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NORMATIVE PLANNING PROCESSES OF CONSUMPTION AND REPLENISHMENT RESOURCES OF GROUPING WITH DELIVERY NEW OBJECTS

The article describes the features and results of normative planning processes of spending and replenishing the grouping resource with the supply of new objects.

The troops have an important task of timely planning for the repair of weapons and military equipment and supplies to the grouping of new objects. It is shown that the solution to this problem is possible only through the use of a mathematical model process of spending and replenishing the technical resource of grouping objects. Using it, you can predict the composition and resource of the group and calculate the optimal plans for maintaining the combat readiness of the group.

The launch of the presented algorithm involves the use of a previously developed enlarged structural diagram of a modeling algorithm. The number of implementations of the modeling process and a certain coefficient that sets the range of the limit on the consumption of the resource of objects in percent are set. The block diagram of the modeling algorithm in the standard planning mode plus the supply of new facilities is presented. It is essentially an extension of the previous algorithm. The initial information, as before, is GR and TipO data structures. The required (minimum acceptable) number of objects in the grouping is added to them. The results are shown for two calculation options: for a single case simulation implementation and for 100 implementations. This allows us to compare the obtained data and qualitatively assess nature of the effect on the type of graphs numbers of simulation implementations.

The block diagram of the algorithm for modeling the process of spending and replenishing a resource in the User Planning mode without supplying new objects is presented.

The form for displaying simulation results (graphs) in the User Planning mode is no different from the form for presenting the results obtained in the Normative Planning modes. Showing examples of the presentation of these results.

Key words: expenditure and replenishment of the resource, repair planning, weapons and military equipment, mathematical model, technical resource, grouping.

Introduction and statement of the problem. The organizations responsible for the operation of groupings have an important task of timely planning for the repair of weapons and military equipment (WME) and the delivery of new objects to the group. Obviously, the solution of such a problem is possible only on the basis of applying a mathematical model of the process of expenditure and replenishment of resource (PERR) of grouping objects, with which you can predict the composition and resource of the group, and taking into account the forecast obtained, find (calculate) optimal plans for replenishing its resource.

The work [1] shows the results of studies of various groups from the point of view of elucidating the patterns of the occurrence of PERR in them. To do this, using the model, various types of groupings can be generated with the given characteristics, and also the optimal plans for replenishing the resource for a specific group of military equipment (user groups) are calculated, these plans are stored in a database, and then refine calculations are made taking into account current changes in grouping. It is assumed that by the time this algorithm is launched, all the necessary data structures have already been created in the random access memory of the personal computer, the user has already selected an implementation option for the grouping for which the simulation is performed. Also, the number of implementations of the modeling process and the coefficient specifying the range of variation of the limit on the expenditure of the resource of objects (in percent) are given. In each iteration, the process of PERR of objects of the i-th type is simulated at a given forecast interval.

The objective of this article is to formulate an PERR simulation algorithm for the supply of new weapons and military equipment in a group.

Analysis of recent research. The real situation in Ukraine in the field optimizations of maintenance and repair (MR) of military and technical equipment shows that developments are carried out only in some areas [2-6] and practically do not concern groups. So, in [2], new technologies for determining the reliability of objects are proposed. In [3], the optimal system of scheduled repairs for individual objects was proposed. In [6], maintenance was offered "as-is" with an adaptive change in the frequency of control.

In [5,6], the results of a study to determine the supply of spare parts, tools and devices (spare parts) are presented. In [7,8], the authors have already begun research on the grouping of objects to optimize the number of repair bodies and evaluate the effectiveness of maintenance of military equipment. In [9], the basic initial actions were studied to construct an enlarged structural diagram of an algorithm for modeling the processes of spending and replenishing the resource of a group of military objects in normative planning mode.

The main results of the study. In [9], the authors proposed an enlarged structure of the modeling algorithm scheme. It is assumed that by the time this algorithm is launched, all the necessary data structures have already been created in the random access memory of the personal computer (PC), the user has already selected the implementation of the GR grouping for which simulation is performed. Also, the number of implementations of the modeling process N_I and the coefficient KV_{Lim} specifying the range of variation of the limit on the expenditure of the resource of objects (in percent) are given. In each iteration, the process of PERR of objects of the i-th type is simulated at a given forecast interval $T_{\text{п}}$ [10].

The block diagram of the modeling algorithm in the **Normative planning + delivery of new objects** mode is shown in Fig. 1. This algorithm, in fact, is an extension of the algorithm considered in [8]. The initial information, as before, is the GR and TipO data structures. The required (minimum acceptable) number of objects in the grouping `TipO`.$N_{\Sigma}^{\text{тр}}$ is added to them. Let us briefly consider the operation of this algorithm.

Operators 1, 11 and 12 form an external cycle in which sequential enumeration of the values of model time t within a given interval of operation time of the group is performed. Operator 2 generates the current value of the model time t. For each value of t, statements 3–10 are executed that determine the state of the process at the current time. Operator 3 sets the initial (zero) values of the variables R_{Σ}, N_{Σ}, $N_{\text{кр}\Sigma}$ and $N_{\text{нов}\Sigma}$, in which the information is generated, which is then used to plot the functions $\overline{R}_{\Sigma i}(t)$, $\overline{N}_{\Sigma i}(t)$, $\overline{N}_{\text{р}\Sigma i}(t)$ and $\overline{N}_{\text{н}\Sigma i}(t)$ at point t.

Operator 4 denotes a group of operators that form the values of variables R_{Σ}, N_{Σ}, $N_{\text{кр}\Sigma}$. These operators are completely analogous to the operators 3-17 of the structural diagram of the algorithm depicted in Fig. 2.5. They have been described in detail above, so here we will not consider them again.

Operator 5 removes from the set of grouping objects (represented by the list `GR.ListO`) all objects that have been decommissioned at a given point in time. Operator 6 checks the condition whether the remaining `TipO`.$N_{\Sigma}^{\text{тр}}$ number of objects N_{Σ} (condition $N_{\Sigma} < N_{\Sigma}^{\text{тр}}$) has dropped below the permissible value of the number of objects in the grouping. If "yes", then the operators 7–9 are executed, with the help of which the addition required number of new objects to the grouping is simulated.

Operator 7 creates a new program object O, representing in the PC OS a new technical object of the type `TipO.Name` added to the group at time t. Operator 8 adds O to the list `GR.ListO`.

Operator 9 increases the values of and by 1 $N_{\text{нов}\Sigma}$ and N_{Σ}. After that, control is returned to operator 6. The actions of operators 6–9 are repeated until the condition $N_{\Sigma} = N_{\Sigma}^{\text{тр}}$ is satisfied.

If condition $N_{\Sigma} \geq N_{\Sigma}^{\text{тр}}$ is satisfied when operator 6 is executed, then control is transferred to operator 10, which adds $\overline{R}_{\Sigma i}(t)$, $\overline{N}_{\Sigma i}(t)$, $\overline{N}_{\text{р}\Sigma i}(t)$ and $\overline{N}_{\text{н}\Sigma i}(t)$ on the graphs, a new point corresponding to the current value of the model time t.

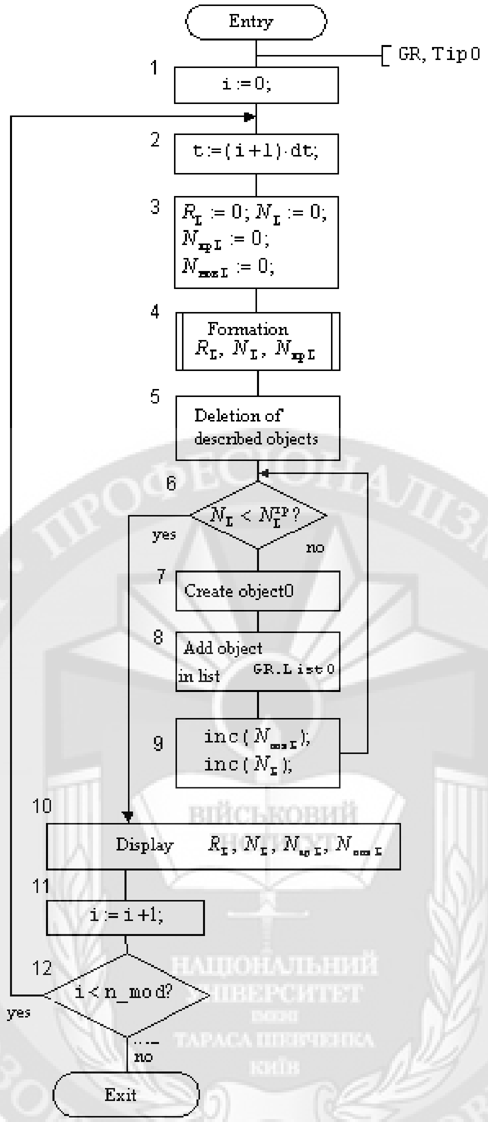
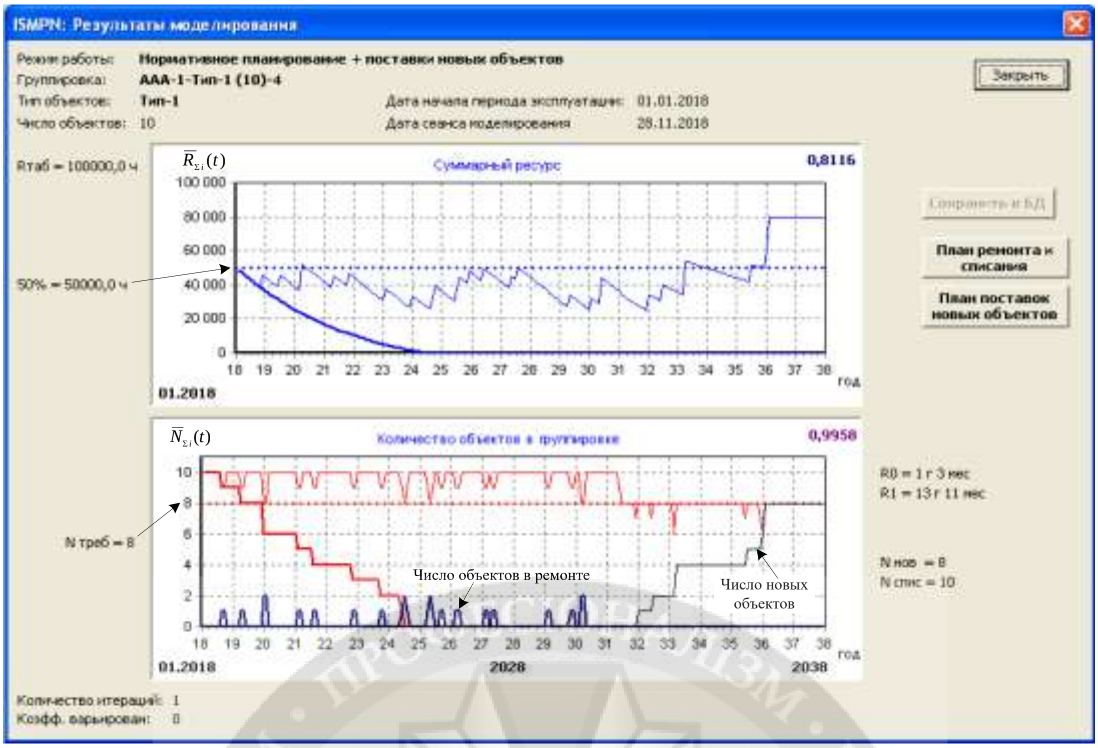


Figure 1 – Modeling algorithm in normative planning mode with the supply of new facilities

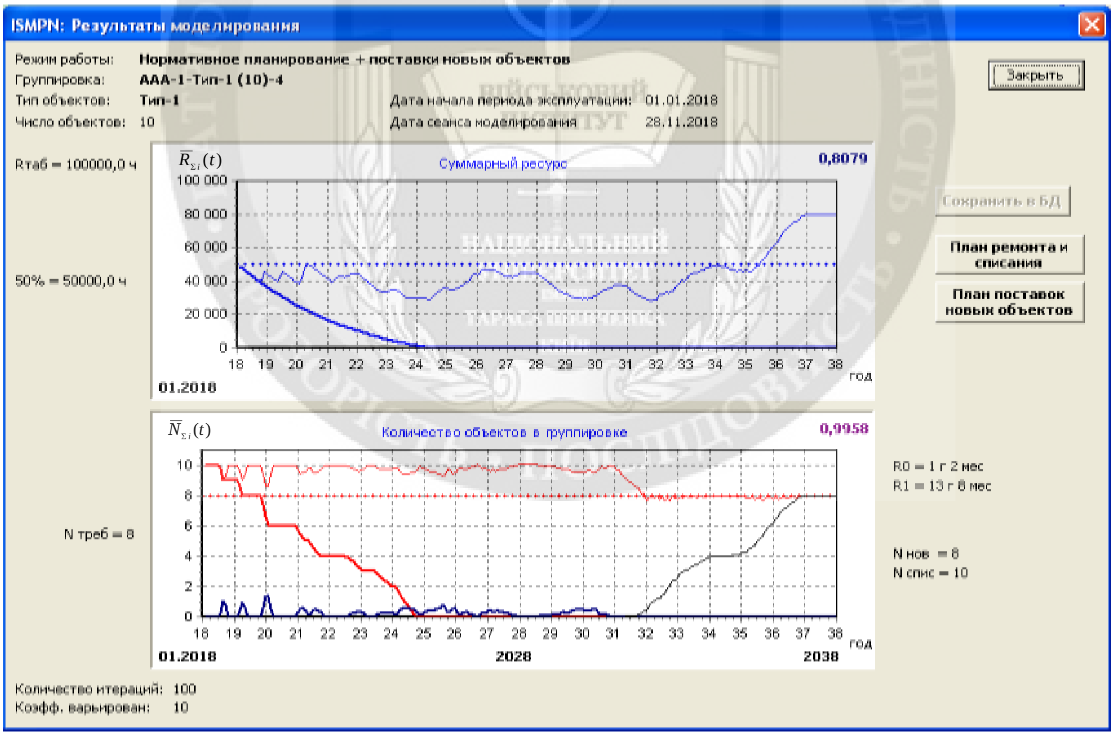
The operator 11 counts the number of points of the discrete model time t for which points on the graphs are already plotted. If their number has not yet reached the set value `n_max`, operator 12 will transfer control to operator 2 and the described graphing process continues as described above. After the completion of the algorithm, graphics will be generated. The graphs will be displayed on the PC screen, as shown in Fig. 2. Functions $\overline{R}_{\Sigma i}(t)$, $\overline{N}_{\Sigma i}(t)$ and $\overline{N}_{\text{р}\Sigma i}(t)$ at the same time, they are formed and displayed taking into account the fact that new objects were received by the grouping within the terms corresponding to the normative supply plan $\Pi_{\text{нов}i}^{\text{н}}$.

As before, in fig. Figure 3 shows the results for two calculation options - for case 1 of the simulation implementation (a) and for 100 implementations (b). This allows us to compare the obtained data and qualitatively assess the nature of the effect on the type of graphs of the number of simulation implementations.

When you click the **Plan for the supply of new objects** (Fig. 2), a form will open (Fig. 3), which displays the optimal (normative) delivery times to the grouping of new objects.



a) one implementation ($N_I = 1, KV_{\text{Lim}} = 0$)



b) 100 implementations ($N_I = 100, KV_{\text{Lim}} = 10\%$)

Figure 2 – Simulation results (**Normative planning mode + delivery of new objects**)

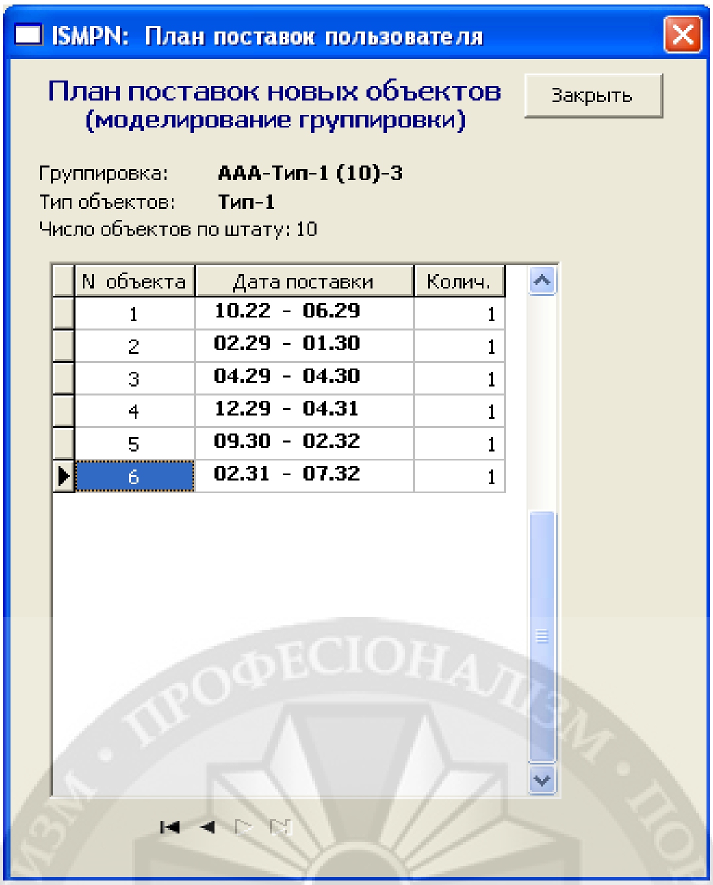


Figure 3 – The form for displaying the supply plan of new objects in a grouping

In user planning modes, initial information for modeling is presented in the same objects G and GR, but created for user grouping. In addition to these objects, additional lists List_KR and List_SP are created that contain information about the user scheduled repair and decommissioning of grouping objects. The elements of these lists are pairs $\langle i, D_i \rangle$ in which i is the identifier (index) of the technical object D_i, and is the date planned by the user, respectively, of sending the i-th object for repair or decommissioning. The lists List_KR и List_SP are generated anew each time when modeling is performed in the **User scheduling modes** (Reg_p> 1).

The block diagram of the algorithm for modeling the PERR in the **User Planning mode** (without deliveries of new objects) is shown in Fig. 4. Consider briefly the operation of this algorithm.

Operators 1, 23 and 24 form a cycle (index i), in which sequential enumeration of moments of model time t is carried out. Operator 2 generates the current value of the model time t.

Operator 3 initializes (sets to zero) the values of the variables, R_Σ, N_Σ and $N_{кр\Sigma}$ in which the values are formed, respectively, of the total resource of the grouping objects, the number of objects in the grouping and the number of objects being repaired at time t,

Operators 4, 20, and 21 form an inner loop (index j), in which all technical objects of the current grouping G are enumerated (by enumerating the elements of the list GR.List_O). Operator 5 selects the next element O (representing a technical object that is part of the grouping) from the list GR.List_O. Operator 6 checks the current state of object O.

If $O.s = 0$, this means that the object O is in a healthy state and performs the task as part of the grouping. In this case, operators 7-14 are then executed.

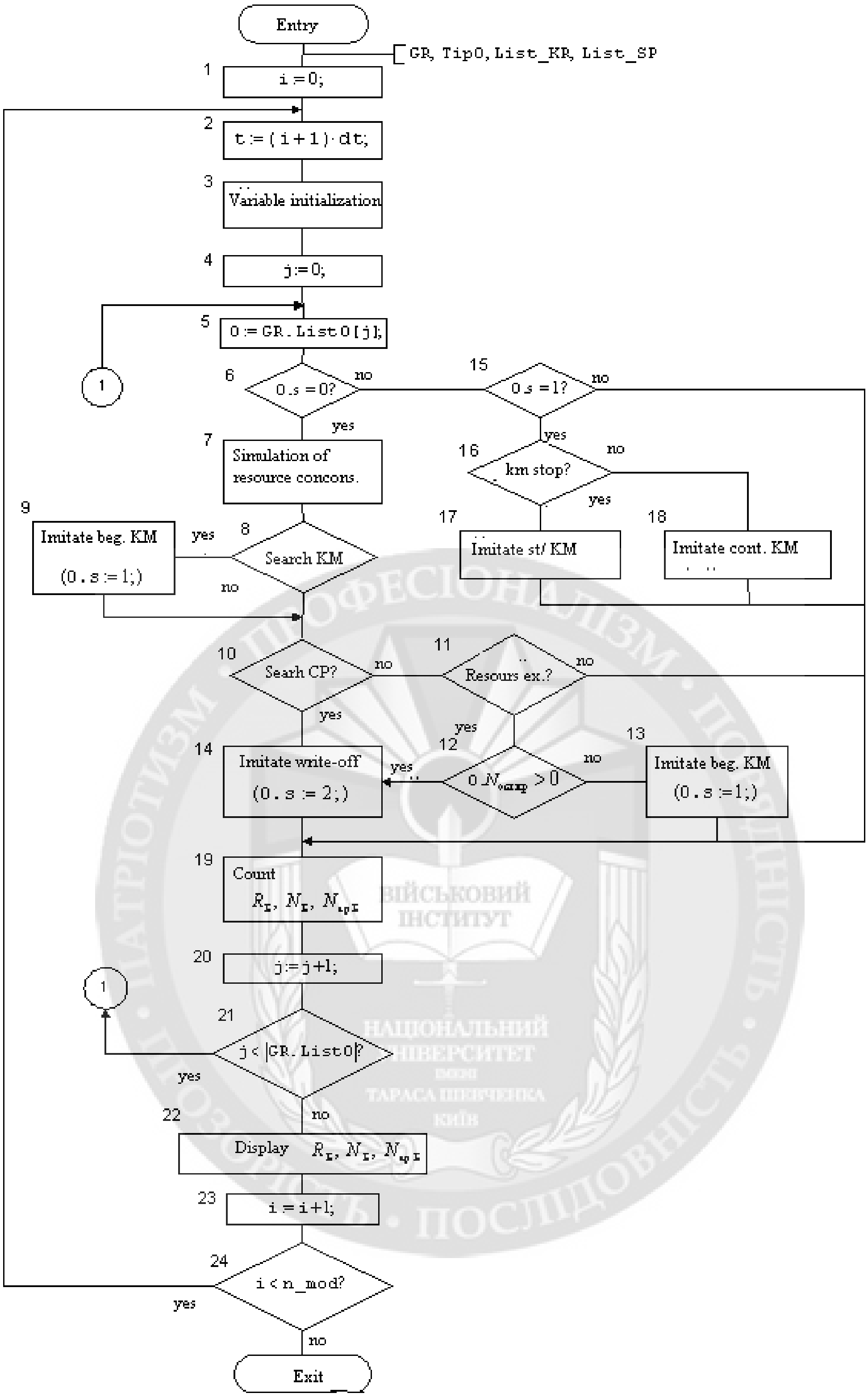


Figure 4 – Modeling algorithm in **User planning mode** (`Reg_p=1`)

The operator 7 simulates the consumption of the resource of the object O over a period of time $dt=[t-dt,t]$: the current values of the residual resource of the object $O.R_{ост}$ and the residual life $O.T_{ост}$ are reduced by $dt \cdot O.Lim0/12$ and dt.

Operator 8 checks whether the CR of object O is scheduled at the current time t. This check is performed by calling the function procedure Poisk_KR(t), which returns True if the CR is scheduled at time t, and False otherwise. If the CR is planned, then operator 9 is executed, which simulates the beginning of the CR, while the following instructions are executed:

$O.s := 1;$

$O.\tau_{кр} := TipO.\tau_{кр};$

$inc(N_{кр\Sigma});.$

The operator 10 checks whether the cancellation of the object O is planned at the current time t. This verification is carried out by calling the function procedure Poisk_SP(t. If the cancellation is planned (the function returns True), then operator 14 is executed that simulates the cancellation of the object. Write-off of the object is simulated by following the instructions $O.s := 2;$. The algorithm allows the option when the user has erroneously planned for the same time both CD and write-off.

The operator 11 checks whether the resource or service life of the object O has been exhausted at the current moment of time (this operator is executed only if the object is not currently being sent to CD or write-off). If yes (exhausted), then statements 12-14 are executed. Operator 12 checks the necessary condition for the object O to conduct subsequent CD. If CD must still be performed to extend the resource of the object (if $O.N_{ост\,кр} > 0$), then operator 13 is executed that simulates the transfer of the object to the state of the CD. Otherwise, operator 14 is simulated to simulate the write-off of the object.

If at the current moment of time the object O is in the state of repair (), the operator 15 transfers control to the operators 16-18, which simulate the continuation of the RC. If $O.s = 1$, at the same time, it turns out that the repair should be completed at the current moment of time, then the operator 17 is executed, simulating the completion of the CD. Otherwise, the operator 18 simulates the continuation of the repair.

After executing the above operators 6-18, control is transferred to the operator 19, which performs the calculation of variables R_Σ, N_Σ and $N_{кр\Sigma}$ characterizing the state of the simulated process at the current time t. Then the operators 20 and 21 are executed, completing the inner loop, in which all the objects in the group are enumerated. The operator 22 displays the obtained values R_Σ, N_Σ and $N_{кр\Sigma}$ in the form of points on the corresponding graphs on the PC monitor screen. Operators 23 and 24 complete the execution of the external cycle, in which the discrete values of the model time t are searched within the specified value of the operating time. These operators are similar to the corresponding operators of the algorithm shown in Fig. 2.5, and do not require any additional explanations.

The form for displaying simulation results (graphs) in the **User Planning** mode is no different from the form for presenting the results obtained in the **Normative Planning** modes. Examples of the presentation of these results are shown in the above figures.

Conclutions. An enlarged structural diagram of the modeling algorithm is proposed. It is assumed that by the time this algorithm is launched, all the necessary data structures have already been created in the RAM of the personal computer, the user has selected the implementation of the grouping for which the simulation is performed. The number of implementations of the modeling process and a certain coefficient that sets the range of variation of the limit on the consumption of the resource of objects in percent are given. The block diagram of the modeling algorithm in the Normative planning mode plus the supply of new objects is developed. The results are shown for two calculation options: for a single case of simulation implementation and for 100 implementations. A block diagram of an algorithm for modeling the process of spending and replenishing a resource in the User Planning mode without supplying new objects has been developed.

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НОРМАТИВНЕ ПЛАНУВАННЯ ПРОЦЕСІВ ВИТРАТ ТА ПОПОВНЕННЯ РЕСУРСУ УГРУПОВАННЯ З ПОСТАВКАМИ НОВИХ ОБ'ЄКТІВ

У статті описані особливості та результати нормативних процесів планування витрат та поповнення ресурсів групування постачанням нових об’єктів.

Перед військами стоїть важливе завдання своєчасного планування ремонту озброєння та військової техніки та поставок до угруповання нових об’єктів. Показано, що вирішення цієї проблеми можливе лише за допомогою використання математичної моделі процесу витрат та поповнення технічного ресурсу групування об’єктів. Використовуючи його, можна передбачити склад та ресурс групи та обчислити оптимальні плани підтримки бойової готовності групи.

Запуск представленого алгоритму передбачає використання раніше розробленої розширеної структурної схеми алгоритму моделювання. Встановлено кількість реалізацій процесу моделювання та певний коефіцієнт, що встановлює діапазон ліміту споживання ресурсу об'єктів у відсотках. Представлена блок-схема алгоритму моделювання в стандартному режимі планування плюс постачання нових засобів. По суті це розширення попереднього алгоритму. Початкова інформація, як і раніше, - це структури даних GR та TipO. До них додається необхідна (мінімально прийнятна) кількість об’єктів у групуванні. Результати показані для двох варіантів розрахунку: для реалізації одного випадку моделювання та для 100 реалізацій. Це дозволяє порівняти отримані дані та якісно оцінити характер впливу на тип чисел графіків реалізацій моделювання.

Представлена блок-схема алгоритму моделювання процесу витрачання та поповнення ресурсу в режимі «Планування користувача» без подачі нових об’єктів.

Форма для відображення результатів моделювання (графіки) в режимі User Planning не відрізняється від форми подання результатів, отриманих в режимах Нормативного планування. Показані приклади представлення цих результатів.

Ключові слова: витрати та поповнення ресурсу, планування ремонту, озброєння та військова техніка, математична модель, технічний ресурс, групування.