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Simulation Modeling of Train Traffic Based on GIS Technologies

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Abstract: *In this article we discuss the issue of simulation modeling of train traffic according to the normative schedule for train traffic using the special platform Any Logic. GIS technologies were used to visualize the movements of the rolling stock. Developed a special database inherent in the time elements of the train schedule. All types of actions of trains at the station and on the tracks are taken into account. Special agents have been created that make it possible to accurately reproduce the model after compilation. The result of this scientific work will be used to determine the impact of automated warning technologies on trains on main lines.*

Keywords: *simulation modeling, shunting, railroad station, Any Logic, Queue, Sink, Agent.*

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1 Introduction

In the field of rail transport, modeling can be very useful. It can help you think through and optimize in detail almost everything: from marshalling yard projects and railway network plans to railway traffic load and resource use.

Design of marshalling yards. Whether designing a new plant or rebuilding an existing one, success will depend on many factors. Simulation allows you to evaluate the effectiveness of different options before embarking on implementation, and thanks to the animation of the model, it can be used to discuss the project with colleagues and make informed decisions by management [1].

Optimization of the use of transport and resources. The efficient operation of the system is the use of locomotives, depots and other resources to the maximum; this approach leads to a quick return on investment. That ability to virtually and risk-free test different ideas and scenarios, you can prioritize future investments, decide which projects are worth implementing in the first place.

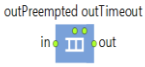
Any Logic allows creating simulation models of railway systems using the built-in Railway Library. Using Any Logic helps to save time and money at all stages: from the design of marshalling yards, operational planning, to the design of railway networks, the calculation of intervals for freight trains and station capacity. All elements of the system and their interactions can be modeled and visualized in detail, which will make it possible to use resources as efficiently as possible [2,3].

Railroad Library is a tool for modeling railroad junctions and transportation systems. It helps to reproduce the work of marshalling yards, train stations, metro stations, trams, technological routes in container terminals and other processes. It allows you to set individual sizes of cars, topology of tracks and switches, acceleration and deceleration of trains [4].

2 Materials and Methods

Any Logic process modeling library supports a discrete-event, or, to be more precise, a "process" approach to modeling. With the help of process modeling library blocks, you can model real-world systems, the dynamics of which is represented as a sequence of operations (arrival, delay, resource capture, separation) over agents representing customers, documents, calls, data packets, vehicles, etc. These agents can have certain attributes that affect the process of their processing (for example, the type of call, and the complexity of the work) or that accumulate statistics (total waiting time, cost) [5, 6].

Table 1. Blocks of modeling library

Names	Options
	Delays agents for a specified period of time. The delay time is calculated dynamically, it can be random, depend on the current agent or on some other conditions.
	The **Queue** block models a queue of agents waiting to be received in blocks following data in a flowchart, or a general agent store. If necessary, you can set the maximum waiting time for the agent in the queue. You can also programmatically retrieve agents from any position in the queue.
	Creates agents. Typically used as the starting point for the flow of agents. Agents can be standard or user-defined agents of type **Agent** . You can configure the unit so that it will create other types of agents, indicating the desired designer type in the parameter **new agent** , and specify the action that must be performed before the new agent leaves block **the Source** , in the field of action of **P when you exit** .
	**Time Measure Start,** together with **Time Measure End,** constitutes a pair of blocks that measure the time spent by agents between two points in the process diagram. Usually, they are used to measure the time an agent spends in the system or the duration of an agent's stay in some sub - process. **Time Measure Start** sets the starting point; it remembers the point in time at which the agent passes through this block. **Time Measure End** calculates, for each agent arriving at it, the difference between the current moment in time and the moment stored by the **Time Measure Start** block referenced by this block.
	**Time Measure End,** together with **Time Measure Start,** constitutes a pair of blocks that measure the time spent by agents between two points in the process diagram. Usually, they are used to measure the time an agent spends in the system or the duration of an agent's stay in some sub - process. **Time Measure End** calculates, for each agent arriving at it, the difference between the current moment in time and the

	moment remembered by the **Time Measure Start** block referenced by this block. One process diagram can contain several **Time Measure End** blocks, each of which can refer to several **Time Measure Start** blocks at **once**. Statistics are collected in two blocks - in one block the distribution of measured times is calculated (element "histogram data " distribution). This statistics can be used, in particular, for plotting histograms. The second data item is dataset dataset. It is convenient to display its values, for example, on a time chart.
in	Destroys incoming agents. Typically used as an endpoint for an agent flow. In order for agents to be removed from the model and destroyed, you need to connect the output port of the last block of the process diagram to the port of the **Sink** or **Exit** block.

3 Results and Discussion

Any Logic provides a unique opportunity to use GIS maps in simulation models:

- Maps can be applied to supply chain models, logistics networks, and in other cases where locations, roads, routes, or regions need to be considered.
- Built-in Google Maps style search makes it easy to find neighborhoods, cities, roads, trains, stations, and rail sidings using GIS data. Search works both when developing and when running a model
- Model elements can be placed on the map and navigated along existing roads and routes based on real spatial data.
- Any Logic provides free GIS maps that you can work with online and offline. If the standard maps do not suit us, you can use tile maps or shapefiles of the required supplier, shown in Fig 1.

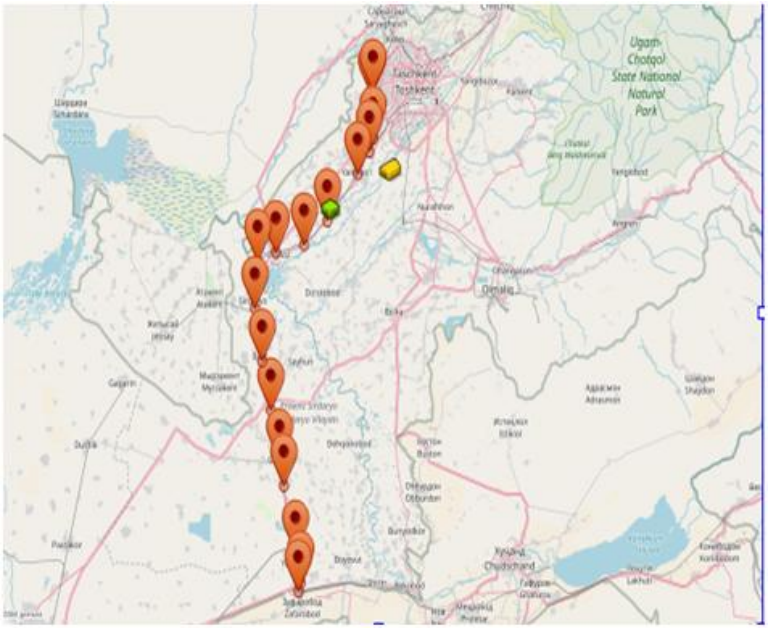
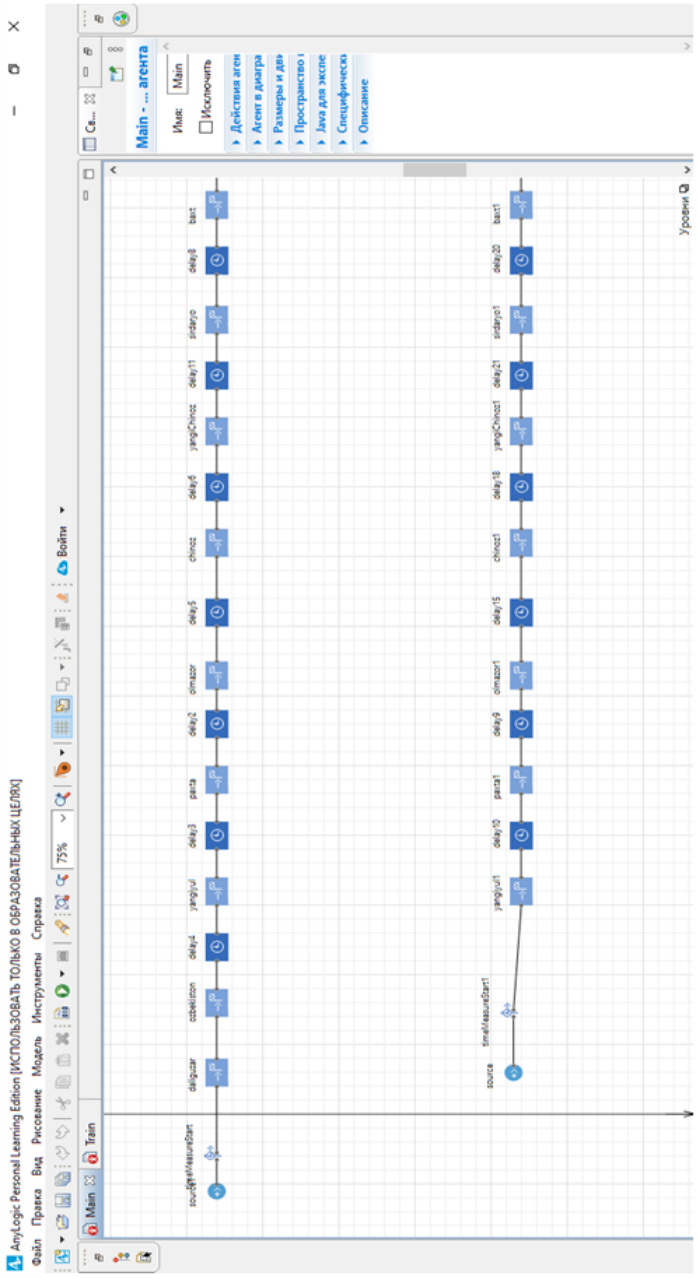


Fig 1. Modeling of transportation processes on Any Logic (by the example of the Tashkent-Khavast station))

Modeling of transportation processes using Any Logic (by the example of the Tashkent - Khavast station)

On the Tashkent (Yangiyul) - Khavast section, in order to carry out the supply chain, first of all, a digital map model was built , which includes a shape file , two agents Tashkent (Yangiyul) - Khavast were drawn up on this section, 8 trains depart according to the schedule, each train is equipped with satellite technologies GPS . If a train moves on a section, its movement is displayed on a GIS map, this gives us great opportunities, for example, profit, management of interval train traffic, ensure the safety and smooth movement of trains, prevent accidents and crashes, reduce fuel use, manage recovery trains, etc [7,8,9]

At the Tashkent (Yangiyul) station, all the main and side tracks are formed in electronic form (digital), each train goes to the destination station on schedule [10]. Information about the time of departure, movement and speed of the trains will be sent by the satellite to the server. On the server, all information is directly processed and transferred to the database for storage [19,20]. Fig 2.



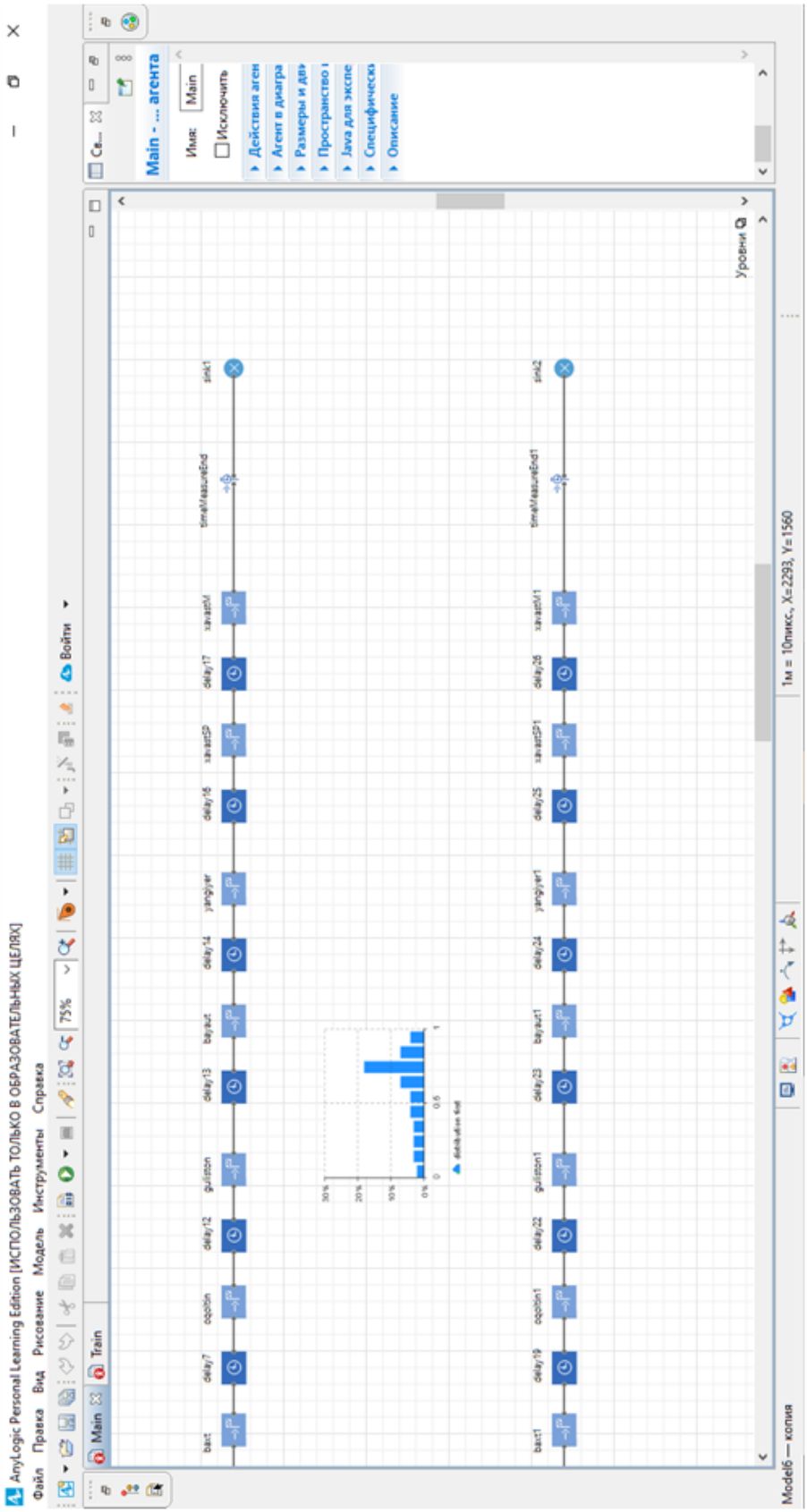


Fig 2. Station Tashkent (Yangiyul) in electronic form. Modeling shunting operations using GIS

In this scientific work, a model is built using Any Logic and the following library capabilities are demonstrated:

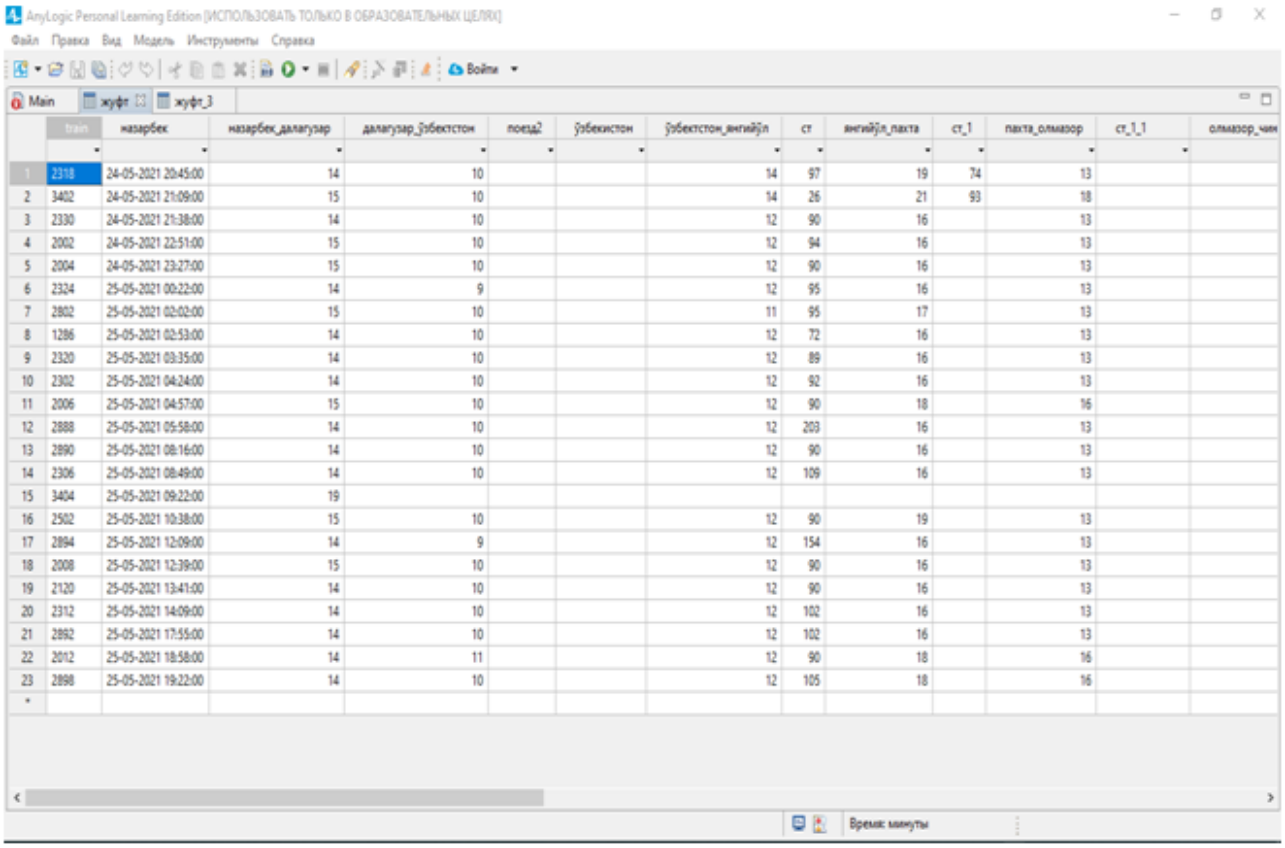
- ✓ creation of a railway network using a GIS map and shape files with real data;
- ✓ combination of different types of spaces in one hierarchical model;
- ✓ Safe movement of trains on the network, automatic conflict resolution.

Trains arriving th tons to haul on station ways and disbanded the directions, thereby forming new trains [11, 12]. Through the satellite, all information is transmitted to the server, where all information is processed, for example: (the train at a given time on what route, at what speed, the number of arriving trains at the station) each process is recorded automatically in the DBMS and then the whole process will be shown on GIS monitoring.

Simulation model of train positioning on the Nazarbek - Khavast section.

The Nazarbek - Khavast section was chosen to simulate the positioning processes. In this case, it provided that all international trains on this section are equipped with devices repositioning. On the basis of the standard train schedule, a database has been created that includes the time of movement and stops of trains on a given section [14, 15].

In the Anylogic environment, the Open Street Map GIS map of the required area is selected . Route points have been placed along which trains will travel. The logic of train movement has been compiled, linking train numbers with the train schedule [16]. As a result, the program will compile the data and in virtual mode simulates the process of train movement along the section while simultaneously storing separate reports on the indicators in Fig 3.



	train	назарбек	назарбек_далагузар	далагузар_ўзбекстон	поезд2	ўзбекистон	ўзбекстон_янгийўл	ст	янгийўл_пахта	ст_1	пахта_олмазор	ст_1_1	олмазор_чин
1	2318	24-05-2021 20:45:00	14	10			14	97	19	74	13		
2	3402	24-05-2021 21:09:00	15	10			14	26	21	93	18		
3	2330	24-05-2021 21:38:00	14	10			12	90	16		13		
4	2002	24-05-2021 22:51:00	15	10			12	94	16		13		
5	2004	24-05-2021 23:27:00	15	10			12	90	16		13		
6	2324	25-05-2021 00:22:00	14	9			12	95	16		13		
7	2802	25-05-2021 02:02:00	15	10			11	95	17		13		
8	1286	25-05-2021 02:53:00	14	10			12	72	16		13		
9	2320	25-05-2021 03:35:00	14	10			12	89	16		13		
10	2302	25-05-2021 04:24:00	14	10			12	92	16		13		
11	2006	25-05-2021 04:57:00	15	10			12	90	18		16		
12	2888	25-05-2021 05:58:00	14	10			12	203	16		13		
13	2890	25-05-2021 08:16:00	14	10			12	90	16		13		
14	2306	25-05-2021 08:49:00	14	10			12	109	16		13		
15	3404	25-05-2021 09:22:00	19										
16	2502	25-05-2021 10:38:00	15	10			12	90	19		13		
17	2894	25-05-2021 12:09:00	14	9			12	154	16		13		
18	2008	25-05-2021 12:39:00	15	10			12	90	16		13		
19	2120	25-05-2021 13:41:00	14	10			12	90	16		13		
20	2312	25-05-2021 14:09:00	14	10			12	102	16		13		
21	2892	25-05-2021 17:55:00	14	10			12	102	16		13		
22	2012	25-05-2021 18:58:00	14	11			12	90	18		16		
23	2898	25-05-2021 19:22:00	14	10			12	105	18		16		

Fig 3. Schedule of train traffic in the DBMS, on the Nazarbek-Khavast section (in an even direction in elecntronic form).

Main | Train | Train2 | Train3 | Train6 | Main | xavas_toq_2 | bayaut_toq

	поезд	хаваст_цп	хаваст_цп_хаваст_сп	хаваст_сп_янгиер	ст_1	янгиер_баяут	ст_2	баяут_гулистон	ст_3	гулистон_оқолтин	ст
1	2201	24-05-2021 19:36:00	9	8		15		10		12	
2	2891	24-05-2021 21:29:00	6	8		17		13	15	12	
3	2101	25-05-2021 01:50:00	6	8		15		10		12	
4	2001	25-05-2021 02:16:00	9	8		17		10		12	
5	2007	25-05-2021 02:33:00	9	8		15		11		12	
6	2895	25-05-2021 04:07:00	9	10	27	18	27	10		12	
7	6453	25-05-2021 04:20:00	8	8		8	1	7	1	12	
8	2009	25-05-2021 06:36:00	9	8		15		11		14	
9	6449	25-05-2021 07:37:00	6	10		16	2	7		10	
10	3473	25-05-2021 09:32:00	9	8		15		10		12	
11	2901	25-05-2021 11:07:00	6	8		15		10		12	
12	6411	25-05-2021 13:40:00	8	10		19	1	7		12	
13	2003	25-05-2021 14:21:00	9	8		14		11		12	
14	1221	25-05-2021 14:48:00	6	10							
15	2107	25-05-2021 14:55:00	9	8		15		10		12	
16	3475	25-05-2021 15:35:00	9	8		15		10		12	
17	2801	25-05-2021 16:00:00	6	8		15		13	5	12	
*											

Fig 4. Train schedule database in, for section Khavast-Nazarbek (in an even direction in electronic form).

System GNSS GLONASS / GPS on the railways so u t us the following features:

- control of the location of independent mobile units on the tracks;
- control of the location of independent mobile units at stations;
- construction of interval control systems;
- determination of the coordinates of railway line objects for the construction of geographic information systems (GIS);

The technological order of positioning will be ironed in a standard form. Namely, the positions will be determined via satellites, which will transmit the coordinates to the processing server. Based on this data, it will be possible to visually monitor train movements and automatically enter accounting. (Figure 1.5.)

Indicators of the train schedule: running, technical, section speed, indicators for the time of passage by trains, deviations from the set time, unscheduled stops, etc. will be recorded in real time [17-20].

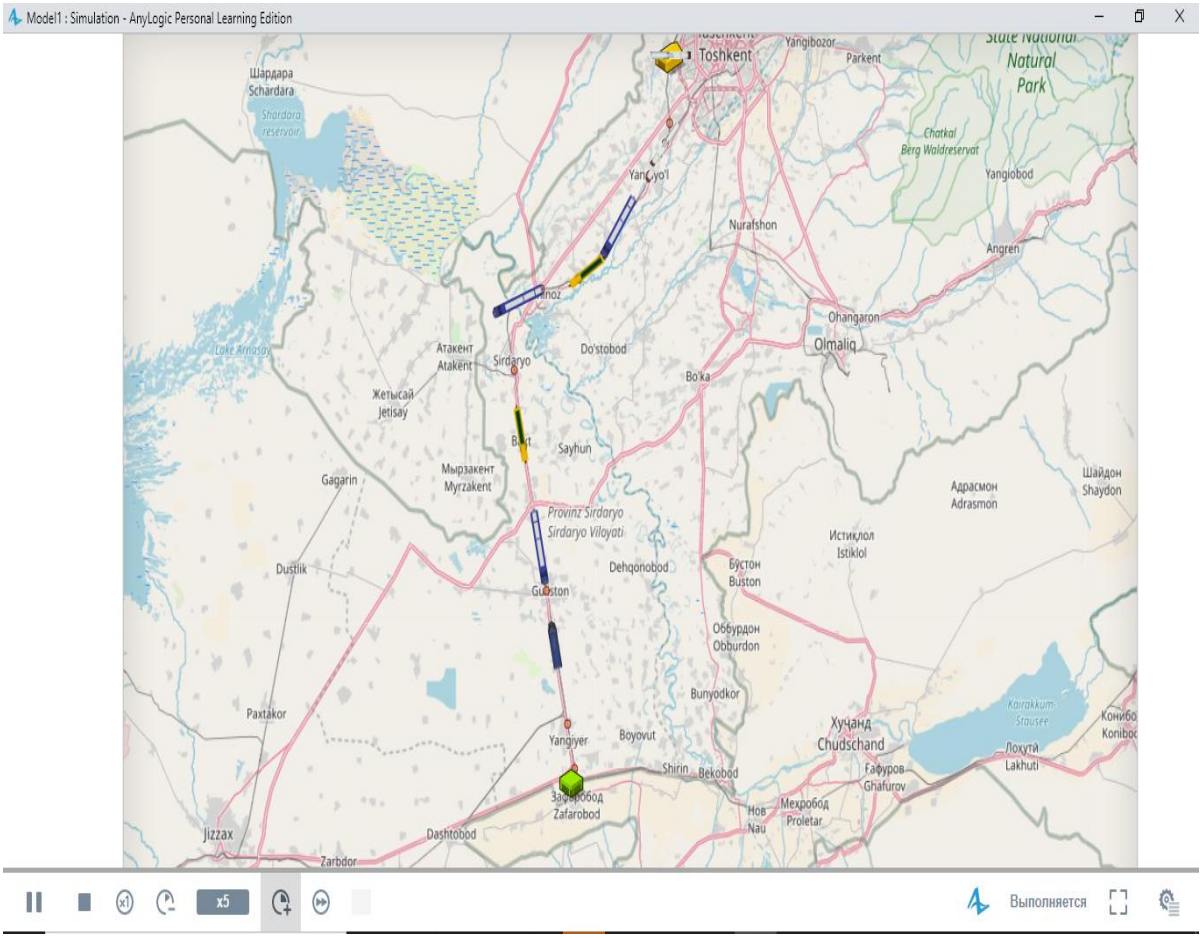


Fig 5. Simulation model of train positioning on the Nazarbek-Khavast section.

4 Conclusion

Based on these indicators, we can manage all processes in advance and plan the train movements optimally.

The use of this module for the production and management needs of UTY JSC will lead to the receipt of future economic benefits.

Due to the implementation of the system on the network of JSC "UTY" for the transportation process, safety requirements are met, the throughput and speed of movement are increased, as a result of which the turnover of the rolling stock is accelerated.

It is expected to reduce the cost of operation in 2.7 times in comparison with traditional technical solutions.

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