Information support and quality of structural analysis of vessel modernization technology

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Abstract. Modernization is an important direction to maintain and increase the efficiency of aging water transport. Vessels of various types and purposes are modernizing due to objective necessity. The actuality of this problem is connected not only with the slow process of renewal of the sea and river fleet, but also with the rapid moral aging of ships, which overtakes their physical aging. Modernization of an existing vessel is often more cost-effective for the shipowner than building or purchasing a new one. For the successful development of this direction it is necessary to have methodological and informational support which allows to determine the best modernization option based on available resources and to evaluate the quality of the work. The article describes an approach to structural analysis and quality assessment of modernization technology using informational support for functional and simulation modeling. Structural analysis of complex processes of modernization of the vessel is implemented in the form of context diagrams of these processes, which are decomposed considering the expert opinion. The proposed method of integration of functional and simulation models allows to allocate optimally all available resources and to assess the efficiency and quality of modernization work.

Keywords: vessel modernization, functional modeling, simulation modeling, context diagrams, decomposition levels, quality assessment, informational support.

1. Introduction

One of the main causes of accidents on vessels is their operation with a significant excess of useful lifetime. Age-related changes, associated with the physical deterioration of elements of a vessel, form negative trends for all groups and types of vessels. Emergency situations and subsequent economical losses can be avoided, if timely modernization of outdated equipment and mechanisms is carried out [1,2]. Many authors write about this in their works. Batygin O. E. and Egorov G. V. point out that without modernization the Russian fleet will exhaust its resources in the next 5-10 years. Moreover, many dry cargo vessels and tankers are already not suitable for navigation and repair [3,4]. In order to improve the competitiveness and the class of the Register of vessels Lazarev A. N., Marchenko S. S. and Alekhine M. Yu. have proposed a new concept - modernization suitability of a vessel [5,6]. Modernization is also necessary for the shipbuilding management system, since it is the comprehensive modernization of the industry that will create the competitiveness of the national shipbuilding industry and fundamentally improve its position in the domestic and world markets. Approaches to effective modernization of transport management systems are described in the article of Shvetsov V., Burmistrov A., Morozov V. [7]. In this regard, the rational organization and quality performance of work of vessel modernization are very important.
The aim of the study is the qualitative implementation of the structural analysis of vessel modernization technology based on the use of modern informational support. The objectives of the study are the formalization of complex processes of the vessel modernization and the representation of the work performed in the form of functional and simulation models with the optimal distribution of available resources.

Modernization of hull, engines and mechanisms, electrical equipment allows to extend the life of a vessel for the period planned by the shipowner in the specifications [8]. Automation of these processes is possible on the basis of application of modern information technologies, software and hardware, providing:

- automated analysis of standard plans of organization and performance of works on modernized vessels;
- operational adjustment of the flow chart of work on the primary information received from a vessel;
- automated generation of a simulation model of the modernization process on a ship according to the corrected flow chart;
- express analysis of the simulation results of ship modernization works;
- a decision on the implementation of a reasonable work plan.

The above processes are implemented on the basis of a virtual model of ship modernization which uses computer tools of functional and simulation modeling.

The task of functional modeling, which is proposed to be carried out using the "BPwin" program, is a formal representation of the sequence of actions carried out according to the instructions to identify "bottlenecks" and shortcomings in the existing technological processes of vessel modernization.

In modern conditions, it is necessary to focus on the quality training of shipbuilding and ship repair enterprises for the modernization of ships, because in the mode of fierce competition it is difficult to stay afloat with a poorly developed production planning process [9].

The approach to the formalization and structural analysis of complex processes composed of construction of diagrams of these processes is generally recognized in the world practice.

2. Methods

Context diagrams are useful for describing complex processes. This method allows you to specify the input and output data with the specification of resources involved in work, and restrictions, imposed on the rules of their conduct. Such diagrams contain direct and reverse links between the individual components of works [10-12]. Links can show the features of modernization process.

Description of the process of work on the modernized vessel begins with the creation of a context diagram in one of three existing notations:

1) Integrated Definition for Function Modeling - to specify the relationships between the components of the process, with the allocation of management and resources for the work;
2) Data Flow Diagrams - to describe the totality of data flows necessary to manage the work;
3) Integrated Definition for Process Description Capture Method - to describe workflows that ensure efficient execution of all component operations.

The context diagram for determining the type of vessel modernization is shown in figure 1.

Context diagram widely and generally characterizes the modeling process of modernization. The decomposition of the context diagram is used to concretize the description of the simulated system functioning.

The quality of the experts' detection of deficiencies in existing processes of organization and work on a modernized vessel depends on the completeness of decomposition operations of context diagrams.

In the process of decomposition, the new diagram shows the same information as the parent one, but more detailed. In this case, the main function of a complex process is represented by a set of subfunctions displayed inside individual blocks that interact in a certain order with external arcs and have additional arcs to illustrate those processes.
The decomposition of the parent diagram can have as many levels as necessary for a simpler and clearer description of the simulated complex process functioning. In this case, each block of a higher-level subfunction at the next level of decomposition is represented by a set of blocks containing more detailed subfunctions, with all the necessary connections [13].

![Diagram of determination of the type of vessel modernization](image)

**Figure 1.** Context diagram of determination of the type of vessel modernization.

The number of decomposition levels can be different, but it is desirable to limit the number of processes represented at each level for the convenience of working with computer versions of diagrams. The context diagram must reflect the specifics of processes under consideration. The result of the first level of decomposition of the context diagram with types of vessel modernization is shown in figure 2.

2.1. **Decomposition of context diagrams based on expert opinion**

Continuing the process of decomposition of the context diagram, its developers should interact with experts in the subject area as well as with specialists in the modernization of the vessel. From this moment, the quality of developed functional model, including its completeness and detailing, depends on the opinion of experts. A version of the "To be" model is created, containing processes that complement and improve previously developed work plan.

The old plan can contain duplicating activities that require additional resources, but do not lead to reduction in their duration. The degree of manageability for individual works is very important. Its decrease is followed by recurrences of spontaneity, which can lead to complications of further work.

In construction of diagrams, not only qualitative, but also quantitative estimates of the simulated processes are possible. These estimates are associated with the cost of modernization and implementation time of processes under consideration with restrictions on the used resources. Evaluation of quantitative indicators is desirable to refer to processes described at the lowest levels of
developed model. After the construction of this model, the used software allows to obtain the final quality indicators of the modernization process.

**Figure 2.** The result of the first level decomposition of the context diagram of vessel modernization varieties.

It is better to present the results of the functional simulation using a hierarchical diagram (see figure 3), which shows all levels of decomposition of the modernization process of the vessel.

### 3. Results and Discussion

Functional modeling procedures describe only deterministic processes that accompany modernization. The results of these processes in practice depend on many random factors, the source of which may be the external environment.

It is possible to consider the influence of random factors on the efficiency of modernization of a ship using methods and means of simulation modeling. The problems of functional and simulation modeling were previously solved independently. This affected both the time of obtaining results and the accuracy of solutions [14-16].

The development of modern computer tools makes it possible to integrate problems under consideration and directly use the results of functional modeling to build appropriate simulation models. Thus, the result of functional simulation modeling is a flow diagram of work carried out during the modernization of a vessel, which can be integrated into the structure of simulation model. The instrumental environment "Arena" can implement this model.
This simulation environment has developed animation capabilities. Besides, it allows to obtain quantitative characteristics of the effectiveness of modernization, taking into account the influence of random factors on processes, and to assess the quality of the performed work. With the condition of independent use of functional and simulation modeling tools, the cost of developing a simulation model might neutralize the effect of its operational use. The considered technique allows moving to a new level of joint use of two modeling tools.

Mastering the capabilities of the tool environment for the simulation of processes of preparation and modernization should begin with the procedures for configuring the blocks used to describe the structure of developed model. The simplest typical simulation model of a preparation process for modernization should include three typical blocks:

1) "Arrive" - to simulate the process of delivering enterprise resources to perform upgrades;
2) "Server" - for pre-processing of information about the functional model for the purpose of operational development of the modernization plan;
3) "Depart" - to complete the preparatory work for the modernization of a vessel.

These blocks allow to create standard modules used to build a simulation model of any complexity to formalize the processes of modernization. Within each module, simulation blocks must be functionally linked in a sequence that corresponds to the semantics of a simulated process.

After the construction of a simulated process structure is completed, parametric adjustment of each module block in accordance with its functional purpose is required. The blocks are set up interactively using the special on-screen windows of the "Arena" tool environment. Some of the selected fields for data entry require mandatory filling, while other fields are perceived by default. The central place is occupied by the field "Time Between", the information in which is entered from the drop-down screen window and allows you to set the distribution law of random variables, characterizing the resources that come to the input of the model. The numerical characteristics, which are entered in the remaining fields of the window, allow to configure the parameters of the resources, planned for use in the modernization of a vessel.

The process of simulation modeling uses a created and configured module and has two components. The first component is dynamic and uses the simulation capabilities of the tool to graphically display the processes, occurring between the blocks of a module. Images of objects,
circulating on the selected and named links between the blocks of a model, can be selected by the developer and reflect the specifics of the simulated process. These may be people, who have arrived to perform modernization works, or technical means, robotic mechanisms, used in the modernization process.

The second component has a standard form and displays numerical simulation results in a form of special tables that characterize the quality of work, carried out on the vessel.

The duration of a dynamic component of a simulation process using animation tools depends on the setting of the "Simulate" block, which is mandatory for any model. Quantitative simulation results, including the accuracy of estimates, depend on the number of statistical tests specified when setting up the "Simulate" block.

When the dynamic part of simulation is completed, the working field of the "Arena" tool displays the situation, corresponding to the result of the last statistical test of the developed model. If the informational content of such an image is considered insufficient by the researcher, it is possible to switch to the mode of interactive communication with the system. The researcher displays a table of quantitative estimates of simulation results and makes additional adjustments to the model blocks in order to obtain estimates of the modernization quality. The obtained results are acceptable for making an optimal decision on their use for operational planning of specific modernization works.

4. Conclusions

Thus, a practical approach to structural analysis and formalization of complex processes of modernization of a vessel, which is implemented through the construction of diagrams of these processes, detailed at the qualitative level, is described.

The proposed method of integration of functional and simulation models for rapid assessment of the effectiveness and quality of planned works on modernization of a vessel is an automated assistant to the head of such works at the stage of resources allocation for the modernization of a vessel.

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