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Improving Command and Control of Forces and Assets in Contemporary Warfare: Theoretical Approaches

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Abstract. The article is devoted to the research of the transformation of troop command and control in the contemporary warfare, which is being shaped under the influence of the information revolution, the development of digital technologies and the widespread use of command and control automation tools. The relevance of the topic is determined by the changing character of combat operations in the russian-Ukrainian war, the emergence of new principles of conducting warfare, in particular battlefield transparency, management of engagement zones, multi-level layering of information and the widespread use of robotic systems. Under such conditions, traditional centralised command and control models lose effectiveness and require adaptation to a highly dynamic operational environment. The aim of the article is to substantiate theoretical approaches to improving the command and control of forces and assets in accordance with the new principles and regularities of the modern battlefield. The methodological framework of the research consists of the comprehensive use of systems analysis, the cybernetic approach, methods of conceptual modelling, comparative analysis and logical generalisation. The work examines the interrelationship between the decision-making authority distribution, the character of interaction between command and control levels and the principles of information distribution in the troop command and control system. As a result of the research, the main areas of evolution of command and control systems for forces and assets from centralised hierarchical structures to decentralised network models have been identified. The need to transition to adaptive command and control systems capable of functioning under the conditions of high uncertainty, rapid changes in the situation and excessive information flows has been substantiated. It has been established that the key factors of effective command and control are the rational distribution of decision-making authority, the organisation of horizontal interaction and the creation of a single information and communication space. The practical significance of the results obtained consists in the possibility of their use during the development of automated command and control systems, the improvement of organisational structures of military command and control and the introduction of artificial intelligence tools into decision-support processes.

Keywords: adaptability, information and communication systems, decision-making, complex organisational and technical systems, control theory, artificial intelligence.

Introduction

Research into trends in the field of international security, as well as the specific features of its development, indicates that a significant number of states since the beginning of the twenty-first

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century have been undergoing profound structural changes in various spheres of social life. On a global scale, these changes are fundamental in nature, comparable, for example, to the invention of firearms or the computer, and are connected with the broad applied use of the results of scientific research and achievements in the field of informatisation, which have determined the transition from post-industrial society to information society or, according to the concise definition first given by Peter Drucker [1], to the information age.

It should be noted that the "*information age*" is a rather conditional concept, which is associated primarily with revolutionary changes in the information sphere, and has a profound impact on the search for and development of new forms and methods of management. The main reason for the revolution in the sphere of informatisation of management processes was technological achievements in microelectronics and microprocessor technology. This contributed to a reduction in the cost of storing, processing and transmitting information, which caused the rapid development of information technologies.

The russian-Ukrainian war has shown that the revolution in the information sphere has influenced the methods of organising warfare, command and control, and weapons development. Within the creation of a new theoretical basis in the information age, the main principles of command and control of warfare are understood differently.

A number of fundamental principles and regularities of warfare in the twenty-first century have emerged and complemented the existing ones, which, unfortunately, are being actively tested in the russian-Ukrainian war:

the principle of battlefield transparency;

the principle of kill-zone management;

the principle of layering information for decision-making;

the principle of saturation of the battlefield with robotic systems.

In the future, the development of the principles of command and control of warfare will be inseparably connected with the development of "*combat*" artificial intelligence. These trends require theoretical understanding and the development of control theory for building effective command and control systems for forces and assets.

Literature Review

The literary sources used for this research can be divided into a number of interconnected groups.

The *first group* includes classical publications on management theory and decision-making theory by Peter Drucker [1], Gerd Gigerenzer [2], Daniel Kahneman [3], Russell Ackoff [4], Stanley McChrystal [5], which present the main principles of systemicity in building management structures, emphasise the need to take into account a wide range of factors when making management decisions and form a methodology of management in complex and uncertain environments. These sources are necessary for a general understanding of management processes and the classification of decision-making conditions under the conditions of the modern battlefield.

The *second group* of scientific works includes the works of domestic scholars who researched control theory in military organisational structures: B. M. Herasymov [6], Ye. O. Horbunov [7], V. Ye. Yarushek [8]. The value of these literary sources consists in the transformation of general management approaches to the specific features of conducting combat operations. Despite some obsolescence, they form the theoretical basis for decision-making precisely in military affairs.

The *third group* of literary sources includes the works of Ye. B. Smirnov, H. A. Drobakha [9; 10], O. M. Zahorka [11], I. S. Rusnak [12], in which information and analytical processes of decision-making support were researched and the theoretical foundations of command and control specifically of groupings of troops were formed. These sources reveal modern approaches and views on the process of decision-making and command and control of military organisational structures, but do

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not take into account changes in the forms and methods of conducting warfare in the russian-Ukrainian war and the new principles that operate on the modern battlefield.

Meanwhile, changes in the conditions of conducting warfare, the formation of new principles and regularities of the battlefield require a review of existing concepts regarding troop command and control.

Methodological Framework

The aim of the article – is to set out theoretical approaches to improving troop command and control in accordance with the new principles and regularities of the battlefield.

The methodological framework of the research consists of a comprehensive combination of systemic, cybernetic, network-centric and information-analytical approaches to researching troop command and control in the contemporary warfare. The theoretical basis consisted of works on management theory, decision-making, systems analysis, military command and control and cybernetics, which examine the regularities of the functioning of complex organisational systems, the specific features of management under the conditions of uncertainty and high dynamics of the environment [1–15].

The research used the method of systems analysis to determine the interrelationships between the command and control structure, the decision-making authority distribution, information support and the character of interaction between command and control levels. The cybernetic approach was applied to substantiate the regularities of the functioning of troop command and control systems in accordance with the theorem of requisite variety, which made it possible to determine the dependence of command and control effectiveness on the complexity and dynamics of the operational environment.

The method of comparative analysis was used to compare centralised and decentralised command and control models, as well as to research the transformation of traditional hierarchical structures into networked command and control systems. The method of conceptual modelling made it possible to form a space of types of command and control of forces and assets and a space of characteristics of the operational environment, which made it possible to determine the directions of evolution of modern military command and control systems.

The method of logical generalisation and scientific abstraction was also applied to form new theoretical provisions regarding the transition from platform-centric to network-centric and zonal command and control under the conditions of battlefield transparency, high speed of information exchange and the widespread use of artificial intelligence.

The practical value of the methodology consists in the possibility of its use during the improvement of command and control systems for forces and assets, the creation of a single information and communication space and the development of prospective automated decision-support systems in the Armed Forces of Ukraine.

Results and Discussions

Before the russian-Ukrainian war, the concept of “network-centric warfare” (NCW) [13] was popular in the scientific space of military command and control theory, which, in its essence, is not a concept of warfare, but specifically of command and control. NCW forms the main technological approaches to implementing the principle of unified command and control.

The emergence of new information tools in the field of command and control of forces and assets became a consequence of an information-technological breakthrough in technical sciences, especially in cybernetics, informatics, computer engineering, and so on.

Command and control within forces and assets in the NATO glossary [14] is defined as the activity of commanders, commanding officers, staffs and other command and control bodies in maintaining the constant combat readiness of forces and assets, preparing operations (combat

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operations) and directing forces and assets while they perform assigned tasks. The given definition reflects only the external manifestation of the command and control function and does not reveal its essential aspects. A special scientific approach is required to identify trends and forecast the directions of development of this complex concept.

Of the three main systemological approaches to researching troop command and control, the *cybernetic* one is the most natural.

One of the main theorems of cybernetics is the theorem of requisite variety, proposed by William Ross Ashby [15]. If it is interpreted in relation to the command and control of a military organisation, it has the following meaning: *for an organisation to function successfully in an uncertain environment, the complexity of decisions and the speed of their adoption must correspond to the complexity and speed of changes taking place in the environment.*

The command and control system must also have more complex decisions in relation to the controlled subsystems. The following well-known fact follows from this regularity: *complex problems do not have simple solutions.*

Therefore, from the entire set of characteristics that determine the most essential modern features of command and control of forces and assets, three key ones can be identified:

the decision-making authority distribution;

the organisation of interaction between persons participating in the preparation (development) of decisions;

the rational distribution of information between participants in the command and control process.

These characteristics form a three-dimensional space in which different types of command and control of forces and assets can be represented (Fig. 1).

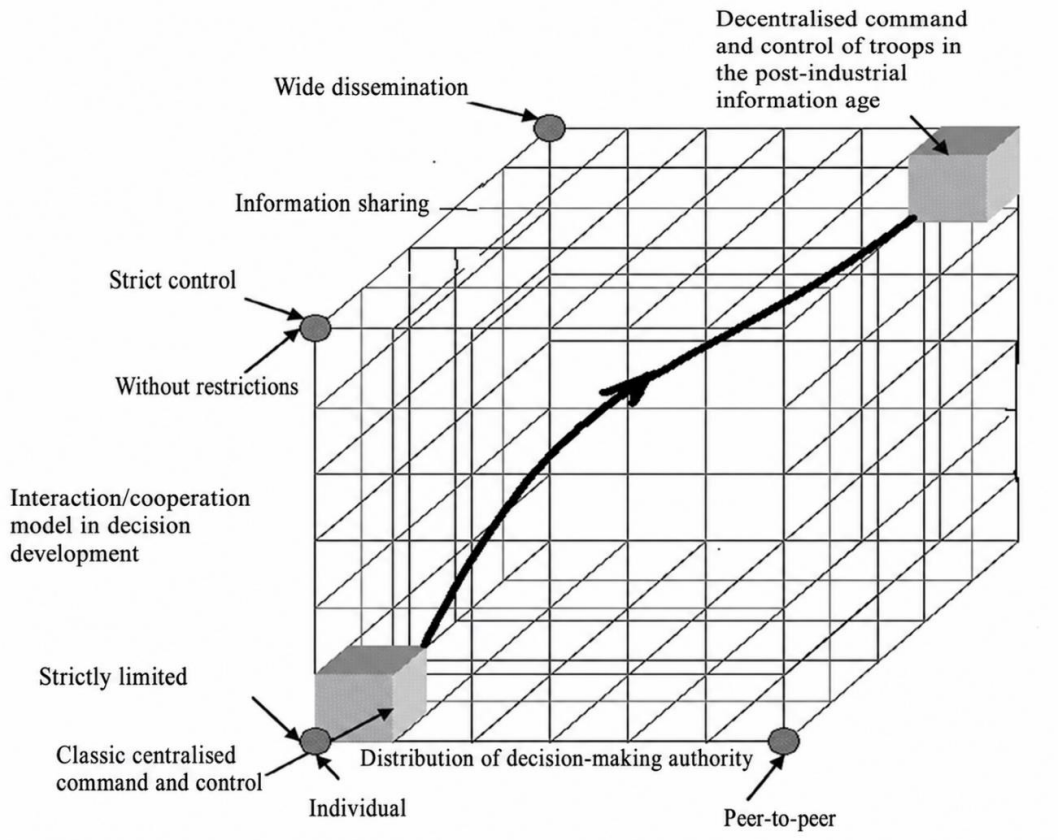


Figure 1. Space of types of command and control of forces and assets

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The location of an organisation in the space of types of command and control of forces and assets is reflected both in relation to individual command and control functions and in the dynamics of transition from one type of command and control to another in the course of conducting combat operations [13].

For example, the functions of collecting intelligence information may be reflected in another part of the representation space than the functions of civil-military cooperation, and may differ sufficiently from how the functions of command and control of forces and assets during the conduct of combat operations will be represented. It is precisely in this way that the location of an organisation in the space of command and control of forces and assets in the absence of a crisis situation will be different from that during a crisis.

Military organisational structures are characterised by a high degree of concentration of management functions. Under previous technical limitations on the pace of processing and delivering information, the command and control body was a monopolist of the most complete information. Only in the command and control body, which was provided with the most complete information, could the best (optimal) decision be developed. In such a command and control system, all information was collected at the centre, transformed into a form convenient for decision development, and then, in the form of detailed instructions, communicated to the troops (forces).

In Fig. 1, at the origin of the coordinates, the area corresponding to classical centralised hierarchical command and control of forces and assets is shown. At the opposite vertex of the coordinate cube, the area corresponding to decentralised network command and control of forces and assets is shown. The tendency of the evolution of classical command and control of forces and assets from centralised to decentralised network command and control can be considered as a process of adaptation of military organisations to changes taking place in the operational environment. It is important to prove that the changes taking place in the external operational environment inevitably lead to the evolution of the command and control system of forces and assets.

Changes in the external operational environment can be characterised by the following factors: battlefield transparency; increased dynamics caused by technological progress; growing complexity associated with the variety of means and methods of action of the asymmetric forces of the conflicting parties; and an expansion of the space of possible actions of the opposing side.

The listed factors can be accepted as three dimensions:

the degree of change in the operational situation (static – dynamic);

the degree of situational awareness (high – low);

the strength of the information position (weak – strong).

Figure 2 presents the space of the external operational situation and the direction of its evolution.

A dynamic operational environment (situation), unlike a static one, is unstable, in which the parties to the conflict introduce various innovations with a rapid pace of renewal.

In a static operational environment, centralised decision-making predominates, in which the actions of forces and assets can be optimised on the basis of more complete information possessed by the strategic-level command and control body. However, in a dynamic operational environment, centralised decision-making may prove untimely for conducting successful combat operations.

When the character of the combat task is familiar, everything is relatively simple [11].

First, information requirements are clear, that is, who needs what information to conduct effective combat operations.

Second, it is clear how interaction should be carried out. This makes it possible to adopt clear decisions with the corresponding distribution of decision-making authority.

The degree of the operational environment awareness is not necessarily determined by its static nature. The information position of an organisation is characterised by the degree to which its information requirements are satisfied. Regardless of the degree of dynamism and the situational

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awareness degree, the strength of the information position has an important influence on the application of the form of command and control of forces and assets.

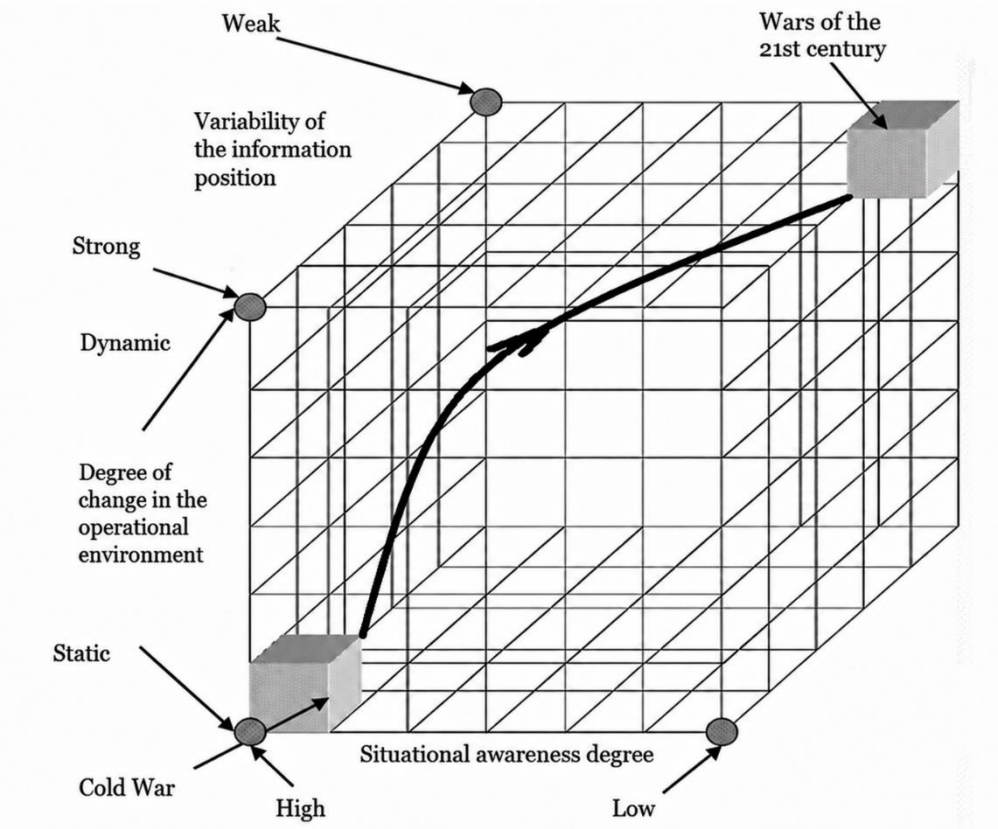


Figure 2. Space of characteristics of the operational environment

A military organisation with very simple information requirements may have a strong information position, although the volume of information may be insignificant.

Meanwhile, forces and assets seeking to use heterogeneous weapons systems to conduct successful actions may have a larger volume of information at their disposal, but have a comparatively weak information position because of high information requirements [13].

It is quite natural that the information position of an organisation also influences the decision-making authority distribution.

The above-mentioned key dimensions of types of troop command and control are not entirely independent. The relationships between them are presented in Fig. 3.

The top dimension – the decision-making authority distribution, influences the character of interaction (cooperation) between command and control levels and the distribution of information between them. However, the character of interaction (cooperation) during the development of decisions may lead to changes in the decision-making authority distribution.

When the operational situation requires a rapid response, commanders at lower levels of subordination should not consult the higher headquarters about a deviation from the plan or wait for a new plan, but should take the initiative, making decisions with an immediate response to the situation. They will report later on what happened, what actions were performed and request support from the senior commander, if the threat has not passed. If these actions are not provided for by existing plans, it is necessary to change the decision-making authority distribution.

The possible distribution of decision-making authority has two opposite logical poles. One pole

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– full centralisation (all decision-making authority is concentrated in one person). The other pole – full decentralisation (each participant in the management process has equal authority in decision-making).

A reflection of the centralisation style is the practice of issuing orders (instructions) on behalf of the commander, even when the orders concerned a certain specialised functional area.

There is a large amount of both empirical and theoretical confirmation [9; 12] that the broad participation of specialists in the preparation of decisions increases their quality. However, there is also the reverse side of this advantage, connected with the fact that the broad participation of specialists in the preparation of decisions may lead to an increase in the time required to prepare and make decisions.

However, this rule does not apply to the preparation and making of decisions in repetitive or simple situations. Repetitive or simple situations differ in that they are familiar, have a finite number of well-understood alternative actions, for which the correct action can be chosen according to a defined algorithm.

Interaction between levels of command and control may be limited to the exchange of data or information, or may be at the level of creative cooperation that influences the achievement of the common goal. In the existing command and control system, all types of interaction were built in such a way as to guarantee control by the centre. That is, traditionally, information must pass through channels controlled by the commander, and all information, as it were, belonged to the commander. As a consequence, interaction preserves a semblance of a hierarchical structure.

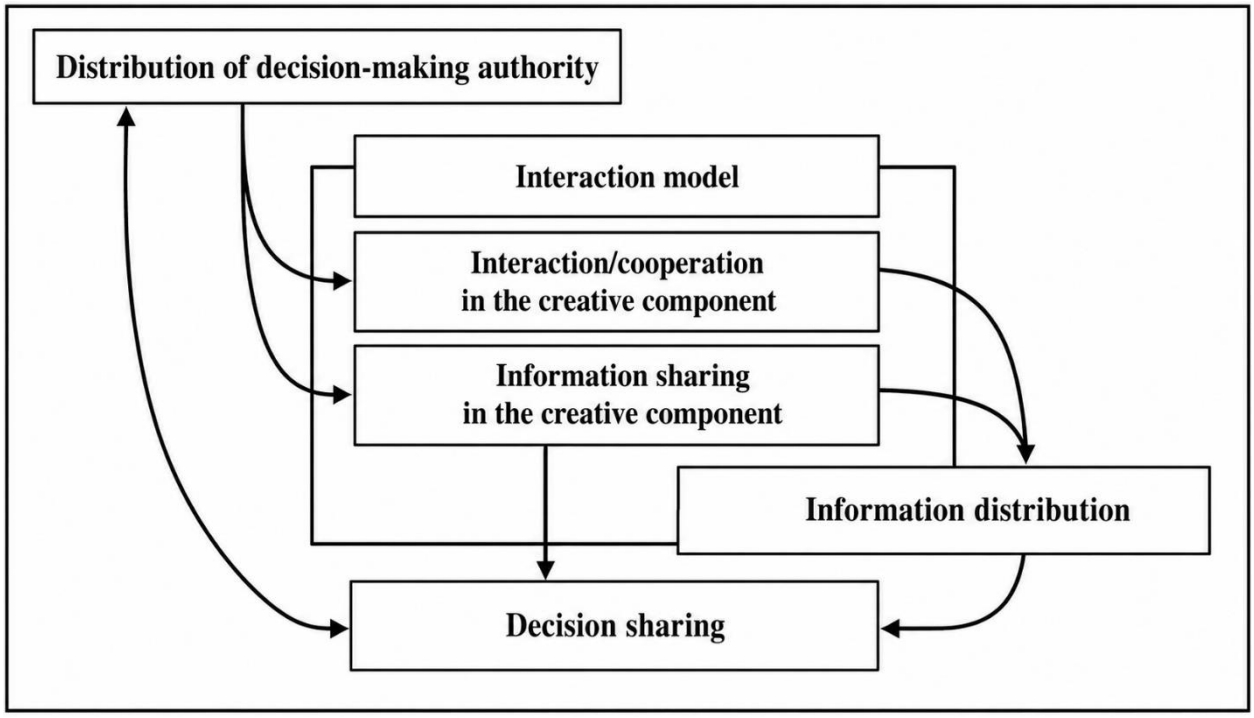


Figure 3. Mutual influence command and control key factors within forces and assets

In many cases, the limited bandwidth of the command and control loop for the passage of multiple decisions, communications and a large volume of actions leads to the need to create several hierarchical levels, which significantly influenced the troop command and control, weapons control and logistics. In addition, each of the services had unique communication systems. The problem consists in the fact that these specialised hierarchies significantly complicated horizontal cooperation and interaction. In modern military organisational structures, network structures are replacing

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hierarchical systems of interaction.

The distribution of information within an organisation depends partly on the decision-making authority distribution, partly on the adopted structure of interaction, partly on the degree of readiness to share information, partly on the degree of readiness of individuals to use this information, and partly on the tools and skills they must acquire.

Ultimately, the distribution of information determines the ability of command and control bodies to develop the substantive part of decisions, both through individual and collective decision-making methods.

Developers of command and control systems for forces and assets spent a great deal of time substantiating requirements for information exchange. It was they who determined: who needed access, to what information and under what circumstances.

All this restrained interaction, limited the distribution of information in accordance with assumptions. At the same time, previously known threats and circumstances assumed the use of a specific military force and adequate projects of command and control systems for forces and assets.

In contemporary warfare, all information becomes available to all objects with restrictions (Delta layers). The resilience of the system to possible errors and information redundancy – are its key elements, which serve to maintain effective information distribution over a given period of time to ensure the performance of the necessary functions.

Thus, the central point in understanding how command and control of forces and assets develops under modern conditions is the awareness of rationality in the decision-making authority distribution, in the choice of the structure and scheme of interaction during the preparation and making of decisions, as well as the distribution of necessary information in accordance with the external operational situation.

The technical aspect in implementing the functions of modern command and control is a single information and communication space – an integral component of the successful implementation of organisational decisions in the field of command and control of joint forces and assets.

The construction of such a complex during the development of artificial intelligence tools should be based on a number of factors (or properties) that were inherent during decision-making:

space – as the ability of models to perceive and compare spatial patterns (zones, fields, formations, and so on);

verbal understanding – as the ability of models to determine the meaning of words and understand speech constructions;

speed – as the ability of a model to produce words quickly in accordance with certain constraints;

ease of operations – as the speed and accuracy of performing computational models;

induction – as the ability to derive (apply) rules to which the totality of a specific set of input influences is subject;

perceptual speed – as the speed and accuracy of detecting certain input influences in an information array or comparing such influences with any others;

deduction – as the ability to build logical conclusions from premises to precise conclusions (solving strategic reflection tasks);

memory – as the ability to memorise and reproduce arbitrary links between standard situations that arise.

The command and control system of forces and assets must take into account the influence of these factors on the quality of the decisions made.

Conclusion

New conditions for conducting warfare and the implementation of principles that were not characteristic before the beginning of the russian-Ukrainian war (battlefield transparency, kill-zone management, information layering), determine the objective need to change the command and control of forces and assets. It is critically necessary to move from rigid hierarchical models to network

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models, from command and control of battlefield units to command and control of zones. The creation and widespread implementation of information systems impose new requirements for the delimitation, as well as management of information within the command and control system loop. The processes of transforming the command and control system must be aimed at achieving the necessary level of flexibility and adaptability.

Recommendations

Based on the results of the conducted research, it is appropriate to recommend the further implementation of adaptive network-centric models of command and control of forces and assets, oriented towards functioning under the conditions of high dynamics, uncertainty and information oversaturation of the modern battlefield. Particular attention should be paid to the development of a single information and communication space that will ensure horizontal interaction between command and control levels, operational data exchange and support for collective decision-making. A promising area is the integration of artificial intelligence tools into automated command and control systems for processing large volumes of information, forecasting the development of the situation and forming recommendations for commanders in real time. It is also recommended to improve the system of the decision-making authority distribution of by expanding the powers of lower command and control levels, which will make it possible to ensure the necessary speed of response under the conditions of dynamic changes in the combat situation. Further scientific research should be directed towards the development of methods for assessing the effectiveness of adaptive command and control systems, models of functioning of "combat" artificial intelligence and mechanisms for ensuring the resilience of information systems under the conditions of active enemy counteraction.

Conflict of Interest

The author declares that he has no competing interests related to the subject of the article.

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Удосконалення процесів управління силами та засобами в сучасних умовах ведення збройної боротьби: теоретичні підходи

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Анотація. Статтю присвячено дослідженню трансформації процесів управління військами в умовах сучасної збройної боротьби, що формується під впливом інформаційної революції, розвитку цифрових технологій та широкого застосування засобів автоматизації управління. Актуальність теми обумовлена зміною характеру бойових дій у російсько-українській війні, появою нових принципів ведення збройної боротьби, зокрема прозорості поля бою, управління зонами ураження, багаторівневого нашарування інформації та широкого використання роботизованих систем. У таких умовах традиційні централізовані моделі управління втрачають ефективність і потребують адаптації до високодинамічного операційного середовища. Метою статті є обґрунтування теоретичних підходів до удосконалення процесів управління силами і засобами відповідно до нових принципів та закономірностей сучасного поля бою. Методологічну основу дослідження становить комплексне використання системного аналізу, кібернетичного підходу, методів концептуального моделювання, порівняльного аналізу та логічного узагальнення. У роботі досліджено взаємозв'язок між розподілом прав прийняття рішень, характером взаємодії між рівнями управління та принципами розподілу інформації в системі управління військами. У результаті дослідження визначено основні напрями еволюції систем управління силами і засобами від централізованих ієрархічних структур до децентралізованих мережевих моделей. Обґрунтовано необхідність переходу до адаптивних систем управління, здатних функціонувати в умовах високої невизначеності, швидких змін обстановки та надлишкових інформаційних потоків. Встановлено, що ключовими факторами ефективного управління є раціональний розподіл прав прийняття рішень, організація горизонтальної взаємодії та створення єдиного інформаційно-комунікаційного простору. Практичне значення отриманих результатів полягає у можливості їх використання під час розвитку автоматизованих систем управління, удосконалення організаційних структур військового управління та впровадження інструментів штучного інтелекту в процеси підтримки прийняття рішень.

Ключові слова: адаптивність, інформаційно-комунікаційні системи, прийняття рішення, складні організаційно-технічні системи, теорія управління, штучний інтелект.