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THE IMPORTANCE (DANGER) ASSESSEMENT METHODOLOGY FOR POSSIBLE DIRECTIONS OF ENEMY STRIKES ON DEFENDING TROOPS

Abstract. *A methodology for the importance (danger) assessing of possible of enemy troops' action directions of using the method of hierarchy analysis is presented, which is advisable to be used by military command bodies when developing a defensive operation plan.*

Keywords: *defensive operation plan, directions of strikes, method of hierarchy analysis.*

Introduction

Statement of the problem. When planning a defensive operation, the most important mission of the military command body (MCB) is to develop a decision on the group of troops use. The basis of the decision is the plan of the defensive operation, that determines: areas of concentration of efforts; methods of defensive actions; operational structure (battle order) of the group of troops. To substantiate the plan of the MCB operation, first of all, the directions of the main and other strikes of the enemy troops are predicted, according to that the efforts of the defending group of troops are distributed and its operational structure (battle order) is determined. In this case, it is advisable to take into account the results of a quantitative assessment of the importance (danger) of the enemy troops' strikes predicted directions.

In connection with the recent events related to the full-scale invasion of the russian federation, the need to predict the directions of strikes by the aggressor’s troops and quantify their importance (danger) when developing the plan of operations is beyond doubt.

Analysis of recent research and publications. From the experience of MCB exercises, when determining the enemy forces’ strikes directions (main and other) on the grouping of troops, a heuristic method is used. This takes into account: the provisions of the operational art and tactics theory; the nature of the terrain; reconnaissance signs regarding the concentration of enemy troops; possible directions of enemy troops advance; lines and areas that the enemy will try to capture during the offensive, etc. A quantitative assessment of the importance (danger) of the predicted strikes directions is not made by the MCB.

In the monograph [1] when making a decision on the use of troops, the predicted strategies (options for use) of opposing groups of troops, which may differ in the directions of strikes, are analyzed. To determine the optimal strategies of the opposing parties, it is proposed to use game theory methods, which allow determining the frequencies of strategies use taking into account the effectiveness of the groups of troops use. However, their importance (danger) is not directly assessed. Game theory methods for determining the frequencies of strategies (methods of combat operations) are also used in work [2]. Methodological provisions for substantiating the operation (combat actions) plan are considered in the monograph [3], that analyzes options for using opposing groups of troops.

The purpose of the methodological provisions is to determine a rational option (method) for one's troops grouping use, taking into account possible options (methods) for using the enemy's troops. For this purpose, the monograph considers the application of game theory methods [4], fuzzy sets [5], taxonomies [6]. Variants of combat actions of the enemy's group of troops, which differ in the directions of strikes, are determined in scenarios based on the forecasting results of the military conflict purpose and the form of troops use. The rational option for using the group of one's own troops is determined based on the results of assessing the effectiveness of the parties' combat actions, that allows us to indirectly judge the importance (danger) of the directions of strikes of the enemy's troops.

Thus, the issue of quantitative assessment of the importance (danger) of the directions of possible strikes by enemy troops was not considered in the above works. At the same time, such an assessment is useful and necessary for developing combat scenarios, in particular for determining the distribution of efforts of one’s troops in order to repel enemy aggression.

Purpose of the article consists in developing a methodology for assessing the importance (danger) of the enemy's directions of strikes against the defending group of troops.

Presentation of the main material

When assessing the importance (danger) of possible enemy troops’ attack directions, a large number of various factors must be taken into account. Therefore, to determine the priorities of alternative directions of attack by enemy troops, it is advisable to apply the method of analysis of hierarchies (AHI) [7]. This method belongs to the class of pairwise comparison methods. The priorities of the directions of blows are established in stages.

The method of hierarchy analysis consists in decomposing the problem into simpler components and in further processing the sequence of expert judgments using pairwise comparisons. To decompose the problem into a hierarchy, it is necessary to determine the directions of enemy troops’ attacks (alternatives) and generalized and partial characteristics (indicators) for their comparison by importance (danger).

Possible directions of enemy strikes are determined taking into account: the predicted goal of the military conflict; possible forms and methods of enemy troop groups use; the composition and areas of deployment of its troops; possible directions of enemy troop advance; lines and areas that the enemy will try to capture in an offensive; lines of directions for introducing second echelons (reserves) into battle; the nature of the terrain, etc.

When predicting the enemy troops' attacks directions, the construction of defense by our troops of the areas that the enemy will try to capture is also taken into account. The general indicators that are proposed to be evaluated when determining the importance (danger) of the predicted directions of attacks by enemy troops characterize the fulfillment of missions related to the advancement and deployment of troops for the offensive, the predicted effectiveness of the use of enemy troops, and their logistical support.

According to the hierarchy in Fig. 1, experts compose one (3x3) at the second level, three (5x5), (4x4), (4x4) at the third level, and thirteen (nxn) square inversely symmetric matrices of pairwise comparisons (*n* is the number of predicted directions of enemy strikes) at the fourth level.

Pairwise comparison matrices are filled in by experts in hierarchical order from top to bottom. A nine-point scale is used for this purpose [7]. A group of experts is appointed to apply the AHI.

When compiling matrices, experts compare the importance: at the second level of the hierarchy – general indicators in relation to the goal of the task; at the third level – partial indicators in relation to general ones; at the fourth level – directions of strikes in relation to partial indicators.

Fig. 1 shows a hierarchical representation of the task of assessing the importance (danger) of the directions of enemy troops' strikes.

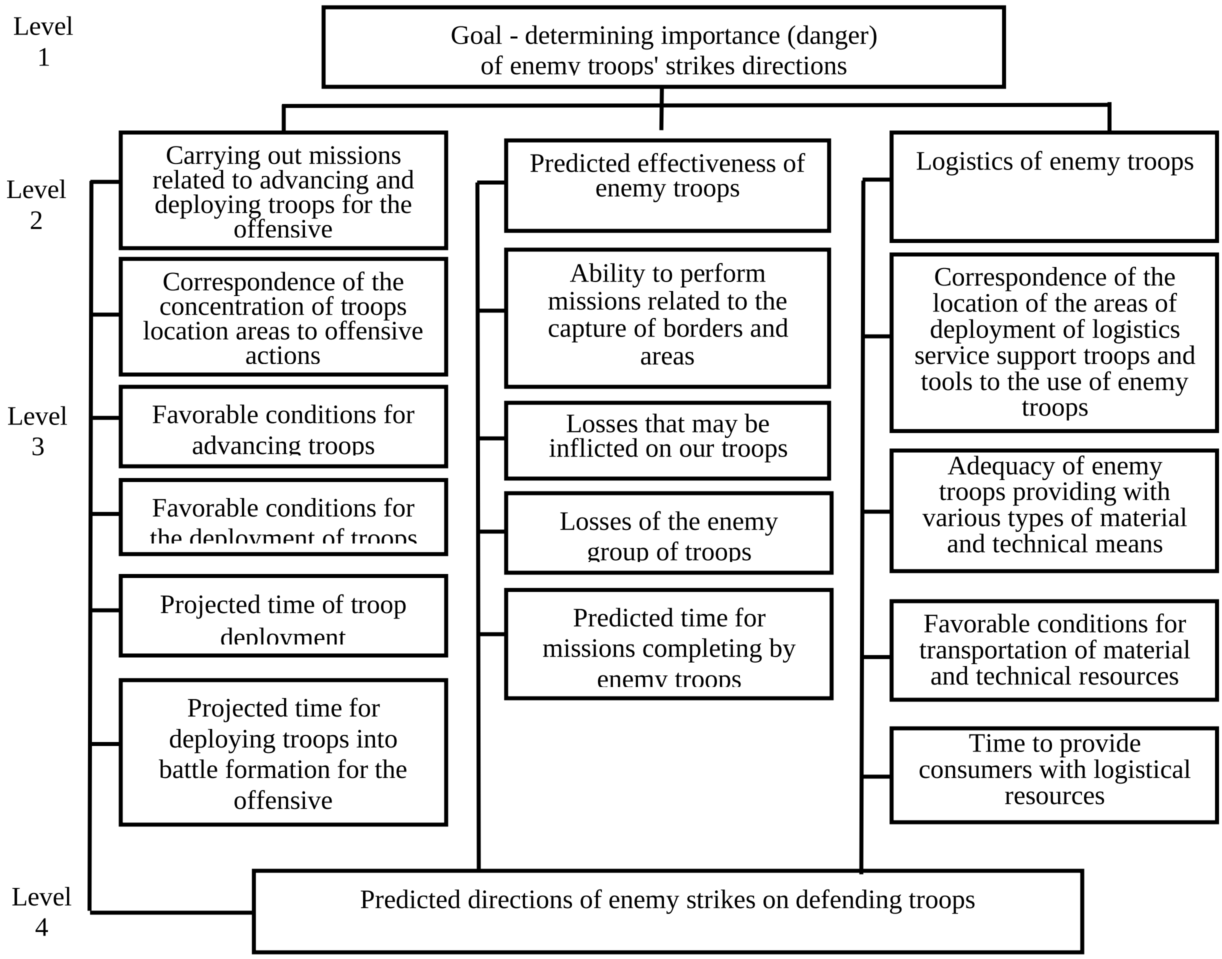

Fig. 1. Hierarchical representation of the importance (danger) assessment task directions of enemy troops' strikes

The hierarchy has four levels: 1 – the goal of solving the problem; 2 – general indicators; 3 – partial indicators; 4 – predicted directions of enemy strikes (alternatives).

When filling out the matrices (Table 1), experts make assessments in the form of weight ratios. ξ-*th* and μ-*th* elements ω_ξ/ω_μ, which are determined by the importance ξ-*th* element compared to μ-*m* element relative to a specified element of the previous level of the hierarchy. The appearance of the pairwise comparison matrix is given in Table 1.

Table 1

Pairwise comparison matrix view

Indicators, alternatives	*P1*	*P2*	• • •	P_μ	• • •	*Ps*
P1	1	$\frac{\omega_1}{\omega_2}$	• • •	$\frac{\omega_1}{\omega_\mu}$	• • •	$\frac{\omega_1}{\omega_s}$
P2	$\frac{\omega_2}{\omega_1}$	1	• • •	$\frac{\omega_2}{\omega_\mu}$	• • •	$\frac{\omega_2}{\omega_s}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮
P_ξ	$\frac{\omega_\xi}{\omega_1}$	$\frac{\omega_\xi}{\omega_2}$	• • •	$\frac{\omega_\xi}{\omega_\mu}$	• • •	$\frac{\omega_\xi}{\omega_s}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮
Ps	$\frac{\omega_s}{\omega_1}$	$\frac{\omega_s}{\omega_2}$	• • •	$\frac{\omega_s}{\omega_\mu}$	• • •	1

Relation $\frac{\omega_\xi}{\omega_\mu}$ in the matrix have the following properties:

$$\frac{\omega_\xi}{\omega_\mu}=\frac{1}{\omega_\mu/\omega_\xi};\ \frac{\omega_\xi}{\omega_\mu}=1\, npu\ \xi=\mu\cdot \tag{1}$$

When involving R experts to assess the importance (danger) of the directions of enemy troops' strikes, the numerical value of the judgment is determined as the geometric mean of the individual expert judgments.

$$\frac{\omega_\xi}{\omega_\mu}=\sqrt[R]{\mathop{\Pi}_{r}\left(\frac{\omega_\xi}{\omega_\mu}\right)_r},\ r=\overline{1,R}, \tag{2}$$

where $\left(\frac{\omega_\xi}{\omega_\mu}\right)_r$ – judgment of the *r*-th expert.

For each pairwise comparison matrix, the components of the eigenvector are calculated using the formula

$$\alpha_\xi=\sqrt[S]{\mathop{\Pi}_{\mu}\frac{\omega_\xi}{\omega_\mu}},\ \xi=\overline{1,S},\ \mu=\overline{1,S}. \tag{3}$$

To obtain the elements of the priority vector, the values of the quantities α_ξ normalize

$$в_\xi=\frac{\alpha_\xi}{\sum_\xi \alpha_\xi},\ \xi=\overline{1,S},\ \sum_\xi в_\xi=1. \tag{4}$$

The consistency (consistency) of experts' judgments when compiling each matrix of pairwise comparisons is checked using the method given in the works [7; 8]. For this purpose, the so-called consistency index is introduced, which takes into account numerical and transitive (ordinal) inconsistency in pairwise comparisons.

The consistency index (CI) is defined as follows:

the sum of the judgments of each column of the pairwise comparison matrix is calculated (Table 1)

$$C_{\mu} = \sum_{\xi} \frac{\omega_{\xi}}{\omega_{\mu}}, \xi = \overline{1,S}, \mu = \overline{1,s}; \tag{5}$$

The value C1 for the first column is multiplied by the value of the first element of the priority vector b1, the value C2 is multiplied by b2, and so on, which allows us to obtain the sum

$$\lambda_{\max} = C_1 в_1 + C_2 в_2 + \cdots + C_{\mu} в_{\xi} + \cdots + C_s в_s; \tag{6}$$

the consistency index is calculated[7]

$$ІУ = \frac{\lambda_{\max} - s}{s - 1}, \; s \rangle 1. \tag{7}$$

Next, the CI is compared with the average random coherences (ARCs) for random matrices of different sizes [7] (Table 2).

Table 2

Average consistency for random matrices

Matrix size	1	2	3	4	5	6	7	8	9	10
Average random consistency	0	0	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

It is believed that the consistency ratio (CR) $ВУ = \frac{ІУ}{CВУ}$ should not be more than 0.1. When this condition is not met, it is necessary to check the correctness of the problem statement and the experts' judgments.

The degree of influence of the *j*-th general indicator α_j ($j = \overline{1,m}$, *m* – number of general indicators) on the importance (danger) of the directions of attack of the enemy troops corresponds to a certain element (component) of the priorities vector of the matrix of the second level of the hierarchy (Fig. 1). According to the hierarchy, for each *j*-th general indicator, l_j partial indicators are closed, the weight of which is determined by the formula

$$P_{tj} = \delta_{tj} \, d_j, t = \overline{1, l_j}, \;\; j = \overline{1,m}, \tag{8}$$

where P_{tj} is the weight of the *t*-th indicator, which is closed to the *j*-th general indicator;

α_{tj} – priority of the *t*-th indicator relative to the *j*-th general indicator.

From the matrices of the fourth level of the hierarchy, the priorities of the directions of strikes of enemy troops are determined relative to the partial indicators (the third level of the hierarchy).

The importance (danger) of the *i*-th direction of attack of the enemy troops is determined by the formula

$$B_i = \sum_{j=1}^{m} \sum_{t=1}^{l\,j} \gamma_{itj} \cdot P_{t\,j}, i = \overline{1,n}, \tag{9}$$

where γ_{itj} – priority of the *i*-th direction of impact relative to the *t*-th indicator, which is closed to the *j*-th general indicator.

As an illustrative example of the application of the methodology, let us consider a military conflict in which it is assumed that the aggressor will conduct a land operation in order to seize part of the territory of a neighboring country. The boundaries and areas that the aggressor will try to seize are determined. When planning a defensive operation of the MCB group of troops, five possible directions of attacks by enemy troops are determined on the topographic map, the composition and areas of concentration of which are identified by intelligence reconnaissance tools. It is necessary to assess the importance (danger) of the identified directions of enemy troops' attacks.

The structural diagram of the methodology for assessing the importance (danger) of possible directions of attacks by the enemy on the defending group of troops is shown in Fig. 2.

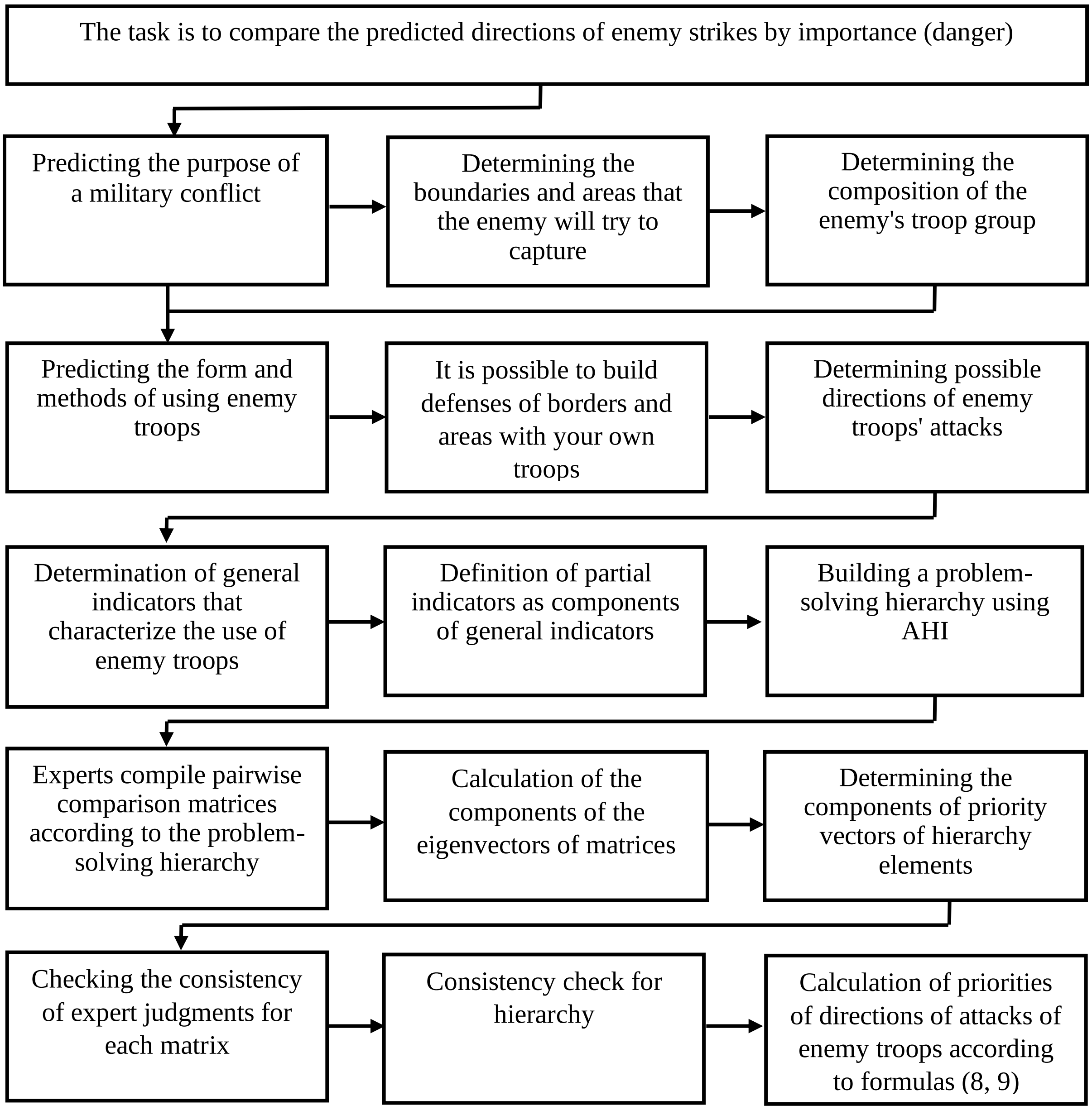

Fig. 1. Structural diagram of the importance (danger) of possible enemy's attacks directions on the defending group of troops assessment methodology

In accordance with the hierarchy of problem solving shown in Fig. 1, for the second level, experts compiled a matrix of pairwise comparisons of general indicators (Table 3).

Table 3

Matrix of pairwise comparisons of general indicators for the second level of the hierarchy

General indicators, P_j	P_1	P_2	P_3	Components of the eigenvector, αj	Components of the priority vector, d_j
P_1	1	3/9	3/7	0,523	0,156
P_2	9/3	1	5/3	1,709	0,510
P_3	7/3	3/5	1	1,118	0,334

λ_{max}= 3,008; IU = 0,004; VU = 0,007.

Next, the experts compiled three matrices of pairwise comparisons for the third level of the hierarchy. The result of determining the components of the priority vectors $\delta_{tj}\left(t=\overline{1,l_j}\right)$ and weights of partial indicators P_{tj} are given in Table 4.

Table 4

Components of priority vectors and weights of partial indicators

Partial indicators, P_{tj}	Components of priority vectors, δ_{tj}			Weights of partial indicators, P_{tj}		
	J = 1	J = 2	J = 3	J = 1	J = 2	J = 3
P_{1j}	0,20	0,25	0,26	0,031	0,128	0,087
P_{2j}	0,15	0,40	0,35	0,023	0,204	0,117
P_{3j}	0,25	0,20	0,15	0,039	0,102	0,050
P_{4j}	0,18	0,15	0,24	0,028	0,077	0,080
P_{5j}	0,22	-	-	0,034	-	-

For thirteen matrices of the fourth level of the hierarchy, the components of the directions of impacts priority vectors γ_{itj} relative to partial indicators are given in Table 5.

Table 5

Components of priority vectors of matrices of the fourth level of the hierarchy

Direction of blows, H_i	J = 1					J = 2				J = 3			
	t = 1	t = 2	t = 3	t = 4	t = 5	t = 1	t = 2	t = 3	t = 4	t = 1	t = 2	t = 3	t = 4
H_1	0,14	0,15	0,17	0,07	0,12	0,09	0,12	0,20	0,25	0,08	0,15	0,19	0,08
H_2	0,17	0,18	0,14	0,18	0,10	0,14	0,15	0,24	0,15	0,12	0,11	0,20	0,16
H_3	0,31	0,25	0,21	0,32	0.27	0,35	0,28	0,19	0,21	0,41	0,34	0,28	0,36
H_4	0,22	0,19	0,36	0,27	0,30	0,27	0,25	0,21	0,19	0,29	0,26	0,12	0,25
H_5	0,16	0,23	0,12	0,16	0,21	0,15	0,20	0,16	0,20	0,10	0,14	0,21	0,15

The results of the assessment of the importance (danger) of the enemy strikes` directions using formula (9) are shown in Fig. 3.

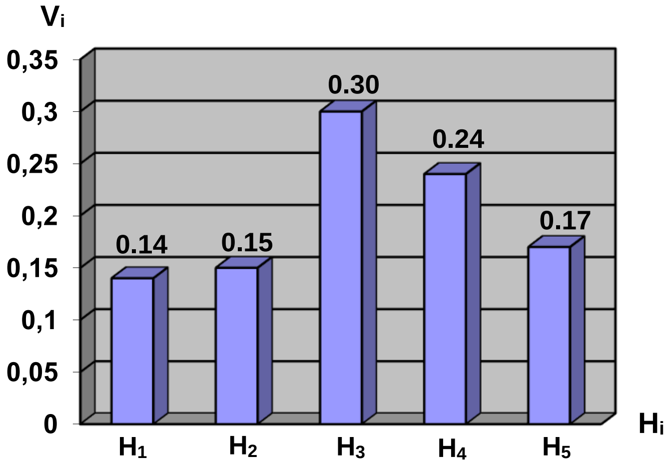

Fig. 3. Coefficients of importance (danger) of enemy troops' attacks directions

The most dangerous is the third direction of the enemy troops' attack, which may be considered the main one when developing the plan of a defensive operation. It is adjacent to the fourth (other) direction of attack, which is also dangerous. The obtained coefficients of importance (danger) (Fig. 3) of the directions of attack of the enemy troops contribute to a reasonable distribution of the efforts of the grouping of our troops when planning the defensive operation operational plan.

Conclusions

A methodology for assessing the importance (danger) of possible directions of attacks by the enemy on a defending group of troops has been developed, which is based on the application of AHI. A system of indicators (general and partial) has been proposed for the application of AHI and a hierarchy of problem solving has been constructed.

Quantitative assessment of the importance (danger) of possible directions of action of enemy troops allows us to more reasonably determine their main direction of attack and to distribute the efforts of our troops when planning a defensive operation.

The methodology can be applied by the MCB when developing a plan for a defensive operation. For this purpose, it is advisable to further develop special mathematical software for the MCB.

References

1. Theory of decision-making by military management bodies: monograph. / ed. by Tkachenko V.I., Smirnova E.B. et al. Kharkiv : KhUPS, 2008. 545 p.
2. Mozharovsky V.N., Zagorka O.M. Basic provisions of the methodology for determining the variant (method) of combat operations and the composition of the grouping of troops (forces) to repel aggression. *Science and Defense.* 2011. No. 1. P. 3-6.
3. Zagorka O.M., Pavlikovsky A.K., Koretsky A.A., Kyrychenko S.O., Zagorka I.O. Theoretical foundations of commanding groups of troops (forces) in modern conditions of armed conflict: monograph / edited by I.S. Rusnak. Kyiv: Ivan Chernyakhivskyi National University of Military Sciences, 2020. 248 p.
4. Wentzel E.S. Operations research. Moscow: Sov. Radio, 1972. 551 p.
5. Gerasimov B.M., Lokaziuk V.M., Oksiyuk O.G., Pomorova O.V. Intelligent decision support systems: a textbook. Kyiv: European University, 2007. 335 p.
6. Pluta W. Multivariate Comparative Analysis in Economic Research: Taxonomic and Factor Analysis Methods (in Polish). Warsaw: PWE, 1977. 150 p.
7. Saaty Th. L., Kearns KP Analytical Planning: The Organization of System. Oxford: Elsevier: 2014. 216 p.
8. Samokhvalov Yu.Ya., Naumenko E.M. Expert evaluation. Methodical aspect. Kyiv: "DUIKT Publishing House", 2007. 263 p.