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V. Shamko

Air Command of the Armed Forces of Ukraine, Vinnytsia

A CONCEPTUAL APPROACH TO DEFINING A STRUCTURE FOR SPATIALLY DISTRIBUTED NETWORK-CENTRIC SYSTEM FOR CONTROLLING THE TIER OF AIR DEFENSE MISSILE COVER

In the context of the Joint Forces operation in eastern Ukraine and the new challenges of the hybrid war on the part of the Russian Federation, there is an urgent need for finding possible ways of building an effective control system for a spatially distributed network-centered air defense missile cover system. The article presents a conceptual approach to the design of the structure that would be effective for controlling such a system, which is based on both the classical construction principles of control systems and the novel network-centric approach to design of control systems. The conceptual approach takes into account the peculiarities of building a spatially distributed tier of air defense missile cover.

Keywords: *system, air defense missile cover, control authorities, structure, effectiveness, method, control function, control task.*

Introduction

Formulation of the problem. The structure of the air defense missile cover (hereinafter referred to as ADCM) has clearly expressed the features and properties of a complex organizational and technical system. It depends on the set of tasks and functions that must be accomplished during anti-aircraft missile defense of objects and troops. Determination of the structure for the ADCM system in accordance with the assigned combat mission is based on the principles of combat use of air defense [1], taking into account the available weapons and military equipment, capabilities and duties exercised by control authorities at control posts while implementing their basic functions. The structure of the ADCM control system also depends on the organizational and staff structure of the units of the air-defense missile troops (ADMT) group, their capabilities, features and the nature of their combat missions.

The methods of constructing organizational management structures, which were usually used in the Armed Forces, were characterized by an overly normative character, insufficient diversity, hypertrophied use of typical solutions, which led to the mechanical transfer of known organizational forms to new conditions [2].

From a scientific point of view, too narrow an interpretation was obtained by the initial factors of structure formation:

a) formation begins with the definition of a number of control posts;

b) priority is given to the number of staff instead of the organization's control performance;

c) rigid structure of control bodies instead of fitting their composition and tasks depending on specific conditions;

d) control bodies performing pre-assigned functions regardless of situational changes;

e) outdated arrangement of staff and their responsibilities in existing organizations that take into account average situation, without analyzing the shortcomings and the degree of suitability of the structures.

This approach does not take into account the peculiarities of the formation of appropriate control structures when using modern means of defense and it does not allow to form an effective structure of the control system of the ADCM to solve combat tasks in modern combat conditions. At the same time, the development of weapons systems, the use of high-tech equipment and intelligent software in them requires new conceptual approaches to be used in order to determine the structure of the control system of a modern spatially-distributed network-centric tier of ADCM.

Analysis of recent research and publications. Based on the analysis in [2; 4–5] of the conditions of preparation and combat operations by the grouping of anti-aircraft missile troops and the structure of the air defense missile cover for critical facilities and troops, the following significant tendencies that adversely affect the effectiveness of the anti-aircraft missile can be identified: insufficient forces and means for air defense missile cover for facilities and troops – the need to cover

objects does not meet the capabilities of the air defense missile troops; obsolete weapons and communications and automation means; objective scarcity of time for making combat decisions; insufficient agility of actions; lack of modern models to carry on geoinformation computational tasks in support of decision making; the irrationality of the organizational and staff structure of the Air Force's control systems in terms of the quality of the tier of air defense missile cover for troops and facilities; long duration of completing and processing the combat documents, lack of formalized documents and electronic maps at headquarters, etc.

The essence of the existing concept lies in the construction of tiered in-depth air defense system (reaching out to the full combat range of the air attack means (AAM)), that would be multilayered in altitude [5]. This is done by applying different types of anti-aircraft missile complexes (AAMC). Conventionally, such a concept can be called the concept of "concentrated" ADCMC system.

Spatial interpretation of the essence of the existing concept is as follows: different types of AAMC are deployed at certain points (certain boundaries) with the possibility of engaging targets at different ranges. That is, the principle of variable firing range from single point is implemented.

Such a system necessitates controlling the fire by entire grouping of AAMC to provide the required in-depth and altitude coverage, which in turn requires a large number of various anti-aircraft missile systems (AAMS) and is very expensive. Moreover, the reaction time and firing control procedures depend on the engagement range, which is due to the firing cycle of AAMC, which takes into account not only the firing dead time, but also the flight time of the missile to the far limit of its kill zone [5].

At present, there is no continuous echelon cover of its territory in the air defense system of the state due to the high level of economic impracticality of this method. When organizing the object cover, its reliability also depends on the number of tiers. Therefore, to cover all the objects identified in the regulatory documents also requires a large number of AAMCs, which may not be sufficient [6].

At the same time, not only the organizational component but also the technical one is taken into account when creating an ARF grouping for the implementation of the armies and facilities. Particular consideration should be given to the technical component, namely, the principles of the construction of armaments and anti-aircraft weapons and how they are implemented in the new environment that determines the enemy air.

The technical component of the existing SAMs is based on the rocket guidance methods used, which require the presence of radar reconnaissance, target and missile tracking radar, as well as radar aiming missiles

at the obligatory condition all elements in a relatively small area of land (ADMC positions).

This feature creates a negative property for the grouping of ADMTs, which consists in the radar visibility of the units (units) that make up the enemy, which allows the enemy not only to recognize the enemy of the combat grouping of ADMT, but also to determine the technical characteristics of ADCMCs. This allows the opponent to make an effective choice of effective ways of combating anti-aircraft weapons.

Thus, on the part of the adversary, the detection of an established ADMT grouping is a definite event, and for air defense the recognition of an enemy's behavior is an uncertain event [7]. The current level of control systems of the enemy allows to maintain uncertainty in its actions and purpose until the beginning of the blow. This uncertainty may not allow the development and effective decision-making on air defense, given the lack of forces and means to build a balanced air defense in all directions.

If the uncertainty of the enemy's actions cannot be responded to by increasing the effectiveness of air defense, then the uncertainty in the actions of the enemy can be answered by the uncertainty of building a combat order of their ADMT grouping, and preferably the entire duration of the strike. This is the principle that should underpin the new concept of building a system of missile defense, and it should formulate other provisions of the concept and requirements for the development of weapons.

The conceptual approach proposed in the article to determine the structure of the control system of a spatially distributed network-centered anti-aircraft missile system differs from the existing ones, which is not based on the use of long-range anti-aircraft missile systems and while constructing the ADCMC with a complicated missile control profile, but rather with the use of the smaller "kill zones" (individual ADCMC areas), which can be spread over large distances.

The purpose of the article is to improve the conceptual known approaches for determining the structure of the control system of the spatially-distributed network-centered air defense missile cover system.

Presenting main material

The material basis of a spatially distributed network-centered anti-aircraft missile defense system may be the anti-aircraft missile system, which is built with new conceptual approaches in mind.

The rapidity of air combat, uncertainty in the design of air enemy actions, improving the tactical and technical characteristics of air strikes leads to the need to create and implement a modern control system for air defense and air defense, which significantly improves the effectiveness of fire control. The use of modern information technologies, technical and software tools,

intellectualization of decision-making and management processes, creation of a single information space allows to increase the quality of management and the effectiveness of warfare by the grouping of ADMT.

The main tendencies (directions) of development of control systems of modern anti-aircraft missile systems are:

use of distributed control systems having a network-centric structure;

increased level of automation of management processes;

development of information support, use of modern methods of information processing;

development of technical support, use of modern distributed computing systems.

The process of building a military command system and the partial tasks of this process (selecting, justifying, and shaping the structure of the command and control system) are based on adherence to basic theoretical provisions. Based on the relevant theoretical foundations, the definite structure of the system is guided by the classical principles of construction of the control system and its components. Let's consider them more thoroughly.

General system principles for building a control system of the air defense system [10]:

1) systematic approach means that during the creation, operation and development of the control system of the ADMC such links between the structural elements of the systems should be established and maintained that ensure its integrity and interaction with other systems;

2) reserve for future updates (open architecture) means that, based on the prospects of development of processes and objects of automation, the control system of the ADMC should be created taking into account the possibility of updating and updating the functions and types of its provision by refining the software and (or) technical facilities or adjustments to existing facilities;

3) the principle of interoperability means that when creating a control system of the ADMC, information interfaces must be implemented by which it can interact with other systems in accordance with the established rules;

4) the principle of standardization (unification) means that when designing the ADMC system, the standard, unified and standardized elements, design solutions, application packages, complexes, components should be rationally applied;

5) the principle of adaptability is the need to create a control system of the air defense system, which has the ability to change its parameters depending on the internal parameters of functioning and characteristics of the environment;

6) the principle of efficiency is to achieve a rational relationship between the cost of creating a control

system of the ADMC and the target effects, including the final results obtained from automation.

The basic operational and tactical principles of building a control system of the air defense system are on-foot [11]:

1) compliance of the purpose of creation, assignment, combat and technical capabilities of the command and control system of the ADMC and its missions, composition and organizational and staff structure of the troops (forces) and means, their control systems, to the level of development of means of air attack and objects under control, to methods of preparation and conducting operations;

2) organizational, software, technical and informational unity of construction of the control system of the air defense system and its subsystems, which provides control of various types of air defense systems, as well as the possibility of interaction of automated control bodies, both vertically and horizontally;

3) balanced development of the ADMC control system in accordance with the development of intelligence systems, a single information field and fire damage to airborne objects;

4) balanced construction of all components of the ADMC and ADMC control system, their ability to integrate with other control systems, as well as systems of management of other means in a unified air defense system (air defense system);

5) comprehensive automation of the most high-speed, time-consuming and high-speed control functions at all levels, the correspondence of the degree of automation of these functions to the dynamics of controlled processes, as well as the role and place of these functions in achieving the overall and intermediate goals of ADMC;

6) ensuring the survivability, adaptation and self-organization of the control system of the ADMC in accordance with changes in the internal and external parameters of its function-updating under different conditions of the environment, composition and parameters of the tasks being solved;

7) rational combination of centralized and decentralized management of the ADMC.

The basic operational and tactical principles of the functioning of the air defense control system include:

1) preservation of the leading role of control operators in the management of the ADMC, the correct combination of the operator's actions with the work of automation means;

2) maximum automation of technical and calculation and information functions assigned to the control system operators;

3) simplicity and convenience of interaction of operators with automation at the input, processing and perception of information;

4) ensuring delimitation of access to information,

prevention of unauthorized actions and unauthorized use of automation means;

5) organization of functioning and maintenance of technical means of the ADCM and the ADCM control system with a limited number of qualified specialists;

6) implementation of automated information exchange with higher, subordinate and interacting entities;

7) ensuring the unification of short/medium range ADCMs based on a comprehensive assessment of the air and ground conditions.

Given the current conditions of armed struggle in the implementation of the concept of network-centric war, along with the classic principles considered, it is advisable to use the principles relating to the construction of a network-centric system of command of troops (forces). At their value, theoretical developments and directions of realization of concepts of network-centric war of the Armed Forces of foreign countries are analyzed, hierarchical structures of management, network architectures of construction of network-center management are possible [9–11]. These principles include:

1) management in a single space (a single information and communication space is created as a way of integrating networks of intelligence systems and facilities, organs and control points, systems of means of destruction);

2) network centric (the structure of the management system is a network of control points and web-links of communication between them);

3) network ready (creation of a network of bodies and control points of the ADMT grouping by means of integration with the networks of other services determines its capability to operate within the joint network-centric control system);

4) mixed structure management (hierarchical (centralized) and non-hierarchical management is used (horizontal links between elements of the multi-armed forces control system are used), coordination of military units is carried out);

5) integration of network architectures (combination of different network architectures (centralized, “on demand”, “swarm”, mixed) when building a network of bodies and control points);

6) compatibility (technical and functional interconnection of local networks of types of Armed Forces and sorts of troops (various forces and means in the area of hostilities);

7) an open system (the possibility of increasing the management system by connecting new sources and consumers of information, its processing and storage means through a unified data exchange network);

8) modularity (complexes of means of automation of heterogeneous forces and means are created from separate rather independent modules, connected technically, informationally and functionally);

9) distribution of information resources (informa-

tion processing and storage in a distributed manner in order to ensure the resilience of the control system in case of failure of one or more components of the network).

Taking into account the considered principles, in the determination of the parameters of the structure of the management system, an appropriate formalized management model is developed. The ADCM control model includes basic provisions for optimization of the automated control of the ADCM and its units in the conditions of minimization of combat service composition and achievement of the maximum level of automation of management functions.

The following is a list of the main tasks of the ADCM control system model:

defining the main directions of development while taking into account the existing approaches to organization of the command and control system of the Air Force, which have in their inventories the ADCMs originating from leading countries of the world;

development of basic forms and methods of management of the ADCM;

determination of principles and technical decisions regarding the structure and composition of the ADCM system;

development of technical solutions for centralized and decentralized management of the ADCM;

development of technical solutions for the implementation of hierarchical and network-centric control method;

development of technical decisions on the functioning of the ADCM control bodies, taking into account the experience of the armies of the leading countries of the world;

development of technical solutions for the management of the ADCM at different stages (operations planning and application management);

development of technical solutions for the interaction of the ADCM;

development of technical solutions for automation of ADCM and its control;

development of technical solutions for radar support of the ADCM.

According to the analysis of the main directions of development of control systems, the output data management system of the ADCM should be developed on the basis of innovative approaches to the creation of the ADCM, including:

1) open architecture of the ADCM should be based on the design features of ADCM, which allows you to create the necessary ADMT grouping from a set of unified components (modules);

2) implementation of Distributed Control System (abbreviated DCS) as a complex of technical and software solutions, which is a feature of which is the integration into a common network of units of the ADCM;

3) development of technical solutions for the organization of a high-stability, high-survivability ADCMC system;

4) implementation of the structure of the management system, which, through the creation of an information-switching network, integrates radar information sources, controls and means of destruction, which allows to provide the ADCMC and ADCMC control bodies with reliable and complete information on the situation in the real-time mode;

5) development of technical solutions for sustainable interaction of the ADCMC in the performance of tasks of destruction (suppression) of the air enemy;

6) providing a high level of automated control (AC) with the technical means of the ADCMC to ensure the necessary control parameters and interaction of the components and products of the ADCMC, the maximum use of combat capabilities of the ADCMC.

The AAMC should ensure that it can be integrated into the system of command and control of higher-level air defense forces and assets.

Conclusions

The conceptual approach to defining the structure of the control system of a spatially-distributed network centered anti-aircraft missile defense system, in addition to the requirements, provisions and principles considered above, should be based on a reasonable system of combat effectiveness indicators that are sensitive to changes in the elements of the air defense cover system and current tactical situation; this approach presumes the use of modern mathematical models and tasks for their rapid calculation and evaluation; it should allow a rational choice of reasonable options for the structure of the control system of the ADCMC, based, first of all, on a given criterion for the effectiveness of the target engagement that takes into account the existing restrictions and assumptions in the performance of combat missions.

These issues require separate study and are planned for further consideration.

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Відомості про автора:

Шамко В'ячеслав Євгенович
Командування Повітряних Сил
Збройних Сил України,
Вінниця, Україна
<https://orcid.org/0000-0002-6305-8221>

Information about the author:

Viacheslav Shamko
Air Command
of the Armed Forces of Ukraine,
Vinnytsia, Ukraine
<https://orcid.org/0000-0002-6305-8221>

КОНЦЕПТУАЛЬНЫЙ ПОДХОД К ОПРЕДЕЛЕНИЮ СТРУКТУРЫ СИСТЕМЫ УПРАВЛЕНИЯ ПРОСТРАНСТВЕННО-РАСПРЕДЕЛЕННОЙ СЕТЕЦЕНТРИЧЕСКОЙ СИСТЕМЫ ЗЕНИТНОГО РАКЕТНОГО ПРИКРЫТИЯ

В.Е. Шамко

В условиях проведения операции Объединенных сил на востоке Украины и новых вызовов гибридной войны со стороны Российской Федерации возникает актуальная проблема поиска возможных путей построения эффективной системы управления пространственно-распределенной сетецентрической системы зенитного ракетного прикрития. В статье предложен концептуальный подход к проектированию структуры системы управления такой системы, основанный как на классических принципах построения систем управления, так и усовершенствованных сетецентрических принципах, учитывает особенности построения пространственно-распределенной зенитной ракетной системы.

Ключевые слова: система, зенитное ракетное прикрытие, органы управления, структура, эффективность, метод, функция, задача.

КОНЦЕПТУАЛЬНИЙ ПІДХІД ДО ВИЗНАЧЕННЯ СТРУКТУРИ СИСТЕМИ УПРАВЛІННЯ ПРОСТОРОВО-РОЗПОДІЛЕНОЇ МЕРЕЖЕЦЕНТРИЧНОЇ СИСТЕМИ ЗЕНІТНОГО РАКЕТНОГО ПРИКРИТТЯ

В.Є. Шамко

В умовах проведення операції Об'єднаних сил на сході України та нових викликів гібридної війни з боку Російської Федерації виникає актуальна проблема пошуку можливих шляхів побудови ефективної системи управління просторово-розподіленої мережецентричної системи зенітного ракетного прикриття.

Структура системи управління зенітним ракетним прикриттям (далі – ЗРП) має чітко виражені ознаки та властивості складної організаційно-технічної системи. Вона залежить від сукупності завдань і функцій, що повинні бути реалізовані під час зенітного ракетного прикриття об'єктів і військ. Визначення структури системи прикриття відповідно до поставленого бойового завдання здійснюється на підставі принципів бойового застосування ЗРВ, з урахуванням наявного озброєння та військової техніки, можливостей органів та пунктів управління щодо реалізації своїх основних функцій. Структура системи управління ЗРП залежить також від організаційно-штатної структури підрозділів угруповання ЗРВ, їх можливостей, особливостей й характеру їх бойових завдань.

Методи побудови організаційних структур управління, що, як правило, застосовувалися в Збройних Силах, характеризувалися надмірно нормативним характером, недостатньою різноманітністю, гіпертрофованим використанням типових рішень, що приводило до механічного переносу відомих організаційних форм в нові умови.

Такий підхід не враховує особливості формування відповідних структур управління при використанні сучасних засобів ЗРВ та не дозволяє сформувати ефективну структуру системи управління ЗРП для вирішення бойових завдань у сучасних умовах бойових дій. Разом з тим, розвиток систем озброєння, використання в них високотехнологічного обладнання та інтелектуального програмного забезпечення потребує нових концептуальних підходів для визначення структури системи управління сучасної просторово-розподіленої мережецентричної системи ЗРП.

В статті запропонований концептуальний підхід до проектування структури системи управління системи ЗРП, який базується на як на класичних принципах побудови систем управління, так і удосконалених мережецентричних принципах, враховує особливості побудови просторово-розподіленої зенітної ракетної системи.

Ключові слова: система, зенітне ракетне прикриття, органи управління, структура, ефективність, метод, функція, завдання.