Some aspects of the navigation period extension in the North-West Basin of inland waterways of the Russian Federation

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Abstract. The Russian Federation has a developed system of inland waterways (IWW) [1]. This system consists of 15 basins. Winter conditions are very harsh in some basins. Such basins, for example, include the Lena Basin. But in some basins, even in winter, conditions that block navigation do not form. These basins include the Volga-Baltic. However, during the extension of the navigation period in such basins, it should be borne in mind that the navigation safety system will have to be upgraded. This paper discusses some aspects, the introduction of which forms the prerequisites for extension of the navigation period on the waterways of the North-Western region of the Russian Federation. In addition, specific recommendations are provided for the implementation of the necessary automated systems to ensure a sufficient level of navigation in winter conditions on the IWW. These recommendations were obtained within the framework of the international project INFUTURE.

1 Introduction

The IWW of the Russian Federation is one of the key systems of the country’s transport complex. Having a number of significant advantages, they have the main drawback-the seasonality of their use. In the European part [2] of the country, the navigation period usually lasts from May to November. This is due to the beginning of ice phenomena and, as a result, the end of the navigation period.

The IWW of the North-West basin provides two main transport functions (fig. 1):

- connection of the Baltic ports [3] with the central regions of the European part of the Russian Federation;
- cargo turnover within the North-West region [4].

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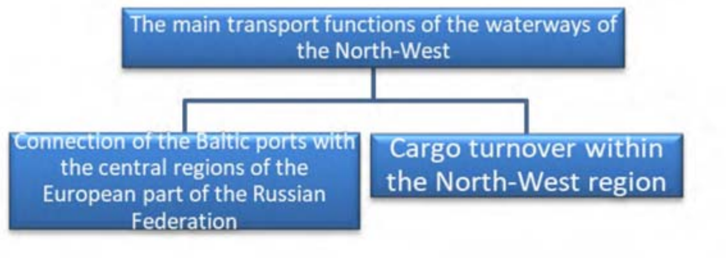

Fig. 1. Main transport functions of the Northwest waterways.

One of the main waterways in the North-West is the Volga-Baltic Waterway (VBWW) [5], which includes the Neva River, Lake Ladoga (its southern route), the Svir River and the Volga-Baltic Canal (fig. 2).

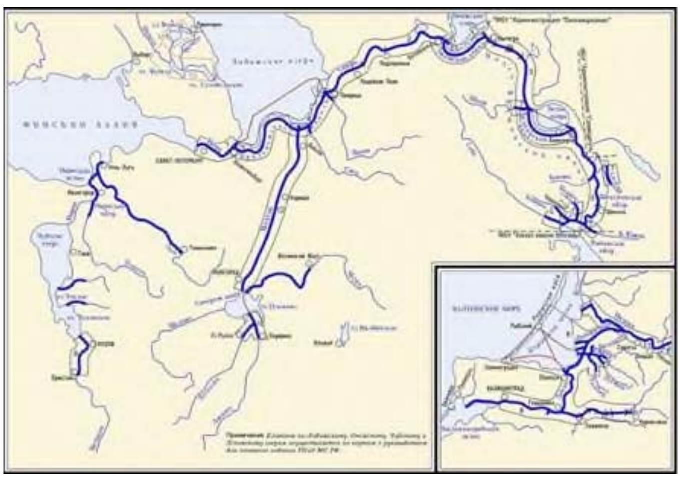

Fig. 2. Structure of waterways of the North-Western Basin of the Russian Federation.

Based on long-term hydrometeorological observations, it was established that due to geographical and climatic features, the ice cover is primarily formed on the Volga-Baltic Canal and the Svir River. Thus, connection with the central regions of the European part of the Russian Federation by water is interrupted. But the Neva River and Lake Ladoga are located closer to the Baltic Sea, in a region with a predominant temperate climate, so the ice cover there is formed later, which allows for extension of navigation in these water areas.

Thus, despite the break with the waterways of the central part of the country, the transport function continues to be carried out to ensure cargo turnover within the North-Western region with the help of inland water transport. Specialists of the “Admiral Makarov State University of Maritime and Inland Shipping” within the frame-work of the INFUTURE project, implemented jointly with the Finnish party, considered the specifics of ensuring the safety of navigation during the extension of navigation period and prepared appropriate recommendations.

2 Methods and materials

We will consider the main features of navigation during the period of its extension. The main factors affecting the level of safety of navigation during the extension of the navigation period are the following:

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- removal/reduction of the number of floating navigation equipment;
- sharp change in navigation conditions.

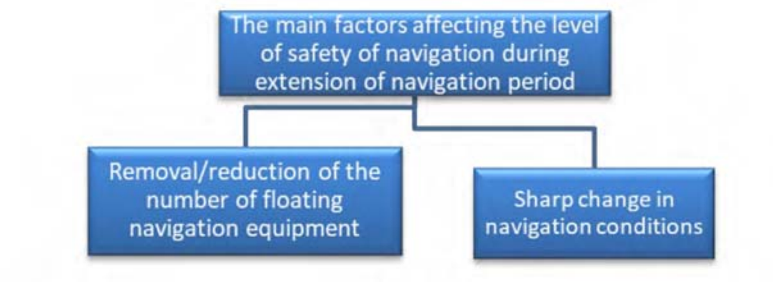

Fig. 3. Main transport functions of the Northwest waterways.

We will analyze each of the factors separately.

After the end of the navigation period, the basins administrations usually remove all floating navigation signs. Only coastal navigation signs remain in their regular places, but without navigation lights. Thus, when navigating in such navigational conditions, skippers may have significant difficulties, which will undoubtedly affect the level of safety of navigation.

Specialists of the "Admiral Makarov State University of Maritime and Inland Shipping" conducted a simulation of the safe traffic of the vessel [6] only using radar station (radar) [7] and electronic navigation map and information display systems (ECDIS) [8] in areas that are difficult for navigation in the conditions of extension of navigation period in the Neva River water area, using the NT Pro navigation simulator.

To evaluate possible solutions that allow ensuring the necessary level of navigation safety of vessels' traffic, the method of mathematical simulation was used using a modern navigation simulator, Navi-Trainer 4000 [9], developed by Transas company and installed at the Department of "Navigation on Inland Waterways".

Fig. 4. General view of the navigation bridge of the Transas NTPro 4000 simulator complex.

The development of exercises is a step-by-step process that allows eliminating random errors during the direct implementation of the simulation and includes the following main stages:

- navigation and hydrographic study of the simulation area;
- selection of the settlement vessel;
- exercise planning;
- pre-playback of created exercises;
- carrying out the exercises.

Mathematical simulation of the controlled traffic of the vessel can be carried out by the following methods:

- real-time simulation method;
- simulation on an accelerated time scale (fig. 5).

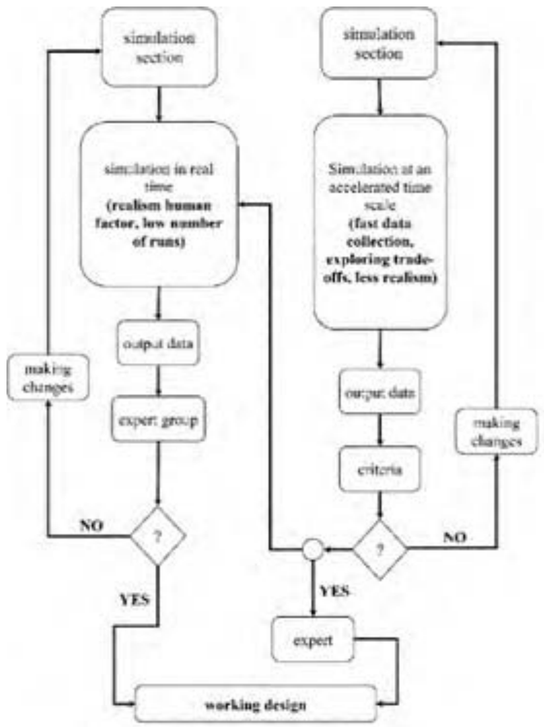

Fig. 5. Schematic representation of the use of real-time and accelerated-time scale simulation methods.

In order to reduce the influence of the human factor, the simulation method on an accelerated time scale was chosen.

The accelerated time scale mode makes it possible to perform a large number of runs in a short period of time, and this property is its main advantage as a design tool. This method does not exclude the involvement of an expert group.

The parameters of the waterway section of interest to the researchers [10] were entered into the simulator model, and the skippers performed the vessel's movement [11-12] along this section, guided by their experience in real conditions and knowing the features of vessel management in the appropriate conditions, after which they gave their comments on the features of vessel management in relation to specific circumstances and conditions of navigation.

This procedure included the following main stages:

- initial acquaintance with the training equipment;
- playing exercises by one or more skippers on models of vessels of the in-tended types (or on models of similar types);
- detailed analysis and analysis of the results of playing maneuvers after each run;
- monitoring and recording of key parameters of vessels traffic and the state of external objects of the model.

As a result of the experiment, it was found that when moving along the section under consideration using only radar for observation, it is necessary to correct the vessel's course according to reliable radar landmarks, which can be considered capes, channels, and characteristic outlines of the coast. Since the edges of the vessel's course are shallow and rocky, and the depths beyond the edges on the shallows are small, the transition from one straight section to another should be carried out smoothly almost everywhere, which will ensure good vessel management and avoid delays and sharp changes in course. As an example, the section of the Ivanovskie Rapids is considered, its complexity is due to a combination of reasons, among the main ones we can single out: a sharp change in the directions of straight sections of the vessel course, alternation of narrow and wide sections, the action of dump streams, significant stream speeds, variability of streams depending on the water level and location (fig. 6).

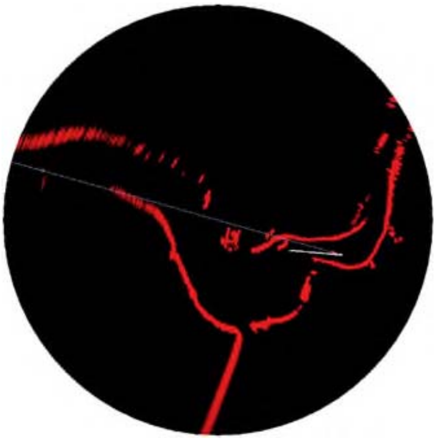

Fig. 6. Display on the all-round view indicator of the radar of the speed vector of the vessel in a curved movement during the turn to the aft Upper Pellovsky target.

Based on the results of the settlement vessel's runs on the difficult for navigation section of the Ivanovskie Rapids and the study of the traffic course with the analysis of the influence of external factors on the vessel, it was decided that it is necessary to set the minimum number of floating signs of navigation equipment at four points:

- to indicate the intersection point of the Upper Pellovsky and Lower Pellovsky targets.
- for the prevention of vessel deviation in the direction of Bolsheporozhskaya luda when rounding Cape Svyatki;
- to evaluate the start point of rotation around Bolsheporozhskaya luda;
- for orientation when making a rotation around Novoderevenskaya luda.

The use of only ECDIS without floating navigational marks when passing the Ivanovskie Rapids section, which is difficult for navigation, can significantly increase the navigational safety of navigation, due to sharp changes in the directions of straight sections of the vessel course, alternation of narrow and wide sections, the action of dump streams, significant stream speeds, variability of streams depending on the water level and location (fig. 7).

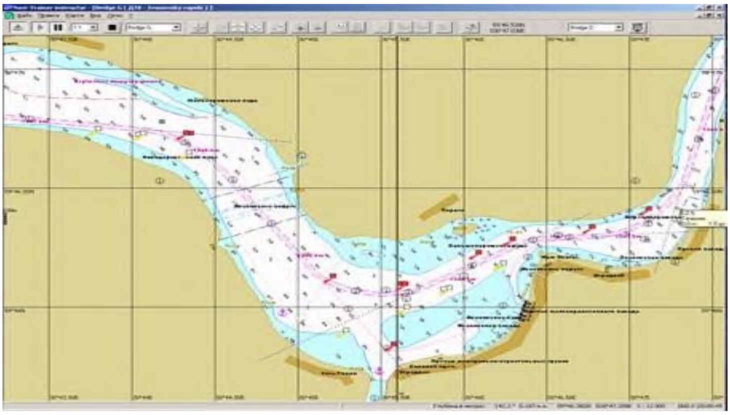

Fig. 7. A fragment of an electronic navigation map of the most dangerous part of the difficult for navigation section of the Ivanovskie Rapids, without displaying signs of floating navigation equipment

Thus, for the successful implementation of the extension of navigation period, the use of up-to-date electronic navigation maps is a prerequisite. A prerequisite for ensuring the safety of navigation during the period of extension of navigation is the deployment of an infrastructure for regular proofreading of electronic navigation maps and bringing maps to the end users. The Neva River basin is provided with high-quality cellular coverage, so it seems appropriate to transmit proofreading data via a cellular communication channel. Lake Ladoga has cellular coverage only in some coastal areas, so we need to get the latest proofreading data before going to the lake part.

A sharp change in navigation conditions during the extended navigation period imposes the need for both monitoring the main parameters in real time and promptly communicating changes to the skippers. Real-time tracking is possible only with the use of automatic sensors, and the monitored parameters are water levels at various points, the hydrometeorological situation and ice conditions (fig. 8).

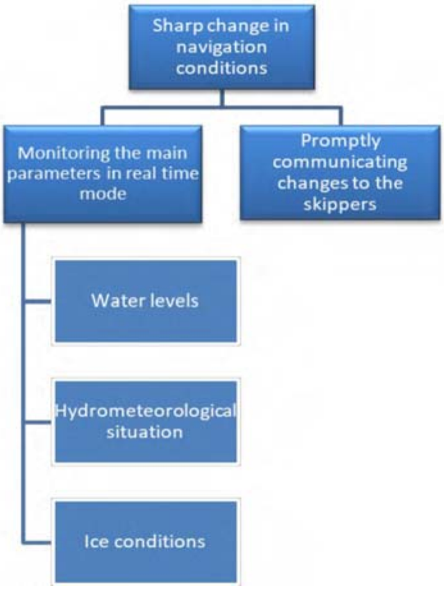

Fig. 8. Areas of work associated with a sharp change in navigation conditions.

Water levels and the hydrometeorological situation will be monitored using automatic stations, and it is advisable to use unmanned aerial vehicles of the airplane type to control the ice conditions.

Prompt communication of information to skippers should be carried out through a specialized portal on the Internet. In the future, the resource of the River Information Service (RIS), namely, the Fairway Information Service, will be used for these purposes.

3 Results

Thus, the main areas of work to ensure navigation in the extended period are (fig. 9):

- creation and regular proofreading of electronic navigation maps;
- prompt delivery of the proofreading of electronic navigation maps to the skippers;
- training of skippers in the use of electronic navigation maps in areas with-out floating navigation equipment;
- installation of automatic water measuring posts, hydrometeorological stations and means of tracking ice conditions;
- creation of a specialized portal on the Internet.

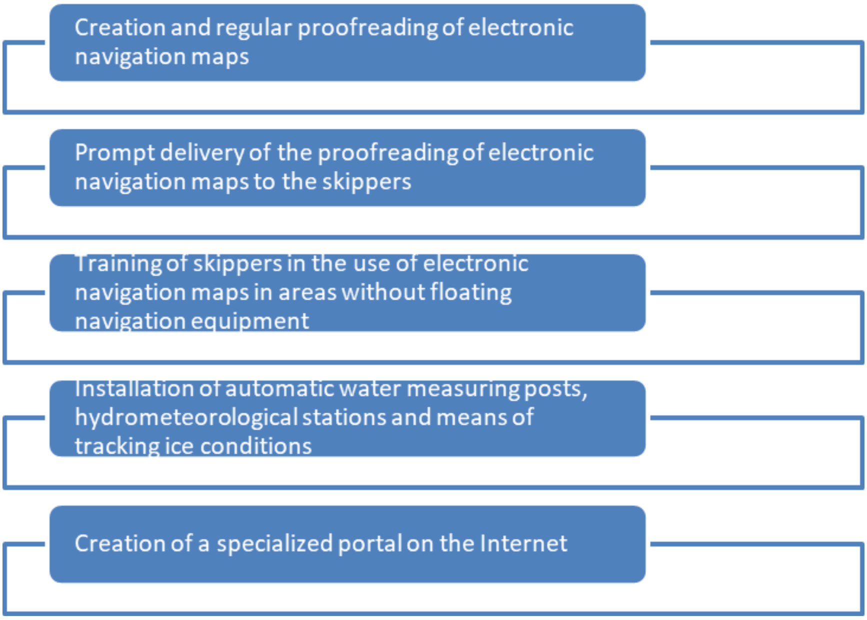

Fig. 9. Areas of work associated with a sharp change in navigation conditions.

4 Discussion

The solutions proposed by the authors are quite expensive, if they are implemented starting from the “zero” cycle, at the same time, if the basin administration has this set of technical means (“Volgo-Balt” state basin administration” has ready-made solutions or at least their elements for each of the listed items) then we only need their “fine” tune to solve a specific task, which is extended navigation. As a result, it is possible to extend the period of use of inland waterways to ensure cargo turnover within the North-West region and make better use of the existing infrastructure, de-spite the presence of an objective limiting factor, which is the seasonality of navigation.

5 Conclusion

The paper proposes a number of constructive measures confirmed by practical experiments that allow the fullest use of the potential of the inland waterways of the Russian Federation as one of the key systems of the transport complex of the Russian Federation.

The presented results were obtained during the implementation of the international project "Future potential of inland waterways" ("INFUTURE").

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