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THE BASIC PROPERTIES OF A COMPLEX MILITARY SYSTEM

The article deals with the basic properties of a complex military system, which is carried out while creating group of troops (forces) and maintaining it in a state when it is capable of solving the tasks assigned to it. This requires deep development of issues not only of modern tactics and the implementation of a stable and continuous management of the troops, but even more complex issues of scientific substantiation of the structure of the military system, the organization of the joint use of various forces within the group of forces. Practically an approach to synthesis can be realized while creating and substantiating components and elements of the structure of the system.

Keywords*: system, the basic properties of a complex military system.*

Introduction

Problem statement. A complex system in modern conditions should have a synergistic effect of interaction between components and elements in a conflict environment in the following main directions [1–4]:

– ensuring the sufficiency of forces for the task to be performed, the coherence of the forces in the information-technical compatibility of the elements of the organizational system (divisions), the elimination of duplication of tasks and management functions;

– the only methodological approach to the basic properties of complex military systems, the use of modern special software, mathematical models and tasks to support decision-making on real-time management, creation of all levels of a single background of the situation;

– construction of a rational version of the structure of the system during the transition to the states, systematization of knowledge, experience and development of thinking managers, organization of information and psychological struggle, ensuring timely response to changes in the situation and possible stress, complex conditions, increasing the timeliness of forces through maneuver, ensuring the balance of the time of developing the concept of action in the conditions of their speed and the difficulties of a comprehensive assessment of the situation, its generalization, etc.

Research publications. In [1–4; 9–12], the basic definitions of a complex system are given, but not all terms of properties are used in the sense that they are laid. In [2], the basic concepts of theory and practice of the Armed Forces of Ukraine are given. In [5–6] new approaches to the analysis of properties and the synthesis of the structure of complex systems have been given insufficient attention of a complex military system.

The research aims and objectives: to provide an interpretation of the basic concepts of properties and the process of analysis and synthesis of the structure of a complex military system.

Statement of basic materials

The analysis of the events of the last decade suggests that the greatest influence on the change of forms and methods of globalization and the implementation of the results of the scientific and technological revolution is the tendencies of information and psychological struggle, ensuring timely response to changes in the situation and possible stressful circumstances.

The system consists of components and elements.

System components are subsystems such as management, engineering, technical support, etc.

The elements of the system are the military formation, with their capabilities for the specific circumstances of the situation.

The assessment of the effectiveness of the functioning of a complex organizational system is carried out considering three axioms: firstly, the equipment has certain *tactical and technical characteristics*; secondly, the formation has the appropriate *capabilities*; the third system has its own *properties (the effect of synergy, hierarchy, endurance, efficiency and stability of functioning, adaptability, operative ness, communicative, concealment, reflectivity, reasonableness, rationality of structuring, controllability, etc.*

The tactical and technical characteristics of the armament, the capabilities of formations, and other properties of the system are characterized by indicators, criteria and norms.

A complex military system is a set of interacting, simultaneously functioning components and elements, each of which performs one or more functions during

the execution of assigned tasks, based on a single concept and plan.

For the description and formalization, the complex military system is presented as [5; 8]:

$$S = S\left(C, I, E, A^i, A^{ie}, A^{ei}\right),$$

where $C = \{C_1, ..., C_k\}$ – the set of components *S*;

$I = \{I_1, ..., I_p\}$ – the set of internal elements *S*;

$E = \{E_1, ..., E_q\}$ – the set of external elements *S*;

A^i – relations of elements (internal structure *S*);

A^{ie}, A^{ei} – relations between the elements (the structure of the links between the internal and external elements of *S* and vice versa).

At present, *the goal of creating a military-purpose system* is to ensure the effective use of all forces within a single system, regardless of their departmental affiliation, and the rational use of existing resources.

Structure of the system is *a mutual arrangement of its elements and a set of relationships and relations between them*, which ensure the integrity of this system and the ability of formations to perform tasks, taking into account the basic properties of interacting subsystems and elements, respectively, the conditions of the situation and the state of forces [5; 8].

The evaluation of the effectiveness of the functioning of a complex military system and its components by the results of modeling the actions of the parties gives rise to a number of problems in the conditions of non-stochastic uncertainty of the parameters of the situation and the actions of the various parties, which make up two classes: problems of analysis; tasks of synthesis of the structure of a complex military system (component).

The tasks of the analysis of the components of the system consist in studying the structure and elements, properties and behavior of the system, depending on the characteristics of input impacts and from the external environment. Often, the tasks of analysis are reduced to the assessment of system efficiency. In this case, the task is to obtain the value of some functional, which reflects the desired efficiency in the form of the vector $C = C(I,E, A^i, A^{ie}, A^{ei})$ for given I,E, A^i, A^{ie}, A^{ei} at the given time *t*.

The tasks of synthesis involve the synthesis of the structure of the system, that is, finding the necessary elements of the system and the links between them. In the synthesis of the structure set the inputs, external influences, signals and a set of internal parameters of the system is sought that satisfies a completely determined limits and the value of such an indicator as $C = \max C\ (I,E, A^i, A^{ie}, A^{ei})$ or vice versa. In the general form, the problems of analysis and synthesis are formulated in this way.

System analysis*:* given *I*, *E*, A^i, A^{ie}, A^{ei}; find C (*I*, *E*, A^i, A^{ie}, A^{ei}).

Synthesis of the system: given *I*, *E*, A^{ie}, A^{ei}; find A^i, that maximizing C (*I*, *E*, A^i, A^{ie}, A^{ei}).

Synthesis control: given *I*, *E*, A^i, A^{ie}; find A^{ei}, that maximizes C (*I*, *E*, A^i, A^{ie}, A^{ei}).

The main tasks of the study of complex systems that require the construction of models of their functioning are as follows.

Tasks of analysis of the structure of a complex system of military use: substantiation of requirements for the grouping of troops (forces) and development of armament samples; specification of the tactical purpose of military formations and systems of military use; testing elements (divisions) in battle; assessment of the efficiency of the system's functioning and the definition of a rational variant of its structure; prediction and assessing the reliability of the system and methods of combat operations of troops (forces) under the specific circumstances of the situation, etc.

Tasks of the synthesis of the structure of the system of military use: the construction of combat units of divisions in the grouping of troops (forces); synthesis and choice of system structure; restoration of the combat capability of the grouping and functioning of the system; determination of the most dangerous actions of forces; making decisions; action planning, etc.

Thus, even in one subject area there is a large number of tasks for elements of the system that require the development and application of mathematical models. However, the solution to these problems encountered a number of serious difficulties. First, these tasks are solved at different times by different organizations and institutions. Secondly, often in one organization, different tasks in one subject area are solved using different models.

To eliminate these contradictions it is necessary to solve interdependent problematic issues: to develop tools for various subject areas, oriented to one or another class of methods; to develop enough universal models that can solve all or at least most tasks in one or another subject area and achieve their approval as industry standards; develop specialized models for solving individual problems that provide an assessment of all or part of the input parameters of the universal model.

Such technology of synthesis and evaluation of the effectiveness of the functioning of complex military systems allows to avoid existing deficiencies, and most importantly, allows to significantly increasing the adequacy of the developed models and tasks, the coherence and effectiveness of the taken decisions.

When creating the *structure of the system*, it is necessary to follow the principles, among which it is possible to identify *general and specific* [1–4].

The main *features* of complex military systems, the implementation of which is fundamental in terms of

solving problems and functions, should include such [8].

The presence of a synergy effect that describes the unidirectional or purposeful action of components, which enhances the efficiency of the system.

The hierarchy of the system as a priority to achieve the goal of functioning of the whole system over the purpose of the functioning of individual elements.

Immergence of the system as the presence of special properties that are not inherent in its subsystems and elements, the impossibility of minimizing the properties of the system to the sum of properties of its components.

The effectiveness of the system and the *rationality* of constructing its components and elements is the property of influencing the achievement of maximum effect with a probability of more than 0.5 at lower costs.

Resilience is the ability to maintain its quality and function under the influence of competitors on system elements in order to eliminate them, disrupt the functioning of technical devices, and limit the data that is needed to solve problems. Resilience is characterized by indicators of reliability, viability, noise immunity, the security of its elements and the probability that with a certain impact of competitors on the elements of the system will not lose their qualities.

Operational readiness of the system is a property that characterizes its ability to begin to perform tasks and implement functions from a given initial state. It is characterized by time indicators (cost and time delay for preparation of the system for use) and probabilistic indicators (the probability that at a given time the system will be able to perform its intended functions).

Reasonableness is confirmation of the facts and data of decisions on the functioning of the system, which are received and used by the management bodies, providing calculations and modeling results that can provide a forecast (prediction) for the development of the situation for the desired period with the given reliability. The justification is characterized by the quality (effectiveness) of the methods of calculations, tasks and models, the completeness of taking factors into account in decision making, etc.

Adaptability, self-organization, synergy in space and time of the system's functioning are adapted to the conditions of the situation and the state of forces – the ability to adapt and maintain their qualities in conditions of unforeseen actions of competitors, changes in composition and strength of forces, the development of the situation and changes in the corresponding tasks and functions of the system. In turn, this property depends on the flexibility, multivariate ness and ability to build the corresponding elements from which the system is composed.

The continuity of the functioning of the system is its property, in which during the decision of tasks there is a constant influence on competitors and there are no situations where the necessary information is missing or arrives late (with a delay that prevents the executive from making a decision). As indicators of continuity it is expedient to use time indicators (duration of time, during which there is no breach of continuity of information provision) and probabilistic indices (the probability that at given interval of time there will be no violations that lead to the impossibility of solving tasks and functions).

Reflection is a property that allows competitors to be biased in obtaining information about the design of the parties' actions, the course and results of actions, reliably predict its actions and impose on it information (disinformation) in order to create a favorable situation for itself. As a measure of reflectivity it is accepted to use the rank of reflections. Given the counteraction to the cover forces (side A) and competitors (side B), there are four levels of reflection: 0 – the parties do not know the purpose of each other's actions; 1, 2 – side A (B) know the plan of the actions of side B (A); 3 sides know the plan of the actions of the parties.

Communicative is a property in which such an interconnection between sources and consumers of information is achieved and the coherence of the data transmitted between them, at which at each control point there is an opportunity to receive in a timely manner any necessary information. It is achieved through the use of management of modern information networks with distributed databases, the creation of network-centric connections in the system.

Secrecy of their actions in the system and misleading competitors is a property in which the hidden actions of the order and results of decision-making are provided, the forecast (prediction) of the situation's development for the period with the required reliability, bringing it to the subordinates, misleading the competitors (creation of false positions and masking, etc.

System control is a property in which the ability to verify the reliability of the data, the results of calculations, forecasts, and also provides verification of the passage of information transmitted between the components (elements) of the system.

From the point of view of achieving more effective functioning of the system it is expedient *to have a rational variant of the structure of such a system.*

The structure of a complex military system determines the composition, distribution of tasks and functions, the mutual relationships of components (subsystems) and elements (forces and means), which are combined to solve a common task in accordance with the changing situation. The definition of the rational variant of the structure of the system requires the search: the type and composition of forces that are included in the

system; their location, subordination; the main information communications that ensure their joint operation.

Under the synthesis of the structure of a complex military system we will understand the creation of a single rational variant of the hierarchical structure of the system, which combines interacting components and elements in accordance with changes in specific conditions of the situation and tasks of forces [2].

The synthesis of the structure of a complex system involves such a statement of the problem**.**

The synthesis is as follows: *to find the composition of the components and elements of the system and the relationships between them*, the implementation of which can satisfy the established requirements for the effectiveness of the functioning of a complex organizational system with known resource constraints, etc.

Synthesis of the structure of a complex military system is carried out on the basis of simulation of the parties' actions using models and tasks, geo information systems based on the determined indicators and criteria.

To assess the *effectiveness of a complex* military *system*, it is expedient to use a *generalized indicator* − for example, the degree of achievement of the goal of action or the degree of performance of tasks at certain costs of resources or losses, as well as partial indicators − the calculated effectiveness of actions and the required efficiency, integral performance measure, mathematical expectation the number of objects that function with given probability, the mathematical expectation of the cost of forces and means, the static and dynamic parties' balance of forces, indicators of components and elements, among which are spatial, temporal, quantitative, probabilistic, etc.

In general, the choice of an structure of a complex military system is made by comparing the ideal, existing and estimated structures [1–2].

The structure of the evaluated system should provide a given effectiveness of the forces in accordance with the projected changes in the conditions of the situation, then it will be considered rational.

When comparing various structures of a complex military system, there is a problem of quantitative measurement of the absolute or at least relative value of the efficiency of functioning of a complex system having an appropriate structure. Such task leads to the need to select the appropriate indicator of efficiency losses, which quantitatively reflects the degree of loss of elements of the system in achieving the goal of forces.

In general, the mutually agreed indicators and criteria used in the analysis and synthesis of the structure of a complex system through the effectiveness of the forces are divided into four groups: quality decision-making indicators and economic feasibility, indicators of the quality of the structure of the system, indicators of the effectiveness of forces and the functioning of the system components [1–2; 7].

As a result, the groups of indicators and criteria for the analysis and synthesis of the structure of a complex system become mutually agreed among themselves through an indicator of the effectiveness of the parties' actions.

Conclusions

Thus, the basic properties (the effect of synergy, hierarchy, endurance, efficiency and stability of functioning, adaptability, operativeness, communicative, concealment, reflectivity, reasonableness, rationality of structuring, controllability), analysis and synthesis of a complex military system is carried out by creating forces and maintaining it in a state when it is able to solve its tasks, requires deep development of issues not only the creation of modern weapons and the implementation of sustainable and continuous management, but even more complex issues of the scientific justification of a complex system, the organization of the joint use of various forces in the force. In practice, the approach to synthesizing of a complex military system can be realized when creating and substantiating the components and elements of a complex military system.

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ОСНОВНІ ВЛАСТИВОСТІ СКЛАДНОЇ ВОЄННОЇ СИСТЕМИ

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У статті розглядаються основні властивості, постановка задачі аналізу та синтезу складної воєнної системи, що здійснюються при створенні угруповання військ (сил) та підтримки його у стані здатності вирішувати бойові завдання. Оцінка ефективності дій угруповання військ (сил) і у цілому функціонування складної воєнної системи здійснюється з урахуванням трьох аксіом: по-перше, озброєння та військова техніка має тактико-технічні характеристики; по-друге, військові формування мають бойові можливості (вогневі, маневрені, розвідувальні тощо); по-третє, складна воєнна система має властивості. Аналіз і синтез основних властивостей складної системи (ефект синергії, ієрархічність, емерджентність, ефективність і стійкість функціонування, адаптивність, оперативність, комунікативність, прихованість, рефлективність, обґрунтованість, раціональність побудови структури, контрольованість) вимагає глибокого розроблення питань не тільки створення сучасного озброєння, а й ще більш складних питань наукового обґрунтування сумісного застосування різних сил в ході ведення бойових дій. Практично підхід щодо аналізу властивостей та синтезу складної воєнної системи може бути реалізований під час створення та обґрунтування компонент та елементів системи, під час тактичних навчань та в ході бойової підготовці з метою обґрунтування структури складної воєнної системи, а також замислу бойових дій командирів військових частин і підрозділів, вироблення рекомендацій військам (силам).

***Ключові слова**: система, основні властивості складної воєнної системи.*

ОСНОВНЫЕ СВОЙСТВА СЛОЖНОЙ ВОЕННОЙ СИСТЕМЫ

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В статье рассматриваются основные свойства, постановка задачи анализа и синтеза сложной военной системы, которые осуществляются при создании группировки войск (сил) и поддержании ее в состоянии способности решать боевые задачи. Оценка эффективности действий группировки войск (сил) и в целом функционирования сложной военной системы осуществляется с учетом трех аксиом: во-первых, вооружение и военная техника имеет тактико-технические характеристики; во-вторых, военные формирования имеют боевые возможности (огневые, маневренные, разведывательные и т.п.); в-третьих, сложная военная система обладает свойствами. Анализ и синтез основных свойств сложной системы (эффект синергии, иерархичность, эмерджентность, эффективность и устойчивость функционирования, адаптивность, оперативность, коммуникабельность, скрытность, рефлективность, обоснованность, рациональность построения структуры, контролируемость) требует глубокой разработки вопросов не только создания современного вооружения, но и еще более сложных вопросов научного обоснования совместного применения различных сил в ходе ведения боевых действий. Практически подход к анализу свойств и синтезу сложной военной системы может быть реализован при создании и обосновании компонент и элементов системы, во время тактических учений и в ходе боевой подготовки с целью обоснования структуры сложной военной системы, а также замысла боевых действий командиров воинских частей и подразделений, выработки рекомендаций войскам (силам).

***Ключевые слова**: система, основные свойства сложной военной системы.*