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# METHODOLOGICAL APPROACH TO MODELING THE SUPPLY OF PARTS FOR COMPLEX TECHNICAL SYSTEMS

***B.S.Otaxanov***
*Namangan Engineering Construction Institute, Namangan, Republic of Uzbekistan*

***H.N.Yodgorova***
*Master student, Namangan Engineering Construction Institute Namangan, Republic of Uzbekistan*

***Annotation**. The article discusses a methodological approach to building a model of a multi-level system for providing spare parts for complex technical systems. The model is intended to substantiate the quantitative and nomenclature composition of sets of spare parts, property and accessories in the context of implementing the requirements for the promptness of restoring the operability of equipment samples as part of the system. The key idea is to submit a simulated flow of applications to the input and study the response of the system of spare parts, property and accessories to them by simulating the time of satisfaction of applications from sets of spare parts, property and accessories of various levels with a sequential increase in their nomenclature and quantitative composition. At the same time, the simulated flow of requests may differ from the simplest one, which makes it possible to reasonably distribute requests for spare parts between sets of spare parts, property and accessories of various levels of content.*

***Key words:** provision of spare parts, spare parts system, simulation model, complex technical system*

Experience in the use of complex technical systems (MTTIT) has shown that the recovery time after failure depends significantly on the availability of spare parts. The absence or scarcity of spare parts leads to a significant increase in recovery time due to the waiting time for spare parts from various sources.

Currently, the cost of spare parts is equal to the cost of complex technical systems (MTT). The composition of the spare parts is associated with high economic costs. In this case, increasing the list and size of spare parts will increase the cost of the spare parts supply system (SEQTT), but there will be no reduction in downtime, or in other words, the costs incurred will not justify the gain.

Analysis of the composition and consumption of spare parts in MTT shows that stocks of certain types of spare parts exceed the required level and are stored in warehouses at a time when other elements are in short supply.

Thus, the introduction of a scientifically based calculation methodology of the composition and list of spare parts into practice and their optimal placement in accordance with the requirements of the degree of recovery of MTTs can achieve great economic efficiency.

Existing optimization methods for optimizing the set of parts required for operation do not provide an optimal solution. There are errors in these existing analytical calculation methods. In particular, when the optimal reserve is calculated according to the methodology defined by GOST RV 27.3.03-2005, the adequacy ratio of spare parts is made taking into account the flow of applications for spare parts. In this case, the flow of applications is explained by the law of


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exponential distribution. However, the laws of distribution of violations of some technical samples (mechanical, electromechanical units and blocks, computing devices, reserve elements, etc.) are not taken into account. Because their distribution is different from the exponential distribution.

In this case, it is better to use the method of simulation modeling processes in the form of "MTT-SEQTT".

In simulation modeling, it is possible to create information about the logical structure of the system under study, the sequence of time transitions of processes during operation, the composition and nature of the state of the system [1]. In this case, it is possible to obtain statistical data whose simulation modeling differs significantly from the real situation, but which is sufficient for statistical processing. This is very important in assessing the need for high-reliability or high-responsibility and resource-intensive MTT elements in an EHTT package. Many articles have been published on this subject [2,3], including the system of regional distribution for complex systems [4,6]. The proposed approach is to concretize and develop these studies in relation to the creation of a multi-level ECT for MTT.

Let's look at the initial condition. MTT should be a set of different types of equipment, each of which should be a set of EHTT-YA (individually). These samples are distributed across a single area and interact to perform a single task. EHTT-G (group) is available for all MTT samples, which are closed with EHTT-YA. Replenishment of EHTT-YA kits is possible only from EHTT-G (group) kits. The EHTT-G (group) kit is filled from an inexhaustible source.

The MTT-SEQTT model represents a combination of MTT samples, EHTT-YA, EHTT-G, and inexhaustible resources. In this case, the model of the technical model is realized in the form of the sum of the random breakdown generator, which mimics the operation of devices and elements. The distribution function F (t) for each element according to the time, appearance, and parameters of the failure is formed based on the actual operation data. In this case, the random occurrence generators of the faults reflect the source of the applications given to the parts in relation to the SEQTT.

Each model of the EHTT kit and the endless source can be thought of as the following unit of devices:

- Application counter with the function of recording violations of a specific element of the list;
- application processing block with the function of forming the stop time of application processing and simulating the administrative time of application processing;
- server for the provision of spare parts and reception from the high SEQTT set to restore the performance of the technical sample;
- Parts delivery time generator, which is activated when there is a spare part on the server;
- Delivery control block representing the communication device for sending the considered application to the lower SEQTT or registrar;
- a block that registers the filling of spare parts, which allows you to set the time of filling with spare parts and put the spare server in the filling mode;
- Transfer of secondary applications to a higher set, a generator that is activated when there are no spare parts on the server and the application to the application counter.

$S_{EQTT}$ The possibility of building a kit model is given in [7] and is implemented in the Simulink modeling environment of the MATLAB mathematical package [8]. In addition, a common element of the SEQTT model is the recorder, which determines the time of receipt of the signal received by the spare part and the signal of the generator to deliver the spare part.



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Taking into account the above, we construct the structure of the SEQTT simulation model (Figure 1).

Basic information for model operation: *Ji* - MTT contained in *i* – an example of a type of technique i $\in$ *1, I;* $N_{\varphi I}$ - *i* – the number of elements of the nomenclature used in the sample of the type technique, $\varphi \in 1$, F; F(t) – $\varphi$ – view of the law of distribution of breakdown time in the nomenclature and its parameters, which allows us to estimate the average operating time before the breakdown; $T_{t\varphi}^{cheg}$ -$\varphi$ – the maximum allowable time of breakdown until the restoration of the nomenclature elements; $T_{et}$ – average time to stop before the application is completed; $1^{YAG}$- $\varphi$ – the number of parts in the nomenclature EHTT-YA.

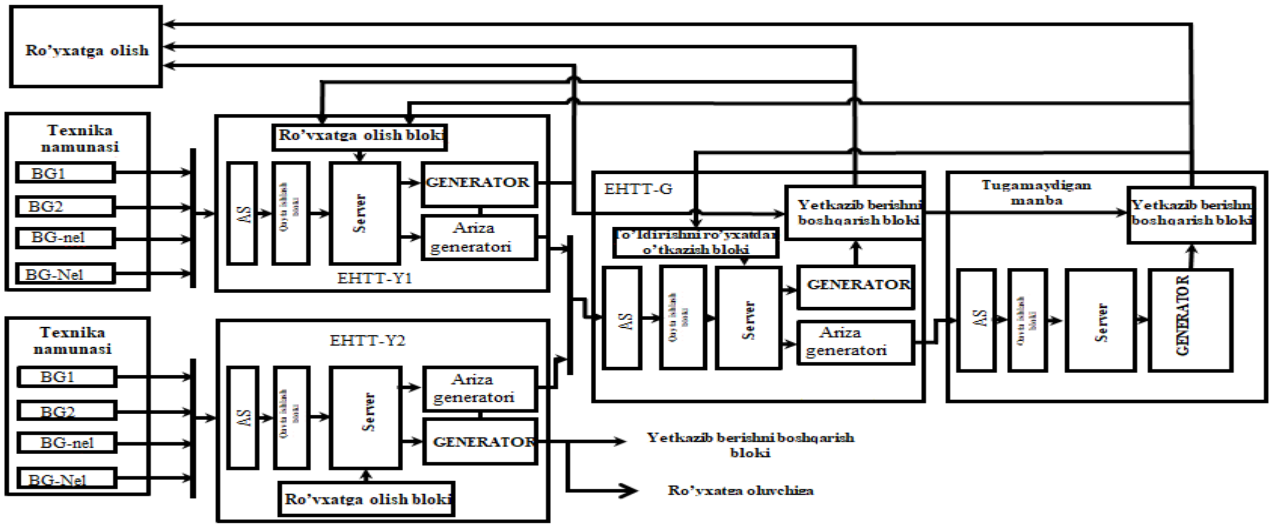


Figure 1. Modeling of spare parts supply system.

BG-Decoration Generator, AS-Application Counter, EHTT-Parts Supply System

The first step is to choose a strategy for completing the SEQTT kits. The following strategies for completing SEQTT kits will be explored: $\gamma$ =1 – periodic replenishment, $\gamma$ =2 – urgent replenishment.

In the second stage, for each nomenclature $S_{EQTT}$ the initial values of the spare parts on the parts server $L_{\varphi bosh}^{ya(g)}$ determined. Inexhaustible spare parts on the server $L_{\varphi}^{tug} = \infty$ we get

In the third stage, each element of the technical sample is generated by the time of possible distortions that correspond to one of the distribution laws. As a result, an array of F (t) distortions of each technique sample is formed over time.

In the fourth stage $S_{EQTT}$ The SEQTT model of the selected completion strategy is implemented.

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