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THEORETICAL BASE OF MODELING THE PROJECT TEAM WITH A SERVICE TECHNICAL SYSTEMS BY SIMULATION

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ABSTRACT

The article proposes a system of simulation for the formation of crews of ships. The main directions of simulation modeling are described, which allow to optimize the volume of work of the team during the operation of the vessel. The model allows you to control: time of each event; the duration of each work; the amount of marriage detected in the work; the duration of the work that is performed repeatedly in connection with the detection of marriage; the total duration of the completion of the repair process of the technical system; the total amount of labor of the project team - the crew of the ship.

Keywords: Project Team, Ship Crews, Simulation System, Network Models, Methodology

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1. INTRODUCTION

The success of the project in modern conditions is primarily determined by the correct formation of the project team - a team of specialists united to achieve common goals and solutions, tasks assigned to them during the project life cycle. For aspects of the creation or selection of project teams are usually responsible (intermediaries) crewing companies, which perform the functions of forming crews for various vessels for shipping companies, cargo owners, other interested parties [1]. Existing methods for forming project teams are based on the use of network models for describing WBS structures. WBS provides the identification of the work required to achieve the objectives of the project. With this approach, the project is defined in terms of hierarchically interconnected result-oriented elements (work packages - work packages, grouped according to given bases / criteria). Each next level of decomposition provides consistent detailing of the project content, which allows for the assessment of completed work volumes, spent money and deadlines. At the lower levels, relatively smaller volumes of work correspond to work packages. This simplifies the evaluation of the percentage of completion and gives the opportunity to more clearly identify the actions needed to achieve the project objectives. The proposed approach to decomposition of works forms the necessary basis for determining measurable indicators (labor input, cost), and also allows us to say with a high degree of certainty that the goals associated with this package of work can and will be achieved. In this research proposes a method of determining the length and complexity of the project individual resources on the basis of simulation [2].

The aim is to build a model, the laboriousness of the work of technical systems, by the method of simulation, which would allow, taking into account the peculiarities of the specialists of the project team-crew, to repair technical devices, systems during the project life cycle.

2. MATERIALS AND METHODS

The unresolved problem remains the creation of a minimum safe crew for the ship, since the minimum crew and the amount of work on the vessel during its operation are not clearly quantified. Since each member of the team performs different functions on the vessel, the problem arises of the number of different specialists for performing certain tasks on the vessel, taking into account its marine characteristics, type of equipment, age, etc.

Network models of projects can be of two types: deterministic (when the nomenclature and the necessary sequence of work are known in advance) and stochastic (the need to perform certain works is probabilistic). In the first case, the development of a network model and calculation of network parameters does not present any difficulties. To solve these problems, critical path methods, PERT [3], as well as widespread information resources can be used: Microsoft Project, Primavera, Project Expert, Planer365. However, at the stage of forming a project team, especially if this project is complex and time-consuming, both the WBS structure itself and the duration of individual operations are probabilistic in nature.

3. RESULTS AND DISCUSSION

Before analyzing various types of models of project teams, we analyze the definitions and characteristics of the team - crew of the ship used in the literature:

- one or more small groups of people functioning as a whole, created to achieve a common goal, with a maximum level of cohesion, interaction, responsibility, identification of group members with it, the level of development of the group, the optimal distribution of mandatory and auxiliary functions [4];
- a group of people organized to jointly solve a common problem in such a way that each participant is responsible for the results of the work of the whole group" [5];

- a team is a small number of people who share goals, values and common approaches to the implementation of joint activities, have complementary skills, take responsibility for the final results, and are able to change the functional-role correlation [6].

Separately, it is necessary to note such an indispensable attribute of the team as the synergy of the interaction of its members, due to which, acting together, team members can achieve greater results than when acting alone.Thus, a contract of employment for the ship. When a sailor arrives on a vessel, the first thing he must do is sign a contract of employment. For example, in a seafarer's contract, an employee, firstly, agrees to go on a ship for one or more voyages; secondly, perform duties or work defined by his competence, position; and the employer, in turn, is obliged to pay for his work and provide maintenance (equipment, tools, allowances, living conditions, etc.), overtime hours (overtime) and working hours [7].

Duration of the contract of the seafarer. It all depends on the type, age of the vessel and position. For example: the duration of the contract of the senior assistant captain on the container ship is four months, and in tow - two. The contract of the seafarer on the bulk carrier is six months, and on the tanker it is four. But everything is purely individual. Seafarer insurance. The shipowner is forbidden to keep at the workplace of the seafarer more than it should be under the contract.

The project [2] has a number of characteristics inherent to it, having determined which it is possible to tell precisely whether the analyzed type of activity belongs to projects. So:

- “temporality” - any project has a clear timeframe, since the seafarer's labor contract is temporary, it has clear deadlines: “the seafarer’s arrival on the ship and assumption of his duties by the end of the contract by sending / change of a seafarer to the place of registration (this does not apply to its results)”;
- “unique products, services, results”, the seafarer's employment contractis unique from the very beginning, as the performance of work and residence, and everyday life of a sailor is provided on the vehicle - the ship. Despite the fact that the final result of the project must be unique, it has a number of characteristics common with process production, as performed by people in the project team - sailors by profession, who work on a shift basis in certain marine conditions (completing a cruise assignment);
- labor agreement (contract) is concluded by a seafarer to perform work on a ship for the provision of services (transportation of goods / passengers by the shipowner);
- limited by the availability of resources (salary and bonuses established by the seafarer under the contract, division of labor to increase productivity);
- the product of the seafarer's labor agreement (contract) is the voyages of the ship [8].

Also, based on this definition, a seafarer’s labor agreement (contract) for a ship’s voyage can be considered a project for the following reasons.

Firstly, any project is always aimed at achieving a specific goal, in our case, the ship’s flight is aimed at transporting goods, passengers safe and sound from the port of departure to the port of destination. The product of such a project is the provision of services for the safe and secure transportation of goods / passengers by crew of the vessel.

Secondly, the main part of the project is directed actions that must be carried out and coordinated by someone, in our case, the ship’s voyage is coordinated by the management of the shipping company (owner of the vessel, cargo) through the appointed person on the ship - the captain who performs the mission and controls the crew of the ship during the voyage.

Thirdly, the project is always limited in time (clear start and end dates for the project). The duration of a vessel voyages can be from 1 (one) day to several months, and in some cases even up to six months. It is worth noting that this period, the cycle may include a frequent number of transitions along the ship's voyage, additional loading or unloading of consignments, or vice versa, a long route from the port to the port. However, the mission of the project's life cycle is strictly limited; in our case, it depends on the fact of the complete replacement / change of the crew of the ship [9]. It should also be noted that the project life cycle has a time frame, i.e. the restriction expressed in the term of the agreement / contract concluded between the owner of the ship, the crewing and the seafarer (ship's crew) to perform the cruise assignment (from 4 to 6 months). However, it is believed that the optimal duration of a seafarer's contract is up to 4 months, after which degradation processes begin in the project team (ship's crew).

Fourthly, there are no identical projects, just like there are no identical ship's voyages, each cruise will have its own peculiarities and differences, in particular: grade, type of transported cargo, consignment / part of cargo, different weather conditions and navigation areas, delays, arrests, accidents , repairs, rotation of the crew (for another, shift), ship's crew at the port, "replacement of a crew of ship member earlier than the term of the agreement (death, illness, injury, family circumstances, etc., are understood as force majeure circumstances) [2].

Thus, the seafarers' labor agreement (contract) for the voyage, as well as any project unique. Therefore, each labor agreement (contract) for a ship's voyage can be considered as a separate project.

Therefore, such a network model is not suitable for solving such a problem. To create a model of a stochastic project, it is possible to use GERT-networks - a method of researching oriented graphs based on generating functions of moments [1]. Any such network has the following properties:

- the network consists of nodes that implement logical functions, and directed branches. Nodes correspond to events or project goals. The branches correspond to the work (operation) of the project and (or) the processes of transferring certain information. Logical functions are designed to simulate the relationships between work and events;
- in the GERT network, a source node is allocated that is used to describe the moment the work on the project begins and one or more drain nodes are used to describe the moments when the project was completed (project stage);
- the implementation of a stochastic network is understood as the implementation of a certain set of branches and nodes sufficient to achieve the project goal (implementation of a given specific set of sink nodes).

Project operations represented by branches are generally characterized by the following set of parameters:

- conditional probability of the operation (the probability of the operation subject to the implementation of the node that is outgoing to it);
- type of probability distribution of the duration of the operation and a set of parameters characterizing the type of distribution;
- account indicator;
- operation number.

The implementation of branches and nodes of a stochastic network is carried out during stochastic tests using the Monte Carlo method. To implement a deterministic branch coming from an implemented node or source, the main GERT procedure is used, which consists in obtaining a random distribution function of the duration of the operation provided by this branch. If the number of degrees of freedom of the node coincides with the number of branches incident to the node, the early moment of the implementation of the i-th network node can be calculated using the critical path method CPM [1] as the longest path preceding this node. In other cases, using the probability distribution of transitions from node to node in one way or another, in each run, we determine the network parameters. The most common error in simulation is the lack of attention paid to evaluating the output. Those, a lot of effort is spent on programming the model, then one run is performed and the resulting estimates are considered as “true”. The observational data obtained as a result of a certain run are not independent and equally distributed. Therefore, classical statistical analysis procedures cannot be applied to them.

The important features, characteristics and functioning results of many systems, both existing and being designed, have already been reproduced in digital form using a process called “digital imitation”. Modeling of the project implementation process is performed in Anylogic 7 environment [8]. Figure 1 shows a network diagram of the repair process of a technical system, consisting of three collapsible nodes. Each node includes three, two and one collapsible part, respectively. Each node of the graph corresponds to a specific event of the repair process of the technical system of the vessel: 1 – the beginning of repair of the vessel mechanism№1; 2 – mechanism №1 dismantled; 3 – mechanism №1 delivered to the place of repair; 4 – removed node №1.1; 5 – node troubleshooting №1.1; 6 – the detail № 1.1.1 of node № 1.1 removed; 7 – troubleshooting the detail №1.1.1; 8 – operability of the detail №1.1.1 restored; 9 – checked the detail №1.1.1; 10 – the detail № 1.1.2 of node № 1.1 removed; 11 –troubleshooting the detail №1.1.2; 12 – operability of the detail №1.1.2 restored; 13 – checked the detail №1.1.2; 14 – the detail № 1.1.3 of node № 1.1 removed; 16 – troubleshooting the detail №1.1.3; 16 – operability of the detail №1.1.3 restored; 17 – checked the detail №1.1.3; 18 – the detail №1.1.3 installed in node №1.1; 19 – detail №1.1.2 ready to install in node №1.1; 20 – the detail №1.1.2 installed in node №1.1; 21 – detail №1.1.1 ready to install in node №1.1; 22 – the detail №1.1.1 installed in node №1.1; 23 – node №1.1 assembled; 24 – control node №1.1 produced; 25 – node №1.2 is healed; 26 – troubleshooting the node №1.2; 27 – the detail № 1.2.1 of node № 1.2 removed; 28 – troubleshooting the detail №1.2.1; 29 – operability of the detail №1.2.1 restored; 30 – checked the detail №1.2.1; 31 – the detail № 1.2.2 of node № 1.2 removed; 32 – troubleshooting the detail №1.2.2; 33 – operability of the detail №1.2.2 restored; 34 – checked the detail №1.2.2; 35 – the detail №1.2.2 installed in node №1.2; 36 – detail №1.2.1 ready to install in node №1.2; 37 – the detail №1.2.1 installed in node №1.2; 38 – node №1.2 assembled; 39 – control node №1.2 produced; 40 – node №1.3 is ready for remove; 41 – node №1.3 is healed; 42 – troubleshooting the node №1.3; 43 – the detail № 1.3.1 of node № 1.3 removed; 44 – troubleshooting the detail №1.3.1; 45 – operability of the detail №1.3.1 restored; 46 – checked the detail №1.3.1; 47 – the detail №1.3.1 installed in node №1.3; 48 – node №1.3 assembled; 49 – control node №1.3 produced; 50 – node №1.3 installed; 51 – node №1.1 ready to install; 52 – node №1.1 installed; 53 – node №1.2 ready to install; 54 – node №1.2 installed; 55 – mechanism №1 assembled; 56 – mechanism №1 delivered to the installation site; 57 – mechanism №1 mounted; 58 – tested mechanism №1; 59 – repair of vessel mechanism № 1 is completed.

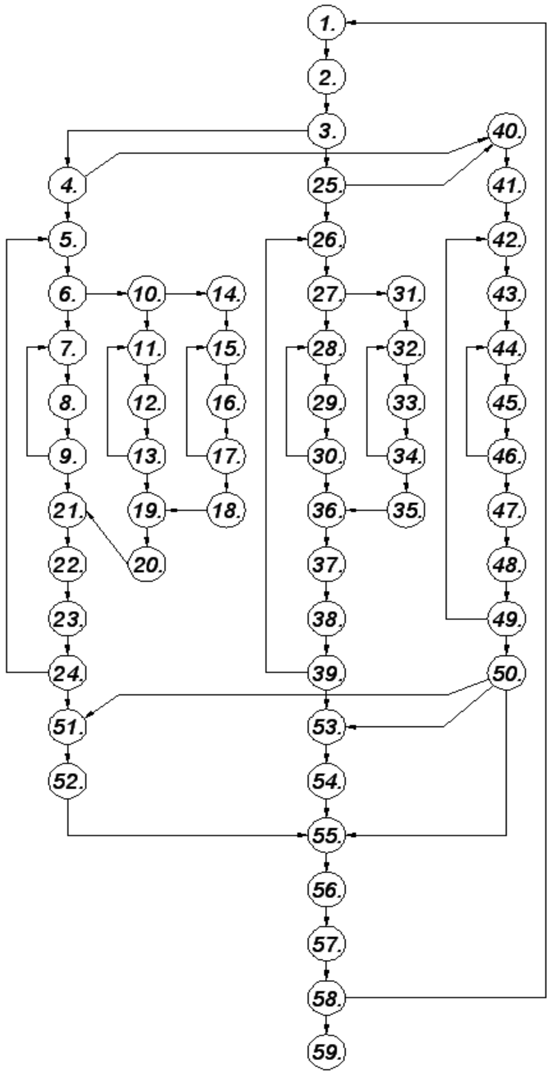

Figure 1 Network diagram of the repair process of the technical system of the vessel

Each connection between the nodes of the graph corresponds to the work necessary to accomplish the listed events. There is a certain likelihood of a return to previous events and activities after monitoring the operability of a part, assembly or mechanism, which is associated with the possibility of marriage occurring in the restoration of parts, assembly and installation of assemblies, and installation of a ship's mechanism.

In addition, the duration of each work schedule can vary by random values. All this reduces the quality of network analysis using standard methods for determining the early and late dates of events and calculating time reserves. The analysis of the graph by the averaged parameters of the duration of the work does not make it possible to assess the spread of values and possible probabilistic changes in the critical path of the process [9].

It is proposed to solve this problem by the method of simulation of this process, which allows you to obtain the necessary statistical data for analysis in the course of computer experiments. For computer experiments, a simulation model is built that takes into account:

- The laws of the distribution of the duration of each work process.
- The ability to restore the health of each part in three ways: by replacing a spare part, manufacturing a new part; elimination of the corresponding defect. The application of each method is characterized by a certain probability.

- The laws of the distribution of the probability of the return of the defective part / assembly / mechanism of the vessel to restoration work after performance monitoring.
- The constructed model allows you to control: the time of completion of each event; the duration of each work; the amount of marriage detected in the work; the duration of the work that is performed repeatedly in connection with the detection of marriage; the total duration of the completion of the repair process of the technical system; the total amount of labor, taking into account some work in parallel with the use of independent resources [10].
- The statistics obtained in the course of a series of experiments on the model make it possible to construct histograms of the distribution of the following quantities: early and late dates of completion of events, the duration of the process, and the loading of labor resources. Such information, in turn, makes it possible to assess, within the framework of a certain confidence interval, the existing time reserves and the risks of disruption of the scheduled time for completion of work by the crew of ship.
- Let us present some results obtained using the simulation model as a result of 1000 runs. Figure 2 shows a histogram of the distribution of time for completion of repair of a technical system. The area under the curve determines the probability of completion of the project by a given point in time. Thus, the proposed method allows you to determine the likelihood of a project being completed by the planned date, or to calculate the project completion date, which can be achieved with a given probability.

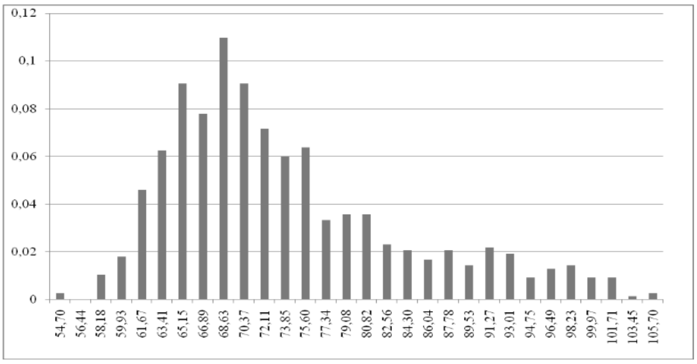

Figure 2 A histogram of the distribution of time for completion of repair of a technical system

Figure 3 shows the distribution of the amount of labor. By building similar dependencies for each project resource, you can plan the optimal composition of the project team taking into account the technical competencies of each participant. The use of a variety of equipment, the increase or decrease in the time to complete tasks, and the use of different numbers of crews of ship for a particular specialty can also be planned and modeled.

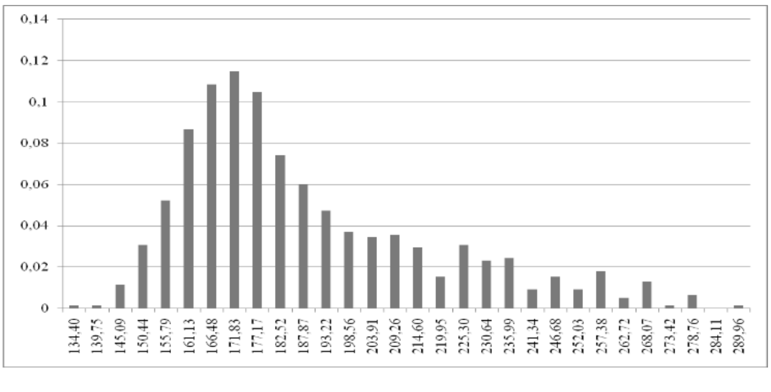

Figure 3 A histogram of the distribution of labor costs for the repair of a technical system, taking into account returns and parallel work

In the daily part diagnostics mode, the user is provided with information on the number of breakdowns and the most probable nodes and parts that could have malfunctioned based on the processing of all previous diagnostic results [11].

By choosing one of the nodes, the values of additional diagnostic parameters are entered, evaluating the state of this node, and determining the causes of the malfunction, determines the optimal technological process of repairing the vessel.

To predict the “aging” process of maintainable technical systems, it is possible to use the method of small deviations [12].

3.1. The essence of the method is as follows

Let the functional dependence of the parameter value of the functional state of the ship’s power plant on the diagnostic parameters characterizing the current technical condition of the plant be known:

$$FS = f(Dn) = \overset{r}{f}(D_1; D_2; \dots D_n) \tag{1}$$

With a small change in the arguments, the increment of the function is determined by expanding it into a Taylor series, by the formula:

$$\Delta FS = \frac{\partial FS}{\partial D_1}\Delta D_1 + \frac{\partial FS}{\partial D_2}\Delta D_2 + \dots \frac{\partial FS}{\partial D_n}\Delta D_n + R(y), \tag{2}$$

where $\frac{\partial FS}{\partial D_1}$; $\frac{\partial FS}{\partial D_2}$; $\frac{\partial FS}{\partial D_n}$ – partial derivatives; ΔD_1; ΔD_2; ΔD_n – final increments of diagnostic parameter values D_1;D_2; …;D_n; R(y) – residual term characterizing the accuracy of calculations when discarding subsequent members of the Taylor series.

Representing this expression in relative increments - variations, and discarding the remainder term, it is easy to obtain:

$$\frac{FS}{FS^0} = \frac{\partial FS}{\partial D_1}\frac{D_1^0}{FS^0}\frac{\Delta D_1}{D_1^0} + \frac{\partial FS}{\partial D_2}\frac{D_2^0}{FS^0}\frac{\Delta D_2}{D_2^0} + \dots + \frac{\partial FS}{\partial D_n}\frac{D_n^0}{FS_0}\frac{\Delta D_n}{D_n^0}. \tag{3}$$

In the presented expression, the index “0” indicates the initial values of the arguments, that is, the values D_1^0; D_2^0; … D_n^0 should be taken equal to the passport values of the diagnostic parameters in the respective operating modes of the ship power plant, and FS_0 =1.

Denoting the relative increments of the diagnostic parameters and the parameter of the functional state of the vessel through δFS; δD_1; δD_2; …; δD_n, we obtain:

$$\delta FS = \beta_{D1}\delta D_1 + \beta_{D2}\,\delta D_2 + \dots + \beta_{Dn}\,\delta D_n, \tag{4}$$

where $\beta_{D1} = \frac{\partial FS}{\partial D_1}D_1^0$; $\beta_{D2} = \frac{\partial FS}{\partial D_2}D_2^0$;… $\beta_{Dn} = \frac{\partial FS}{\partial D_n}D_n^0$ – pair correlation coefficients between the values of the FS parameter and the FS value is diagnosed if the value of this diagnostic parameter changes by 1%. The error of the method depends on the accuracy [13; 14].

Thus, the following parameters are the result of modeling an expert system for assessing and predicting the condition of ship equipment:

- the timing of the diagnostic work;
- the expected time points at which certain failures will take place;

- optimal repair processes;
- an institution, a crew member responsible for the condition of this type of equipment.

3.2. Data on the task

The whole range of work that must be performed by the crew during the flight is possible on the following groups:

- operations performed with known periodicity (for example, daily);
- operations, the need for which is random (repair work, force majeure situations).

For each elementary operation *i*, when the crew is allocated on day *r*, the following initial data are required;

- the average time t and r required to complete the operation;
- the priority of the operation (set on a 100-point scale: if the priority is less than 50, then the work may be delayed the next day so as not to resort to overtime work or in the case of a low index of morale of performers);
- focus of the operation: benefit for the individual, crew or mission;
- technological sequence - numbers of previous elementary operations;
- a list of necessary resources (equipment and contractors);
- information about the need for alteration of the operation in case of unsatisfactory quality of its implementation [15].

3.3. Personnel data

The third set of data prepared for computer simulation contains information about the personnel who should be included in the crew of the closed system. Personnel are classified by type L. Each type of staff includes everyone who is familiar with the same specialty [16, 17].

The model provides that each *i*-th crew of ship member must have a major specialty corresponding to his main type number. Along with this, since each crew of ship member could be trained to perform various types of work, the model provides for the possibility for each crew of ship member to have one or two additional, different from the main specialty [18]. Therefore, among other required personnel data, the following should be indicated:

- the probability that the average crew of ship member has one and only one additional specialty, Ra = 1;
- the probability that the average crew of ship member has two (but no more) additional specialties, Ra = 2,
- the number of types of staff for the ordinary performers, Te;
- the number of types of personnel for the command (management) staff, T0;

The types of specialties to which an individual is trained in addition to the main one are called the “first additional” and “second additional” specialties [19].

Each element of the matrix (the maximum rank of which is 3) represents the probability that the performer of one type has sufficient training to perform the functions of performers of another type or specialty. It should be expected that many elements of the matrix will be equal to “0”, and this reflects the fact that the performers of one profile do not have the training to work in other specialties [20]. Such data is usually obtained from personnel information, or it can be estimated based on prior experience.

3.4. Parameters and constants

The model uses the following six parameters:

- Crew growth Δ - the number of people who should be added to the crew after each series of N simulations.
- The threshold morale index M is a value between zero and one. When the morale index is less than M, certain prescribed elementary operations (carry-over code 3) are delayed, and the execution time of other operations increases. Values of this parameter taken within the limits of 0, 3 to 0, 8 usually give reasonable results. The choice of the exact value to be used is made on the basis of common sense and depends on the concepts of the system and the personnel subsystem considered by the analyst [16].
- The nominal duration of the working day W (in tenths of an hour). If more than W hours are required to complete a given day's work, the surplus is considered overtime.
- The probability P of occurrence of a critical situation on average within one day. Critical situations cause the appearance of tension, which, by assumption, persists during the performance of one elementary operation [17].
- The initial pseudo-random number R0; used as necessary to generate a sequence of pseudo random numbers.
- The number of operations N that must be performed with a given number of crew.

As input data of the model, it is also necessary to specify a set of constants, depending on the problem being solved. Their values do not change during one simulation run. However, since these constants contain information about the staff, medical and psychological, social, information, it may be desirable to change their values as new and more reliable information is received. For this reason, the constants are selected so that they can be changed as easily as the model parameters [21].

The first series of constants sets information about the professional competency of the middle crew of ship members at the beginning of the assignment. In order to establish additional specialties of each crew of ship member during calculations taking into account simulated reality, a probability table is necessary and has additional specialties. The adopted symbols and approximate values are shown in Table 1.

Table 1 Indicators of professional qualification and capacity of the crew of ship

№	Professional crew of ship efficiency	Main specialty of seafarers	Both additional specialties of seafarers
1	Average qualification	$K_1^1 = 0.8$	$K_5^1 = 0.6$
2	Average quadratic qualification deviation	$K_2^1 = 0.1$	$K_6^1 = 0.1$
3	Minimum qualification	$K_3^1 = 0.6$	$K_7^1 = 0.2$
4	Maximum qualification	$K_4^1 = 1.0$	$K_8^1 = 1.0$

These constants are the parameters of the normal distribution, which is used later in determining the level of qualification with which each crew of ship member proceeds with the assignment. The constant values for this series can usually be obtained from the personnel reports. The integral (accumulated) probability distributions of various salary rates and various specialties among crew ofship members are specified in the second series of constants. These probabilities are used in determining the technical specialty and the wage rate at which each crew of ship member begins the project assignment [18].

The third series of constants are three weighting factors of the initial orientation of the crew of ship members. These constants represent the average values, according to which the direction of the crew of ship at the beginning of each simulation of the task is determined by the Monte Carlo method (in total, they must give unity) [20].

For example:

Personal orientation $K_1^3 = 0.2$

Collective orientation $K_2^3 = 0.4$

Business orientation $K_3^3 = 0.4$

The value of K_1 is usually chosen below other values, since it can be assumed that most crew members focus more on ships crew and focus more on crew and task than on themselves.

The fourth series consists of five constants representing the coefficients in the equation for evaluating the overall efficiency of performing an elementary operation:

Full efficiency constant $K_1^4 = 1.0$

Psychological Efficiency Constant $K_2^4 = 0.3$

Communications Performance Constant $K_3^4 = 0.2$

Professional Efficiency Constant $K_4^4 = 0.3$

Environment friendly constant $K_5^4 = 0.2$

The three constants of the fifth series are used to determine the incidence of diseases in the crew of ship at the end of each day and to encourage its members. The corresponding values are obtained from the personnel reports and medical records:

K_1^5 - probability of crew reward any given day;

K_2^5 - probability of crew disease on any given day;

K_3^5 - the average duration of each disease (in days).

The next series of three constants is formed by the coefficients used in the numerical analysis of the efficiency equation at the end of each day to obtain a series of smoothed crew of ship efficiency values [13].

The last constant characterizes the expected level of efficiency that needs to be achieved so that an elementary operation can be considered successful completed. The value of the constant is taken equal to 0.95; this indicates that an elementary operation is considered to be successfully completed if the quality of its execution corresponds to a level no worse than 95% of the required. Each run ends with the release of new data for printing, which the system analyst can use to compare alternative systems, select the composition and number of the project team, and also to compare job options in order to optimize the planned activity taking into account the restrictions imposed by the doctrine, finances, and technical capabilities [18].

4. CONCLUSION

The proposed method for determining the duration and complexity of the project by means of simulation allows to increase the reliability of the forecast of the deadlines and to form the optimal project team. This method is especially effective when used in projects whose nomenclature is not predetermined, for example, in repair projects of complex technical systems. In addition, the use of the method allows you to calculate the required ship's crew, taking into account the actual technical condition of its mechanisms, devices and systems. A model for simulating the behavior of the "operator-ship" system has been developed with the goal of quantitatively optimizing the crew of the ship depending on the characteristics of the ship (type, age, technical condition), the cargo transported, and the planned voyage. The model provides for the ability of seafarers to own several professions and allows them to be used in extreme situations not in their main specialty, which affects the efficiency and quality of the functions and work performed on the ship.

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