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CONCEPTUAL FRAMEWORK FOR THE USE OF UNMANNED AERIAL SYSTEMS IN THE PROTECTION OF THE STATE BORDER

Introduction. *In today's environment, the proper quality of state border protection cannot be achieved by increasing the number of border guard units. Technical and technological advantages play a decisive role in defeating a strong enemy. One of the ways to improve the capabilities of border guard units is to introduce unmanned aerial systems to protect and defend the state border.*

Problem Statement. *In Ukraine, there is an urgent need to regulate the powers, grounds, and methods of using unmanned aircraft by the security and defense forces, as well as to improve enforceability of the procedure for its use.*

Purpose. *To define the conceptual framework for the use of unmanned aerial systems in the protection of the state border of Ukraine and the ways to improve the relevant regulatory framework of Ukraine.*

Material and Methods. *General scholarly research and special methods have been employed, the main of which are logical-semantic, system-structural, historical, observation, and comparison.*

Results. *The history of implementation, problems and promising areas of use of unmanned aerial systems in the protection of the state border have been studied. Attention has been drawn to the rapid development of unmanned technologies, which leads to their widespread use on the battlefield and in law enforcement. Emphasis has been placed on analyzing the negative trends in increasing number of violations related to the use of unmanned aerial vehicles.*

Conclusions. *The research has proved the need to improve the classification of unmanned aerial vehicles, as defined by NATO standards and EU regulations, given the possibility and necessity of using the same-type unmanned aerial vehicles in the military, law enforcement, and civilian spheres. It is necessary to put into operation nationwide digital platforms for drone control, which can perform almost all tasks previously performed exclusively by manned aircraft.*

Keywords: *unmanned aerial vehicles, unmanned aerial system, drones, use of airspace, state border.*

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Since 1991, the protection of the state border of Ukraine has been built with due regard for the development of good neighborly relations and the rejection of the use of military force to resolve conflicts. In this regard, there has been a consistent demilitarization of the bodies and units of state border protection, replacing their military tasks with law enforcement ones. This is reflected in the regulatory framework, personnel training system, and provision of border guard units with the necessary technical means, weapons and ammunition. The state border protection systems implemented by 2022 did not make it possible to successfully counteract Russian [26] aggression and to stop the rapid advance of enemy troops deep into the territory of Ukraine.

In today's environment, the quality of state border protection cannot be achieved by increasing the number of border guard details. Technical and technological advantages play a decisive role in defeating a strong enemy. One of the ways to improve the capabilities of border guard units is to introduce unmanned aerial systems to protect and defend the state border. Their use makes it possible to remotely detect and neutralize enemy forces and means, document illegal activities, etc. While some places were inaccessible and/or too remote (both visually and physically), they are now observable and reachable, even remotely [25].

The problems of organization and use of unmanned aerial vehicles are reflected in the works of O. Ananin, A. Balendr, I. Balytskyi, Y. Danyk, Y. Demchenko, L. Grekova, O. Islamova, I. Katerynchuk, O. Komarnytska, R. Koslowski, G. Linhanna, L. Marin, V. Mishra, I. Ordynska, Y. Parshukov, S. Pedrozo, R. Sabolchi, M. Schulzke, M. Tepan, G. Chandra, T. Chubina, B. Sharma and others. At the same time, the problem of improving the quality of counteracting the illegal use of unmanned aerial vehicles remains unresolved. This is evidenced by the growing number of unlawful uses of UAVs at the Ukrainian border.

Thus, in 2021, the State Border Guard Service of Ukraine detected 359 violations of the state border in the airspace (119, in 2016; 160, in 2017;

157, in 2018; 306, in 2019; 320, in 2020), of which 44% were not classified, 53% were related to the use of unmanned and 3% to manned aircraft. As compared with 2016, the number of violations of flight rules in areas with a special regime of airspace use in the border regions of Ukraine increased 4 times (22, in 2016; 11, in 2017; 40, in 2018; 48, in 2019; 45, in 2020; 90, in 2021). Almost 95% of such violations were committed by unmanned aerial vehicles. The above statistics show that unmanned aircraft are rapidly penetrating all areas of public life and the criminal environment.

The purpose of the research is to define the conceptual framework for the use of unmanned aerial systems in the protection of the state border of Ukraine and the ways to improve the relevant regulatory framework of Ukraine.

An unmanned aerial vehicle is an aircraft whose flight is controlled remotely or which flies autonomously according to a specific program [28]. The spread of unmanned aerial vehicle technologies around the world is due to the rapid development of artificial intelligence and 3D printing technologies. They allow for the rapid development and improvement of technical means, reducing the complexity and number of manual operations in the process of performing a flight task and processing the information received [11]. Even the global volunteer community of 3D printer owners has become one of the suppliers of scarce parts to the Armed Forces of Ukraine to repair equipment damaged in combat, including unmanned aerial vehicles [33].

One of the main assets of drones — in addition to their being unmanned or remotely piloted aircrafts — is that they perform tasks usually characterized as the other “3 Ds”: dull, dirty and dangerous. From the technical viewpoint, they are surveillance tools and they enable the coverage of vast and remote areas that would be more difficult to reach with traditionally piloted aircrafts [21].

The main advantages of unmanned aircraft are economic attractiveness, greater maneuverability, lower piloting practice costs, no impact on the remote crew of overloads typical of combat air-

craft pilots, and a longer equivalent flight range. The loss of an unmanned aerial vehicle in combat does not lead to the risk of pilot death. In today's environment, it is impossible to perform all the necessary tasks exclusively with unmanned aircraft. Especially in combat, manned and unmanned aircraft should be used in combination [19]. Military specialists of the advanced economies believe that in the modern combat environment, the reconnaissance unmanned aerial vehicles may solve the task of aerial reconnaissance more effectively and efficiently, as compared with the piloted reconnaissance aircraft [34].

There are three degrees of autonomy for unmanned aerial systems. The first is related to processes where a human remains part of the workflow. The second is constant human control over the autonomous execution of the mission by the unmanned vehicle, provided that all key decisions regarding the flight mission are made exclusively by humans. The third is the complete operational autonomy of an unmanned vehicle without human intervention [11].

Regardless of the degree of autonomy, for a long time the main purpose of unmanned aerial vehicles was to obtain intelligence. The experience gained by Ukraine on the battlefield also showed the need to use strike drones, because "they have greater surveillance capability and afford greater precision than other weapons, they can better prevent collateral civilian casualties and injuries" [2].

The following types of unmanned aerial vehicles are distinguished by their service life: those intended for multiple use and those that cannot be restored after a single use. According to the control features, they are: remotely controlled by the operator; programmed for autonomous operation; and having both functions. Each of these types has its advantages and disadvantages. They should be used in a comprehensive manner and depending on the specific tasks at hand.

The modern commercial market makes it possible to create a powerful group of unmanned aircraft without significant financial costs, which can perform some of the tasks traditionally performed

exclusively by pilots. Certain types of drones are difficult to detect and destroy by existing air defense systems, which makes them attractive for use on the battlefield. Certain terrorist organizations have already paid attention to this [20].

Since 2007, the European Commission has been actively supporting the development of new technologies for the use of unmanned aerial vehicles under the SESAR (Single European Sky Air Traffic Management Research) programme. Since 2021, €1.6 billion has been invested to create a European digital airspace and ensure the safety of unmanned aircraft operations. Competition in the unmanned aviation market is ensured by the synergy of the civil and defense sectors. Starting in 2023, European countries are planning to launch the "U-Space" system for managing unmanned aircraft traffic [10].

Civilian unmanned aerial systems of the European Union (which do not require verification and are suitable for performing state border protection tasks) are divided into four classes: "C0" – mass with payload up to 250 grams, maximum speed up to 19 m/s, flight altitude up to 120 m; "C1" – mass with payload up to 900 grams, maximum speed up to 19 m/s; flight altitude up to 120 m or to a specific value chosen by the external pilot; "C2" – mass with payload up to 4 kg, have a minimum speed limit of 3 m/s; flight altitude up to 120 m or to a specific value chosen by the external pilot; have an interface with geographic information systems; "C3" – mass with a payload of up to 25 kg, dimensions not exceeding 3 m; flight altitude up to 120 m or to a specific value chosen by the external pilot; have an interface with geographic information systems; "C4" – mass with a payload of up to 25 kg, do not have automatic control modes, except for the flight stabilization function, which does not change its trajectory [4].

The European Strategy for the Implementation of Unmanned Aviation until 2030 envisages: provision of services in the civil and defense sectors; ensuring the emergency services and law enforcement agencies; and transport services. Market segments include: manufacturers of unmanned

aerial systems and payloads (photo and video equipment, other monitoring and measurement tools); operators providing passenger services and transporting cargo; suppliers of specialized technologies (software, communication systems, flight control, automation, response to various situations); distributors selling or leasing unmanned aerial systems to third parties; suppliers of navigation and surveillance telecommunications infrastructure [10].

In the field of law enforcement, unmanned aerial vehicles are used to search for offenders; reconnaissance of territories and objects; detect, track and influence various objects; intercept offending unmanned aerial vehicles; and relay radio signals. Mobile on-board or ground control systems are used in hard-to-reach areas and terrain with difficult terrain. They are a complex, multi-level structure that ensures the quality of the flight task in a certain area and the transmission of the received information to the appropriate control point [6].

The use of unmanned aerial vehicles in forensic investigations is facilitated by the following factors: the ability to document a crime scene without leaving any traces; the availability of a large fleet of technical equipment that can be used to take photos and videos of traces from the angles and distances required by the investigator; the ability to detect traces hidden from the human eye over large areas automatically using ultraviolet and infrared radiation; and the ability to penetrate hard-to-reach places. Unmanned aerial vehicles can also be used to quickly deliver collected materials for expert examination [29].

According to NATO standards, there are three classes of unmanned aerial vehicles depending on their tactical and technical characteristics: the first is of the tactical level (up to 150 kg and miniature up to 66 grams, operating at altitudes up to 3,000 and 200 feet, radius up to 5 m and 25 km); the second is also of the tactical level (from 150 to 600 kg and small up to 15 kg, operating at altitudes up to 5,000 and 18,000 feet, radius of actions up to 50 and 200 km), and 200 feet, radius up to 5 and 25 km); the third – of the strategic and operational level (over 600 kg, operation at

an altitude of 45 thousand and 65 thousand feet, strategic and operational level and maximum possible radius of action) [12].

Taking into account the rapid development of unmanned aviation, there is a lag between the legal regulation in this area and the actual needs. For example, the NATO STANAG 4670 standard (which was developed in 2006) remains inconsistent with national legislation in some countries. In this regard, the ATP-3.3.7 standard has become more widely used, but in some countries it is also applied with restrictions [31].

A new strategic vision for the development of border aviation was introduced in the Ukrainian political system in 2006. Thus, the Development Concept of the State Border Guard Service of Ukraine for the period up to 2015 envisaged the acquisition of new types of aircraft and unmanned aerial vehicles with modern optical, radar and thermal imaging equipment [7].

This was due to the expectation of an economic effect similar to the results of using unmanned vehicles in other areas of human activity. Deterrents included the lack of trained personnel, infrastructure and regulatory framework necessary for the use of unmanned aircraft in state border protection; the final uncertainty of their operational characteristics; and an incomplete strategic vision of the prospective tasks that could be performed by unmanned aircraft in the interests of protecting and defending the state border of Ukraine.

The first experience of using unmanned aerial systems in state border protection was gained in 2015 during field tests of industrial models of unmanned aerial vehicles (weighing up to 25 kg) of five domestic and foreign manufacturers. At that time, they were planned to be used exclusively for aerial reconnaissance in the areas of responsibility of border guard units. None of the tested models were adopted. The main reasons were: low reliability of the design and communication channels; poor image quality in the infrared spectrum; insufficient level of process automation, which required long training of operators; lack of automatic target tracking modes [32].

As part of a state defense order, the State Border Guard Service of Ukraine received the first five “Spectator-M” unmanned aerial systems in 2017, with technical specifications that ensured the fulfillment of its tasks. One complex included 3 unmanned aerial vehicles, digital secure communication channels and monitoring equipment. The training of the first remote crews was completed in January 2018 [30].

In the period from 2018 to 2023, the state border protection agencies and units gained practical experience in using unmanned aerial systems to protect and defend the state border, conducting surveillance and monitoring the development of the situation in the areas of responsibility, in combat situations, and transmitting and receiving information to interacting entities.

Currently, border aviation performs the following tasks: ensuring compliance with the state border and border regime; protection of the state border and sovereign rights of Ukraine in its adjacent and exclusive (maritime) economic zones; transport and sanitary transportation; formation of a modern aviation structure, introduction of innovative approaches to the use of manned and unmanned aviation [24].

Unmanned aviation is considered a separate element of the aviation of the State Border Guard Service of Ukraine. The current level of science and technology makes it possible to perform all these tasks in the near future using aviation systems or in combination with manned aircraft. After the outbreak of hostilities, thanks to the development of volunteer activities, the fleet of unmanned border guard aircraft was replenished with new models of unmanned aerial vehicles with modern attachments. The staff of border guard units gained new knowledge, skills and abilities to use them, which influenced a change in conceptual views on the further development of border guard aviation.

Today, hundreds of unmanned aerial systems are used by border guard units to protect and defend the state border of Ukraine. They include unmanned aerial vehicles of various purposes and design features. The existing algorithm of the metho-

dology for selecting the option of their use includes several stages: preparation of initial data (assessment of the technical capabilities of the available equipment, the feasibility of their use); preparation of a terrain map (determination of initial values for calculating the size of the terrain matrix element and the azimuth scanning step, construction of a digital terrain model); determination of the main elements of the flight task (control zone, its area, length of the state border section); selection of a rational variant of the flight task [6].

One or more unmanned aircraft (depending on their classification), together with the elements necessary to perform a specific flight task, are part of an unmanned aircraft system. They may include: remote piloting stations; communication and surveillance equipment; navigation equipment; computers; flight and equipment control system; emergency flight termination system; devices for monitoring technical condition; weapons; special equipment [28].

Given the fact that border unmanned aerial vehicles should be integrated into the overall system of monitoring the situation on the state border, documenting illegal activities, tracking targets, fire support for border units during combat and making management decisions, it is advisable to provide for their supply and use as part of unmanned aerial systems regardless of the actual number of unmanned aerial vehicles in the unit.

Researchers have noted the imperfection of Ukraine’s legislation on the use of airspace by unmanned air vehicles, as compared with many countries in Western Europe, the United States, and Australia. In particular, it is necessary to regulate the restrictions on the operation of unmanned air vehicles in certain areas, define the rules of safe piloting, protection of personal data, protection of private life and property [8]. But regulations aimed at minimizing the risks associated with drones must therefore be directed at establishing rules for states and non-state actors alike [13].

The experience of using unmanned air vehicles in the protection and defense of the state border shows that the term “unmanned aircraft” as de-

fined in the Air Code of Ukraine is not perfect [1]. It does not take into account the fact that some unmanned air vehicles do not have an external control station and perform a flight mission according to a pre-established program.

The Law of Ukraine “On the State Border of Ukraine” defines that airspace protection is entrusted to the Armed Forces of Ukraine [17]. The need to improve counteraction to the illegal use of unmanned aerial vehicles requires consolidation of efforts of the Armed Forces of Ukraine and the State Border Guard Service of Ukraine according to their powers. Certain types of unmanned aerial vehicles can already be destroyed by border guard detail at the place of their detection. At the same time, it is necessary to improve the system of coordination of efforts of the subjects of integrated border management to control the distribution of targets and means of their destruction.

It is necessary to supplement the Laws of Ukraine “On the State Border Guard Service of Ukraine” [16] and “On the National Police” [18] with additional rights and obligations regarding: forcibly terminating the flight of an unmanned aerial vehicle by intercepting remote control signals, damaging or destroying it; counteracting the illegal use of unmanned aerial vehicles in the area with a special regime of airspace, along the state border, over the facilities of the State Border Guard Service of Ukraine; using unmanned aerial vehicles (taken into service and staffed) to stop illegal activities, destroy reconnaissance and sabotage groups, illegal armed groups, technical means of an offender, an armed enemy that endanger the life, health, rights and freedoms of people, or a law enforcement officer.

Legal regulation of social relations in the field of unmanned aerial vehicles should be balanced with methods of persuasion and coercion. The actualization of new threats to Ukraine’s national security requires expanding the disposition of Art. 281 “Violation of Air Flight Rules”, Art. 282 “Violation of Airspace Use Rules” and Art. 334 “Violation of International Flight Rules” of the Criminal Code of Ukraine [5] and defining new

offenses that is typical for today. The use of unmanned aerial vehicles should be an aggravating feature, which is justified by the need for more careful planning of the crime by the offender and the difficulty of detecting and detaining him.

The Code of Ukraine on Administrative Offenses is also limitedly applicable to prosecuting offenders for violations of airspace using unmanned aerial vehicles. The offenses described therein relate exclusively to “air transport” [3]. The content of this concept is insufficiently described in the current legal provisions. It needs to be replaced by “aircraft”.

Recently, more and more attention has been drawn to the need to take into account the mechanisms that guarantee that distant crews obtain the required level of competence, complete periodic theoretical and practical tests, and medical examinations. In international practice, there are still no standardized approaches to the organization of training, but training programs of the relevant categories of personnel most often distinguish three areas: subject basic knowledge; content and procedure for performing flight tasks; and peculiarities of flight operations [31].

According to the ATP-3.3.7 standard, the qualifications of unmanned aerial vehicles are divided into four levels. The first is to perform flights at an altitude of up to 900 meters. Operators of micro and mini drones must also obtain this qualification. The second level is to fly at an altitude of up to 1500 meters and operate tactical unmanned aerial vehicles of the first class (according to NATO classification). The third is to fly at an altitude of up to 18,000 meters and operate tactical unmanned aerial vehicles of the second class. The fourth is the flight in the entire airspace, the operation of third-class unmanned aerial vehicles (strategic and operational) and strike drones [9].

In accordance with European legislation, mandatory training includes: a theoretical training course (legal norms governing the use of aviation; types of aircraft designs, main characteristics of aircraft that determine the conditions of their use; understanding the capabilities and limita-

tions of an external crew; collection and usage of meteorological information; basics of navigation; resource management; identification of threats, errors and their handling); periodic demonstration and maintenance of theoretical knowledge (introduction of a system of regular competency checks, which is aligned with exploitation risks); practical skills (flight preparation; inspection and maintenance of the vehicle; planning of fuel and power consumption; assessment of weather conditions and airspace restrictions; aerodrome operations; safety measures; control of the vehicle in different weather conditions; actions as part of the crew in normal and emergency situations; practical usage of telecommunication, navigation equipment and communications); demonstrating and sustaining practical skills [27].

The experience of the State Border Guard Service of Ukraine shows that training UAV crews is no less difficult than training of pilots. This is due to the need to ensure the safe use of airspace, to provide crews with knowledge of the basics of piloting, the work of aerodrome services, and to keep technical equipment ready for use. Each person in the distance crew is also responsible for possible harm to other people and the environment.

A modern Operator Training Center was established at the State Border Guard Service of Ukraine with the support of the United States to organize a system of training for distance crews. Thanks to the assistance received, it was possible to create the necessary training base in a short time, taking into account the best international practices, implement training programs and ensure that the relevant categories of personnel complete periodic competency tests.

After the end of hostilities and renewal of control over all sectors of the state border, the main threats will remain armed and other provocations, crossing of the state border by sabotage and reconnaissance groups from russia and belarus to commit terrorist acts, prepare provocations and a new invasion [22]; attempts of illegal movement of weapons and ammunition across the border [23]; shelling of the territories of the Ukrainian border;

attempts of illegal crossing of the state border by local residents and illegal immigrants [14]; organized economic crime [15]; drug trafficking etc.

Counteracting these threats requires a combination of protection (military function) and security (police function) measures of the state border by all subjects of integrated border management. UAVs can be effectively used to counter all these threats. A positive effect is achieved due to mobility, unexpectedness, cost-effectiveness, the difficulty of detection and destruction by the enemy, implementation of technologies for the automation of flight control and analysis of the data received, and increased completeness of situational awareness within the time available for decision-making.

A wide range of promising flight missions requires the use of unmanned aerial and multi-rotor aircraft, including reconnaissance, strike, and strike-reconnaissance drones, to protect the state border. New promising areas for the use of unmanned aerial vehicles may include: intercepting and destroying air targets; providing forensic support; delivering weapons, ammunition, and other material resources to units that perform missions in distant and hard-to-reach areas for a long time; creating a field of targets in the air for training air defense units.

CONCLUSION

There are three stages in the development of border aviation in Ukraine. The first (2006–2015) is preparatory. The second (2015–2018) was the establishment of a system for training distance crews, creation and equipping border guard units with unmanned aerial vehicles. The third (since 2018) is the practical use of unmanned aerial vehicles in the protection and defense of the state border of Ukraine.

The implementation of unmanned aviation in state border protection should take place within the framework of the development of aviation of the State Border Guard Service of Ukraine. Promising models of unmanned aerial vehicles should be integrated into unmanned aircraft systems and

a unified system for monitoring the situation and managing the activities of the bodies and units of the State Border Guard Service of Ukraine. Unmanned aerial systems should be able to perform reconnaissance and strike missions, conduct electronic warfare, carry out transportation, provide forensic expertise and destroy individual enemy air targets, etc.

The necessity and possibility of integrated use of civilian and military unmanned aerial vehicles for the protection and defense of the state border of Ukraine is complicated by differences and imperfections in international and national legislation. At the same time, the unmanned aerial systems received by the state border guard bodies and units must be compatible with the relevant systems of other subjects of integrated border management and NATO standards.

The need of the hour is to develop a Strategy for the Use of Unmanned Aerial Vehicles by the Security and Defense Forces of Ukraine. This document should define: tasks for improving the relevant regulatory framework, its adaptation to the legislation of the European Union and NATO standards; creation of a unified digital airspace; decla-

rations of the main areas of application of UAVs, which will serve as a guide for scientists, developers and industry; planned budget expenditure for scholarly research, purchase of technical means and incentives for market participants and R&D institutions; directions and timing of adjustments to the training programs for the training of UAV crews; organization of competitions on the use of UAV as an incentive to find new technical solutions and expand the scope of their use.

The growing complexity of UAVs and the missions they can perform requires continuous improvement of the personnel training system. Training of distant crews should be conducted throughout the entire service career of the relevant categories of military personnel.

Areas for further research could include: development of a Strategy for the use of UAVs by the security and defense forces of Ukraine; improvement of standardization of tactical and technical characteristics, manufacturing, and exploitation of UAVs in the security and defense sector; use of unmanned aerial vehicles and unmanned swimming vehicles to protect the maritime sector of the state border and the exclusive (maritime) economic zone of Ukraine.

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КОНЦЕПТУАЛЬНІ ЗАСАДИ ВИКОРИСТАННЯ БЕЗПІЛОТНИХ АВІАЦІЙНИХ КОМПЛЕКСІВ У ОХОРОНІ ДЕРЖАВНОГО КОРДОНУ

Вступ. У сучасних умовах належного рівня охорони державного кордону неможливо досягнути через збільшення кількості прикордонних нарядів. Вирішальну роль у перемозі над сильним противником відіграють технічні та технологічні переваги. Одним із способів підвищення спроможностей прикордонних підрозділів є впровадження безпілотних авіаційних комплексів для охорони та захисту державного кордону.

Проблематика. В Україні існує нагальна потреба врегулювання повноважень, підстав, способів використання безпілотної авіації силами сектору безпеки та оборони держави, а також удосконалення відповідальності за порушення порядку її використання.

Мета. Визначення концептуальних засад використання безпілотних авіаційних систем в охороні державного кордону України та шляхів удосконалення відповідної нормативно-правової бази.

Матеріали й методи. Використано загальнонаукові та спеціальні методи, зокрема логіко-семантичний, системно-структурний, історичний, спостереження та порівняння.

Результати. Досліджено історію впровадження, проблеми і перспективні напрями використання безпілотних авіаційних комплексів у охороні державного кордону. Закцентовано увагу на стрімкому розвитку безпілотних технологій, що призводить до більш масового їх використання на полі бою, у правоохоронній діяльності. Проаналізовано негативні тенденції щодо збільшення кількості порушень, пов'язаних з використанням безпілотних літальних апаратів.

Висновки. Доведено необхідність удосконалення класифікації безпілотних літальних апаратів, що визначена стандартами НАТО та регламентами ЄС, з урахуванням можливості та потреби використання однотипних безпілотних апаратів у військовій, правоохоронній і цивільній сферах. Необхідно ввести в експлуатацію загальнодержавні цифрові платформи для управління безпілотниками, за допомогою яких можливо виконувати майже всі ті завдання, які раніше виконувалися виключно пілотованими літальними апаратами.

Ключові слова: безпілотна авіація, безпілотний авіаційний комплекс, дрони, використання повітряного простору, державний кордон.