

Combat Drones in Ukraine

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Drones are playing an important role in the war in Ukraine. Without a large conventional air force, the Ukrainian military is employing a number of high- and low-end imported and domestically produced drones to devastating effect against Russian forces. This article examines how Ukrainian and Russian forces are employing these drones and their effects on the battlefield.

Ukrainian resistance to Russia’s invasion surprised not only Russian president Vladimir Putin but also Western intelligence agencies and prominent analysts.¹ A wide range of drones are among the celebrated systems proving effective for Ukrainian forces, most notably the Baykar Bayraktar TB2. This combat drone now has a song and music video dedicated to its success against Russian troops.² Aside from this famous battle-tested drone, both sides have other drones now employed in combat. This article analyzes the drones being used by Ukraine and Russia, their effects on the battlefield, and implications for future combat.

Background

The Russian invasion of Ukraine, labeled a “special operation” by Putin, began on February 24, 2022. The planned days-long invasion soon turned into a war of attrition that, by its eighth month, had triggered Europe’s largest refugee crisis since World War II. As of October 2022, more than 4.6 million Ukrainians remain outside their own country, with millions more internally displaced.³

The Russian military under Putin has employed similar tactics to those used in the Second Chechen War. Putin further perfected these tactics—“siege, destroy, and take over”—with a heavy reliance on airpower and private military contractors in the Syrian

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1. Zack Beauchamp, “Why the First Few Days of War in Ukraine Went Badly for Russia,” Vox, February 28, 2022, <https://www.vox.com/>.

2. _Skrrq_, “Bayraktar—Official Song (English),” March 2, 2022, YouTube video, <https://www.youtube.com/>.

3. Florian Zandt, “Chart: 6.8 Million Seeking Refuge from Russian Invasion,” Statista, June 2, 2022, <https://www.statista.com/>.

Civil War.⁴ Even though Western intelligence agencies estimated Russia would control Ukraine within four to five days, Russian forces, as of October 20, 2022, failed to control more than the areas directly bordering Russia, including the oblasts surrounding Luhansk, Donetsk, Mariupol, and Kherson.⁵ Moreover, Russia failed to seize and hold Ukraine's capital, Kyiv, Putin's main target.

Although this article is largely focused on offering readers an understanding of the drones impacting the battlefield in Ukraine, it is worth noting the role of drones is unsettled within the security studies literature. Some analysts argue drones are, in fact, a revolutionary technology.⁶ Others disagree and suggest they play a lesser role in reshaping conflict.⁷ The truth, however, is likely somewhere in between. The war in Ukraine is certain to provide greater clarity in understanding the role drones play in conflict in general. But this analysis does not take a position on this critical topic at this early stage of their use.

The article employs the Department of Defense definition of unmanned aircraft systems (UAS): "That system whose components include the necessary equipment, network, and personnel to control an unmanned aircraft."⁸ The term *drone* is the common vernacular used to describe UAS.

Ukraine's Drones

When Ukraine gained independence from the Soviet Union in 1991, the country inherited an antiquated defense infrastructure that included more than 750 factories and 140 research institutes, representing 30 percent of the Soviet Union's defense industry.⁹ After Russia's seizure of Crimea in 2014, the country accelerated the development of

4. Jason Breslow, "What the Lessons from Putin's War in Syria Could Mean for Civilians in Ukraine," National Public Radio, March 1, 2022, <https://www.npr.org/>; and Krystel von Kumberg, "Russian Counter-insurgency Doctrine during the Second Chechen War 1999-2009," *Georgetown Security Studies Review* (website), March 6, 2020, <https://georgetownsecuritystudiesreview.org>.

5. Mason Clark, "Russian Offensive Campaign Assessment," Backgrounder (Washington, DC: Institute for the Study of War, October 23, 2022), <https://www.understandingwar.org/>.

6. James Rogers, "Future Threats: Military UAS, Terrorist Drones, and the Dangers of the Second Drone Age," in *A Comprehensive Approach to Countering Unmanned Aircraft Systems* (Kalkar, Germany: Joint Air Power Competence Center, 2021), <https://www.japcc.org/>; James Rogers, "The Dark Side of Our Drone Future," *Bulletin of the Atomic Scientist*, October 4, 2019, <https://thebulletin.org/>; and Kerry Chavez and Ori Swed, "The Proliferation of Drones to Violent Non-State Actors," *Defence Studies* 21, no. 1 (2021), <https://www.tandfonline.com/>.

7. Antonio Calcara et al., "Why Drones Have Not Revolutionized War: The Enduring Hider-Finder Competition in Air Warfare," *International Security* 46, no. 4 (2022), <https://direct.mit.edu/>.

8. Chairman of the Joint Chiefs of Staff (CJCS), *Joint Air Operations*, Joint Publication 3-30 (Washington, DC: CJCS, September 17, 2021), <https://www.jcs.mil/>.

9. Christian Mamo, "Revitalizing Ukraine's Defense Sector, and with It, Its Military," *Emerging Europe*, March 26, 2021, <https://emerging-europe.com/>.

defense technologies and began to modernize the military.¹⁰ These efforts included cooperating with many Western nations to acquire state-of-the-art military hardware and software. In this regard, Ukraine's homegrown military drone technology was relatively young when Russia invaded in February 2022.¹¹ Many drones Ukraine has deployed against Russia were purchased from foreign nations, with Turkey leading the list of suppliers before the start of the war.

Baykar Bayraktar TB2

The Baykar Bayraktar TB2 is a medium-altitude, long-endurance unmanned combat aerial vehicle that, according to the manufacturer, is capable of remotely controlled or autonomous flight operations. This immensely popular drone is manufactured by the Turkish defense company Baykar Defense.¹² The manufacturer's primary objective is to build a less expensive alternative to Western drones, primarily for the Turkish Armed Forces. Although it is not comparable to state-of-the-art American drones like General Atomics' MQ-9 Reaper or Northrop Grumman's RQ-4 Global Hawk, its appeal lies in a brutally efficient cost-benefit calculation on the battlefield.

The TB2 can fly for almost 24 hours at a maximum altitude of 25,000 feet. It is 6.5 meters (approximately 21 feet) long with a wingspan of 12 meters (approximately 39 feet) and a maximum take-off weight of 650 kilograms (1,433 pounds).¹³ Commonly called the Bayraktar, it can be equipped with four laser-guided bombs. Notably, these bombs are proving incredibly effective against Russian tanks and other armored vehicles.¹⁴

Before its appearance in Ukraine, this drone was used in Syria, Libya, and Azerbaijan.¹⁵ In 2019, the Armed Forces of Ukraine began acquiring the Bayraktar TB2S, then upgraded to the TB2 as a part of its military modernization program.¹⁶ Outmanned, outgunned, and primarily relying on unbreakable resolve, Ukrainian forces have found this drone to be very effective as a force multiplier.¹⁷

10. Ted Galen Carpenter, "Whitewashing Ukraine's Corruption," Cato Institute (website), April 6, 2022, <https://www.cato.org/>; and Liam Collins, "In 2014, the 'Decrepit' Ukrainian Army Hit the Refresh Button. Eight Years Later, It's Paying Off," *The Conversation*, March 8, 2022, <https://theconversation.com/>.

11. John Wendle, "The Fighting Drones of Ukraine," *Air & Space Magazine*, February 2018, <https://www.smithsonianmag.com/>.

12. Baykar Technology, "Bayraktar TB2," Baykar Technology (website), accessed September 21, 2022, <https://www.baykartech.com/>.

13. Baykar Technology, "Bayraktar TB2."

14. Christiaan Hetzner, "The Cheap, Slow, and Bulky Drones Taking Down Russian Armored Tanks for Ukraine," *Fortune*, March 4, 2022, <https://fortune.com/>.

15. Scott Crino and Andy Dreby, "Turkey's Drone War in Syria—A Red Team View," *Small Wars Journal*, April 16, 2020, <https://smallwarsjournal.com/>.

16. "Ukrainian Navy Has Received First Unit of Turkish-Produced Bayraktar TB2 UCAV System," *Defense Express*, July 18, 2021, <https://en.defence-ua.com/>.

17. Aaron Stein, "The TB2: The Value of a Cheap and 'Good Enough' Drone," *Airpower after Ukraine* series, Atlantic Council (website), August 30, 2022, <https://www.atlanticcouncil.org/>.

Several dozen TB2s are now thought to be in Ukraine's arsenal. They are used to disable multiple launch rocket systems and take out columns of armored tanks and personnel transporters.¹⁸ In June, Ukraine may have also hit two oil depots well inside Russian territory using these drones, bringing the war behind the front lines and embarrassing Russia's air defenses.¹⁹ These drones have also been used for reconnaissance and surveillance.²⁰

But the TB2 has its limitations and is certainly far from invincible.²¹ The exact performance of the drone is difficult to assess effectively given the proliferation of Russian disinformation and misinformation.²² According to Russian-linked sources, TB2s are regularly shot down. Given the relative simplicity of the technology used in the TB2, the losses to advanced Russian air defenses are not unexpected. The balance between relatively inexpensive and more advanced drones may prove to be the most interesting aspect of Ukraine's use of the TB2.

Punisher

In addition to the TB2, the Ukrainian Army is using a small and nimble locally made drone known as the Punisher, which has successfully completed numerous missions against Russian forces.²³ The drone is designed and manufactured by UA Dynamics, a company operated by veterans of the Crimea conflict. The company describes the drone as "reusable, fast, unexpected, precise, lethal."²⁴

The Punisher has a 2-kilogram (4.5 pounds) combat payload, 45-kilometer (28 miles) range, and 43-knot cruising speed. It has a 2.3-meter (6.5 feet) wingspan and can fly at 400 meters (1200 feet) altitude for missions of up to 90 minutes.²⁵ Their small size and low altitude allow them to reach deep behind enemy lines with little risk of detection before or during strikes and then return for a quick five-to-seven-minute servicing. This combination of characteristics has reportedly allowed Punisher drones to hit supply lines

18. Hetzner, "Cheap, Slow, and Bulky."

19. Andrew Roth, "Drone Crashes into Russian Oil Refinery in Possible Attack," *Guardian*, June 22, 2022, <https://www.theguardian.com/>.

20. Stavros Atlamazoglou, "Why the Bayraktar TB2 Drone Was Such a Game Changer in Ukraine," *1945*, May 31, 2022, <https://www.19fortyfive.com/>.

21. Dylan Malyasov, "Russia Shoots Down 6 Ukrainian Bayraktar TB-2 Drones," *Defence Blog*, April 28, 2022, <https://defence-blog.com/>.

22. "Turkish TB2 Falling Like Flies, Another Ukrainian TB2 Drone Shot Down by Russia," *Defense View*, July 27, 2022, <https://www.defenceview.in/>.

23. Alia Shoaib, "Ukraine's Army Is Using a Nimble 'Game-Changing' Drone Called the Punisher That Has Completed Scores of Successful Missions against the Russians, Says Reports," *Business Insider*, March 5, 2022, <https://www.businessinsider.com/>.

24. Bruce Crumley, "Ukraine's Mid-Size Punisher Drone Is Living Up to Its Name against Russian Forces," *Drone DJ*, March 8, 2022, <https://dronedj.com/>.

25. "Reusable Airstrike Drone with the Cheapest Cost of Mission in the World," UA Dynamics, March 31, 2022) <https://uadynamics.com>.

supporting Russian troops and strike ground vehicles and trains transporting fuel and other resources to these troops.

Quadcopter Drones

The Ukrainian Territorial Defense Force is training volunteers in tactics employing drones, including making and deploying Molotov cocktails in the battle against Russian forces.²⁶ Ukraine's DJI-inspired (DJI is a Chinese manufacturer of small quadcopter drones) drone added another dimension to Ukraine's defense. The drone is a quadcopter that can stay aloft while carrying a Molotov cocktail horizontally and is reportedly triggered remotely to drop the explosive. The front-loaded camera appears to be angled straight downward, possibly to offer a clear view of intended targets directly below.²⁷ The use of consumer drones by Ukrainian forces for attacking Russian troops rather than for surveillance is another indication of the innovative employment of drones generated by the war in Ukraine.

Interestingly, recent reports suggest DJI is supporting both Ukraine and Russia.²⁸ If these reports are accurate, it exemplifies the role affordable commercial drones can play and that their ubiquity may make it the combatant that most wisely and creatively uses drones the one that succeeds in conflict.

Warmate 1

The Warmate 1 is a microloitering munition developed by the Polish company WB Electronics. Vaguely plane-shaped with a centrally mounted wing and a v-tail, the drone weighs around 5.3 kg (12 pounds) and has a top speed close to 150 kilometers (93 miles) per hour. It can remain aloft about 70 minutes and has an operating range of approximately 15 kilometers (9 miles), line-of-sight with a payload capacity of 1.4 kilograms (3 pounds).²⁹ The drone's control system allows a single operator to fly it to desired locations autonomously or manually control it. Ukraine uses this drone for surveillance and reconnaissance and for attacking Russian positions.³⁰

26. Illia Ponomarenko, "Who Can and Can't Join Ukraine's Territorial Defense Force," *Kyiv Independent*, January 7, 2022, <https://kyivindependent.com/>.

27. Ben Kessler, "Ukrainians Develop Drone That Drops Molotov Cocktails," *New York Post*, March 10, 2022, <https://nypost.com/>.

28. "Chinese Drone Maker DJI Is Equipping Both Ukraine and Russia," SOFREP, August 18, 2022, <https://sofrep.com/>.

29. "The Warmate," WB Group (website), accessed September 19, 2022, <https://www.wbgroup.pl/>.

30. Jonathan Baran, "Kamikaze Drones Are Showing Up in Bigger Numbers in Ukraine," *Washington Post*, March 24, 2022, <https://www.washingtonpost.com/>.

Switchblade

In March 2022, the Biden administration provided Ukraine with American-made Switchblade kamikaze drones as part of a military aid package, transferring about 100 drones.³¹ The Switchblade has two variants—the 300 and 600. The 300 is designed for pinpoint strikes on personnel, and the larger 600 is meant to destroy tanks and other armored vehicles.³² The Switchblade's effect on the battlefield is unknown.

Tupolev Tu-141 Strizh

The Ukrainian arsenal also includes the Soviet-era jet-powered Tupolev Tu-141 Strizh drone, a large, high-altitude UAS. Even though the Tu-141 was designed to conduct reconnaissance, it can also attack enemy positions, though with little success in past wars. Despite the limited success of these drones in the past, Ukraine upgraded the platform and fielded a useful Tu-141 fleet after the Russian invasion in 2014. This UAS looks more like a cruise missile than a traditional drone. It is rocket launched from its trailer and flies a predetermined course at transonic speed.³³

While flying a predesignated path, the Tu-141 can collect various forms of intelligence. After its flight, the drone launches a parachute for recovery, allowing it to be reused. This drone created consternation among NATO members in March 2022, when an armed Tu-141 flew from western Ukraine, crossed Romanian and Hungarian airspace, and crashed in Zagreb, Croatia.³⁴ No official statement came from the Croatian or Ukrainian governments regarding who fired this drone. According to a source close to the Ministry of Defense of Croatia, the crashed drone belonged to Ukraine and was carrying a bomb to strike Russia's positions but veered off course, ran out of fuel, and crashed.³⁵ As this article was going to press, Russia reported that modified versions of the Tu-141 struck two Russian airbases hundreds of miles from the Ukraine border.³⁶

31. Paul McCleary and Alexander Ward, "U.S. Sending Switchblade Drones to Ukraine in \$800 Million Package," *Politico*, March 16, 2022, <https://www.politico.com/>.

32. Ken Dilanian, Dan DeLuce, and Courtney Kube, "Biden Admin Will Provide Ukraine Killer Drones Called Switchblades," NBC News, March 15, 2022, <https://www.nbcnews.com/>.

33. "TU-141 VR-2, Strizh (SWIFT)," Global Security (website), n.d., accessed October 27, 2022, <https://www.globalsecurity.org/>.

34. Tyler Rogoway, "Tu-141 'Strizh' Missile-Like Drone from the War in Ukraine Looks to Have Crashed in Croatia (Updated)," The Drive, March 11, 2022, <https://www.thedrive.com/>.

35. Radio Free Europe (RFE)/Radio Liberty's Balkan Service, "Drone That Crashed Last Month in Zagreb Was Carrying Explosives, Investigators Say," RFE, April 13, 2022, <https://www.rferl.org/>.

36. Patrick Tucker, "Explosions at Russian Air Bases May Change Several Nations' Calculations," Defense One, December 6, 2022, <https://www.defenseone.com/>.

Russia's Drones

Despite being the world's second-largest arms exporter and producing advanced air and space systems, Russia's drones are not among the most advanced in the world.³⁷ Still, in recent years, the country has appeared to be highly concerned about the importance of drones in modern warfare, and Russian interest in drone development has increased dramatically.

Obviously, Russia lags behind the West in this sector, both in commercial and defense technology. But based on its proven ability to develop complex air and space systems, Russia is expected to master the competencies required for designing and manufacturing highly capable drones. Currently, Russia is employing domestically produced drones in Ukraine, which has prompted many Western companies to cease cooperating with Russian firms. Moreover, sanctions in place now will likely hamper Russian efforts to catch up with Western and Chinese drone manufacturers, particularly as critical technology transfers remain part of the technology sanctions.

Kalashnikov Kyb

The Kalashnikov Kyb drone, introduced in 2019 by Zala Aero, is a blended wing-body drone with uplifted wingtips. The aircraft is more than a meter wide and a meter long with a flight duration of 30 minutes. It typically cruises at 80 kilometers (50 miles) per hour but can fly up to 130 kilometers (78 miles) per hour for short distances. It has a payload capacity of three kilograms (6.6 pounds).³⁸ Russia's ground forces started using this drone to attack targets in Ukraine soon after the invasion commenced. Ukrainian forces have recovered at least two of the Kyb drones—evidence that Russia is using them in its invasion.³⁹

Eleron-3SV

The Russian company ENICS developed the Eleron-3SV drone in 2013. The drone conducts round-the-clock reconnaissance using optical and electronic tools and has an operating range of 25 kilometers (15 miles). It can remain in the air for two hours.⁴⁰ Eleron-3SV drones have operated in the Donbas region since 2015 and were used in the Syrian theater. Russia has employed these drones in Ukraine, and the Ukrainian Army has reported capturing two.⁴¹

37. Samuel Bendett, "Where Are Russia's Drones?" Defense One, March 1, 2022, <https://www.defenseone.com/>.

38. "Loitering Munition: KYB-UAV," Zala Aero (website), 2022, <https://zala-aero.com/>.

39. Stefano D'Urso, "Russia Is Now Using Loitering Munitions in Ukraine," Aviationist, March 17, 2022, <https://theaviationist.com/>.

40. ENICS Aero, "ELERON-3—ЭНИКС," ЭНИКС, 2019, <http://enics.aero/>.

41. "Russian Eleron-3SV Drones Destroyed in Donbas," Inform Napalm, July 6, 2019, <https://inform.napalm.org/>.

Orlan-10

The Orlan-10 drone is a medium-range, multipurpose UAS developed by the St. Petersburg-based firm Special Technology Center. This drone entered the war early, and Russia used it to attack Ukrainian military assets and for aerial reconnaissance and electronic warfare. For surveillance and reconnaissance purposes, this drone is usually used in a group of two or three.

The first drone is used for reconnaissance at an altitude of 1–1.5 kilometers (4,000 to 6,000 feet) above a target; the second drone is used for electronic warfare; and the third transmits surveillance information to the control center.⁴² The drone has a maximum speed of 150 kilometers (90 miles) per hour and a combat range of 140 kilometers (80 miles). It can remain in flight for a maximum of 16 hours and has a service ceiling of 5,000 meters (15,000 feet). Its capabilities are not yet fully known but it serves in many of the same capacities as the previous drones described.

Forpost R

The Forpost R is a Russian license-produced version of the Israeli IAI Searcher II drone.⁴³ Forpost R has a maximum speed of 200 kilometers (120 miles) per hour, a mission endurance window of about 18 hours, and a service ceiling of 20,000 feet. This drone conducted its maiden flight on August 23, 2019 and joined the Russian Armed Forces in 2020. The primary objective of the Forpost R is to conduct reconnaissance, and the 500-kilogram (1200 pounds) air vehicle is equipped with improved radar identification equipment among other reconnaissance devices. On March 11, 2022, a Russian Forpost R drone was destroyed by Ukrainian forces. Ukraine's military claimed the drone crossed into Polish airspace before reentering Ukrainian airspace, where it was shot down.

Orion E

The Orion-E combat drone is considered Russia's best strike drone. Russian forces first used the Orion-E in combat in Syria against forces opposing the Assad regime.⁴⁴ The Russian Ministry of Defense even claimed that the drone has "fighter-like" capabilities.⁴⁵

42. "Orlan 10 Unmanned Aerial Vehicle," Air Force Technology, March 15, 2021, <https://www.airforce-technology.com/>.

43. "Russia Uses Forpost-R Armed Drone with Guided Missile to Destroy Rocket Launcher of Ukrainian Army," Army Recognition, March 13, 2022, <https://www.armyrecognition.com/>.

44. Mansij Asthana, "Tested in Syria, Russia's Very Own Combat Drone 'Orion' Ready for Action: Watch Now," *Eurasian Times*, February 24, 2021, <https://eurasianimes.com/>.

45. David Hambling, "Russia Reveals New Drone Capabilities, Hinting at What It Could Bring to Bear in Ukraine," *Forbes*, December 23, 2021, <https://www.forbes.com/>.

Developed by Kronshtadt, the drone has two variants: the export variant called Orion-E and the Inokhodets variant used by the Russian military.⁴⁶ It is a middle-altitude, long-flight drone with a maximum flight altitude of about 8,000 meters (25,000 feet) and can remain in the air for up to 24 hours. The drone's cruising speed is up to 200 kilometers (120 miles) per hour with a maximum payload of 250 kilograms (550 pounds). It features a turret under the nose with electro-optical and infrared cameras, and it possesses a laser-target designator to deliver guided weapons.

The Orion-E can carry up to four air-to-ground missiles, and its arsenal includes the KAB-20 and KAB-50 adjustable aerial bombs, the UPAB-50 guided gliding aerial bomb, and the X-50 guided missile.⁴⁷ The drone is expected to field electronic warfare systems soon. Russia has not disclosed how many Orion drones it operates in Ukraine, but it has claimed the drone has been used to attack Ukrainian positions successfully. Simultaneously, online photographic evidence shows the Ukrainians shot down at least one Orion-E.⁴⁸

As the previous discussion of Russian drones in Ukraine suggests, Russia's claims that it fields state-of-the-art drones are certainly questionable.⁴⁹ To suggest Russia lacks dominance may be a generous description of the state of Russian capabilities. Simply stated, Russian drones are rarely in evidence in Ukraine. This failure is leading to speculation among analysts that follow the war in Ukraine that Russian drones are being held in reserve for a later escalation in the conflict.⁵⁰

Others suggest logistical issues constrain drone use—as evidenced by the widespread reports of abandoned and broken Russian military vehicles.⁵¹ This is prompting some to conclude Russia may not be able to support drone operations in Ukraine. According to other experts, one of the biggest reasons may be a lack of trust in domestic technology in its early stages.⁵²

The offensive use of drones by Ukraine and Russia is roughly equivalent, even though the impact on the battlefield for each nation is not. This is, in part, because Ukraine enjoys an advantageous position when it comes to counter drone technology. Defensive drone technologies evolved from costlier systems (surface-to-air missile radars used to detect

46. Linda Kay, "Russian Orion-E Drone Makes Its First Kill in Ukraine," *Defense World*, March 8, 2022, <https://www.defenseworld.net/>.

47. Kay, "Orion-E Drone."

48. Linda Kay, "Ukraine Shoots Down Russia's Israel-Origin Surveillance UAV That Entered Polish Airspace," *Defense World*, March 16, 2022, <https://www.defenseworld.net/>; and Emily Atkinson, "Ukrainian Troops Celebrate as They Shoot Down Russian Drone and Flip the Bird as It Falls from the Sky," *The Independent*, April 11, 2022, <https://www.independent.co.uk/>.

49. Sebastien Roblin, "Russia Has Big Plans to Become a Drone Superpower (Like Stealth Drones)," *1945*, July 13, 2021, <https://www.19fortyfive.com/>.

50. Bendett, "Russia's Drones?"

51. Brendan Walker-Munro, "Why Have Russia's Killer Drones Failed in Ukraine?" *Asia Times*, March 30, 2022, <https://asiatimes.com/>.

52. Brendan Walker-Munro, "Drones over Ukraine: Fears of Russian 'Killer Robots' Have Failed to Materialize," *The Conversation*, March 29, 2022, <https://theconversation.com/>.

and destroy drones) to cheaper systems (directed energy and electronic warfare). Ukraine holds the advantage here because of its work with Western militaries and defense firms after the invasion of Crimea in 2014.⁵³

The Russian defense sector's progress in drone development was stymied in recent years by technology embargoes by Western nations and the lack of a sufficient domestic industrial base. Ukraine's greater-than-expected logistical and technological support from Western firms post-Crimea, including in the drone and counterdrone areas, showed in the early months of Russia's invasion, where Ukraine held a distinct advantage.⁵⁴ Whether this advantage remains as the war turns into a protracted engagement is yet to be determined. Western assistance may or may not outpace Russian efforts to close the gap.

Countering Drones

Russia has deployed its advanced electronic warfare systems in Ukraine for comprehensive protection against air assets, including Ukrainian drones. Russian tactics have involved the simultaneous deployment of the Krasukha-2/4, R-330Zh Zhitel, and RB-301B Borisoglebsk-2 ground-based electronic warfare systems, which use a combination of jamming and spoofing.⁵⁵ Each system is designed to target a different element of the electromagnetic spectrum. Russia has also used these systems to conduct reconnaissance of Ukrainian radio communications, followed by interference once targets were identified.

The Ukrainian military has successfully hit some of Russia's electronic warfare systems. Moreover, they captured the command module of a Krasukha-4, considered the most advanced system developed by Russia.⁵⁶

The Krasukha-2 system, also in the Russian arsenal, consists of three vehicles based on the Kamaz-6350 truck and can jam airborne warning and control systems at ranges of up to 250 kilometers (150 miles). It can also jam other airborne radars such as radar-guided missiles. The Krasukha-4 resembles the Krasukha-2 but can also effectively disrupt low-Earth orbit satellites and cause permanent damage to targeted radio-electronic devices.⁵⁷ The truck-based R-330Zh Zhitel system can interfere with satellite communications equipment, navigation systems, and mobile phones within a 30-kilometer (20 mile)

53. Josh Spires, "How Counter-Drone Systems Defeat and Destroy Rogue Drones," Drone DJ, December 20, 2020, <https://dronedj.com/>.

54. Vikram Mittal, "Puzzling Out the Drone War over Ukraine to Date, Russia Has Had Little to Show for a \$9 Billion Investment in UAVs," Institute of Electrical and Electronics Engineers (IEEE) Spectrum, March 22, 2022, <https://spectrum.ieee.org/>.

55. "R-330 ZH Zhitel: Mobile Truck-Mounted Jamming Communication Station – Russia, Army Recognition, February 26, 2022, <https://www.armyrecognition.com/>.

56. Alia Shoaib, "Ukraine Captures Russian Hi-Tech Warfare System, Could Hold Military Secrets," *Business Insider*, March 26, 2022, <https://www.businessinsider.com/>.

57. Samuel Cranny Evans, "Russia Trials New EW Tactics," *Janes Defence Weekly*, June 14, 2019, <https://www.janes.com/>.

radius. Although these systems were not initially designed for counter-drone activities, they are useful if employed correctly.

Conclusion

Looking back on nine months of the war in Ukraine, it is evident the TB2 and other combat drones engaged in the conflict are making a useful contribution to the war. Yet, they are unlikely to be the deciding factor against a Russian army buoyed by greater manpower and long-range artillery.⁵⁸

Still, as a result of the apparent success of its drone force, Ukraine is not only destroying critical targets but aiding in the degradation of morale among Russian forces. For Russian soldiers already struggling to rationalize their experience in Ukraine with the justification they were initially given for the war, adding the fear of attack from unseen drones only makes the anxiety of war more challenging. The fear of the unseen leads to a sense of helplessness, which diminishes hope. Thus, it should be no surprise that good order and discipline is often breaking down among Russian troops.⁵⁹

The war in Ukraine clearly demonstrates drones are altering the dynamics of war. For Ukraine, airpower is largely taking the form of drones, a first for a large nation. Democratic and authoritarian regimes like Ukraine and Russia know that military drone technology is quickly becoming central to warfare. Given the relative cost-effectiveness of drones—compared to similar manned aircraft—they are challenging the existing assumptions about the use of airpower, allowing lesser adversaries to engage effectively in aerial warfare.

Turkey, the manufacturer of the most popular drone in Ukraine's arsenal, has a defense budget that is a fraction of that of the United States. Yet the country is still managing to develop and export highly capable and cost-effective drones. Turkey is accomplishing its success in the midst of a technological boycott by Western countries due to its role in Syria, Libya, and Azerbaijan.⁶⁰ If the first months of the war in Ukraine teach us anything about the present and future of drones in warfare, it is that they will appeal to countries that cannot afford costly manned fighters. The war between Armenia and Azerbaijan is already an example. These same states will rely on drones and develop new tactics, techniques, and procedures that employ them in unexpected ways. → ✨

58. Sean Hollister, "DJI Drones, Ukraine, and Russia—What We Know about Aeroscope," *The Verge*, March 23, 2022, <https://www.theverge.com/>.

59. Allison Quinn, "Russian Soldier Breaks Down: We Are Just Meat Here," *Yahoo News*, July 7, 2022, <https://news.yahoo.com/>.

60. "US Imposes Sanctions on Turkey over Russia Weapons," *BBC News*, December 14, 2020, <https://www.bbc.com/>.

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