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MANAGEMENT EFFICIENCY ASSESSMENT MODEL OF CIVIL PROTECTION FORCES UNDER MARTIAL LAW CONDITIONS

Purpose. Development of a management efficiency assessment model of civil protection forces under martial law conditions. It is necessary to ensure an adequate level of operational response, sustainability of functioning, and rational use of resources in the face of increasing threat dynamics, taking into account the specifics of the functioning of the Unified State Civil Protection System during a special period.

Methodology. The study employs a computational approach to assessing the effectiveness of civil protection management, utilizing a network graph to determine the integral function of the normal (Gaussian) distribution.

Findings. A management efficiency assessment model of civil protection forces under martial law conditions, including the relevant blocks (measures), direct and feedback links between them, has been developed. On the basis of this model, a calculation task was developed, with the help of which the probability of performing the entire complex of partial works on management organization for a specific task was calculated.

Originality. The proposed management efficiency assessment model of civil protection forces under martial law conditions allows for increasing the efficiency of the relevant management body. This is ensured by achieving a balance between the available and required time and the formation of a time reserve for performing managerial actions, which allows the entire complex of works to be completed within the time specified by the head of the top management. The application of the proposed model also helps to increase the probability of timely completion of management tasks, taking into account the acceptable values of partial work performance indicators.

Practical value. An example of determining the effectiveness of management organization by calculating the probability of performing the entire complex of partial works on management organization for the selected task is considered, which is confirmed by the previous theoretical assumptions.

Keywords: *efficiency, model, management organization, time balance, martial law, civil protection*

Introduction. Because of the armed aggression against Ukraine, martial law has been imposed on its territory since February 2022. In response, the State Emergency Service of Ukraine, in cooperation with the regional and Kyiv city state administrations, as well as other public authorities, enterprises, institutions and organizations of all forms of ownership, was instructed to immediately ensure that the Unified State Civil Protection System (hereinafter – USCPS), including its functional and territorial subsystems, is brought into a state of readiness to perform assigned tasks in a special period [1].

In accordance with the Order of the Cabinet of Ministers of Ukraine No. 179-r, the Civil Protection Plan of Ukraine for a special period was put into effect under such conditions. According to this document, the USCPS was assigned the 'Full Readiness' status, which indicates that its organizational structures have been brought to the highest possible level of functional capacity to perform certain tasks in a special period [2].

Currently, the tasks assigned to the USCPS during the special period have become significantly more complicated due to the conduct of hostilities, constant shelling of residential buildings, and critical infrastructure of Ukraine by the armed forces of the aggressor country. At the same time, the burden on the management system (hereinafter – MS) of the USCPS is increasing, and therefore, the requirement for this system to manage the civil protection forces in a timely manner is becoming more urgent [3].

In addition, the effectiveness of the civil protection force MS needs to be improved, in particular by reducing the time required to perform the tasks assigned to it in these conditions. That is why the development of a management efficiency assessment model of civil protection forces under martial law conditions is currently one of the most urgent tasks of management science and practice.

Literature review. The subject matter of the article is closely related to the scientific research of other scholars. Thus, Yu. Kucherenko, A. Nosyk, A. Tkachov and Ye. Shubin considered the issue of current assessment of the effectiveness of the integrated military management system by the management bodies in a short time according to the methodology, the peculiarity of which is the application of the decomposition principle of the mentioned system into subsystems by functional characteristics, as well as further determination of their effectiveness, taking into account such factors as the importance, timeliness and quality of task performance [4]. In general, agreeing with the authors' conclusions, we note that the efficiency of functioning of complex systems is significantly influenced by the factor of agility of management bodies, since a decision made on the basis of information that loses relevance may call into question the performance of tasks in rapidly changing circumstances.

In the scientific studies by O. Voitko, V. Katsalap and Yu. Babii [5, 6], an approach to assessing the effectiveness of the strategic communications system of the Ministry of Defense and the Armed Forces of Ukraine based on the use of the expert evaluation method, is

substantiated. While agreeing with the proposed approach, we should note that it would be advisable to consider the sequence of application of the mentioned method in the case when the assessment of one of the experts differs significantly from the opinions of the entire group of experts.

In their study, A. Kramarenko and M. Vyshnevska substantiate the organizational and economic mechanism of functioning of the system for evaluating the effectiveness of personnel management with a view to improving the quality of implementation of management decisions. It is noted that the value of the weighting coefficients for certain indicators is determined depending on the priorities formed within a particular management context [7]. We consider this issue controversial because the priorities of each person may differ significantly, and therefore, the final results of the assessment may have some discrepancies.

Methodology for assessing the effectiveness of support system for emergency and recovery operations related to military emergencies was improved by V. Kotsiuruba and S. Hannenko. In their research, indicators and criteria for assessing the effectiveness of this system were selected and substantiated [8]. At the same time, it would be desirable to clarify how the authors took into account the peculiarities of the emergence and accumulation of demining tasks in the proposed methodology.

The works by M. Khomik [9, 10] define a generalized assessment scheme and propose an analytical and simulation model of the use of troops (forces) of the Armed Forces of Ukraine and other military formations in the process of eliminating the consequences of natural, man-made, and military emergencies. However, the author did not address the question of which methods for assessing the effectiveness of task performance and decision-making methods are used under conditions of uncertainty when assessing the effectiveness of troops in emergencies.

Kirsanov S. has developed a methodological approach to determining the requirements for the agility of command-and-control bodies within the framework of a promising automated system of troop management. The scientist emphasizes that in this system, information flows in a circle according to the stages of the troop management cycle [11, 12]. We believe that the author's statement that the proposed approach determines the sequential order of modelling the automated control process is fair. At the same time, we note that it would be appropriate to describe the management cycle in which information circulates.

Unsolved aspects of the problem. At the same time, despite the numerous scientific contributions of scholars conducting research on the above-mentioned issues, in our opinion, the development of tools for assessing the effectiveness of civil protection forces management under martial law, in particular, the agility of MS, remains an insufficiently addressed problematic issue.

Purpose. Development of a management efficiency assessment model of civil protection forces under martial law conditions by implementing an integrated approach aimed at improving the efficiency of management organization.

Methodology. The study uses the calculation method for assessing the effectiveness of MS and the corresponding graph for determining the integral function of the normal distribution, which allowed developing a management efficiency assessment model of civil protection forces under martial law conditions.

Results. In order to achieve the aim of the study, the first stage of the paper considers possible criteria for assessing the compliance of the USCPS's MS with current requirements and identifies the most important ones, in particular, regarding its functioning under martial law conditions.

The current requirements for the continuous readiness of the MS for action stipulate that under any circumstances and in any conditions all levels of management – from the state to the object level – as well as all components of the MS (bodies and control points, communication systems, automated and specialized systems) must be ready for effective operation during a special period. The degree of preparedness of the USCPS's MS should be ahead of the degree of preparedness of its components, in particular, the systems at the regional, local, and object levels [13, 14]. At the same time, the improvement of the readiness of the MS at all levels should be focused on ensuring the fastest possible transition from peacetime to martial law, given the complexity of the conditions of operation during a special period. This means that the main criterion for assessing the readiness of the MS is the time required to bring it to a state of readiness to act under martial law conditions. The form of this relationship, in particular, calculated using mathematical dependencies, may be different. For example, it is impossible to predict with certainty the consequences of negative factors arising under martial law conditions, in particular, during the transfer of the MS to higher levels of functioning, namely, when and with what intensity they will affect its components. Therefore, the processes of bringing the MS to readiness can be time-determined only in some cases, while in general they are probabilistic. The duration of these processes will vary within the value of the mathematical expectation or in accordance with the established normative indicators.

In addition, the available data on the absolute duration of the MS's processes functioning are insufficient to draw conclusions about the impact of its readiness on the level of realization of the potential capabilities of the civil protection forces. It is important not only to comply with the established timeframe for the implementation of management measures, but also to ensure the time balance in one's favor, which will allow avoiding the impact of negative martial law factors on the effectiveness of the USCPS's MS.

Based on the above mentioned, we have established that in order to assess the impact of the time factor on the organization of measures to manage the USCPS under martial law conditions, the following criteria should be taken into account: absolute duration of measures to bring the MS to readiness for action; time balance; difference between available and required time, which are applied only in cases where there is a reason to believe that the time for performing each individual measure is deterministic. In other situations, these criteria are not sufficient to fully assess the effectiveness of the process.

Under martial law conditions, the time factor becomes a priority in the process of organizing civil pro-

tection measures, which requires a clear and verified approach to its assessment.

The criteria we have chosen are relevant, complementary, and operationalized indicators of the effectiveness of management processes in the context of martial law. Their use allows for a comprehensive assessment of the preparedness and capacity of the MS to respond effectively within a limited time, in particular, provided that reliable data on the time parameters of management actions are available.

Thus, the absolute duration allows assessing the agility of actions, the time balance allows determining the degree of correspondence between resources and needs, and the difference between the available and required time allows identifying critical time gaps that may affect the effectiveness, sustainability, and reliability of the MS. The combined use of these criteria provides a more objective assessment of the system's readiness to perform its assigned tasks in conditions of high threat dynamics.

That is why, in these conditions, we consider it expedient to apply evaluation criteria that take into account the probabilistic nature and the presence of elements of uncertainty in the processes under study. Such criteria, in our opinion, include: mathematical expectation of duration of measures implementation to ensure the functioning of the MS; probability of timely response of the MS to the impact of negative factors caused by martial law conditions; probability of implementing certain measures within the established (directive or standard) timeframe. At the same time, depending on the processes' nature, the main criteria, in our opinion, are: for deterministic processes – the time balance (i.e., the occurrence of time reserve or time shortage for the impact of negative factors); for probabilistic processes – the probability of a timely response to these factors [15].

The 'time balance' criterion is objectively suitable for assessing deterministic processes, as it is based on clearly defined parameters of the duration of the threat impact and response, does not require statistical or probabilistic data, and provides a simple interpretation of the results by comparing the available and required time. It allows for the timely identification of time shortages or reserves, which is very important for making management decisions in the field of civil protection, where a delay in their implementation can have irreversible consequences. The time balance can be easily integrated into planning procedures, is universal for different types of measures, and does not require complex modelling, making it an effective and practically applicable tool for assessing the timeliness of management actions.

Under martial law conditions, when the level of instability and dynamism of changes significantly complicate the planning and implementation of management measures [16], there is a need to apply probabilistic evaluation criteria that can take into account elements of uncertainty in the studied processes. Unlike the deterministic ones, these criteria reflect the probabilistic nature of performing managerial functions.

For example, the mathematical expectation of measures implementation duration makes it possible to estimate the average time for the implementation of a set of work in the context of variability in the duration of certain actions. The probability of a timely response of the MS to negative factors allows assessing the ability of the system to respond promptly to external threats within a given time frame. The probability of completing measures within a specified timeframe is an integral indicator of the system's ability to achieve the planned results, taking into account risks and unforeseen circumstances.

A characteristic feature of these criteria is their ability to reflect the variability of results over time and reduce the level of subjectivity in assessing management efficiency. They provide increased flexibility of analysis, which is important for making well-grounded decisions in crisis situations.

The above-mentioned criteria for assessing the management efficiency directly correlate with the concept of management agility, which is defined as the ability of the leaders of management bodies (hereinafter – MB) to solve the tasks in a timely manner, which ensures the prevention of the impact of negative factors caused by martial law, as well as a quick response to changes in the situation and timely influence on the development of events. That is why compliance with this requirement, along with ensuring a high level of readiness for action, is linked to the time criteria for the implementation of management cycles. Accordingly, the management agility can be assessed according to the previously outlined criteria, among which the key ones are the time balance and the probability of a timely response to events under martial law conditions.

At the same time, management efficiency can be assessed through forecasting, in particular, by obtaining management efficiency indicators before creation (application) of the MS and before implementation of actions by civil protection forces. This task can be solved by modelling actions method (physical, mathematical or combined), as well as by certain types and complex of calculations, which can result in indicators of internal and external management efficiency, in particular, comparative assessments of different options for management organization and implementation.

Thus, one of the ways to obtain the results of comparative evaluation of different MS variants according to the criteria considered is physical modelling of civil protection forces' actions, i.e., repeated exercises with the participation of these forces and the MS. In order to exclude the influence of other criteria on the course and outcome of the civil protection forces' actions, all parameters of their actions, except for the parameters characterizing the MS, remain unchanged. We believe that the most effective way to obtain the results of a comparative evaluation of different MS variants by a set of criteria is a mathematical modelling of civil protection forces' actions. This modelling can be carried out by means of models that would take into account the comprehensive impact on the course and outcome of the actions of civil protection forces of the parameters characterizing the MS and the links (including information ones) between the MB of USCPS.

Within the framework of the proposed approach, it is considered expedient to use both certain types of calculations and their complex for a comprehensive assessment of management efficiency, in particular, by determining the numerical values of partial criteria with their subsequent aggregation into integral and generalized indicators of comparative effectiveness of different MS variants.

In this regard, at the second stage of the study aimed at developing of a management efficiency assessment model of civil protection forces under martial law conditions, the existing calculation method developed for analyzing the military-type MS efficiency was adapted to the needs of the USCPS. This approach is used to assess the level of readiness and agility of the MS's functioning, in particular, by analyzing the correlation between the available and required time for implementing management decisions.

In order to quantify these characteristics, it is proposed to use the method for constructing and analyzing the network graph of works, which is formed by the emergency response headquarters. On the basis of such a graph and the relevant mathematical models, the mathematical expectation of the total duration of the management cycle, standard deviations of the actual terms of performing certain works, the time of early and late start and completion of works, time reserves are calculated, as well as the definition of the critical path and assessment of the probability of timely completion of the management cycle and an adequate response to changing circumstances in wartime.

Our study uses clarified terms in accordance with the subject area, in particular: management is understood as the activity of the MB aimed at ensuring the constant readiness and capability of civil protection forces to perform their assigned tasks, as well as at directing their actions in case of a threat or emergency occurrence. The purpose of management is to achieve maximum efficiency of involving the civil protection forces in such conditions. The relevant functional tasks that make up the content of the MB's management activity are detailed in the diagram (Fig. 2, block 2) [15]:

1. Warning and informing civil protection forces about the threat and occurrence of an emergency.

2. Continuous acquisition, collection, study, summarization, imaging, and analysis of data on circumstances, their transformation into management information, and preparation of data for decision-making.

3. Decision-making.

4. Communicating tasks to civil protection forces.

5. Action planning (refining the response plan).

6. Organizing and maintaining continuous interaction between the MB and civil protection forces.

7. Organizing and maintaining comprehensive support for civil protection forces' actions.

8. Preparing civil protection forces for their assigned tasks and directing them in the performance of their activities.

9. Control and assistance to subordinate MB.

In what follows, we use the constructed network graph of MB's works (Fig. 1) [15].

Let us assume that the graph of the MB's works in solving a certain management task has already been formed (Fig. 2, block 3), and for each partial action within management organization, estimates of the minimum ($t_{\min}$), maximum ($t_{\max}$), and most probable ($t_{m.p.}$) duration are determined. In addition, a list of works that form the critical path has been established (Fig. 2, blocks 4, 5), the total duration of which reflects the total time spent on the implementation of the relevant management task assigned to the MB. Under such conditions, the mathematical expectation of the duration of each partial management action ($\mu t_{\exp}$) is calculated by the formula (Fig. 2, block 6) [15]

$$\mu t_{\exp} = \frac{t_{\min} + 4t_{m.p.} + t_{\max}}{6},$$

where $\mu t_{\exp}$ is mathematical expectation of the duration of each partial work, min; $t_{\min}$ is minimum work performance duration, min; $t_{\max}$ is maximum work performance duration, min; $t_{m.p.}$ is the most probable work performance duration, min.

The standard deviation of the actual duration of each work performance within the management organization from the corresponding mathematical expectation is determined by the formula (Fig. 2, block 7) [15]

$$\sigma t_{\exp} = \frac{t_{\max} - t_{\min}}{6},$$

where $\sigma t_{\exp}$ is standard deviation of the actual duration of each work performance from the mathematical expectation, min; $t_{\max}$ is maximum work performance duration, min; $t_{\min}$ is minimum work performance duration, min.

The mathematical expectation of the critical path duration (M), defined as the sum of mathematical expectations of duration performance for partial works on management organization that are part of the critical

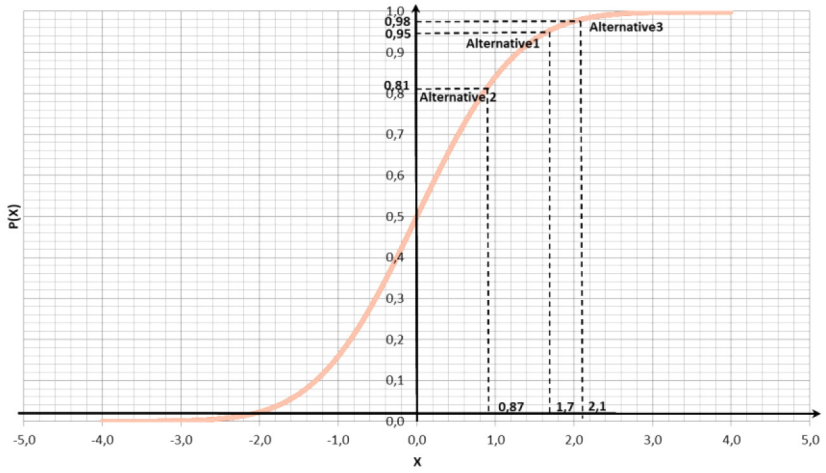

Fig. 1. Graph of determining the integral function of the normal distribution law (Gaussian distribution) for analyzin gthe probability of timely completion of partial works on management organization of civil protection forces

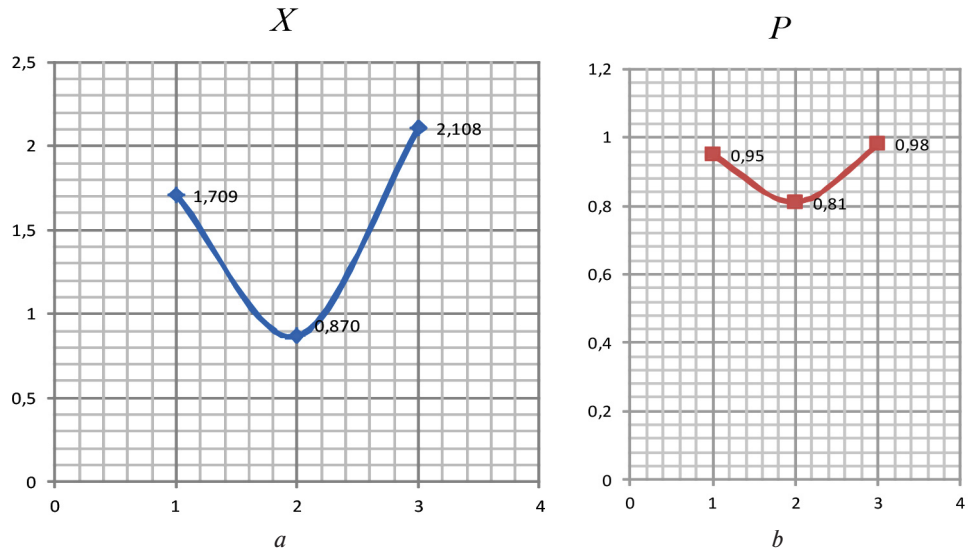

Fig. 2. Dependence of the probability of completion of the entire complex of works on management organization on the value of the normalized variable:

a – value of the normalized variable; b – probability of completion of the entire complex of works on management organization

path, is calculated using the appropriate formula $M = \sum t_{exp}$ (Fig. 2, block 8).

The standard deviation of the actual duration of management task performance from their mathematical expectation is determined by the formula shown in Fig. 2, block 9 [15]

$$\sigma M = \sqrt{\sum \sigma t_{\text{exp}}^2},$$

where σM is standard deviation of the actual time for management task performance from the mathematical expectation, min; σt_{exp}^2 is standard deviations of work performance time attributed to the critical path, min.

In this case, the sum sign includes only those standard deviations of work performance time that are attributed to the critical path. Based on the obtained values of the time parameters, it is possible to determine the key evaluation criterion – the probability of completion of the entire complex of works on management organization (P) within the time limit set by the higher MB (T_A).

Taking into account that the organization of civil protection forces management involves performing a wide range of interrelated tasks, according to the central limit theorem of probability theory, there are reasonable grounds to believe that the time distribution on the completion of a set of partial operations that constitute a certain task approaches a normal distribution. This, in turn, makes it possible to apply a graphical method for determining the integral function of the normal distribution law (Fig. 1).

Subsequently, alternatives to the USCPS's MS are selected in accordance with the established directive timeframe (Fig. 2, blocks 10, 12). The basis for constructing a network graph is the value of the normalized variable X, which is calculated by the corresponding mathematical formula (Fig. 2, block 11) [15]

$$X = \frac{T_A - M}{\sigma M},$$

where X is the value of the normalized variable, unitless; T_A is available time to complete the work on the management organization task, min; M is mathematical expectation of the critical path duration, min; σM is standard deviation of the actual time for management task performance from the mathematical expectation, min.

According to the network graph, we estimate the value of P – the probability of completion of the entire complex of works on management organization for a specific task within a given timeframe by alternatives of MS, and thereby we can determine the research criterion (Fig. 2, block 14). We select the best alternative of MS according to the highest probability of completion of the entire complex of works on management organization that meets the research criterion (Fig. 2, block 15). Then we determine the probability of completing the entire complex of partial works on management organization for task 2 using the example given in the study.

If the criterion is not met, changes are made to the timing of works on the critical path due to the available feedback in order to adjust the parameters of the proposed assessment model to achieve a time balance. The dependence of the probability of completion of the entire complex of works on management organization on the value of the normalized variable is shown in Fig. 2.

At the third stage of the study, a management efficiency assessment model for civil protection forces under martial law conditions was developed (Fig. 3). When solving management tasks in the face of a threat and an emergency occurrence, it is necessary to take into account the law of correspondence between available and required time, which reveals one of the most important requirements for management – its agility.

In the course of planning and managing the actions of civil protection forces, it is necessary to achieve a balance of time by comparing available and required time, and to identify its reserve or shortage. To this end, it is necessary to consider two types of time: available and required, which come into conflict with each other during the response to emergencies of the MB and civil protection forces.

Available time (T_A) is the time interval within which the MB's head needs to complete the entire list of tasks

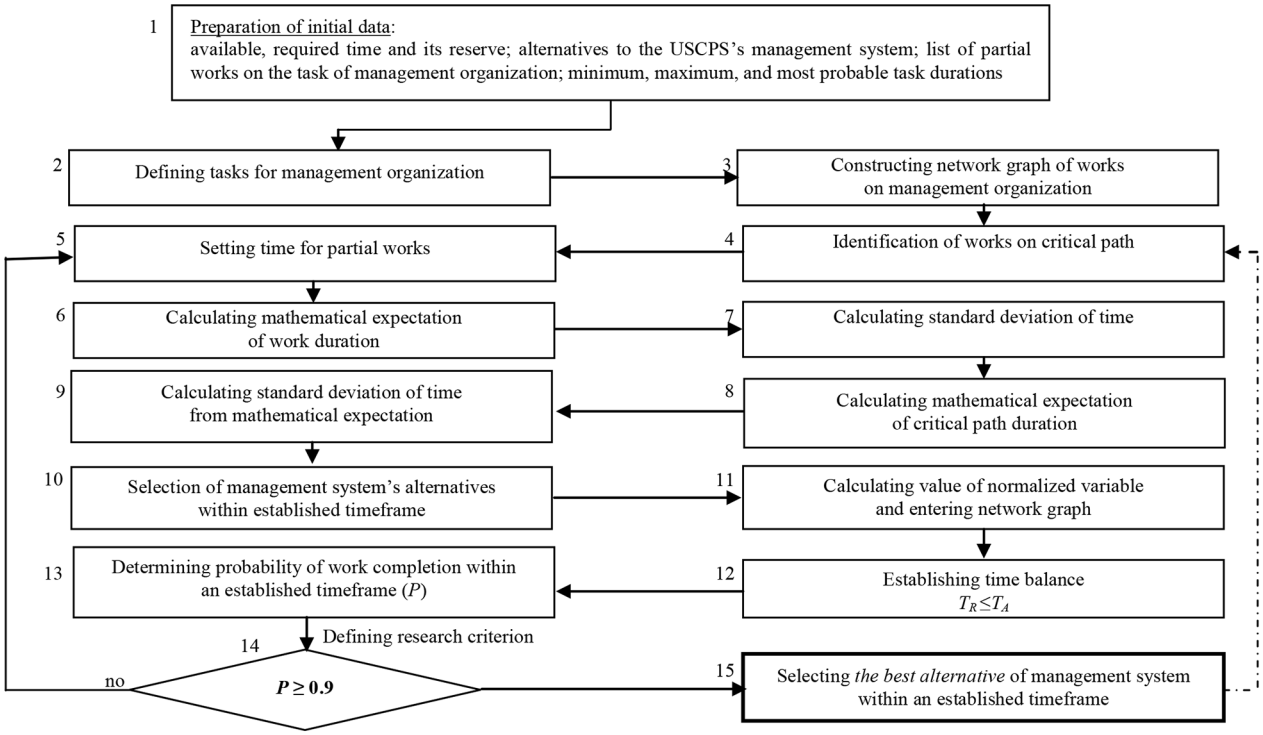

Fig. 3. Schematic of the management efficiency assessment model of civil protection forces under martial law conditions

on management organization, which is determined by the head of the top management in the form of specified or directive time (determined by guidelines).

Required time (T_R) is the time during which the MB's head is able to organize all management activities, taking into account the level of training, readiness for action, provisions, capabilities of management bodies and civil protection forces, the state of the MS, and methods of work used by the head.

In the applied aspect, a favorable time balance is ensured only when the duration required to perform management activities does not exceed the available time, which allows for the implementation of actions within the specified limits. At the same time, we note that the lower the value of the required time compared to the available time, the greater the time reserve has the MB's head, which provides him with the opportunity to compensate for unforeseen situations, errors in time calculations, the presence of elements of randomness, and uncertainty of circumstances. If the required time is greater than the available time, a lack (shortage) of time occurs that does not allow for the implementation of the entire list of planned activities.

Thus, the ratio of required to available time can be represented by the inequality $T_R \leq T_A$, which is accepted in this study as one of the key criteria for achieving the goal of management organization in emergencies. At the same time, another important research criterion is suggested here, namely the probability of completing the entire complex of works on management organization within the available time, which is defined by the expression $P \geq 0.9$.

The mentioned criterion is formulated taking into account provisions of the Methodology approved by order No. 273 of the State Emergency Service of Ukraine (Annex 4) [17]. In accordance with provisions of the stated Methodology, the MB's level of preparedness to perform assigned tasks in case of a threat or occurrence of emergencies is assessed as 'high' if at least 90 % of the main tasks are performed in the high alert mode as well as in the emergency mode.

Under such conditions, it is advisable to establish the work performance duration on management organization during emergency response under martial law. According to the Regulation on the Emergency Response Headquarters (hereinafter – Headquarters), the main tasks and functions of the Headquarters include direct organization and coordination of actions of the civil protection forces, of the Armed Forces of Ukraine, of other military formations, bodies and units of the Ministry of Internal Affairs involved in emergency response, as well as ensuring information interaction with the emergency management centers of the appropriate level. Taking into account the similarity of action sequences and activities content of the Headquarters' task force to the actions of military headquarters, it is logical to bring the relevant time indicators in line with the indicative standards for the implementation of measures to organize actions given in [18].

In order to test the developed management efficiency assessment model of civil protection forces under martial law conditions, the study modelled this process on the basis of the initial data of a possible actions' scenario of the USCPS's MS. Initial data for calculating the probability of the entire complex of MB's work completion on management organization in general under task 2 'Continuous acquisition, collection, study, summarization, imaging and analysis of data on circumstances, their transformation into management information, preparation of data for decision-making' were divided into partial works, namely:

1. Acquisition, collection, study, summarization, and imaging of information.

2. Analysis of data on circumstances and their transformation into management information.

3. Preparation of data for decision-making.

Available time to complete the mentioned task (T_A), which is set by the head of the higher MB, is 90 minutes, as defined, for example, in [18]. Based on proposed principles of the management efficiency assessment model of civil protection forces [19, 20] under martial law and the initial data, in particular, due to the developed calculation task, the study obtained the criterion value of the performing probability for one of the tasks on management organization according to USCPS's MS's alternatives (Table).

Thus, according to the research criterion of determining the probability of completion of the entire complex of works on management organization under task 2 within the specified timeframe ($P \geq 0.9$), the first alternative of the USCPS's MS outperforms the second by 1.25 times, in particular due to the formation of a greater time reserve for management organization.

The above-mentioned highlights the need to implement an integrated approach aimed at improving the effectiveness of management organization by achieving an optimal balance between the available and required time for performing managerial actions and forming a time reserve.

The approach described and substantiated by us, which is based on mathematical modelling of civil protection forces' actions, allows ensuring timely managerial decision-making in situations of high dynamics of the operational situation, which significantly reduces the probability of organizational failures and loss of control. Achieving an optimal balance between time resources (available and required time) and management workload helps to reduce the risk of untimely performance of tasks and functions, and ensures the MS's adaptability to unforeseen circumstances by forming a time reserve.

In addition, the application of an integrated approach creates opportunities for integration of analytical, simulation, and calculation methods, including network planning, probability estimation, and the normal distribution of time for completing tasks. Such an approach ensures an increase in the accuracy of management efficiency assessment and provides a basis for making informed decisions within a specified timeframe.

Coordination of management processes at different levels of organizational structure, achieved through a balanced approach to planning and implementing management actions, contributes to increasing the overall efficiency of the USCPS's functioning. In addition, the focus on integration into the European and Euro-Atlantic security space requires the implementation of similar approaches that are typical for EU and NATO countries, given their compliance with modern standards of strategic management.

Conclusions. The paper develops a management efficiency assessment model of civil protection forces under martial law conditions by introducing an integrated approach aimed at improving the effectiveness of management organization.

The study was conducted in four stages. At the first stage, assessment criteria for the USCPS's MS were

Table

Values of indicators for calculating the probability of completion of the entire complex of partial works on management organization under task 2

No.	Indicator name	Management system's alternatives		
		1	2	3
1	Available time (T_A), min	90	90	90
2	Required time (T_R), min	80	85	75
3	Time reserve (T_{res}), min	10	5	15
4	Time to perform partial works, minimum, most probable, maximum (t_{min}, $t_{m.p.}$, t_{max}), min first second third	 10, 30, 40 5, 20, 30 20, 30, 40	 10, 30, 45 5, 25, 40 20, 30, 35	 5, 20, 30 15, 25, 35 10, 30, 45
5	Mathematical expectation of the duration of partial works, min first (μt_{exp1}) second (μt_{exp2}) third (μt_{exp3})	 28 19 30	 29 24 29	 19 25 29
6	Standard deviation of the actual performance time from the mathematical expectation of the first work (σt_{exp1}), min of the second work (σt_{exp2}), min of the third work (σt_{exp3}), min	 5 4 3.3	 5.8 5.8 5	 4 3.3 5.8
7	Mathematical expectation of the critical path duration (M), min	77	82	73
8	Standard deviation of the actual time for management task performance from the mathematical expectation (σM), min	7.14	9.6	7.7
9	Value of the normalized variable (X)	1.709	0.870	2.108
10	Probability of completion of the entire complex of works on management organization under task 2 within the specified timeframe according to the management system's alternatives (P_1, P_2, P_3)	0.95	0.81	0.98

considered, and the main criterion of MS's efficiency was defined based on indicators of management organization's agility. At the second stage of the study, the existing calculation method for assessing the effectiveness of military systems was adapted to assess the USCPS's MS for managing civil protection forces under martial law. This method is based on the construction of a network graph of works. At the third stage, a management efficiency assessment model of civil protection forces under martial law conditions was constructed, which includes relevant blocks (measures), direct and feedback links between them. On the basis of this model, a calculation task was developed, with the help of which, at the fourth stage of the study, the probability of completion of the entire complex of partial works on management organization under task 2 'Continuous acquisition, collection, study, summarization, imaging and analysis of data on circumstances, their transformation into management information, preparation of data for decision-making' was calculated.

It is proven that the application of the developed model in practice ensures an increase in the effectiveness of management organization by achieving an optimal balance between the available and required time for performing managerial actions and forming a time reserve.

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Модель оцінювання ефективності управління силами цивільного захисту в умовах воєнного стану

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Мета. Розроблення моделі оцінювання ефективності управління силами цивільного захисту в умовах воєнного стану. Така необхідність зумовлена потребою забезпечення належного рівня оперативного реагування, стійкості функціонування й раціонального використання ресурсів в умовах зростання динаміки загроз, з урахуванням специфіки функціонування єдиної державної системи цивільного захисту в особливий період.

Методика. У дослідженні використано розрахунковий підхід до оцінювання ефективності управління силами цивільного захисту, що передбачає застосування мережевого графіка для визначення інтегральної функції нормального (гауссівського) розподілу.

Результати. Розроблена модель оцінювання ефективності управління силами цивільного захис-

ту в умовах воєнного стану, що включає відповідні блоки (заходи), прямі й зворотні зв'язки між ними. На основі зазначеної моделі розроблена розрахункова задача, за допомогою якої проведені розрахунки ймовірності виконання усього комплексу часткових робіт з організації управління за визначеним завданням.

Наукова новизна. Запропонована модель оцінювання ефективності управління силами цивільного захисту в умовах воєнного стану дозволяє підвищити ефективність роботи відповідного органу управління. Указане забезпечується завдяки досягненню балансу між наявним і потрібним часом та створенню резерву часу на виконання управлінських дій, що дозволяє виконати увесь комплекс робіт у визначений керівником вищої ланки управління час. Застосування запропонованої моделі також сприяє підвищенню ймовірності своєчасного виконання завдань з організації управління, ураховуючи прийнятні значення показників виконання часткових робіт.

Практична значимість. Розглянуто приклад визначення ефективності організації управління шляхом проведення розрахунків імовірності виконання усього комплексу часткових робіт з організації управління за обраним завданням, що підтвердили попередні теоретичні припущення.

Ключові слова: *ефективність, модель, організація управління, баланс часу, воєнний стан, цивільний захист*

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