

## Russian Drone Innovations are Likely Achieving Effects of Battlefield Air Interdiction in Ukraine

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### Executive Summary

The Russian integration of combined unmanned aerial vehicle (UAV) attack tactics and adaptations is giving Russian forces important advantages on the battlefield in Ukraine and facilitating Russian advances on key Ukrainian towns. Russian UAV adaptations are likely achieving some effects of battlefield air interdiction (BAI): The use of airpower to strike targets in the near rear of the frontline to impact battlefield operations in the near term.[1] Neither Ukraine nor Russia has been able to conduct BAI using manned aircraft or UAVs due to the density and sophistication of adversary air defenses and electronic warfare (EW) over the past three years, but Russian forces are now achieving partial BAI effects in support of their offensives.[2] Russia's allies, especially the People's Republic of China (PRC), have enabled Russia to develop and scale the production of UAVs that are more resistant to EW interference and capable of operating at longer distances, higher speeds, and in challenging environments. Ukraine and its partners must invest urgently in kinetic anti-drone systems that are not reliant on EW to secure near-rear areas and, ultimately, frontline positions as well.

**Russian forces are actively achieving some effects of battlefield air interdiction (BAI) of Ukrainian ground lines of communication (GLOCs) with tactical unmanned aerial vehicles (UAVs), enabling Russian advances in eastern Ukraine.** BAI is the use of air power to strike targets in the near rear of the frontline to impact battlefield operations in the near term.[3] These operationally significant targets include roads, railways, and bridges (infrastructure that supports GLOCs); command posts; ammunition depots; assembly areas; and training grounds. In simple terms, BAI aims to deny the adversary the use of crucial logistics lines and facilities necessary to sustain battlefield operations. Ukrainian servicemen and analysts reported that Russian forces began to systematically target Ukrainian GLOCs and other operationally significant targets with tactical first-person-view (FPV) UAVs and loitering munitions across the entire frontline as early as Winter and Spring 2025, effectively using these UAVs to interdict Ukrainian logistics ahead of the Russian Summer 2025 offensive.[4] Ukrainian sources noted that Russian forces previously only operated tactical UAVs on the battlefield, but that they have adapted these UAVs to strike Ukraine's near rear areas.[5] Russian forces recently made notable advances in the Lyman, Siversk, Kostyantynivka, Pokrovsk, and Novopavlivka directions, likely after achieving limited BAI effects with new FPV drone and loitering munitions adaptations.

**Neither Ukraine nor Russia has previously been able to conduct BAI using manned aircraft or UAVs due to the density and sophistication of adversary air defenses and electronic warfare (EW) over the past three years.**[6] Russia has largely used its aircraft to launch long-range missile strikes against Ukrainian infrastructure in the deep rear and to launch glide bombs along the frontline, but has not used aircraft directly over the battlefield. Ukraine has shown that it is possible to conduct at least partial BAI using ground-based systems during the 2022 Kherson counteroffensive when Ukrainian forces used US-provided HIMARS to deprive Russian forces of the use of the Antonivsky Bridge and the roadway over Kakhovka Dam.[7] Neither Ukrainian nor Russian UAVs can fully accomplish BAI effects such as destroying a bridge or a highway due to payload limitations. UAVs, however, are increasingly targeting individual vehicles on the GLOCs,



defensive positions such as trenches, and infrastructure targets that are accomplishing interdiction effects similar to those that BAI aims to achieve. These interdiction effects include keeping adversary reinforcements and supplies from arriving at the frontlines in a timely manner.

## **Russian Partial BAI Effects**

**Russian forces are reportedly denying Ukrainian forces the use of key highways and GLOCs located deeper in the rear with tactical UAVs, which is complicating Ukrainian defensive operations in the Pokrovsk direction and the eastern fortress belt.** The Ukrainian government temporarily banned civilians from using the stretches of the T0514 Dobropillya-Lyman highway between Kramatorsk, Serhiivka, Andriivka, and Dobropillya starting on July 16 due to the elevated threat posed by Russian FPV drones.[8] The T0514 highway is an important GLOC that stretches parallel to the current frontline and towards the Ukrainian fortress belt in Donetsk Oblast, connects to Ukraine's major logistics hub in Kramatorsk, and links with remaining Ukrainian GLOCs in the Pokrovsk direction near Dobropillya. The T0514 highway runs between 25 and 54 kilometers from the active frontline, indicating that Russian forces have significantly improved their tactical UAV capabilities and can threaten Ukrainian GLOCs deeper in the rear than before. Ukrainian Donetsk Oblast Administration Head Vadym Filashkin reported that Russian UAVs "fully control" the T0514 and other unspecified highways, likely implying that Russian forces established fire control (the ability to deny Ukrainian forces use of the road without physically occupying it) over the highway.[9] Filashkin stated that Ukrainian forces are installing anti-drone nets along the T0514 and other highways to protect against modernized Russian FPV UAVs, Lancet loitering munitions, and other unspecified UAVs.[10] Filashkin specified that Ukrainian authorities are having difficulties delivering humanitarian and medical aid to Kostyantynivka, Pokrovsk, and Myrnohrad because Russian forces are using FPV UAV drones, particularly fiber optic drones, to maintain fire control over all roads leading to these cities.[11] Russian sources also amplified footage in mid-July 2025 showing destroyed trucks along a highway and claimed that the footage shows that Russian forces are interdicting the T0514 highway with tactical UAVs.[12]

Russian UAV strikes on Ukrainian military equipment along the GLOCs are enabling Russian forces to make rapid advances in the Pokrovsk direction after months of grinding assaults. Russian UAVs are particularly targeting Ukrainian vehicles along the critical T0515 highway in Rodynske (3km northeast of Pokrovsk), which is one of the two remaining Ukrainian GLOCs in the Pokrovsk direction. Ukrainian servicemen stated in late July 2025 that Ukrainian logistics problems on Pokrovsk's northern flank are "critical" due to Russian UAV attacks on Ukrainian vehicles on the T0515 highway.[13] One Ukrainian serviceman stated that Russian forces strike two or three Ukrainian vehicles daily on the T0515 highway, forcing Ukrainian servicemen to bring up supplies by foot and complicating Ukraine's defensive operations in the Pokrovsk direction.[14] Ukrainian electronic and radio warfare expert Serhiy "Flash" Beskrestnov reported, citing data from an unspecified medical facility in the Pokrovsk direction, that 70 percent of the injuries sustained by Ukrainian forces and civilians result from FPV drone attacks along Ukrainian highways.[15] Russian persistent drone strikes at longer ranges are likely forcing Ukrainian forces to take alternative roads and further stretch GLOCs, which is likely impacting Ukraine's defensive operations that rely on the consistent flow of equipment, supplies, and manpower. Russian UAVs are creating the effects that deny Ukrainian forces the use of GLOCs without physically destroying the GLOC infrastructure as traditional BAI would seek to do.

**Russian forces are restricting Ukrainian movements in the immediate rear with tactical UAVs, hindering Ukrainian troop rotations and evacuations.** Ukrainian sources observed that the battlefield "kill zone"\* or contested "grey zone" — an area immediately near the frontline where a mass of tactical strike and



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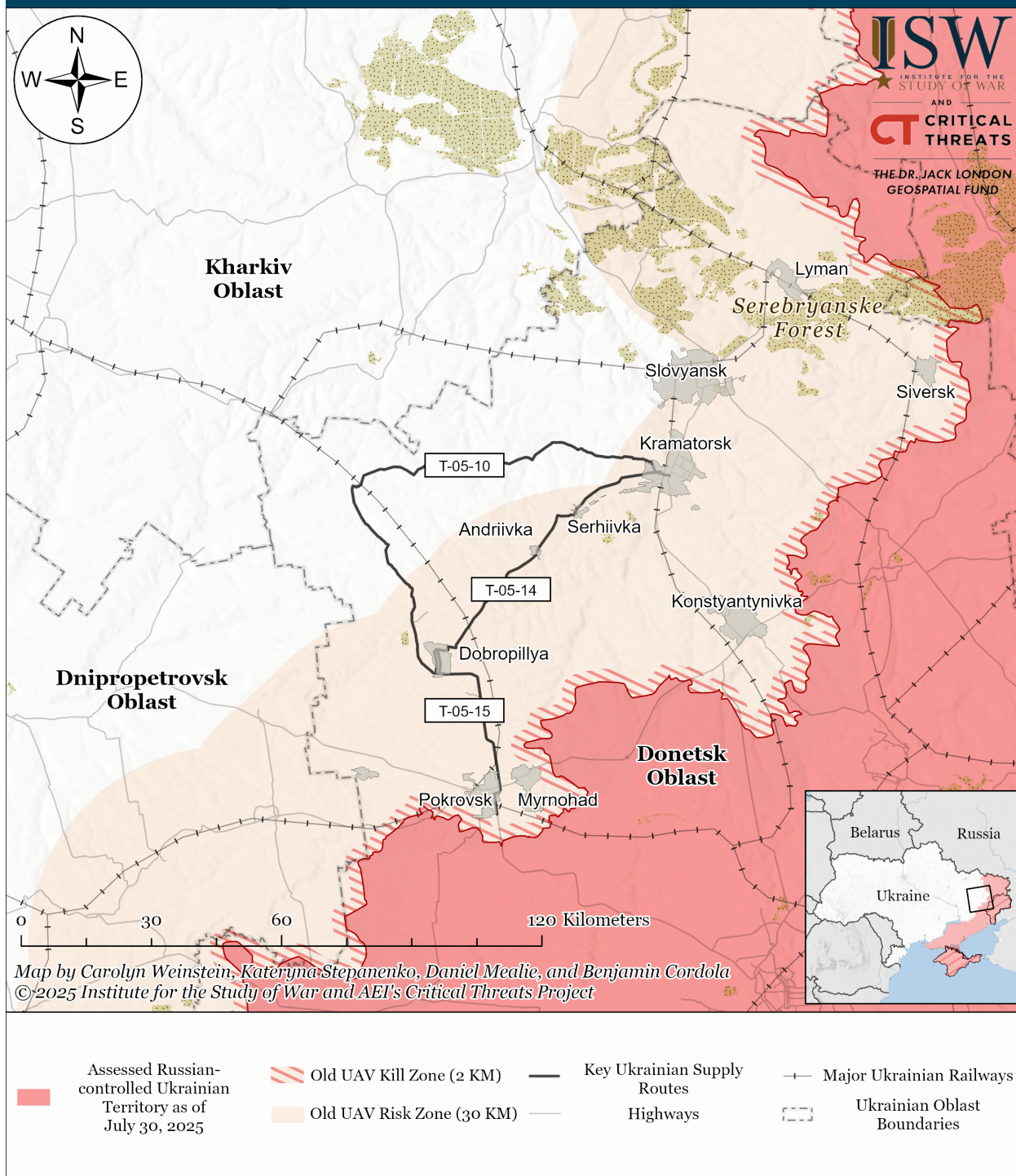
reconnaissance drones pose an elevated risk to any equipment or personnel that enters the area — extended up to at least 10 kilometers from the frontline.[16] Some Ukrainian sources observed that the "kill zone" in 2024 was only 500 meters to two kilometers, but had since sharply increased in 2025 due to drone innovations.[17] A Ukrainian serviceman operating in the Kostyantynivka direction stated that any vehicles that attempt to operate within five kilometers of the frontline are as "good as finished," while vehicles trying to maneuver in the 10-kilometer range are in danger of Russian drone strikes.[18] A Ukrainian serviceman operating near Dobropillya in the Pokrovsk direction similarly stated that using a car for logistics is "virtually suicidal" and that Ukrainian forces walk up to 14 kilometers to deliver materiel to the frontlines.[19] Ukrainian sources noted that the increased use of FPV drones is complicating Ukrainian movement in the immediate rear, resulting in Ukrainian forces having to remain on the frontlines for protracted periods of time without rotations.[20] Ukrainian servicemen also noted that they have a harder time entering and leaving the frontlines and sustaining logistics on the battlefield.[21] These conditions will likely make it increasingly challenging for Ukrainian forces to restore maneuver, or even to hold their current positions, without appropriate counter-drone measures.



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## Previous Extent of Russian Partial Battlefield Air Interdiction Effects in Ukraine

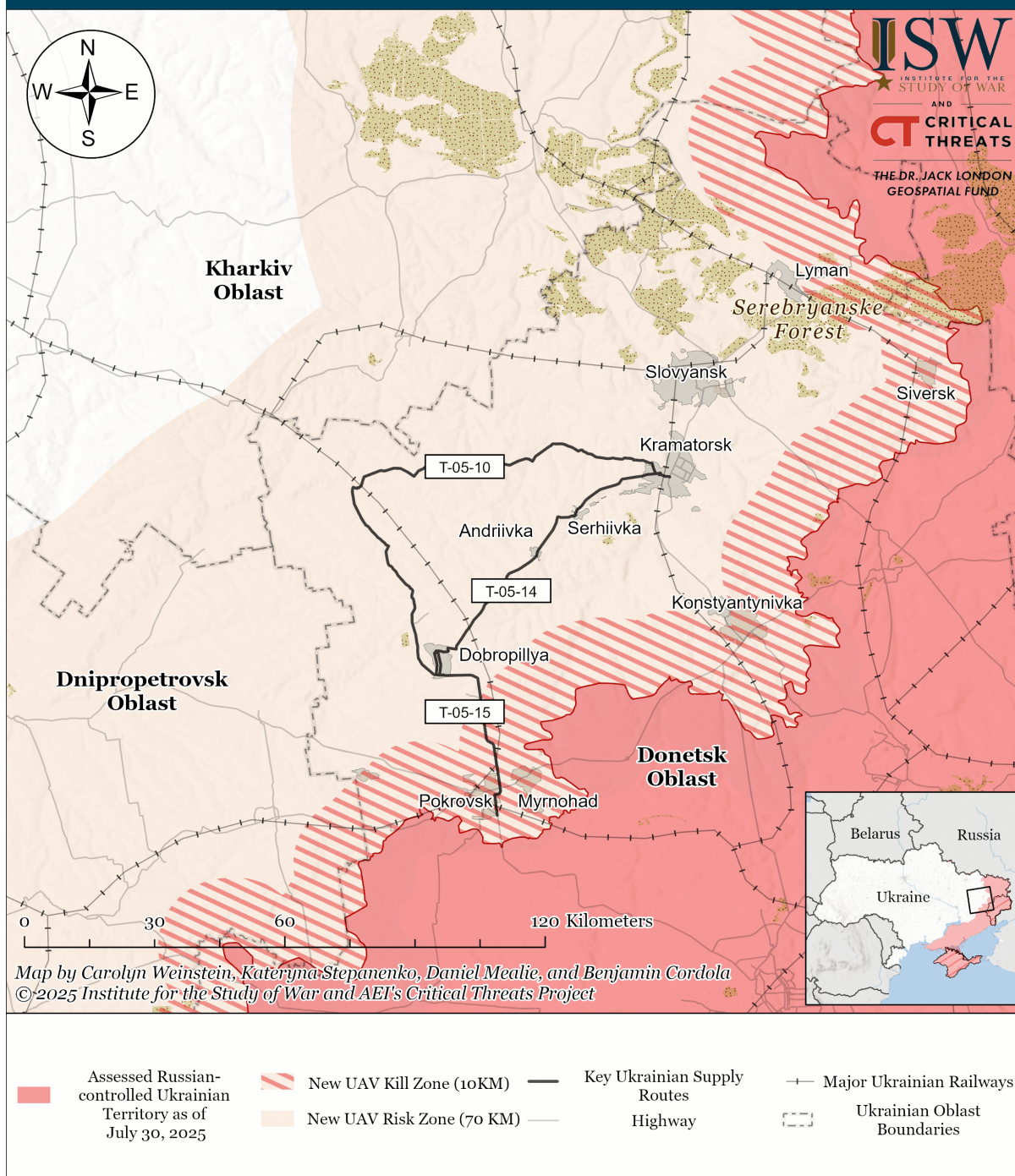




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## Current Extent of Russian Partial Battlefield Air Interdiction Effects in Ukraine





**Russian UAVs are also enabling Russian forces to advance in forested environments in Lyman and Siversk directions, where Russian forces have historically struggled to operate.** Beskrestnov warned in March 2025 that Russian forces had improved their ability to interdict Ukrainian GLOCs in forested areas such as the Serebryanske Forest (in Lyman and Siversk direction) using fiber optic FPV drones.[22] Beskrestnov noted that Russian fiber optic UAVs are increasingly denying Ukrainian forces the ability to move safely along forest roads, which were previously protected from Russian FPV drones due to tree coverage. Beskrestnov explained that tree coverage used to make it very difficult for Russian forces to operate FPV drones and strike targets deep in the woods because the trees interfere with radio signals. Beskrestnov stated that Russian forces are now disrupting Ukrainian logistics, supplies, and rotations in the Serebryanske Forest by targeting Ukrainian trucks driving along forest roads. Beskrestnov observed that Ukrainian forces were surprised by the Russian fiber optic UAV attacks because they were not used to seeing drones operating in this challenging terrain. A Ukrainian serviceman noted in mid-July 2025 that there is a large contested "grey zone" in the Serebryanske Forest, likely due to the increasing use of UAVs in the forest area.[23] Terrain features such as forests and dense vegetation sometimes snag the fiber optic cables, resulting in the UAV disconnecting from the drone operator, but the success rate is apparently high enough to impact Ukrainian operations.[24]

**Russian forces are actively targeting Ukrainian training grounds in the near rear with precise missile strikes enabled by improved reconnaissance UAVs.** Russian forces have conducted at least seven precise missile strikes on Ukrainian training grounds, military infrastructure, and force concentration points since late 2024 with support from Russian reconnaissance UAVs.[25] The Ukrainian Ground Forces most recently reported that Russian forces struck a Ukrainian training ground on July 29, resulting in three dead and 18 wounded Ukrainian servicemen, and Russian sources claimed that Russian forces used Iskander ballistic missiles to strike a Ukrainian training ground in Chernihiv Oblast.[26] Russian forces also launched Iskander ballistic missiles on a Ukrainian training ground in Kherson Oblast on June 22; a training unit in Dnipropetrovsk Oblast on June 1; a training exercise 50 kilometers from the international border in Sumy Oblast on May 20; a training ground in Cherkaske, Dnipropetrovsk Oblast on March 1; a brigade gathering in Zarichne, Zaporizhia Oblast (15km north of the frontline) on November 3, 2024; and a force concentration near Bezdryk, Sumy Oblast (3km west of Sumy City) on September 4, 2024.[27] The affected Ukrainian training grounds and force concentrations were located in frontline or near frontline regions, indicating that Russian forces are achieving some limited effects of BAI using a combination of reconnaissance drones and Iskander missiles.

**Russian forces are striking Ukrainian military-industrial and civilian infrastructure in the near rear with improved tactical UAVs.** Russian forces began leveraging tactical UAVs with extended ranges or other modifications to target Ukrainian military-industrial and civilian infrastructure in major frontline cities — both as part of Russian long-range UAV and missile strike packages and as part of a likely effort to establish persistent fire control beyond the normal 25-kilometer artillery range. Ukrainian regional officials reported that Russian forces have been actively using Molniya, Chernika, and Lancet UAVs in their strike packages against industrial infrastructure, hospitals, and military enlistment offices in the cities of Kharkiv, Sumy, Kramatorsk, Zaporizhzhia, and Kherson since early 2025.[28] Russian forces are also using tactical UAVs to establish persistent fire control over settlements in the near rear. Russian forces have been striking Dobropillya, which some Russian sources described as an important Ukrainian logistics hub for the Pokrovsk direction, with over 70 FPV drones per day.[29]

## **UAV Innovations and New Tactics**



**Russian forces are achieving partial BAI effects and advancing on the battlefield by taking advantage of improved technology and new combined UAV tactics.** Recent Russian UAV innovations, such as increased FPV flight ranges, the incorporation of limited artificial intelligence (AI)/machine learning (ML) capabilities, the proliferation of fiber optic UAVs, the integration of thermobaric warheads, the fielding of sleeper drones, and other technological adaptations, are giving Russian forces important advantages on the battlefield in Ukraine. Russian forces have also been using these technological adaptations in combination with one another to facilitate Russian advances on key Ukrainian towns. The changing UAV tactics are allowing Russian forces to conduct more sophisticated strikes on Ukrainian logistics, defensive positions, and military-industrial infrastructure.

**Russian forces are now capable of striking GLOCs and military infrastructure deeper in the rear with extended tactical UAV flight ranges.** Russian forces extended the range of tactical UAVs by using repeater UAVs, which are equipped with a radio repeater that extends communication signals by acting as a relay station.[30] Russian Molniya fixed-wing FPV drones can now fly at an average range of up to 50 kilometers — a notable increase from the average tactical FPV flight range of five to 15 kilometers.[31] Some Russian loitering munitions, such as Lancets, can also strike targets at distances between 70 and 110 kilometers.[32] Ukrainian sources reported that Russian forces are using Lancet loitering munitions less often than Molniya FPV drones in combat, likely because of the Lancet's relatively high unit cost of \$35,000 and the paucity of specialized drone operators.[33] Ukrainian-controlled parts of Donetsk and Kherson oblasts are within the new 70-kilometer tactical drone strike zone, meaning that Russian improved mid-range strike UAVs could increasingly deny Ukrainian forces the use of key GLOCs and logistics hubs in the near rear.[34] Russian forces are also trying to use medium range Lancets to counter Ukrainian unmanned surface vehicles in the Black Sea at distances over 50 kilometers.[35]

**Russian forces improved their precise strike capabilities by equipping medium range reconnaissance and strike UAVs with AI/ML capabilities, longer-lasting charges, and increased resistance to EW interference.** Russian forces have been using reconnaissance UAVs such as Orlan to identify targets of operational significance in the rear, such as air defense systems, and using less sophisticated ZALA and Supercam reconnaissance UAVs to detect Ukrainian personnel and equipment movements in the immediate rear.[36] Russian Orlan-10 and Orlan-30 reconnaissance UAVs have internal combustion engines that allow the UAV to fly at altitudes up to six kilometers and up to 120 kilometers deep into the rear and to fly for about 10 hours.[37] ZALA and Supercam UAVs have an electric motor that allows them to fly at shorter distances and altitudes without being detected by thermal imagers.[38] Russian improved reconnaissance UAVs are likely enabling Russian forces to launch more precise and coordinated drone, missile, or artillery strikes on Ukrainian military infrastructure in the near rear and more accurately strike Ukrainian force concentrations.

Russian developers reportedly modified Chernika-2 lightweight “flying wing” UAV to have a larger 3.5-kilogram warhead, a 100-kilometer range, and AI/ML-powered optical navigation system, which enables Chernika-2 UAVs to destroy dugouts and heavy military equipment at a greater distance and to defeat Ukrainian EW jamming.[39] Chernika-2 drones reportedly use machine vision to automatically reach a predetermined target or position using images of the terrain uploaded into the drone — even in environments where Ukrainian forces are jamming their communications signals. Russian forces reportedly fielded modified ZALA Z-16 reconnaissance UAVs with new communications channels and autonomous navigation capabilities and operated these drones over 100 kilometers from the frontline near Borzna, Chernihiv Oblast.[40]



**Russian forces are increasingly relying on modified fiber optic UAVs to interdict Ukrainian positions and logistics and to launch precise strikes on Ukrainian military equipment in the immediate rear.** Fiber optic drones are not a particularly sophisticated technological adaptation (wire-guided munitions are a decades-old phenomenon), but Russian forces were able to impose new battlefield dilemmas on Ukrainian forces starting in mid-2024 because these drones were resistant to EW interference, enabled precision strikes on armored equipment, and were scalable due to their simplicity.[41] Ukrainian sources reported that Russian fiber optic UAVs proved instrumental in undermining Ukrainian GLOCs in Kursk Oblast in Spring 2025, and Russian forces have since been using these UAVs to disrupt Ukrainian GLOCs, movement, and rotations in the prioritized frontline directions of Sumy, Kupyansk, Lyman, Kostyantynivka, Pokrovsk, and Novopavlivka.[42] Russian forces used to be able to strike to a tactical depth of around seven kilometers with fiber optic UAVs in early Spring 2025, but have since increased the tactical depth to around 20 kilometers in Summer 2025.[43] Beskrestnov noted that fiber optic UAVs that are capable of flying at longer ranges have a small warhead of around 1.5 kilograms to three kilograms, but that this warhead is sufficient to immobilize a car and injure people in that car.[44]

**Russian forces are ambushing Ukrainian GLOCs, personnel, and military equipment by using fiber optic controlled sleeper UAVs, or drones that are modified to operate on the ground in a low-power standby mode for extended periods.[45]** Russian forces deploy sleeper UAVs to locations such as rooftops, hilltops, and roads, after which the UAV lands, powers down, and remains electronically silent and physically inactive. Russian developers integrated a Gibernator (hibernator) module into Russian FPV UAVs that allows Russian forces to make the UAVs hibernate for several weeks and remotely activate to launch a surprise precision strike on Ukrainian targets.[46] Russian sleeper UAVs rely on a fiber optic tether to maintain control, which makes these UAVs undetectable to most EW systems as they do not make any radio-frequency emissions. Russian forces, in other words, are achieving additional partial BAI effects with low-cost, high-lethality sleeper UAVs that can execute precision strikes from concealed positions.[47]

**Russian forces are trying to destroy Ukrainian defensive positions at depth with new FPV drone modifications incorporating thermobaric warheads.** Thermobaric warheads, also known as vacuum or aerosol bombs, are a type of explosive munition that generates a high-temperature explosion by dispersing and igniting an aerosol cloud of explosives while sucking out the surrounding oxygen.[48] Russian forces began integrating thermobaric warheads, such as Shmel thermobaric weapons, into Molniya-2 and Lancet UAVs to destroy Ukrainian trenches and fortifications.[49] Russian milbloggers notably claimed that Russian forces have been using these UAVs with thermobaric warheads to destroy Ukrainian defensive positions in Sumy Oblast during Russia's Summer 2025 offensive.[50]

**Russian forces are increasingly adopting combined UAV tactics to optimize the use of the improved UAV capabilities and develop complex operations.** Russian forces are increasingly using UAVs to set conditions for Russian ground assault operations. A Ukrainian serviceman observed that Russian groups of two or three people often launch assaults with direct support from FPV and fiber optic UAVs in the Pokrovsk direction.[51] Another Ukrainian serviceman added that Russian forces attack Ukrainian GLOCs in the Pokrovsk direction with three to five UAVs at a time, while jamming Ukrainian drones with deployed EW systems. Russian forces reportedly employ fiber optic UAVs against Ukrainian armored vehicles while actively jamming Ukrainian UAVs, effectively taking advantage of the Russian UAVs' resistance to EW and preventing Ukrainian forces from using UAVs to counter Russian UAV and ground assaults.[52] Russian forces are also using fiber optic UAVs to neutralize EW systems before launching other FPV UAV strikes.[53] Russian forces are



reportedly using Mavic quadcopter UAVs to target Ukrainian infantry and leveraging FPV UAVs such as Molniya drones against Ukrainian military equipment in the Kostyantynivka direction.[54]

Russian forces developed new UAV ambush tactics that enable them to deny Ukrainian forces the use of GLOCs and achieve surprise. Kupyansk Raion Military Administration Head Andriy Kanashevych stated in mid-July 2025 that Russian drone operators are hunting any vehicles moving along roads leading to Kupyansk and ambushing them at opportune moments, making any movement outside and in the city dangerous.[55] Ukrainian servicemen noted that Russian forces are leveraging fiber optic UAVs for ambush tactics, described above, against Ukrainian vehicles in Kostyantynivka and Novopavlivka directions.[56]

Russian forces are actively coordinating various UAV types to achieve operational effects in the near rear. Russian forces reportedly modified their tactical drone packages to extend the strike range of FPV UAVs to up to 300 kilometers by coordinating between UAVs. Russian forces reportedly launch strike packages of two reconnaissance and one strike UAV, in which the middle reconnaissance UAV (such as the Orlan UAV) performs repeater drone functions.[57] Russian forces, for example, reportedly used this tactic to reconnoiter a Ukrainian airfield near Myrhorod, Poltava Oblast (140km from the international border), presumably ahead of the missile strikes on Myrhorod airfield on July 9 by using one Orlan repeater 70 to 80 kilometers from the frontline to support another Orlan drone that was reconnoitering the airfield.[58] Russian forces are facilitating timely precision missile strikes against Ukrainian training grounds with help from tactical reconnaissance UAVs with extended ranges, which are making the Ukrainian near rear more transparent.

**Russia is leveraging its Rubikon Center for Advanced Unmanned Technologies units to improve its theater-wide drone capabilities and integrate new UAV tactics, including in priority frontline areas in Donetsk Oblast.** Ukrainian servicemen operating in the Kostyantynivka direction reported that the recent arrival of drone operators of the Rubikon Center — Russia's recently formed drone training and innovation center — represented a "turning point" in Russia's tactical drone capacity.[59] Russia reportedly deployed Rubikon drone units to Kursk Oblast in early 2025, where Rubikon drone operators equipped with fiber optic drones played a significant role in eliminating the remaining Ukrainian salient. Russia has since redeployed some Rubikon units from Kursk Oblast to eastern Ukraine, mainly to Donetsk Oblast, in Spring and Summer 2025.[60] Rubikon units are also reportedly fielding Russian FPV interceptor UAVs.[61]

**The People's Republic of China (PRC) is actively enabling Russia's drone adaptations and production by providing drone components and production capabilities.** Ukrainian Foreign Intelligence Service (SZRU) Spokesperson Oleh Aleksandrov stated in June 2025 that Chinese manufacturers provide Russia with hardware, electronics, navigation, optical, and telemetry systems, engines, microcircuits, processor modules, antenna field systems, control boards, and navigation systems.[62] Aleksandrov reported that the PRC uses shell companies to avoid sanctions and to provide drone components to Russian drone manufacturers, and that Russia has a critical dependency on the supply of Chinese parts for both tactical and long-range UAVs. Aleksandrov noted that Russian manufacturers produced up to two million small tactical UAVs in 2025 with Chinese support. Russian developers used Chinese components to integrate AI/ML capabilities into Russian drones such as the V2U strike unmanned aerial vehicles (UAVs), which Russian forces recently fielded in Sumy Oblast.[63] PRC companies also reportedly developed a 50-kilometer-long fiber optic coil, likely to enable Russian forces to fly fiber optic UAVs at a longer range.[64] Russian military manufacturers have been increasingly reliant on PRC parts to scale up production of long-range Shahed UAVs.[65]

## Conclusion



**Increased Russian drone strikes against targets along Ukrainian GLOCs are imposing new complex UAV detection and protection requirements on Ukrainian forces across the entire 1,200-kilometer frontline.** Ukrainian forces are installing improvised anti-UAV netting along busy highways and important defensive positions in an effort to defeat various types of FPV drones and loitering munitions.[66] Russian forces are rapidly adapting to these anti-UAV netting efforts by using UAV swarms to poke holes in the netting and are using tactical UAVs to loiter near netting tunnel exits.[67] Ukrainian servicemen noted that their only effective countermeasures against Russian fiber optic UAVs are small arms, which are proving to be less effective as Russia continues to scale its fiber optic UAV production and use.[68] Ukrainian forces also need to develop new radars and ways of identifying UAVs, such as sleeper and fiber optic UAVs, which do not emit radio-frequency signals.[69]

**Further drone adaptations may render traditional EW and air defense countermeasures ineffective on the battlefield.** Ukrainian EW systems are becoming less effective against new EW-resistant or medium range drones, although EW systems are unlikely to become completely obsolete due to the likelihood that radio-controlled FPV drones will remain in large numbers on the battlefield because of their simplicity and low cost. Beskresnov observed that the effectiveness of Ukrainian EW systems mounted on trucks is decreasing because Russian FPV drones are operating on a wider range of frequencies, which makes it challenging for Ukrainian forces to defeat them.[70] Beskrestnov reported that Ukrainian forces do not have enough stationary EW systems to protect all rear areas to a depth of 30 to 40 kilometers and need additional systems to protect against EW-resistant fiber optic UAVs.[71] Traditional air defense countermeasures may be insufficient to resist tactical UAVs en masse, as they are scarce and expensive to operate and scale. Ukraine's Unmanned Systems Forces (USF) reported that traditional air defense missiles can cost up to one million dollars, for example.[72] Ukrainian mobile fire groups may also have a more challenging time shooting down tactical drones that are flying beyond the frontlines, at higher altitudes, or hibernating until activation.

**Ukraine can prevent Russian forces from achieving the limited effects of BAI by urgently developing tactical kinetic anti-drone systems.** Ukrainian developers urgently need to develop a variety of new and inexpensive kinetic countermeasures, both for long-range Shahed and tactical UAVs on the battlefield and in the rear. Ukrainian developers have fielded some tactical UAV interceptors, such as Shrike FPV interceptors that cost \$300 to \$500 and can target Russian reconnaissance and strike UAVs.[73] Ukrainian forces notably posted footage in April 2025 reportedly showing Shrike interceptors targeting Russian Supercam and Merlin reconnaissance drones.[74] Ukrainian developers recently tested robotic air defense modules, which can be fitted with machine guns and are designed to engage low-flying and slow-moving aerial targets.[75] Ukrainian forces are also reportedly planning to start using prototypes of reusable interceptor drones that fire projectiles at Russian UAVs to lower costs and offset shortages of drone interceptor production.[76]

**Ukraine will also need to continue to develop EW systems and countermeasures to suppress radio-controlled FPV UAVs that are still present in large numbers on the frontlines.** Beskrestnov observed that radio-controlled UAVs still dominate "in percentage terms," and Russia will likely continue to use these drones in combination with more advanced FPV UAVs and loitering munitions out of cost efficiency.[77] Ukraine will need to develop new EW capabilities that are able to suppress UAVs at greater distances.

**The West should continue to invest in Ukrainian anti-drone innovations, as the United States and its allies may face similar modern warfare dilemmas in the near future.** The PRC is seemingly intensifying its covert support of the Russian UAV and counter-drone systems production efforts and is likely learning valuable technological and tactical lessons to accommodate Russian parts and equipment orders. The



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adversary entente of Russia, the PRC, North Korea, and Iran may use these lessons in future wars against the United States or its allies.

**Russia's current technological advantage on the frontlines is concerning, but it can likely be made fleeting. Ukraine's ability to adapt, develop new countermeasures, and innovate existing technologies and tactics is one of the key rate determiners of Russia's ability to sustain efforts to achieve some effects of BAI that have been facilitating Russian advances in Spring and Summer 2025.**

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\*Ukrainian military analysts describe the “kill zone” as an area of elevated drone strike risk, in contrast to the US doctrine, which describes the “kill zone” as an area in which drones can strike any equipment or personnel that enters the area. Ukrainian military analysts argue that both Russian and Ukrainian forces continue to operate in these drone “kill zones” for extended periods of time, where they are exposed to elevated drone strike risks but are not always hit with drone strikes upon entering or operating in the area.

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