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From the Frontlines to the Future

Assessing Emerging Technology in Russia's Invasion Strategy and NATO's Next Moves

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Introduction

This piece is a series in the Defense, Emerging Technology, and Strategy (DETS) Program's analysis on the war in Ukraine, including a corresponding policy brief on Ukraine's Battlefield Technologies and Lessons for the U.S. published in July 2023.

This paper provides an overview of how emerging technology (ET) is shaping Russian armed forces conduct in the invasion of Ukraine and the specific lessons the North Atlantic Treaty Organization (NATO) can draw from the current state of play. In assessing the current situation on the ground, we begin by defining ET and highlighting Russia's use of ET in Ukraine - both on offense and defense.

The predominant game-changing ET thus far on both sides of the battlefield has been Unmanned Aerial Vehicles (UAVs), which sit at the intersection of AI, next-generation communication networks, and energy propulsion technology. While our analysis focuses heavily on UAVs, we do examine other ET pathways - including Russia's failed operationalization thus far of hypersonics and sensor fusion in the Sukhoi SU-57.

Finally, we examine ET's impact on Russian tactics and strategy at this stage of the conflict. We argue the conflict has been defined by conventional force employment and lack of air superiority; the primary cumulative role of ET for Russia has been an extension of the conflict, as both sides experience a transparent battlefield.

We conclude with specific implications for NATO to update and review its ET strategic imperatives:

- ***Revisit hi-tech to hi-tech assumptions:*** ET responses need to fully account for Russia's ability to counteract ET weaponry with low-tech, easy-to-mitigate responses, especially in conjunction with conventional means
- ***ET means sustained conflict:*** changing warfare with increased battlefield transparency is leading to longer sustained conflicts of attrition
- ***ET is a lagging indicator***: new unpredicted systems will continue to rapidly change the battlefield and NATO must prepare for the unexpected
- ***Seek out cost-effective defenses against planned ET:*** Ukraine needs affordable and rapidly implementable ways to defend itself against the Shahed-13
- ***Civilian competence for ET scaling:*** if Russia can fuse the military-industrial complex with civilian agency, Russia's model may be more scalable at mass production on a tactically relevant timeline than Ukraine
- ***The future of Russian ET*** will be characterized by specific asymmetric advantages, employing ETs in gray zone conflicts, and dual use ETs to enhance deniability

Framing the Edge

Defining Emerging Technology

The exponential pace of technological innovation and the prolific nature of ET within the defense sector have been recognized in NATO's 2022 Strategic Concept.[1] This concept will be used to anchor our analysis in defining and classifying the different areas of ET. At present, ET is broadly grouped by NATO as encompassing nine areas of priorities, which are artificial intelligence (AI), autonomy, quantum, biotechnologies and human enhancements, hypersonic systems, space, novel materials and manufacturing, energy propulsion, and next-generation communication networks.[2]

For the purposes of this analysis, we define ET as technological tools that:

A. Are only now beginning to cross the threshold of operationalization and are early on in becoming the standard throughout the relevant force structure
B. Possess the ability to fundamentally alter the tactical and strategic calculus of the warfighting, inclusive of creating asymmetric impact vis- à-vis the investment in the technology

Our definition of ET technological tools is inclusive of stand-alone systems, force-multiplier add-ons, and conjunctions of existing and new technology combinations that are in the process of being tested in the battlefield.

NATO has clearly highlighted the importance of creating standards and principles within the ET space, a concern that the United Nations started identifying in 2017.[3] In the absence of these standards and principles at present, this paper takes a broader approach to ETs by including UAVs within our scope of analysis since UAVs sit at the intersection of AI, next-generation communication networks, and energy propulsion technology. Moreover, we have excluded cyberwarfare from our analysis because in Russian doctrine it sits distinctly under the holistic auspices of information operations, which both encompasses cyberwarfare and information operations.[4]

Russia's UAV Lessons Entering Ukraine

Russia's ET strategy is guided by lessons learned in prior theaters of war, specifically Syria, where multiple UAV attacks were carried out on its base in Hmeimim in 2018.[5] From 2019 onwards, the Hmeimim base attacks have been used as a case study for incorporating drone attacks and the relevant electronic warfare elements counteracting these attacks in all major Russian military exercises and drills. The Russian military has also standardized counter-UAV training to improve force protection measures and protect critical infrastructure; these tactics include training ground forces on downing UAVs using firearms.[6]

Russia has also applied lessons learned from other theaters of conflict in developing its ET strategy. In Libya, the Russian military closely watched as combat drones attacked its allies, and Soviet-era anti-aircraft systems had limited success against UAVs.[7] On offense, Russia took note as the international community reported[8] on the possible use of an autonomous Turkish drone, the Kargu-2,[9] which was similar to the KUB-BLA sold by the Zala Aero Group.[10] Similarly, Russia took note of Azerbaijani forces deploying Turkish-built smart drones in the 2020 Nagorno-Karabakh war[11] and paid even closer attention when the same model drones were used against Russian-made -Pantsir S1 air defense systems in Syria and Libya.

In the short term, Russia responded with conventional weaponry, replacing the Pantsir air defense with the Tor-M2 air defense missile systems. The Tor-M2 was more successful (downing 45 drones)[12] since it detects UAVs with at least 70% probability, at a range of 5.5-9 miles, and at the lowest detectable altitude level of 100-200 feet. But, UAVs can be more challenging to detect and take down in the dark, at lower altitudes, and at slower speeds.[13] The Tor-M2's success guided the Russian MoD's investment in early warning radars, anti-aircraft systems, an electronic warfare network infrastructure and development of its UAV program.[14]

Russia's early failures to counter Ukrainian drones on the battlefield and recent low-tech drone attacks on the Kremlin have shown that Russian investments and lessons learned in Syria did not necessarily result in effectively countering the UAV threat. Small UAVs are easy to maneuver, have a very low radar signature, fly at low speeds, and the cost of deploying anti-aircraft systems in dealing with UAVs is very expensive. Early on, Ukraine's volunteer and hobbyist drone units - namely Aerorozvidka - upskilled Ukraine's military capabilities faster than Russia anticipated; the iterative superiority caught Russia by surprise despite extensive experience countering UAVs.

Within Russia proper, consider the city of Moscow's air defenses, which are postured to deter cruise missiles, ICBMs and air strikes. Anti-UAV defenses are a notable omission and Moscow's plan to upgrade its missile defense capability by the end of this year does not account for drones either.[15] These considerations have especially shaped the Russian military's offensive and defensive postures in Ukraine, specifically in using a combination of existing conventional weapons capabilities and adaptation of legacy equipment to mitigate Ukraine's ET capabilities.

On Offense: Russian Employment of ET on the Ukrainian Battlefield

Unmanned Aerial Vehicles (UAV)

Russia's most prolific and widespread use of ETs in Ukraine has been UAVs. Russia uses UAVs in combat to primarily serve as a real-time link between intelligence, rapid target acquisition, and destruction - more commonly referred to as the "reconnaissance-strike/reconnaissance-fire complexes."[16] However, while reports of Russian UAV use in Ukraine are numerous, the extent to which Russia is using UAVs is conventional in nature, with many Russian claims of sophisticated and innovative employment of drones throughout the conflict overstating the capabilities of Russian forces.

Procurement

Russia was estimated to have around 2,000 drones at the beginning of the conflict.[17] The majority of these units were indigenously produced, such as the Orlan-10 (medium range, multipurpose surveillance drone) and the Orion (Medium altitude, long-endurance reconnaissance drone). While these drones have been tested in Syria and Ukraine, ultimately, reports of these systems on the battlefield have decreased, leading to the conclusion that these systems are dwindling in number.[18] This decline, coupled with early supply chain issues, has forced Russia to import the majority of their UAV arsenal from commercial sources.

Two major sources form the basis for resupplying Russia's UAV arsenal. First, Russia has imported commercial systems from China-based DJI's. Such Commercial Off the Shelf (COTS) equipment options signify that Russia's industrial base is not burdened by UAV production, as Russian forces can simply modify the equipment to the use. Although Russia has not employed COTS UAVs at the scale and effectiveness as Ukraine, the short development times, cheaper cost and adaptability of these drones have still provided a significant operational advantage. Second, Russia has relied heavily on Iranian drone imports of the Shahed-136 and Mohajer-6 systems.[19] While imports are currently sustaining UAV operations in Ukraine, Russia has implemented measures to ramp up domestic production, aiming to produce over 6,000 Shaheds domestically by 2025.[20]

Employment

Initially, Russia's limited quantity of UAV systems restricted the impact drones made in Ukraine during the early stages of the invasion. While likely exaggerated, Russia continues to claim that UAVs are integrated throughout their force structure, including motorized rifle, reconnaissance, and tank brigades.[21] At the very least, Russia's aspiration to embrace ET across its force structure speaks to the recognition that ET-driven innovation must be central to responding to the Ukrainian forces. While Russia continues to use drones for more conventional missions such as Intelligence Surveillance and Reconnaissance (ISR), targeting, and propaganda, Russian drone tactics have evolved in three major ways since the beginning of the conflict.

1. **Affordable Mass:** Russia has turned to the Lancet drone, a low-cost, loitering munitions drone produced by the Russian-based ZALA Aero Group.[22] With over 1,500 new systems ordered as of October 2023,[23] Russia is planning to increase use of this system throughout the battlespace. Russia has also adapted and weaponized the Lancet into a "kamikaze" role, accepting high rates of attrition, by rigging these UAVs with explosives and crashing them into Ukrainian targets.[24]

2. **Adapted Mission Sets:** Russian drone employment has focused on civilian infrastructure and terrorizing civilians as swarms of Shahed drones harangue both Ukrainian troops and cities. UAVs are also being modified for Electronic Warfare (EW), as the Orlan-100 drone is being modified with Leer-3 EW capabilities. This drone is used to jam Ukrainian surface-to-air missiles and communications.[25]

3. **Standardization of New Tactics:** Russia has formalized the way it employs drones in battle, using network warfare tactics with computerized command and control tactics for drone operations.[26] These operations have been standardized with new TTPs and training to further cement drone operations as a key component of Russia's Ukraine campaign.[27]

Hypersonic Missiles

UAVs have played a significant role in warfare over the last several decades, but one ET that is nascent on the battlefield is hypersonic missiles. Hypersonic threats are recognized by NATO as a critical challenge due to their speed, maneuverability, and unpredictable trajectory - which makes tracking their flight path challenging and limits the window to intercept.

While Russia claims operational ability of three of the four hypersonic weapons in testing, only the Kinzhal has been seen on the Ukraine battlefield.[a] The Kinzhal has been in service since 2017, initially deployed on fighter jet sorties over the Black and Caspian Seas, and subsequently tested in Syria.[28]

Days before the invasion, Russia deployed fighter jets with the Kinzhal to Syria to counter the US Carrier Strike Group in the Mediterranean - demonstrating Russia's view of the Kinzhal as a key part of their deterrent arsenal.[29] The Kinzhal was then first used early in the conflict, destroying underground weapons depots in March 2022. A year later, the U.S.-made Patriot air defense system shot down a Kinzhal in May 2023.[30] Since this first incident, Ukraine has shot down an additional six Kinzhals fired on Kyiv.

Ukraine's downing of the Kinzhal has two key impacts on not only the current invasion but warfare moving forward: (1) the Kinzhal's employment in Ukraine has called into question the value-add of hypersonics in conflict; (2) the inability to evade modern missile defense systems puts to question the claimed effectiveness of Russia's hypersonic program, especially as the Kinzhal slows significantly over its flight course and is not always accurate. Russia has also employed this weapon sporadically through conflict, leading to the conclusion that its hypersonics arsenal is limited.

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[a] Russia's hypersonic arsenal is currently understood to be the following four platforms:

A. Kinzhal: Air-launched ballistic missile (range 1500-2000 km) with Mach 4-10 capability. Launched from the MiG-31 with potential future use in the TU-22M3 Backfire Bomber. This is the only hypersonic weapon system confirmed to be used in conflict.
B. Tsirkon: Ship-launched Hypersonic Cruise Missile (HCM) (range 1000 km) with Mach 9 capability. It had a projected 2023 deployment, although it has not yet been seen in Ukraine. Used to strike ground or naval at targets, and most Russian naval vessels could be equipped to carry this weapon.
C. Avangard: ICBM-launched Hypersonic Glide Vehicle (HGV) (range 6000 km) with Mach 27 capability. Russia claimed 2020 deployment of this weapon and given its ability to carry either a 2 Megaton-yield nuclear or conventional payload, it is a deterrence-based strategic weapon. This weapon is used on the SS-18 Satan and SS-19 Stiletto ICBMs, and with future use on the SS-X-30, an ICBM capable of carrying 3 Avangard missiles. This system has been tested 4 times with one recorded failure.
D. Zircon: Ship-launched HCM (range 1000 km) with unknown Mach capability. Russia claims a perfect test record, but the missile "suffers from inherent limitations of existing HCM technologies."

Sensor Fusion

The third ET worth highlighting in Russia's offense is sensor fusion. Sensor fusion involves processing and fusing data from different sensors, particularly in the multi-domain context with the goal of enhancing situational awareness and decision-making capabilities.[31] The most cutting-edge sensor fusion in Russia's arsenal is the SU-57 fighter.

Similar to the U.S. F-35 and honed over the skies in Syria, the Russian SU-57 fighter is equipped with sensor fusion technology. These fifth-generation fighters contain numerous systems to provide the pilot with an unparalleled operating picture in the sky; "sensor fusion is the integration of data from multiple sensors to produce a more consistent, accurate, and useful"[32] operating picture than any sensor can give alone. Augmenting sensor fusion with AI and machine learning will fundamentally shift air operations as the plane and pilot work as one machine, making split second decisions with a complete view of the battlefield. Machine learning allows the plane to continuously develop throughout training and operations to hone these decision-making processes.

There are conflicting reports about whether Russia has deployed the SU-57 to Ukraine, and even positive reports indicate the SU-57 is serving in very limited roles.[33] Russia's acquisition of sensor fusion technology, however, is important to note for the future of their emerging weapons technology strategy, especially as more use cases of such technology are deployed over time.

Credibility of Russian ET

Since the initial invasion, Russia has cited extensive use of ET on the battlefield and has touted extensive ET capabilities. Regarding hypersonics, President Vladimir Putin stated, "... in our advanced developments, we are definitely the leaders."[34] The Russian military has, "hyped their exoskeleton-based combat suits, which reportedly offer increased armor coverage, situational awareness and mobility."[35]

While Russia continues to use some ET, such as UAVs, extensively in their campaign, the Kremlin's other ET claims often appear to be exaggerated or unsubstantiated. Russia undoubtedly sees the value of ET in Ukraine and uses threats of advances in ET for deterrence and posturing.

Additionally, "the Kremlin has a bad habit of claiming to possess sophisticated operational weapons systems, like the Su-57 5th Generation stealth fighter jet or T-14 Armata battle tank," yet these systems fail to show up on the battlefield. [36] Another such claim is the Uran-9, an unmanned combat ground vehicle (UCGV); Russia claims this tank will be deployed in the Donbas to counter Ukrainian Abrams and Leopard tanks. [37] With its 7.62mm machine gun and 2x guided anti-tank missiles, the Uran-9 has reportedly autonomously navigated a 100km route.[38] Future plans include pairing the UCGV with swarm drones and integrating it further into Russian ground forces with a 20-strong UCGV unit.[39] Overall, the buzz word of emerging tech is being used as a deterrent; Russia is focusing more on leveraging the rhetoric of ET, while deployment of actual new hardware lags behind expectations.

On Defense: Russia's Response to Ukrainian ET Implementation

Ukraine's Explosive use of UAVs

At the battlefield level, Ukrainian ET operationalization has centered around UAVs and strikingly with the extensive usage of non-military drones operated by volunteer and hobbyist drone units (namely the Aerorozvidka).[40] As mentioned earlier, non-military drones possess several advantages such as ease of availability, replaceability, modifiability, maneuverability (due to their smaller sizes) and economy of cost (allowing for a high churn due to losses). Commercial drones were not without limitations; predominantly vulnerable to electronic jamming, source detection and limited night capability due to additional cost incurred of installing such upgrades.

Ukraine's ET implementation of UAV innovation, however, possesses the advantage of becoming a testing ground for multiple international partners. By deploying different types of UAVs to test out the various iterations of the technology, much like the attacks on Russia's based in Hmeimim, Ukraine can counteract some of the limitations posed by off the shelf commercial equipment.[41] German AI-powered drones,[42] British 3D-printed drones,[43] Australian cardboard drones,[44] and compact Norwegian Black hornet surveillance drones[45] are all being tested on Russian forces.

Electronic Warfare

The electromagnetic spectrum (EMS) is defined in military doctrine as, "a military or intelligence operation that uses all or parts of the electromagnetic spectrum (EMS) – radio waves, microwaves, millimeter waves, infrared, visible light, ultraviolet light, x-rays, and gamma rays – to detect actions or communications, protect against enemy activities, communicate, and/or deny an adversary's use of those signals."[46]

Given the realities and restrictive sanctions from the West,[47] Russia has heavily relied on robust electronic warfare tools in all aspects of defense. In defense of hardened positions like Sevastopol, Russia has employed powerful jamming capabilities to protect the Black Sea Fleet from Ukrainian UAVs.[48, 49] On the battlefield itself, Russia is playing across the electromagnetic spectrum to jam Ukrainian command and control signals and to disrupt the flow of data between Ukrainian elements.[50]

Russia's EMS jamming capabilities are difficult to accurately detect because they are adaptive and fast-changing. Given the breadth of the electromagnetic spectrum, the Russian military's EMS signals disrupting UAV flights have become complex and numerous. The signals Russia is using to jam span thousands of systems that Ukraine needs to track; not to mention the countless parameters that reliably separate one EMS emitter from all the others.

Russian systems, "are increasingly software-defined and adaptive, designed to evade accurate detection using straightforward means."[51] Ukraine is likely fighting cutting edge EMS jamming with conventional detection. Russia employs irregular pulse patterns in low-probability-of-intercept (LPI) radars that can, "switch rapidly between waveforms in a matter of seconds or can even generate new modes, thus confounding the entire approach of using preset lookup tables to identify those systems."[52] Moreover, the Russian military employs a mix of portable & mobile EW systems, with a focus on reconnaissance and the jamming of hostile UAV control and navigation channels at low to medium altitudes.

Given the extensive Soviet history of Russia's advanced EMS operations, Russia announced the development of the Triton defense system[53] in August 2023 which has the reported capability of suppressing control channels across four frequency bands and data transmission of UAVs. The system can be remotely controlled and is powered by battery or the tank's onboard network.[54] Moreover, the new RB-109 Bylina electronic warfare system is expected to be deployed starting in 2025. The easy-to-deploy system excels in independently deciding how to organize suppression of hostile targets using elements of artificial intelligence. Russian military experts project that the system's introduction will improve Russia's electronic warfare effectiveness by 40%.

Conventional & Low Tech Responses

At the same time, Russia's response to Ukraine's ET operationalization has spanned the full spectrum. One example from the low tech side is Russia's use of old tires piled on aircraft. In order to reduce the heat signature and absorb the potential impact of kamikaze UAVs, overhead imagery shows Russia piling tires on top of combat aircraft.[55]

On the conventional side, Russia's Black Sea Fleet has encountered Ukraine's sea drones[56] and lost vitally important vessels - like the Moskva[57] last summer. Here, Russia is taking a conventional defensive approach against naval autonomous systems: equipping surface vessels with kinetic and electronic warfare systems, and training crew to repel attacks with high caliber machine guns. Not all Ukrainian ET successes are being met with Russian ET defenses, but rather Russia is playing along the entire spectrum of weapons technology to counter Ukraine's ET-centric resistance.

ET's Impact on Russia's Strategy

Given Russia's offensive and defensive employment of ETs, what has the impact been on Russia's overall strategy of the war? Immediately following the failed full invasion of Ukraine, Russia's strategy shifted to a focus on the Donbas region. Over the past 22 months, this strategic objective has remained largely unchanged. Despite claims of the game changing nature of ET, this sixth generation of warfare has had little impact on the broader strategic objectives. We see two major elements defining Russia's calculus both at the strategic and tactical level: the style of troop deployments and lack of air superiority. Then, we examine the primary cumulative role of ET in the transformation of the battlefield.

Force Employment

At the outset, Russia intended to use a modernized employment of battalion tactical groups (BTG), modeled after Western forces and one better suited to Russian manning. The BTG would, "keep the brigade as a parent formation and have maneuver units based on a mechanized infantry battalion with attachments to form a combined arms unit".[58] Putin designed BTGs for short, high intensity conflict; this had success in Syria, but during the early months of the invasion of Ukraine the BTGs sustained heavy casualties and became smaller in their design. A cornerstone of Russian doctrine for a decade preceding Ukraine fell by the wayside, and Putin shifted to, "division-sized formations in the hopes of having a strong enough unit able to withstand heavy casualties without losing its combat capability".[59] ETs had limited impact on this major change - if only that Ukraine's successful employment of mass UAVs contributed to the BTGs casualties.

Air Superiority

At the onset of Russia's invasion of Ukraine, analysts assumed Russian air superiority was a foregone conclusion. A year and a half into the conflict, Russia has been unable to gain air superiority defined as being able to conduct air operations "without prohibitive interference by the opposing force."[60] No one makes the case for the crucial role of air power more than President Zelensky himself when he emphasizes to NATO the need for advanced air defense systems and F-16s to break through Russia's lines.

Fixed wing aircraft, while effective in limited air to air combat along the front lines, have been largely denied in Ukrainian airspace. Russia's inability to suppress Ukrainian air defenses has meant fighters have to conduct standoff strikes from Russian territory.[61] Russia is relying on long range weapons, but they are unable to strike effectively because they lack precision targeting data partially because Ukrainian air defenses deny Russia persistent fixed-wing airborne ISR.[62] Despite Russia's advances in some areas of ET, they have failed a crucial first objective in a land campaign: air dominance.

The SU-57 coming online could impact this given its sensor fusion capabilities, as discussed above. This ET would allow Russian pilots to make faster decisions, therefore increasing its ability to evade Ukrainian air defense systems. While there are conflicting reports about whether Russia has deployed or even has the capability to deploy SU-57 units to Ukraine,[63] this technology could help Russia establish air superiority, a potential turning point in this war.

Transformation of the Battlefield

The primary cumulative role of emerging technology for Russia has been an extension of the conflict, as both sides experience a transparent battlefield. This transparency, facilitated by advanced surveillance and reconnaissance technologies, has led to a prolonged, attritional warfare where each side continuously adapts to the evolving tactical landscape.

Although much of the narrative surrounding the conflict has been on the impact of ETs, the transparency has transformed the battlefield into a more traditional conventional land warfare fight highly dictated by geography. The physical domain rather than the technologic one has a huge bearing on warfighting in the region; mountains and valley systems impact all functions in combat from logistics, to maneuvering, to concealment.

And in this war of attrition, Russia continues to use Soviet style tactics by deploying manpower in large numbers in order to reinforce its sheer force size structure and to continue bleeding Ukraine of its finite ET resources, despite best efforts by Western partners. Defense analysts have postured that ET could result in a decline in those killed in action as thousands of UAVs are downed and the front lines are extended; but in this first ET war, such claims may not be bearing out as much: Russia seems intent on blunting any ET impact by taking on alarmingly high casualties.

At a strategic level, the true impact of ETs in the Ukrainian theater of war is, rather shockingly, how it has transformed a 2023 European conflict into one resembling 1916 Europe at the Battle of Verdun with extremely static front lines. Real-time ISR enables real-time adaptation and real-time defense; the advantage of the conflict has gone to the defender as offensive operations are harder to conceal.

At a tactical level, however, the difference between the battlefield of WWI and eastern Ukraine today, is that rapid ET innovation could offer a local breakthrough at any time along a static line. Dual use technology can and has been rapidly weaponized, and this acceleration of the process is highly adaptive and difficult to predict. Enhanced fusion of Russian military instruments of power with civilian agency will enable Russia to adapt ETs far faster, enabling rapid development and vertical integration of capabilities in both hybrid and conventional settings. This will also reduce the burden upon delivering large scale, complex military specific systems and enable agile experimentation to provide greater support to smaller formations at pace and generate affordable mass. To do so, Russia will need to leverage a wider set of commercial (non-national) supply chains which may yet prove to be the greater challenge.

Implications for NATO

Given Russia's employment of ETs both offensively and defensively we put forth several lessons NATO should consider, grounded in the key takeaway that the war remains a largely conventional fight where mass is critical:

Revisit hi-tech to hi-tech assumptions - The West often assumes that ET requires a commensurate hi-tech ET response. Given the supply chain pressures put forth by the sanctions regime on Russia, the Russian military forces are innovating across the entire spectrum of technology options, oftentimes using low-tech tactics to counteract high-tech ET. To that end, Russia has identified simple solutions - like tires on strategic aircraft for protection from kamikaze drones. Moving forward, ET responses need to fully account for Russia's ability to counteract ET weaponry with low-tech, easy-to-mitigate responses, especially in conjunction with conventional means.

ET means sustained conflict - Changing warfare with increased battlefield transparency brought by ET is leading to longer sustained conflicts of attrition. Both sides have visibility into the enemy, and NATO needs to prepare for a yearslong war in Ukraine because of this. Furthermore, a long war at this point plays into Russia's hands as support degrades and the world shifts to the next crisis. Ukraine needs to effectively employ multi domain operations (MDO) to connect effects across domains for any hope of breaking a stalemate.

Lagging indicator - ET is dynamic and hardware coming online could have a significant impact. Even if certain aspects of Russian ET are not a concern at the moment, it is important to be prepared for the possibility of the future. Russia has lost a significant volume of hardware in the conflict; the Russian armed forces will likely look strikingly different in six to ten years and ET will play an increasing role. This is especially true with Russia using ETs to adapt legacy equipment for the future battlespace.

Seek out cost-effective defenses against planned ET - Ukraine needs affordable and rapidly implementable ways to defend itself against the Shahed-136, which Russia is planning to employ en masse. RUSI identified, "one option could be compact radar and/or laser ranging and sighting systems to allow numerous existing anti-aircraft guns to be much more accurate and effective against them".[64] Moving forward, Russia will seek out recycle/reuse/repurpose opportunities given the high churn of UAV warfare and supply chain crunches, incentivizing UAVs that have higher versatility, reparability, and reusability.

Examine the role of civilian competence for ET scaling - Unlike Ukraine, Russia does not possess a counterpart to the citizen-sourced Aerorozvidka ecosystem that Ukraine's drone operations draws heavily from for innovative UAV tactical adjustments on the battlefield.[65] Whereas Ukrainian forces have been able to lean on volunteer and hobbyist civilian counterparts to test out different UAV iterations, small tactical units within the Russian forces have been left to conduct their own testing on commercial drones, sans civilian collaboration. Ukraine's competitive advantage is in innovation and flexibility, but if Russia can fuse the military industrial complex with civilian agency, Russia's model may be more scalable at mass production on a tactically relevant timeline.

The future of Russian ETs - Three elements characterize the future picture of Russia's employment of ETs. (1) Russia is looking for specific asymmetric advantages because they know they cannot compete across the board with NATO. These asymmetric advances will likely be concentrated in ETs within hypersonics, space, and subsurface. (2) With the rise of gray zone conflicts globally, Russia will seek to leverage ETs not just for asymmetric advantages against NATO, but in non-traditional combat spaces. Layering of ETs will increase Russia's effectiveness in destabilization efforts while avoiding full scale military engagement. (3) Dual use ETs will further assist to blur the lines and assist in deniability. Russian advances in unmanned underwater vehicles (UUVs), although yet to make an impression on the war in Ukraine, provide one such data point of an upcoming ET that will assuredly be dual purpose and capable of augmenting gray zone conflicts.

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