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V. Pashchenko

O. Bilenko

METHOD OF FORMING A COMPLEX OF COMBAT EQUIPMENT FOR SECURITY FORCES

A method for forming a combat equipment complex for security forces personnel has been developed, the essence of which is to form a set of possible variants of a combat equipment complex based on available samples of elements of its subsystems, determine the performance indicators of the task in the case of using each formed variant of the combat equipment complex and select from the available set of variants of the complex that best ensures the specified conditions for performing the task. The application of the method makes it possible to form a combat equipment complex for a specific task and conditions of its performance, as well as to evaluate already known combat equipment complexes in terms of their provision of specified performance indicators for the performance of assigned tasks.

Keywords: *combat equipment, security officer, performance indicators, method, algorithm.*

Statement of the problem. In the current conditions of warfare, as well as in the performance of law enforcement tasks, the combat equipment of security personnel (CEPs) is becoming one of the main factors that directly affect the effectiveness of the tasks. For example, the speed of movement, tactical manoeuvres, adaptation to changing situations during the task and the survivability of a security officer in extreme conditions largely depend on the correct selection and compatibility of combat equipment (CE) elements [1]. On the other hand, the tendency to increase the functional characteristics of the elements of the combat equipment often leads to an increase in its total weight, which negatively affects the manoeuvrability of the SPS.

The contradiction between the requirement for high functional characteristics of BE elements and the requirement for manoeuvrability of the BFG becomes one of the key problems when selecting combat equipment elements [2]. For example, increasing the level of protection by increasing the protection area or installing high-end protective elements or adding additional modules, such as ammunition pouches, medical kits, communications equipment, etc., certainly increases the survivability of the BFG and its effectiveness in a direct encounter with the enemy. Table 1 shows that with an increase in the class and area of protection of the body armour, its weight can increase up to two times or more. This leads to an excessive load, and therefore makes it difficult to perform tasks involving active movement, such as patrolling, reconnaissance or assault operations.

Thus, the issue of developing approaches to the selection of the elements of the BESF that would rationally combine these contradictory aspects becomes relevant. One of the ways to resolve this contradiction is to create a method of forming a combat equipment complex (CEC) for security forces personnel.

Analysis of recent research and publications. Changes in the nature of assigned tasks in recent decades, as well as the emergence of new types of threats and the development of munitions, have significantly affected approaches to the selection of combat equipment for military personnel. Modern military science pays considerable attention to improving the mobility, protection and functionality of equipment, adapting it to the new conditions of combat operations.

In the leading countries of the world, concepts and scientific approaches aimed at improving combat equipment are being actively implemented, in particular within the framework of the "soldier of the future" concept [3–7].

Table 1 – Main characteristics of body armour for security forces

No.	Type of body armour	Characteristics of body armour				
		Protection class	without additional protection		with additional protection	
			protection area, m^2	total weight, kg	protection area, m^2	total weight, kg
1	"Sich"	4	0.1664	10.0	0.2054	13.0
2	"Corsair M3m-2"	2	0.4100	3.2	0.770	6.2
3	"Corsair M3m-3"	3	0.4100	6.3	0.770	7.9
4	"Corsair M3m-4"	4	0.4100	7.0	0.770	9.4
5	"Corsair M3m-5"	5	0.4100	8.0	0.770	10.4
6	"Corsair M3m-6"	6	0.4100	8.6	0.770	13.6
7	"Oberig-4"	4	0.5000	9.5	0.837	14.0
8	"Oberig-6"	6	0.5000	9.6	1.100	15.6

This concept envisages the creation of modular combat equipment, which allows for the rapid adaptation of equipment to the conditions of the assigned tasks and maintaining high efficiency, reducing the overall weight of the equipment and increasing the level of protection. Examples of the successful implementation of such concepts can be seen in the armies of the United States, the United Kingdom, Germany, France and other countries, which are introducing modular systems based on a single basic complex with the possibility of upgrading individual elements.

Ukraine is also conducting research and development of combat equipment for servicemen of the Army units of the Armed Forces of Ukraine. Scientific papers [8, 9, 10] analysing the development of combat equipment in Ukraine cover a wide range of issues, from protection and destruction systems to power supply and control equipment. Scientists pay special attention to the development of tactical and technical requirements for each element of equipment, taking into account the experience gained during the anti-terrorist operation, the Joint Forces Operation and combat operations during a full-scale war. Study [8] provides an analysis of the rational construction and development directions of the combat equipment complex based on the use of modular systems that allow combining protection, mobility and functionality.

Scientific works [11, 12] consider the impact of ergonomics and compatibility of combat equipment elements on the effectiveness of combat missions. The importance of applying the principles of echeloning equipment elements depending on the type of combat mission is emphasised. A methodology for the distribution of items of clothing and food supply in the elements of combat equipment in accordance with the type of task has been developed, which allows to avoid excessive weight and ensure maximum functionality.

Some works cover the issues of improving specific elements of combat equipment, such as protective equipment [9], small arms [10], uniforms [13], tactical backpacks, unloading systems [14], as well as the development of specialised elements for work in conditions of radiation and chemical contamination [15].

Studies [16–21] also cover the issue of formulating requirements for the tactical and technical characteristics of small arms for security forces.

However, these research results are mostly limited to the formation of requirements for the characteristics of individual elements of combat equipment or their individual selection for a task, but do not consider the combined effect of BE elements on the results of tasks performed by a security forces officer

Thus, there is a need to create a method of forming a combat equipment complex that considers the combined effect of BE elements on the results of performing assigned tasks.

The purpose of the article is to develop a method for forming a complex of combat equipment for security forces.

Summary of the main material. The modern process of performing the tasks assigned to the security forces is characterised by the enemy's use of the latest weapons, including unmanned aerial vehicles, remote fire control systems, and high-precision weapons, which significantly affect the requirements for CSES.

The problems of choosing the elements of the BE include: the need to reduce the total weight of the BE without losing the basic functional properties of its elements; ensuring the versatility of equipment elements; adaptability of the BE to different scenarios of performing tasks and conditions.

The weight of individual elements of combat equipment is the only parameter that connects them

and affects the ability of security forces personnel to perform their tasks effectively, so the development of the method should begin with consideration of this parameter. Studies show that excessive weight of the UE can lead to a loss of speed and mobility, increased fatigue and reduced cognitive abilities during tactical actions [22]. A mismatch between the weight of the equipment and the specifics of the task can significantly reduce the efficiency of actions, which is especially critical during enemy fire.

To illustrate the above, based on the initial data (Table 2), let's consider scenarios for performing two tasks using three equipment options for each task (Tables 3, 4).

Table 2 – Conditions of tactical tasks performed

List of source data	Initial	
	Task No. 1	Task No. 2
Content of the task	To disrupt the operation of electronic warfare equipment	Approach the front line of the enemy's defence, reconnoiter the strength and composition of his combat formations and return with intelligence information
The setting	The enemy, after an unsuccessful offensive, moves to defend the outskirts of a civilian settlement. A system of sentry posts is placed in front of the enemy's front line at a distance of 500 m along the front on average	The enemy conducts defensive actions along the border between the occupied settlements and has defensive positions that are equipped in engineering terms. In front of the front edge of the enemy's defence, at a distance of up to 300 m along the front, there is a system of watch posts
The enemy	The enemy's units organisationally consist of three motorised infantry and one tank company, and include grenade launcher, anti-tank, anti-aircraft and mortar platoons, a communications platoon and a radio electronic reconnaissance unit. The enemy is armed with small arms, melee weapons, tanks, armoured personnel carriers, as well as reconnaissance and strike UAVs and reconnaissance equipment	The enemy's units organisationally consist of three motorised rifle companies, as well as a communications platoon, an electronic intelligence unit, grenade launcher, anti-tank, anti-aircraft and mortar platoons. In addition, the enemy is armed with close combat weapons, armoured personnel carriers, as well as reconnaissance UAVs and reconnaissance equipment
Additional conditions for completing the task	The main electronic warfare equipment is located in the depths of the combat formations (behind the reverse slope of the terrain), but some of the devices (the hardware container of the Repellent-1 electronic warfare system) are located on the line of sight and fire contact at a distance of 1,600 m from the area visually visible to the enemy. The terrain in the area of the selected positions is characterised as semi-closed. The task will take no more than 2 hours to complete. In the event of contact with the enemy, immediate retreat in the opposite direction and, if possible, destroy enemy forces and equipment	The enemy's guard forces have organised a system of surveillance and patrolling. It is established that the patrol passes along the route between company strongholds every 10 minutes and is not equipped with surveillance equipment. The task is performed at dawn. A high level of concealment must be maintained throughout the entire period of the task. The terrain on which the task is performed is open (visibility up to 1000 m) and has natural shelters located at a distance of 200...300 m from each other. The time to complete the task is up to 5 hours. In the event of contact with the enemy, you should immediately withdraw in the opposite direction and, if possible, destroy the enemy's forces and means

Table 3 – Options for combat equipment of the security force group for task No. 1

Combat equipment subsystem	Elements of the combat equipment subsystem	A sample element of the combat equipment subsystem		
		option number 1	option number 2	option number 3
Defeat	Small arms with ammunition	VSSK Vykhlop sniper rifle	Desert Tech HTI sniper rifle	VSSK Vykhlop sniper rifle
		UAR-15	UAR-15	UAR-15
Protection	Personal protective equipment	Body armour "Oberig-4" with additional protection	"Corsair M3m-3" bulletproof vest without additional protection	"Corsair M3m-2" body armour without additional protection
		Kevlar helmet MICH	Kevlar helmet MICH	Kevlar helmet TOR
	Means of concealment and danger warnings	Tactical camouflage suit with leaves	Tactical camouflage suit with leaves	Tactical camouflage suit with leaves
			Backpack REB Contra-Drone	
Management	Means of communication	HARRIS RF-7800S	HARRIS RF-7800S	–
	Intelligence and surveillance equipment	Thermal imager AGM FUZION LRF TM50-640	Thermal imager AGM FUZION LRF TM50-640	–
	Navigation tools and orientation	Zebra ET45 tablet	Zebra ET45 tablet	Compass
Life support	Individual equipment and uniforms	Warbelt shoulder strap system	Warbelt shoulder strap system	Novator RS-1 belt and shoulder system
	Medical supplies	Individual medical military first aid kit iFAK Assault Kit CCRK	Individual medical military first aid kit iFAK Assault Kit CCRK	Military Maxi first aid kit
Average weight of combat equipment per employee in the group		29.7 kg	29.3 kg	14.6 kg

Table 4 – Options for combat equipment of the security force group for task No. 2

Combat equipment subsystem	Elements of the combat equipment subsystem	A sample element of the combat equipment subsystem		
		option number 1	option number 2	option number 3
Defeat	Small arms	UAR-15	UAR-15	UAR-15
	Ammunition to arms	120 pcs. are equipped in stores, 330 pcs. in clips	120 rounds in magazines, 330 rounds in clips	120 pcs. are equipped in stores, 330 pcs. in clips
	Hand grenades	RGD-5 - 2 pcs.	RGD-5 - 2 pcs.	RGD-5 - 2 pcs.
Protection	Personal protective equipment	Corsair M3m-5 body armour with additional ballistic protection	Corsair M3m-5 body armour with additional ballistic protection	Corsair M3m-5 body armour with additional ballistic protection
		Kevlar helmet MICH	Kevlar helmet MICH	Kevlar helmet MICH
	Means of concealment and danger warnings	Tactical camouflage suit with leaves	Tactical camouflage suit with leaves	Tactical camouflage suit with leaves
Management	Means of communication	HARRIS RF-7800S	HARRIS RF-7800S	HARRIS RF-7800S
	Intelligence and surveillance quipment	Carbon spyglass 25-75x100 WP	Explore Scientific G400 15x56 WP Phase Coating binoculars	Monocular Vortex Solo 10x36 WP BAK4 IPX7
	Navigation and orientation tools	Tablet Zebra ET45	Tablet Zebra ET45	Tablet Zebra ET45
Life support	Individual equipment and uniforms	Warbelt shoulder strap system	Warbelt shoulder strap system	Warbelt shoulder strap system
	Medical supplies	Individual medical military first aid kit iFAK Assault Kit CCRK	Individual medical military first aid kit iFAK Assault Kit CCRK	Individual medical military first aid kit iFAK Assault Kit CCRK
Average weight of combat equipment per employee in the group		29.8 kg	26.5 kg	25.3 kg

The execution of tasks involves three stages, namely: covert movement from the starting point to the place of task execution, direct execution of the task and return to the starting point.

Using the scientific and methodological apparatus for determining the effectiveness of visual search [23, 24] and the effectiveness of shooting, the probability of completing the task at each stage and in general was determined.

In Task No. 1, the distance from the starting point to the place of performance of the task for equipment options 1 and 3 will be longer than for option 2, due to the distance of effective use of small arms (600 m for the VSSK Vykhlop sniper rifle and 1100 m for the Desert Tech HTI). Taking this into account, the distance to be covered by the group for equipment variant No. 2 will be 500 m, and for variants No. 1 and 3 – 1000 m. The probabilities of non-detection of the ASB by the enemy P_{nd} during their movement to the place of task execution are calculated in accordance with [23]. The time of the airborne vehicle in the enemy's field of view during the first and third stages is determined on the basis of the dependencies described in [22].

The results of calculations of the probability of non-detection of the ASB by the enemy at the first stage of the task are as follows: for the equipment variant No. 1 $P_{ndp1} = 0.62$, variant No. 2 $P_{ndp2} = 0.94$ and variant No. 3 – $P_{ndp3} = 0.89$.

The probability of completing the second stage of the task (the probability of hitting the target W) at the corresponding distances is: for the equipment variants No. 1 and 3 – 0.99, and for the variant No. 2 – 0.97.

The conditions for the third stage of the task depend on the concealment of the use of weapons. The VYHLOP VSSK provides a silent and flameless shot, so the group will not be detected by the enemy during the fire mission. In view of this, the probability of undetection by the enemy at the third stage of the task for equipment options No. 1 and 3 will be the same as at the first stage.

As a result of the use of weapons for equipment variant No. 2, there is a high probability of detecting the group due to the significant noise of the shot (about 168 dB). For this reason, the third stage of the task will be carried out under enemy fire (mortars, grenade launchers and attack UAVs). At the same time, UAVs, in particular FPVs, pose the greatest threat at a particular time, so electronic warfare equipment is provided for the 2 outfit. Considering the use of mobile electronic warfare equipment, the probability of the group not being hit by the enemy P_{null} will be about 0.5.

The probability of completing the task by the group P_w for each variant of the BE was determined on the basis of the probability multiplication theorem, since P_{nvp}, P_{nup} and W are independent events. According to the results of the calculations, the probability of completing the task by the group for equipment variant No. 1 is $P_{v1} = 0.37$, variant No. 2 $P_{v2} = 0.46$ and variant No. 3 – $P_{v3} = 0.79$.

Thus, the example above shows that the formation of the EWE is a non-trivial task that is difficult to solve intuitively. Thus, the highest probability of completing the task was shown by the equipment variant that does not have the highest characteristics of the elements of the destruction and protection subsystems. This is due to the influence of both the characteristics of the UE and the enemy's capabilities, as well as their correlation, on the results of the task.

In task No. 2, the groups need to cover a distance of up to 300 m across open areas of terrain that are visible to the enemy. In view of this, and by analogy with the calculations of the first stage of task No. 1, in accordance with [23], the probabilities of non-detection of the BOB by the enemy were calculated: for equipment variant No. 1 $P_{nd1} = 0.79$, variant No. 2 $P_{nd2} = 0.88$, and variant No. 3 – $P_{nd3} = 0.92$.

The probabilities of completing the second stage of the task (probability of detecting enemy objects P_{in}) are calculated in accordance with [23] and are: for the equipment variant No. 1 $P_{in1} = 0.99$, variant No. 2 $P_{in2} = 0.96$, and variant No. 3 – $P_{in3} = 0.86$.

The conditions of the third stage of the task are identical to those of the first stage. Therefore, the probability of undetection by the enemy at the third stage of the task for all equipment options will be the same as at the first stage.

The probability of completion of the task by the group P_{in} for each variant of the BE was determined on the basis of the probability multiplication theorem, since P_{nvp} and P_{in} are independent events. According to the results of the calculations, the probability of the group performing the task for equipment variant No. 1 $P_{v1} = 0.62$, variant No. 2 $P_{v2} = 0.75$ and variant No. 3 – $P_{v3} = 0.72$.

In this case, the highest probability of completing the task is provided by the equipment variant that has average characteristics of reconnaissance and surveillance means, which is not obvious at first glance. This example confirms the complex influence of many factors on the results of the task, including the characteristics of the means of various subsystems of combat equipment and the parameters of the situation. This necessitates the development of methods and techniques for substantiating the composition of the combat equipment for performing certain tasks.

The authors of this article propose a method of forming a complex of combat equipment for security forces, the flowchart of the algorithm of which is shown in Figure 1.

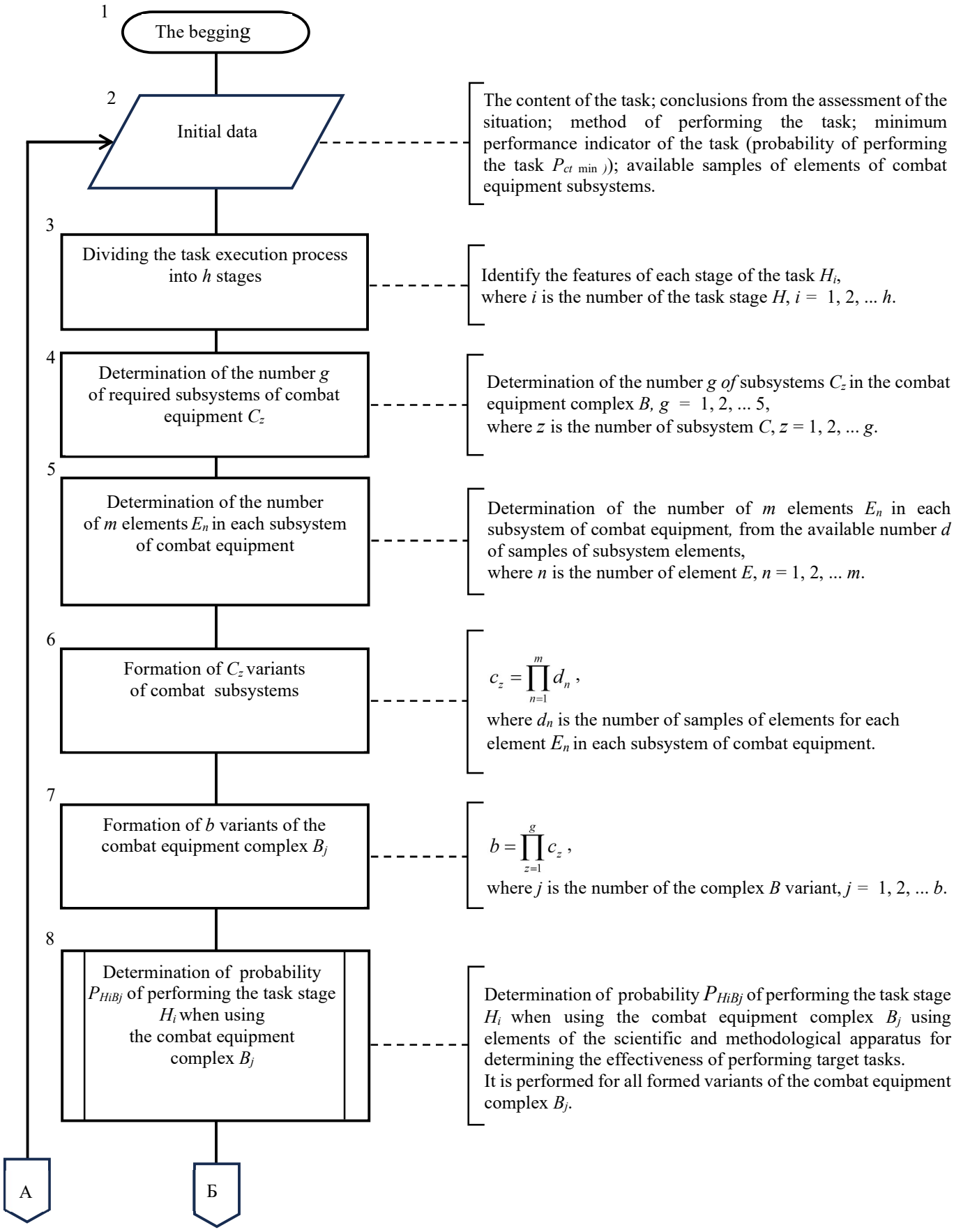

Figure 1 – Algorithm of the method of forming a complex of combat equipment for a security officer

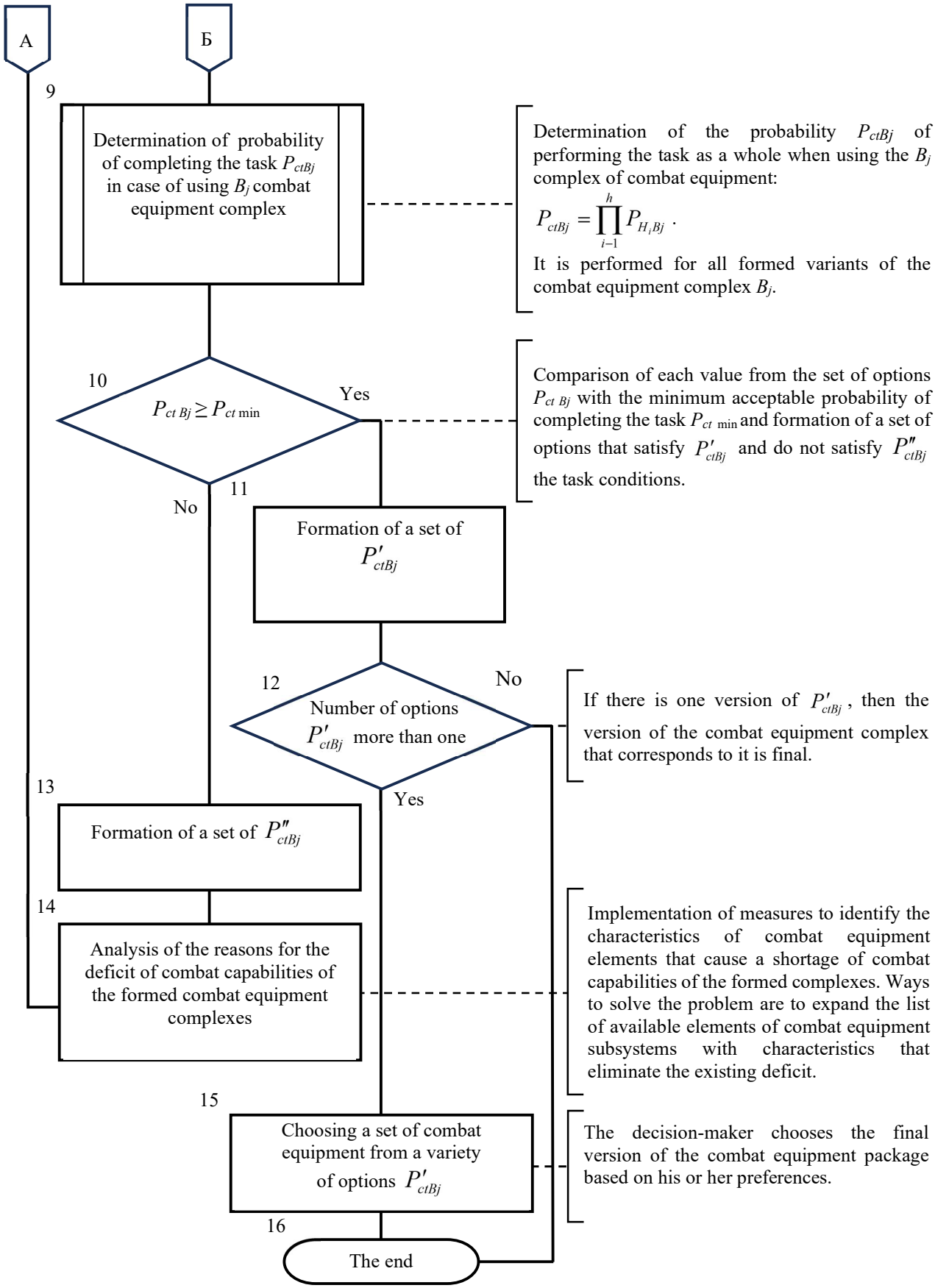

Figure 1, sheet 2

The initial data for the method (block 2 of the algorithm) are:

– the content of the combat (service-combat, special) task;

– conclusions on the assessment of the situation [conclusions on the assessment of the environment and its impact on the battlefield (area of operation); enemy forces (criminals) and their options, risks associated with the task, etc;]

– the way the task is performed;

– minimum performance indicators of the task (probability of completing the task $P_{ct\,(\min)}$, etc.);

– samples of elements of combat equipment subsystems are available.

In block 3 of the algorithm, based on the initial data, the task execution process is divided into h stages and the features of each task stage H_i are determined, where i is the task stage number, $i = 1, 2, \ldots h$.

Taking into account the peculiarities of each stage of the task and the list of available samples of elements of combat equipment subsystems in block 4 of the algorithm, the number g of subsystems C_z in the combat equipment complex B is determined, where $g = 1, 2, \ldots 5$.

In block 5 of the algorithm, based on the available number d of samples of combat equipment subsystem elements, the number m of elements E_n in each combat equipment subsystem is determined, where n is the number of element E in the subsystem, $n = 1, 2, \ldots m$.

Block 6 of the algorithm provides for the formation of variants c_z of subsystems of combat equipment C_{zk} from the available d_n number of samples of elements for the m-th element of subsystem C_z, where k is the number of the variant of subsystem C_z, $k = 1, 2, \ldots c_z$. Since each of the E_n elements of subsystem C_z can be selected from the d_n samples, the total number of variants c_z for each subsystem C_z is equal to:

$$c_z = \prod_{n=1}^{m} d_n . \qquad (1)$$

In block 7, variants b of the combat equipment complex B_j are formed, where j is the number of the variant of the complex B, $j = 1, 2, \ldots b$. The number of variants b depends on the total number of variants c_z for each of the g subsystems of the combat equipment:

$$b = \prod_{z=1}^{g} c_z . \qquad (2)$$

As an indicator of the effectiveness of the task performance, the probability of its completion is taken. Therefore, block 8 determines the probabilities P_{HiBj} of completing the stages of the task H_i in the case of using the B_j CBA. In doing so, elements of the scientific and methodological apparatus for determining the effectiveness of performing targeted tasks (detection of enemy objects, defeat of targets, concealment of actions and objects, etc.)

Based on the determined P_{HiBj} in block 9 of the algorithm, the probability of completing the task as a whole P_{ctBj} is calculated in the case of using the B_j CBA:

$$P_{ctBj} = \prod_{i-1}^{h} P_{H_i Bj} . \qquad (3)$$

The operations in blocks 8 and 9 of the algorithm are performed for each of the CBA variants formed in block 7. As a result, a set of variants P_{ctBj} is obtained.

In block 10 of the algorithm, each value from the set of options P_{ctBj} is compared with the minimum acceptable probability of completing the task $P_{ct\,(\min)}$. Based on the results of the comparison, sets of options are formed that satisfy P'_{ctBj} (block 11 of the algorithm) and do not satisfy P''_{ctBj} (block 13 of the algorithm) the task condition.

Block 12 of the algorithm involves determining the number of options that make up the set P'_{ctBj}. If the set P'_{ctBj} consists of only one option, then it is this option that is selected as the final one. Otherwise (the set P'_{ctBj} is composed of more than one option), the decision maker selects the final variant of the ECE from the set of options P'_{ctBj} based on his or her preferences (block 15 of the algorithm).

If the sets P'_{ctBj} do not contain any options, then the reasons for the shortage of combat capabilities of the formed combat equipment complexes are analysed (block 14 of the algorithm).

Such a deficit may be due to the characteristics of individual combat equipment elements that reduce the likelihood of performing individual task stages and the task as a whole. In this case, consideration should be given to changing the initial conditions by expanding the list of available samples of combat equipment subsystem elements with characteristics that eliminate the existing deficit.

Thus, a method of forming a complex of combat equipment for security forces personnel has been developed, which consists in forming a set of

variants of combat equipment from existing samples of combat equipment elements, determining the performance indicators of the task using each variant of combat equipment and selecting from the available set of such a variant of combat equipment that best meets the requirements of the task. In case there is no such variant in the formed set of combat equipment that meets the requirements of the task, it is planned to analyse the reasons for the shortage of combat capabilities of the formed combat equipment complexes and make targeted changes to the initial data by entering into the list samples of elements of subsystems of combat equipment with characteristics that eliminate the existing shortage.

Conclusions

1. It has been established that the formation of a combat equipment complex is a non-trivial task that is difficult to solve intuitively. This is due to the complex influence of many factors on the results of the task, including the characteristics of the means of various subsystems of combat equipment and the parameters of the situation.

2. A method of forming a complex of combat equipment for security forces personnel has been developed, the essence of which is to form a set of possible variants of a complex of combat equipment based on available samples of elements of its subsystems, determine the performance indicators of the task in the case of using each formed variant of the complex of combat equipment and select from the available set of variants of the complex that best provides the specified conditions for performing the task.

3. The developed method makes it possible to form a complex of combat equipment for a specific task and conditions of its implementation, as well as to evaluate already known complexes of combat equipment for ensuring the specified performance indicators of the tasks.

The direction of further research is to develop partial methods and techniques for determining the performance indicators of individual stages of the task and the task as a whole in cases of using different complexes of combat equipment by security forces.

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В. В. Пащенко, О. І. Біленко

МЕТОД ФОРМУВАННЯ КОМПЛЕКСУ БОЙОВОГО ЕКІПІРУВАННЯ ПРАЦІВНИКІВ СИЛ БЕЗПЕКИ

Установлено, що формування комплексу бойового екіпірування є нетривіальним завданням, яке складно розв'язати на інтуїтивному рівні. Це пояснюється складним комплексним впливом на результати виконання завдання багатьох чинників, серед яких характеристики засобів різних підсистем бойового екіпірування та параметри обстановки.

Розроблено метод формування комплексу бойового екіпірування працівників сил безпеки, який полягає у формуванні множини варіантів комплексу бойового екіпірування з наявних зразків елементів бойового екіпірування, визначенні показників ефективності виконання завдання за допомогою кожного варіанта комплексу бойового екіпірування та виборі з наявної множини такого варіанта комплексу бойового екіпірування, який найкраще задовольняє вимоги поставленого завдання. У разі, якщо немає у сформованій множині комплексів бойового екіпірування такого варіанта, що задовольняє вимоги завдання, то передбачається аналіз причин дефіциту бойових можливостей сформованих комплексів бойового екіпірування та внесення цілеспрямованих змін у вихідні дані шляхом введення у перелік зразків елементів підсистем бойового екіпірування таких, які мають характеристики, що усувають наявний дефіцит.

Розроблений метод дає змогу сформувати комплекс бойового екіпірування для конкретного завдання та умов його виконання, а також оцінювати вже відомі комплекси бойового екіпірування щодо забезпечення ними заданих показників ефективності виконання поставлених завдань.

Ключові слова: *бойове екіпірування, працівник сили безпеки, показники ефективності, метод, алгоритм.*

Bilenko Oleksandr – Doctor of Technical Sciences, Professor, Chief Researcher of the Research Center of the National Academy of the National Guard of Ukraine
https://orcid.org/ 0000-0001-6007-3330

Pashchenko Viktor – Candidate of Technical Sciences, Doctoral Student of the National Academy of the National Guard of Ukraine
https://orcid.org/0000-0002-6859-0700