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JUSTIFICATION OF THE NUMBER OF SAMPLES OF WEAPONS AND MILITARY TECHNIQUES FOR PERFORMING TASKS

During the research of the use issue of samples of weapons and military equipment in operations, a significant correlation was established between the predicted effectiveness of such use and the characteristics of the quantitative and qualitative composition of samples of weapons and military equipment. Taking this into account, it is clear that while preparing any operation, it would be desirable to have such a basis of the composition of samples of weapons and military equipment, which is well-founded and can only be adjusted in the conditions of a certain operation. The objects of the research are the samples of weapons and military equipment that are the part of the groups of troops (forces). However, the results of the analysis show that the existing methods for substantiating the composition of samples of weapons and military equipment need improvement. First of all, this concerns the determination of the basic (support) version of the composition of samples of weapons and military equipment (WME). As in the existing methods, the basic (support) version of the composition is not determined, it is chosen by comparing the composition of one's troops and the enemy's troops according to their combat potential. This approach does not provide an opportunity to compare the groups, taking into account the specifics of the use of their striking equipment and to create the necessary balance of forces at all stages of the operation.

Taking into account the above, we conducted the researches that made it possible to determine that with certain proportions, characteristic of the organizational structure of the absolute majority of military formations, there is a close to linear relationship between the number of their personnel and WME and combat potential.

Based on the research results, an improved method of determining the basic (support) composition of samples of weapons and military equipment in operation is proposed.

Keywords: *samples of weapons and military equipment, predicted efficiency of use, composition of troops, multi-criteria optimization methods.*

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1. Introduction

The rapid growth of the mobility and autonomy of actions of the armed forces requires the creation of such groups of troops (forces) that would be able to focus the main efforts on repelling the attack of the attack groups of the enemy's troops (forces) [1, 2].

The development of military science indicates the need to develop new approaches to justifying the composition of army groups in terms of justifying the number and composition of samples of weapons and military equipment that are created for conducting operations [3, 4].

It should be noted that substantiating the composition of military groups (forces) in terms of the number and composition of samples of weapons and military equipment (WME) is a rather complex task in terms of method. It is characteristic while solving such a problem that the quantitative and qualitative state of samples of weapons and military equipment, which can be included in the composition of a group of troops, has an ambiguous effect on the indicators of the effectiveness of its use and is characterized by many criteria. Therefore, it is proposed to apply multi-criteria optimization methods to justify the composition of samples of weapons and military equipment of groups of troops (forces).

Summarizing the results of the conducted analysis, the main shortcomings of the mentioned works are:

– the coefficients that reduce the effectiveness of the use of WME samples, their technical perfection, which, in turn, do not allow to fully assess the effectiveness of the grouping in operations are not taken into account;

– those samples of weapons and military equipment that were created during the preparation and conduct of command and staff exercises were chosen as the basic (reference) options for the composition of samples of weapons and military equipment of groups of troops (forces);

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– the comparison of the groups was carried out mainly according to their combat potential, which does not allow taking into account the specifics of the use of shock weapons.

Therefore, *the object of research* is the samples of weapons and military equipment that are the part of groups of troops (forces).

The aim of research is to improve the method for determining the basic (reference) version of the composition of samples of weapons and military equipment of groups of troops (forces).

2. Research methodology

According to the results of the conducted research, in the currently existing methods, one of the most important stages in the preparation of any operation is the determination of the composition of samples of weapons and military equipment of the operational grouping of troops (forces) [5–7]. However, as it was stated above, the formation of the basic (reference) variant of its composition was not foreseen in such methods.

On the basis of the author's hypothesis regarding the need to create a basic version in these conditions, an improved version of the method for determining the basic (reference) version of the composition of samples of weapons and military equipment is proposed below. This option will be able to resist the grouping of the enemy's troops and provide the necessary ratio of forces and devices at certain stages of the operation, which are determined by time parameters.

To simulate the above-mentioned processes, let's consider the groupings of the opposing troops – A is their troops and B is the enemy's troops, which are capable of potentially participating in a force confrontation against each other during a military operation. At the same time, each of the groups has in its composition a certain number of defeat devices, which are installed on samples of WME and the personnel that ensures their use [8–10].

Then, let's denote N_i^A is the number of destruction devices (DD) of WME of our troops, N_j^B is the number of DD of WME of the enemy: $(i=\overline{1,n})$, $(j=\overline{1,m})$; ω_{ij} is the number of DD of our troops for each WME of the enemy; ω_{ji}^B is the number of DD of enemy troops for each WME of our troops. The specified amount of DD ω_{ij} and ω_{ji}^B should ensure the destruction of enemy objects with a given probability W_r. Provided that each sample of WME is provided with the necessary number of ammunition of the DD for conducting combat operations during the specified time (conducting an operation, combat operations).

Let's assume that for each type of ammunition, the number of personnel L_i and devices of providing WME samples for their combat use are known.

The selection of the basic composition of the samples of weapons and military equipment of our troops is determined on the basis of the assumption that the composition and number of the enemy's troops is known, so the composition and number of the grouping of our troops at the end of the operation is determined by reverse calculation.

In these conditions, it is proposed to solve the problem of determining the initial number of samples of WME of the grouping of its troops A:

$$N_i^A,\ \left(i=\overline{1,n}\right),$$

which must ensure, by the time of the completion of the combat operation T, the necessary ratio between fire (shock) devices k_i, which are the part of the enemy's troop groups:

$$\frac{N_i^A(T)}{N_i^B(T)} \geq k_i,$$

if there are the same types of WME samples in opposing groups $n=m$.

It should be noted that during the operation of groups of troops (forces), all important objects are covered by air defence forces and devices of air defense and electronic warfare (EW). This reduces the effectiveness of the use of shock samples of WME – q_i^A are our troops, q_i^B are the enemy troops, q_{techi}^A, q_{techi}^B is the coefficient of technical excellence of air defence and electronic defence equipment of our troops A and enemy troops B.

The value of the coefficients of reduction in the effectiveness of the striking WME use is given in Table 1.

Table 1

Coefficients of reduction in the effectiveness of the striking WME use

No.	Characteristic name	Range of change	Indicators taken into account while determining the importance of the radio-electronic environment
1	Effectiveness of radio-electronic suppression	0.1–0.4	Insignificant effect on radio-electronic devices
		0.41–0.79	Partial malfunction of radio-electronic equipment
		0.8–1.0	The use of radio-electronic devices is impossible
2	The effectiveness of air defense	0.1–0.4	The use of airspace without restrictions
		0.41–0.79	The use of airspace is limited
		0.8–1.0	The use of air space is not possible
3	Coefficient of technical excellence	0.1–0.4	Obsolete samples of WME
		0.41–0.79	Samples of WME that have undergone modernization
		0.8–1.0	The latest samples of WME

Since it is about the number of WME samples, it is possible to neglect the high accuracy of solving the given problem and solve it approximately. An approximate solution to the above task is given below.

The task, which was formulated above, is convenient to solve in matrix form. To do this, let's bring all the matrices and vectors to one dimension $l=\max(n,m)$ by introducing the missing components of the WME samples into the composition of the opposing groups.

Let's mark:

– vectors of the average number of DD of the opposing sides:

$$N^A=\left(N_i^A\right)_{l\times 1};\ N^B=\left(N_j^B\right)_{l\times 1};$$

– transposed matrices of intensities of striking effects (fire performance) of WME samples:

$$\Lambda^A=\left(\lambda_{ij}^A\right)_{l\times l}^T;\ \Lambda^B=\left(\lambda_{ij}^B\right)_{l\times l}^T.$$

Let's suppose that during the combat operations, each of the parties will strike $r=[T/\Delta t]$ with a discreteness

interval Δt, where the symbol [ ] means the operator of selection of a whole part of a number. It is assumed that during the strikes, enemy objects will be hit with:

– the probability of hitting enemy targets with the fire devices of our troops:

$$W_{ij}^{A}=\left(\gamma_{ij}^{A}\frac{q_{ij}^{A}}{\omega_{ij}^{A}}\right)q_{techi}{}^{A},$$

– the probability of hitting the objects of our troops with the enemy's DD:

$$W_{ji}^{B}=\left(\gamma_{ji}^{B}\frac{q_{ji}^{B}}{\omega_{ji}^{B}}\right)\cdot q_{techi}{}^{B},$$

where γ_{ij}^{A}, γ_{ji}^{B} are the importance of enemy objects for damage ($0\le\gamma\le1$); q_i^A and q_i^B are the coefficients of reduction in the effectiveness of the use of striking samples of WME: q_i^A are our troops, q_i^A are enemy troops.

The set of strikes by DD can be represented as a continuous Poisson flow with intensities:

$$\lambda_{ij}^{A}=-\frac{r}{T}\ln\left(1-W_{ij}^{A}\right);$$

$$\lambda_{ji}^{B}=-\frac{r}{T}\ln\left(1-W_{ji}^{B}\right),$$

where r is the number of strikes with a given probability.

At the same time, it is proposed to describe the equation of the dynamics of combat between opposing groups in a matrix form as follows:

$$\frac{dN^{A}}{dt}=-\Lambda^{B}N^{B};\ \frac{dN^{B}}{dt}=-\Lambda^{A}N^{A},\qquad(1)$$

with the initial conditions $N^{A}(0)$ is the initial composition of forces and devices of our troops; $N^{B}(0)$ is the initial composition of the enemy's forces and devices.

In order to determine the ratio between the number of one type DD of opposing groups of troops at the time of completion of the combat operation T, let's introduce a matrix:

$$K(T)=\begin{pmatrix}k_1(T) & 0\\ 0 & k_1(T)\end{pmatrix},$$

which:

$$N^{A}(T)=K(T)N^{B}(T).\qquad(2)$$

The matrix K sets constant ratios between the groups of our troops and the enemy's troops.

Let's write the differential equations from expression (1) in the form of a difference:

$$N^{A}(T)-N^{A}(T-\Delta t)=-\Delta t\Lambda^{B}N^{B}(T-\Delta t);$$
$$N^{B}(T)-N^{B}(T-\Delta t)=-\Delta t\Lambda^{A}N^{A}(T-\Delta t).\qquad(3)$$

Let's substitute the values $N^{A}(T)$, $N^{B}(T)$ into equation (1) and get:

$$N^{A}(T-\Delta t)-\Delta t\Lambda^{B}N^{B}(T-\Delta t)=$$
$$=K(T)\left(N^{B}(T-\Delta t)-\Delta t\Lambda^{A}N^{A}(T-\Delta t)\right).\qquad(4)$$

After bringing similar terms, let's get the following ratio between the numbers of groups at $T-\Delta t$ step:

$$N_{A}(T-\Delta t)=\left(l+KW^{A}\right)^{-1}\left(K+W^{B}\right)\times$$
$$\times N^{B}(T-\Delta t)=K(T-\Delta t)N^{B}(T-\Delta t),\qquad(5)$$

where $K(T-\Delta t)=\left(l+K(T)W^{A}\right)^{-1}\left(K(T)+W^{B}\right)$; $W^{A}=\Delta t\Lambda^{A}$; $W^{B}=\Delta t\Lambda^{B}$ is the probability of hitting enemy objects at the interval Δt.

Thus, moving in the reverse direction (to the moment of the operation start $t=0$), let's obtain the required ratio of the number of opposing groups of troops:

$$N^{A}(0)=K(0)N^{B}(0).\qquad(6)$$

The matrix $K(0)$ is determined from the recurrent equation:

$$K(t-1)=\left(l+K(t)W^{A}\right)^{-1}\left(K(t)+W^{B}\right),\qquad(7)$$

where $t=1,2,...,r$ is the number of strikes.

Based on the ratio of the numbers of opposing WME samples of troop groups at the end of the operation and the known initial number of WME samples of the enemy troop group (B), it is possible to calculate the initial number of WME samples of one's troop group (A).

3. Research results and discussion

The block diagram of the proposed method is shown in Fig. 1.

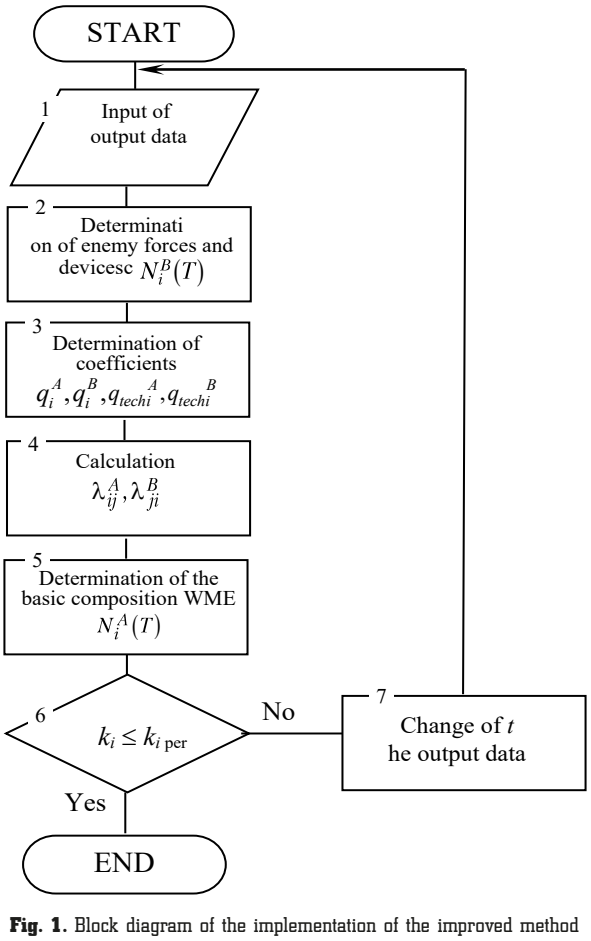

Fig. 1. Block diagram of the implementation of the improved method

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Using the proposed method allow:
– to determine the composition and number of samples of weapons and military equipment that must be involved in the execution of combat tasks;
– to take into account the coefficient of technical perfection of samples of weapons and military equipment, which must be involved in the performance of combat tasks;
– to take into account the effectiveness of the use of weapons and military equipment used in combat missions;
– to take into account the effectiveness of air defense and radio-electronic warfare in the course of using samples of weapons and military equipment in the course of combat missions.

The specified method is expedient to use in automated troop management systems in order to increase the efficiency of management decision-making by the people who make them.

The limitations of the use of the specified method are the availability of reliable and complete information about the composition and number of samples of the enemy's weapons and military equipment.

4. Conclusions

The existing methods used military formations that were created in the course of conducting command and staff exercises, which led to a decrease in the efficiency and validity of options for the composition of the troops accepted by headquarters and command.

An improved method for selecting the basic (support) variant of the composition of samples of weapons and military equipment of an operational group of troops for the conduct of an operation is proposed, in which, unlike the existing one for the purpose of choosing the basic (support) variant of the composition of an operational group of troops in the operation, the following is additionally provided for:
– the use of dependence on the necessary ratio between the samples of weapons and military equipment of the groups at the end of the operation;
– taking into account the effect of the effectiveness of the enemy's electronic suppression and air defence on the number of devices that must be engaged to achieve the goal of the operation;
– a comparison of the grouping of our troops and the enemy's troops, taking into account the specifics of the use of striking weapons;
– taking into account the coefficient of technical perfection of samples of weapons and military equipment.

The practical significance of the improved method lies in the fact that, on its basis, at the stage of operation planning, it is possible to justify the basic (support) composition of samples of weapons and military equipment of an operational grouping of troops in a defense operation.

The use of the improved method will allow reducing the efficiency of decision-making by officials of the operational grouping of troops in the operation, on average, by 25 % due to the formation of the basic (support) combat composition at the stage of planning the use of troops (forces).

Conflict of interest

The authors declare that he has no conflict of interest in relation to this research, including financial, personal, authorship or other, which could affect the research and its results presented in this article.

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