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USAGE OF UNMANNED AERIAL VEHICLES ON THE BASIS OF EXPERIENCE OF THE RUSSIAN-UKRAINIAN WAR (2022–2025)

INTRODUCTION

An analysis of the latest military conflicts of the 21st century (Syria, Iraq, Nagorno-Karabakh) shows the growing role of reconnaissance, strike and attack unmanned aerial vehicles (UAVs) as their main component. They have been used even more intensively during the war between Russia and Ukraine, which began on 24 February 2022. Experience has shown that UAVs have become one of the leading factors in modern armed struggle, radically changing the tactical and operational situation on the battlefield and, accordingly, in the operational lanes. This fact has led to significant changes in the tactics of defensive and offensive combat, as well as in the theory and practice of preparing and conducting operations by tactical, operational and even operational-strategic groups of troops. These changes need to be understood, scientifically interpreted and implemented in the practical activities of troops, and this task is extremely urgent in the current situation. The Armed Forces of Ukraine have gained unprecedented combat experience, which is of considerable theoretical and practical interest. The purpose of this article is to summarise the experience of using unmanned aerial vehicles during the Russian-Ukrainian war in 2022–2025. During more than three years of active hostilities, has been accumulated quite a significant experience of their use which allows us to draw certain conclusions.

In Ukraine, the use of unmanned aerial vehicles has repeatedly been the subject of scientific research by specialists in various branches of science, including history. A considerable amount of historiography has been accumulated, revealing both the processes of the emergence of unmanned aircraft, the development of UAVs and the forms and methods of their combat and operational use. Among the fundamental scien-

tific works that represent the points of view of Ukrainian scientists on the development of unmanned aerial vehicles and their use in military affairs, worth mentioning the monograph "The Use of Unmanned Aerial Vehicles in Military Conflicts of the Present" of the group of authors under the general editorship of S. Mosov (Mosov, 2013). The authors have studied the main aspects of the topic in detail, but they focused on the performance of reconnaissance missions by UAVs and their work as part of reconnaissance and strike systems. At that time, the usage of UAVs to strike ground targets was not as widespread as during the repulsion of Russian aggression against Ukraine (the monograph was published in 2013). However, the authors noted that this area of UAV use is extremely promising, as it is gaining more and more development and in the coming years UAVs will become an important component of the firepower system. In fact, this statement was evidenced by the experience of military conflicts in the Caucasus and the Middle East in the first quarter of the 21st century.

The reason for this is not so much the complicated nature and complexity of the issues raised, but rather the extremely dynamic change in the situation, the constant search and implementation of new tactical and technological solutions that significantly change the nature of UAVs and the entire picture of armed struggle. Obviously, a more complete and adequate summary of the experience of the UAVs usage will be possible after the end of hostilities. However, in order to timely identify and clarify trends, promising areas for the development of unmanned aerial vehicles and methods of their use, it is necessary to constantly monitor the situation on the battlefield, analyse it and develop appropriate conclusions and recommendations.

The authors, being involved in this activity, constantly analysing the combat experience and using both general scientific methods (analysis, generalisation, deduction and induction) and special historical methods (problematic and chronological method, method of historical comparative studies), consider it necessary to acquaint the scientific community with the results of the study of the experience of using UAVs gained over the three years of the Russian-Ukrainian war.

The issue of UAVs employment for strikes against enemy targets – given the scale and intensity of their use under current conditions – has been, and remains, a subject of extensive research by scholars around the world. In particular, this topic has received considerable attention from Polish researchers. Its relevance has increased in the context of recent developments, notably following the raid conducted by a group of Russian reconnaissance UAVs on September 10, 2025.

Studies conducted by Polish researchers demonstrate a high level of attention to the UAV usage in contemporary armed conflicts, particularly in the context of Russia's war against Ukraine. For instance, M. Magiera (2025: 263) emphasizes that the Ukrainian experience with UAVs has enabled the creation of a "transparent battlefield," where informational superiority is achieved through the large-scale collection and transmission of data. Drones have, in fact, become a cornerstone of network centric operations, significantly altering the nature of warfare. In the monograph "Wojna dronów: militarne wykorzystanie bezzałogowych statków powietrznych" (Kopeć, Wasiuta, Wójtowicz, 2021: 112–118), the authors outline the transformation of UAVs from purely reconnaissance tools into weapon systems capable of performing strike missions at tactical, operational, and strategic depths. Essentially, UAVs have acquired the status of strate-

gic assets in modern warfare. The authors also note that as early as 2014, Ukraine had become a testing ground for new forms and methods of UAVs employment.

Significant attention is also drawn to scholarly works and analytical reviews by American and Israeli experts, as these two countries have, in many ways, pioneered the operational use of UAVs in armed conflict. For example, American researchers D. Rassler and Y. Veilleux-Lepage, in their article "On the Horizon: The Ukraine War and the Evolving Threat of Drone Terrorism" (Rassler, Veilleux-Lepage, 2025), analyze how the war in Ukraine is accelerating the evolution of drone-related tactics and technologies among terrorist organizations. The authors examine the scale of drone deployment, the types of missions conducted (including reconnaissance, strikes, and sabotage), as well as threats to civilian infrastructure. The authors conclude that the war in Ukraine serves as an "innovation hub" for the theory and practice of UAV combat employment. At the same time, they warn that the accumulation and dissemination of experience in the use of strike-capable UAVs increases the risk of their proliferation among non-state actors, thereby leading to the need of new countermeasures development.

Similarly, T. A. Schmidt views the Russian-Ukrainian war as a "live laboratory" in which new approaches to integrated missile and air defense are being tested. Particular emphasis is placed on the role of UAVs in reconnaissance, artillery fire adjustment, and information warfare. The author concludes that UAVs have become a critical means of data collection, and that the effectiveness of modern air defense systems increasingly depends on their synergy with unmanned aerial platforms (Schmidt, 2024).

Given Iran's role in supporting Russian aggression against Ukraine, the scholars refer to the article by Israeli analyst "The Iranian Involvement in the War in Ukraine and its Implication on Broader Arenas as the Middle East" (Bouks, 2023). The Israeli analyst examines the technical specifications and combat use of Iranian UAVs in Ukraine, as well as their potential in a broader regional context.

Summarizing the contributions of scholars from various countries and academic circles, it can be stated that there is a general consensus on the fact that UAVs have become a key instrument in military operations in Ukraine – ranging from tactical reconnaissance to precision strikes against strategic targets deep within enemy territory. Their widespread and intensive use indicates that military art has entered a new phase of development, characterized by the increasing physical distance of human operators from the battlefield, and by automatization of target acquisition, identification, and strike decision-making. This trend suggests a gradual reduction in human involvement, and potentially, in certain scenarios, the complete removal of the human operator from the decision-making loop. It is also worth noting that Polish researchers place particular emphasis on the integration of UAVs into network centric operations, highlighting their role in reducing casualties and enhancing the accuracy and effectiveness of artillery fire.

FACTORS THAT IMPACTED THE USE OF UNMANNED AERIAL SYSTEMS DURING THE RUSSIAN-UKRAINIAN WAR

The experience of using UAVs during the countering of the large-scale Russian invasion showed that they were used for aerial reconnaissance and fire control, striking

ground and air targets both on the line of direct contact and inland, including strategic rear facilities, providing communications as signal repeaters, and delivering cargo to inaccessible places. Several factors contributed to the widespread use of UAVs during the Russian-Ukrainian war.

The most important role was played by a number of tactical factors. Both sides needed significant air support for their ground forces. First of all, it concerned aerial reconnaissance and fire on ground targets not only in tactical and operational depth, but also in strategic depth. At the same time, the density and capabilities of the parties' air defence systems from the very beginning of large-scale invasion made it virtually impossible for aircraft to fly even at a distance of up to 10 km from the line of contact. In such circumstances, UAVs proved to be a fairly effective alternative to manned aircraft.

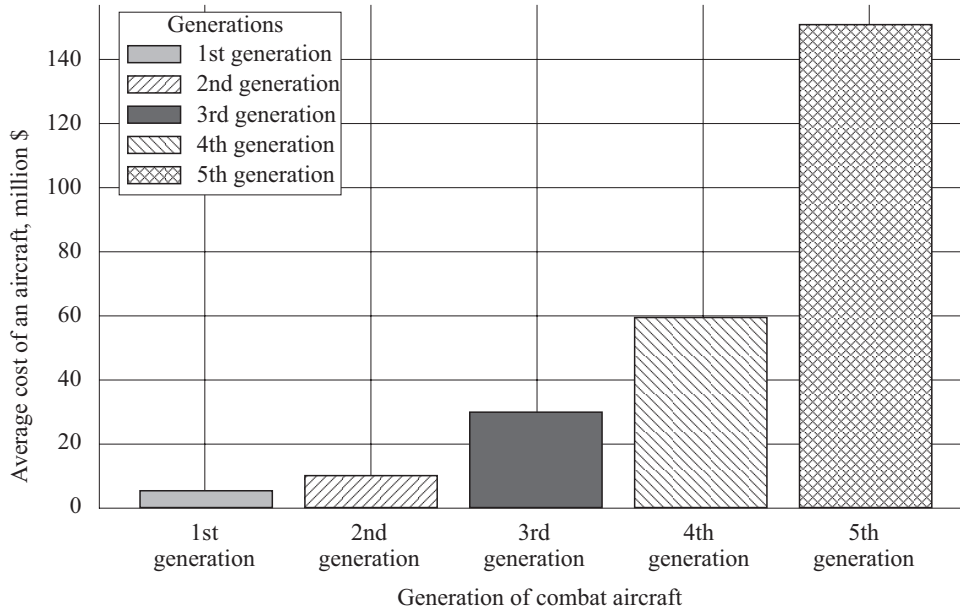
The widespread of usage of UAVs by the Ukrainian side was significantly contributed by the lack of artillery systems, ammunition and long-range anti-tank defence systems. The Russian army's considerable superiority in tanks, armoured vehicles and artillery required the search for innovative ways to solve the problem of timely detection and fire damage on the far approaches to the combat formations of Ukrainian troops. The solution was found in the use of both reusable and disposable UAVs (kamikaze drones). At the beginning of the hostilities, Ukrainian troops actively used civilian multicopter UAVs equipped with improvised explosive devices or shots from hand-held anti-tank grenade launchers, mainly RPG-7. They proved extremely effective, especially given that they hit targets in the least protected upper part of the hull.

The active, manoeuvrable nature of modern combat required the most immediate fire support, as well as constant monitoring of the situation, including at the company and platoon levels. Aviation was physically unable to fulfil the requests of combined arms units and subunits to strike ground targets, and reconnaissance aircraft could not constantly stay over the battlefield and provide information to tactical unit commanders. At the same time, units armed with small UAVs successfully performed these tasks, immediately responding to requests from commanders, targeting enemy targets virtually online.

The economic factor was also very important: the cost of strike and reconnaissance UAVs is hundreds to thousands of times less than that of manned aircraft performing similar tasks. In addition, the use of manned aircraft in conditions of dense and effective air defence of the parties was more likely to result in the loss of aircraft and flight crew, and the smaller payload of UAVs was compensated for by their number. Compared to manned aviation, unmanned aviation is clearly superior in terms of economic performance. Thus, the cost of manned aircraft is estimated at tens and hundreds of millions of dollars, with this figure showing a steady upward trend from generation to generation of aircraft (Figure 1):

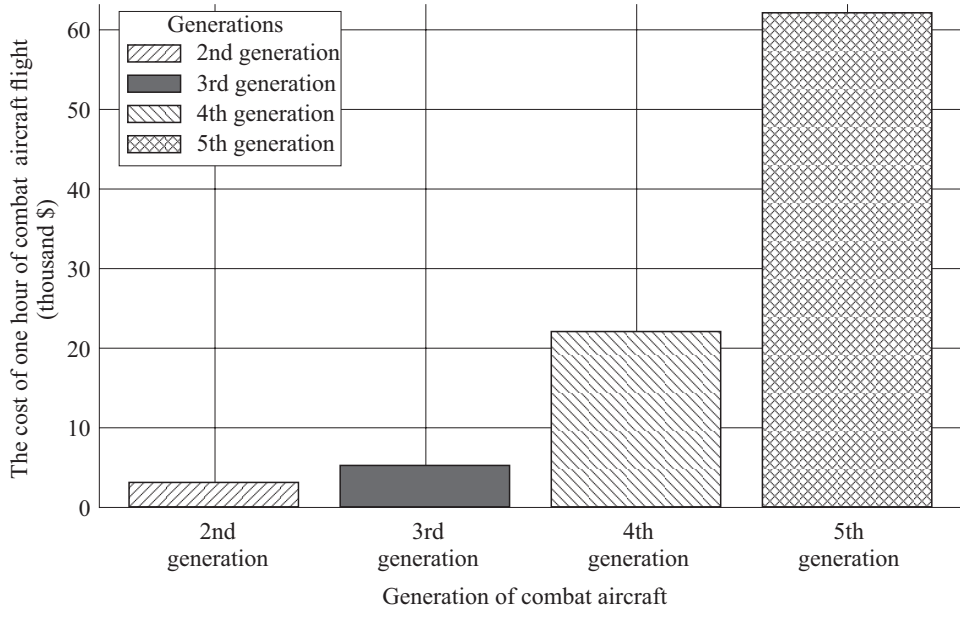
The cost of operating manned aircraft is also quite significant. It is estimated by such an important indicator as the cost per flight hour. It includes direct costs, such as the cost of fuel, consumables, electricity, maintenance of aircraft, part of the cost of the aircraft itself, equivalent to the consumption of the designated resource for one hour, etc. (Figure 2):

Figure 1. The dependence of the average cost of a combat aircraft on its generation belonging



Source: Mosov S. (ed.) (2013), *The Use of Unmanned Aerial Vehicles in Military Conflicts of the Present*, Publishing house Kyiv-Mohyla Academy, Kyiv.

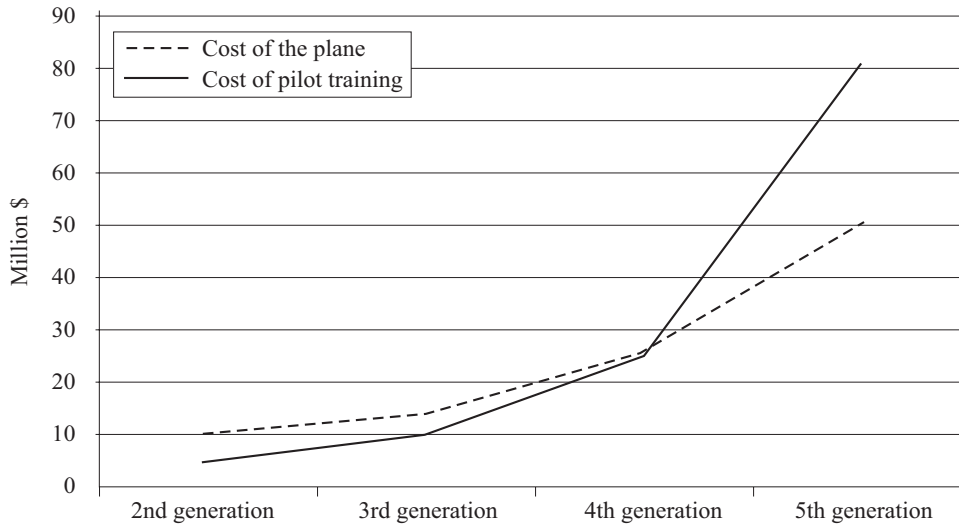
Figure 2. Increase of the cost of one hour flight for different generations of combat aircraft



Source: Mosov S. (ed.) (2013), *The Use of Unmanned Aerial Vehicles in Military Conflicts of the Present*, Publishing house Kyiv-Mohyla Academy, Kyiv.

The cost of training flight crews was also growing accordingly. At the same time, training a pilot of the highest qualification (equivalent to the class qualification of a sniper pilot for the Ukrainian Air Force) is almost equal to the cost of an aircraft, regardless of which generation it belongs to (Figure 3).

Figure 3. Comparative cost of combat aircraft and pilot training



Source: Mosov S. (ed.) (2013), *The Use of Unmanned Aerial Vehicles in Military Conflicts of the Present*, Publishing house Kyiv-Mohyla Academy, Kyiv.

At the same time, it should also be considered that flight crew training takes years, while experience has shown that UAV operators can be trained in two months. So, it can be concluded that from an economic point of view, unmanned aviation also has significant advantages over manned aviation.

The level of technology development has also contributed to the rapid progress of unmanned aviation. Modern information technology has reached such a level that both the unmanned aircraft and its control equipment have become so compact that they can be used by units of any level, up to and including a mechanised (infantry) unit or a reconnaissance or assault group.

The active usage of space navigation systems, artificial intelligence elements and advanced control for UAVs has contributed to increasing their autonomy, suddenness of use, target hit accuracy at a level not inferior to high-precision weapons and controllability during combat missions. Currently, one of the main tasks for scientists and engineers is to introduce artificial intelligence elements into UAV control systems, which is believed to allow the UAV control system to identify targets, develop and implement an attack scheme while evading enemy countermeasures, and in the case of a group attack (swarm attack), also distribute targets within the group, guided by certain priority considerations. In addition, modern and advanced information exchange systems already allow for the transmission of real-time intelligence information to command and control points. As a result, the time from the moment a target is detected to the launch

of a strike, if there are available firepower, rarely takes more than one to two minutes, even if the target is tens of kilometres away from the line of contact.

SPECIFIC FEATURES OF THE USAGE OF UNMANNED AERIAL VEHICLES IN THE CONDUCTING THEIR MAIN COMBAT MISSIONS

In a combat situation, UAVs are an extremely effective tool for performing strikes, aerial reconnaissance, targeting, artillery fire adjustment, radio reconnaissance and other tasks.

The main advantages of using UAVs are:

– relatively small size and lower visibility compared to manned aircraft;
– high accuracy of hitting ground and surface targets, which is close to that of precision weapons;
– low cost of UAV maintenance and operation;
– significant time savings on training of operators and technicians compared to training of combat aircraft pilots;
– significantly lower production costs compared to conventional aircraft;
– significantly lower cost compared to many anti-aircraft guided missiles and air-to-air guided missiles, which are the main weapons for hitting air targets (Havrylenko, Yakutovych, 2025).

After the collapse of the USSR, post-Soviet countries, including Ukraine and Russia, did not pay much attention to the development of UAVs, despite the fact that the experience of military conflicts in the late twentieth and early twenty-first centuries showed a steady tendency towards increasing their role and the extent of their use in armed struggle. However, it is worth noting that since 2011, when Russia introduced a new programme of mass rearmament of its armed forces, serious measures have been taken to create a wide range of UAVs and provide them to the army. There were two main ways of supplying its army with UAVs for various purposes: development of its own models (the main one) and licensed production of foreign ones.

The basis of the Russian UAV fleet is made up of indigenously developed vehicles, such as the "Orlan-10" tactical reconnaissance UAV, tactical UAVs of the "Eleron" and "Zala" families, etc. Also in service is the "Forpost" tactical reconnaissance and strike unmanned aerial vehicle system, which is an Israeli Searcher system, manufactured in Russia under licence. In addition, taking into account global trends in the development and use of UAVs, Russian manufacturers have begun production of single-use strike UAVs (the so-called kamikaze drones), the "Kub-BLA" and "Lancet" (Demianenko, 2025). The private enterprise "Kronshtadt" has also developed the tactical reconnaissance and strike complex "Inokhodets" (in export variant – "Orion"), but it has not yet become widespread, as the "Kronshtadt" group has managed to produce only 30 units of advanced UAVs (*Russia uses Kronshtadt*, 2022). In general, Russian UAVs meet the requirements for their performance, but in most cases do not differ from the global average.

The only Russian strike UAVs are the "Forpost-R" (equipped with two missiles weighing no more than 100 kg, 30 in total) and the experimental "Orion" and S-70

"Okhotnik," which are still prototypes. After the loss of two "Forpost" UAVs, the enemy refused to use them as strike drones. There was also the loss of one Iranian-made "Mohajer-6" reconnaissance and strike UAV over the Black Sea (at least four UAVs of this type have been shot down so far). In addition to the aforementioned UAVs, in the course of hostilities, Russians use air targets of the "Adjutant," "Klyon," "E-95M" and "BM-B" systems to expose the positions of Ukrainian air defence systems and as decoys. There has also been a case of the use of a Soviet-made Kh-55 cruise missile with a weight imitator instead of a warhead. A feature of the war has been the widespread use of tactical mini-UAVs such as the DJI "Mavic" or DJI "Spark," both for reconnaissance and fire control, as well as for other combat missions. For example, mini-UAVs are used to drop Molotov cocktails or homemade mini-air bombs that are attached to a suspension made from a 3D-printed device, and the bombs themselves are either fragmentation or fragmentation hand grenades or VOG-17 grenades equipped with stabilisers, also printed on a 3D printer (Savchenko-Halushko, 2025).

The enemy has also using UAVs made by the Chinese company SJRC (F11, F74K-Pro), the American company Autel Robotics, Xiaomi (FIMI series), as well as unnamed or little-known UAVs, mostly made in China (Korshets', Horbenko, 2023: 10). Even despite being under international sanctions, Russians are quite actively using products of Chinese companies for production, including UAVs (Deutsch, Balmforth, 2024).

Despite the requirements of the country's top military and political leadership to replace imported components of weapons and military equipment with Russian analogues, the general weakness of Russian unmanned aerial vehicles is their dependence on foreign components, ranging from the element base of electronic equipment to elements of reconnaissance, control and engine systems. Naturally, since the beginning of the large-scale aggression and the imposition of international sanctions, primarily on military and dual-use goods, technologies and services, Russian manufacturers have faced significant problems, which has significantly slowed down and, in some cases, made it impossible to produce and supply UAVs to the army.

The Russian leadership tried to solve this problem by purchasing the relevant products from its allies. However, Chinese manufacturers have refused to have any contact with the sanctioned country. The only success in this regard is Russia's purchase of a number of UAVs from Iran, including the "Mohajer-6," "Shahed-129," "Shahed-191" (Delfynov, 2022) reconnaissance and strike systems and "Shahed-136" (Trofimov, Nissenbaum, 2022) kamikaze drones.

In our opinion, this is an another evidence of systemic problems in the Russian military-industrial complex, which potentially will not allow them to achieve a decisive technical superiority over the Armed Forces of Ukraine, which, in turn, can count on military-technical support from the world's leading military-technological countries. At the same time, it is important to mention that Iran is not a trendsetter in the world's unmanned aerial vehicles and does not have the ability to develop and implement innovative technologies in this area, borrowing ideas and components mainly from China and a number of other countries.

For the sake of objectivity, it is worth noting that the situation with equipping the Ukrainian Armed Forces with modern UAVs before the start of large-scale Russian

aggression was no better, if not worse, than in Russia. Ukrainian manufacturers have developed a number of reconnaissance UAVs, mainly for tactical use. Just like the Russian industry, the Ukrainian industry is dependent on imported components, but in the current political environment this is not a critical problem. A rather successful solution was the conclusion in 2018 of a contract between Ukrspecexport and the Turkish company Baykar Makina for the purchase of Bayraktar TB2 tactical reconnaissance and strike UAVs. The contract was mutually beneficial, as Ukraine received a fairly modern unmanned reconnaissance and strike system for the first time, and Turkey received Ukrainian aircraft engines for serial and advanced UAVs, instead of those previously purchased from Canada. The Turkish side also provided the supply of aviation weapons, technical support for operation and training of personnel (*Ukraine will buy more than 20 more Bayraktar*, 2021). Before the war began, Ukraine received two sets of six UAVs each: one went to the Air Force and the other to the Navy. Subsequently, deliveries continued, especially after the start of the large-scale Russian invasion.

The closest analogues of the "Bayraktar TB2" UAV are the Russian "Inokhodets" and the Iranian "Mohajer-6" and "Shahed-129," but in terms of their characteristics and technological level, they are significantly inferior to such UAVs as the "MQ-1C Grey Eagle," "MQ-9 Reaper" (USA) and "Hermes 900" (Israel). However, the mass production of Russian UAVs has faced the difficulties described above, and the capabilities of the Iranian industry are hardly comparable to Turkish. In addition, the "Bayraktar TB2" has demonstrated its capabilities quite well in a number of military conflicts in recent years: in Syria, Libya, Nagorno-Karabakh, and Ukraine. This allowed Turkish manufacturers to identify and eliminate design flaws, which led to significant interest from foreign customers in the complex, which together contributed to both the expansion of production and further modernisation and development of new UAVs. The Armed Forces of Ukraine also received batches of not only reconnaissance but also attack UAVs, including 100 "Switchblade" kamikaze drones (USA) (*Switchblade: Ukraine will receive the latest kamikaze drones from the US*, 2022).

However, before the start of Russia's large-scale aggression, the UAV fleet of the Armed Forces of Ukraine consisted mainly of the following types:

Ukrainian production:

– small (tactical) – PD1 (Ukrspecsystems LLC);
– mini (tactical) – A1C Furia (Athlon Avia LLC), Spectator M (Meridian OJSC), Leleka100 (Production and Innovation Company DEVIRO LLC), Mara 2P (Karboline LLC);
– foreign production:
– mini (tactical) – Fly Eye and Warmate by WB Electronics (Poland), RQ-11B Raven (AeroVironment) (USA);
– micro (tactical) – Spy Arrow (Thales OPTRONIQUE SAS (France) (*UAVs in the Armed Forces of Ukraine...*, 2011).

In Ukraine, UAVs have been used to carry out all their standard tasks. They have become one of the main instruments of aerial reconnaissance. Their role in adjusting artillery fire has grown to such an extent that almost from the very beginning of hostilities, artillery on both sides has almost never been used without the use of information from UAVs. From the very beginning of hostilities, UAVs have been widely

used to engage the enemy. For example, there have been multiple cases of strikes by the Ukrainian Armed Forces' Bayraktar TB2 UAVs against columns of troops on the march and units in areas of concentration and refuelling, as well as rear facilities of Russian troops in operational (40–150 km) depth since February 2022 (Martynets', 2025). However, with the deployment of the air defence system of ground forces by Russian troops, the use of Bayraktar TB2 reconnaissance and strike UAVs to perform strike missions on the battlefield and deep in enemy combat formations has become virtually impossible, as such targets do not pose a significant problem for modern air defence systems. In addition, the systemic disadvantage of such UAVs is the presence of a communication channel between the operator and the UAV, which made it possible to detect the UAV's control centre, launch a fire strike against it or, more often, suppress the radio control channel with electronic warfare.

Typically, tactical UAVs are used in pairs for reconnaissance missions: one vehicle performs the main task, while the other acts as a repeater. It is also possible to conduct reconnaissance with a single UAV, but this requires information exchange via satellite. This option significantly increases the stability of control due to the difficulty of detecting and suppressing the radio channel, significantly increases the operational depth and allows for a more complete implementation of the UAV's flight characteristics.

Firepower missions using reconnaissance and strike UAVs were usually carried out from an altitude of more than two kilometres. This made it possible to increase the secrecy of the UAV's approach to the target area, ensure the surprise of the strike, and increase the survivability of the UAV. Typically, the optoelectronic equipment on board the UAV ensured the successful direct hit of the target.

Combat experience of the usage of UAVs as a tool of striking enemy targets indicates that the most common tactic involves the integration of reconnaissance and strike UAVs. In particular, the Armed Forces of Ukraine have demonstrated effective usage of the FlyEye reconnaissance UAV in conjunction with multiple Warmate loitering munition UAVs – both systems developed and mass-produced by the Polish company WB Electronics. The FlyEye UAV conducts aerial reconnaissance within a designated area located in the tactical depth of the enemy's battle formations (up to 20–30 km). Upon identification of targets, a group of Warmate strike UAVs is deployed to the area and proceeds to engage the detected targets sequentially. Due to continuous monitoring of strike results, the commander of the Unmanned Systems Forces unit is able to promptly retarget strike UAVs towards newly identified targets, thereby avoiding the unnecessary expenditure of loitering munitions on targets that have already been neutralized (Defence-UA, 2022).

Feedback which was gathered by the authors through numerous interviews with officers of the Unmanned Systems Forces of the Armed Forces of Ukraine, clearly indicates that the combination of FlyEye and Warmate UAVs has proven to be an effective combat system. This configuration is characterized by high reliability, considerable strike capability, sufficient endurance, and strong resistance to electronic countermeasures affecting the bidirectional communication channels. A major advantage of the Warmate UAV is its compatibility with various types of warheads – including high-explosive fragmentation, explosively formed, and thermobaric munitions, which allows it to effectively engage a wide range of ground targets while adapting to specific

operational environment. Moreover, unlike many other loitering munition systems, the Warmate UAV can be equipped with reconnaissance payloads, which allows it to function not only as a loitering munition but also as a reconnaissance platform. This dual-use capability significantly enhances the tactical flexibility of the system and expands its operational utility beyond that of most UAVs in its class. Since the system is quite simple in technological production, enabled the launch of licensed production of this type UAVs in Ukraine (WB Electronics, 2021).

Almost from the beginning of hostilities, the use of FPV (First Person View) kamikaze strike UAVs has become widespread. Usually, they were used in conjunction with reconnaissance UAVs, which allowed them to immediately engage detected targets. In this case, strike UAVs were most often used against group targets, including convoys of vehicles on the march and on the battlefield, enemy armoured vehicles, artillery and air defence systems in positional areas. Targets were usually hit sequentially. In case of disabling the enemy's equipment, several UAVs were used to destroy it completely. The consequence of this use of UAVs was that conducting an offensive in the classical way, i.e. with the creation of strike groups with a large number of armoured vehicles, became virtually impossible, as armoured vehicles were usually detected and destroyed at a distance of up to 10–15 km from the line of contact (Stepanov, Orikhovskyi, Lutsyshyn, Hashenko, 2023: 7).

Concerning the ways of using kamikaze drones, it could be said that they achieved the greatest results when conducting group strikes. In this case, it was possible to strike simultaneously and sequentially from several directions, and the presence of several small and inconspicuous targets in the air made it difficult to detect and engage them. The sound of a running engine is a demasking feature of such drones. One of the results of their effective use in certain areas of the frontline was the emergence of panic in some units even when a distinctive sound appeared. Analysing the experience of using UAVs, the authors concluded that the main ways of using attack drones on the battlefield and in tactical depth were:

– echeloned strikes by a group of UAVs with the distribution of targets according to their priority;
– "free hunting" in a designated area;
– strikes of unmanned systems against quickly identified enemy targets.

The main methods of hitting the targets were the use of kamikaze drones and reusable UAV strikes with special and improvised munitions. A certain phenomenon of the Russian-Ukrainian war was the use of heavy bomber drones. The priority in their development belonged to Ukraine, which created the most powerful known strike UAV "Vampire," capable of dropping several munitions weighing up to 15–20 kg, which is quite a lot for strike weapons of this class. Such drones can even use 120 mm mortar shells prepared for dropping or install TM-62 anti-tank mines weighing up to 10 kg (Pechers'kyj, Tarasov, 2024).

Commercial mini-quadcopters with 3D-printed tools of dropping fragmentation munitions and hand grenades are also widely used as attack UAVs.

Combat experience has shown that the strengths of kamikaze drones are their small size and cost. Their small size makes them difficult to detect, shoot down or evade. In addition, for the same reason, they are virtually invulnerable to military air defence

systems, which are unable to detect them and aim an anti-aircraft gun (machine gun) or launch a missile. Their low cost allows them to be used on a massive scale: according to the experience of three years of war, up to 80% of targets on the battlefield and in tactical depth were hit by direct hits with such UAVs. Thus, kamikaze drones have become the main means of firepower, to some extent displacing such traditional leaders as aviation, missile forces and artillery.

The weaknesses of the kamikaze drones were their low payload of up to 3 to 5 kg, which does not always allow them to hit protected targets, the presence of remote control, which creates opportunities for suppressing the control channel, detecting the control point and its fire, and a certain dependence on meteorological conditions, as such drones are equipped with optical information sensors. One of the ways to address these shortcomings, along with the use of communication channels with increased noise immunity, the use of repeater drones for control signals and even UAVs carrying attack drones, was to create FPV drones controlled via fibre-optic cable. The Russian army first used such equipment in 2024. Their advantages were:

1. Absolute resistance to electronic warfare. Conventional FPV drones can be jammed by electronic warfare systems, making them ineffective in combat zones. Fibre-optic drones do not have this problem, as the signal is transmitted by physical cable, not radio waves.
2. Protection against the threat of signal interception. One of the risks of using conventional drones is the possibility of signal interception by the enemy. Fibre-optic drones do not emit a signal, so they cannot be "detected" and taken under control.
3. High video quality. The optical cable transmits the video signal without interference, delays or distortion. The operator receives a clear image from the UAV's video camera even in difficult conditions, which increases the accuracy of operations.
4. Ability to operate in underground and enclosed spaces. Conventional radio-controlled UAVs have problems with signal transmission in tunnels, buildings, and other enclosed spaces. A fibre-optic drone operates without restrictions, as the signal is transmitted through a cable.

The experience of using FPV drones with fibre optics has also revealed their disadvantages:

1. Limited flight range. The length of the fibre optic cable determines the maximum distance the drone can move away from the operator. Typically, the cable length is between 3 and 10 km, which may not be enough for some missions.
2. Increase in overall weight and dimensions. The presence of a cable increases the weight of the drone, which can reduce its speed, manoeuvrability, payload, and flight duration.
3. Risk of cable damage. During the flight, there is a possibility of cable damage or breakage, which will lead to loss of communication with the drone.
4. Higher cost. Fibre optic drones are more expensive than conventional FPV models due to the complexity of the design and the cost of the optical cable (*What is an FPV drone*, 2025). Analysing the experience of using kamikaze drones by the Ukrainian Armed Forces, American analysts have come to the following conclusions.

Firstly, due to the limited range and capabilities of US-made systems, the use of kamikaze drones will be on a smaller tactical scale than the Israeli systems that dominated the Armenian armed forces in 2020. However, if such munitions perform well against the Russian army, the United States and other NATO members should consider augmenting their kamikaze drone arsenals with more technologically advanced systems. These could complement existing long-range artillery systems with limited anti-tank munitions.

Secondly, anti-tank kamikaze drones could replicate the success of Javelin anti-tank missile systems and similar weapons in Ukraine. In addition, they are capable of operating far beyond line-of-sight and can destroy tanks in defensive positions, not only during their manoeuvres. This confirms the opinion of analytics who questioned the invulnerability of the modern tank, and its superiority on the modern battlefield.

Thirdly, if a small group of infantrymen has weapons that approach the firepower of medium-calibre artillery systems (105–122 mm), this causes increased danger to enemy forces in protected or safe areas of the battlefield. Long-range strikes can be launched from anywhere and disrupt operations across the entire theatre by identifying and destroying targets such as fuel depots, supply convoys, and headquarters. Consequently, military planners will have to change the way they allocate resources to combat units from the battlefield, forcing the US Army to revise some aspects of its doctrine (Deveraux, 2022).

The usage of UAVs for striking enemy targets in strategic depths is worth a separate discussion. While Russian forces had quite powerful strategic aviation, missile forces and a navy capable of striking with cruise, ballistic and even aerial ballistic missiles, the Ukrainian side had no long-range firepower at all at the beginning of the large-scale aggression. However, long-range missile weapons proved to be so expensive, and Ukraine's air defence system proved to be so effective, that the Russians were forced to look for alternative firepower. In addition, Russian can not build-up missile stockpiles under sanctions at the proper level. According to the Ukrainian edition of Forbes, the cost of the Kh-101 cruise missile is $13 million, the "Kalibr" naval cruise missile is $6.5 million, the "Iskander" tactical missile is $3 million, the "Onyx" anti-ship missile is $1.25 million, the Kh-22 anti-ship missile is $1 million, and the "Tochka-U" tactical missile is $0.3 million. At the same time, some of the missiles remained in service since Soviet times and were not produced in the post-Soviet era. Under these circumstances, the Russian leadership decided to use Iranian long-range kamikaze UAVs, the "Shahed-136." In Russia, its production is localised and it is manufactured under the name "Geran-2."

This barrage munition, once launched, flies along a programmed route and hits a pre-programmed target. The device is autonomous, with flight control provided by an inertial system with correction from the space radio navigation system. The warhead is usually a high-explosive fragmentation device weighing up to 50 kg. The UAV itself is fairly cheap and suitable for mass production, which is why strikes of this type are carried out en masse, in large groups throughout Ukraine. Composite materials are widely used in the design, which makes it difficult for radar stations to detect such a target. On the marching section, the UAVs follow the target at an altitude of up to 2 km, which makes it difficult to hit with anti-aircraft artillery, and in the vicinity of the

target, it drops to 100–200 m. The speed of these drones is low, up to 150–160 km/h. At the same time, the interference resistance of the primitive navigation system is low, which makes it possible to counter them with electronic warfare. According to the Air Force Command of the Ukrainian Armed Forces, electronic warfare can be used to knock 30 to 50 per cent of enemy UAVs off course and even send them back. The rest are successfully hit by anti-aircraft machine guns and small-calibre anti-aircraft artillery (Tkachenko).

Armed Forces of Ukraine, lacking long-range missile weapons, began to develop its own long-range UAVs in the face of full-scale aggression. Ukrainian developers have managed to create a fairly successful line of such drones, which are actively used primarily at military and oil industry facilities, logistics and airfields. Having different assets at its disposal, the Ukrainian side can apply them more flexibly, using certain strike UAVs based on the tasks, state and capabilities of the enemy air defence system on the flight route and in the target area, target characteristics, etc. The parties' actions are common to the massive use of strike UAVs in groups of several dozen to several hundred vehicles, the use of mostly night time, and flight to a target with a variable profile (flying at an altitude of up to 2 km on the route and descending to a very low altitude during the attack). These differences are caused by the higher technological level of Ukrainian UAVs, which the Russian forces are trying to compensate with their numbers. The advantage of Ukrainian UAVs was demonstrated by the Armed Forces of Ukraine throughout August 2025. As a result of the strikes, a relatively small number of Ukrainian UAVs disabled 17 oil refineries on the territory of Russia, which contributed to the emergence of a fuel crisis – both for agriculture and for logistics on the national scale and for its armed forces. This result can be considered a strategic success, given that strikes on the enemy's oil industry infrastructure continue, while their intensity and effectiveness are steadily increasing (Magyar).

Thus, strategic strike UAVs can be considered a certain alternative to cruise and ballistic missiles, while their lower speed, resistance to fire and electronic attack are their systemic disadvantages. In addition, the much lower weight of warheads makes it impossible to hit protected targets, and the lack of a homing system and communication with the control centre allows them to strike only at stationary targets whose coordinates are known in advance. At the same time, a significant advantage of such weapons compared to long-range missiles is their extremely low cost and suitability for large-scale production, incomparable to cruise and ballistic missiles. The combined use of various types of missiles and long-range strike UAVs in massive combined strikes theoretically increases the likelihood of achieving the strike's objective. It should be noted, however, that repeated attempts to conduct such strikes on Ukrainian targets have always been met with extremely effective counteraction by the Ukrainian defence forces, which have used anti-aircraft missile systems of various classes, anti-aircraft artillery, aviation and electronic warfare assets under centralised control throughout the country (Andrukh, Rieznik, 2022: 176, 177). This comprehensive approach that has allowed Ukrainians to continue their resistance for four years in the face of total numerical superiority of the enemy.

A fundamentally new invention of the Russian-Ukrainian war was the use of UAVs in the interests of air defence, primarily to combat enemy UAVs. One of the prob-

lems in the fight against UAVs was the disparate cost of UAVs and their destruction means. Thus, while one UAV of the Shahed-136 type can cost $20,000, the cost of one surface-to-air missile ranges from $140,000 to $500,000 (the Soviet S-300 missile and the American AIM-120 missile for the NASAMS system, respectively) (Boffey, 2022). The use of anti-aircraft artillery is much cheaper, but the number of highly effective anti-aircraft artillery systems such as Skynex is not as high as in Ukraine, and the world is measured in units (and all of them are currently fighting in the Ukrainian Armed Forces), while others do not always demonstrate high efficiency, spending a huge number of shells to hit one target. The Ukrainian Armed Forces have come up with a rather creative solution – to use other drones guided by an operator to intercept kamikaze drones (*Anti-aircraft FPVs versus drones with "machine vision"*, 2024). Without a doubt, this is a fundamental innovation in the art of air defence. According to the command of the 414th Separate Brigade of the Unmanned Systems Forces of the Armed Forces of Ukraine, in the last four days alone, the brigade's units have successfully intercepted 33 enemy UAVs of various classes (Magyar). At the same time, it is too early to say that this method of using UAVs has become all-encompassing, but the prospects of this direction are undeniable.

CONCLUSION

It can be stated that the Russian-Ukrainian war was an important stage in the development of the theory and practice of combat and operational use of UAVs. The scope of tasks performed by unmanned aerial vehicles has not changed significantly compared to military conflicts of recent decades. However, the intensity of UAV use, the depth of their impact, and the proportion of enemy fire destruction tasks have increased significantly. UAVs played a special role in improving the effectiveness of missile and artillery forces, significantly contributing to the accuracy of fire, reducing the time and cost of ammunition, and thus increasing the overall effectiveness of enemy fire. The tasks and countermeasures against UAVs have also been updated.

During the analysis of the experience of using UAVs during the Russian-Ukrainian war, the following trends can be identified:

– the transition of the role of the main means of aerial reconnaissance to unmanned aerial systems (systems);
– increasing the role of UAVs in the system of general fire support;
– increasing the role of UAVs in the striking objects in strategic depth;
– increasingly active involvement of UAVs in air defence tasks, primarily against enemy strike UAVs.

The war experience has shown that the systemic problem of UAVs is the insufficient interference resistance of their remote control systems. Any measures and means of protecting control channels are compensated by the improvement of electronic warfare. As a promising way to resolve this dialectical contradiction, it is proposed to use elements of artificial intelligence in the UAV control system which will make it possible to use such UAVs, especially strike UAVs, autonomously, identifying the target and making a decision to attack it directly by the UAV itself.

In case of a group attack by a so-called thinking swarm, the integration of computing devices of UAV control systems into a single network will only increase their performance. Such researches are actively developing, in particular in Russia and Ukraine, and there are no significant theoretical and technological problems in creating such systems at the current technological level of science and technology development. At the same time, there is an ethical problem: to what extent is humanity ready to grant technical systems the right to make independent decisions on the destruction of humans? In addition, there is always the possibility of a friendly object being misidentified as an enemy and, accordingly, a surprise attack on its troops or civilian objects in general. At the moment, there is no answer to this question.

The main areas of countering them were direct fire on UAVs in the air by firepower, electronic and optoelectronic countermeasures, detection and destruction of enemy UAV control points. Given the growing role of UAVs in armed struggle, it can be concluded that the side of a military conflict that will be able to ensure the superiority of its unmanned aircraft and successfully counteract enemy UAVs will gain a number of direct and indirect advantages in conducting reconnaissance, adjusting fire and engaging the enemy by all means, which will significantly contribute to achieving tactical and operational results.

REFERENCES

Andrukh O. O., Rieznik V. I. (2022), *The experience of using and countering unmanned aerial vehicles during the Russian-Ukrainian war. Abstract of papers: Experience of the use of armed forces in wars and military conflicts of the XX – early XXI centuries: trends and patterns: materials of the interuniversity scientific and practical seminar* (pp. 171–177), Kyiv.

Anti-aircraft FPVs versus drones with "machine vision": new footage of air combat, https://defence-ua.com/weapon_and_tech/zenitni_fpv_proti_droniv_z_mashinnim_zorom_novi_kadri_borotbi_u_povitri-18335.html.

Boffey D., *Financial toll on Ukraine of downing drones "vastly exceeds Russian costs"*, https://www.theguardian.com/world/2022/oct/19/financial-toll-ukraine-downing-drones-vastly-exceeds-russia-costs (15.03.2025).

Bouks B. (2023), *The Iranian Involvement in the War in Ukraine and its Implication on Broader Arenas as the Middle-East – The Test Case of Unmanned Drones*, "National Security and the Future", 24(3), Bar-Ilan University, p. 143–152.

Defence-UA (2022), *Armed Forces of Ukraine Receive First Warmate Kamikaze Drones under the Army of Drones project*, Defence Express, August 3, https://defence-ua.com (14.09.2025).

Delfynov A. (2022), *WP: Russia received drones from Iran to fight in Ukraine*, https://www.dw.com/ru/wp-rossia-polucila-bespilotniki-iz-irana-dla-boev-v-ukraine/a-62966072 (10.03.2025).

Demianenko V. (2022), *Weapon of the enemy: what is known about Russian Lancet kamikaze drones*, https://armyinform.com.ua/2022/07/07/zbroya-voroga-shho-vidomo-pro-rosijski-drony-kamikadze-lanczet/ (12.03.2025).

Deutsch A., Balmforth T. (2024), *Exclusive: Russia produces kamikaze drone with Chinese engine*, https://www.reuters.com/world/europe/russia-produces-new-kamikaze-drone-with-chinese-engine-say-european-intel-2024-09-13/?utm_source=chatgpt.com.

Deveraux B. (2022), *Loitering munitions in Ukraine and beyond*, https://.com/2022/04/loitering-munitions-in-ukraine-and-beyond/ (15.03.2025).

Havrylenko A., Yakutovych B. (2025), *Visions of creating a ground-based aviation complex for UAVs*, https://www.ukrmilitary.com/2016/06/poglyady-nak-bpla.html (14.03.2025).

Kopeć R., Wasiuta O., Wójtowicz T. (2021), *Wojna dronów: militarne wykorzystanie bezzałogowych statków powietrznych*, Wydawnictwo Naukowe Uniwersytetu Pedagogicznego, Kraków, 301 pp.

Korshets' O., Horbenko V. (2023), *Lessons from the usage of Unmanned Aerial Vehicles in the Russian-Ukrainian War*, The air power of Ukraine. No. 1(4), Pp. 9–17.

Landa V., Hnennyj K. (2022), *In half a day, the Russians fired missiles at Ukraine worth $400–700 million*, https://forbes.ua/war-in-ukraine/rosiyani-za-pivdobi-vipustili-raket-po-ukraini-na-400-800-mln-infografika-forbes-10102022-8899 (11.03.2025).

Magiera M. (2025), *Wykorzystanie bezzałogowych statków we współczesnym konflikcie zbrojnym do agregacji danych z pola walki*, "Przegląd Politologiczny", (1), pp. 259–269, DOI: 10.14746/pp.2025.30.1.16.

Magyar, *Telegram channel of the commander of the 414th Brigade of the UBAS Birds of Magyar*, https://t.me/robert_magyar.

Martynets' S. (2025), *The Armed Forces of Ukraine showed a video of Bayraktar striking at the accumulation of Russian equipment*, https://ukraine.segodnya.ua/ua/ukraine/v-vsu-pokazali-video-kak-bayraktar-udaril-po-skopleniyu-tehniki-rf-1605627.html (12.03.2025).

Mosov S. (ed.) (2013), *The Use of Unmanned Aerial Vehicles in Military Conflicts of the Present*, Publishing house Kyiv-Mohyla Academy, Kyiv.

Pechers'kyj A., Tarasov R. (2024), *Vampire hexacopter on the front line: how the high-speed and long-range heavyweight drone works*, https://armyinform.com.ua/2024/12/20/geksakopter-vampire-na-peredovij-yak-praczyuye-shvydkisnyj-i-dalekosyazhnyj-dron-vazhkovagovyk/ (10.03.2025).

Rassler D., Veilleux-Lepage Y. (2025), *On the Horizon: The Ukraine War and the Evolving Threat of Drone Terrorism*, CTC Sentinel, 18(3), March, Combating Terrorism Center, West Point, p. 1–24.

Russia uses Kronshtadt Orion Inokhodets drone in Ukraine armed with guided missile (2022), https://www.armyrecognition.com/ukraine_russia_invasion_conflict_war/russia_uses_kronshtadt_orion_inokhodets_drone_in_ukraine_armed_with_guided_missile.html (11.03.2025).

Savchenko-Halushko T. (2025), *The War of Drones: the effectiveness of UAVs on the battlefield*, https://armyinform.com.ua/2022/08/04/vijna-droniv-pro-efektyvnist-zastosuvannya-bpla-na-poli-boyu/#:~:text=Ці%20дрони%20вони%20використовують%20для,боєкомплектів%20на%20базі%20зс%20рф.

Schmidt T. A. (2024), *The Russia-Ukraine Conflict Laboratory: Observations Informing IAMD*, "Military Review", March. U.S., Army University Press, p. 22–31.

Stepanov H., Orikhovskyi P., Lutsyshyn A., Hashenko S. (2023), *Views on the development of the use of unmanned aircraft in drone-centric operations based on the experience of armed conflicts and the Russian-Ukrainian war*, The air power of Ukraine, No. 2(5), p. 5–9.

Stepanov, Orikhovskyi, Lutsyshyn, Hashenko, 2023

Switchblade: Ukraine will receive the latest kamikaze drones from the US (2025), https://mil.in.ua/uk/news/switchblade-ukrayina-otrymaye-novitni-drony-kamikadze-vid-ssha/ (14.03.2025).

The Air Force of the Armed Forces of Ukraine, The official telegram channel, https://t.me/kpszsu (14.03.2025).

Tkachenko V. (2024), *What Shahed-136 kamikaze drones are capably of and why they are difficult to shoot down*, https://fakty.com.ua/ua/ukraine/suspilstvo/20240907-na-shho-zdatni-drony-kamikadze-shahed-136-ta-chomu-yih-vazhko-zbyvaty/ (12.03.2025).

Trofimov Y., Nissenbaum D. (2022), *Russia's Use of Iranian Kamikaze Drones Creates New Dangers for Ukrainian Troops*, https://www.wsj.com/articles/russias-use-of-iranian-kamikaze-drones-creates-new-dangers-for-ukrainian-troops-11663415140?mod=hp_lead_pos8 (15.03.2025).

UAVs in the Armed Forces of Ukraine and their use in the Joint Forces Operation, https://defpol.org.ua/index.php/2011-07-25-15-56-49/1020-bpla-u-zbroinykh-sylakh-ukrainy-ta-ikh-vykorystannia-v-operatsii-ob-iednanykh-syl (11.03.2025).

Ukraine bought strike drones from Turkey: video, photos, https://biz.liga.net/ekonomika/all/novosti/ukraina-zakupila-u-turtsii-udarnye-bespilotniki-video-foto (13.03.2025).

Ukraine will buy more than 20 more Bayraktar drones from Turkey, https://www.slovoidilo.ua/2021/09/13/novyna/suspilstvo/ukrayina-kupyt-turechchyny-shhe-20-bezpilotnykiv-bayraktar (13.03.2025).

WB Electronics (2021), *WARMATE – Loitering Munitions System*, Product brochure, WB Group, https://wbgroup.pl (14.09. 2025).

What is an FPV drone with fibre optics? Advantages and disadvantages, https://bezpeka-veritas.com.ua/shcho-take-fpv-dron-z-optovoloknom-perevahy-ta-nedoliky/ (13.03.2025).

ABSTRACT

The purpose of the article is to present the summarize of the experience of using unmanned aerial vehicles during the Russian-Ukrainian war in the period of 2022–2024. The methodological basis of the study is based on the principles of historicism, objectivity, and critical analysis of various sources. The authors used general scientific research methods, primarily analysis, synthesis, deduction, induction, as well as special historical methods, including historical comparative studies, historical genetic and problematic chronological methods. The scientific novelty of the obtained results is that the authors for the first time in historiography revealed the strategic, operational and tactical content of the usage of unmanned aircraft during the Russian-Ukrainian war, identified the main forms and methods and trends of its use. Information on the main factors that influenced the use of unmanned aerial vehicles in the Russian-Ukrainian war has been clarified and supplemented.

It has been established that the issue of the usage of unmanned aerial vehicles and its impact on the further development of military art is of considerable interest to the world scientific community. However, the incompleteness of events, constant tactical and technological changes that occur during an unfinished war and the secrecy of a significant array of sources have led to a relatively small amount of historiography on the topic. The use of unmanned aircraft was influenced by a combination of tactical, scientific, technological and economic factors. It was their influence that determined the direction of development of forms and methods of using unmanned aircraft. The main tasks performed by the parties' unmanned aerial vehicles were to destroy enemy strategic rear facilities, fire on the enemy in operational and tactical depth, conduct aerial reconnaissance, and adjust artillery fire. Unmanned aerial vehicles were also used to provide logistical support to units in hard-to-reach areas, conduct electronic warfare, air defence and communications. The main forms of use of unmanned aircraft were air operations, systematic combat operations, air strikes of various scales, and special combat flights. The main methods of performing tasks were echeloned and single strikes, drops and launches of aircraft, barrage strikes, duty in certain areas, and flights with a variable profile. The article identifies trends in the development of the military art of unmanned aircraft, and outlines ethical and philosophical problems associated with attempts to introduce elements of artificial intelligence into the control system of strike unmanned aircraft systems. On the basis of the results obtained, the authors provide relevant recommendations.

Keywords: Russian – Ukrainian war, unmanned aerial system, unmanned aerial vehicle, aerial reconnaissance, artillery fire adjustment, air strike, fire damage, air drop, operation, electronic warfare, kamikaze drone, swarm attack, artificial intelligence

WYKORZYSTANIE BEZZAŁOGOWYCH STATKÓW POWIETRZNYCH NA PODSTAWIE DOŚWIADCZEŃ Z WOJNY ROSYJSKO-UKRAIŃSKIEJ (2022–2024)

STRESZCZENIE

Celem artykułu jest przedstawienie podsumowania doświadczeń wykorzystania bezzałogowych statków powietrznych podczas wojny rosyjsko-ukraińskiej w latach 2022–2024. Podstawa metodologiczna badania opiera się na zasadach historyzmu, obiektywizmu i krytycznej analizy różnych źródeł. Autorzy zastosowali ogólne metody badań naukowych, przede wszystkim analizę, syntezę, dedukcję, indukcję, a także specjalne metody historyczne, w tym historyczne studia porównawcze, historyczne metody genetyczne i problematyczne metody chronologiczne. Nowością naukową uzyskanych wyników jest to, że autorzy po raz pierwszy w historiografii ujawnili strategiczną, operacyjną i taktyczną treść wykorzystania bezzałogowych statków powietrznych podczas wojny rosyjsko-ukraińskiej, zidentyfikowali główne formy i metody oraz trendy jego wykorzystania. Wyjaśniono i uzupełniono informacje na temat głównych czynników, które wpłynęły na wykorzystanie bezzałogowych statków powietrznych w wojnie rosyjsko-ukraińskiej.

Ustalono, że problem wykorzystania bezzałogowych statków powietrznych i jego wpływu na dalszy rozwój sztuki wojennej jest przedmiotem znacznego zainteresowania światowej społeczności naukowej. Jednak niekompletność wydarzeń, ciągłe zmiany taktyczne i technologiczne, które zachodzą w trakcie niedokończonej wojny oraz tajność znacznej liczby źródeł doprowadziły do stosunkowo niewielkiej ilości historiografii na ten temat. Na wykorzystanie bezzałogowych statków powietrznych wpłynęła kombinacja czynników taktycznych, naukowych, technologicznych i ekonomicznych. To ich wpływ określił kierunek rozwoju form i metod wykorzystania bezzałogowych statków powietrznych. Głównymi zadaniami realizowanymi przez bezzałogowe statki powietrzne stron było niszczenie strategicznych zapleczy wroga, ostrzeliwanie wroga na głębokości operacyjnej i taktycznej, prowadzenie rozpoznania lotniczego i korygowanie ognia artyleryjskiego. Bezzałogowe statki powietrzne były również wykorzystywane do zapewniania wsparcia logistycznego jednostkom w trudno dostępnych rejonach, prowadzenia walki elektronicznej, obrony powietrznej i łączności. Głównymi formami wykorzystania bezzałogowych statków powietrznych były operacje lotnicze, systematyczne operacje bojowe, ataki powietrzne o różnej skali i specjalne loty bojowe. Głównymi metodami wykonywania zadań były uderzenia echelonowe i pojedyncze, zrzuty i starty samolotów, uderzenia zaporowe, dyżury w określonych rejonach oraz loty o zmiennym profilu. W artykule zidentyfikowano trendy w rozwoju sztuki wojennej bezzałogowych statków powietrznych oraz przedstawiono problemy etyczne i filozoficzne związane z próbami wprowadzenia elementów sztucznej inteligencji do systemu sterowania uderzeniowymi systemami bezzałogowych statków powietrznych. Na podstawie uzyskanych wyników autorzy przedstawiają stosowne rekomendacje.

Słowa kluczowe: wojna rosyjsko-ukraińska, bezzałogowy system powietrzny, bezzałogowy statek powietrzny, rozpoznanie lotnicze, regulacja ognia artyleryjskiego, atak lotniczy, uszkodzenia ogniowe, zrzut lotniczy, operacja, walka elektroniczna, dron kamikaze, atak roju, sztuczna inteligencja

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