

# METHODOLOGICAL APPROACH TO JUSTIFICATION OF THE DISTRIBUTION OF THE ARMED FORCES OF THE STATE IN PEACETIME AND WARTIME MILITARY FORMATIONS TAKING INTO ACCOUNT MILITARY AND ECONOMIC ASPECTS

Volodymyr Mozharovskyi<sup>1</sup>, Serhii Hodz<sup>2</sup>

**Abstract.** The division of the armed forces into peacetime and wartime military formations (MFs) is carried out taking into account a number of aspects, namely military and political, military and strategic, military and economic, physical and geographical, operational (operational and tactical), demographic, regulatory, etc. An important place is given to the military and economic aspects, such as macroeconomic indicators of the condition and development of the national economy, the dynamics of changes in its military budget and the maximum possible degree of military and economic tension (opportunities for the deployment of military organization in a special period); the degree of dispersion, protection and vulnerability of important economic facilities of the country, its transport capabilities (infrastructure); cost indicators for maintaining unions (units) with varying degrees of preparedness for the mission execution for the purpose intended, their mobilization (transition to the wartime table of organization and equipment) and alerting; opportunities for the country's economy to modernize and produce new models of AMH, providing the needs of troops (forces) with the necessary material means (fuel and lubricants, food, property, etc.).

Analysis of the problematic issues of organizing the armed forces, in particular their division into peacetime and wartime MFs, reflects the following contradiction: on the one hand, increasing the number of permanent readiness (peacetime) unions (units) involves the growth of the amount of financial costs for their maintenance, but at the same time reduces the time for their alerting; on the other hand, increasing the number of wartime unions (units) that need to be mobilized and alerted, provides a reduction in financial costs for their maintenance, but increases the time to alerting.

According to the authors, the solution to this contradiction requires a comprehensive approach, which provides an in-depth consideration of the experience of troops and the use of theoretical research methods to justify the division of armed forces in the peacetime and wartime MFs. However, there is a lack of methods (methodological approaches) that would allow the in-depth consideration of resource and time limitations on the maintenance and alerting of troops, and on this basis, justification of the optimal division of the armed forces into unions (units) with varying degrees of manpower and equipment organization, security, training and preparedness to execute missions for the purpose intended. In this regard, the authors propose a methodological approach, which, taking into account military and economic aspects, in particular, the average annual financial resources required for the maintenance, mobilization (completion) and alerting unions (units) of a certain type, will allow a more reasonable approach to the division of the armed forces into peacetime and wartime MFs. The methodological approach presented in the article also applies to others formed in accordance with the legislation of MFs, which are entrusted with tasks and functions for the national security, protection of the country's sovereignty, territorial integrity and inviolability.

**Key words:** alertness and mobilization preparedness, armed forces, military formations, unions (units), military and economic aspects, financial resources, methodological approach, optimization problem.

**JEL Classification:** F45, H83, C18

*Corresponding author:*

<sup>1</sup> Central Scientific Research Institute of the Armed Forces of Ukraine, Ukraine.

E-mail: [military.technology@icloud.com](mailto:military.technology@icloud.com)

ORCID: <https://orcid.org/0000-0003-3542-5407>

<sup>2</sup> Central Scientific Research Institute of the Armed Forces of Ukraine, Ukraine.

E-mail: [sergiigodz1968@ukr.net](mailto:sergiigodz1968@ukr.net)

ORCID: <https://orcid.org/0000-0002-7860-2330>

## 1. Introduction

The armed forces are responsible for national security, protection of its sovereignty, territorial integrity and inviolability. One of the requirements for the armed forces is the need to keep a certain composition of MFs in permanent preparedness to respond immediately to threats to the military security of the state, the rest of MFs should be kept in preparedness for mobilization (transition to the wartime table of organization and equipment) and preparedness to execute missions on purpose in a special period. To this end, by purpose, tasks, manning level, equipment with armament and military hardware (AMH), logistics support (LS), training and preparedness for executing missions for the purpose intended, MFs (subunits, unions, units) are divided into those, which are kept deployed in peacetime, i.e., MFs of permanent preparedness (peacetime MFs) and those, which are subject to mobilization and alerting in a special period (wartime MFs) (Mozharovskiy, Hodz, 2018; Hodz, Mozharovskiy, Pantiushenko, 2020; Mozharovskiy, Hodz, Sakovskiy, 2019).

The division of the armed forces into peacetime and wartime military formations (MFs) is carried out taking into account a number of aspects, namely military and political, military and strategic, military and economic, physical and geographical, operational (operational and tactical), demographic, regulatory, etc. An important place is given to the *military and economic aspects*, such as macroeconomic indicators of the condition and development of the national economy, the dynamics of changes in its military budget and the maximum possible degree of military and economic tension (opportunities for the deployment of military organization in a special period); the degree of dispersion, protection and vulnerability of important economic facilities of the country, its transport capabilities (infrastructure); cost indicators for maintaining unions (units) with varying degrees of preparedness for the mission execution for the purpose intended, their mobilization (transition to the wartime table of organization and equipment) and alerting; opportunities for the country's economy to modernize and produce new models of AMH, providing the needs of troops (forces) with the necessary material means (fuel and lubricants, food, property, etc.) (Mozharovskiy, Hodz, 2018; Mozharovskiy, Hodz, 2019).

Analysis of the problematic issues of organizing the armed forces, in particular their division into peacetime and wartime MFs, reflects the following contradiction: on the one hand, increasing the number of permanent preparedness (peacetime) unions (units) involves the growth of the amount of financial costs for their maintenance, but at the same time reduces the time for their alerting; on the other hand, increasing the number of wartime unions (units) that need to be mobilized and alerted, provides a reduction

in financial costs for their maintenance, but increases the time to alerting.

According to the authors, the solution of this contradiction requires a comprehensive approach, which provides an in-depth consideration of the experience of troops and the use of theoretical research methods to justify the division of armed forces in the peacetime and wartime MFs. However, there is a lack of methods (methodological approaches) that would allow the in-depth consideration of resource and time limitations on the maintenance and alerting of troops, and on this basis, justification of the optimal division of the armed forces into unions (units) with varying degrees of manpower and equipment organization, security, training and preparedness to execute missions for the purpose intended. In this regard, the authors propose a methodological approach, which, taking into account military and economic aspects, in particular, the average annual financial resources required for the maintenance, mobilization (completion) and alerting unions (units) of a certain type, will allow a more reasonable approach to the division of the armed forces into peacetime and wartime MFs. Some provisions on this methodological approach have been set out in publications (Hodz, Mozharovskiy, Pantiushenko, 2020).

The purpose of the article is to present the essence and main content of this methodological approach.

## 2. Main content of the methodological approach

Methodological approach to substantiation of the division of the armed forces into unions (units) of permanent preparedness (peacetime) ( $N_p$ ) and unions (units) that are subject to mobilization and alerting in a special period (wartime) ( $N_w$ ) (taking into account economic aspects) includes source data and elements of the calculation process (algorithm).

**Output data** provide indicators that are necessary to calculate the required number of unions (units) of permanent preparedness and those that are subject to mobilization, as well as financial resources (funds) necessary for their maintenance and alerting.

The initial data should include the following indicators:  $N = \sum_j N_j = N_p + N_w$  is a predetermined total number of unions (units) of the armed forces, taking into account their  $j$ -th types to be distributed;  $t_{p,j}$ ,  $t_{w,j}$  is the time (normative) for completion (mobilization) and alerting of one union (unit) of  $j$ -th type;  $T_{p,j}$  is the time (normative) for completion,  $T_{w,j}$  is mobilization and alerting of all unions (units) of  $j$ -th type;  $T_p$  is the total time (normative) of completion and alerting unions (units) of all types of permanent preparedness,  $T_w$  is mobilization and alerting unions (units) of all types to be demobilized;  $T_{p,jn}$ ,  $T_{w,jn}$  is the time taking into account the limitations required to alerting

unions (units) of  $j$ -th types;  $c_{pj}$ ,  $c_{wj}$  are the average annual financial resources (funds) (excluding the cost of AMH), which are necessary for the maintenance, completion (mobilization) and alerting one union (unit) of  $j$ -th type;  $C_{pj} = c_{pj} \cdot N_{pj}$ ,  $C_{wj} = c_{wj} \cdot N_{wj}$  – are the average annual financial resources (funds) required for maintenance, completion (mobilization) and alerting unions (units) of  $j$ -th type;  $C_{ij} = C_{pj} + C_{wj} \leq C_{ijl}$  are the average annual financial resources (funds) that are needed to maintain and alert  $N_j = N_{pj} + N_{wj} \leq N_{jn}$  all unions (units) of  $j$ -th type;  $C_p = \sum_j c_{pj} \cdot N_{pj}$  are the average annual financial resources (funds) required for maintenance, replenishment and alerting  $N_p = \sum_j N_{pj}$ , unions (units) of all  $j$ -th types;  $C_w = \sum_j c_{wj} \cdot N_{wj}$  are the average annual financial resources (funds) that are needed to maintain, mobilize and alert,  $N_w = \sum_j N_{wj}$  unions (units) of all  $j$ -th types;

$$C_i = C_p + C_w = \sum_j C_{ij} = \sum_j (C_{pj} + C_{wj}) = \sum_j c_{pj} \cdot N_{pj} + \sum_j c_{wj} \cdot N_{wj}$$

are the total average annual financial resources (funds), which are necessary (depending on the level of development of the country and the military and political situation) for the maintenance and alerting unions (units) of all  $j$ -th types;  $C_{il} = \sum_j C_{ijl}$  are the total financial resources (funds) (subject to limitations), which are allocated by the state for one year for maintenance and alerting  $N$  unions (units) of all types (value  $C_{ijl}$  is determined not only on the basis of economic capabilities of the state but also taking into account the values  $T_{pjn}$ ,  $T_{wjn}$ ; values  $C_{ijl}$ ,  $T_{mjn}$ ,  $T_{gn}$ ,  $N_{pj}$ ,  $N_{wj}$  are interconnected, they cannot be appointed independently of each other). It is assumed that the total number of  $N = \sum_j N_j = N_p + N_w = \sum_j (N_{pj} + N_{wj})$  unions (units), to be distributed are determined in advance. Financial resources (funds) is necessary to maintain and alert them. It should be noted that  $C_i \leq C_{il}$ .

Taking into account the indicators of the initial data, we formulate in more detail the contradiction mentioned above:

– *on the one hand*, there is considered an attempt or expediency to keep most or all of  $N = N_p$  unions (units) deployed in peacetime, which minimizes the total time  $T$  to bring them ready to execute missions for the purpose intended. However, in this case, taking into account the average annual financial costs  $c_{pj}$  (excluding the cost of AMH) for the maintenance, completion and alerting one union (unit) significantly increases the total financial costs  $C_{pj} = c_{pj} \cdot N_{pj}$ . These costs may exceed the allocated (subject to

limitations) average annual financial resources  $C_{il} = \sum_j C_{ijl}$ ;

– *on the other hand*, the other extreme is considered when in the special period the majority or even all  $N = N_w$  unions (units) will be subject to demobilization and alertness. This version of their maintenance, taking into account the average annual financial costs  $c_{pj} > c_{wj}$  (excluding the cost of AMH) to mobilize and alert one union (unit) minimizes the necessary total financial costs  $C_{wj} = c_{wj} \cdot N_{wj}$  (for example, holding mobilization meetings, classes, etc.). However, in this case, the time  $T$  to alert these unions (units) increases significantly and complicates the process of their combat coordination (for example, due to the possible lack of personnel trained in full in peacetime).

As a result of such a contradiction, in fact, there is a problem of finding a compromise solution, i.e., the most acceptable option for the division of the total number of MFs  $N$  into peacetime unions (units)  $N_p$  (those deployed in peacetime) and wartime unions (units)  $N_w$  (those that are subject to mobilization and alerting in a special period with reduced staff). This takes into account the limitations on the allocated average annual financial resources  $C_{il}$  and time  $T_{mn}$ ,  $T_{gn}$ , required for maintenance and alerting of  $N_p$ ,  $N_w$  unions (units).

### 3. Stages of the calculation process (algorithm)

The algorithm for substantiating the division of the armed forces into unions (units) of permanent preparedness and those to be mobilized and alerted in a special period includes *two successive and interrelated stages*.

**At the first stage** the calculation of the following indicators is performed: the required value of human, material and financial resources, subject to limitations  $C_{il}$  on the average annual financial resources allocated for completion (mobilization) and alerting of  $N_{pj}$ ,  $N_{wj}$  number of unions (units) of  $j$ -th types; required (maximum allowable) number  $N_{pj}$  and  $N_{wj}$  of unions (units) of  $j$ -th types taking into account time limitations  $T_{pjn}$ ,  $T_{wjn}$  for alerting.

It is assumed that the strength of the armed forces to perform missions of national defence, as well as the total number  $N$  of unions (units) of the armed forces to be distributed, are the predetermined values. For example, the number of armed forces is determined in accordance with the forecast of the military and political (military and strategic) situation, intentions and capabilities of a potential aggressor, military and economic (resource) capabilities of the state, and so on. The set limits on financial resources (funds)  $C_{ijl}$  allocated and time  $T_{pjn}$ ,  $T_{wjn}$ , required for alerting the unions (units) of  $j$ -th type. It is these

indicators that largely determine the possible number  $N_j = N_{pj} + N_{wj}$  of all unions (units) of  $j$ -th types. It is also taken into account that depending on the availability of trained personnel and the necessary means, troops (forces) can be alerted in *successive* and *parallel* ways. In a successive way, each subsequent union (unit) is alerted after alerting the previous union (unit), i.e., in the absence of parallel sections for alerting this or that union (unit). In a parallel way, the unions (units) are alerted almost simultaneously; this on average takes the time  $t$  of alerting one union (unit). To perform calculations, a value is entered that will characterize one or another way of alerting unions (units) in the presence of the necessary resources. This value is called a *coefficient of simultaneity (parallelism)*  $\beta$  of the start of alerting (this coefficient can also be called the coefficient of simultaneity (parallelism) of works on alerting unions (units)). When  $\beta = 0$  there is a *successive* way, when  $\beta = 1$  there is a *parallel* way, when  $0 < \beta < 1$  there is a combined way of alerting unions (units). Accordingly, for unions (units) of permanent preparedness, given their staffing (crews), there can be taken on average  $\beta_{pj} = 0,7-0,9$ ; for unions (units) to be mobilized, given the uneven supply of these unions (units) with mobilization resources, the lack of the required number of services (crews) prior to their alerting, there can be accepted, according to the experience of troops, on average  $\beta_{wj} = 0,2-0,6$ .

Given the timeliness ( $T_{pj}$  "  $T_{pjn}$ ,  $T_{wj}$  "  $T_{wjn}$ ) of alerting unions (units) of  $j$ -th type, we have:

$$T_{pj} = N_{pj} \cdot t_{pj} \cdot (1 - \beta_{pj}) + t_{pj} \cdot \beta_{pj} \leq T_{pjn}, \quad \text{at } 0 < \beta < 1 \quad (1)$$

$$T_{wj} = N_{wj} \cdot t_{wj} \cdot (1 - \beta_{wj}) + t_{wj} \cdot \beta_{wj} \leq T_{wjn}, \quad \text{at } 0 < \beta < 1 \quad (2)$$

These time indicators are interrelated. Each of them depends on the number of peacetime and wartime unions (units)  $N_{pj}$ ,  $N_{wj}$  of  $j$ -th type, as well as from the allocated financial resources. Taking into account (1), (2) we obtain:

$$N_{pj} \leq \frac{T_{pjn} - t_{pj} \cdot \beta_{pj}}{t_{pj} \cdot (1 - \beta_{pj})}, \quad 0 < \beta_{pj} < 1, \quad (3)$$

$$N_{wj} \leq \frac{T_{wjn} - t_{wj} \cdot \beta_{wj}}{t_{wj} \cdot (1 - \beta_{wj})}, \quad 0 < \beta_{wj} < 1. \quad (4)$$

Taking into account the average annual costs  $c_{pj}$ , which are necessary for the maintenance, completion and alerting of one union (unit) of  $j$ -th type  $N_{pj}$ , as well as average annual costs  $c_{wj}$ , which are necessary for the maintenance, mobilization and alerting of one union (unit) of  $j$ -th type  $N_{wj}$ , this can be written:

$$c_{pj} \cdot N_{pj} \leq c_{pj} \cdot \frac{T_{pjn} - t_{pj} \cdot \beta_{pj}}{t_{pj} \cdot (1 - \beta_{pj})}, \quad (5)$$

$$c_{wj} \cdot N_{wj} \leq c_{wj} \cdot \frac{T_{wjn} - t_{wj} \cdot \beta_{wj}}{t_{wj} \cdot (1 - \beta_{wj})}. \quad (6)$$

Adding the right and left parts of these inequalities we obtain:

$$c_{pj} \cdot N_{pj} + c_{wj} \cdot N_{wj} \leq c_{pj} \cdot \frac{T_{pjn} - t_{pj} \cdot \beta_{pj}}{t_{pj} \cdot (1 - \beta_{pj})} + c_{wj} \cdot \frac{T_{wjn} - t_{wj} \cdot \beta_{wj}}{t_{wj} \cdot (1 - \beta_{wj})}. \quad (7)$$

This takes into account that values  $N_{mj}$  and  $N_{ej}$  should fulfil not only conditions (3) – (6) but also the condition of correspondence between the necessary  $C_{ij}$  and average annual funds  $C_{ij\text{o}\delta M}$ :

$$C_{ij} = C_{mj} + C_{ej} = c_{mj} \cdot N_{mj} + c_{ej} \cdot N_{ej} \leq c_{mj} \cdot \frac{T_{mj\text{nonp}} - t_{mj} \cdot \beta_{mj}}{t_{mj} \cdot (1 - \beta_{mj})} + c_{ej} \cdot \frac{T_{ej\text{nonp}} - t_{ej} \cdot \beta_{ej}}{t_{ej} \cdot (1 - \beta_{ej})} \leq C_{ij\text{o}\delta M}. \quad (8)$$

From (8), the relationship between the maximum values  $N_{pj}$  and  $N_{wj}$  can be obtained taking into account the allocated financial resources  $C_{ij}$ :

$$N_{pj} \leq \frac{C_{ijl} - c_{wj} \cdot N_{wj}}{c_{pj}} = \frac{C_{ijl}}{c_{pj}} - \frac{c_{wj}}{c_{pj}} \cdot N_{wj}, \quad c_{pj} > c_{wj} \quad (9)$$

The same equation, expressed with  $N_{ej}$ , can be written:

$$N_{wj} \leq \frac{C_{ijl} - c_{pj} \cdot N_{pj}}{c_{wj}} = \frac{C_{ijl}}{c_{wj}} - \frac{c_{pj}}{c_{wj}} \cdot N_{pj}, \quad c_{pj} > c_{wj}. \quad (10)$$

The time  $T_p$  for completion and alerting all  $N_p = \sum_j N_{pj}$  peacetime unions (units) of peacetime will be determined by the maximum value of the time of alerting unions (units) of  $j$ -th type, which should not exceed the required (maximum allowable) time subject to value restrictions  $T_{pjn}$ . Similarly, the time  $T_w$  for mobilization and alerting all  $N_w = \sum_j N_{wj}$  unions (units) to be mobilized will be determined by the maximum value of the time of alerting unions (units) of  $j$ -th type, which should not exceed the required (maximum allowable) time subject to value restrictions  $T_{wjn}$ . The acceptable time limits  $T_{pjn}$ ,  $T_{wjn}$  for alerting troops are prior; on their basis, there are determined the number  $N_{pj}$ ,  $N_{wj}$  and the necessary funds for this  $C_{ij}$ . Increasing the financial resources  $C_{ijl}$  allocated in the interests of the troops will change the value  $N_j = N_{pj} + N_{wj}$  and the overall value  $N = \sum_j (N_{pj} + N_{wj})$  subject to the condition  $T_{pj} < T_{pjn}$  or  $T_{wj} < T_{wjn}$  for alerting unions (units) at the expense of the measures connected with reduction of time  $t_{pj}$ ,  $t_{wj}$  for alerting one union (unit) of  $j$ -th type.

In the case of limitations, the distribution problem  $N_j = N_{pj} + N_{wj}$  of unions (units) of  $j$ -th type on the peacetime unions (units)  $N_{pj}$  and wartime unions (units)  $N_{wj}$  depending on the selected condition of the source and other data, taking into account the time  $t_{wj}$ , necessary for mobilization and alerting one union (unit) of  $j$ -th type  $N_{wj}$ , as well as time  $t_{pj}$ , necessary for completion and alerting one union (unit) of  $j$ -th type  $N_{pj}$ .

In terms of finding the right solutions, there can be used *three main options* (regarding priority selection): *the first option* supposes that the priority is the predetermined total number of unions (units) to be distributed according to the order of their maintenance and the time spent for alerting them, as well as the required number of unions (units) of permanent preparedness; *the second option* means that the priority is the average annual financial resources (funds), which are allocated in the interests of unions (units) of  $j$ -th type of the total amount of funds allocated per year in the interests of unions (units) of all types, as well as the required number of unions (units) of permanent preparedness; *the third option* means that the priority is the time required (maximum allowable) taking into account the limitations for alerting unions (units) of the relevant types of permanent preparedness and those to be mobilized in a special period.

*The first option:* a predetermined number  $N = \sum_j N_j = N_p + N_w = \sum_j (N_{pj} + N_{wj})$  of unions (units) to be distributed according to the order of their content and time spent for alerting them, as well as the required value  $\sum_j N_{pj}$  of unions (units) of permanent preparedness for combat duty and other tasks in peacetime are priority (set). In this case, the maximum allowable number  $\sum_j N_{wj}$  of unions (units) to be mobilized will be calculated:

$$\sum_j N_{wj} = N - \sum_j N_{pj}, \tag{12}$$

After this, for the known values  $t_{wj}, \beta_{wj}$  the time is calculated

$$T_{wjn} = N_{wj} \cdot t_{wj} \cdot (1 - \beta_{wj}) + t_{wj} \cdot \beta_{wj}, \tag{13}$$

Required for alerting  $N_{wj}$  unions (units) of  $j$ -th type. According to the known values  $c_{pj} > c_{wj}$  the necessary financial resources (funds)  $C_1$  are determined for maintenance and timely ( $T_{pj} < T_{pjn}, T_{wj} < T_{wjn}$ ) alerting of the mentioned number  $N = \sum_j N_{pj} + \sum_j N_{wj}$  of unions (units).

*The second option:* the allocated amount of financial resources (funds)  $C_{1jl}$ , as well as the required value  $N_{pj}$ , consequently,  $T_{pjn}$ , are priority (set). In this case, the maximum allowable number  $N_{wj}$ , according to the known values  $c_{pj} > c_{wj}$ , will be calculated:

$$N_{wj} = \frac{C_{1jl} - c_{pj} \cdot N_{pj}}{c_{wj}} = \frac{C_{1jl}}{c_{wj}} - \frac{c_{pj}}{c_{wj}} \cdot N_{pj}, \tag{14}$$

Then the time, calculates the time required to mobilize and alert this number of unions (units) of  $j$ -th type calculates according to the known values  $t_{wj}, \beta_{wj}$ :

$$T_{wjn} = N_{wj} \cdot t_{wj} \cdot (1 - \beta_{wj}) + t_{wj} \cdot \beta_{wj}. \tag{15}$$

The total number  $N_j$  of unions (units) of  $j$ -th type in accordance with the average annual financial resources (funds) allocated for their maintenance  $C_{1jl}$  will be:

$$N_j = \frac{T_{pjn} - t_{pj} \cdot \beta_{pj}}{t_{pj} \cdot (1 - \beta_{pj})} + \frac{C_{1jl} - c_{pj} \cdot N_{pj}}{c_{wj}}. \tag{16}$$

*The third option:* the time  $T_{pjn}, T_{wjn}$ , is priority (set), then according to the known values  $t_{pj}, \beta_{pj}, t_{wj}, \beta_{wj}$  the values are clearly determined under the accepted conditions:

$$N_{pj} = \frac{T_{pjn} - t_{pj} \cdot \beta_{pj}}{t_{pj} \cdot (1 - \beta_{pj})}, \tag{17}$$

$$N_{wj} = \frac{T_{wjn} - t_{wj} \cdot \beta_{wj}}{t_{wj} \cdot (1 - \beta_{wj})}, \tag{18}$$

According to the known values  $c_{pj} > c_{wj}$  the financial resources  $C_{1j} = C_{1jl}$  (8) necessary to maintain and alert the number  $N_{pj}, N_{wj}$  found are determined. Then, the certain funds  $C_{1j}$  can be used to maintain and subsequently alert  $N_j$  of unions (units) of  $j$ -th type:

$$N_j = N_{pj} + N_{wj} = \frac{T_{pjn} - t_{pj} \cdot \beta_{pj}}{t_{pj} \cdot (1 - \beta_{pj})} + \frac{T_{wjn} - t_{wj} \cdot \beta_{wj}}{t_{wj} \cdot (1 - \beta_{wj})}. \tag{19}$$

Using one of the selected priority options, the total number  $N$  of unions (units) is calculated, which can be distributed according to the order of their maintenance, taking into account the time spent and allocated funds for alerting  $N$  of unions (units). The problem is considered solved if the condition  $N = N_n$  is fulfilled, with  $T = T_n$  of alerting all unions (units) of  $j$ -th types. In this case, it is considered that the average annual financial resources (funds)  $C_{1jl}$ , allocated for unions (units) of  $j$ -th type from the total amount of funds  $C_{1l}$ , allocated for unions (units) of all types, are enough for  $N_{pj}, N_{wj}$  of unions (units) of  $j$ -th types out of the total number  $N = N_n$  of unions (units). If the condition is not fulfilled, it is necessary to increase the allocation of average annual financial resources (funds)  $C_{1l}$  or shorten the time  $t_{pj}, t_{wj}$  for alerting one union (unit) of  $j$ -th type.

*The second stage.* It is known that for the same allocated (subject to limitations) average annual financial resources  $C_{1l} = \sum_j C_{1jl}$ . different values of indicators can be obtained regarding the number of unions (units) of permanent preparedness ( $N_{pj}$ ) and unions (units) to be mobilized ( $N_{wj}$ ). So, taking into

account the previously stated contradiction, the problem of distribution of unions (units) of  $j$ -th type in relation to the order of their content provides an optimization option for its solution, i.e., finding the optimal values  $N_{opj}$ ,  $N_{owj}$ , given their integrity, subject to conditions-limitations regarding the allocated average annual financial resources (funds)  $C_{1jl}$  and time  $T_{pjn}$ ,  $T_{wjn}$  required for alerting these unions (units). The criterion for solving this problem may be the desire to achieve the maximum relative to the total number  $N_j$  of unions (units) of  $j$ -th type.

It is assumed that the unions (units) can be alerted in a sequential, parallel or combined way depending on the degree of their staffing, equipment and training; therefore, the coefficient of simultaneity (parallelism)  $\beta$  – of the start of alerting unions (units) of  $j$ -th type is calculated. To record the optimization problem, the following indicators are taken into account:  $C_{1jl}$  is the average annual financial resources (funds) allocated for unions (units) of  $j$ -th type of the total amount of funds  $C_{1l} = \sum_j C_{1jl}$ , allocated for unions (units) of all types;  $C_{1j}$  is the required amount of financial resources (funds) to alert all the unions (units) of  $j$ -th type; the time  $T_{pj}$  "  $T_{pjn}$ ,  $T_{wj}$  "  $T_{wjn}$  for alerting unions (units) of  $j$ -th type. It should be noted that  $c_{pj} > c_{wj}$ ,  $t_{pj} < t_{wj}$ . The proposed optimization problem belongs

$$C_{1j} = C_{pj} + C_{wj} = c_{pj} \cdot N_{pj} + c_{wj} \cdot N_{wj} = c_{pj} \cdot \frac{T_{pjn} - t_{pj} \cdot \beta_{pj}}{t_{pj} \cdot (1 - \beta_{pj})} + c_{wj} \cdot \frac{T_{wjn} - t_{wj} \cdot \beta_{wj}}{t_{wj} \cdot (1 - \beta_{wj})} \leq C_{1jl}, \quad (22)$$

Where variables  $N_{pj}$ ,  $N_{wj}$  are non-negative integers, with  $c_{pj} > c_{wj}$ ;  $t_{pj} < t_{wj}$ ;  $\beta_{pj} > \beta_{wj}$ .

The optimization problem mentioned (20–22) is provided for unions (units) of  $j$ -th type. However, such a problem can be written in a more general form, as the linear integer programming problem in a standard (symmetric) form:

$$\max N = N_p + N_w = \sum_j N_{pj} + \sum_j N_{wj} = \sum_j (N_{pj} + N_{wj}). \quad (23)$$

The limitations set: values  $N_p = \sum_j N_{pj}$  and

$$C_1 = (c_p \cdot N_p) + (c_w \cdot N_w) = \sum_j C_{1j} = \sum_j (c_{pj} \cdot \frac{T_{pjn} - t_{pj} \cdot \beta_{pj}}{t_{pj} \cdot (1 - \beta_{pj})} + c_{wj} \cdot \frac{T_{wjn} - t_{wj} \cdot \beta_{wj}}{t_{wj} \cdot (1 - \beta_{wj})}) = C_p + C_w \leq C_{1l},$$

where variables  $N_p$ ,  $N_w$  are non-negative integers, with  $c_{pj} > c_{wj}$ ;  $t_{pj} < t_{wj}$ ;  $\beta_{pj} > \beta_{wj}$ ;  $(c_p \cdot N_p)$  and  $(c_w \cdot N_w)$  are the scalar product of vectors given in the coordinate form:  $c_p \{c_{p1}, c_{p2}, c_{p3}, \dots, c_{pj}\}$  is the vector of average annual costs (excluding the cost of AMH) for the maintenance, completion and alerting of each of the unions (units) of  $j$ -th type deployed in peacetime;  $c_w \{c_{w1}, c_{w2}, c_{w3}, \dots, c_{wj}\}$  is the vector of average annual costs (excluding the cost of

to the class of problems of linear integer mathematical programming. The essence of this problem is the need to find the values of variables  $N_{pj}$  and  $N_{wj}$  of unions (units) of a certain  $j$ -th type, which deliver the extremum – the maximum of a given scalar function, taking into account the accepted system of conditions-limitations on financial resources (funds)  $C_{1jl}$  and sometimes  $T_{pjn}$ ,  $T_{wjn}$ . With regard to the system of limitations, it is assumed that limitations, like variables, are non-negative values, and the number of limitations-equations is less than the number of variables. Given the above, the objective function of the linear integer programming problem will be written as:

$$\max N_j = N_{pj} + N_{wj}. \quad (20)$$

With limitations: values  $N_{pj}$  and  $N_{wj}$  should fulfil the condition regarding the timeliness of alerting unions (units) of  $j$ -th type:

$$T_{pj} = N_{pj} \cdot t_{pj} \cdot (1 - \beta_{pj}) + t_{pj} \cdot \beta_{pj} \leq T_{pjn}, \\ T_{wj} = N_{wj} \cdot t_{wj} \cdot (1 - \beta_{wj}) + t_{wj} \cdot \beta_{wj} \leq T_{wjn}; \quad (21)$$

values  $N_{pj}$  and  $N_{wj}$  should fulfil the condition of balance between the required average annual financial resources (funds)  $C_{1j}$  and financial resources (funds)  $C_{1jl}$ , allocated per year for unions (units) of  $j$ -th type of the total amount of funds  $C_{1l}$ :

$N_w = \sum_j N_{wj}$  should fulfil the condition of timeliness of alerting unions (units):

$$T_p = \sum_j N_{pj} \cdot t_{pj} \cdot (1 - \beta_{pj}) + t_{pj} \cdot \beta_{pj} \leq T_{pn}, \\ T_w = \sum_j N_{wj} \cdot t_{wj} \cdot (1 - \beta_{wj}) + t_{wj} \cdot \beta_{wj} \leq T_{wn};$$

values  $N_p$  and  $N_w$  should fulfil the condition of balance between the required total average annual financial resources (funds)  $C_1$  and total financial resources (funds)  $C_{1l}$ , allocated for a year for unions (units) of all types:

AMH) for maintenance, mobilization and alerting of each union (unit) of  $j$ -th type, with  $c_{pj} > c_{wj}$ ;  $N_p \{N_{p1}, N_{p2}, N_{p3}, \dots, N_{pj}\}$  is the vector of unions (units) of  $j$ -th type, deployed in peacetime;  $N_w \{N_{w1}, N_{w2}, N_{w3}, \dots, N_{wj}\}$  is the vector of unions (units) of  $j$ -th type to be mobilized in a special period.

#### 4. Example of calculations

An example of solving the linear integer mathematical programming problem according to the third option of

Table 1  
**The results of solving the linear integer mathematical programming problem  
on the third option of priorities (option)**

Indicators	Calculations max $N_j = N_{pj} + N_{wj}$								
	<i>j</i> -th type of unions (units)								
	<i>j</i> -1	<i>j</i> -2	<i>j</i> -3	<i>j</i> -4	<i>j</i> -5	<i>j</i> -6	<i>j</i> -7	<i>j</i> -8	<i>j</i> -9
$c_{pj}$ (mln UAH)	85.8	97.9	231	264	42.9	13.1	40	80	50
$t_{pj}$ (hours)	38	22	44	26	36	28	12	24	17
$\beta_{pj}$	0.8	0.7	0.71	0.8	0.7	0.71	0.83	0,8	0,71
$t_{pj} \cdot (1 - \beta_{pj})$	7.6	6.6	12.76	5.2	10.8	8.12	2.04	4,8	4,93
$t_{pj} \cdot \beta_{pj}$	30.4	15.4	31.24	20.8	25.2	19.88	9.96	19,2	12,07
$T_{pjn}$ (hours)	48	24	48	28	40	30	24	48	34
$N_{pj} \leq \frac{T_{pjn} - t_{pj} \cdot \beta_{pj}}{t_{pj} \cdot (1 - \beta_{pj})}$	2.32	1.30	1.31	1.38	1.37	1.25	6.88	6,00	4,45
$T_{pj} = N_{pj} \cdot t_{pj} \cdot (1 - \beta_{pj}) + t_{pj} \cdot \beta_{pj}$	48.0	23.98	47.95	27.98	39.99	30.0	23,99	48,0	34,0
Cond. fulfilled: $T_{pj} \leq T_{pjn}$	yes	yes	yes	yes	yes	yes	yes	yes	yes
$C_{pj} = c_{pj} \cdot N_{pj}$ (mln UAH)	199.06	127.27	302.61	364.32	58.77	16.38	275,2	480,0	222,5
$c_{wj}$ (mln UAH)	25.4	29.0	68.25	78.0	12.65	3.7	10	16	10
Cond. fulfilled: $c_{pj} > c_{wj}$	yes	yes	yes	yes	yes	yes	yes	yes	yes
$t_{wj}$ (hours)	107.28	136.75	89.89	186.11	180.38	124.86	93,64	133,33	82,66
Cond. fulfilled: $t_{pj} < t_{wj}$	yes	yes	yes	yes	yes	yes	yes	yes	yes
$\beta_{wj}$	0.6	0.5	0.5	0.6	0.5	0.6	0,6	0,6	0,6
Cond. fulfilled: $\beta_{pj} > \beta_{wj}$	yes	yes	yes	yes	yes	yes	yes	yes	yes
$t_{wj} \cdot (1 - \beta_{wj})$	42.913	68.374	44.896	74.445	90.188	40.946	37,456	53,333	33,064
$t_{wj} \cdot \beta_{wj}$	64.369	68.374	44.896	111.67	90.188	74.916	56,184	80,0	49,596
$T_{wjn}$ (hours)	326	194	242	240	314	194	218	288	192
$N_{wj} \leq \frac{T_{wjn} - t_{wj} \cdot \beta_{wj}}{t_{wj} \cdot (1 - \beta_{wj})}$	5.96	1.81	4.35	1.72	2.46	2.86	4,27	3,90	4,30
$T_{wj} = N_{wj} \cdot t_{wj} \cdot (1 - \beta_{wj}) + t_{wj} \cdot \beta_{wj}$	320.13	192.13	240.19	239.72	312.05	192.02	216,12	287,99	191,77
Cond. fulfilled: $T_{wj} \leq T_{wjn}$	yes	yes	yes	yes	yes	yes	yes	yes	yes
$C_{wj} = c_{wj} \cdot N_{wj}$ (mln UAH)	151.38	52.49	296.89	134.16	31.12	10.58	42,7	62,4	43,0
$C_{1j}$ (mln UAH)	355.0	200.1	610.0	510.0	100.1	28.5	320,0	548,0	270,00
$C_{1l}$ (mln UAH)	2941.7								
$C_{1j} = C_{pj} + C_{wj}$ mln UAH	350.44	179.76	599.5	498.48	89.89	26.96	317,9	542,4	265,5
$C_1 = \sum_j C_{1j}$ mln UAH	2870.83								
Cond. fulfilled: $C_{1j} \leq C_{1l}$	yes	yes	yes	yes	yes	yes	yes	yes	yes
Cond. fulfilled: $C_1 \leq C_{1l}$	yes								

(End of Table 1)

Optimal values obtained									
$N_{oj} = N_{opj} + N_{owj}$	7	2	5	2	3	3	10	9	8
$N_{op} = \sum_j N_{opj}$	23 (46.9 % of $N_o$ )								
$N_{ow} = \sum_j N_{owj}$	26 (53.1 % of $N_o$ )								
$N_o = N_{ow} + N_{op}$	49								

priorities is given in Table 1. Here,  $j$ -th type of unions (units) means unions (units) of the corresponding types of troops such as mechanized, tank, artillery, anti-aircraft missile brigades (regiments), etc.

## 5. Conclusion

The main content of the methodological approach to justify the division of armed forces, as the basic component of forces of national security, on peacetime and wartime MFs taking into account *military and economic aspects*, in particular the average annual financial resources required for the maintenance, mobilization (completion) and alerting unions (units) of a certain type. The authors believe that the originality of this methodological approach is as follows:

- the proposed algorithm of calculations (1) – (19) allows to solve the problem of distribution of armed forces by several options, depending on the chosen condition of initial data (options of priority) It provides for the use of three priority options: *the first option* supposes that the priority is the predetermined total number of unions (units) to be distributed according to the order of their maintenance and the time spent for alerting them, as well as the required number of unions (units) of permanent preparedness; *the second option* means that the priority is the average annual financial resources (funds), which are allocated in the interests of unions (units) of  $j$ -th type of the total amount of funds allocated per year in the interests of unions (units) of all types, as well as the required number of unions (units) of permanent preparedness; *the third option* means that the priority is the time required (maximum allowable) taking into account the limitations for alerting unions (units) of the relevant types of permanent preparedness and those to be mobilized in a special period. According to the selected priority, the total number of unions (units) is calculated, which can be distributed according to the order of their maintenance. The

problem is considered solved if the condition  $N \leq N_n$  is fulfilled, with  $T \leq T_n$  alerting of all types of unions (units). In this case, it is considered that the allocated average annual financial resources (funds) are enough to form the required number of peacetime and wartime unions (units). If this condition is not fulfilled, it is necessary to increase the allocation of average annual financial resources (funds) or shorten the time for alerting one union (unit) of  $j$ -th type. The advantage of this methodological approach, compared to the known ones, is that depending on the selected priority and a predetermined number of unions (units), it allows you to easily determine the number of unions (units) of permanent preparedness and unions (units) to be mobilized, taking into account the time for alerting them, which does not exceed the allowable values for the time of alerting, as well as the allocated average annual financial resources (funds);

- the optimization problem offered (20) – (22) allows you to determine the maximum number of unions (units) in relation to the order of their maintenance, taking into account the limitations on the time required to alert unions (units), as well as allocated financial resources. The advantage of this optimization problem, compared with the known problems of this area of research, is that due to the developed equations of the relationship between the main indicators of the distribution, it is confined to the known linear integer programming problem taking into account the most important restrictions on the time of alerting unions (units) and allocated financial resources.

It is believed that the methodological approach outlined in the article (the main content) allows a more reasoned approach to the division of the armed forces into peacetime and wartime unions (units), taking into account military and economic aspects, in particular, average annual financial resources required for the maintenance, mobilization (completion) and alerting unions (units) of a certain type.

## References:

- Mozharovskiy, V. M., & Hodz, S. V. (2018). Metodichni aspekty obhruntuvannya boiovoho skladu zbroinykh syl derzhavy z pozytsii teorii vedverenoho zbytku [Methodical aspects of the substantiation of a staff of the armed forces of a state from the standpoint of prevented damage theory]. *Kibernetika i systemnyi analiz*, vol. 54, no. 1, pp. 154–167.

- Mozharovskiy, V. M., & Hodz, S. V. (2018). Matematychna model obhruntuvannya optymalnogo boiovoho skladu zbroinykh syl derzhavy z pozytsii teorii vidvernenoho zbytku ta z urakhuvanniam ekonomichnykh chynnykiv [Mathematical model of the substantiation of the optimal combat staff of the armed forces of the state from the standpoint of the theory of prevented damage and with regard to economic review]. *Kibernetika i systemnyi analiz*, vol. 54, no. 5, pp. 150–159.
- Mozharovskiy, V. M., & Hodz, S. V. (2019). Zahalni pidkhody do obhruntuvannya boiovoho skladu zbroinykh syl u zalezhnosti vid voienno-ekonomichnykh mozhlyvostei derzhavy [General approaches to justification of combat staff of the armed forces in dependence to military-economic resources of the country]. *Baltic Journal of Economic Studies*, vol. 5, no. 5, pp. 100–109. doi: 10.30525/2256-0742/2019-5-5-100-109
- Hodz, S. V., & Mozharovskiy, V. M., Pantiushenko, R. V. (2020). Optymizatsii rozpodilu navchalnykh hodyn kompleksnoi prohramy boiovoi pidhotovky ziednannia (chastyny) mizh spetsialistamy (pidrozdilamy) rodiv viisk [Optimizing of the distribution of the educational hours of an integrated programme of the combat preparation of a union (unit) between specialists (departments) of the branches]. *Nauka i tekhnika Povitrianykh Syl Zbroinykh Syl Ukrainy*, vol. 3(40), pp. 25–35.
- Mozharovskiy, V. M., Hodz, S. V., & Sakovskiy, H. A. (2019). Metodolohichni osnovy rozroblennia kompleksnykh prohram boiovoi pidhotovky viiskovykh formuvan syl oborony derzhavy [Methodological foundations for the development of comprehensive programmes of combat training of military formations of the state defense forces]. *Zb. nauk. pr. TsNDI ZS Ukrainy*, vol. 4(90), pp. 16–24.
- Sakovskiy, H. A., & Hodz, S. V. (2019). Optymizatsiia rozpodilu boiovoho skladu Zbroinykh Syl Ukrainy na ziednannia (chastyny) myrnoho ta voiennoho chasu [Optimization of the distribution of the fighting force of the Armed Forces of Ukraine to peacetime and wartime unions (units)]. *Trudy universytetu: zb. nauk. pr. NUO Ukrainy im. Ivana Cherniakhovskoho*, vol. 1(151), pp. 5–14.
- Sakovskiy, H. A., & Hodz, S. V. (2018). Kontseptualni aspekty obhruntuvannya rozpodilu Zbroinykh Syl Ukrainy na viiskovi formuvannia postiinoi hotovnosti ta ti, shcho pidliahaiut vidmobilizuvanniu v osoblyvyi period [Conceptual aspects of substantiation of the division of the Armed Forces of Ukraine into military formations of permanent preparedness and those that are subject to mobilization in a special period]. *Zn. nauk. pr. TsNDI ZS Ukrainy*, vol. 2(84), pp. 103–109.
- Mozharovskiy, V. M., & Hodz, S. V. (2016). Matematychna model obhruntuvannya boiovoho skladu Zbroinykh Syl Ukrainy cherez velychynu vidvernenoho zbytku viisk v operatsii [Mathematical model of substantiation of the combat composition of the Armed Forces of Ukraine through the magnitude of prevented damage to troops in the operation]. *Trudy universytetu: zb. nauk. pr. NUO Ukrainy im. Ivana Cherniakhovskoho*, vol. 6(139), pp. 265–283.
- Romanchenko, I. S., Shuienkin, V. O., Sakovskiy, H. A., & Hodz, S. V. (2019). Matematychni osnovy teorii utrymanna viisk za stupenem ikh hotovnosti [Mathematical bases of the theory of maintaining troops according to the degree of their preparedness]: monograph. Kyiv: TsNDI ZS Ukrainy.
- Mozharovskiy, V. M., Hodz, S. V., & Repilo, Yu. Ye. (2020). Matematychna model planuvannya periodychnosti provedennia navchalnykh zboriv iz viiskovozoboviazanykh z urakhuvanniam neliniinoi zalezhnosti shvydkosti vtrachannia nymy ranishe nabutoi informatsii [Mathematical model of planning the frequency of training meetings with the persons subject to military service, taking into account the nonlinear dependence of the rate of loss of previously acquired information]. *Zb. nauk. pr. TsNDI ZS Ukrainy*, vol. 1(91), pp. 52–62.
- Mozharovskiy, V. M., & Hodz, S. V. (2016). Porivnialnyi analiz boiovykh potentsialiv Zbroinykh syl Ukrainy ta zbroinykh syl inshykh derzhav [Comparative analysis of the combat potential of the Armed Forces of Ukraine and the armed forces of other states]. *Trudy universytetu: zb. nauk. pr. NUO Ukrainy im. Iana Cherniakhovskoho*, vol. 1(134), pp. 40–44.
- Mozharovskiy, V. M., Hodz, S. V., & Taran, O. V. (2019). Funktsionalna zalezhnist rivnia navchenosti ziednannia (chastyny) vid vydilenoj na boiovu pidhotovku kilkosti navchalnykh hodyn ta yikh rozpodilu mizh spetsialistamy (pidrozdilamy) rodiv viisk [Functional dependence of the level of training of the union (unit) on the number of training hours allocated for combat training and their distribution among specialists (departments) of the branches]. *Spilni dii viiskovykh formuvan i pravookhoronnykh orhaniv derzhavy: zb. mater. mizh. nar. nauk.-prakt. konf. (Odesa, 12–13 veresnia)*. Odesa: Viiskova akademiia.
- Sakovskiy, H. A., & Hodz, S. V. (2017). Deiaki pohliady na problemni pytannia rozpodilu boiovoho skladu Zbroinykh Syl Ukrainy na viiska myrnoho ta voiennoho chasu [Some views on the problematic issues of division of the Armed Forces of Ukraine into peacetime and wartime troops]. *Zb. nauk. pr. TsNDI ZS Ukrainy*, vol. 3(81), pp. 76–83.