Запропоновано підхід щодо оцінки спроможностей угруповань військ (сил) на основі використання комбінаторного методу з обмеженою базою аргументів на прикладі функціональної групи спроможностей "Застосування".

Оцінка спроможностей угруповання військ (сил) здійснюється в рамках оборонного планування з метою визначення перспективного складу Збройних Сил України (сил оборони). Сучасний Порядок оцінки спроможностей угруповання військ (сил) в Збройних Силах України ґрунтується на експертних методах оцінювання. Недоліками визначеного Порядку є суб'єктивність, довготривалість та персоналозатратність (періодичне відволікання фахівців від виконання функціональних обов'язків). Тому розроблення нових підходів оцінки спроможностей угруповань військ (сил) на основі сучасних наукових аналітичних методів, що позбавлені зазначених недоліків є актуальним науковим завданням.

Згідно зі стандартами НАТО, спроможності поділяються на дев'ять функціональних груп, які містять 464 спроможності. Для розроблення методу оцінки спроможностей з використанням аналітичних методів з врахуванням існуючої нормативної бази, проведено аналіз існуючого Порядку оцінки спроможностей угруповання військ (сил) в Збройних Силах України. В ході аналізу встановлено, що функціональні групи спроможностей є різнорівневими. Їх доцільно поєднати у три класи: клас технічного оснащення, клас рівня підготовки особового складу і клас інституційних спроможностей. При цьому визначено, що носії спроможностей в залежності від рівня функціонування є різними за природою. Тому вони потребують оцінювання за різними складовими. Їх запропоновано розрізняти на: елементарні (зразки озброєння та військової техніки) та групові (підрозділи, військові частини, з'єднання, угруповання).

В результаті досліджень встановлено аналітичну залежність впливу елементарних носіїв спроможностей на ефективність виконання завдань груповими носіями спроможностей. Зазначений підхід буде реалізований в автоматизованій системі підтримки прийняття рішень в ході оборонного планування на основі спроможностей.

Застосування підходу дозволить зменшити вплив суб'єктивного фактору та скоротити час на прийняття обґрунтованого рішення щодо необхідного складу угруповання військ (сил) для виконання покладених завдань, оцінити достатню кількість варіантів його застосування. Крім того, реалізація запропонованого підходу надасть можливість визначити: кількісну та якісну потребу Збройних Сил України (сил оборони) в оснащенні зразками озброєння та військової техніки, необхідний обсяг ресурсів для розвитку Збройних Сил (сил оборони). Запропонований аналітичний метод дозволить без участі експертів оцінити роль кожного військового формування зі складу сил оборони, визначити пріоритетний план розвитку спроможностей Збройних Сил України (сил оборони)

Ключові слова: оборонне планування на основі спроможностей, носії спроможностей, функціональні групи спроможностей, угруповання військ (сил)

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ASSESSMENT OF CAPABILITIES OF MILITARY GROUPINGS (FORCES) BASED ON THE FUNCTIONAL GROUP "ENGAGE"

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1. Introduction

It is not possible to determine the structure of the armed forces, capable of providing defense of the state in the face of global changes (political, economic, power and others) without a comprehensive study of possible conditions of application. In this case, it is necessary to determine: the purpose, goals and ways of application, structure of tasks, which the armed forces must be ready to execute, the needs for resource provision for the development and retention.

High-quality provision and distribution of defense resources in the armies of the leading countries of the world is based on the modern scientific approach – the methodology for software-target planning. The leading countries of the world have

been using this methodology over the past decades, adapting it to the conditions of national economies and legislation. The modern Ukraine also follows this path.

The policy of Euro-Atlantic integration, which is determined in the "Annual national program under the auspices of the NATO-Ukraine Commission in 2018" [1] and in the NATO program "The process of planning and assessment of forces", is gradually implemented in the state. These programs identify measures for bringing the Armed Forces of Ukraine in full interoperability with the armed forces of the NATO countries.

One of the tasks of the defense reform in Ukraine is the development of the defense planning system as a component of the national planning system in the sector of security and defense. According to this task, the principles of defense planning used by the NATO member countries and modern methods of capability development, including the Capability Based Planning, are implemented. The ultimate goal of planning is the formation of predicted economic conditions of development of defense forces capabilities that are sufficient to perform these tasks.

However, the introduction of the method of capability based defense planning (CBDP) in practice of defense forces faces specific difficulties. On the one hand, the procedures of this method of planning are quite labor intensive. On the other hand, there are some unsettled issues in the regulatory-legislative base of the country. In addition, there are some difficulties of implementation in the practice of the Armed Forces of Ukraine of the defense planning experience of the leading countries of the world. This is related to the national features of the experience of military construction in Ukraine, the lack of rigidly regulated rules of defense planning in member countries of the NATO.

Capability based defense planning consists of four stages: *Planning, Programming, Budgeting, Execution control and analysis (PPBE).*

At the stage of Planning, an overall analysis of the development of military-political situation around Ukraine with prospects (for 10–15 years) is carried out. The following tasks are solved at this stage:

– to predict the dynamics of development of global and regional security;

– to study the factors that in the course of their development can lead to armed conflicts between states;

– to predict the ambitions of the own state;

– to study the conflicts, in the course of which military force can be applied.

This forms the basis for understanding the desired state of defense forces for a long term.

At the stage of programming the main problem is to determine the required amount of investments and rational allocation by the government programs. The tasks of this stage include: drawing up plans of increasing defense force capabilities of the state; determining the capabilities of the states to provide the defense forces with necessary resources.

At the stage of budgeting, the plan of the development of capabilities of the state is implemented through the use of the allocated resources by their distribution according to plan of the development of the capacities of defense forces of the state.

The fourth stage of defense planning (execution control and analysis) is one of the most important stages. At this stage, planners and people in charge of funds evaluate the quality of the achievement of ultimate results of planning, effectiveness of spending budget funds.

To perform these operations, it is necessary to determine the mechanism of distribution capabilities while defense planning. Therefore, one way of implementing the CBDP method in the practice of defense forces is the development of an automated decision support system (DSS) of defense process planning in the Armed Forces of Ukraine (defense forces).

The idea of a mechanism for the rational distribution of defense resources for the effective development of capabilities of the armed forces is known [2–12]. One of the implementations of the mechanism of the automation of the process of defense resources distribution [12] is shown in Fig. 1.

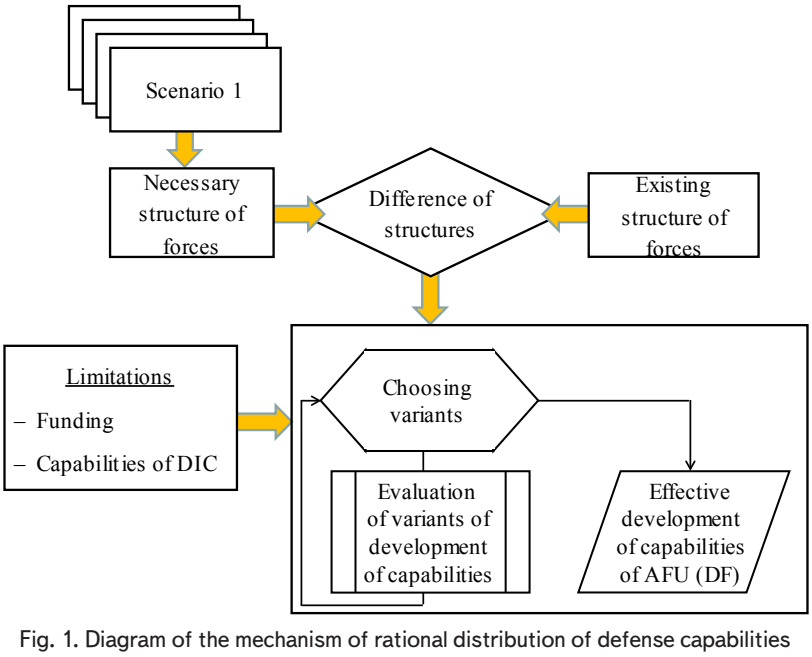

Fig. 1. Diagram of the mechanism of rational distribution of defense capabilities

To solve the problem of the rational distribution of defense resources, we used the following initial data: a set of scenario variants; the specified required structure of troops (forces) to perform the tasks by scenarios; the existing structure of the Armed Forces of Ukraine (defense forces) (AFU (DF)).

The capabilities of the military-industrial complex of the country (countries-partners), the amount of defense force financing act as restrictions.

In such problem statement, the difference between the existing and the required structure of troops (forces) determines the structure of forces that needs to be modified (to form, to reform, to disband) in due time for the effective implementation of tasks by the predictable scenarios.

Today, the problem of determining the desired composition of the AFU (DF) to perform the tasks by the scenarios are solved by the experts of the planning bodies of the General headquarters of the Armed Forces of Ukraine. The set tasks are solved without the use of modern automation means. This leads to some subjectivity in the course of determining the capabilities the AFU regarding the execution of set tasks. In addition, the limited capability for integrated comprehensive assessment of the variants of troops (forces) distribution for execution is noted.

Based on the above, the problem of the need to develop a decision support system that will reasonably and correctly determine the required structure of the AFU (DF) that is able to perform the tasks, set by scenarios, is relevant.

There are certain challenges in the course of solving the set task. Thus, the main normative base, which currently determines the procedure for capability-based defense planning in the Ministry of defense of Ukraine and the Armed Forces of Ukraine, is the following:

Recommendations on defense planning in the Ministry of defense of Ukraine and in the Armed Forces of Ukraine [13];

Unified list (catalog) of capabilities of the Ministry of defense of Ukraine and the Armed Forces of Ukraine [14];

Recommendations on organization of conducting capability evaluation in the Armed Forces of Ukraine [15].

In the Recommendations on defense planning in the Ministry of defense and the Armed Forces of Ukraine [13] (hereinafter referred to as Recommendations on DP), the concept of capability is defined.

Capability (operational, combat, special) is the ability of the structural unit (element) of the AFU (DF) or the totality of forces and means to perform certain tasks (to ensure implementation of the determined military objectives) under certain conditions of the situation, resource provision according to established standards [13].

Each structural unit (element) of the AFU (DF) can have more than one combat (special) capability and each capability can be implemented by more than one structural unit (element). The capabilities of troops (forces) are determined (detailed) by the standards that are specific to a structural unit (element) of each type (kind of troops) of the Armed Forces [13].

This definition of capability distinguishes between the concepts of "structural unit (element) of the AFU (DF)" and "their (author) capability to execute certain tasks under certain conditions, resource provision and in accordance with established standards". That is, a structural unit of the AFU (DF) is the carrier of these capabilities.

The capabilities carrier is expected to perform the set tasks with certain efficiency taking into consideration: conditions of the situation that occurred; the structure of troops (forces) of the parties, their state; determined standards for execution of a set task.

The list of capabilities carriers, the corresponding list of capabilities, references to standards of performance of certain tasks are contained in the Unified list (catalogue) of capabilities of the Ministry of defense of Ukraine and the Armed Forces of Ukraine [14] (hereinafter referred to as the Capabilities catalogue).

The order of organization of conducting the capability evaluation is determined in the Recommendations on the order of organization of conducting capabilities evaluation in the Armed Forces of Ukraine [15] (hereinafter referred to as Recommendations with OEC).

This document proposes the use of the expert methods during capabilities evaluation. It determines how to determine the capability level and identify the ways of improvement of the specified capability with the involvement of a certain group of experts. The proposed tool is important when solving problems that require non-trivial decisions in the course of a radical change in the situation, which significantly affects the capability evaluation mechanism. But on the other hand, this method means that a part of high-level experts will not be able to perform their official duties for a (long) period of time. Thus, according to the Recommendations on OEC [15], to evaluate a certain capability, it is necessary to create a working group of 10–12 people, including the head of the group; the secretary; an expert who can assess the capabilities of the enemy; a specialist knowing the techniques for conducting capabilities evaluation; a representative of the body of military management; a representative of the civil organization; a representative of a scientific institution; an expert of an inspection body; a representative of the unit that directly applies the studied object; an expert in evaluation of the predicted financial expenses; a representative of the body of purchasing armament and military equipment (AME).

However, the Capabilities catalogue [14] now contains 464 capabilities. Thus, it is even difficult to imagine how much time is needed to assess these capabilities and what group of specialists needs to be distracted from their direct official duties. It is also necessary to determine whether it should be required to create permanent working groups, because when it comes to last capability assessment, the evaluation of the first groups of capabilities can be hopelessly outdated.

Therefore, for the procedure of capabilities assessment, it is necessary to develop another method, which would not require creation of expert groups to assess a significant number of capabilities.

In addition, some other difficulties occur when implementing the capability-based defense planning method. Thus, the CBDP procedures require a considerable number of trained professionals. In the regulatory and legislative base of the country, there is no clear algorithm of realization of the CBDP method, the responsibility of certain officials (organizational structures) for the implementation of stages (phases) of defense planning were not determined. In addition, there are certain difficulties in "copying" defense planning experience of the leading countries of the world. National features of military building experience in Ukraine, the lack of rigidly regulated rules of CBDP in the member countries of NATO, on the one hand, lead to certain freedom of action, and on the other hand, cause the necessity of independent development of its national capability-based defense planning method, focused on threats.

2. Literature review and problem statement

The idea of a mechanism for rational allocation of defense resources for the effective development of the capabilities of the armed forces in conceptual terms was borrowed from the leading experts on defense planning.

Thus, a renowned expert in CBDP, Program Director of the Research Center on the problems of state security and defense of the Bulgarian Academy of Sciences, Dr. Todor Tagarev reveals the problem of the place of defense planning in the defense policy of the country in his work [2]. He specifies time dimensions of defense planning, suggests alternative approaches to defense planning, and considers linking policy goals to the structure of the armed forces.

A more detailed consideration of the concept of defense capability management is described in a paper by Gerd Frorat, the former head of the military budget department, the financial advisor to the Commander in Chief of the armed forces and the head of the Center of accounting, finance and analysis of the armed forces of Germany [3]. The author in his work points out the difficulties and problems associated with defense funding management. He tells about the rules of budgetary funds allocation and points out the

need for taking into consideration the international norms and standards in the field of financial management.

It is possible to get acquainted with certain specific features of the defense management areas in the papers of other well-known specialists on this issue. Thus, the Project Director of the European research center of security problems named after George K. Marshall Jack Treddenik reveals the essence of human resources management [4]. The senior researcher of Tallinn International Centre for defense studies, Anthony Lawrence in his papers [5] deals with the problem of the features of management in the procurement area.

There are some known regulatory and guidance documents that can be used to understand the capability-based defense planning procedure.

Thus, it is possible to determine the stages and main steps of carrying out the defense planning procedure in the guidelines on capability-based defense planning [6]. The paper by Kegan Mark [7] focuses on the principle algorithm of the capability-based defense planning procedure. The issues regarding the specificity of allocation of the financial defense budget, procedures of its implementation can be studied in publications [8, 9]. Specifics of the defense planning procedure in the countries of the NATO block can be explored in publications [10, 11].

The above scientific publications [2–11] provide a solid foundation for solving the set task of the effective implementation of the capability-based defense planning procedure. However, the authors do not go beyond conceptual understanding of the problem. This is due to the fact that specific features of the state structure, the legislative framework of the country and the other have a significant impact on solving the set task.

Some attempts to solve this particular issue with taking into consideration the national features of the implementation of the capability-based defense planning procedure can be found in the national periodical scientific publications. But they also have certain shortcomings.

Thus, it is possible to separate two groups of articles. Some of them are of the conceptual nature [17–19, 21–24], which does not make it possible to address the issues of practical calculations in the course of implementing the CBDP procedures. The others are aimed at solving the set task without taking into consideration the influence of capabilities [16, 20].

Thus, for example, in the article [16], the authors offer theoretical and methodological bases regarding the system of effective planning management and the use of the programs of the AFU development. In this case, it is proposed to use the method of expert-significant intermediate scenarios. The article does not contain any practical methods for effective planning of the programs of the AFU development.

Article [17] proposes the method for evaluation of the level of military and economic security of a country. But the authors do not go beyond conceptual schemes and the list of threats to the military and economic security of Ukraine. There is no clear idea about how to calculate the level of the military and economic security. That is, the mechanism of this assessment is not specified.

Article [18] proposed the method for statement of activities and tasks in the programs of the AFU development. The disadvantage is the lack of a mechanism for evaluation of the necessary and existing capabilities. Based on this, the authors address the method of expert estimations. This method requires prior work regarding the selection of highly qualified experts and has a subjectivity factor.

Article [19] proposed the technique of allocation of the defense budget of Ukraine to the components of the defense forces. The authors propose to allocate the budget to the components of the defense forces, depending on the account of the share of defense forces units that take part in execution of defense tasks. This is an approach, which makes it possible to obtain certain quantitative estimates. But it is quite rough and does not take into consideration the needs of these components of the defense forces, the tasks that they must perform according to the scenarios and capabilities and importance of formations to execute the set tasks. This leads to ambiguity in calculations.

An extensive list of political, economic, demographic, material and technical indicators is used in article [20] to substantiate the amount of the AFU. But this work does not cite the parameters that determine the required structure of the AFU (DF) to execute the task by predictable scenarios. The used indicators can act just as restrictive in the course of the implementation of the necessary quantitative and qualitative structure of the AFU.

In article [21], the authors raised the issue of the necessity of resources-based planning, but it is explored only at the conceptual level. The authors provide information in the generalized-algorithmic form. This does not make it possible to use the results obtained by the authors in practice.

In article [22], the authors developed the ideas concerning the prospects of the development of the defense planning system by determining the need for resources of the elements of the organizational structure of troops (forces). These conceptual views do not make it possible to use them in practice.

The authors of article [23] offer the original scheme of the interdependence of the processes of defense planning, operational planning and budget planning. The stages of defense planning are described quite thoroughly.

In article [24], the authors provided practical proposals on the transformation of a mechanized battalion into a heavy battalion. This is an interesting research result as a special case of transformation, which requires studying for the development of the mechanism of transformation of AFU groups.

3. The aim and objectives of the study

The purpose of this study is to determine the ways of evaluation of capabilities of grouping of troops (forces) during the execution of the tasks under certain scenarios.

To accomplish the goal, the following tasks were set:

– to identify how capabilities carriers are characterized through functional groups of capabilities;

– to determine the way how to correlate multi-dimensional capabilities carriers (such as a tank company and a tank);

– to determine how to correlate different carriers of capabilities (such as a tank company and a repair company);

– to determine how to evaluate capabilities of a grouping of troops (forces) during solving the tasks on purpose.

4. Materials that address the ways to estimate the capabilities of groupings of troops (forces) based on functional groups

4. 1. Determining the carriers of capabilities based on functional groups. Mutual influence of carriers of capabilities

Subdivisions, units, formations, and accordingly, groupings of troops (forces) formed on their basis, are known to be

the main carriers of capabilities. All the known capabilities of the AFU (DF) can be united into certain functional groups of capabilities [11]. The following functional groups of capabilities are known:

– ENGAGE – covers the capabilities of units and subdivisions of the kinds and types of troops (forces) to implement the key tasks for the purpose;

– FORCE SUPPORT – covers the capability to train AFU (DF) for defense;

– deployment and mobility of troops (PROJECT) – covers the capabilities of delivery facilities, training troops (forces) to advance to areas of destination;

– SUSTAIN – covers the capabilities in the field of combat, rear, technical and medical support;

– CONSULT, COMMAND & CONTROL – covers the capabilities of the control bodies to control the use of troops (forces);

– PROTECT – covers the capabilities to provide protection against threats from the air, sea, anti-mine fight, PCB protection, etc.;

– reconnaissance (INFORM) – covers the capability of reconnaissance, surveillance and targeting;

– cooperation in the field of security and defense (PREPARE) – covers the capabilities to ensure regional security by providing (obtaining) assistance with building up the operational capacities of partner countries (capabilities of national forces and facilities);

– military and political control, resource management (CORPORATE MANAGEMENT & SUPPORT) – covers the capabilities for regulatory and legal support, capabilities development planning, resourcing, budget planning and accounting.

Capabilities carriers at the physical level are samples of the AME, which execute their task with certain effectiveness. If we take into consideration one of the elementary capability's carriers (such as a tank), it becomes clear that it consists of certain units. The quality of functioning of units is evaluated through certain characteristics. All characteristics can be attributed to certain functional groups of capabilities (Fig. 2).

The formula expression that combines the elements of functional groups of capabilities into one cumulative assessment of an elemental capabilities carriers are listed below (1).

$$E_{AME} = K_u \cdot f(E_u) + K_r \cdot f(E_r) + K_m \cdot f(E_m) + \\ + K_b \cdot f(E_b) + K_g \cdot f(E_g) + K_z \cdot f(E_z) \quad (1)$$

Formula expression (1) contains six functional groups out of nine. These are the following functional groups: E_u is the integration of the AME sample into the general system of control; E_r is the reconnaissance capabilities of the AME sample; E_g is the survivability of the AME sample; E_b is the firing capabilities of the AME sample; E_z is the provision (autonomy) of the AME sample; E_m is the maneuvering capabilities of the AME sample.

The following functional groups of capabilities were left out of the focus of the integrated capability of an elemental carrier of capabilities of the AME sample:

E_q is the readiness to execute tasks. This functional group is determined by the level of personnel training regarding the use of the AME sample for the purpose both individually and as a part of the unit [25]; E_{DIC} is the military-political guidance, resource management, E_{csd} is the cooperation in the field of security and defense. These functional groups of capabilities are of the institutional character (military-political level of governing the state) and perform the functions of resource provision of the AFU (DF) for their effective execution of tasks on purpose. The estimation of the last two functional groups of capabilities is determined by the result of the calculation of the required amounts of resources in order to bring the structure of the AFU in conformity for effective functioning under the expected scenarios. This takes into consideration the capabilities of the military-industrial complex of Ukraine and partner countries concerning the implementation of the program of the AFU (DF) development.

Thus, having analyzed the functional groups of capabilities, it is possible to conclude that by their purpose they can be divided into three classes. The class of technical support – functional groups of capabilities: "Engage", "Corporate management and support", "Force support", "Inform", "Project", "Protect", "Sustain". The class of the level of personnel training is the functional group of capabilities "Readiness to perform tasks". The class of institutional capabilities is the functional groups of capabilities: "Corporate management and support", "Prepare".

In addition, after grouping the functional capability groups for each carrier by a particular rule, there is a possibility to determine its cumulative capability. The methods of grouping functional groups of capabilities in a certain cumulative capability are known. For example, this procedure may be implemented by the methods of regression analysis. In the case of a limited data sample for determining mathematical models of influence of the functional groups on the cumulative capability of each typical AME sample, it is proposed to use the combinatorial method with a limited base of arguments (Fig. 3). The information on this matter contained in open sources in given in the list of literature [26–30].

This technology for determining the general formula expression for capabilities carriers of one type makes it possible (Fig. 4):

– to determine the weight of the functional groups of capabilities of the AME sample when solving the tasks for the purpose;

– to determine the state of its capabilities (even long-term).

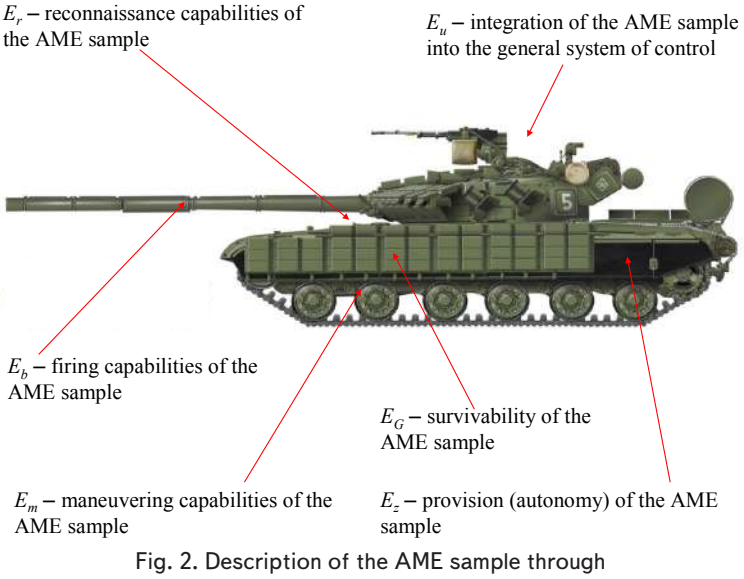

Fig. 2. Description of the AME sample through known functional groups of capabilities

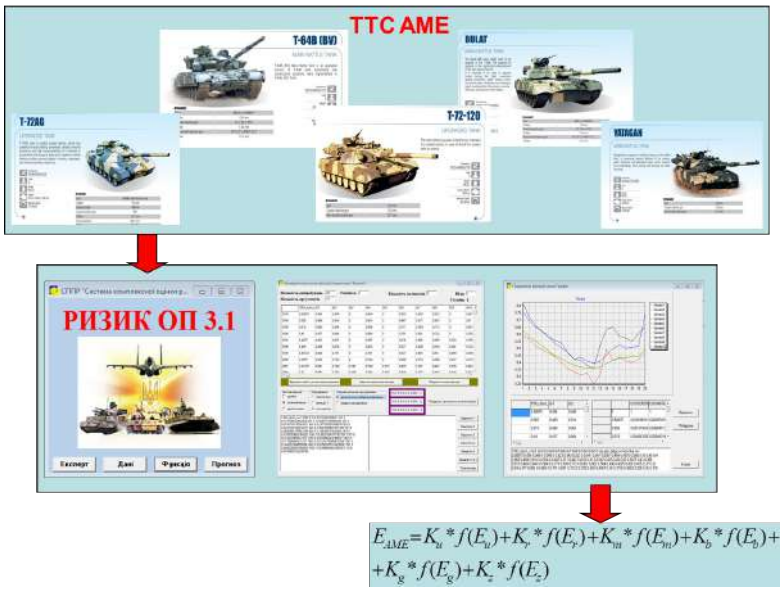

Fig. 3. The principle of functioning of the software product for determining the general formula expression for capabilities carriers of one type

$$E_{AME(\text{tank})}=0{,}1*f(E_u)+0{,}14*f(E_r)+0{,}14*f(E_m)+0{,}24*f(E_b)+$$
$$+0{,}17*f(E_g)+0{,}21*f(E_z)$$

E_u - integration of the AME sample into the general system of control;
E_r - reconnaissance capabilities of the AME sample;
E_m - maneuvering capabilities of the AME sample;
E_z – provision (autonomy) of the AME sample;
E_b - firing capabilities of the AME sample;
E_g - survivability of the AME sample.

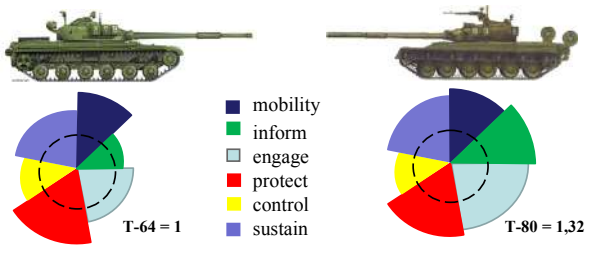

Fig. 4. Comparison of the capabilities of elementary carriers of capabilities to determine the capability of the AME by known TTC

The effectiveness of functioning of a group carrier of capabilities (subdivision, unit, formation, grouping of troops (forces)) depends not only on its own capabilities. During combat actions (operations), the effectiveness of execution of the set tasks also depends on how the enemy will permit to implement own capabilities.

Thus, the main component of the integrated capability is the functional group of capabilities that meets the purpose of the group carrier of capabilities "Engage" of troops (forces) (E_{fb}). The cumulative capability of a group carrier of capabilities when confronting the enemy forces can be reduced through:

– an insufficiently effective control system (functional group "Consult, command and control) ($E_{fu}\epsilon$R [0..1]);

– weak reconnaissance capabilities of a grouping (functional group "Inform") ($E_{fr}\epsilon$ R [0 .. 1]);

– limited possibilities regarding the modification of the operative construction of troops during the operation (functional group "Project") ($E_{fm}\epsilon$R [0...1]);

– an insufficient level of capabilities regarding ensuring survivability of a grouping (functional group "Protect") ($E_{fg}\epsilon$R [0...1]);

– insufficient possibilities regarding ensuring performance of military actions by a grouping (functional group "Sustain") ($E_{fz}\epsilon$R [0...1]);

– limited readiness of troops (forces) regarding the execution of tasks for the purpose (functional group "Force support") ($E_{fq}\epsilon$R [0 .. 1]).

The general formula expression of evaluation of the cumulative capability of a group carrier of capabilities is shown in (2).

$$E_f = E_{fb}\cdot E_{fu}\cdot E_{fr}\cdot E_{fm}\cdot E_{fg}\cdot E_{fz}\cdot E_{fq}. \qquad (2)$$

In the course of the evaluation of capabilities of a grouping of troops (forces), certain scenarios are implemented taking into consideration the possible structure, state and intentions of enemy forces, other important features of conducting military actions that could affect the outcome of confrontation (Fig. 5).

For this purpose, the scenarios are determined that may arise in specific future, which will expectedly cause the need for using defense forces to solve the crisis. For each of the scenarios, the tasks, which defense forces must solve to obtain a positive result of application, are determined. In this case, assessment of the capability to execute a specific task by a certain structure of the defense force is selected based on the defined standards of task execution by the groupings of defense forces. Comparing the possible options of the structure of own forces to solve the set task in terms of the minimum cost of its solution, the required structure of the AFU (DF) is determined.

After comparing the required structure of defense forces with the existing structure, the necessary structure that needs to be built up within a specific term for execution of specified tasks for the purpose in full degree is determined. Hence, there arises a requirement for the necessary level of funding of the defense forces of a country. But, typically, there is a shortage of financial resources to solve the set tasks. In this case, the task is solved on rational distribution of the allocated financial resources for defense for effective development of capabilities in order to maximally meet the needs of defense of a country.

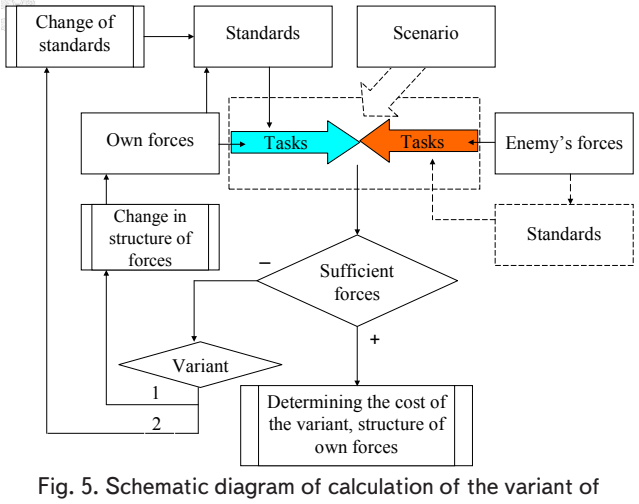

Fig. 5. Schematic diagram of calculation of the variant of solving the tasks of a grouping of troops (forces) under specified scenario

4. 2. Procedure for determining group carriers of capabilities based on the functional group of capabilities "Engage"

The main component of the integrated capability is the functional group of capabilities "Engage". The functional group of capabilities "Engage" is intended to assess the operative (combat) capabilities of troops (forces). The original data for evaluation of operative (combat) capabilities of troops (forces) include: specific features of action of own troops and the enemy's troops, the structure of forces of the parties, peculiarities of the areas, seasons and other important factors.

The potential capability regarding the infliction of damage to the enemy is assessed for each party (Fig. 6).

For such assessment, it is necessary to possess the information about the fighting capabilities of the constituent elements of a grouping of troops (forces).

The basis for calculating firing capabilities of a grouping of troops is fighting capabilities of the AME samples, calculated through reduced ammunition (a).

The effective depth of dislocation in the operative structure of the own forces is determined for the specified AME samples depending on the nature of warfare, specific features of the terrain and seasons.

Based on the dislocation (in the case of simplification of calculations, it is the depth of the dislocation), the radius of the effective application of the OVT sample for enemy's facilities (groups of OVT samples) is determined.

Based on these data, the table of the availability depth of OVT samples facilities is formed. On the other hand, the calculation of the expected location (location depth) of the enemy's facilities and protection from the application of the OVT samples are calculated.

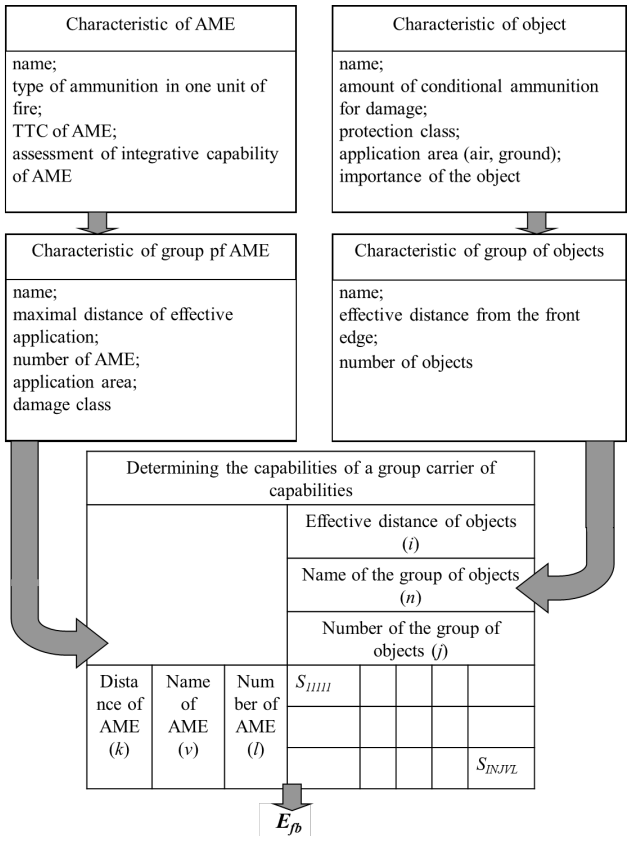

Fig. 6. Estimation of firing capabilities of a grouping of troops (forces)

5. Results of study into the impact of forces of a party on objects of the opposing party with respect to the functional group of capabilities "Engage" of troops (forces)

The idea of calculations implies the calculation of the possibility of influence of the weapons of the parties on the enemy in the whole depth of its location. The possible location of the objects that can be under the target influence of the enemy is taken into account on the linear projection. In this case, the option of distribution density of the location of an object in the operative building of troops (forces) is selected (by default the uniform distribution law is accepted).

Thus, for example, a certain operative construction of troops (forces) of motorized infantry division (Fig. 7) is presented in the table that defines: the name of the element; the number of elements of the same type with the same conditions of location and structure; the distance of the element from the front edge towards the depth (from the first line of the main area of defense); the importance of the element in the course of solving the set task; the number of typical shots, which is enough to defeat the object (Table 1).

Table 1

Characteristics of objects of motorized infantry division in defense

Name	Number of elements	Distance min–max, km	Importance	Number of shots
FCP mid	1	15–25	50	50
BCP mid	1	20–35	100	75
RCP mid	1	40–50	75	75
CP 1,2 mibr	2	10–20	50	50
11,12,21,22 mib	4	0–10	20	200
13,23 tb	2	0–10	25	300
15,25 ib	2	0–10	15	150
51,52 rc	2	0–5	15	40
16,26 sadn	2	5–10	25	100
61,62,63 zrabatr	3	10–20	25	50
17,27 eatc	2	0–20	25	50
41 adnGFA	1	5–15	30	100
42 radnGFA	1	10–20	40	100
14,24 tb	2	0–20	25	200
CP 3 mibr	1	10–40	50	50
31,32 mib	2	0–35	25	200
33,34 tb	2	0–35	30	300
36 sadn	1	5–35	30	100
37 eatc	1	0–35	30	50
64,65,66 zrabatr	3	25–35	25	50
71 tal	1	35–40	35	150
81 ebr	1	25–35	30	300
82 bRChBd	1	25–35	15	100
Total	39			4,630

Based on the possible location of the objects in the course of the operation (combat), the axis of the required intensity of use of weapons on the enemy's facilities is formed from the front edge (Table 2). The diagram of the required intensity of use of weapons on the areas of the expected location of the objects of first party is shown in Fig. 8.

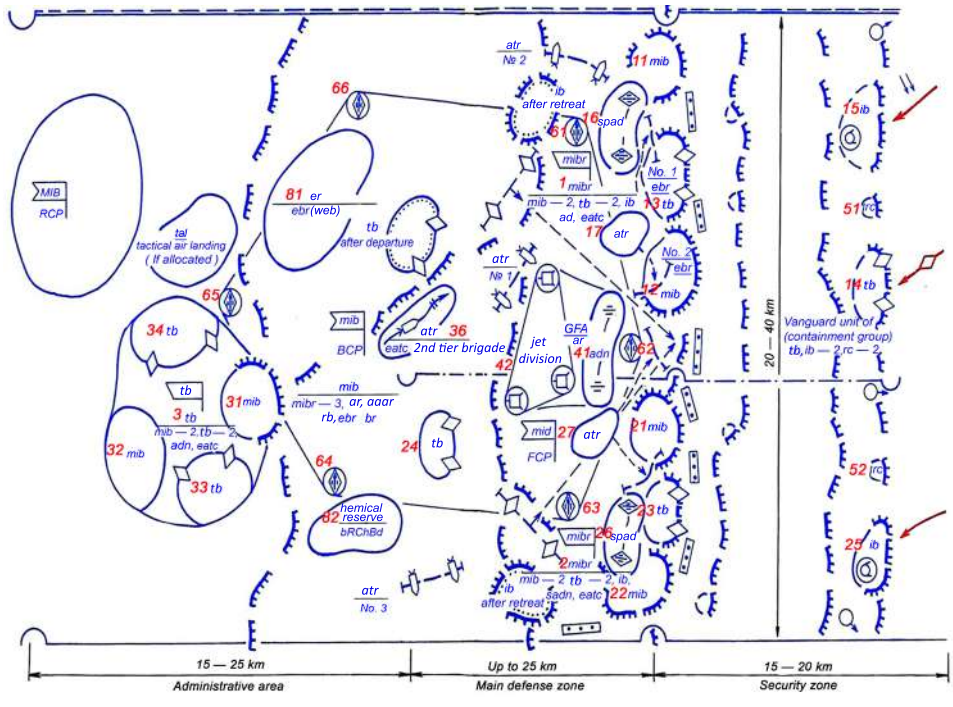

Fig. 7. Battle formation of motorized infantry division in defense,

In the face of the shortage of typical ammunition to defeat the enemy's objects, it is necessary to know the areas of the most effective use of weapons. To do this, the required zonal specific weight of weapon application (W_j) is determined from the formula expression (3).

$$W_j = \sum_{i=1}^{I}\left(\frac{B_i}{N_i}\cdot\frac{N_{ij}}{N_j}\right), \qquad (3)$$

where B_j is the determined importance of an object that is located in given zone; N_j is the total number of typical shots, sufficient for defeating the objects in the given zone; N_i is the total number of typical shots, sufficient to defeat the facilities; N_{ij} is the mathematic expectation of the number of typical shots, sufficient for defeating an object taking into consideration the probability of its location in given zone and probable location in other zones; i=1...I is the number of objects of the enemy to be defeated; j=1...J is the number of conditional zones of operative construction of a grouping of the enemy.

The calculation of the necessary zonal specific weight of weapon application is shown in Table 3. The diagram of the zonal specific weight of weapon application is shown in Fig. 9.

Table 2

Mathematical expectation of using typical shots by the probable dislocation of objects of motorized infantry division in the course of the operation (combat actions)

Name of element/ distance from the front edge	0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50
FCP mid				25	25					
BCP mid					25	25	25			
RCP mid									37.5	37.5
CP 1,2 mibr			50	50						
11,12,21,22 mib	400	400								
13,23 tb	300	300								
15,25 ib	150	150								
51,52 rc	80									
16,26 sadn		200								
61,62,63 zrabatr			75	75						
17,27 eatc	25	25	25	25						
41 adnGFA		50	50							
42 radnGFA			50	50						
14,24 tb	100	100	100	100						
CP 3 mibr			10	10	10	10	10			
31,32 mib	57.1	57.1	57.1	57.1	57.1	57.1	57.1			
33,34 tb	85.7	85.7	85.7	85.7	85.7	85.7	85.7			
36 sadn		16.7	16.7	16.7	16.7	16.7	16.7			
37 eatc	7.1	7.1	7.1	7.1	7.1	7.1	7.1			
64,65,66 zrabatr						75	75			
71 tal								150		
81 ebr						150	150			
82 bRChBd						50	50			
Total	1,204.9	1,391.6	526.6	501.6	216.6	476.6	476.6	150	37.5	37.5

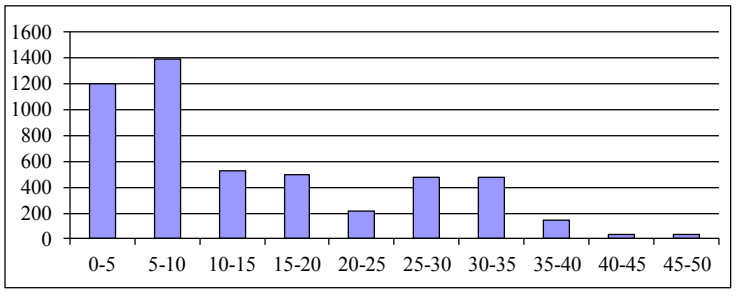

Fig. 8. Mathematical expectation of using typical shots at probable dislocation of facilities of motorized infantry division

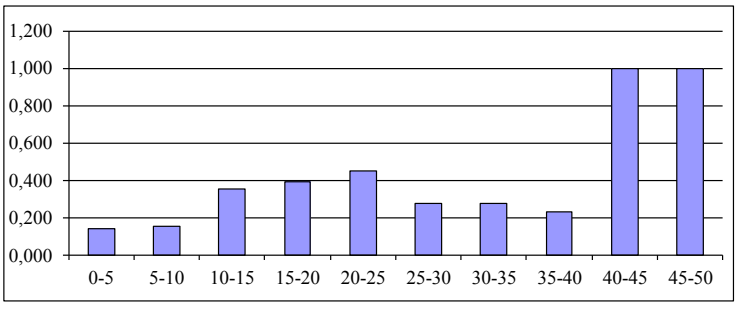

Fig. 9. Calculation of necessary zonal specific weight of weapon application

The impact of weapons of all defeating potential is traditionally reduced to the typical shot. The need for ammunition for destruction of a certain object is also calculated in typical shots.

No doubt, the proposed diagram of the necessary zonal specific weight of the weapon application will be subsequently corrected after taking into consideration the effectiveness of characteristics of a grouping for other components of functional groups of capabilities.

When calculating the quantitative impact of the parties in the course of warfare (operations), the possible number of shots is calculated through reciprocal characteristics of the opposing groups. Thus, when determining the number of shots that can be made by the AME sample, the ratio of combat potentials of the parties for a certain AME type is taken into account. If there are several modifications of AME samples type, the average fighting potential ($E_{AME\Sigma}$) is calculated (4).

$$E_{AME\Sigma} = \frac{\sum_{i=1}^{n}(E_{AME}(i)\cdot N_{AME}(i))}{\sum_{i=1}^{n} N_{AME}(i)}, \quad (4)$$

where $E_{AME}(i)$ is the effectiveness of functioning of the AME sample of the i-th type; $N_{AME}(i)$ is the number of the AME samples of the i-th type.

Thus, if the combat potentials of a certain kind of AME of the parties are not the same, the number is recalculated. During the recalculation, the number of AME samples with less combat potential decreases (the potential possibility of application in relation to the best AME samples decreases). But the recalculation refers to the same number of OVT samples.

Table 3

Calculation of zonal specific weight of typical shots

Name of the element/ distance from front edge	0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50
FCP mid				0.05	0.115					
BCP mid					0.154	0.07	0.07			
RCP mid									1	1
CP 1,2 mibr			0.095	0.1						
11,12,21,22 mib	0.033	0.029								
13,23 tb	0.031	0.027								
15,25 ib	0.012	0.011								
51,52 rc	0.025									
16,26 sadn		0.036								
61,62,63 zrabatr			0.071	0.075						
17,27 eatc	0.01	0.009	0.024	0.025						
41 adnGFA		0.011	0.028							
42 radnGFA			0.038	0.04						
14,24 tb	0.01	0.009	0.024	0.025						
CP 3 mibr			0.019	0.020	0.046	0.021	0.021			
31,32 mib	0.006	0.005	0.014	0.014	0.033	0.015	0.015			
33,34 tb	0.011	0.009	0.024	0.026	0.059	0.027	0.027			
36 sadn		0.004	0.010	0.010	0.023	0.011	0.011			
37 eatc	0.004	0.003	0.008	0.008	0.020	0.009	0.009			
64,65,66 zrabatr						0.079	0.079			
71 tal								0.23		
81 ebr						0.031	0.031			
82 bRChBd						0.016	0.016			
Total	0.143	0.152	0.355	0.392	0.450	0.278	0.278	0.230	1.000	1.000

Example 1.

To determine the relative number of tanks and corresponding number of shots of opposing parties. On condition that:

party 1 – T-64 – 100 pieces.; c/p=1.00; 32 shots in each tank (totally 3,200 shots);

party 2 – T-90 – 50 pieces.; c/p=1.30; 40 shots in each tank (totally 2,000 shots).

Calculation.

Combat potential is in favor of side 2. That is why side 1 will be subject to recalculation.

The relative assessment of combat potentials ACP=1/1.3=0.77.

That is why the reduced number of tanks T-64 will make up: 50+50·0.77=88.5 pieces (totally 2,832 of reduced shots).

In this case, at the next stages of calculations, the capabilities of reconnaissance, firing capabilities (distance, accuracy, destructing effect of a shot), possibilities regarding control the AME sample, etc. remain tabular.

In addition, if party 1 has more equipment with greater combat potential than party 2, the combat potential of this party decreases several times before reaching the full consideration of the effect.

Example 2.

To determine the number of tanks and corresponding number of shots of opposing parties. On condition that:

party 1 – T-64 – 40 pieces; c/p=1.00; 32 shots on each tank (totally 1,280 shots);

party 2 – T-90 – 50 pieces; c/p=1.30; 40 shots on each tank (totally 2,000 shots).

Calculation.

Combat potential is in favor of party 2. That is why party 1 is subject to recalculation.

Relative assessment of combat potentials ACP=1/1.3=0.77.

So, the reduced number of tanks T-64 will make up: 30·0.77+10·0.77·0.77 = 29.03 pieces (totally 929 reduced shots).

Thus, the general formula expressions for calculating the reduced amount of equipment depending on the physical quantity and the famous combat potentials are shown below (5).

For $c/p_1<c/p_2$:

$$\begin{cases} \hat{N}_1 = N_2 \cdot \left(\dfrac{c/p_1}{c/p_2} + \dfrac{N_1}{N_2} - 1 \right), \\ \hat{N}_1 = N_2 \cdot \dfrac{c/p_1^{\left[\frac{N_1}{N_2}\right]}}{c/p_2} \cdot \left(1 + \left(\dfrac{N_2}{N_1} - \left[\dfrac{N_2}{N_1} \right] \right) \cdot \left(\dfrac{c/p_1}{c/p_2} - 2 \right) \right), \end{cases} \quad (5)$$

where [*] is the integer part of the number; N_1, N_2 are the total amount of equipment of a certain type of parties; $\hat{N}_1$ is the calculated reduced number of equipment of a certain type of party 1; c/p_1; c/p_2 are the combat potentials of equipment of the parties.

6. Discussion of the results of research into assessment of carriers of capabilities with the use of functional groups of capabilities

The determined Order of the organization of conducting capabilities evaluation [15] suggests using the expert methods of evaluation. Obviously, this is a compromise nowadays. The expert methods of evaluation require considerable time of working on a specified problem. They need constant distraction of a certain number of leading specialists from performing their functional responsibilities. This method is characterized by subjectivity.

Solving the problem of evaluation of capabilities of a grouping of troops (forces) by automating these procedures is elimination of the main defects of the modern Order of organizing evaluation of capabilities, which is used in the Ministry of Defense of Ukraine and in the Armed Forces of Ukraine, and when the Law of Ukraine "On the national security of Ukraine" is passed, it should be applied to all defense forces of the country.

Compared with the Order of organization of conducting capabilities evaluation, the proposed Method of evaluation of capabilities of a grouping of troops (forces) by automating these procedures has certain drawbacks. Thus, during its development, the Method will require significant efforts on the part of leading specialists of certain direction of activities of the AFU (DF). The above-mentioned specialists are required to develop a mathematical model of the processes that are carried out in the course of solving specific tasks. However, on the other hand, once created, the Method of evaluation of capabilities of a grouping of troops (forces) will make it possible to obtain an effective estimation of capabilities without participation of experts – specialists of high qualification.

During the development of the Method of evaluation of capabilities of a grouping of troops (forces), the existing regulatory base was taken into consideration [13–15]. One of the key points of evaluation of capabilities carriers is their characteristic through the functional groups of capabilities. These functional groups are of different levels, and in the opinion of the authors of the article, such a division is not quite optimal. But with the aim of the better adaptation of the Method to the modern regulatory base, it was proposed to select three classes of functional groups of capabilities: the class of technical equipment, the class of the level of personnel training and the class of institutional capabilities. This made it possible to bring certain clarity into the list of the proposed functional groups of capabilities.

On the other hand, a different nature of carriers of capabilities was emphasized. Thus, at the level of the AME, carriers of capabilities are technical in nature. At the level of groupings, carriers of capabilities are organizational in nature. It was therefore proposed to distinguish between elementary (physical) carriers of capabilities and group carriers of capabilities. To estimate the characteristics of elementary carriers of capabilities, it was proposed to apply the combinatorial method with the limited base of arguments, developed by the authors.

This article started solving the problematic issue concerning determining the desired structure of defense forces for scenarios in the specified term. The method for determining group carriers of capabilities for the functional group of capabilities "Engage" was proposed as an example. In subsequent studies, it is planned to reveal the approaches to evaluation of capabilities for functional groups "Consult, command and control", "Force support", "Inform", "Project", "Protect", and "Sustain".

In the future, after the development of the method of evaluation of capabilities and including it into the technique of development of the plan for rational development of the AFU (DF) taking into consideration the limitations by financial defense resources, it is necessary to address the problem of taking into consideration the risks of the failure to fulfill the plan of rational development of the AFU (DF) in the course of its implementation.

7. Conclusions

1. It was determined that the functional groups of capabilities can be divided into three classes: the class of technical equipment of capabilities carriers (functional groups of capabilities: "Engage", "Consult, command and control", "Force support", "Inform", "Project", "Protect"); the class of personnel training level (functional group of capabilities "Readiness to execute tasks"); the class of institutional capabilities (functional groups of capabilities: "Corporate management and support", "Prepare").

2. Capabilities carriers are divided into elementary (physical) and group carriers. Elementary capabilities carriers include samples of armament and military equipment. They can be described through the functional groups of capabilities related to the class of technical equipment. In turn, the group capabilities carriers (military formation, grouping of troops (forces)) can be described through the classes of technical equipment of capabilities carriers and the level of personnel training.

3. The effectiveness of execution of a task according to the scenario by a group carrier of capabilities depends on:

– the influence of the enemy (enemy's capabilities regarding the execution of tasks);

– effectiveness of implementation of capabilities by elementary carriers of capabilities that are the basis of efficiency of functioning of a group carrier of capabilities;

– effectiveness of implementation of capabilities according to functional groups of capabilities.

4. Integrated capability regarding the execution of tasks in the course of operations (combat actions) depends on the capabilities to perform necessary functions by seven functional groups of capabilities:

– functional group of capabilities "Engage", which corresponds to the purpose of a group carrier of capabilities of troops (forces);

– functional group "Consult, command and control" determines effectiveness of the control system;

– functional group "Inform" determines reconnaissance capabilities of a grouping;

– functional group "Project" determines the capabilities regarding an operative change in the construction of troops;

– functional group "Protect" determines the capabilities of a grouping regarding ensuring its survivability;

– functional group "Sustain" determines the effectiveness of implementation of capabilities regarding ensuring conduction of military operations;

– functional group "Force support" determines the level of readiness of troops (forces) regarding the execution of tasks for the purpose.

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