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Unmanned aerial vehicles in the course of Russo-Ukrainian war

The article analyzes the use of unmanned aerial vehicles (UAVs) in the Russo-Ukrainian war. Based on the results of analysis, a conclusion about the change in Russia's approach to the use of unmanned aerial vehicles in this war was made – from the priority of operational UAVs to tactical ones. It also describes the role of UAVs in increasing the effectiveness of the situational awareness systems «Delta» and «Kropyva». In addition, the change in use of electronic warfare tactics due to the mass use of UAVs on the battlefield is considered. The change of approaches in the use of operational-level UAVs after the strengthening of air defence and radio-electronic warfare by both sides of military conflict was considered. The role of military-civilian cooperation was analyzed whilst providing the Defence Forces of Ukraine with UAVs as well as training operators. In addition, the article considers UAVs as a key component of Ukraine's Strategic Communication, which facilitates real-time information dissemination and media coverage. Obtaining real-time data from UAVs significantly improves decision-making capabilities on the battlefield, facilitating more informed and effective strategic actions.

Key words: unmanned aerial vehicles, Russo-Ukrainian war.

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Formulating the problem. The armed aggression of the Russian Federation against Ukraine is accompanied by active use of unmanned aerial vehicles, which are widely engaged for aerial reconnaissance and surveillance, adjusting artillery fire, controlling the fire damage assessment and other special tasks.

The Russo-Ukrainian war is the first war in the world in which UAVs are integrated into every phase of hostilities with a large fleet, air defence and electronic warfare systems on each side. This wide application of UAVs leads to a change in warfare tactics and the further development of military art in conditions of rapid technological progress.

Therefore, the results of studying the impact of the large-scale use of UAVs by both sides of the war on its course is becoming relevant.

Analysis of recent researches and publications. A large number of Ukrainian and foreign specialists and scientists were engaged in research of the use of UAVs in military conflicts. To date, there are many publications devoted to the use of UAVs during various military operations [1–9]. These studies include an analysis of UAV use by the armed forces of the Russian Federation during military operations in Chechen Republic in the period 1994–1996 and 1999–2003, in Georgia in 2008, Syria, as well as in the framework of the Anti-Terrorist Operation and Joint Forces Operation in the Luhansk and Donetsk Regions. However, history of wars does not know yet such a massive use of equipment of this kind, as after the beginning of full-scale invasion of the Russian Federation into Ukraine [10]. Therefore, it has to be mentioned that there are still no relevant publications among periodical scientific writings devoted to the analysis of UAVs role in the course of operations (combat operations), impact of their large-scale use on Russo-Ukrainian war and nature of future military conflicts in general.

The **purpose** of the article is to analyse changes that have occurred in methods and tools driving the war in modern conditions, due to the increased role of unmanned aerial vehicles in order to substantiate the possible directions of countering enemy UAVs and development of means of this type to conduct air combat in the near future.

Main part. Today, the Russian Federation and Ukraine are waging the world's first full-scale war of drones. Drones are at the heart of precision fire. Drones are collecting vast amounts of video footage. During its flight time, the drone can transmit a few kilobytes, but essential information such as the type of target and its coordinates – even when the drone moves quite fast or its communications are unstable.

The digital transformation of hardware illustrates the convergence of traditional and modern methods of warfare. A significant portion of the equipment Ukraine has obtained are pieces of historical treasure, like some types of American howitzers or Soviet missile launchers designed prior to the Cuban missile crisis. Additionally, a vast amount of this equipment does not have any sensors.

But Ukrainian enthusiasts and warriors, equipped with desire, skills, and thirst for victory are turning those exhibits of cold-war into augmented, networked and upgraded species, the steel borg assimilating the men, machinery and technology [11].

The use of UAVs on the battlefield

The full-scale Russian aggression began with a massive missile and air strikes on military targets at one time with illegal crossing of Ukrainian borders by Russian tanks. In the first days of the full-scale offensive, battalion tactical groups of the Russian Federation advanced at a high pace. However, at that time, those groups practically did not use UAVs, even reconnaissance ones, which became one of the main reasons for their defeat as a result of Defence Forces of Ukraine actions. Only after the transition to positional warfare, the information about the use of UAVs by Russian armed forces began to appear.

The Orlan-10 has become one of **the most widespread and effectively used UAV of the Russian army**. These UAVs are considered the «eyes» of Russian artillery, playing a crucial role in providing situational awareness and aerial reconnaissance. The Orlan-10 has demonstrated its versatility by being deployed in various configurations, including electronic warfare (EW) roles, where they were able to disrupt Ukrainian communications with specially embedded jamming capabilities. A distinct feature of Orlan-10 is Russia's decision to employ relatively inexpensive components and civilian optics, such as the «EOS 5D Mark II» cameras, for its production. This cost-saving measure has enabled Russia to produce a substantial quantity of these drones, contributing to their wide usage in the ongoing conflict in Ukraine since 2014.

As of February 2022, according to various estimates, Russian army had from 1,5 to 5 thousand UAVs of this type. These drones were actively used by Russian military, working almost non-stop to help to achieve a variety of military objectives.

However, making good use of EW, the Ukrainian military periodically managed to land the Orlan-10 UAV, which led to severe losses for Russian troops. According to official data of Ukraine as of June 2023, 130 of Orlan-10 UAVs were lost, with more than 100 of these losses occurred since February 2022.

These drones have been extensively engaged by Russian forces, operating non-stop to assist in accomplishing various military objectives. If one of Orlans crashes, the operator can immediately start the use of another one. Together with a significant amount of Russian artillery, they pose a serious threat to the Armed Forces of Ukraine (AFU).

Due to its massiveness and Centralized State Order, Orlan-10 UAVs are able to meet the needs of Russian army, despite the fact that their tactical and technical characteristics are inferior to UAVs of developed countries, together with Ukrainian «People's Drone» PD-2.

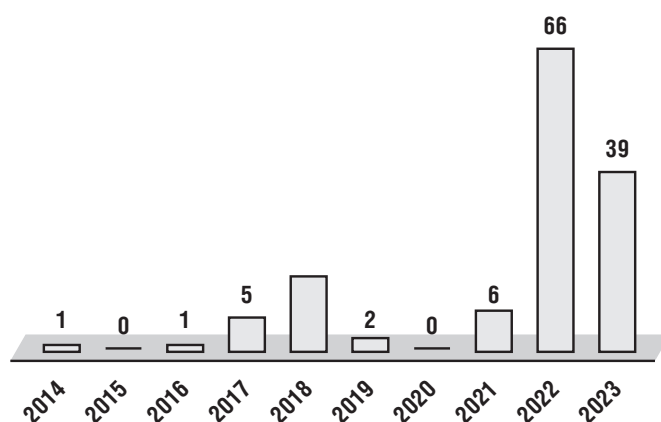


Fig. 1. Losses of the Orlan-10 UAV in Russo-Ukrainian war

In recent decades, the Russian Federation has invested significant efforts in the development of UAVs on an industrial scale. In the same period, Ukraine, unfortunately, did not make similar efforts in its own UAV development. Until 2014, Ukraine did not adopt any UAV.

This gap in national production of unmanned technologies development became one of the most essential problems that Ukraine faced at the beginning of 2014. Immediately after the annexation of Crimea and part of Donbas occupation, the Ukrainian government began to show interest in creating its own unmanned aerial vehicles.

Some state-owned enterprises have begun the development of complexes designed for reconnaissance and strikes against the enemy (for example, «Gorlytsia» in 2016 and «Sokil-300» in 2021). However, unfortunately, these projects were never completed due to a number of circumstances. Currently, Ukraine possesses several UAV types, which are in service, but they are produced by private companies.

However, Ukrainian reconnaissance UAVs are still produced in relatively small quantities and are not able to fully meet AFU's needs. One of the main reasons for such limited production is the lack of manufacturing capacity, which forces Ukraine to compensate this catastrophic shortage with imported models.

The effective reconnaissance at a distance of up to 100–200 km was the main effort, and Ukrainian specialists have designed prototypes for these tasks, such as «Fury», «Stork» and others. These small-sized UAVs have just over one meter length and a guaranteed range up to 100 km, they are mainly used for reconnaissance and adjusting artillery fire.

However, before the start of a full-scale war, the mass procurement of these military UAVs was not provided, and many of them were already lost during hostilities. As a result of losses, the need increased, and new production didn't have time to cover this need. In particular, the high

cost of UAV production of this level becomes a limitation, and their acquisition is possible only due to large volunteer funds that finance important military projects.

In connection with the shortage of military UAVs, in 2014 **volunteers took the initiative to provide Defence Forces of Ukraine with commercial UAVs**, which became an important additional means for reconnaissance and fire correction. Currently, even individual platoons and divisions are often equipped with several UAVs, which gives them opportunity to conduct tactical reconnaissance in various combat conditions, explore enemy positions, track movements, and adjust artillery fire. Together with that, UAVs adapted for military needs and capable of attacking enemy positions, allowing precision strikes by dropping grenades, have become especially valuable.

Commercial drones turned out to be effective reconnaissance and combat means that significantly increased AFU capabilities on the battlefield. The use of these UAVs made it possible to obtain important intelligence data, ensure the accuracy of strikes and increase the level of security for the Ukrainian military.

At the same time, this type of UAVs has limited resistance to the enemy's EW, which makes it difficult to use them in combat conditions. Therefore, Ukrainian military developed measures aimed at **modifying commercial UAVs**.

First of all, additional antennas, which are installed to increase the communication range and resistance to EW. They can significantly improve the operation of UAVs at long distances, which allows UAV to work more effectively in difficult EW conditions, as well as to ensure more stable communication even during manual control. In addition, the installation of a second battery, which can increase the flight time by 40%.

The next possible modification of commercial UAVs is the use of dropping systems, which turn them into attack UAVs. This is still usually done by military right on the field, but there are also private developments of such systems. The main task of attack UAVs is to deliver explosive devices, such as plural fragmentation grenades, to the enemy's position. Although this type of UAV modification is effective for striking the enemy, the significant risk of losing such UAV due to conversion, as well as possible damage to the operator from an explosive device, must be considered.

It is important to note that commercial UAVs can deliver further more strikes on the enemy, and to find much more applications on the battlefield. The main advantage of such application of that UAVs is **the ability to destroy equipment dozens or even hundred times more expensive than they are**, ensuring the effectiveness of military operations.

In the present war context, the use of commercial UAVs has become a separate direction allowing to achieve great effectiveness on the battlefield. Constant improvements in technology and skilful use of commercial UAVs helps to ensure successful results in combat operations.

In addition, **commercial UAVs** in Russo-Ukrainian war are used to perform **very specific and important tasks**. Due to destruction of Kakhovska dam by Russians, many towns and villages were flooded and people were trapped without water and food. With the help of Mavic-3, the Ukrainian military managed to deliver water to a person who was waiting for help on the roof of a house in the flooded village of temporarily occupied Oleshky.

Similar cases indicate that commercial UAVs can have an extremely wide range of applications, including humanitarian operations and rescue missions where speed and efficiency are crucial. The ability to deliver aid, including water, medicine and medical supplies, can also save troops surrounded by the enemy.

The ability of UAVs to perform reconnaissance and offensive tasks allows the Ukrainian military to find new ways to use this equipment in combat conditions. Thus, there are cases when commercial UAVs **influenced the psychology of the enemy, forcing them to surrender** in the absence of other ways out.

At the same time, despite the successful experience of using commercial UAVs, it is necessary to continue the development and implementation of military unmanned systems that would meet the requirements of modern military operations, having increased stability, as well as the ability to perform more complex tasks. This will help to ensure high-quality and efficient frontline work and reduce the losses.

During the Russo-Ukrainian war, **FPV (First Person View) drones** began to be widely used. Their uniqueness lies in the possibility of their control through special glasses, which gives an operator the feeling of being inside, like a pilot.

FPV drones exhibit great speed and manoeuvrability, which is extremely effective on the battlefield. The ability to reach speeds of more than 100 kilometres per hour and hit moving target with great accuracy, flying even into the tank hatches and narrow windows, makes them particularly useful on the battlefield.

One of the key advantages of FPV drones is their affordable price compared to traditional UAVs. They are half the price of the DJI Mavic-3, but at the same time capable of carrying a heavy payload that can hit an enemy tank costing several million dollars.

However, it should be noted that such drones, like other civilian ones, are not EW-resistant, so their use in the zone of active hostilities is risky.

It is important to continue design, development and application of FPV drones for specific tasks as well as to constantly improve their technical characteristics and resistance to EW. This would make them even more effective.

As for the beginning of the full-scale invasion, Russian Federation did not show much interest in that class of UAVs. However, during a year of active hostilities, Russian troops revised their strategy and realized the present need to increase a number of small UAVs at their disposal.

They've seen the benefits of commercial UAVs within warfare and are now actively building their own «fleet» of civilian UAVs for use in military operations. It is worth to note that at present, Russian Federation has **shown significant interest in the development of FPV UAVs**. By acquiring cheap and effective «Boomerang» drone from China, they understood the importance of this type of technology in modern warfare. Their advantage is in access to a scientific and manufacturing base as well as source parts from China, which allows them to build their own UAVs. In addition, Russians pay serious attention to training and creating many schools to train UAV operators.

This shows that Russian Federation has recognized the importance of these technologies' development in the conduct of modern military operations, and we must be vigilant and responsible in ensuring our security and control of the situation. In reality, the «drone war» is becoming more and more under consideration, and understanding the enemy and its technological efforts will give us advantages in applying these technologies in military operations and further developing the capabilities of our military.

Incorporation of UAVs to Situational Awareness Systems

In military conditions, UAVs are used to collect footage of Russian positions. If the operator identifies a Russian tank, he can manually indicate its location in Ukrainian «**Kropyva**» («the nettle») application. This program provides information about the tank position to all artillery batteries in the immediate vicinity. This innovative system is often called the «Uber for artillery» because it significantly reduces reaction time, reducing it from dozens of minutes to just a few. «Kropyva» operates as a web service that does not require server equipment in different brigades. It only requires an internet connection, authorization and access to a digital map. Gathered to one screen, the user can see complete information about the enemy, including details about personnel, equipment, warehouses, fleet, aircrafts or other objects.

The «**Delta**» system collects data from various sources, such as drones, satellite imagery and radio interceptions. It continuously interacts with NATO Situational Awareness Systems, which allows receiving intelligence data from their networks. Also, «Delta» system began to include information provided directly by citizens of Ukraine. The Ministry of Digital Transformation of Ukraine has launched a chat-bot called «**yeVoroh**», which Ukrainians can use to report the evidence of occupiers and/or enemy equipment. The main advantage of this bot is authorization through governmental, commonly-used application «**Diia**» («Action»). With high security of «Diia», saboteurs cannot spam fake photos or videos, and AFU receives true information verified by designated services.

At the same time, «**Kropyva**» **specifically cover the needs of artillery units**, opposed to «Delta» which is the general

system for situational awareness. «Kropyva» was developed by volunteers who started helping the army since 2014. Thanks to «Kropyva», the deployment time of artillery batteries was reduced by five, the time to hit unplanned targets reduced by almost three times, and the time to determine counter-battery positions reduced by ten compared to old Soviet era computers [12].

Now the program is not limited to artillery units. It provides daily updates to the front line, allowing personnel to see enemy positions, share intelligence data and communicate with command posts. Under such conditions, it is extremely important for UAVs to be constantly in the air and to transmit information to control centres in «online» mode. The app also contains a navigator, a map with accurate heights and depressions, the ability to convert military coordinate systems, measure distances between objects and calculate the range of specific artillery to hit specific targets. This is a good example of **combining the work of UAVs with automated control systems**, which significantly increases the effectiveness of the entire tactical unit.

Electronic Warfare

The widespread use of UAVs during the Russo-Ukrainian war changed the tactics of using EW, prompted the development of special EW tools to combat UAVs. In wartime conditions, there are almost two ways to neutralize a drone using the means of appropriate value. It can be shot down, but to achieve this it is needed to hit a moving aerial target 10 centimetres height, at a considerable distance. The second way is to block UAV's control, navigation signal and information transmission by creating powerful interference on all essential radio channels. This is the main task of EW, and Russian Federation has always been strong in this field.

It developed a large number of radio-electronic warfare systems, such as R-330Zh «**Zhytel**», 1L269 «**Krasukha**», «**Murmansk-BN**», RB-301B «**Borisoglebsk-2**», «**Tirada**», «**Palantir**», «**Dziudoist**» [13].

Although electronic warfare technologies in Russia have always been at a significantly developed level, in early 2022 they still were not fully adapted to such a new realities of war. The massive military use of small drones stimulated the development of portable, mobile systems, the so-called trench electronic warfare.

The appearance of unmanned aerial vehicles on the battlefield made **significant adjustments to EW tactics**. EW equipment could be a highly visible target, and this equipment cannot be effectively hidden from UAVs. Because of its electronic radiation, it is easy to recognize, detect and destroy. That is why Russians began to focus on the development of portable mobile electronic warfare systems that possess more effective countermeasures against UAVs. Such systems can quickly respond to a threat and block the operation of a drone.

A serious breakthrough in this area came about six months after the start of Russian hostilities. Anti-drone guns and «trench» EW devices, in particular the «Polyus-21» and «Stryzh-3» complexes, began to appear actively on Russian positions. The «Polyus-21» complex is often disguised by installing it on buildings and communication towers, to hide it among mobile communication transmitters.

The «Stryzh-3» complex can operate in a passive mode, which allows it to hide from radio reconnaissance. It has six to eight antennas directed in a circle, which monitor the air around and determine the direction of the drone's approach. The Stryzh complex allows the drone to approach to a sufficient distance, where it ensures 100% suppression of signals, after that it emits a necessary power to destroy the threat.

Today, Ukrainian aerial scouts manage to successfully resist Russian «trench» EW using **special remote antennas**. AFU is armed now with a number of modern «trench» EW systems that successfully cope with assigned tasks. As early as 2014, our defence-industrial complex began to create various models of EW trench complexes.

For example, the «Enclave», «Nota», «Bukovel» and other complexes were designed specifically to counter enemy drones. Radio reconnaissance plays an extremely important role in radio warfare. Using radio signals, experts can determine the location of the enemy's electronic warfare equipment and type of approaching UAV. Thus, EW trench systems, which are not used constantly, but only in the presence of a threat, turned out to be the most effective.

Such systems work successfully against civilian UAVs, but there is **another problem for EW – it is not capable of suppressing all frequencies**. Solving these tasks becomes key to the further development of radio-electronic systems and ensuring the effectiveness of countering enemy drones.

Bayraktar TB2 as Strike to Reconnaissance Platform

It is also worth paying attention to important aspects regarding the use of UAVs in Ukraine, focusing particular on Bayraktar TB2.

During a full-scale invasion, AFU successfully used Bayraktar TB2 as effective strike UAVs. These UAVs turned out to be extremely useful for conducting strikes against convoys of Russian vehicles headed for Kyiv. Thanks to their high level of manoeuvrability and the ability to carry shock weapons, these drones destroyed enemy equipment with great efficiency, helping to preserve important facilities and protect the capital.

In addition, Bayraktars proved to be indispensable in attacks on Russian military bases and ships on Zmiinyi Island in the Black Sea. Due to their accuracy and ability to strike from great heights, they contributed to the destruction of important military targets. Another achievement of the Bayraktar was their contribution to the destruction of the aggressors during the battle for Chornobaivka.

After both sides of the conflict improved air defence and EW, Bayraktar TB2, as well as Russian Orions and

Forposts, were moved to the rear for reconnaissance and surveillance missions.

Russian «Terror» Drones

After the beginning of a full-scale aggression, since September 2022, Iranian kamikaze drones Shahed-131/136 are extensively used by our terrorist adversary. They use these drones to attack military facilities and critical infrastructure. It caused a lack of water, heat, and electricity during the cold part of the year.

The Shahed-136/131 UAV can fly over 2,000 kilometres and has a warhead weight of 40–50 kg. An important feature of this UAV is its design and materials from which it is made. The Shahed-136/131 UAV is made of Getinax, which is a layered pressed material based on paper and impregnated with epoxy resin. The propeller of this drone is made of wood. These features make it almost invisible on radar and make it difficult for the enemy to detect and intercept.

Shahed-136/131, taking into account its low cost, which is about 20 000 USD, makes it an affordable and effective solution for the enemy in carrying out kamikaze attacks on important objects and infrastructure.

As of July 2023, the enemy used more than 1,600 Shahed-136/131 UAVs, about 240 of those managed to make it through our air defence. This shows that although we have learned how to effectively shoot down these UAVs, the threat they pose remains a large and pressing problem. The effectiveness of Shaheds destruction is shown in Figure 2.

Shahed-136/131 is still a problem for our air defence. They are cheap to manufacture, which makes them available and effective for the enemy.

Comparing the cost of these UAVs with the cost of the missiles we use to shoot them down, we see a significant difference. Missiles used to combat UAVs cost way much more. In addition, they drain our air defence system resources. However, due to the fact that these UAVs can cause serious damage by attacking critical infrastructure and important objects, their downing is critically necessary.

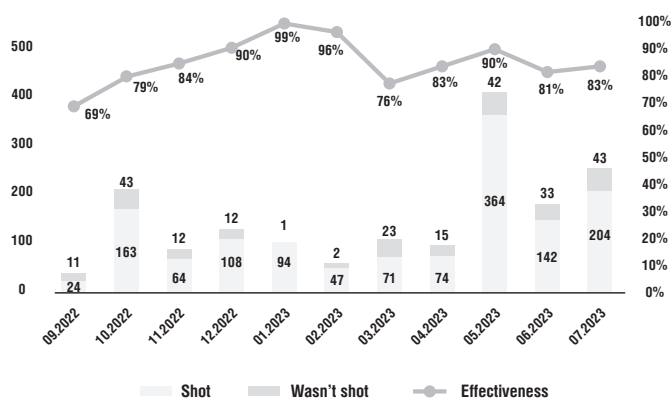


Fig. 2 Efficiency of shooting down Shahed-136/131 UAV in the Russo-Ukrainian war

Assessing the situation, we see that the solution to the problem of shooting down Shaheds should not be limited only to the calculation of the cost of the missiles. The most important thing is to understand the real consequences of their attacks and elaborate on effective countermeasures. This problem represents the task of developing cheaper and more effective means of countering these UAVs, and also determines the need to find optimal and economically justified solutions to counter this threat.

Military-Civilian Cooperation for UAV acquisition and training

As it was mentioned, earlier in 2014, Ukraine faced a catastrophic shortage of unmanned aerial vehicles. The lack of our own production of UAVs forced us to compensate this deficit through imports. Currently, more than 30 types of drones from around the world are used in the Armed Forces of Ukraine.

At the same time, the successful use of UAVs in combat requires comprehensive training of operators, including UAV control skills and basics of EW understanding. Such training will help to ensure the successful execution of combat missions and reduce risks for servicemen during the use of UAVs in combat conditions.

From the very first days of the war, the Ukrainian command faced a shortage of professional operators to control UAVs, and fighters were forced to operate UAVs without proper training. From the very beginning of hostilities, there were cases when enemy managed to hit our positions in just five minutes after the launch of the UAV. The average survival time of UAVs at the beginning of the war was very low, as the enemy actively used means of electronic warfare. The lack of operator's professionalism and confidence put our positions in a vulnerable position, allowing the enemy to effectively attack our military facilities.

Today, more than **20 volunteer schools and training centres for UAV operators function in Ukraine**. Those schools differ in training model formats, but have one common goal – they aim to prevent casualties due to unqualified drone control and ignorance of safety rules.

Our volunteer organizations, who provided the military with drones clearly understood the need to train civilian drone operators instead of just giving away such an expensive appliance – they needed to be sure that it would be driven by professionals, which could be proven by a certificate of being specialist in three areas, such as **tactical intelligence, adjustment and guidance of artillery and projectile dropping systems**.

The irony here is that these schools do not train on Ukrainian-made drones. That happens because Ukrainian models of drones mostly belong to a «wing» class, when schools do not use such drones because they cannot be mastered in four days. Therefore, the training is carried out at special military bases in Ukraine and abroad, the location of which can not be disclosed yet.

In addition, today, **personal technologies such as tablets, smartphones and other devices** play a huge role in the training of UAV operators. Thanks to these technologies, operators have convenient access to training modules that are constantly updated. This approach allows improving the theoretical and practical training of operators, without the need to remove them from the combat zone, which is extremely important in modern conditions of warfare.

To conclude this point, we can summarise that the Military-Civilian Cooperation for UAV acquisition and training was crucial for the Ukrainian oppose from the very first day, as it was even named as the «Victory Drones» and «Drone Army» phenomena.

UAVs as a key component of Ukrainian Strategic Communication

The other aspect of UAVs is they are a key component of Ukrainian Strategic Communication. The use of such an asset plays a significant role in Real-time Information Distribution and Media Coverage as we know that UAVs are equipped with advanced communication technologies to facilitate the swift transmission of critical information. This real-time data enhances decision-making capabilities on the battlefield. They can also access the Remote and Hazardous Areas saving lives of our soldiers and journalists.

At the same time, UAV-captured imagery and footage, imaginary of Border surveillance and Intelligence serve as credible evidence to **debunk false narratives propagated by adversary**. As we already mentioned, UAVs can also deliver **humanitarian aid**. Therefore, UAVs have become indispensable assets in Ukraine's communication strategy, enabling the nation to maintain situational awareness, foster public support, and project its message to both domestic and international audiences.

Conclusions

The experience of the Russo-Ukrainian war confirms that in modern conditions any country can actively use combat UAVs and gain a strategic advantage over their opponents. **The use of UAVs during the war in Ukraine is record-breaking**. Mass use of UAVs may become a reality for many countries in the near future. The Ukrainian experience has shown that the size and scope of UAV use surpasses all previous military conflicts. Unmanned Aerial Vehicles have become an integral part of strategic and tactical planning of military operations.

During the year of the full-scale war, the Russian troops changed their attitude to the use of small UAVs and began to actively increase their number. Realizing that they will lose the «war of drones», **Russian Federation began to form its own «fleet» of drones**, which is based on the inclusive use of civilian UAVs. Thus, at the beginning of 2023, the number of small UAVs in the Russian armed forces increased exponentially. The Russian military are actively developing in this direction and creating their own UAVs.

For this, they have significant scientific and manufacturing potential, as well as an access to necessary components from China. In addition, Russian Federation is actively deploying many schools for UAV operators training. This indicates a solemn approach to the development of this area and a desire to provide UAVs with qualified and efficient operators. These steps indicate that the Russian Federation **trying to intercept the initiative of UAVs use** in military operations and developing its own technologies in this direction. In this regard, Ukraine must be ready to respond to these challenges and continue development in the field of unmanned systems.

The Russo-Ukrainian war showed that enemy forces are capable of using UAVs massively, so other countries should also be prepared for the fact that they will encounter similar technologies in future military conflicts. In addition, the development of technology can lead to the **replacement of complex combat drones with simple quadcopters**, which will be much more affordable and highly effective.

All of these factors suggest that **unmanned technology will be a defining element of future military strategy**.

Experience gained analyzing UAV exploitation in Russo-Ukrainian war

1. In the very beginning of the war Russia prioritized the deployment of operational and strategic UAVs. However, there has been a noticeable shift in their approach, with a current focus on augmenting the usage of tactical, small UAVs. This strategic shift is likely aimed at narrowing the previous tactical UAV advantage achieved by Ukraine.

2. The Ukrainian Armed Forces have effectively integrated UAVs into their operational framework to enhance their situational awareness capabilities, particularly through the utilization of systems such as «Delta» and «Kropyva.» Those UAVs play a vital role in providing real-time information and data to these situational awareness systems. The ongoing efforts in this domain are focused on constant improvement and refinement of digital connections between various sensors and shooters, aiming to optimize efficiency and effectiveness of the overall system.

3. Incorporation of personal technology has sparked a revolution in the usage of UAVs on the battlefield. Its impact is evident across various aspects, ranging from operator training to real-time deployment and information dissemination. In the context of modern military operations, personal technology has evolved into an indispensable tool, empowering military personnel with enhanced capabilities and significantly augmenting the effectiveness of UAV-based strategies.

4. The advent of UAVs has triggered significant changes in the dynamics of electronic warfare. Traditional vehicles equipped with electronic warfare systems have become highly conspicuous targets, unable to evade detection by drones. Approximately six months after the full-scale invasion, a notable breakthrough in electronic warfare tactics occurred. Russian positions began receiving

substantial supplies of anti-drone rifles and trench electronic warfare equipment. These technologies were evidently introduced in response to challenges posed by UAVs, providing more agile and covert means to counter the drone threat and better protect their forces on the battlefield.

5. Due to the strengthening of air defence capabilities and the expanded use of radio-electronic warfare after several months of full-scale war, such as «Bayraktar TB2», as well as the Russian models «Orion» and «Forpost», began to be used only for reconnaissance purposes. However, a need for more cost-effective alternatives to replace them remains.

6. The Iranian «Shaheds» are prompting Ukraine to focus on the development of affordable countermeasures. It is highly likely that the most optimal and effective approach to counter these UAVs would involve finding economically viable solutions that align with the cost-efficiency of offensive equipment.

7. Volunteer organizations, which facilitated the provision of UAVs to the Ukrainian military, demonstrated a clear understanding of the imperative to train UAV operators. As a result, the collaborative efforts between the military and civilian sectors in acquiring and training UAV operators played a pivotal role in bolstering the capabilities of Ukrainian opposition.

8. UAVs represent a crucial element of Ukrainian Strategic Communication. Their deployment plays a significant role in facilitating real-time information distribution and media coverage. The acquisition of real-time data through UAVs greatly enhances decision-making capabilities on the battlefield, contributing to more informed and effective strategic actions.

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