan. A graphical model of the behavior of groups of objects for conflicting flows in bottlenecks has been developed, being the basis for the simulation model.

1 Introduction

Modern conditions with the comprehensive interaction of exogenous and endogenous factors, the wide branching of the competitive environment and the uncertainty of the future situation, the development and complication of economic relations between organizations, the availability of a large amount of information give rise to the multivariance of management decisions, to work out which it is required to consider the diversity of cause-and-effect relationships in the operation of economic entities [1]. This is a comprehensive activity that requires an integrative approach to apply professional knowledge in the subject area of management, logistics, statistics, system analysis and other sciences that study the dynamic description of processes and the description of system behavior.

The use of specialized software tools that allow reproducing the structure and processes of functioning of a real system, as well as conducting computational experiments with their help, greatly simplifies all these processes [2]. Such software tools are based on simulation methods that allow describing the behavior of the system from the point of view of the algorithmic approach in the form of formal models. The resulting models describe the

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processes and objects of the systems in such a way as they would be implemented in reality in a given time interval [3]. At its core, this is an experimental test, which is less resource-intensive, dynamic and allows changing any parameters during the experiment.

Considering the Central Eurasian Transport Corridor as a comprehensive system of interrelated objects and processes, the use of simulation methods to assess the effectiveness of its operation and the concepts of modernization or operational management is relevant and in demand. The need for such an approach is explained by the visible effect in favor of the real economy of the states through which the transport corridor passes [4]. From the point of view of the geographical location of the Republic of Kazakhstan, this enables to reorient cargo flows subject to the development of latitudinal routes according to the strategy of "turn to the East" [5, 6]. Therefore, in order to maintain the long-term interest of any state in them, transit routes should help solve the internal problems of transport and logistics infrastructure, containerization of the economy, administration, and the establishment of interregional relations, including in the EAEU space [7, 8].

The purpose of the study is to develop a methodology for improving the regulation and modernization of the transport infrastructure of the Republic of Kazakhstan within the framework of international transport corridors using simulation methods.

The practical significance of the study is obvious and lies in the creation of concepts for the development of a transport corridor that can significantly increase the absolute benefits from transit flows and exports of services. *The theoretical significance* of the study lies in the creation of formal models of real objects of the subject area with all qualitative and quantitative characteristics, sets of rules for the interaction of their processes, to develop scenarios for the sustainable development of territories, assessing and predicting the ecological state of the corresponding regions, etc.

2 Materials and methods

The object of the study is the railway track of the Central Eurasian Transport Corridor passing through the territory of the Republic of Kazakhstan. It includes two latitudinal branches: Aktobe – Kyzylorda – Shymkent – Almaty – Altynkol; Petropavlovsk – Kokshetau – Astana – Karaganda – Balkhash – Dostyk [source: https://cargo.rzd.ru/ru/9789].

The use of simulation modeling methods to build simulation models of transport infrastructure facilities is only possible using the so-called input data. As Chernova [9] and Krasnikov [10] put in their studies on similar subjects, the input data include all elements that are part of the structure of the object and reflect its essential characteristics for modeling. To obtain them, the method of structural analysis is used. In addition to the elements of the structure of the object, it is required to establish links between them and relationships between emerging internal and external processes. For this purpose, it is recommended by scholars to comprehensively use the methods of synthesis, system analysis, and stepwise inclusion or exclusion [11, 12].

To create a model that reflects the behavior of objects, the method of agent-based modeling is used. As the researchers note, it enables to obtain a model in which all elements of the system are divided into groups with similar behavior [9, 10, 13]. A graphical method is used to visualize models. It allows using a set of standard graphic elements to create models that demonstrate particular characteristics of the system or its individual processes or objects [13].

3 Results

The developed methodology for applying simulation modeling to the transport system is as follows:

1. Choice of an object that is part of the transport infrastructure.
2. Identification of significant flows: transport (rail, road) and pedestrian.
3. Flow structuring: identification of qualitative and quantitative characteristics (for example, traffic intensity, number of lanes or tracks, public transport schedules, etc.).
4. Identification of conflict flows. Conflict flows are those transport flows that intersect or merge. They create significant difficulties in organizing traffic, scheduling traffic, adjusting the phases of traffic lights and modernizing infrastructure.
5. Formalization of the data obtained in 2–4 above for compiling a graphical model of the behavior of groups of objects of selected flows.
6. Creation of a simulation model.
7. Development of unique scenarios for the behavior of objects for conducting experiments (for example, changing the number of lanes, increasing the duration of the prohibiting traffic signal, building an automobile bridge over railways, etc.).

As an example of the application of the said methodology, presenting the results for the city of Aktobe. Through Aktobe, there is a railway line related to the international transport corridor. In addition to the movement of freight trains, it is used for passenger traffic. Within the city, there are a few branches from the main railway towards industrial areas. The main railway line crosses highways eight times, in two cases out of eight, conflict flows are formed:

1. At the crossing near the intersection of Beibitshilik Avenue and Turgenev Street.
2. At the crossing near the intersection of Mayakovsky and Zinchenko Streets (Fig. 1).

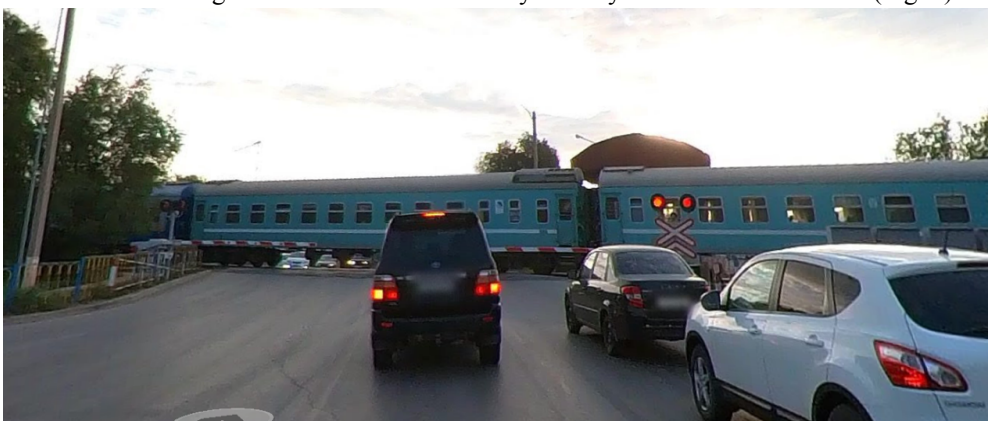

Fig. 1. Railway crossing at the intersection of Mayakovsky and Zinchenko streets in Aktobe (Google Maps source: https://goo.gl/maps/oJpoyMeS5VcyjNecA).

The conflict of flows arises due to the crossing of railroad tracks by road transport. Such a place is equipped with sound and light alarms. This complicates the movement of road transport due to a significant waiting time for the passage of trains. From the point of view of railway traffic, these crossings create problems, since the situation of a car or a pedestrian entering the crossing with a prohibition signal in front of a moving train is not excluded. Any such emergency situation can for a long time stop the movement of all types of transport on the corresponding part of the road.

Let us consider in more detail the second case with conflicting flows. In addition to the fact that there is a direct intersection of automobile flows with railways, street intersections are located near the crossing. All this creates a tight traffic schedule and a potential difficulty in crossing the open crossing. Fig. 2 shows the general scheme of flows that occur at the crossing.

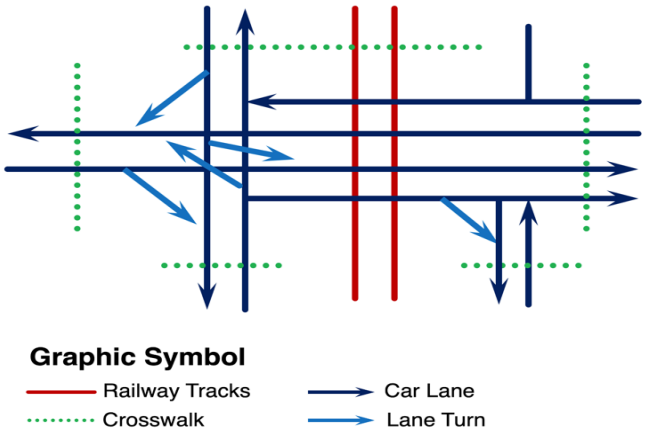

Fig. 2. Traffic scheme at the intersection of Mayakovsky and Zinchenko streets near the railway crossing in Aktobe.

It should be noted that all pedestrian crossings are not regulated, which creates additional difficulties for traffic.

For the simulation model, a state diagram was created (Fig. 3), which demonstrates the behavior of road transport when driving on a given section.

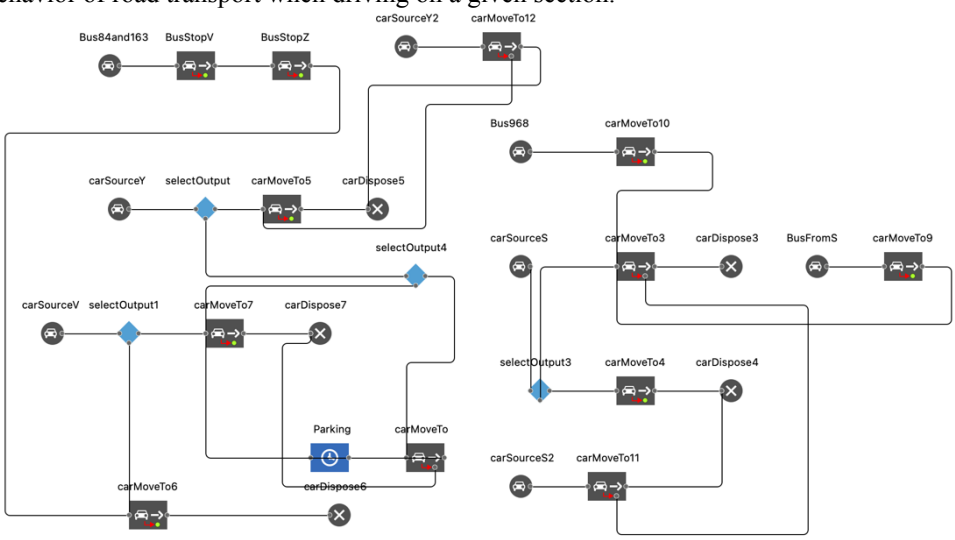

Fig. 3. Road transport state diagram.

The created diagram reflects all the features of the movement of road transport through the studied railway crossing. Features of delays at the direct crossing of railway tracks and stopping before the train passes are set by programming tools in the *carMoveTo*$_i$ blocks.

An analysis of railway crossings in the city, which are formed when roads cross railway branches to industrial zones, showed that insignificant conflicting flows are formed in these places. The insignificance lies in the fact that the intensity of railway traffic is not permanent and does not create permanent and prolonged traffic closures. The intersection of the railway track creates a slight slowdown in car traffic at the corresponding intersections.

4 Discussion

To date, simulation modeling is a powerful tool for studying the behavior of real systems, allowing collecting and processing the necessary information on the behavior of the system by creating its computer model [2, 13, 14]. The result of the application of simulation modeling methods, as scholars note in their studies, enables to obtain the values of the characteristics of the simulated system and the behavior model of its objects [3, 15, 16].

The developed methodology can be applied to any object of the transport system or the system as a whole. This statement is confirmed by the results of a number of studies on similar topics [9, 10]. Restrictions on the size of the transport network or the number of types of vehicles in terms of the modeling process are absent [2, 3, 13]. Restrictions are possible only by the computing power of software and hardware that reproduce the corresponding simulation model.

5 Conclusion

Foreign trade and transport have always been among the factors contributing to the development of the national competitiveness. Of great importance for the integration of the economy of the Republic of Kazakhstan into the world economic space is the expansion of transport railway corridors from China, Russia, the countries of Southeast Asia and the Middle East. To do this, it is necessary to solve the problem of insufficient capacity of the railway infrastructure by creating transport hubs, reducing the number of conflict flows when crossing railways by highways, etc.

The solution to such problems is the creation of formal models by means and methods of simulation modeling. The resulting models enable to conduct experiments on the modernization of the adjacent infrastructure, to assess changes in the ecological state of territories, to analyze traffic, etc. All this can be carried out both for the short run (hours, days, weeks) or the long run (months, years, decades). The results obtained can be used to create scenarios for the operational management of objects and processes, concepts for sustainable development of territories, templates for responding to emergencies.

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