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Simulation of organizing and carrying out of repair for ship engineering products

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Abstract. To ensure competitiveness with foreign enterprises, there is a need to reduce production time and cost of ship engineering products (SEP). This paper presents data of simulation for a repair process of SEP. The aim of researching is the justification of functional and simulation using for organizing the process of repair of SEP during required time and with cost reduction. The paper uses methodology of structural analysis in two types of notations. To obtain the quantitative result, the GPSS World environment is used. The results in the form of histograms of the processes of maintenance and repair of SEP confirm the effectiveness of proposed technologies.

1. Introduction

Currently there is a problem of ensuring the competitiveness of domestic shipbuilding enterprises [1, 2]. This requires the solution of a large number of tasks, one of which is the technological modernization of enterprises for various stages of the life cycle of ship engineering products (SEP). Analysis of the market of SEP is carried out in the paper of A. G. Bogdanov [3], the peculiarities of the SEP and causing problems, on the solution of which the economic well-being and competitiveness of domestic enterprises depend, are considered. The article of M. A. Aleksandrov [4] examines the state and provides prospects for the development of marine engineering.

The heterogeneity of engineering products used on ships requires, if it is possible, the same stages of their life cycle for the rational maintenance and repair. A preliminary cost estimation of organizing and conducting the repair of SEP is proposed to be justified with the use of tools of functional and simulation modeling. Complex use of these tools allows you to present the simulation results visually and reduce the costs of repairing shipboard engineering products.

The functional part of the SEP model can be considered as a priority in relation to its other components: the mathematical and technological models. The results of the study of this model in relation to the existing processes of technological preparation and the repair of the SEP itself serve as a starting point for correcting the original prototype model of these processes in order to improve them and achieve the best indicators of cost and other criteria, as well as decide on a possible reengineering of the existing repair process of SEP. In these latter days, unified means of creating functional models of complex processes have dominated. They are based on the use of IDEF0, DFD, IDEF3, IDEF1X standards [5]. This circumstance allows us to objectively compare the results of the study of functional models created by various performers for specific SEP repair technologies. Domestic and foreign experience of SEP standardization is considered in the work of A. P. Fomin [6].



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2. Functional modeling

In conditions of market economy, the use of functional models allows you to analyze the costs of all stages of the life cycle of a ship engineering product and, through their redistribution, increase the share of profits at the stage of its operation and repair of SEP using integrated logistics support technologies. The whole range of issues related to operation, maintenance and repair of SEP, is accepted to call its logistic support. This definition includes: routine inspections, various types of repair, issues of control and adjustment of SEP, supply of spare parts, diagnostics and preparation for operation. The listed activities are regulated by relevant documents, the release date of which refers to the time of SEP commissioning. For many native SEPs, the planned time of their operation is approaching to the limit value. In this case, the task of forecasting activities related to the increase of the lifecycle stage of SEP such as exploitation becomes an actual task.

We will consider current, medium and capital repairs of the SEP. For the first two types, the problem of evaluating of spare parts (SP) which are available on a ship is relevant.

As a rule, the number and composition of spare parts for a particular ship engineering product is calculated at the design stage and these estimates can be corrected during operation of the SEP. Such adjustments are made on the basis of information on failures of ship equipment in the course of its operation; however, in some cases, such information does not reflect the true state of affairs in this area. As a result, the volumes of spare parts, transported on the vessel are overestimated, which leads to a decrease in the efficiency of its operation. Under the processes presented in the functional model diagram (figure 1), it is customary to understand the procedures for calculating and modeling the needs of the ship engineering product in the spare parts based on the results of its operation at a certain time interval. The purpose of the detailed description of the relevant processes is their expert analysis to identify weak links in the existing organizational and technical structures related to the maintenance and repair of the ship engineering product [7]. Examples of weak links include:

- processes without control;
- duplicate work;
- non-optimal document flow;
- lack of controlling links between processes, etc.

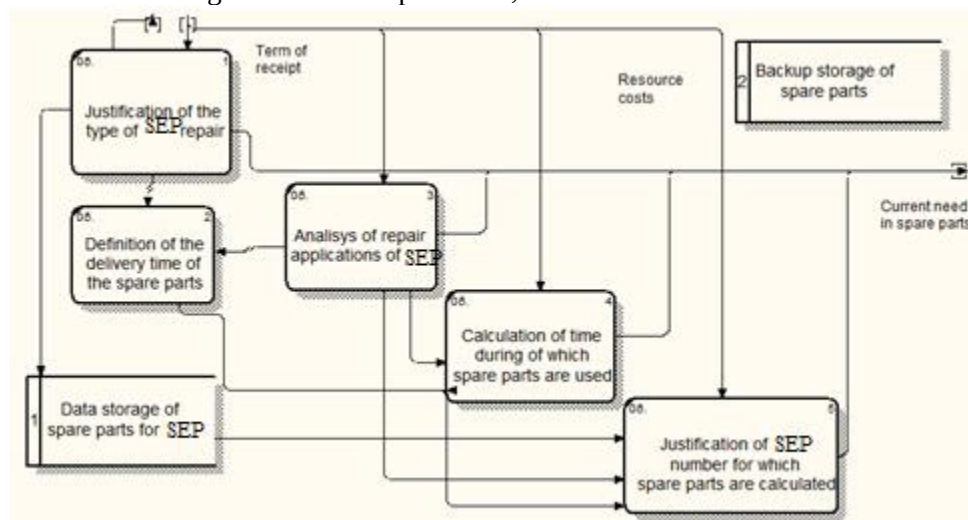


Figure 1. A diagram of the decomposition of the contextual description of the process of the needs of the ship engineering product in the spare parts.

The interaction between the expert and the developer of the functional model is iterative and ends when a consensus is reached between them in the period of improvement of the developed functional model [8].

The final purpose of functional modeling is to create such a variant of the studied process which would ensure its implementation in minimal time or with minimal costs. All stages of logistical support for SEP should be automated by creating an appropriate information support system (ISS). To develop the ISS of the life cycle (LC) of the SEP, it is necessary to previously develop a workflow diagram in the IDEF3 standard (figure 2) [9].

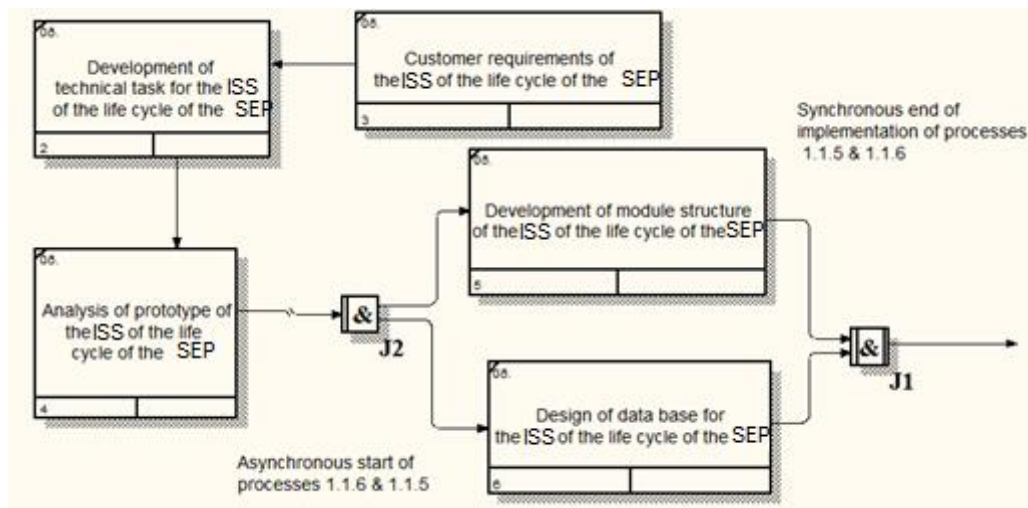


Figure 2. A workflow diagram showing the process of creating the main components in the information system of the ISS of the SEP life cycle.

3. Results and discussion

The use of functional models makes it possible to obtain a deterministic estimate of the costs of performing various types of SEP repairs. However, many random factors that occur during the operation of the SEP require obtaining probability estimates of the processes under consideration. Complexing of the technologies of functional and simulation modeling allows to quantify the results of solving the problems of SEP repair. Figure 3 give us an example of the structure of the simulation model of the repair process of the ship engineering product in the GPSS World environment, which includes three typical modules. Using these modules, you can programmatically describe:

- features of the implementation of maintenance of SEP to assess the cost of its implementation;
- the implementation of the average repair of SEP on board the vessel;
- overhaul with the preliminary dismantling of the ship engineering product.

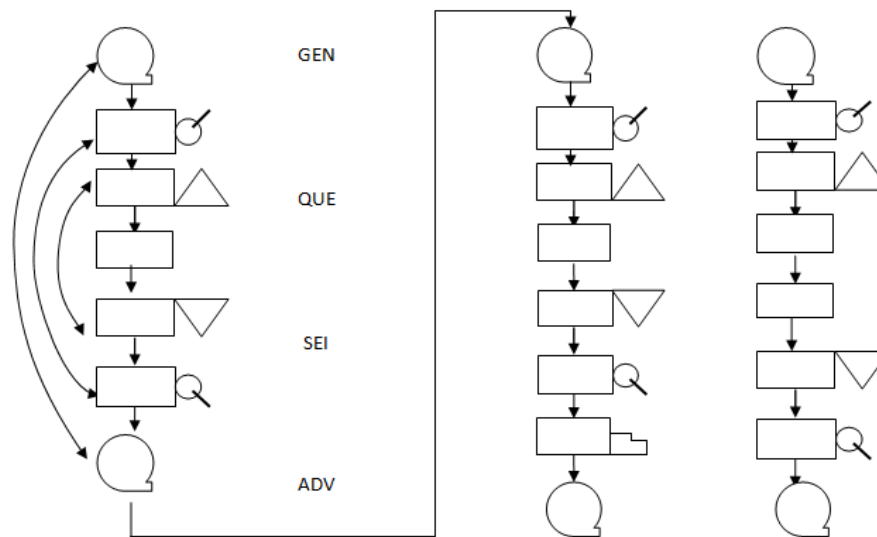


Figure 3. The structure of the simulation model of the process of maintenance and repair of shipboard engineering products in the GPSS World environment.

The specialist in the subject area should set (figure 4) statistical data characterizing the stages of repair of shipboard products. The most common form of presentation of such data is the distribution function of random variables characterizing the prehistory of operation and maintenance of the SEP in case of its failure, breakdown or malfunction. For the analytical description of the processes under consideration, we use the Erlang law of the k -th order [10]:

$$F_k(t) = \frac{\lambda(\lambda \cdot t)^k}{k!} \cdot e^{-\lambda t}, t > 0.$$

The Erlang law is transformed into an exponential law, if $k = 0$: $F_0(t) = \lambda \cdot e^{-\lambda t}$, where λ characterizes the intensity of receipt of applications for the implementation of various types of repair of SEP.

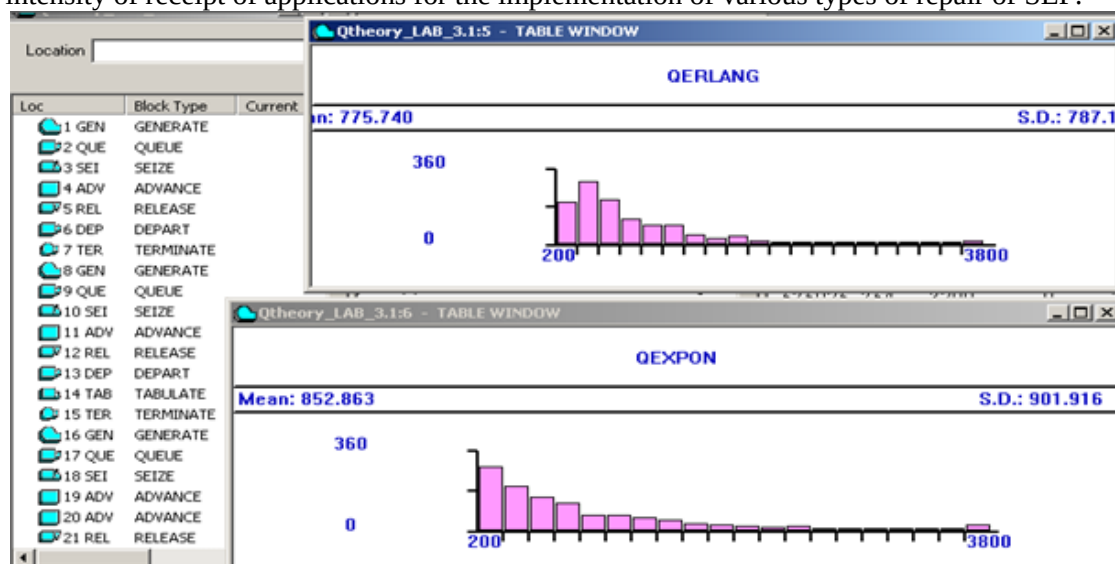


Figure 4. The structure of the program and the results of modeling the process of repairing the SEP.

4. Conclusion

Figure 4 shows the structure of the program and the simulation results of the process of repairing the ship engineering product. The icons that open each line of the simulation program make it easier to debug it, because they allow you to track the order of passing transaction in a step mode.

The graphic output of the simulation results in the form of histograms of the distribution functions of random variables allows you to track both the general trends of the studied processes and to quantify the mathematical expectations and standard deviations of the corresponding parameters. Thus, the use of functional and simulation technologies allows us to organize the processes of technical preparation and repair of ship engineering products in order to achieve the required deadlines for its implementation with high quality work results.

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