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DEVELOPMENT OF AN IMITATION MODEL OF CONTAINER TRANSPORTATION BY RAILWAY AREA OF DOSTYK-ZHEZQAZGHAN-ILETSK

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The relevance of the study is attributed to the need to further increase of the traffic and freight capacity of container transportation in the Dostyk-Aktogai-Mointy-Zharyk-Zhezqazghan-Saksaulskaya-Kandyagash-Aktobe-Iletsk section of the National Company "Kazakhstan Temir Zholy". The purpose of this article is to evaluate the effectiveness of the proposed modernization associated with the further development of the above railway transport corridor for container transportation. The research method involves solving this problem by applying computer modeling of container transportation along this corridor, in particular, developing a simulation model based on Anylogic software and processing the results. The results of the study are the data obtained based on simulation modeling and comparing it with the current data on container flows along the Dostyk-Zhezqazghan-Iletsk corridor. The significance of the study lies in proving the effectiveness of measures to modernize the infrastructure of the section and the development of this railway transport corridor for container trains. Article materials may be useful for logistics companies in Kazakhstan and abroad.

Key words: railways, container transportation, simulation model, Anylogic, SIRDP-E

INTRODUCTION

The main tendency in the development of railway transport in the world is to increase the competitiveness of railway transportation in relation to other modes of transport. Container rail transit is the youngest and fastest growing segment of the rail transportation market, and the transportation of goods in large containers is one of the promising directions for the development of the rail transport.

In this regard, the Republic of Kazakhstan is a link in the creation of transport corridors between Asia and Europe, in terms of organizing an international container traffic.

It should be noted that at present the structure of cargo flow and the economy of transportation determine the main direction of transit through the territory of Kazakhstan.

The key role of Kazakhstan as the country of receiving the bulk of Chinese container transit is confirmed by the choice of the route through the country as the main one in the activities of the Eurasian Railway Alliance (UTLC ERA JSC), created by Russia, Belarus and Kazakhstan in 2014. The volume of container traffic according to the China-Europe-China route at the beginning of May of this year increased by 16% compared to the same period last year and amounted to 102 thousand 20-foot containers (TEU). The company plans to increase annual transit to 1 million TEU by 2024 [1].

The predominance of the "Chinese" orientation in container transit along the Trans-Siberian Railway is due to the formation of a new economic space by China due to the implementation of the "One Belt, One Way" project [2] that has land ("Silk Road Economic Belt" project [3]) and sea (project "Economic belt of the sea Silk Road of the XXI century" [4]) components.

The advantageous neighborship with China and the targeted policy of the leadership of the Republic of Kazakhstan ensures the passage of container transit with proper quality, the revenues from which make up about 30% of the revenues of "NC "Kazakhstan Temir Zholy" JSC.

The undoubted advantage of the Trans-Siberian Railway when crossing international container transit is a shorter delivery time compared to the traditional sea route. For example, it takes 13-16 days by rail to deliver a container from the Chinese city of Chongqing (a large industrial center) to the German city of Duisburg, and 40-45 days for a route through the Suez Canal.

An alternative to this direction is the route passing through the territory of the Republic of Kazakhstan along the China-Europe/China transport corridor via the Chongqing-Duisburg route. It should be noted that the delivery time for the specified route through the territory of the Republic of Kazakhstan is 12-14 days.

In addition, the following main transport corridors run through the territory of the Republic of Kazakhstan [5-7]:

1. China-Caucasus / Turkey (+ Southern Europe);
2. China-Iran, Iraq;
3. Russia, China-Central Asia.

The above routes also have significant advantages, expressed in short delivery times compared with the sea route.

Figure 1: Kazakhstan railway map with marked transport corridors Dostyk-Zhezqazghan-Iletsk
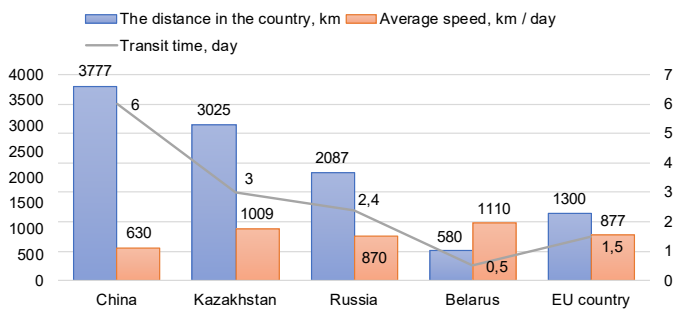

Figure 2: Characteristics of the China-Europe International Transport Corridor

METHODOLOGY

Current situation

The organization of the transport corridor Dostyk-Zhezqazghan-Iletsk became possible after the construction and commissioning of a new branch Zhezqazghan-Saksaulskaya (the total length of the new route is 2719.8 km) (see Figure. 1).

It was previously believed that rail transit on the China-Europe route could not compete with the sea one. There was a lack of common standards and technologies at the junctions, common principles of pricing, traffic schedules, etc.

To ensure competition between rail and sea transports, a rail container service was developed between China and Europe. A route with the length of 10,796 kilometers runs through the territory of five countries: China, Kazakh-

stan, Russia, Belarus and the EU countries. The transit time is 15-16 days, the average speed is 690 km/day.

Figure 2 presents data on distances in the countries, the average speed and their transit time.
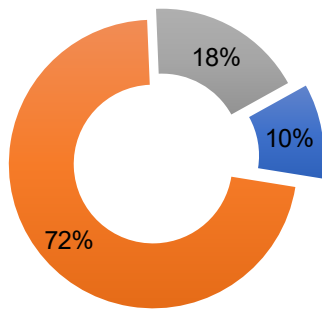
Figure 2 shows that the main share of the distances is in China and Kazakhstan. The Republic of Kazakhstan provides the maximum transit speed (1009 km/day). Due to the smallest distance, the minimum transit time through the corridor belongs to the Republic of Belarus (0.5 days).

However, the traffic capacity of the railway transport corridor when organizing transportation, including container transportation, depends on the infrastructure of the section and many other factors. One of the decisive factors is the train traffic control system (TTCS) [8].

Table 1 presents the main technical characteristics of the transport corridor Dostyk-Aktogai-Mointy-Zharyk-Zhezqazghan-Saksaulskaya-Kandyagash-Aktobe-Iletsk, which reflect the length (total and by sections), the number of stations, as well as the type of traction on the sections and equipping them with various interlocking devices (TLL – Track-Lever Locking, RI – Relay Interlocking, REI – Relay-Electronic Interlocking (hybrid element base), EI – Electronic Interlocking) at stations, block systems on the haul (AB – Automatic Block, SAB – Semi-Automatic Block and RB – Radio Block) and centralized traffic control systems (RCTC – Relay Centralized Traffic Control, ECTC–Electronic Centralized Traffic Control) [9].

Table 1: Technical characteristics of the transport corridor Dostyk-Iletsk

Sections	Length, km	Number of stations	Type of tractions	Type of EC	Type of AB	Type of CTC
Dostyk-Aktogai	318	14	Autonomous	TLL, RI	AB	ECTC
Aktogai-Mointy	522,4	20	Autonomous	RI	AB	RCTC
Mointy-Zharyk	215,1	8	Electric	RI	AB	ECTC
Zharyk-Zhezqazghan	417,8	15	Autonomous	TLL, RI	SAB	ECTC
Zhezqazghan-Saksaulskaya	517	26	Autonomous	EI	RB	ECTC
Saksaulskaya-Kandyagash	438,4	30	Autonomous	RI, EI	AB	ECTC, RCTC
Kandyagash-Aktobe	95,7	7	Autonomous	RI, REI	AB	ECTC
Aktobe-Iletsk	195,4	22	Autonomous	RI	AB	RCTC, ECTC
Total length and number of stations	2719,8	142				

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Figure 3: Percentage of interval train traffic control equipment in the Republic of Kazakhstan [9]

Figure 3 shows a diagram with the operation statistics of the TTCS on the railway network of the "National Company" Kazakhstan Temir Zholy" Joint Stock Company ("NC "KTZh" JSC).

The diagram shows that the main share of TTCS is in relay-contact systems (72%) of the volume operated in the Republic of Kazakhstan. At the same time, there is a tendency for further development of systems [10] using the "moving block sections" technology [11, 12].

The organization of this transport corridor is directly related to the further development of infrastructure, which includes railway automation and telemechanics systems, which is dictated by the need to increase the volume of container traffic.

AnyLogic

One of the methods for solving this problem is simulation modeling. The container transportation model along the Dostyk-Zhezqazghan-Iletsk transport corridor was developed using AnyLogic 8.5.0 software for multi-method modeling [13].

This product allows you to create models using a set of active elements that simulate real-world objects, and experiments that specify settings for launching the model. The software is based on the Java programming language and supports three well-known modeling methods [14, 15]:

- system dynamics;
- discrete event modeling;
- agent modeling.

This product is widely used for research in many fields of science. Thus, for example, the fifth chapter [16] provides a detailed overview of the main components of agent-based modeling: agents, interaction, and environment. The authors of works [17, 18] used an approach based on modeling and simulating advances in the research approach in developing effective operational policies and practices for managing container flows.

In addition, this product was also used to study multi-modal container transportation [19].

The functioning of any transport system is presented as a chronological sequence of events.

Modeling of such a system belongs to the agent [20].

At that, the following modeling goals were set:

- determination of the operating mode of the transport corridor;
- determination of the expected effect of the modernization of the infrastructure (train traffic control systems) of the Dostyk-Zhezqazghan-Iletsk railway corridor;
- improvement of container transportation technologies.

Model implementation

Statistical data on the transport corridor Dostyk-Zhezqazghan-Iletsk were chosen as the initial information for modeling.

The model addresses the reduction of inter-train intervals due to the use of modern interval control systems for train movement, which implies the presence of systems with moving block sections.

The algorithm of this model is set using standardized blocks and is configured using existing methods or using the Java language.

Input of the initial data takes place in the start window of the experiment, the values of which can be changed.

Model time is a minute. The accelerated mode of operation of the model allows to run an experiment corresponding to one calendar month in several minutes.

The model is visualized in Animation and Statistic modes, which allows to demonstrate the operation of this transport corridor.

The simulation results are presented in digital and graphic forms (see Figure. 4).

The model was developed using an agent-based approach, which represents the components and interactions of the supply chain - trains, stations and hauls. Objects are modeled as separate agents with custom behavior.

Then the agents communicate and interact in an environment that has its own dynamics, namely in the Geoinformation System (GIS) of the stations Dostyk, Aktogai, Mointy, Zharyk, Zhezqazghan, Saksaulskaya, Kandyagash, Aktobe and Iletsk.

Therefore, realistic times and routes are modeled on the railway from Dostyk station to Iletsk station and vice
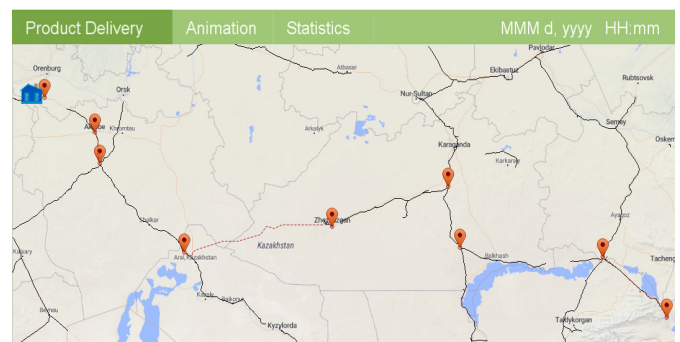

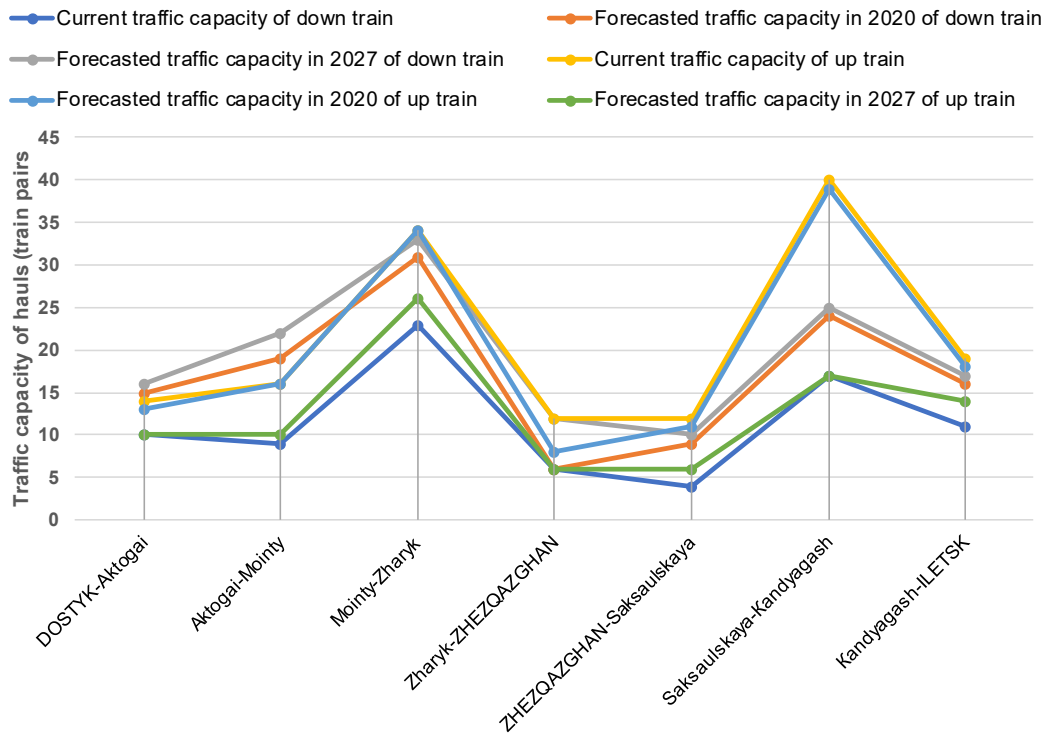*Figure 4: Agent modeling window with GIS maps*

Figure 5: The traffic capacity of section hauls of Dostyk-Zhezqazghan-Iletsk

versa. The model output is a dynamic animation of simulation runs during which containers are transported between stations in the transport corridor to meet demand.

SIMULATING RESULTS

The result of simulation in the AnyLogic environment allowed to identify the bottlenecks in the organization of the Dostyk-Zhezqazghan-Iletsk railway transport corridor (see Figure. 5).

As can be seen from Figure 5, in this transport corridor, one of the bottlenecks restricting container traffic is the Zhezqazghan-Saksaulskaya section, where temporarily interval train traffic control system using the SIRDP-E radio channel works in the semi-automatic blocking mode [9].

Restoring the efficiency of the SIRDP-E system using innovative technologies and switching to the coordinate traffic control mode allows solving this problem, thereby contributing to an increase in the route speed of container trains.

CONCLUSION

The developed model based on the Anylogic software made it possible to examine the operation of the system in detail and calculate its maximum efficiency related to the further development of the transport corridor for container transportation. In addition, the model made it possible to determine where the investments should be prioritized.

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