

#GIDSresearch 5 / 2024

Sergej Sumlenny

## **The Russian-Ukrainian War: A New Way of War and Emerging Trends**

The Deployment of Drones in Battle and latest Developments – Impressions from the Frontline

#GIDSresearch | No. 5 / 2024 | December 2024 | ISSN 2699-4380

The present article is one of several working papers resulting from a workshop conducted prior to the 2024 Kiel International Seapower Symposium on the topic 'Re-Learning War: Lessons from the Black Sea'. The workshop was co-hosted by the GIDS and the Institute for Security Policy at Kiel University (ISPK) on 20 June 2024. The topic of each paper was discussed during the workshop. All articles have been peer-reviewed and will also be published in the ISPK's 'Policy Brief' format.

The German National Library lists this publication in the German National Bibliography; detailed bibliographic information can be obtained online via <http://dnb.dnb.de>

ISSN 2699-4380

This contribution is available under Creative Commons Licence CC BY-NC-ND 4.0 International (Attribution-NonCommercial-NoDerivatives).  
For further information on the license, please refer to: <https://creativecommons.org/licenses/by-nc-nd/4.0/deed.en>



This #GIDSresearch is published by the German Institute for Defence and Strategic Studies (GIDS) – DSSF (Directorate Strategic Studies and Research).

Contributions may be retrieved free of charge from the GIDS website: [www.gids-hamburg.de](http://www.gids-hamburg.de)

#GIDSresearch reflects the personal opinions of the authors and does not necessarily represent the views of the GIDS.

Proposed citation:

Sergej Sumlenny, The Russian-Ukrainian War: A New Way of War and Emerging Trends. The Deployment of Drones in Battle and latest Developments – Impressions from the Frontline, #GIDSresearch 5/2024, GIDS: Hamburg.

GIDS

German Institute for Defence and Strategic Studies  
Führungsakademie der Bundeswehr  
Manteuffelstraße 20 · 22587 Hamburg  
Tel.: +49 (0)40 8667 6801  
[buro@gids-hamburg.de](mailto:buro@gids-hamburg.de) · [www.gids-hamburg.de](http://www.gids-hamburg.de)

## Content

1	Introduction .....	1
2	Naval Drone Warfare: Sea Denial vs. Full Sea Control .....	2
3	From Bayraktars to Mavics.....	5
4	FPV Kamikaze Drones: A Long-Expected Gamechanger?.....	6
5	Drones as Bombers and Interceptors.....	7
6	Long-Range Drones – Filling the Cruise Missile Gap .....	8
7	R&D in the Field.....	9
8	Conclusions .....	10
	List of References.....	12



---

Sergej Sumlenny\*

# The Russian-Ukrainian War: A New Way of War and Emerging Trends

## The Deployment of Drones in Battle and latest Developments – Impressions from the Frontline

### 1 Introduction

The Russo-Ukrainian war has introduced the mass usage of drones in most battlefield situations. From surveillance drones used at squad level, kamikaze drones hitting strategic targets hundreds of kilometres behind enemy lines and naval drones capable of destroying a modern naval vessel to surveillance drones used to guide artillery strikes – Ukraine has turned into a testing ground for a variety of technological advancements and new strategic ideas.

While many experts, enthusiasts, and soldiers like Ukraine's former Commander-in-Chief Valery Zaluzhny see drones as a game changer, a whole new type of weapon paving the way for a qualitatively new style of warfare<sup>1</sup>, others, including Ukraine's prominent head of military intelligence (HUR) Kyrylo Budanov, do not believe in the decisive character of drones, in spite of all their advantages.<sup>2</sup>

Apart from addressing the question whether drones can become a decisive weapon on the battlefield, this paper discusses the limitations associated with this type of weapon, depending on factors such as the deployment scenario (land or naval warfare), the operating environment, the technological level of the adversary, production capacities, etc. The paper also considers the assumption that drones will 'only' serve as an addition, albeit a powerful and extremely efficient one in terms of cost-damage ratio, to other weapon systems from ATMGs to SS missiles, and as a technical support tool for ground forces in general, as well as for recce groups and other specialised units.

Starting with an analysis of the origins of drone usage in Ukraine, this paper then goes on to describe relevant developments in drone technology and to examine the current state of drone usage as well as political, economic, and practical aspects of drone production in Ukraine. It does not address any aspects of Russian drone warfare.

---

\* Sergej Sumlenny is the founder and managing director of the European Resilience Initiative Center gGmbH (ERIC) in Berlin, a non-partisan think tank focusing on defence and foreign policy analysis. Since 2023, ERIC has also raised over €1 million in donations to support Ukrainian Army units with drones and other electronic equipment.

In November 2024, Sergej Sumlenny co-founded United Unmanned Systems, a German-Ukrainian drone manufacturing company based in Ukraine.

1 Cf. Zaluzhny 2024.

2 New Voice 2024.

## 2 Naval Drone Warfare: Sea Denial vs. Full Sea Control

One of the most spectacular examples of Ukraine using unmanned weaponry is its naval drone warfare against Russia's Black Sea fleet. The idea to use naval unmanned vehicles to hit larger naval vessels is not new, however, and was not developed by the Ukrainians. In the 1930s and 1940s, the U.S. had already worked on developing aerial unmanned systems able to hit enemy vessels.<sup>3</sup> In the 1980s, the Tamil Tigers tried to use naval drones (basically speedboats with explosives on board) to hit vessels of Sri Lanka's Navy.<sup>4</sup> In 2017, Houthi rebels hit the Saudi frigate *Al Madinah* with a kamikaze naval drone, although without sinking the ship.<sup>5</sup> Yet, even though the Ukrainians have not developed anything new, they have significantly improved the tool. Ukraine's success can be attributed to three factors: a) much better communication; b) the mass production of drones; c) the creative use of drones, including wolf-pack attacks and coordinated attacks of aerial drones.

The path to Ukraine's naval drone fleet was not without challenges. Through the 1990s and 2000s, Ukraine strove to create a classical fleet of naval vessels. Notable examples for these aspirations include the corvette *Volodymyr Velykyi*, announced in 2011 to be delivered in 2016, never to be finished<sup>6</sup>; seven Gyrza-class gunboats, designed by Mykolaiv shipyards and produced in Kyiv until 2020<sup>7</sup>, mostly known for their unsuccessful engagement with Russian vessels in the Kerch Strait in 2018<sup>8</sup>; and two Ada-class corvettes built in Turkish shipyards that should have provided Ukraine with some additional firepower,<sup>9</sup> but have been unable to deliver any successes yet.

Somewhat contrary to Ukrainian ambitions, a massive fleet of naval drones was key to effectively pushing the Russian Black Sea Fleet back – at least to the eastern harbours of the sea, possibly even to the Caspian Sea.<sup>10</sup> Two naval drone programmes were separately launched by two competing intelligence agencies in Ukraine in early 2022. First, the SBU, a civil intelligence service, developed an unmanned surface vehicle nicknamed 'Sea Baby', a remote-controlled speedboat carrying a warhead with up to 800 kg of explosives. The other contender, the Main Directorate of Intelligence (HUR), answered with their 'Magura' drone, with a very similar design, capable of carrying 320 kg of explosives for up to 450 nautical miles. Both drones can reach a speed of 20 knots (cruise speed) and 45 knots (top speed).<sup>11</sup> In 2022, Ukrainian drones had already started hitting Russian naval vessels, oil tankers, but also infrastructure objects such as the Kerch bridge, or the Novorossiysk oil terminal.<sup>12</sup> In 2023, Ukraine increased the intensity of its attacks, damaging even the most modern Russian signals intelligence

---

**3** Mizokami 2020.

**4** Freeze 2009.

**5** Lagrone 2017.

**6** Offshore-Energy 2011.

**7** Grotnik 2023.

**8** Ukrayinska Pravda 2018.

**9** Defense Express 2024.

**10** Nikolov 2024.

**11** Dovgan 2023.

**12** Yann 2023.

gathering vessel *Ivan Khurs*<sup>13</sup> and a Karakurt-class missile corvette.<sup>14</sup> The latter had only entered service with the Russian Black Sea Fleet in July 2023.

Until early 2024, when Russia withdrew its Kalibr-capable vessels to the Caspian Sea, Ukrainian drones participated in several video-footage-confirmed strikes against Russian vessels.<sup>15</sup> The videos confirm key components of the successful tactics employed by Ukrainian drones. The successful sinking of a vessel requires multiple hits by several drones. Obviously, given its relatively low speed and the limited amount of explosives it carries (300-500 kg), the impact of a drone cannot be compared with the damage inflicted by a missile with its high speed and massive warhead (as evidenced by the 1982 hit on *HMS Sheffield*<sup>16</sup> or the destruction of Russian Black Sea Fleet flagship *Moskva* by two Neptune hits<sup>17</sup>). And, unlike torpedoes, drones hit vessels above sea level, not below. Thus, a combined attack by a pack of drones is required.

A successful drone attack also requires a highly reliable fast-speed communication system, preferably satellite communication. In 2022, Ukraine's first attack on the harbour of Sevastopol reportedly failed after Elon Musk had unexpectedly denied Ukraine the use of his Starlink communication system.<sup>18</sup> Several drones lost connectivity and washed ashore, giving the Russians time to prepare for further Ukrainian attacks.<sup>19</sup>

The final part of Ukraine's success with naval drones is related to their low costs and the possibility to produce the vehicles from available components without risking shortages. Most drones are produced using engines and other parts from commercial scooters (e.g. the South Korean Sea-Doo).<sup>20</sup> The fuses used in these drones are standard contact fuses from Soviet-era high explosive aerial bombs.<sup>21</sup> Combined with a price of USD 250,000 up to 350,000 per unit, drone production is highly resilient to attempts to undercut it. With spare parts being available on the global market, low production costs, and given the fact that the technological level of the product allows it to be assembled at any workshop capable of working with speedboats, the production of naval drones cannot be stopped neither by economic means nor by targeted strikes against production facilities.

It seems the only functional way for Russia to fight naval drones is having helicopters constantly patrol the sea surface, destroying drones by gunfire. Their small size and low profile make them invisible to radars, transforming the fight against drones almost into a close combat operation. With their tactics of countering Russian defence strategies (e.g. by sending swarms of aerial drones), Ukrainian troops challenge Russian air defence systems and endanger Russian helicopters. Reportedly, in June 2024, friendly air defence fire destroyed a Russian Kamov helicopter while the latter was engaged in repelling naval drones.<sup>22</sup>

<sup>13</sup> Stavskaya 2023.

<sup>14</sup> Radio Svoboda 2024.

<sup>15</sup> Novyny.LIVE 2023; TSN TV 2024.

<sup>16</sup> Cobain 2017.

<sup>17</sup> Guardian News 2022.

<sup>18</sup> Chiappa 2023.

<sup>19</sup> Talmazan 2023.

<sup>20</sup> Yann 2023.

<sup>21</sup> Dovgan 2023.

<sup>22</sup> The Insider 2024.

Nevertheless, alongside the strengths of drone warfare there are also weaknesses. While being a cheap and effective means of destruction of larger vessels and thus able to prevent the enemy's navy from using contained waters, drones cannot fully control the sea. They are also limited in their distance and highly dependent on intelligence data providing them with target coordinates. This probably explains the high number of attacks on the Russian navy within or close to harbours – a free hunt for vessels on the open sea is not possible for naval drones (yet). It is also (as yet) unrealistic to expect drones to be able to operate in harsh conditions such as storms and large waves common on the high seas. Still, new ways of utilizing naval drones are currently being developed in Ukraine. Examples include arming naval drones with anti-air and surface-to-surface MLRS missiles.<sup>23</sup> This can transform naval drones into mobile artillery or air defence platforms, using the sea surface to manoeuvre, especially in coastal areas and relatively calm waters.

The latest developments in drone warfare are proof of this inherent limitation in the capabilities of naval drones. While new features and ways of application are constantly developed for land warfare drones, naval drones have almost disappeared from the news. Now that Russia has moved most of its fleet from the Black Sea to the Sea of Azov, and even to the Caspian Sea, Ukrainian drones are left without targets to hunt. This might seem paradoxical: since Ukraine effectively pushed the Russian fleet from the Black sea, there have been no more naval victories for Ukraine, and neither has a follow-up land operation been launched. There is, however, a very logical explanation: Ukrainian naval drones are unable to penetrate the Russian defences placed in front of the Kerch bridge, which guards the entrance into the Sea of Azov, and therefore the drones cannot hit Russian vessels north of the Kerch bridge. Ukraine is also incapable of conducting a landing operation in Crimea, or elsewhere, as it lacks conventional vessels such as cruisers, corvettes, and frigates to suppress Russian land forces and to provide air defence, and of course landing vessels to carry out the landing operation itself. The destiny of Crimea will be decided by a land operation, without involving naval drones.

It is for the same reason – the lack of conventional vessels – that Ukraine has also been unable to expand its control over the Black Sea by other means, for example by sending conventional vessels to key zones of the sea, using them for air defence (for example, protecting Ukraine from Russian cruise missiles flying over the Black sea). With drones alone, this type of control is impossible to achieve. Of course, this does not mean that Ukraine's deployment of naval drones has had no impact – the destruction of Russian naval vessels capable of carrying Kalibr missiles alone has saved countless Ukrainian lives. The coasts of Ukraine's Odesa and Mykolaiv regions are also safe from Russian landing operations. But in contrast to the drones used in land warfare, naval drones have demonstrated very clear limits in terms of usability: they only serve to deny the enemy control of a limited maritime area, within reasonable distance from the shore, and only in calm waters and with enough reconnaissance support. The stunning success of Ukrainian naval drones in the Black Sea can be partly explained by the very unique character of that theatre of operations. While there is no limit to Ukraine's drone supply (they are easily produced in Ukraine and released into the waters of the Black Sea), Russia cannot simply add more naval vessels to the Black Sea by transferring assets

---

<sup>23</sup> Shwartz 2024.



from other fleets (i.e. the Northern, Baltic or Pacific Fleets), since Türkiye controls – and limits – access to the Black sea via the Straits. This renders the Black Sea a very special battlefield, characterised by confined waters, short distances to the shore, a lack of high waves, and other aspects favourable to drones.

### 3 From Bayraktars to Mavics

Since Russia began its full-scale invasion of Ukraine, the Ukrainian Army's use of aerial drones has seen a number of changes. Between 2015 and 2021, Ukraine had used small surveillance drones to localize targets for their own artillery, without using drones for direct strikes.<sup>24</sup> During the first weeks and even months of the full-scale war, Ukrainian troops relied on the classic ways of fighting the invading army. They used ATGMs, artillery, and Turkish-built Bayraktar TB2 drones<sup>25</sup> for their sneak attacks on Russian convoys, defensive actions against advancing Russian troops, and larger-scale counter-attacks. These drones had already demonstrated their efficiency in the Azerbaijani-Armenian conflict over Nagorno-Karabakh in 2021.

As the Bayraktar drones started to lose their efficiency amid strengthened Russian air defences<sup>26</sup>, the Ukrainians embarked on a journey into unknown waters of drone utility. The first peak in google searches for 'дрони', the Ukrainian word for 'drones', occurred in October 2022<sup>27</sup>, and since then Ukrainians have searched for information about drones more often than ever before. In December 2023, Ukraine's President Volodymyr Zelenskyy announced plans to produce 1 million FPV drones within the next year.<sup>28</sup> In June 2024, Ukraine even created a separate branch of the armed forces for drone operations – the 'Unmanned Systems Forces', with their first commander Colonel Vadym Sukharevskyi, who is also the deputy Commander-in-Chief of the Ukrainian Army. On the occasion of the presentation of the new branch and its commander, Deputy Defence Minister Ivan Havryliuk stated that with these forces, Ukraine 'will get the opportunity to strike Russian targets at every possible depth, from battle formations in direct proximity to our [Ukrainian] units to the Ural mountains'.<sup>29</sup>

Drone tactics have evolved since early 2022. The first wave of drone warfare came in late 2022 with the mass usage of off-the-shelf commercial drones, mostly produced by the Chinese DJI company under the Mavic trademark, including the Mavic 3T thermal night vision drone, which is able to take video and photo footage even in the harsh environments of the high seas. From non-thermal to night vision systems, these drones cost between €1,500 and 5,400 and provided the Ukrainian artillery with exceptional image quality, up to 28x zoom. They were especially useful for guiding mortar fire, and even to coordinate attacks of infantry units. The entire liberation of Robotyne in the Zaporizhzhya region by the famous 47th mechanised brigade in August 2023 was

<sup>24</sup> Zhirokhov 2021.

<sup>25</sup> Gosselin-Malo 2023.

<sup>26</sup> Ibid.

<sup>27</sup> Google-Trends service, search for 'дрони' word (drones), last accessed on 25-11-2024 <https://trends.google.de/trends/explore?date=today%205-y&geo=UA&q=%D0%B4%D1%80%D0%BE%D0%BD%D0%B8&hl=en>.

<sup>28</sup> Romanenko 2023.

<sup>29</sup> Militarnyi 2024b.

coordinated using Mavic drones donated by the European Resilience Initiative Center, a German NGO, according to soldiers of the brigade.<sup>30</sup>

The use of DJI Mavic drones had its issues, though. Being a commercial drone, the Mavic, if used with pre-installed software, allowed any person, including Russian artillery units, to easily localize the drone's starting position and the current position of its pilot.<sup>31</sup> This led to losses amid drone operators, which is why – starting in early 2023 – the Ukrainians developed their own software for this type of commercial drones. Another challenge was related to the fact that the Chinese drone manufacturer DJI officially obliged its dealers in Europe to undertake all possible steps to prevent the selling of the drones into Ukraine or to Ukraine-related European clients. These complications led to criticism against the use of these drones by Defence Minister Ryzhnikov, who derogatorily named them 'wedding drones',<sup>32</sup> pointing out the fact that they are often used for taking footage of large weddings, claiming that Ukraine's Army did not have the need for such civilian technology. Still, the DJI Mavic – with and without thermal imaging – remains the most reliable and popular surveillance drone for Ukraine. The Ukrainian army uses Mavic drones (and drones produced by other companies, e.g. Autel) for different types of operations starting from the infantry squad level, but a special focus lies on the needs of artillery units.

This gap between the living reality of Ukraine's army and Western military tradition has resulted in disappointments during military training in Germany. The use of drones is not part of the training programme established for the Ukrainian army. In September 2023, I conducted interviews with soldiers of Ukraine's 47<sup>th</sup> mechanised brigade who had participated in the EUMAM UA training mission in Germany.<sup>33</sup> They expressed their disappointment that their trainers did not have any knowledge of drone warfare (besides a basic knowledge of the existence of winged drones) and that Ukrainian soldiers were not even allowed to use their own commercial quadcopter drones, which they had brought with them to Germany to test different battle situations. This ban was based on security rules that prohibited them from bringing non-certified electronic equipment into training areas. As a result, Ukrainian artillery units earmarked to use drones to guide mortar shells had no chance to train for the daily situations they would face in Ukraine.

## 4 FPV Kamikaze Drones: A Long-Expected Gamechanger?

The most significant development on the drone battlefield in Ukraine came with the appearance of FPV (first-person view) aerial drones. FPV drones have been developed as cheap and short-range weapons allowing to precisely hit not only infantry or other soft targets, but also armoured vehicles and tanks. A typical FPV drone is a light quadcopter built around a 7-inch or a 10-inch frame produced out of carbon or aluminium, or even printed on a 3D printer and hardened later. It has a fixed-focus camera (this dramatically reduces its optical capacities compared to commercial Mavic drones) and, depending on the size of its frame (7 or 10 in), can carry an explosive device weighing

---

**30** Interview with soldiers of the 47th mechanised brigade, September 2023, Zaporizhzhya.

**31** Flesh 2024.

**32** Censor 2023.

**33** Interview with soldiers of the 47th mechanised brigade, September 2023, Zaporizhzhya.

1.5 kg or 3 kg, respectively, making it an ideal platform for carrying anti-personnel shrapnel IEDs or anti-tank RPG grenades. FPV drones are normally used together with an off-the-shelf surveillance drone that provides pilots with an aerial overview of the battlefield, helps to identify targets, and also documents the success or failure of the attack.

In the middle of 2023, the Ukrainian army began to constantly increase the use of FPV drones. From autumn 2023, due to the shortage of artillery shells, the deployment of FPV drones has turned into the only available substitution of firepower for Ukrainian units. When Ukraine experienced a severe shortage of 155 mm shells in December 2023, President Zelenskyy proposed an initiative of producing 1 million FPV drones within a year. In January 2024, I delivered new drones to Ukrainian units fighting at Avdiivka in the Donetsk region. Some of the soldiers expressed the opinion that with FPV drones, they would be able to efficiently repel Russian attacks even if they had only 15-20% of the artillery shells they actually needed. The situation became even more dire in late January and early February, as fighting units had to rely almost exclusively on FPV drones, resulting in the loss of Avdiivka. This notwithstanding, FPV drones had already proven to be a highly efficient anti-artillery, anti-tank, and anti-personnel weapon.

Marking this success, starting from early 2024, several brigades added an FPV company to their structure, a unit working exclusively with FPV kamikaze drones. In addition to this FPV company, some brigades also added FPV kamikaze drone squads to each of their battalions. Such an extensive use of FPV drones, originally caused by a lack of 155 mm shells, has since gained its own momentum and has significantly influenced the philosophy of the Ukrainian army, stimulating initiative and decision-making on the lower levels of its hierarchical structure and increasing the fire range of its most basic units. Popular leaders of army-related NGOs like Serhiy Sternenko openly called for more government investment in drones and for the creation of a separate drone corps, comparing it to the creation of the air force or tank units in WW I.<sup>34</sup> These demands ultimately led to the aforementioned creation of the Unmanned Systems Forces in June 2024.

## 5 Drones as Bombers and Interceptors

Drones had been used as improvised bombers by Ukrainian units even before the mass-arrival of FPV drones. Back in 2022, commercial drones were used for dropping hand grenades. Heavy DJI Matrix drones, capable of carrying several kilograms of weight, dropped 82 mm mortar mines. Currently, dropping IEDs or hand grenades is mostly a task for FPV drones, as they are much cheaper (€300-400 compared to €2,000 for a simple Mavic or even €8,000 for a Matrice) and bombing missions expose drones to enemy electronic warfare (jamming) and gunfire, increasing the risk of losing an expensive off-the-shelf drone. Each unit using drones has its own workshop where blasters make IEDs out of automatic grenade launcher grenades or C4 packages. A 3D printer is considered standard equipment of a workshop, printing tail units for drones, or hulls for IEDs. Workshops also produce fuses of their own design, re-purposing ignition or

<sup>34</sup> Grunt 2024.

tracer ammunition. The only warhead that is used without any modifications is the RPG grenade. Soldiers say it can be easily fitted to a drone, and does not require any adjustments.

An impressive, but rarely used way of utilizing drones is bomber operations, as they require heavy carrier drones able to transport and drop a TM-62 anti-tank mine. Such drones, with prices above €1,000, can carry one mine and drop it on the enemy's position or on a vehicle. More expensive bomber drones, nicknamed 'Vampire' (or 'Baba Yaga' in Russian army slang, partly adopted by the Ukrainians), can carry even more weight, but cost up to €10,000. Losing them is too expensive for any unit, so they are used with great caution.

Even though a number of experiments have been conducted involving the use of AI for FPV drones or equipping drones with other types of armament like machine guns, this has not led to the implementation of such technologies. The intended application of AI in drones is mostly limited to functions providing support to the pilot, e.g. marking objects that could be identified as targets (vehicles, tanks, soldiers, etc.), and uncovering potential camouflage. So far, however, AI is not used to help select targets, but only in a limited way to guide the drone to its target, if the signal is lost.

Another significant development is indicated by several confirmed interceptions of winged drones by FPV drones.<sup>35</sup> Russian winged drones are especially dangerous as they provide the Russian army with precise information, leading to attacks by artillery, ballistic missiles, or Lancet loitering ammunition. Russian winged recon drones of the Orlan, SuperCam, and Zala series fly above 5,000 m, and provide Russian artillery units with valuable information for strikes. Until 2024, it was nearly impossible to hit them with other means than an AA missile (except for rare cases in which a Yak-52 slow-flying propeller plane with a machine gunner on the co-pilot seat was used to hunt such drones). Since summer 2024, numerous cases of interceptions of Russian winged drones have been recorded, as Ukrainians have developed high-speed winged FPV drones.<sup>36</sup> Ukrainian drones have also intercepted at least five Russian helicopters, including a Mi-28 attack helicopter and a Ka-52 attack helicopter – a task which was seen as nearly impossible before.<sup>37</sup> The Ukrainian army has also developed new types of warheads for drones and has armed drones with incendiary weapons. In September 2024, several cases were reported of drones being used to drop burning thermite mixture on Russian positions as Ukraine's 108<sup>th</sup> territorial defence brigade presented its 'Dragon' drone.<sup>38</sup>

## 6 Long-Range Drones – Filling the Cruise Missile Gap

Currently, Ukraine has up to 19 different models of long-range UAVs that can be used for reconnaissance or for kamikaze attacks on Russia's infrastructure.<sup>39</sup> The oldest models among them are the Tu-141 Strizh and the Tu-143 Reys, both old Soviet reconnaissance UAVs developed in the 1970s, which Ukrainians have modified into long-range kamikaze drones. Their most spectacular mission was an attack on Russia's strategic

---

<sup>35</sup> Suchomimus 2024.

<sup>36</sup> Compare: Sternenko 2024.

<sup>37</sup> Militarnyi 2024a.

<sup>38</sup> Expres 2024.

<sup>39</sup> Andrusyak 2024.

Engels airbase on the middle of the Volga in late 2022, damaging at least one Tu-95 Bear bomber.<sup>40</sup> Ukraine's modern reconnaissance drone Valkyrie was developed between 2015 and 2017. Most of the other long-range kamikaze drones have been developed during the last two years of the full-scale war. Examples include the winged drones Bober (Beaver) and Lyuty (Furious), developed in 2022 and 2023, respectively. Both can carry explosive warheads up to 200 kg over a distance of 800 km.<sup>41</sup> Other kamikaze drones produced by Ukraine are more or less re-designed light airplanes, transformed into carriers of explosives. They were used in April 2024 to attack Russia's Shahed drone production site in Yelabuga, Tatarstan.<sup>42</sup> These drones fill the gap of cruise missiles, which Ukraine lacks. Apart from a small number of Hrim-2 ballistic missiles and Neptune anti-ship missiles (capable of attacking land targets), Ukraine has no domestically produced long-range cruise missiles at its disposal, and it had not been allowed to use the Storm Shadow and SCALP missiles provided by the UK and France beyond its sovereign territory until November 2024. Contrary to cruise missiles, long-range drones produced in Ukraine lack speed and do not carry warheads powerful enough to damage even soft targets like oil refineries.

## 7 R&D in the Field

Ukraine has concentrated most of its production capacities, resources, and public interest on FPV drones. Despite the fact that these drones are assembled from Chinese components, production chains are mostly safe as the parts are very basic and offered by numerous companies. This secures their import to Ukraine and makes them impervious to Chinese export bans, compared to the off-the-shelf Mavic or Autel drones used before.

According to developers and producers of FPV drones I talked to between June and October 2024, Ukrainian drone production has exceeded 1 million units per year, with over 98% of them being FPV drones. The mass production of drones has led to a mass testing of drones on the battlefield, resulting in new and more effective ways of drone production. Production costs of a modern effective FPV drone have dropped from over €400 to €300 per unit (including batteries) within a year, and cheap and less reliable drones can be produced for even less than €250, according to Front Line Kit, a volunteer organisation that also manufactures drones.<sup>43</sup>

The most limiting factor in drone warfare is a drone's flying distance, which is currently limited to about 25 km. This distance can be increased by using a commercial winged drone as a carrier. This drone also serves as a repeater for the radio signal after it drops an FPV drone 30-40 km from the starting point, effectively increasing its flying range to 50-60 km. Increasing the distance this way does not lead to any significant lag in signal transmission. The carrier/repeater is usually a Chinese-produced hobby aircraft available for €8,000 on Chinese online selling platforms.

<sup>40</sup> New Voice 2023.

<sup>41</sup> Akimova 2024.

<sup>42</sup> BBC News Russian Service 2024.

<sup>43</sup> Interview with Front Line Kit head engineer & designer German Timchik and Front Line Kit founder Richard Woodruff, June 2024, Lviv. As of November 2024, Front Line Kit forms part of the newly founded company United Unmanned Systems, which is based in Ukraine and focuses on drone production.

Increasing drone reliability is another important factor in research and development. According to Front Line Kit, the cheapest drones with prices of €200-250 have an efficiency rate of 10-15%, meaning that only 1 in 10 drones hits their target, often not only because of enemy electronic warfare, but because of technical malfunction during the flight. Thinking about the fact that the guaranteed kill of an armoured target often requires 2-3 hits, a unit may need up to 20-30 very cheap drones for one tank kill. High-quality drones costing €300-350 have an efficiency rate of over 30%, which effectively leads to a better price/hit ratio. As drone-active units can use up to 3,000 drones per month (battalion level), and usually have full videos of the flights recorded by the drone itself in first-person flight view plus footage from a surveillance drone, this allows drone operators and drone producers to analyse the weak spots of their drones and to find ways to improve their quality. As a result, the guaranteed destruction of a battle tank can be achieved with only 3-6 drones spent, or a money equivalent of €900-1,800.

The main problem for FPV drones remains enemy EW, which breaks radio contact between the drone and the pilot. Since increasing the signal power has its natural technical limits, the only efficient way to neutralize enemy EW is using a repeater drone. Still, as this costs up to €8,000, the question of economic efficiency arises for many units. According to Ukrainian drone producers, over time drone prices will drop further, while technological progress will allow Ukrainian firms to produce drones of higher quality or better specification. Overall, FPV drones will continue to become more and more accessible. 'The reality is that every idiot with access to YouTube can kill you. If you do not have a jammer, you will simply die', - I was told by German Timchik, head engineer with FPV drone producer Front Line Kit. The same concerns have been expressed by the commander of a drone unit in the Ukrainian army. The lack of 155 mm ammunition has triggered the development of a new weapon in Ukraine, and this weapon is here to stay – even after this war.

## 8 Conclusions

The development of drone warfare in Ukraine is characterised by several aspects. In the first stages of the conflict, Ukraine used drones in order to fill gaps in its strike capacities, in both the naval and land theatres of war. Secondly, amid using off-the-shelf drones, Ukraine has put a lot of effort into producing its own drones, tailor-made for specific needs. Finally, these Ukraine-made drones are being developed by both government and private entities, often at grass-roots level, on a crowd-funding, trial-and-error basis. Despite this somewhat improvisational approach, drones have provided the Ukrainian army with enough firepower to achieve a significant victory over Russia's Black Sea fleet, and to hold back the Russian winter offensive of 2023/24, despite a massive lack of 155 mm artillery shells. In the summer of 2024, Ukraine achieved a significant leap in the development of drones for land and aerial warfare, having produced enough drones to start striking several Russian strategic objects deep behind the frontlines, and to use drones also for air interception missions.

As promising as drone development looks, it does have certain limitations. Drones can provide units with a significant increase in firepower, especially at squad and platoon levels. Still, drones alone cannot achieve – and sustain – control over a contested area. This aspect is not immediately obvious on the land, as infantry units using drones



naturally fulfil the task of taking control, but it is more than apparent at sea. Ukrainian drones did push Russia's fleet from most parts of the Black Sea, but this did not result in any offensive naval operation on the part of Ukraine. Drones alone can only hit targets but cannot achieve sea control.

For the 2024/2025 campaign, one can expect the following in the development of drones:

- The price per unit will drop further while reliability will increase, raising the numbers of drones used per strike drones battalion to up to 5,000 kamikaze and even more FPV drones. Any enemy target more valuable than €1,000 identified by a drone pilot will be hit without hesitation, as this creates a favourable cost-benefit balance.
- Anti-air drones will make an important addition to MANPAD and AA guns, filling the capability gap between them and the SAM batteries, thus helping to protect the sky against enemy helicopters and reconnaissance drones at low cost. Other types of warheads will be used as well, turning drones into standardized carriers of goal-specific warheads.
- EW development will be pursued further, with the aim of creating 'death zones' for enemy drones without harming own drones. As the number of frequencies is limited, this will turn into a complex task.
- AI development, which is still taking baby steps, will be promoted further aiming at the goal of thwarting the enemy's EW efforts without the need for a communication link to a pilot. It would be unreasonable to expect that AI could fulfil other roles such as guiding drone swarms in patrolling missions with a 'license to kill', as this would require a massive increase of battery lifetime. Still, AI development will be aimed at achieving the goal of being able to send AI-guided drones in the direction of a known enemy position (for example during an enemy attack, or in order to support an attack of friendly forces).
- Naval drones will remain an interdiction tool for Ukraine, as Ukraine will not be able to build a navy strong enough to conduct drones-supported landing operations. Therefore, naval drones will only fulfil a secondary role to ensure a relative reduction of the danger from the Black Sea fleet, while the main battle will be fought on land. For other countries with similar geographic conditions (confined waters, an enemy with a fleet of conventional vessels), naval drones can be useful for significantly improving the level of their coastal defence.

Overall, drones will be used even more actively than today as a cheap and reliable tool to notably increase the firepower of any unit up to, and including, battalion level. In terms of significance, this development can be only compared to the invention of machine guns or rear-loaded artillery. Countries that continue to ignore this development and rely on traditional ways of using expensive wing drones as observation tools in combination with artillery and air strikes in support of their infantry will suffer significant losses in the event of a land war against an adversary experienced in drone warfare.

## List of References

- Akimova, Yuliya (2024): ‘Bober’, ‘Lyuty’ ta ‘Valkiriya’: Yak ukrainski drony znyshchuyut voroga na gronti ta v tylu (‘Bober’, ‘Lyuty’ and ‘Valkyriya’: How Ukrainian drones destroy the enemy on the frontline and behind it), in: RBK-Ukraina from 13-05-2024, <https://www.rbc.ua/rus/news/bober-lyutyi-ta-valkiriya-k-ukrayinski-droni-1715609106.html>, last accessed on: 18-07-2024.
- Andrusyak, Anastasiya (2024): Dlya udariv po NPZ I aerodromakh RF: yak I de v Ukraini vyroblyayut dalekobiini BPLA (foto) (For strikes against Russia’s oil refineries and airfields: how and where in Ukraine long-range UAVs are being produced (photo)), in: Focus from 30-04-2024, <https://focus.ua/uk/digital/643498-dlya-udariv-po-npz-i-aerodromah-rf-yak-i-de-v-ukrajini-viroblyayut-dalekobiyni-bpla-foto>, last accessed on: 18-07-2024.
- BBC News Russian Service (2024): Bepilotniki atakovali predpriyatiya v Tatarstane. Chto izvestno I pri chem tut iranskie drony (UAVs have attacked businesses in Tatarstan. What is known and how Iranian drones are related to this), 02-04-2024, <https://www.bbc.com/russian/articles/c3gll1njr4yo>, last accessed on: 18-07-2024.
- Censor (2023): Ministre Reznikov, kazhete vesilni drony? Tse vesillya tsinoyu zhyttia nachykh khloptsiv’, - Zinovyeva (‘Minister Reznikov, do you say they are wedding drones? Our boys pay with their lives for this wedding’, - Zinovyeva), 08-04-2023, [https://censor.net/ua/news/3410897/ministre\\_reznikov\\_kajete\\_vesilni\\_drony\\_tse\\_vesillya\\_tsinoyu\\_jyttya\\_nashyh\\_hloptsiv\\_zinovyeva](https://censor.net/ua/news/3410897/ministre_reznikov_kajete_vesilni_drony_tse_vesillya_tsinoyu_jyttya_nashyh_hloptsiv_zinovyeva), last accessed on: 18-07-2024.
- Chiappa, Claudia (2023): Elon Musk sabotaged Ukrainian attack on Russian fleet in Crimea by turning off Starlink, new book says, in: Politico from 08-09-2023, <https://www.politico.eu/article/elon-musk-ukraine-starlink-russia-crimea-war-drone-submarine-attack-sabotage/>, last accessed on: 18-07-2024.
- Cobain, Ian (2017): Exocet Missile: How the Sinking of HMS Sheffield Made It Famous, in: The Guardian from 15-10-2017, <https://www.theguardian.com/uk-news/2017/oct/15/exocet-missile-how-sinking-hms-sheffield-made-famous>, last accessed on: 17-07-2024.
- Defense Express (2024): Ukrainian Ada Class Corvette Hetman Ivan Mazepa’s Equipment in All Details, 08-07-2024, [https://en.defence-ua.com/analysis/ukrainian\\_ada\\_class\\_corvette\\_hetman\\_ivan\\_mazepas\\_equipment\\_in\\_all\\_details-11098.html](https://en.defence-ua.com/analysis/ukrainian_ada_class_corvette_hetman_ivan_mazepas_equipment_in_all_details-11098.html), last accessed on: 17-07-2024.
- Dovgan, Konstantyn (2023): Ubiitsy mosov i korabley: kak ukrainskie nadvodnyye drony “malyshi” derzhat v strakhe flotiliyu Rossii (Killers of Bridges and Vessels: How Ukrainian Naval Drones “Sea Baby” Spread Fear Among Russian Fleet), in: 24 Channel from 18-08-2023, [https://24tv.ua/ru/sea-baby-dron-harakteristiki-chto-izvestno-o-nadvodnyh-dronah-sbu-24-kanal\\_n2374928](https://24tv.ua/ru/sea-baby-dron-harakteristiki-chto-izvestno-o-nadvodnyh-dronah-sbu-24-kanal_n2374928), last accessed on: 17-07-2024.
- Expres (2024): Nova zbroya vypaliue posadki z okupantamy: Ukraina vyprobuvala dron ‘Drakon’ (New Weapon Burns Plants with Occupiers: Ukraine has tested its ‘Dragon’ drone), in: 04-09-2024, <https://expres.online/podrobitsi/nova-zbroya-vipalyue-posadki-z-okupantami-ukraina-viprobuvala-dron-drakon>, last accessed on: 07-09-2024.
- Flesh, Serhii (2024): Pro ukraiinsku versiyu proshyvky ‘1001’ dlya droniv DJI (On ‘1001’ version of software for DJI drones), in: Military from 13-01-2024, <https://mil.in.ua/uk/blogs/pro-ukrayinsku-versiyu-proshyvky-1001-dlya-droniv-dji/>, last accessed on: 18-07-2024.
- Freeze, Colin (2009): Ships of fleeing Tamils stir fear of hidden Tigers, in: The Globe



- and Mail from 23-10-2009, <https://www.theglobeandmail.com/news/national/ships-of-fleeing-tamils-stir-fear-of-hidden-tigers/article4289929/>, last accessed on: 17-07-2024.
- Gosselin-Malo, Elisabeth (2023): Are the once-vaunted Bayraktar drones losing their shine in Ukraine?, in: DefenseNews from 31-10-2023, <https://www.defense-news.com/global/europe/2023/10/31/are-the-once-vaunted-bayraktar-drones-losing-their-shine-in-ukraine/>, last accessed on: 18-07-2024.
- Grotnik, Tomasz (2023): Ukraine's Final Gyurza-M-Class Gunboat Starts Factory Trials Near Kyiv, in: NavalNews.Com from 27-02-2023, <https://www.navalnews.com/naval-news/2023/02/ukraines-final-gyurza-m-class-gunboat-starts-factory-trials-near-kyiv/>, last accessed on: 17-07-2024.
- Grunt (2024): 'Za dronamy maibutne': volonter Serhii Sternenko pro kolonku Zaluzhnogo, FPV ta snaryadnyi golod ('The future is controlled by drones': volunteer Serhii Sternenko about Zaluzhny's column, FPV, and ammunition hunger), unspecified date in February 2024, <https://grnt.media/opinion/sergij-sternenko-pro-kolonku-zaluzhnogo-fpv-ta-snaryadnyj-golod/>, last accessed on: 18-07-2024.
- Guardian News (2022): Footage appearing to show damaged Russian warship Mosvka emerges, in: YouTube from 19-04-2022, <https://www.youtube.com/watch?v=CW6D3F9aBpg>, last accessed on: 17-07-2024.
- Lagrone, Sam (2017): Navy: Saudi Frigate Attacked by Unmanned Bomb Boat, Likely Iranian, in: USNI News from 20-02-2017, <https://news.usni.org/2017/02/20/navy-saudi-frigate-attacked-unmanned-bomb-boat-likely-iranian>, last accessed on: 17-07-2024.
- Militarnyi (2024a): U Kurskoj oblasti FPV-dron uraziv rosiiskii Mi-28 (An FPV drone has hit a Russian Mi-28 in Kursk region), 07-08-2024, <https://mil.in.ua/uk/news/u-kurskij-oblasti-fpv-dron-urazyv-rosijskyj-my-28/>, last accessed on: 07-09-2024.
- Militarnyi (2024b): V ZSU prezentuvaly novyi rid viisk – Syly bezpilotnykh system (The Ukrainian Armed Forces have presented a new Corps: Unmanned Systems Corps), 11-06-024, <https://mil.in.ua/uk/news/v-zsu-prezentuvaly-novyj-rid-vijsk-syly-bezpilotnyh-system/>, last accessed on: 18-07-2024.
- Mizokami, Kyle (2020): The Surprising History of Unmanned Navy Systems, in: U.S. Naval Institute, Vol. 146/6/1,408, <https://www.usni.org/magazines/proceedings/2020/june/surprising-history-unmanned-navy-systems>, last accessed on: 17-07-2024.
- New Voice (2023): Udar po Engelsu. Viiskovy ekspert rozpoviv, shcho mogla zastosuvaty Ukraina (A strike on Engels. A military expert explained what Ukraine could have used), 31-01-2023, <https://nv.ua/ukr/ukraine/events/yak-ukrajina-mogla-atakuvati-engels-viyskoviy-ekspert-novini-ukrajini-50301133.html>, last accessed on: 18-07-2024.
- New Voice (2024): Drones will not bring 'decisive advantage' to either Ukraine or Russia, says HUR chef, 16-02-2024, <https://english.nv.ua/nation/drones-have-been-in-full-use-by-both-sides-for-a-year-now-50393447.html>, last accessed on: 02-09-2024.
- Nikolov, Boyko (2024): Russia moved Karakurt-class warship to Caspian via inland waterways, in: BulgarianMilitary.Com from 04-05-2024, <https://bulgarianmilitary.com/2024/05/04/russia-moved-karakurt-class-warship-to-caspian-via-inland-waterways/>, last accessed on: 17-07-2024.
- Novyny.LIVE (2023): Ataka morskoho drona (Attack of a Naval Drone), in: YouTube from 10-08-2023, <https://www.youtube.com/watch?v=EbT9dOkci1M>, last

- accessed on: 17-07-2024.
- Offshore-Energy (2011): Corvette Vladimir Veliky to Join Ukrainian Navy by 2016?, 24-08-2011, <https://www.offshore-energy.biz/corvette-vladimir-veliky-to-join-ukrainian-navy-by-2016/>, last accessed on: 17-07-2024.
- Radio Svoboda (2024): Rassldovateli podtverdili potopleniye raketnogo korablya 'Ziklon' v Sevastopole (Investigators Confirmed Sinking of Missiles Vessel 'Ziklon' in Sevastopol), 23-05-2024, <https://www.svoboda.org/a/rassledovateli-podtverdili-potoplenie-raketnogo-korablya-tsiklon-v-sevastopole/32960360.html>, last accessed on: 17-07-2024.
- Romanenko, Valentyna (2023): Zelensky: We'll produce 1 million drones next year, in: Ukrainska Pravda from 19-12-2023 <https://www.pravda.com.ua/eng/news/2023/12/19/7433765/>, last accessed on: 18-07-2024.
- Shwarts, Kateryna (2024): Rossiyanе v panike: na ukrainskikh morskikh dronach zametili rakety (foto, video) (The Russians are panicking: one noticed missiles installed on Ukrainian naval drones (photo, video)), in: UNIAN from 06-05-2024, <https://www.unian.net/war/r-73-na-ukrainskie-morskie-drony-ustanovili-rakety-rossiyane-v-panike-foto-video-12627864.html>, last accessed on: 18-07-2024.
- Stavskaya, Yana (2023): Podbit korabl Chornomorskogo flota 'Ivan Khurs': poyavilov video (Black Sea Fleet Vessel 'Ivan Khurs' has Been Hit: A Video Appeared), in: UNIAN from 25-05-2023, <https://www.unian.net/war/podbit-korabl-cher-nomorskogo-flota-ivan-hurs-poyavilos-video-12270045.html>, last accessed on 17-07-2024.
- Sternenko, Serhii (2024): Masshtabny nebisnyi rusoriz (Massive Sky Russian Massacre), in: Serhii Sternenko's X account from 06-09-2024: <https://x.com/sternenko/status/1831973525445591101/video/1>, last accessed on 07-09-2024.
- Suchomimus (2024): Ukrainian FPV Drones Intercept ZALA 421 and Orlan-10 Drones, in: YouTube from 01-06-2024, <https://www.youtube.com/watch?v=9LeJH8iZ6ZM>, last accessed on: 18-07-2024.
- Talmazan, Yuliya (2023): Ukraine is furious with Elon Musk for thwarting an attack on Russia's navy, in: NBC News from 08-09-2023, <https://www.nbcnews.com/news/world/musk-stopped-ukraine-attack-russian-fleet-starlink-rcna104019>, last accessed on: 18-07-2024.
- The Insider (2024): 'Druzhestvennym ornem' sbit vertolet Ka-29, 'golye oklady' dlya rosiiskikh voyennykh v prigranichye Kharkovskoi oblasti. Chto proiskhodit na fronte (A Ka-29 helicopter shot down by 'friendly fire', 'basic salaries' for Russian military in areas close to border of Kharkiv oblast. What is going on on the frontline), 21-06-2024, <https://theins.ru/news/272580>, last accessed on: 18-07-2024.
- TSN TV (2024): Vidnovlennyyu ne pidlyahaye! HUR pokasaly yak drony vidpratsyuvaly po rosiyskomu korablyu RF 'Sergey Kotov' (No Repair Possible! HUR Demonstrated How Drones Worked Against Russian 'Sergey Kotov' Vessel), in: YouTube from 05-03-2024, <https://www.youtube.com/watch?v=yG-gHUtcvj8>, last accessed on: 17-07-2024.
- Ukrayinska Pravda (2018): Viina u Kerchenskiy prototsi: taran, shturmovyky ta zakhoplennya ukrayinskykh korabliv (War in the Kerch Strait: Ramming, Storm Assault and Hijacking of Ukrainian Vessels), 25-11-2018, <https://www.pravda.com.ua/articles/2018/11/25/7199243/>, last accessed on: 17-07-2024.

- Yann (2023): Udarni morski drony u viini proty Rosii (Assault Naval Drones in the War Against Russia), in: *Militaryni* from 20-06-2023, <https://mil.in.ua/uk/articles/udarni-morski-drony/>, last accessed on: 17-07-2024.
- Zaluzhny, Valery (2024): Ukraine's army chief: The design of war has changed, in: *CNN* from 08-02-2024, <https://edition.cnn.com/2024/02/01/opinions/ukraine-army-chief-war-strategy-russia-valerii-zaluzhnyi/index.html>, last accessed on: 02-09-2024.
- Zhirokhov, Mikhail (2021): Finish dlya 'Leleki-100'. Pochemu bespilotnik v voyskakh s 2015 g., a prinyat na vooruzheniye tolko seichas (A finish line for 'Leleka-100'. Why this UAV is being used by the army since 2015, but officially accepted into service only now), in: *Dsnews.ua* from 18-05-2021, <https://www.dsnews.ua/politics/finish-dlya-leleki-100-pochemu-bespilotnik-v-voyskah-s-2015-g-a-prinyat-na-vooruzhenie-tolko-seychas-18052021-425272>, last accessed on: 18-07-2024.