Modernization of the infrastructure of a river station of the north-south transport corridor using the simulation method

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Abstract. The paper presents the main fragments of the simulation model of a river port on the water section of the international transport corridor passing through the territory of the Russian Federation. The necessity of modernization and improvement of the infrastructure has been substantiated, the factors influencing the carrying capacity of the water corridor have been identified. A study of the river station in the city of Cheboksary in the Republic of Chuvashia (Russia) was carried out and its main objects were presented. The rules for the interaction of the objects being the basis of the simulation model, have been established. The resulting model allows generating scenarios for predicting changes in the characteristics of a river station, ship schedules, assessing the quality of the implementation of processes and the level of managerial decision-making.

1 Introduction

The International North-South Transport Corridor is the main route for the transportation of goods from India, Southeast Asia, Africa and the Middle East to Europe and back, bypassing the Suez Canal [1]. According to Russian experts, the domestic ports of the transport corridor cannot cope with the growing cargo traffic due to the lack of berths, terminals, cranes and other infrastructure and congestions in the shallow Volga-Don Canal [2]. All this increases the time for ships to pass through the transport corridor. Passenger traffic is an additional capacity constraint.

The segment of the passenger fleet of Russia is represented by small vessels, transport fleet and high-speed vessels, designed mainly for short passenger transportation and the cruise fleet, focused on multi-day long tourist routes [3]. River transport is underdeveloped in Russian cities. This is due to many reasons, which primarily include the depreciation of transport infrastructure components (hydro engineering facilities, berths, ports, etc.). As Matsuev notes in his paper, the problems of the development of water transport in Russia are of a systemic nature, which cannot be solved without the interaction of public authorities and business [4].

The development and modernization of infrastructure will not only increase the competitiveness of passenger river transport (for example, in comparison with rail

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transport), introduce new technologies into transportation processes, but will also increase the capacity of bottlenecks in problem areas, including for freight traffic [5, 6]. All this will ensure the interaction of types of water transport within the framework of the transportation process along transport corridors [4, 7].

Thus, the purpose of the study is to create a model that provides the organization of management processes for a river station related to the North-South water transport corridor. The set goal can be achieved only by creating a simulation model that demonstrates all the qualitative and quantitative characteristics of the real object of study.

The theoretical significance of the study enables to obtain the characteristics of the real object in order to create integrated programs for the modernization of objects and organization of processes, conduct research in ecology, urban planning and sustainable development of territories. The practical significance of the study lies in the creation of a digital twin of the real object, enabling to reproduce its behavior (or individual parts) in the implementation of various scenarios. Such scenarios include options for upgrading infrastructure for the purpose of sustainable development, forecasting environmental changes, waterway congestion, passenger traffic density, etc.

2 Materials and methods

The object of the study is the river station belonging to JSC “Cheboksary River Port” and located on the Volga River. The station provides river pleasure trips, river excursions, rent of motor ships, transportation of bulk and grain cargo, comprehensive fleet maintenance, loading and unloading operations and servicing transit ships.

To create a study design, it was necessary to collect valid quantitative and qualitative characteristics of the study object. As noted by researchers, this requires the complex use of methods of structuring, synthesis, and analysis [8-10]. The standard use of such methods made it possible to establish all the significant objects of the processes being implemented at the river station, the connections between them, as well as potentially external influences.

Based on the data obtained, the rules for the interaction of all elements have been established in the form in which they can be used to create a simulation model. For this, the methods of mathematical and agent-based modeling were applied [9, 11, 12]. Using the graphical method, models were developed that allow visualizing the main settings of the simulation model [8, 9, 13].

3 Results

The simulation model allows showing the behavior of the elements of the object of study (agents). Such agents for the river station include:

- passengers of cruise ships who come to the city for a short time to see it (a characteristic feature is the fact that they do not move luggage, reducing travel time);
- regional passengers who periodically use river transport for delivery to their place of work or residence (the presence of hand luggage or baggage);
- tourists renting boats for a short period;
- service personnel (porters, loaders, security service and other employees of the station);
- people meeting passengers.

The rules of interaction of the listed agents are shown in Fig. 1 in the form of a state diagram.
Fig. 1. State diagram of human agents of the river station.

In addition to human agents, the behavior of agents that are water vessels was considered. Their behavior must be taken into account in the simulation model, as it affects the scheduling of the movement of all vessels along the transport corridor. Riverboat agents serviced by the station include:
- cruise ships that moor for a certain time, consisting of the time of embarkation and disembarkation of passengers and the excursion program;
- passenger transport for regional or interregional transportation;
- boats for a short river trip;
- transit vessels;
- cargo ships to/from the port.

Fig. 2 shows the state diagram of the simulation model for agents being river vessel.

Fig. 2. State diagram of river vessel in the simulation model.

The behavior of each of the agents in Fig. 2 depends on the traffic schedule (the delay element is responsible for this).

The behavior of all agents is concentrated within certain routes. The general scheme of such routes in relation to the layout of the river station is shown in Fig. 3.
The main characteristic of passenger routes is their access to the berths through the security check area. This creates a certain time delay when a large number of people arrive. Thus, the main qualitative and quantitative characteristics used in the simulation model are presented.

4 Discussion

Simulation modeling using the method of agent-based modeling is focused on the behavior of individual participants in the system that form certain groups [7, 9]. In research work related to the use of this method, significant objects are identified, for which rules of behavior are established. Together, this forms the global behavior of the entire system. Changing the parameters of each of the objects, adding or removing them from the model allows creating a scenario for predicting events in the short or long term or evaluating the consequences of making any management decisions [9-11, 14].

The results obtained are valid, accurate and reliable, as a set of general scientific research methods used in the problem area was used. They do not contradict the results obtained by other teams of authors.

5 Conclusion

The use of modern digital technologies in water transport helps to create new business models, services, operations and concepts, the use of which ensures the sustainable development of the industry. Simulation tools for digital transformation enable to improve industry standards and infrastructure, and build long-term partnerships with technology leaders.

Improving the efficiency of freight and passenger transportation, the quality of logistics services, reducing service time, movement and environmental impact is possible only with the use of forecasting methods and tools. Simulation modeling is a universal tool that allows obtaining results on the behavior of objects and processes at different time intervals and any input data.
References

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