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## **FORMALIZED MATHEMATICAL MODEL FOR ASSESSING THE COMBAT CAPABILITY OF MILITARY UNITS**

*It is noted that combat readiness characterizes the ability of a military unit to perform a combat mission and is being a defining element of its combat readiness. The factors on which combat readiness depends are given.*

*A formalized mathematical model for assessing the combat readiness of military units for performing the assigned tasks has been developed, which is being a system of analytical dependencies. A control algorithm that implements a formalized model for assessing the combat readiness of military units for performing the assigned tasks has been proposed.*

**Keywords:** *formalized mathematical model, control algorithm, combat readiness, military unit, factors.*

**Statement of the problem.** The violation of the inviolability and territorial integrity of Ukraine as a result of the armed aggression by Russia and the terrorist nature of conducting military operations on the territory of our country have caused significant losses to its economy and the well-being of the population. These factors have focused attention on the problems of increasing the level of defense capability of the state [1, 2].

Modern war is a test of the material and spiritual forces of the people, the state, and the armed forces, which prompts each country to maintain its defense capability at such a level as to guarantee the reliable protection of society. The defense capability of the state is characterized by the ability to defend itself in case of armed aggression or armed conflict. The ability of the state to ensure military security depends on its military potential. The military power of the state is the sum of forces and means allocated by the state from the military potential for a certain period to protect its interests; the realized part of the state's military potential.

The direct military power of the state is embodied in the armed forces, the ability of the state to maintain and improve them, increase their combat readiness, replenish with trained personnel, provide modern weapons and military equipment (WME) and all types of supply in peacetime and wartime. The units of the Armed Forces of Ukraine (AFU) together with the units of the National Guard of Ukraine (NGU) ensure the deterrence of the armed aggression against Ukraine and repel it, © H. Ivanets, S. Horielyshev, M. Ivanets, 2024

protect the state border of Ukraine, and also participate in measures aimed at combating terrorism [3, 4].

In modern conditions, in case of new military threats to the national security of Ukraine, decisive importance is given to the readiness of the personnel of the Armed Forces of Ukraine (AFU) and the National Guard of Ukraine (NGU) to perform the assigned tasks, that is, its combat readiness. The basis of combat readiness is combat capability. Combat capability is the ability to conduct combat operations, perform combat tasks [1]. In other words, combat capability characterizes the ability of a military unit or a subdivision to perform the assigned tasks, in particular to conduct combat operations. It is determined by the degree of staffing, the state of WME, the level of personnel training, its moral and combat qualities, the coordination of units and staffs, the provision of material means and other factors [1].

Therefore, currently the development of a formalized mathematical model for assessing the combat capability of military units is being a relevant scientific and practical problem in the military sphere.

### **Analysis of recent research and publications.**

Today there exist two views on the concept of combat capability and combat readiness among scientists [5]. Some scientists consider combat capability to be an element of combat readiness, while others – on the contrary, assert that combat

readiness is an element of combat capability. This is explained by the close interconnection of the concepts mentioned above.

We will base on the fact that combat capability is the ability of a unit to fulfil the assigned combat task. The combat capability of a unit is a defining element of its combat readiness and is characterized by the degree of its readiness to perform combat tasks. The main indicators of the combat capability of a unit are the technical condition of WME, the reliability and size of the technical resource, the availability of trained personnel (crew, service), ammunition equipment, means of transportation and supply, completeness with spare parts, tools, accessories and operational documentation, the time to bring them to readiness for the combat use in any conditions of the situation [6].

In the article [7], the authors interpret combat capability as the ability to conduct combat operations and perform combat tasks. Accordingly, among the factors that determine the level of combat capability, we can also mention the following: the degree of staffing, the state of weapons and the availability of military equipment, the level of personnel training, its moral and combat qualities, the coordination of units and staffs, the provision of material means, etc.

The authors of the article [8] interpret combat capability as a "defining state of the ability of troops (units, employees) to conduct combat operations, perform combat tasks". The level of combat capability depends on the staffing of units and formations, the nature and intensity of combat operations, losses and the possibility of their rapid replenishment, the training of personnel, the provision of material means, etc.

In the publication [9], the combat readiness of the forces (troops) of NATO countries is defined as a combination of three different but closely coordinated indicators: readiness of material and technical support, combat capability, combat readiness of individual units.

The authors of the publication [10] consider combat readiness as the ability of troops to conduct combat operations for a certain period of time, and the state of combat readiness is determined by the level of training and equipping of units, the state of their training, the degree of material and technical

support, as well as the ability to alert and mobilization readiness.

A systematic approach to assessing the military forces and units readiness for actions in emergency situations was proposed by the authors of the article [11]. In this case, the indicators of the probability of no-failure operation of technical means, as well as the level of professional training and the level of staffing of the unit with personnel were taken into account.

In the article [12], the readiness level of a unit to perform the assigned tasks is assessed based on indicators from the staffing of units with personnel, technical means, individual means of protection, training of personnel, availability of material and technical resources, etc. The average value of these indicators, taken with the corresponding weight coefficients, is considered as an indicator of the level of readiness. The proposed indicator of the readiness level of the unit does not fully reflect the readiness of the unit to perform the tasks set at any time and the degree of no-failure operation of it as a whole system over the time of task implementation.

Thus, the analysis of literary sources shows that the problem of assessing the combat capability of military units to perform the assigned tasks (conducting combat operations) requires further research in the indicated direction from a systematic point of view.

According to this, **the purpose of the article** is to develop a formalized mathematical model for assessing the combat capability of military units to perform the assigned tasks (conducting combat operations) and to propose a control algorithm for its implementation. To achieve the set goal, it is necessary to solve the following tasks:

- to develop a formalized mathematical model for assessing the combat capability of military units to perform the assigned tasks (conducting combat operations);

- propose a control algorithm that implements the developed mathematical model.

**Summary of the main material.** We will define the combat capability of a military unit as a single integral system during the performance of combat tasks which depends on the potential technical capability of this unit and the level of professional and moral-psychological training of personnel for performing the assigned tasks:

$$CC = F(P_T, P_{PMP}), \quad (1)$$

where  $CC$  – the level of combat capability of a military unit;

$P_T$  – potential technical capability of a military unit to perform the assigned tasks (conducting combat operations);

$P_{PMP}$  – the level of professional and moral-psychological training of the military unit personnel to perform the assigned tasks (conducting combat operations).

The potential technical capability of a military unit to perform the assigned tasks (conducting combat operations) is characterized by: the degree of compliance with staffing, technical readiness, resource, tactical-technical characteristics (TTC) of WME of the military unit with the complexity of the tasks being performed. The potential technical capability of a military unit is determined by many factors [13], including: staffing with modern WME, their operational and tactical-technical characteristics, indicators of technical perfection of WME, provision with consumable material and technical means (for example, fuel and lubricants, spare tools and accessories). The magnitude of the potential technical capability of military formations and units ( $P_T$ ) depends on the indicators of technical perfection of weapons and equipment samples of these formations (units), as well as on the operational indicators of these samples.

$$P_T = G(K_{TD}, K_E), \quad (2)$$

where  $K_{TD}$  – generalized coefficient of technical perfection of WME of a certain military unit;

$K_E$  – generalized operational coefficient of WME samples of a certain military unit.

Technical perfection of WME samples (their technical level) [14] is understood as a relative characteristic of the quality of these samples, which is based on the comparison of values of tactical-technical characteristics (TTC) that determine the technical perfection of evaluated samples with the corresponding values of basic samples indicators, taken as a standard.

The generalized coefficient of technical perfection of WME of a military unit characterizes the degree of compliance of the main TTC of weapon samples of different types with modern requirements and takes into account the available number of samples of the  $i$ -type WME, coefficients

of technical perfection of samples of the  $i$ -type WME, the number of different types of WME samples of a military unit.

$$K_{TD} = W(k, N_{AV_i}, K_{TD_i}), \quad (3)$$

where  $k$  – the number of different types of WME samples of a military unit;

$N_{AV_i}$  – available number of the  $i$ -type WME samples of a military unit;

$K_{TD_i}$  – coefficient of technical perfection of the  $i$ -type WME samples.

The generalized operational coefficient of all the WME samples of a military unit  $K_E$  is determined by the completeness, technical readiness and resource reserves of WME of a military unit [15]:

$$K_E = Q(K_{YK}, K_{TR}, K_{RR}), \quad (4)$$

where  $K_{YK}$  – coefficient of the military unit completeness with the WME;

$K_{TR}$  – coefficient of the technical readiness of a military unit;

$K_{RR}$  – coefficient of resource reserves of the available WME of a military unit.

The WME completeness of a military unit is characterized by the completeness coefficient, which is determined by the ratio of the available quantity of the WME samples to their standard quantity:

$$K_{YK} = L(N_{AV}, N_{SHT}), \quad (5)$$

where  $N_{AV} = \sum_{i=1}^k N_{AV_i}$  – available number of WME of this military unit;

$N_{SHT}$  – the number of WME of the military unit according to the staffing list.

The technical readiness of a unit is characterized by a technical readiness coefficient [13, 14], which is determined by the ratio of the number of technically ready WME samples of a military unit to the available ones:

$$K_{TR} = V(N_{TR}, N_{AV}), \quad (6)$$

where  $N_{TR}$  – the number of technically ready WME

samples of the military unit among the available ones.

The resource of WME samples of the military unit is significantly important. The resource of WME samples of a military unit is characterized by a coefficient of resource reserve of WME samples of all types that this unit is being equipped with. The coefficient of resource reserve of WME samples mainly characterizes the degree of physical wear (aging) of WME samples of a unit:

$$K_{RR} = U(N_{is}, R_{is}, N_{AV}), \quad (7)$$

where  $R_{is}$  –  $s$ -th necessary limit of the resource reserve for the available  $i$ -type WME samples;

$N_{is}$  – the number of available  $i$ -type WME samples with the  $s$ -limit of the resource reserve.

The level of professional and moral-psychological training of personnel to perform the assigned tasks ( $P_{PMM}$ ) characterizes its professional ability and moral-psychological qualities. It is determined by the staffing of the unit with specialists, professional and moral-psychological training for taking actions in combat conditions:

$$P_{PMM} = H(P_{OS}, P_{PP}, P_{MP}), \quad (8)$$

where  $P_{OS}$  – the probability of staffing of the unit personnel with specialists;

$P_{PP}$  – the probability of the professional readiness to perform the assigned tasks (conducting combat operations);

$P_{MP}$  – the probability of the moral-psychological readiness to perform the assigned tasks (conducting combat operations).

Professional readiness for performing the assigned tasks (conducting combat operations) is characterized by a complex of knowledge, skills, training of personnel in conducting combat operations in various situations and according to their purpose, the presence of professional

experience of the personnel of a military unit [16, 17]. Moral-psychological training is aimed at increasing mental resilience and psychological readiness of personnel for taking actions on the battlefield under difficult and dangerous circumstances, in a situation that is rapidly changing, during prolonged nervous and psychological stress, overcoming difficulties associated with the performance of military duties.

So, the formalized mathematical model for assessing the combat capability of military units to perform the assigned tasks is a system of 8 analytical dependencies [expressions (1–8)], which are given above.

The developed formalized mathematical model implements the principle of a systematic approach for solving the problem of assessing the combat capability of military units to perform the assigned tasks (conducting combat operations). The control algorithm for implementing the formalized mathematical model for assessing the combat capability of military units to perform the assigned tasks (conducting combat operations) is shown in Figure 1.

The control algorithm consists of 10 blocks, which are located on 6 hierarchical levels.

The first level consists of:

– a block for collecting and processing information about the staffing of military units with WME, technical condition, tactical-technical, and operational characteristics;

– a block for collecting and processing information about the staffing of military units with personnel, the level of professional and moral-psychological training.

On the second level there are:

– a block for analyzing the information about the equipment of military units with WME, technical condition, tactical-technical and operational characteristics;

– a block for analyzing the information about the staffing of military units with personnel, the level of professional and moral-psychological training.

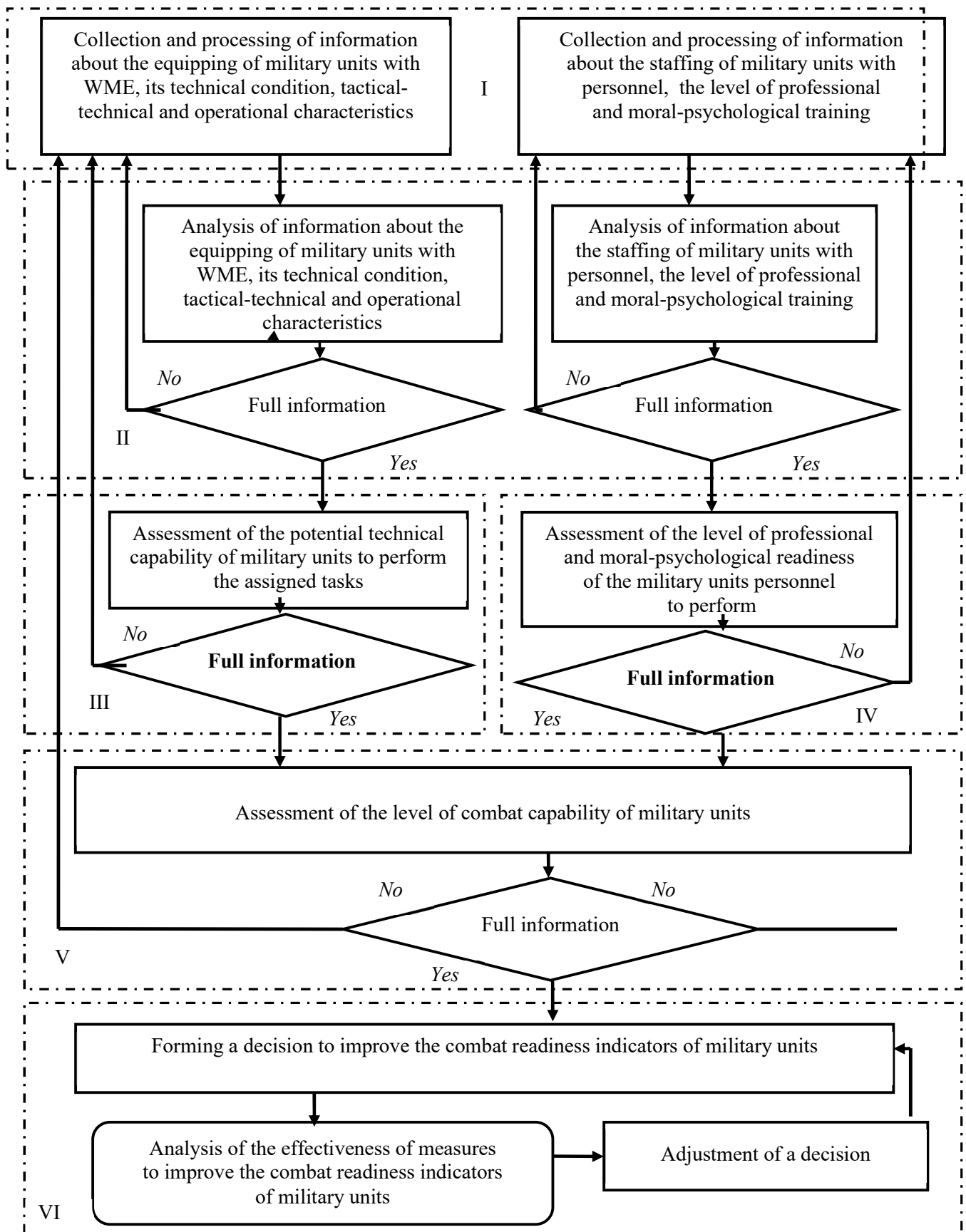


Figure 1 – The control algorithm of the formalized mathematical model realization

On the third level, there is a block for assessing the potential technical capability of military units to perform the assigned tasks (conducting combat operations). On the fourth level, there is a block for assessing the professional and moral-psychological preparation of military units personnel to perform the assigned tasks (conducting combat operations). The blocks on the third and fourth levels have the ability to work simultaneously, that is, the principle of parallelizing processes is implemented.

On the fifth level, there is a block for assessing the level of combat readiness of military units. The sixth level consists of: a block for making a decision to improve the indicators of combat readiness of military units, a block for analyzing the effectiveness of measures to improve the indicators of combat readiness of military units, and a block for adjusting the decision.

Thus, the control algorithm for implementing the formalized mathematical model for assessing the combat readiness of military units to perform the assigned tasks (conducting combat operations) consists of 10 blocks, which are located on 6 hierarchical levels and are connected by direct and reverse logical connections.

### **Conclusions**

1. The basis of combat readiness of military units is their combat capability. Combat capability characterizes the ability of a military unit or a subdivision to perform the assigned tasks (conducting combat operations). It is determined by the degree of staffing, the state of WME, the level of professional and moral-psychological preparation, the coordination of units and staffs, the provision of material means, and other factors.

2. A formalized mathematical model for assessing the combat readiness of military units to perform the assigned tasks (conducting combat operations) has been developed. This model is a system of analytical dependencies that describe the level of combat readiness of military units, their potential technical ability to perform tasks (conducting combat operations), the degree of compliance of the basic tactical-technical characteristics of different types of weapons samples used by military units with modern requirements for technical equipment, operational capabilities of samples of WME of military units, the degree of their equipment with WME, the technical readiness of military units, the level of resource reserve of available WME of military units, the level of professional and moral-

psychological readiness of the military units personnel to perform tasks (conducting combat operations). This implements the principle of a systematic approach to solving the problem of assessing the combat readiness of military units to perform tasks (conducting combat operations).

3. A control algorithm that implements a formalized mathematical model for assessing the combat readiness of military units to perform their assigned tasks has been developed. Its use involves the following procedures: collection, processing, analysis of information about the equipment of military units with WME, their technical condition, tactical-technical and operational characteristics; staffing of military units with personnel, level of professional and moral-psychological training; assessment of the potential technical ability of military units to perform tasks (conducting combat operations); assessment of the professional and moral-psychological readiness of military units personnel to perform tasks (conducting combat operations); assessment of the combat readiness of military units; formation of a decision to improve the indicators of combat readiness of military units; analysis of the effectiveness of measures to improve the indicators of combat readiness of military units and adjustment of the decision. This control algorithm consists of 10 blocks, which are located on 6 hierarchical levels and are connected by direct and reverse logical connections. The direction of further research is to establish more detailed interconnections between elements and blocks of different levels and automation of these processes.

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### **ФОРМАЛІЗОВАНА МАТЕМАТИЧНА МОДЕЛЬ ОЦІНЮВАННЯ БОЄДАТНОСТІ ВІЙСЬКОВИХ ПІДРОЗДІЛІВ**

*Боездатність характеризує спроможність військового підрозділу виконати поставлене бойове завдання і є визначальним елементом його бойової готовності. Вона залежить від багатьох чинників, зокрема від ступеня укомплектованості військових підрозділів особовим складом та спеціалістами, рівня їхньої підготовки, морально-психологічних та бойових якостей, наявності і стану необхідного озброєння та військової техніки, показників їхньої надійності і технічного ресурсу, забезпеченості витратними матеріально-технічними засобами, злагодженістю підрозділів і штабів, забезпеченості матеріальними засобами та іншими чинниками.*

*Розроблено формалізовану математичну модель оцінювання боездатності військових підрозділів до виконання завдань за призначенням, яка являє собою систему з восьми аналітичних залежностей, що описують: рівень боездатності військових підрозділів, потенційну технічну спроможність підрозділів до виконання завдань за призначенням, ступінь відповідності основних тактико-технічних характеристик зразків озброєння сучасним вимогам щодо технічного оснащення, експлуатаційні можливості зразків озброєння та військової техніки підрозділів, ступінь укомплектованості підрозділів озброєнням та технікою, технічну готовність підрозділів, рівень запасу ресурсу озброєння та військової техніки, рівень професійної та морально-психологічної підготовки особового складу військових підрозділів до виконання завдань за призначенням.*

*Крім того, наведено керуючий алгоритм, який реалізує формалізовану математичну модель оцінювання боездатності військових підрозділів до виконання завдань за призначенням. Його використання передбачає виконання таких процедур: збирання, оброблення, аналіз вихідної інформації про військові підрозділи, оцінювання боездатності військових підрозділів, формування рішення щодо поліпшення показників боездатності військових підрозділів, аналіз ефективності заходів з поліпшення показників боездатності військового підрозділу та коригування рішення. Він складається із 10 блоків, які розміщені на 6 ієрархічних рівнях і пов'язані прямими та зворотними логічними зв'язками.*

*Напрямом подальшого дослідження є встановлення більш детальних взаємозв'язків між елементами і блоками різних рівнів та автоматизація цих процесів.*

**Ключові слова:** *формалізована математична модель, керуючий алгоритм, боездатність, військовий підрозділ, чинники.*

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