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The Analysis of Global Trends in the Development of Operational (Operational-Strategic) Reconnaissance-Strike Complexes Based on Unmanned Aerial Vehicles

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Abstract. The relevance of the research is determined by the growing role of reconnaissance–strike complexes of the operational and operational–strategic level under the conditions of modern armed conflicts, first of all under the conditions of the russian–Ukrainian war, which is accompanied by the rapid development of unmanned aerial technologies, network-centric command and control principles and high-precision strike means. In this regard, the article is aimed at a comprehensive analysis of global trends in the development of reconnaissance–strike complexes based on unmanned aerial vehicles, the identification of the main directions of the evolution of their components, and the formulation of scientifically substantiated proposals concerning the prospective development of such complexes with the aim of achieving an asymmetric military-technological advantage. The leading approach to the study of this issue is the system and structural-functional approaches in combination with comparative and critical-analytical analysis of open sources, which makes it possible to consider reconnaissance–strike complexes comprehensively as integrated multi-component systems, to assess the interrelationship of their elements and to identify the leading global technological trends. The article determines global trends in the development of reconnaissance–strike complexes of the operational (operational-strategic) level created on the basis of unmanned aerial vehicles (both with regard to such complexes as a whole and with regard to their components); reveals the directions for increasing the autonomy, network interaction and strike capabilities of reconnaissance–strike complexes; identifies the growing role of artificial intelligence, swarm technologies and mass expendable unmanned aerial vehicles; substantiates the expediency of transition to modular, serial and economically efficient solutions. The materials of the article have practical value for specialists in the field of defence planning, as well as for scientific and design organisations of the defence-industrial complex, and may be used in the formulation of requirements for prospective reconnaissance–strike complexes and in substantiating the directions of their further development.

Keywords: reconnaissance–strike complexes; unmanned aerial vehicles; unmanned aerial complexes; operational–strategic level; artificial intelligence; swarm technologies; network-centric systems; high-precision strike; defence technologies.

Introduction

Under the conditions of modern geopolitical challenges and military threats that have faced Ukraine over the past ten years, military-technological superiority over the adversary has become a key element in ensuring the state's defence capability and the effective conduct of combat operations. The war that has continued since 2014, especially in the phase of the full-scale invasion after 24 February 2022, has put forward new requirements for the Armed Forces of Ukraine regarding technological adaptation, the modernisation of armaments and the introduction of innovations.

The relevance of the research is determined by the need for a comprehensive analysis of contemporary global trends in the development of armaments, the assessment of technologies introduced by the aggressor state, the study of national experience in modernising samples of weapons and military equipment, as well as the identification of prospective directions for the development of the domestic defence-industrial complex.

The aim of the article is a comprehensive analysis of innovative solutions in the field of defence technologies, the assessment of existing technological developments in Ukraine, the identification of the main directions for the further development of high-technology armaments, as well as the formulation of proposals for technical solutions that ensure the achievement of an asymmetric advantage over the adversary.

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Issues concerning the development of reconnaissance–strike complexes (RSC) of the operational (operational–strategic) level created on the basis of unmanned aerial vehicles (UAVs) were considered in [1]. A retrospective analysis and development trends of unmanned aerial complexes (UACs), taking into account current programmes for their creation, are presented in [2]. A view on the development of RSC in accordance with trends in armed struggle is set out in [3]. An analysis of combat operations conducted by reconnaissance–fire complexes during the repulse and deterrence of the full-scale armed aggression of the russian federation against Ukraine is provided in [4]. Prospects for the development of strike UACs of the defence forces of Ukraine are considered in [5]. The necessity of introducing into armaments UAC command and decision-making systems based on artificial intelligence is emphasised in [6]. A methodology for the selection of UACs for the defence forces of Ukraine is proposed in [7]. Prospects for the development of UACs with UAVs of the "multicopter" type are examined in [8]. Trends in the development of UAVs with hybrid propulsion systems are highlighted in [9]. The peculiarities of the employment of UAVs in wars and methods of countering them are analysed in [10].

Methodological Framework

The methodological framework of the research is formed by a set of mutually complementary scientific approaches, methods and principles that ensure a systematic, objective and representative analysis of the development of RSC under modern conditions. The scientific approaches (Table 1), methods (Table 2) and principles (Table 3) that constitute this framework are presented below.

Table 1. Scientific approaches used to study global development trends of the specified RSC

Approaches	Purpose of use
System approach	For considering RSC as an integrated set of interdependent components – sensor subsystems, communication channels, information processing means, delivery platforms and strike means. This makes it possible to assess RSC not as a set of technologies but as a single multifunctional system in which a change in one element alters the overall capabilities of the complex.
Structural-functional approach	For determining the functional role of individual components of RSC and their contribution to the overall effectiveness of the processes of "detection–identification–strike"
Comparative approach	For comparing global practices, technological solutions and doctrinal approaches of different states (the United States, the United Kingdom, France, Türkiye, Israel, China, Ukraine, etc.). This provides an opportunity to identify general trends and specific development models.
Critical-analytical approach	For analysing information from open sources: scientific publications, data of analytical centres, defence industry materials, conclusions regarding the war in Ukraine, and assessments of NATO and other international structures. The application of this approach made it possible to avoid incorrect generalisations, to take into account different viewpoints and to formulate conclusions on the basis of verified data.

Table 2. Research methods used to study global development trends of the specified RSC

Approaches	Purpose of use
Method of analysis and synthesis	For structuring information on RSC technologies and concepts, identifying the main technical trends, and generalising the obtained data in the form of systematic conclusions
Content analysis	For processing a large body of sources (analytical reports of defence agencies, annual reports of military-industrial companies, military-technical reviews, scientific articles and official NATO documents).
Expert-analytical method	For interpreting complex technical data, assessing the results of the introduction of new technologies and the prospects for their practical application under the conditions of modern conflicts.
Scenario analysis method	For analysing the prospects for the development of RSC up to 2030–2035, and for assessing the impact of new technologies (AI, UAV swarms, software-defined munitions, edge computing) on the operational and strategic capabilities of the armed forces.

It should also be noted that the limitations of the research included the use only of open-source intelligence (OSINT) materials without access to classified military documents; the limited availability of precise technical characteristics of the latest systems, which is compensated for by the analysis of available patents, marketing materials and expert assessments; and the dependence of the

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assessment of the operational effectiveness of UAVs and RSC in the war in Ukraine on fragmented data (due to information constraints of the parties).

Table 3. Principles of researching the development of the specified RSC

Principles	What validates the use
Objectivity	The analysis is based on the use of data confirmed by several information sources.
Comprehensiveness	The analysis covers technological, doctrinal, tactical, political and industrial aspects.
Relevance	The analysed sources include materials of 2020–2025 that reflect current trends.
Scientific justification	The analysis is based on a number of scientific research methods.
Interdisciplinarity	The analysis combines knowledge from different fields of science (technical, military).

Results

As a result of the conducted analysis, global trends in the development of RSC of the operational (operational-strategic) level, which are created on the basis of the UAV, have been identified. Such trends are conditionally divided into three components, which relate both to such RSC as a whole and to the UAC and UAV that form part of these RSC. The identified trends are considered below.

Global trends in the development of the specified RSC as a whole

Based on the analysis of the prospects for the development of unmanned aviation of the armed forces of the leading countries of the world, it has been determined that, in general, the main global trends in the development of the specified RSC are as follows:

ensuring the possibility of simultaneous control from the ground command post of the RSC of several reconnaissance-strike UACs, and from ground control stations of the UAC – of groups of UAV of different types (reconnaissance-strike (reconnaissance, strike), relay platforms) with minimal operator intervention, as well as ensuring the possibility of transferring UAV control functions from one UAC to another and to the ground command post of the RSC;

inclusion in the structure of the RSC of "mothership UAVs", which serve as carriers of smaller strike UAV (single-use or reusable), ensuring the possibility of their autonomous employment after release from the carrier and their return on board after completing combat missions (for reusable UAV);

ensuring capabilities for conducting continuous reconnaissance within the entire area of responsibility of the RSC, its processing and dissemination to external UAC crews and/or directly to strike the UAV in real time and in a form suitable for their immediate employment;

increasing capabilities for high-precision fire engagement of stationary and moving targets in the shortest possible time within the designated area of responsibility of the RSC under any meteorological conditions and at any time of day;

ensuring the possibility of combat control of the air elements of the RSC from ground command posts (control stations) in real time during their flight within the designated limits of the RSC area of responsibility through the use of satellite channels and airborne relay platforms;

ensuring interaction with external reconnaissance assets (radar, radio, radiotechnical, electro-optical) and command and control assets in a single information space in order to enhance the level of situational awareness and the possibility of selective dissemination of reconnaissance information both to own UAC (UAV) and to other combat platforms (strike assets) in real time;

ensuring the possibility of organising interaction with other RSC created on the situational principle of employment, or directly with other strike assets deployed on air, land and maritime platforms, in order to increase the power of fire impact on the enemy in designated areas of combat operations in real time;

ensuring the possibility of the mass employment of the UAV from the structure of the RSC (in groups or "swarms") and control of their group flights (in the future – in joint combat formations with

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manned aircraft) in real time (as required) in order to overload and disorganise enemy air defence systems and increase the effectiveness of engagement of important enemy objects;

improvement of software and hardware support to ensure the possibility of information exchange and organisation of interaction between different control subsystems within the RSC (in particular, the creation of data-exchange interfaces between the automatic target recognition system and the weapon control system, between systems that ensure situational awareness of the ground and air environment, etc.);

enhancement of the capabilities of technical support units responsible for the operation of RSC components, including the incorporation into their structure of groups for employment support, repair and maintenance of UAC (UAV) and their command posts (ground control stations).

Global trends in the development of UAC within the specified RSC

As a result of the conducted analysis, the following main trends in the development of UAC within the specified RSC have been identified:

enhancement of the strike capabilities of UACs through equipping them with single-use strike UAVs with jet engines, as well as aerial target simulators developed on their basis, which will ensure the possibility of more rapid strikes against moving objects (targets) in the operational depth after receiving reconnaissance information about them and will create conditions for more effective deception and overloading of the enemy air defence system;

enhancement of the strike capabilities of UACs through equipping them with reconnaissance-strike (strike) reusable UAVs with long-range aviation munitions of the “air-to-surface” and “air-to-air” classes, which will ensure more effective overcoming of the enemy air defence system and engagement of objects located at considerable distances from the line of combat contact;

enhancement of the reconnaissance capabilities of UACs in terms of surveillance and imagery airborne reconnaissance (electro-optical in the visible and infrared spectrum, radiotechnical, radar) by day and by night under simple and complex meteorological conditions;

increasing the level of automation of UACs on the basis of artificial intelligence in order to ensure automated control of individual UAV, their groups (swarms) at all stages of flight (take-off, en-route flight, strike delivery, landing, etc.), as well as the possibility of their effective performance of combat and special tasks in the tactical, operational and strategic depth of the enemy;

increasing the effectiveness of control of group flights and swarms of UAV (in the future – in common combat formations with aircraft in order to master the forms and methods of joint employment with manned aviation);

enhancement of the resistance (resilience) of data transmission, command and control lines of UAVs under the influence of enemy electronic warfare assets (exposure to electromagnetic emissions of natural and artificial origin);

integration of UACs into automated command and control systems of troops (forces), ensuring their compatibility with UACs developed (employed) by partner countries within a common infrastructure (including the possibility of using unified communication and navigation systems (networks)) for the conduct of joint operations;

development of networked systems based on distributed artificial intelligence that will allow a group of UAVs to be employed as a single entity with automatic task distribution among the UAV in the group in real time in accordance with the evolving operational-tactical situation;

inclusion in the structure of UAC of relay UAV, aerostat-based relay platforms and satellite communication means in order to ensure information exchange between reconnaissance (strike) UAV and ground control stations beyond radio line-of-sight zones.

Global trends in the development of UAVs within the specified RSCs

The conducted analysis made it possible to identify the following main trends in the development of UAVs within the specified RSCs:

equipping reconnaissance UAVs with onboard compact multi-frequency radiotechnical suites

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incorporating passive reconnaissance means, side-looking and all-round surveillance radars with active electronically scanned arrays (AESA), and high-resolution electro-optical systems;

implementation in onboard AESA radars of a wide range of operating modes enabling the identification of small-size ground objects by their radar signatures (in particular, SAR/ISAR modes (synthetic aperture / inverse synthetic aperture), which provide resolution at the level of 1–2 m), detection of moving ground and low-altitude air targets (including GMTI (Ground Moving Target Indication) mode), as well as acquisition of radar imagery of objects concealed by soil, snow, sand and forests (low-frequency subsurface radar mode);

increase in the detection range of onboard radars for ground objects in the active mode (up to 250 km);

enhancement of the capabilities of onboard passive radiotechnical means for target detection based on their own emissions (up to 400 km);

improvement of the resolution of electro-optical reconnaissance means (less than 1 angular minute) in the visible and infrared spectra (both in static image formation modes and in video streaming modes with wide-area and focused fields of view);

enhancement of the capabilities of onboard reconnaissance means in target selection, recognition and prioritisation against the background of the underlying surface, radio interference and high-intensity false signals;

equipping UAVs with electro-optical and infrared reconnaissance devices capable of detecting targets at low, medium and high altitudes with equal effectiveness and functioning both by day and by night;

ensuring the possibility of cueing electro-optical stations based on external preliminary target designation and/or their own algorithms (including localisation of a target by its radio emission detected by the onboard radar);

enhancing capabilities of single-use strike UAVs to engage mobile ground moving targets through equipping their warheads with their own homing seekers (radar, infrared, laser);

equipping reusable reconnaissance-strike UAVs with their own self-defence missile armament (in particular, “air-to-air” and “air-to-surface” missiles), as well as effective electronic warfare means to counter enemy air defence and electronic suppression assets, which will ensure the possibility of UAVs approaching reconnaissance objects at a distance corresponding to the maximum realisation of their reconnaissance capabilities;

equipping UAVs with communication and data transmission systems of the MP-CDL (Multi-Platform Common Data Link) type, which ensure the possibility of organising the exchange of reconnaissance information with other combat (reconnaissance, strike) platforms and their command posts within a single information space, as well as the provision (reception) of target designation during joint employment in designated areas of combat operations;

integration into the software and hardware of UAVs of elements of artificial intelligence and machine vision in order to automate navigation processes, target detection, their recognition (by category, type, condition), tracking, guidance to the target and its engagement;

ensuring the functioning of UAVs in an autonomous mode that does not require operator intervention after their launch (start), through the use of onboard integrated inertial-satellite navigation systems with different types of sensors;

improvement of onboard inertial systems in order to enhance the navigation accuracy of UAVs through the use of improved sensors and new algorithms for compensating time-dependent errors in the measurement of navigation parameters on the basis of artificial intelligence;

increasing the endurance of UAVs, development of compact modular-type observation equipment, ensuring the transmission of reconnaissance data in real time through the use of various communication channels;

increasing the flight range of UAVs, as well as reducing their thermal and acoustic signature

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through the replacement of traditional internal combustion engines with new-type propulsion systems (in particular, liquid hydrogen engines, electric motors and hybrid versions);

introduction of technologies to reduce fuel consumption and increase the service life of compact turbogenerators and turbojet engines, development of new energy-efficient compact air-aluminium power sources for UAVs;

development of power converters and electrical installations of UAVs with intelligent self-diagnostics and failure compensation functions;

increasing the flight speed of UAVs through equipping them with turbojet and turboprop engines, as well as hybrid propulsion systems (turbojet (turboprop) engines integrated with electric motors);

development of hypersonic UAVs capable of reaching speeds exceeding Mach 5, which will significantly accelerate the process of engaging objects (targets) located in the operational and strategic depth of the enemy and will practically preclude the destruction of such UAVs by traditional air defence systems;

development of reconnaissance-strike UAVs based on the integration of two types of drones – reconnaissance and loitering strike – which ensures the detection of targets at long distances and the immediate direction of a loitering munition towards the target for its engagement;

development, on the basis of UAVs, of decoy aerial targets capable of imitating the signatures of various aircraft in order to deceive enemy air defence, as well as interceptor UAVs designed to engage aerial targets of different types (including FPV drones, helicopters and UAVs of the “Shahed” type);

reduction of radar and thermal signatures of UAVs through the manufacture of their airframes using new composite materials and stealth technologies (by analogy with the carrier-based variant of the fifth-generation fighter F-35C), the use of radar-absorbing and/or radar-scattering coatings, as well as the creation of plasma formations around the most powerful radar-reflective elements of UAVs, synchronised with radar emissions, which allows operations under conditions of strong enemy air defence;

use of new technologies for the miniaturisation and enhancement of onboard equipment capabilities, development on this basis of compact radio communication modules with increased range of command and telemetry channels, as well as high-capacity onboard batteries that extend the operating time of onboard equipment and the endurance of UAVs;

development of new optical odometry and stabilisation technologies enabling UAVs to fix their position on terrain using a specific marker, information about which is obtained from their onboard cameras (a key advantage of these technologies is independence from GPS connectivity, which increases the resistance of UAVs to electronic interference);

development of fibre-optic cables with improved properties (strength, flexibility, quality, etc.) to ensure stable control of UAVs in complex terrain conditions at maximum possible distances under conditions of active electronic countermeasures;

advancement of sensor technologies (research into the integration of various sensors (lidars, radars, cameras, etc.) in order to improve environmental perception accuracy and enhance the navigation capabilities of UAVs);

advancement of communication technologies (development of new protocols and standards for data transmission between UAVs and ground stations, including the use of 5G and other high-speed channels);

development of collision-avoidance systems (creation of technologies for detecting and preventing collisions with other objects in the air and on the ground, including algorithms for analysing sensor data);

development of energy-efficient systems (research aimed at improving the energy efficiency of UAVs through the use of new types of batteries, solar panels and other energy sources);

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development of multi-antenna systems (creation of technologies for coordination and interaction of several UAVs within a single mission, enabling the performance of more complex tasks);

advancement of cyber security technologies (protection of UAVs against cyber threats in order to increase the effectiveness and safety of their employment during mission execution in operations (combat actions));

development of multi-channel technical vision systems capable of analysing information in the optical, radio and infrared spectra;

improvement of technical vision systems in order to ensure reliable detection and identification of objects (targets), taking into account their possible distortions under conditions of optical and radio interference;

improvement of algorithms for processing information on detected objects (targets) through the application of machine learning and artificial intelligence technologies;

ensuring multi-position monitoring of terrain on the basis of technical vision methods and integrated processing of radar frame streams, with the possibility of recognising and predicting the location of objects (targets);

implementation of technologies aimed at enhancing the quality and autonomy of navigation and solving positioning tasks, including improvement of the software and hardware of onboard optical navigation systems in order to increase their resolution through the use of convolutional neural networks;

implementation of technologies for cooperative monitoring and terrain mapping based on data from UAVs operating as a group;

development of intelligent onboard information-navigation complexes based on multispectral (multi-sensor) technical vision systems, ensuring the processing of heterogeneous measurement data using artificial intelligence;

development of integrated correlation-extreme onboard navigation systems with joint processing of information on objects (terrain) obtained in different spectra (visible, infrared and radar);

improvement of onboard software and hardware in order to ensure the possibility of autonomous control, navigation and interaction of individual UAVs (their groups) in flight through the development and implementation of effective neural-network algorithms of swarm interaction, elements of artificial intelligence, and technologies of learning and self-learning of UAV groups;

improvement of communication organisation systems and task-allocation algorithms within a UAV group;

development of an integrated system for group control, interaction and behavioural organisation of a UAV group during the execution of assigned tasks;

enhancement of the strength and service life of UAV structures through the development and use of polymer composite materials based on nanomodified infusion and adhesive compounds, as well as lattice composite load-bearing structures;

development of technical systems for safe thermal inspection (detection) of possible structural defects of UAVs, preventing damage to their composite skins during inspection;

development of technologies for the joint employmnt of UAVs and manned aircraft within the airspace;

enhancing resistance of UAV information channels to interference through ensuring their protection by means of quantum encryption technologies;

implementation of a modular design principle for UAVs, ensuring the compatibility of modules at structural, energy and information levels in order to provide UAVs with modernisation potential and maintain their required technical level during the operation phase with minimal costs.

Promising trends in UAV development (primarily single-use systems) should also include the

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mastering and implementation of simplified manufacturing technologies (including the materials used), while preserving the main efficiency requirements in order to ensure mass production and the fastest possible delivery to the troops. This is expected to ensure the mass employment of UAVs as one of the key factors of their effectiveness (primarily due to the possibility of overloading the enemy air defence system and depleting its stocks of surface-to-air missiles as a result of prolonged attacks). One example is the domestically produced strike UAV "AQ 400 Scythe", "Kosa", developed by the company "Terminal Autonomy", the design of which is based on the concept of rapid and efficient production with minimised logistical costs while ensuring maximum functionality, making it a cost-effective instrument for military operations in terms of the "effectiveness–cost" criterion.

Discussions

For a comprehensive analysis, it is appropriate to consider relevant opinions and research findings of foreign specialists.

Sources [11], [12] provide data on the number of countries employing RSCs over a certain period. These data indicate a significant increase in unmanned and autonomous strike means (including UAVs) within RSCs employed at the operational level. For clarity of analysing these data, the authors of the article constructed a corresponding graph (Fig. 1) and diagrams (Fig. 2).

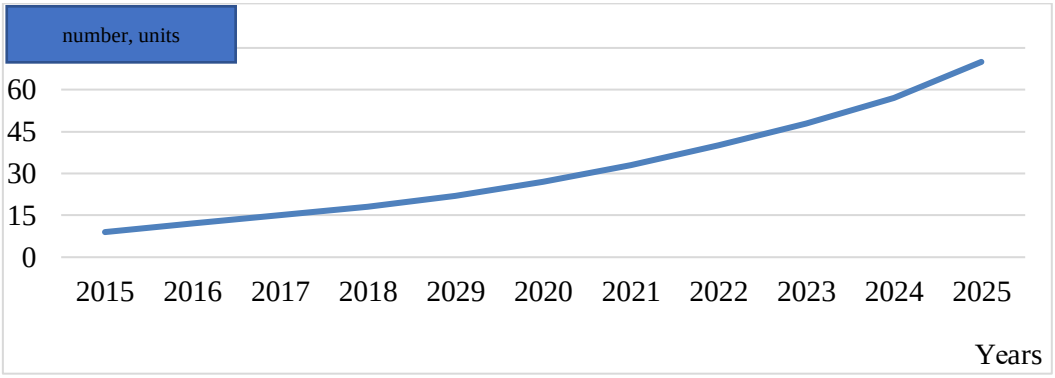


Figure 1. Dynamics of the increase in the number of states integrating RSCs into their armed forces during 2015–2025

The analysis of the data presented in Figs. 1 and 2 indicates a significant increase over the past 10 years in the number of states integrating RSCs into their armed forces, as well as a considerable growth in the share of strike UAVs and loitering munitions within these RSCs.

Researchers in [13] analyse the economic feasibility of single-use and reusable UAVs, which is important for shaping an effective composition of RSCs and optimising strike UAV systems. In publication [14], the authors consider the optimisation of task allocation among UAVs in multi-mission operations, which makes it possible to enhance the effectiveness of operational RSCs. Report [15] analyses the role of precision strikes in strategic confrontation, including the integration of UAVs, cruise missiles and information systems within operational-strategic RSCs. The authors in [16] developed a swarm control algorithm for UAVs intended for future highly autonomous RSCs, ensuring a high level of coordination. The current state of applying multi-agent models for the control of unmanned systems, which forms the basis for the development of autonomous RSCs, is presented by the author in [17]. Analytical review [18] provides an overview of global trends in the development of loitering munitions, which constitute one of the key strike components of modern RSCs. Study [19] offers an empirical analysis of the employment of russian loitering munitions, providing practical insight into the effectiveness of single-use strike UAVs under the conditions of modern warfare.

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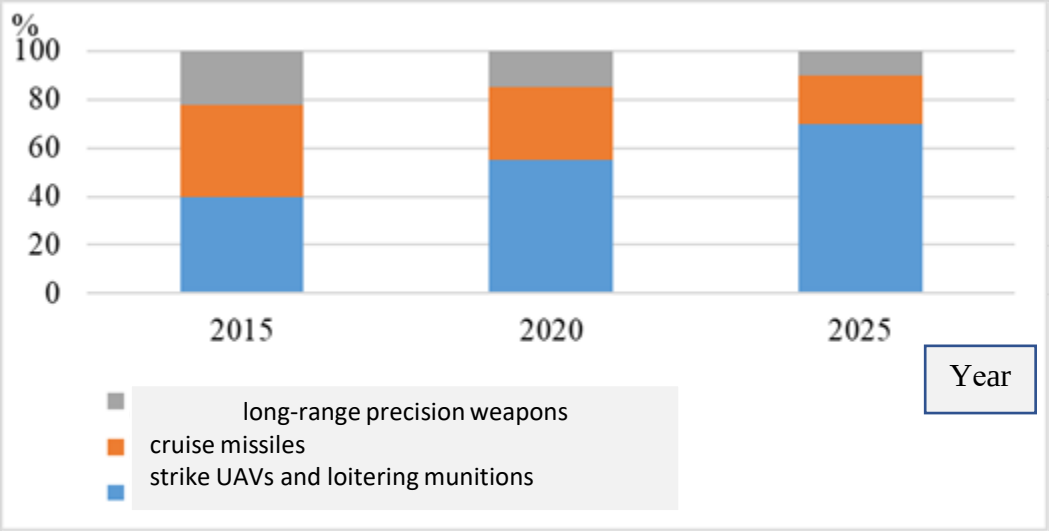


Figure 2. Proportion of strike means of different types (loitering munitions, cruise missiles, strike UAVs, long-range precision weapons) within RSCs

Conclusion

1. The conducted analysis confirmed that operational and operational-strategic level RSCs, created on the basis of UAVs, constitute one of the key elements of modern warfare and determine the character of armed struggle in the twenty-first century. Global trends indicate a transition from individual strike means to integrated network-centric systems in which UAVs of different classes, reconnaissance, command and control, and strike assets operate within a single information space. The obtained results make it possible to assert that the development of the specified RSCs should be based on the principles of asymmetric response to the enemy, priority of network-centric solutions, wide employment of artificial intelligence and swarm technologies, as well as close interaction between science, the defence-industrial complex and combat units.

2. It has been established that the dominant trend in the development of the specified RSCs is the increasing level of automation and autonomy through the implementation of elements of artificial intelligence, distributed control systems and swarm algorithms. This makes it possible to significantly shorten the “detection–identification–engagement” cycle, reduce the workload on operators and enhance the resilience of the complexes to the loss of individual elements under combat conditions. At the same time, the specified RSCs are developing in the direction of deep integration with automated troop command and control systems, as well as with other reconnaissance and fire engagement means of different basing (air, land and maritime). This increases the effectiveness of the employment of these RSCs and the flexibility of their use at the operational and operational-strategic levels.

3. The analysis of the development of UACs within the specified RSCs revealed a clear trend towards combining reusable strike platforms with single-use UAVs and loitering munitions. Such an approach ensures the possibility of employing RSCs in accordance with the operational-tactical situation based on an optimal “effectiveness–cost” ratio, creates conditions for overloading enemy air defence systems and increases the overall survivability of RSCs.

4. It has been determined that the development of UAVs within the specified RSCs is taking place along the lines of increasing range, speed, endurance and reduced detectability, as well as through a qualitative leap in the capabilities of onboard sensor systems. The integration of multispectral reconnaissance means, AESA radars, technical vision systems and machine learning

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ensures increased target recognition accuracy and the effectiveness of UAV employment under conditions of active enemy electronic countermeasures. At the same time, it is important to ensure the simplification of UAV production technologies and the possibility of their rapid adaptation to changes in the operational-tactical situation. Examples of domestic developments demonstrate the expediency of focusing on serial production, modularity and rapid upgrading of UAV designs, taking into account real combat experience.

A further research direction may be the development of a methodological framework for substantiating the optimal composition of RSCs based on UAVs, taking into account their technological level, possible employment scenarios and economic constraints.

Recommendations

The practical value of the obtained results consists in the fact that they may be used for:

the development of state programmes for the advancement of armament and military equipment (in terms of the creation and modernisation of RSCs), the selection of priority topics for relevant research and development and experimental design work, and the formulation of appropriate technical solutions;

substantiation of operational-tactical and tactical-technical requirements for prospective RSCs created on the basis of UAVs, as well as for their components;

formation of the scientific and methodological basis of the educational process in higher military educational institutions and within the officer training system during the teaching of disciplines related to the development of armament and military equipment, etc.

Conflict of Interest

The authors declare that they have no competing interests related to the subject of the article.

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Аналіз світових тенденцій розвитку розвідувально-ударних комплексів оперативного (оперативно-стратегічного) рівня, що створюються на основі безпілотних літальних апаратів

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Анотація. Актуальність дослідження зумовлена зростанням ролі розвідувально-ударних комплексів оперативного та оперативно-стратегічного рівня в умовах сучасних збройних конфліктів, насамперед у контексті російсько-української війни, що супроводжується стрімким розвитком безпілотних авіаційних технологій, мережецентричних принципів управління та засобів високоточного ураження. У зв'язку із цим статтю спрямовано на комплексний аналіз світових тенденцій розвитку розвідувально-ударних комплексів на основі безпілотних літальних апаратів, визначення ключових напрямів еволюції їхніх складових та формування науково обґрунтованих пропозицій щодо перспектив розвитку таких комплексів з метою набуття асиметричної воєнно-технологічної переваги. Провідним підходом для дослідження зазначеної проблематики є системний та структурно-функціональний підходи у поєднанні з порівняльним і критично-аналітичним аналізом відкритих джерел, що дозволяє комплексно розглянути розвідувально-ударні комплекси як інтегровані багатокомпонентні системи, оцінити взаємозв'язок їхніх елементів і виявити провідні світові технологічні тренди. У статті визначено світові тенденції розвитку розвідувально-ударних комплексів оперативного (оперативно-стратегічного) рівня, що створюються на основі безпілотних літальних апаратів (як стосовно таких комплексів у цілому, так і стосовно їхніх складових); розкрито напрями підвищення автономності, мережевої взаємодії та ударних можливостей розвідувально-ударних комплексів; виявлено зростання ролі штучного інтелекту, ройових технологій і масових витратних безпілотних літальних апаратів; обґрунтовано доцільність переходу до модульних, серійних й економічно ефективних рішень. Матеріали статті становлять практичну цінність для фахівців у сфері оборонного планування, наукових і проєктних організацій оборонно-промислового комплексу, їх може бути використано під час формування вимог до перспективних розвідувально-ударних комплексів та обґрунтування напрямів їх подальшого розвитку.

Ключові слова: розвідувально-ударні комплекси; безпілотні літальні апарати; безпілотні авіаційні комплекси; оперативно-стратегічний рівень; штучний інтелект; ройові технології; мережецентричні системи; високоточне ураження; оборонні технології.