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Ukraine's Lessons for Future Combat: Unmanned Aerial Systems and Deep Strike

Harry Halem

ABSTRACT: The Russia-Ukraine War holds many lessons for the US Army and American policymakers and leaders on the nature and role of reconnaissance-strike complexes in modern combat, especially Ukraine's development of a battle-management system that fuses unmanned aerial systems and satellite reconnaissance to enable the fire coordination for deep strikes into the enemy rear. In the research presented here, open-source analysis and interviews in Ukraine focus on the development and employment of reconnaissance-strike complexes with respect to deep strike and the likelihood of mutual territorial attack.

Keywords: unmanned aerial systems, deep strike, reconnaissance-strike complex, electronic warfare, Russia-Ukraine War

The Russia-Ukraine War presents the first instance in which both combatants deploy robust, if still largely primitive, reconnaissance-strike complexes (RSCs) that they innovate during wartime. This situation allows observers to identify fundamental mechanics of the interaction between these complexes that provide programmatic and intellectual lessons for the US Army as it prepares to face near-peer adversaries for the first time since the 1980s. Ukraine's experience demonstrates the relevance of RSCs to the deep fight—in Ukraine's case, a complex enabled by unmanned aerial systems (UAS) is employed to allow for strikes deep into the Russian rear, using a handful of precision weapons to generate major effects.

This analysis first identifies the roots of Ukrainian military learning from 2014–22 and argues that the Russia-Ukraine War constitutes a watershed moment in combat because both sides employ a primitive RSC. It then explicates the technical and operational characteristics of Ukraine's unmanned aerial system and intelligence, surveillance, and reconnaissance (ISR) system and identifies the manner in which Ukraine's UAS-ISR system generates opportunities for deep strike. Finally, it outlines several programmatic and intellectual takeaways for the US Army, particularly on the role of deep strike.

Context: Ukraine's Strategic Problem and Military Learning

The current Armed Forces of Ukraine (ZSU) reflect a cross section of Ukrainian society, making civilian applications like Signal and Scribble Maps crucial to Ukrainian UAS-ISR use as new soldiers turn to technologies they know from civilian experience. Nevertheless, the system's basic idea—to create a pervasive UAS-ISR complex, link it to commanders, and enable distributed fires—has existed since the 2014 Donbas war because Ukraine has confronted a relatively consistent strategic problem.

The Russian armed forces have outmatched the ZSU since the Donbas war began.[1] In 2014, Ukraine had around 6,000 combat troops, had just experienced a traumatic change in political leadership, and had virtually no international partners even when compared to Russian-backed forces in eastern Ukraine.[2] Yet, Ukraine's ragtag forces gained an advantage over the Russian-backed separatists, prompting a Russian intervention, and despite setbacks, performed reasonably well.[3] From that point, Ukraine's strategic problem was apparent: it confronted a qualitatively and quantitatively superior Russian military while lacking clear allies. The Ukrainian armed forces were, therefore, compelled to innovate.

Despite Ukraine's structural political issues, specific bureaucratic shifts and its political culture gave the ZSU a learning advantage over the Russian military. In 2018, Ukraine redesignated the Anti-Terrorist Operation—

Author's Note: In between this article's composition and publication, one of its sources, and one of my close friends, was killed in action. His loss, like so many others, came in defense of his country and serves as a reminder of the sacrifices liberty demands.

Acknowledgments: I spent several weeks in Ukraine in March 2023 and discussed unmanned aerial systems (UAS) employment in intelligence, surveillance, reconnaissance, and targeting (ISR/T) contexts with a variety of active Ukrainian military personnel. My dataset is, of necessity, incomplete. Any number of interviews do not indicate a legitimate sample size for data experimentation. The nature of this war and the time that analysts have to collect and process information indicate that my conclusions are more inductive inferences subject to future refinement than deductive truths. Nor did my limited Ukrainian linguistic abilities help the situation. I am indebted to those Ukrainian soldiers and civilians, among many others in Ukraine, who were willing to help bridge the gap with subjects who would have struggled to communicate with me. Indeed, the openness of many Ukrainians to foreign observers should not be underestimated—in retrospect it should come as no surprise that a nation of 44 million struggling for its existence should welcome all the help it can receive from external assessors. One unimpeachable conclusion I can draw is that the United States and its allies should leverage this cultural reality and get as many analysts—uniformed and civilian—into Ukraine as possible. Moreover, in a war as violent and intense as this one, any data rapidly lose accuracy with time. All conclusions must be updated with fresh information.

1. Mykhaylo Zabrodskyi et al., *Preliminary Lessons in Conventional Warfighting from Russia's Invasion of Ukraine: February–July 2022* (London: Royal United Services Institute [RUSI], November 2022), 13–18, 36.

2. Lawrence Freedman, *Ukraine and the Art of Strategy* (New York: Oxford University Press, 2019), 106–16.

3. Freedman, *Art of Strategy*, 114. See also Andriy Zagorodnyuk et al., "Is Ukraine's Reformed Military Ready to Repel a New Russian Invasion?," *UkraineAlert* (blog), Atlantic Council (website), December 23, 2021, https://www.atlanticcouncil.org/blogs/ukrainealert/is-ukraines-reformed-military-ready-to-repel-a-new-russian-invasion/.

the bureaucratic title for Kyiv's operations in the country's east—as the Joint Forces Operation.[4] This change formally recognized Russia as a belligerent in the conflict and shifted command responsibility from the Security Service of Ukraine to the Ukrainian General Staff. This transition enabled a robust learning process within the Armed Forces of Ukraine since its soldiers and officers could openly discuss the war they were fighting. Internal learning dovetailed with the West's training missions.[5] The Russian military, by contrast, was never formally at war. The Syrian Civil War became its reference point—a conflict in which Russia held absolute air control and played an enabling role was not a helpful analogy to the current Russia-Ukraine War.[6] Moreover, multiple high-level Ukrainian commanders today experienced combat in the Donbas or were part of the post-2014–15 training cycle and are far younger than their Western counterparts, indicating significant cultural turnover that enables innovation.[7]

Also developed from 2014–22 was the sophisticated volunteer nongovernmental (NGO) system that interfaced directly with the military since the earliest days of the Donbas war. Most notable of these NGOs is the UAS-focused Aerorozvidka.[8] Relations between the Ukrainian defense ministry and these NGOs have been fractious at times. Even in wartime, it took months for the defense ministry to begin procuring unmanned aerial systems for units directly—and today, private donations remain essential. The elements of the current Ukrainian system, however, have deep roots in the strategic culture of the ZSU.

Historical Trends and Modern Strike

The Ukrainian armed forces' UAS-ISR system, an outgrowth of their unique strategic culture, is of interest for more than just tactical and

4. Adam Coffey, "Commentary – Ukraine Declares 'Anti-Terrorist Operation in the Donbas' Officially Over: What Does That Mean?," RUSI (website), May 16, 2018, https://rusi.org/explore-our-research/publications/commentary/ukraine-declares-anti-terrorist-operation-donbas-officially-over-what-does-mean.
5. Per the author's work in Ukraine (March 29, 2023), these missions have had a cultural effect since the 1990s, which only intensified after 2014 when the ZSU pivoted to a war footing. See also John Jaworsky, "Ukraine's Armed Forces and Military Policy," *Harvard Ukrainian Studies* 20 (1996): 238–40.
6. For Russian assessments of Syria, see Mason Clark, *The Russian Military's Lessons Learned in Syria*, Military Learning and the Future of War Series (Washington, DC: Institute for the Study of War [ISW], January 2021), 11–12.
7. "General Valerii Zaluzhnyi: Commander-in-Chief of the Armed Forces of Ukraine," Ministry of Defence (MoD) of Ukraine (website), last updated September 23, 2021, https://www.mil.gov.ua/en/ministry-of-defence-leader/general-valerii-zaluzhnyi.html; Yuri Lapaiev, "New Appointments in the Ukrainian Military: Occasion for Restrained Optimism?," *Eurasia Daily Monitor* 18, no. 132 (August 2021), https://jamestown.org/program/new-appointments-in-the-ukrainian-military-occasion-for-restrained-optimism/; and "Lieutenant General Serhii Shaptala: Chief of General Staff of the Armed Forces of Ukraine," MoD of Ukraine (website), last updated September 23, 2021, https://www.mil.gov.ua/en/ministry-of-defence-leader/lieutenant-general-serhii-shaptala.html.
8. Patrick Tucker, "Ukraine's Drone Warriors," *NATO Source* (blog), Atlantic Council (website), March 10, 2015, https://www.atlanticcouncil.org/blogs/natosource/ukraine-s-drone-warriors/.

programmatic reasons. The Russia-Ukraine War, the first large-scale conflict since the 2003 invasion of Iraq, is also the first war during which both sides have had to innovate and modify their reconnaissance-strike complexes and, indeed, the first conflict in which both combatants have something approximating RSCs.

The RSC concept has its roots in Soviet and Russian doctrine but is conceptually identifiable in Western military thought.[9] In brief, the reconnaissance-strike complex is an integrated intelligence, surveillance, reconnaissance, and targeting (ISR/T) fires system, in which the time between target identification and engagement is extremely compressed.[10] Sensors and shooters operate together in a harmonized network that makes combat a game of target identification, in which the side that is found first is usually killed.[11]

The RSC concept is inextricably linked to intellectual-doctrinal developments in the 1980s in the United States and Soviet Union.[12] Both doctrines increasingly pointed toward attacking the enemy at operational depth, a more natural line for the Soviets with deep operational theory, but one that finally translated into the West.[13]

A properly constructed RSC should enable the synchronization of violence across an immense battlespace at depth and width, creating a combat area orders of magnitude larger than what was historically feasible.[14] The US military deployed an early reconnaissance-strike complex in the Iraq wars, while China and Russia have deployed their own RSCs since the late 2010s.[15] These complexes should also include artificial intelligence (AI); the fact that neither Ukraine nor Russia employs major AI indicates the degree to which their reconnaissance-strike complexes are still primitive.

9. Lester W. Grau and Charles K. Bartles, *The Russian Reconnaissance Fire Complex Comes of Age* (Oxford, UK: University of Oxford Changing Character of War Centre/Axel and Margaret Axson Johnson Foundation/Pembroke College Oxford, May 2018), https://www.ccw.ox.ac.uk/s/The-Russian-Reconnaissance-Fire-Complex-Comes-of-Age-lz7p.pdf.

10. B. A. Friedman, "Reconnaissance-Strike Tactics and Maneuver Warfare I," *Marine Corps Gazette* (April 2022), WE3, https://mca-marines.org/wp-content/uploads/Reconnaissance-Strike-Tactics-and-Maneuver-Warfare-I.pdf.

11. Andrew F. Krepinevich, *Maritime Warfare in a Mature Precision-Strike Regime* (Washington, DC: Center for Strategic and Budgetary Assessments, 2014), 82–83, https://csbaonline.org/uploads/documents/MMPSR-Web.pdf.

12. See Milan Vego, *Recce-Strike Complexes in Soviet Theory and Practice* (Fort Leavenworth, KS: Soviet Army Studies Office, June 1990), https://apps.dtic.mil/sti/pdfs/ADA231900.pdf; and Michael J. Sterling, *Soviet Reactions to NATO's Emerging Technologies for Deep Attack*, RAND Note (Santa Monica, CA: RAND Corporation, August 1985), https://www.rand.org/content/dam/rand/pubs/notes/2009/N2294.pdf.

13. Douglas W. Skinner, *Airland Battle Doctrine*, Professional Paper 463 (Alexandria, VA: Center for Naval Analyses, September 1988), 13, 31.

14. Gordon R. Sullivan and James M. Dubik, "Land Warfare in the 21st Century," in *Envisioning Future Warfare* (Fort Leavenworth, KS: US Army Command and General Staff College Press, 1995), 12.

15. Andrew F. Krepinevich Jr., *The Origins of Victory: How Disruptive Military Innovation Determines the Fate of Great Powers* (New Haven, CT: Yale University Press, 2023), 39ff.

Ukraine is not the first conflict in which UAS and loitering munitions have been deployed at large scale. The Second Nagorno-Karabakh War included extensive UAS employment and, arguably, a nascent RSC on Azerbaijan's part.[16] Azerbaijan's success (at least partly) stemmed from structural deficiencies in the Armenian military, namely its lack of short-range air defenses against loitering munitions, inability to intercept fixed-wing UAS consistently, and limited electronic systems.[17]

By contrast, the Russia-Ukraine War provides sufficient scale and sophistication for conclusions to be drawn. Indeed, it is the first case of two militaries deploying and modifying their reconnaissance-strike complexes at scale in a competitive manner during wartime. Ukraine and Russia use much of the same equipment in their RSCs, while Russia has replicated Ukrainian employment methods.

Ukrainian UAS-ISR System

The ZSU has developed a sophisticated method of UAS employment that is integrated with a broader battle-management system that also receives information from US and private satellites.[18] Precision-guided munitions are increasingly capable of hitting any individual target. Historically, however, weapons performance has exceeded practical ISR range.[19] Ukraine demonstrates how unmanned aerial systems can narrow the precision-ISR gap through the creation of a UAS-enabled reconnaissance-strike complex.

Ukraine's UAS-ISR system accomplishes two goals. First, it transforms traditional artillery fired in battery into "precision" weapons that can individually engage targets and rapidly improve accuracy. Second, it enables the Ukrainian armed forces to employ artillery in a distributed manner by facilitating responsive surveillance over a much wider area when combined with

16. Jack Watling and Sidharth Kaushal, "Commentary – The Democratisation of Precision Strike in the Nagorno-Karabakh Conflict," RUSI (website), October 22, 2020, https://rusi.org/explore-our-research/publications/commentary/democratisation-precision-strike-nagorno-karabakh-conflict.
17. Shaan Shaikh and Wes Rumbaugh, "The Air and Missile War in Nagorno-Karabakh: Lessons for the Future of Strike and Defense," Center for Strategic and International Studies (CSIS) (website), December 8, 2020, https://www.csis.org/analysis/air-and-missile-war-nagorno-karabakh-lessons-future-strike-and-defense.
18. See Aaron Stein, "Airpower after Ukraine – The TB2: The Value of a Cheap and 'Good Enough' Drone," Atlantic Council (website), August 30, 2022, https://www.atlanticcouncil.org/content-series/airpower-after-ukraine/the-tb2-the-value-of-a-cheap-and-good-enough-drone/. On Kropyva's defense mapping software, see David Axe, "There's a Good Reason the Russian Air Force Is Faltering. Ukrainian Air-Defense Crews Have Better Apps," *Forbes* (website), October 18, 2022, https://www.forbes.com/sites/davidaxe/2022/10/18/theres-a-good-reason-the-russian-air-force-is-faltering-ukrainian-air-defense-crews-have-better-apps/; *Kyiv Independent* News Desk, "News Feed – Ukraine to Introduce Delta Situational Awareness System for Military," *Kyiv Independent* (website), February 4, 2023, https://kyivindependent.com/government-introduces-nato-standard-delta-management-defense-system/; and "GIS 'ARTA': Automated Command and Control System," n.d., GIS ARTA (website), https://gisarta.org/en/.
19. Benjamin F. Koudelka Jr., *Network-Enabled Precision Guided Munitions* (Maxwell Air Force Base, AL: Air War College Center for Strategy and Technology, November 2005), 86.

a fluid battle-management system. This capability reduces the need for exposed logistics hubs and decreases Russian counter-battery effects, thereby allowing the ZSU to remain competitive despite a materiel disadvantage.

Ukraine's UAS-ISR system requires the four types of UAS outlined in table 1 below.[20] It must be noted that Russian forces increasingly replicate Ukrainian practices, though on average without commensurate results because of poor training standards, less effective equipment, and a lower-quality officer and technical specialist corps. Given the author focused overwhelmingly on Ukrainian tactics, techniques, and procedures during his time in-country and only incidentally discussed Russian practices, the UAS description focuses largely on Ukrainian ISR/T practices. Moreover, while factory specifications vary from the information depicted below for each type of unmanned aerial system, battlefield conditions often limit operational range.

Table 1. Four types of unmanned aerial systems required by Ukraine's UAS-ISR system

Diameter	Cost	Range	Service Ceiling	Special Features
Small > 1 meter	< $1,000	5 kilometers	> 1,000 meters	First-person view, copter, used for very short-range reconnaissance and as loitering munitions
Medium 1 meter	$1,000 – $10,000	6 kilometers	1,000 meters	Short-range reconnaissance, light ordnance, and night work
Large 1–3 meters	$10,000 – $30,000	10 kilometers	> 1,000 meters	Backbone of Ukrainian ISR
Fixed-Wing > 3 meters	> $30,000	> 20 kilometers (some reach several 100 kilometers)	1,000 meters plus	Highest-quality sensors

Units often share information at the fireteam and squad level, but most intelligence analysis and target distribution occurs at the company to battalion level. The system's flexibility stems from Ukraine's technological literacy and extensive efforts to shift UAS-dense units around the front line. Much UAS training occurs through private charities that acquire unmanned aerial systems on the European market, transfer systems to units, train operators, and conduct the equivalent of doctrinal development.

20. Information in table 1 comes from the author's interviews, alongside other information in the public domain. See Jeffrey A. Edmonds and Samuel Bendett, *Russia's Use of Uncrewed Systems in Ukraine* (Arlington, VA: Center for Naval Analyses, March 2023), 10, https://www.cna.org/reports/2023/03/Russian-Uncrewed-Systems-Ukraine.pdf; and David Hambling, "Editors' Pick: Ukraine's Next-Generation Drone Fleet Is Packed with Upgrades," *Forbes* (website), March 1, 2023, https://www.forbes.com/sites/davidhambling/2023/03/01/ukraines-next-generation-drone-fleet-enhances-capabilities/.

The Ukrainian battlespace is extraordinarily congested. A 20-kilometer zone around the contact line contains extensive trench lines, ground-based electronic warfare (EW) systems, air defenses, artillery batteries, and counter-battery radars. Moreover, most Ukrainian UAS are dual use, making them operationally intuitive and cheap but decreasing their resilience to electronic warfare and the quality of their sensors and optics. Copter optics, with their roughly 20-kilometer daytime range, create a 30-kilometer ISR range. Major Russian targets are beyond this bubble, however, given Russia's adjustment of logistics after its 2022 deployment of the high-mobility artillery rocket system (HIMARS).[21] While large unmanned aerial systems have optics that can identify targets 40–80 kilometers away—and much better range than copter UAS—they are loud and vulnerable to point air defense and EW. Even large copter UAS are too loud for night operations, but smaller copters with worse optics limit the range of artillery.

To compensate for electronic warfare, Ukrainian units deploy all unmanned aerial systems, barring first-person view drones, with four-man teams comprised of a driver or scout, drone operator, navigator, and gimbal operator.[22] Since UAS are jammed so often, the crew must track movements manually to prevent losses from inattention.[23] Experienced UAS operators are the most valuable military occupation specialty to the ZSU, bar combat medics, and they lose far fewer unmanned aerial systems than the publicly quoted average would imply.[24]

Deep Strike and Fires Corridors in Ukraine

While skilled operators can reduce EW disruption to UAS, the range question remains. An effective RSC must be capable of facilitating strikes across the battlespace, particularly into the enemy's depth. Fighting deep is critical in the Ukrainian case because of the need for a breakthrough and Russian fires volumes.

21. Jack Watling and Nick Reynolds, *Meatgrinder: Russian Tactics in the Second Year of Its Invasion of Ukraine*, RUSI Special Report (London: RUSI, May 19, 2023), 11, https://static.rusi.org/403-SR-Russian-Tactics-web-final.pdf.

22. Per the author's interviews (March 24, 25, and 27, 2023), two-man teams are uncommon. They are restricted to medium UAS and highly competent operators.

23. The author's interviews (March 25, 27, and 30, 2023) indicated the majority of losses came from inattentive operators.

24. The author's interview subjects emphasized both military occupation specialties. Particularly in drone-specialist ISR units and artillery formations, UAS losses are extremely low. Moreover, by recovering hostile or lost friendly unmanned aerial systems, units can augment numbers over time. The author found that an average loss rate of one unmanned aerial system per month was typical for his subjects, though once again, line unit UAS losses are dramatically higher. The RUSI team, from which the 10,000-per-month figure generally stems, has also found the same need for contextualization.

Beyond the first few weeks of fighting, particularly around Kyiv, thickening front lines have defined the war, necessitating a breakthrough.[25] Conducting or foiling a breakthrough requires winning the deep fight.[26] Breaking through a thickly defended front line and defending it requires extreme effort.[27] A sophisticated logistical system is crucial because artillery amplifies the role of logistics, which urban combat amplified again.[28] On the offensive, artillery is needed to suppress and destroy defensive positions to enable an armored breakthrough.[29] On the defensive, artillery is needed to blunt attacking spearheads and ultimately destroy them. Deep strikes are needed both to starve the front line of shells, disrupt electronic assets, and suppress defender command-and-control (C2) nodes and to disrupt the attacking force.

The difficulty, therefore, is applying precision at distances of 30–100 kilometers: the Ukrainian armed forces must sequence fires to maximize precision effects and avoid Russian counter-battery fire. The solution is to create what can be termed fires corridors, gaps in the electronic warfare and antiair warfare (AAW) defensive system that UAS and long-range fires can exploit.[30]

In Ukraine, US space-based capabilities and commercial satellite imaging help the ZSU identify targets.[31] Suppressing or destroying the Russian EW-AAW blanket that defends the front line, however, currently requires unmanned aerial systems simply for their imaging responsiveness, even if these civilian-specification models are vulnerable to Russian jamming.

25. Dan Rice, "The Untold Story of the Battle for Kyiv," *Small Wars Journal* (website), May 31, 2022, https://smallwarsjournal.com/jrnl/art/untold-story-battle-kyiv.
26. Jonathan Bailey, "The Birth of the Modern Style of Warfare in the Great War," Defence Viewpoints from the UK Defence Forum (website), July 8, 2014, https://www.defenceviewpoints.co.uk/military-operations/the-birth-of-the-modern-style-of-warfare-in-the-great-war. See also Stephen Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle* (Woodstock, UK: Princeton University Press, 2004), 29–39.
27. Georgii Samoilovich Isserson, "The Foundation of Deep Strategy," in *Deep Operations: Theoretical Approaches to Fighting Deep*, ed. Jack D. Kem (Fort Leavenworth, KS: Army University Press, 2021), 15–23, https://www.armyupress.army.mil/Portals/7/combat-studies-institute/images/LSCO%20DeepOps%20book%20interactive%20with%20cover%20spread%2012Nov21.pdf.
28. Alexander Grinberg, "Glass Cannons from Grozny to Mariupol: What Should the US Military Learn from Russia's Use of Artillery in Protracted Urban Sieges?," Modern War Institute (website), February 13, 2023, https://mwi.usma.edu/glass-cannons-from-grozny-to-mariupol-what-should-the-us-military-learn-from-russias-use-of-artillery-in-protracted-urban-sieges/.
29. *Kyiv Independent* News Desk, "News Feed – Zaluzhnyi: Russia Uses up to 60,000 Rounds of Ammunition Daily," *Kyiv Independent* (website), August 16, 2022, https://kyivindependent.com/zaluzhnyi-russia-uses-up-to-60-000-rounds-of-ammunition-daily/.
30. Zabrodskyi et al., *Preliminary Lessons*, 3.
31. David T. Burbach, "Airpower after Ukraine: Early Lessons from the Russia-Ukraine War as a Space Conflict," Atlantic Council (website), August 30, 2022, https://www.atlanticcouncil.org/content-series/airpower-after-ukraine/early-lessons-from-the-russia-ukraine-war-as-a-space-conflict/. See also Ariel E. Levite, *Integrating Cyber into Warfighting: Some Early Takeaways from the Ukraine Conflict* (Washington, DC: Carnegie Endowment for International Peace, April 18, 2023), 6, https://carnegieendowment.org/files/Levite_Ukraine_Cyber_War.pdf.

The UAS-ISR complex is remarkably effective at mapping Russian frontline forces, enabling decentralized battery operation. To strike deep, enough fires must be concentrated to suppress or destroy multiple AAW, EW, artillery, and counter-battery assets 10–15 kilometers into Russian-held ground. This action creates a hole in the enemy AAW-EW network through which fixed-wing UAS can be used to identify the target and engage it with precision weapons at 70-plus kilometers. The deeper the target, the longer the window must be.

Fires corridors allow Ukraine to conduct deep strikes at scale, thereby targeting the logistical underpinnings of the Russian military. Indeed, the primacy of the deep fight is the central lesson analysis of the Russia-Ukraine War provides for future combat.

Ukraine has waged three successful anti-logistical efforts demonstrating the relevance of deep strike. First, Ukraine used a handful of Western-provided HIMARS to derail the summer 2022 Donbas offensive. A limited Ukrainian attack in the forest west of Izyum, the Russian forward supply hub in the Donbas, provided Ukraine an ideal position for HIMARS strikes against Russian logistics and C2 nodes. The effect was almost immediate: after taking Syeverodonetsk and Lysychansk and surging forward toward the Bakhmut-Siversk-Soledar line, Russian forces abruptly halted in the face of Ukraine's deep strikes. The relevance of deep strike is reinforced by the fact that Russia had continued its advance before the HIMARS campaign began.[32] Naturally, other factors were relevant here, particularly Ukraine's choice to commit reserves to Syeverodonetsk, thereby prompting Russian reserve commitments as well.[33] Nevertheless, deep strike plays a crucial role.

Second, in the fall of 2022, Ukrainian deep strikes helped enable the Kharkiv offensive. Along with a deception campaign to reduce Russian force density, long-range strikes disrupted Russian logistics command and control, generating the operational vulnerability Ukraine exploited.[34]

32. Karolina Hird et al., Russian Offensive Campaign Assessment (Washington, DC: ISW, July 24, 2022), https://www.understandingwar.org/sites/default/files/Russian%20Operations%20Assessments%20June%204.pdf.

33. Kateryna Stepanenko, Mason Clark, and George Barros, *Russian Offensive Campaign Assessment* (Washington, DC: ISW, June 4, 2022), https://www.understandingwar.org/backgrounder/russian-offensive-campaign-assessment-june-4.

34. Franz-Stefan Gady and Michael Kofman, "Ukraine's Strategy of Attrition," *Survival* 65, no. 2 (April–May 2023): 10. Although Gady and Kofman do concede that long-range strikes against C2 and logistics degraded Russian responses through three months of careful strikes, they correctly insist upon the broader theater strategic context, Russia's rotation of quality units, and limited remaining forces in Kharkiv oblast. The point is that an undercurrent of deep strikes prompted other changes that hollowed out Russia's defenses in Kharkiv, enabling major gains.

Third, Ukraine leveraged the unique conditions of the Kherson bridgehead between September and November 2022 to erode the Russian position, ultimately prompting a withdrawal from the Dnieper River's right bank. Long-range artillery played a decisive role in this campaign, hitting Russian rail and road links to the bridgehead and ultimately hollowing out Russian logistics so thoroughly as to compel a withdrawal.

In each case, the operative factor was a general hollowing out of enemy capacity. By shortening some aspect of the Russian system—typically Russia's ability to sustain large-scale forces deployed forward, but also by disrupting the Russian C2 network—Ukraine could compel Russia to roll its forces back, either retreating or halting an offensive.

As of this writing, Ukraine is on the offensive again. Although there are weeks to months of fighting ahead, the ZSU engaged in another deep-strike campaign that incudes loitering munitions, cruise missiles, and sabotage.[35] The Russians, however, have responded with a UAS-RSC of their own. Russia's greatest innovation has been on the counter-battery side.[36] Russia's Lancet loitering munitions, cued by the Russian UAS-ISR system linked to counter-battery radars, attack Ukrainian artillery as Ukraine seeks to create fires corridors. The Lancet flies fast enough to evade most Ukrainian short-range air-defense weapons. Ukraine's response has been better dispersion as well as disruption to ISR-focused unmanned aerial systems, alongside a probable reduction in the number of towed artillery pieces deployed near the front line. Russian and Ukrainian RSCs are therefore interacting in a fluid manner.

Winning the deep fight need not entail completely paralyzing enemy C2 and logistics, though paralysis is ideal on the offensive. The objective, rather, is to impose costs upon enemy logistics. This burden will force the enemy to extend the distance between its major logistics hubs and the front line, complicate transportation, and force the enemy to devote time and resources to defending against deep attack. The result will be a diffusion of enemy resources even after logistical adjustment.

Russian fires weight has decreased across the front, as the Russian military now struggles to sustain the countrywide bombardment curtain it employed throughout 2022, primarily because deep strikes have forced

35. *Kyiv Independent* News Desk, "News Feed – *CNN*: Ukraine Starts 'Shaping Operations' for Counteroffensive," *Kyiv Independent* (website), May 12, 2023, https://kyivindependent.com/cnn-ukraine-starts-shaping-operations-for-counteroffensive/.

36. Jack Watling, "Commentary – Ukraine's Counteroffensive Begins: Shall the Leopards Break Free?," RUSI (website), June 14, 2023, https://www.rusi.org/explore-our-research/publications/commentary/ukraines-counteroffensive-begins-shall-leopards-break-free.

a logistics redistribution. This change creates additional failure points in the system. Defensive forces in fixed positions receive less materiel. Mobile reserves are exposed to long-range strikes with outsized impact, as incidents like the Makiivka Strike demonstrate.[37] Moreover, C2 nodes must be light and mobile, or very well hardened, either requiring more defensive resources or increasing the cognitive load on commanders.

The Russian logistical system was likely more exposed to pressure than other alternatives because of its lack of truck-based transports, manpower-intensive system, and emphasis on rail transport.[38] Yet, the United States has logistical chokepoints as well, in particular, a reliance upon large depots—admittedly much farther from the combat zone than the Russian system—and upon civilian transports that may not be available in wartime.[39]

Ukraine's success has stemmed from an ability to leverage a small number of long-range precision weapons to hit high-value targets in the Russian rear area. Leveraging precision effects requires careful preparation to ensure, in the Ukrainian case, they can be applied through the creation of fires corridors to strike deep. In a competitive duel with Russia's reconnaissance-strike complex, striking deep allows Ukraine to roll Russian forces back by creating C2 and logistical seams. Ideally, over time, this situation will enable a breakthrough and exploitation.

Implications for the US Army

While the Russia-Ukraine War is an illustrative case, it is unique in many respects. Both sides derive their doctrine from similar sources and employ similar or identical weapons. Neither side can break the other's integrated air defense network—Ukraine for lack of modern airframes, Russia for lack of enough precision-guided munitions—meaning deep strike is primarily a missile-based phenomenon. Russia and Ukraine also field armies with far less overall experience than anticipated before the war, having gone through several rounds of mobilization, making logistical and command centralization all the more appealing and strikes against logistics and C2 nodes more fruitful. Russia has refused to deploy

37. *Guardian* Staff and Agencies, "Explainer – Makiivka Strike: What We Know about the Deadliest Attack on Russian Troops since Ukraine War Began," *Guardian* (website), January 4, 2023, https://www.theguardian.com/world/2023/jan/04/makiivka-strike-what-we-know-about-the-deadliest-attack-on-russian-troops-since-ukraine-war-began.

38. Alex Vershinin, "Feeding the Bear: A Closer Look at Russian Army Logistics and the Fait Accompli," War on the Rocks (website), November 23, 2021, https://warontherocks.com/2021/11/feeding-the-bear-a-closer-look-at-russian-army-logistics/.

39. Michael Trimble and Jobie Turner, "Asymmetric Advantage or Achilles Heel: Logistics in the U.S. Military," *Strategy Bridge* (website), June 14, 2022, https://thestrategybridge.org/the-bridge/2022/6/14/asymmetric-advantage-or-achilles-heel-logistics-in-the-us-military.

kinetic anti-satellite interceptors, nor is there much available in the open source about satellite jamming, an undeniably relevant factor in future wars. Ukraine and Russia both defend some of the world's most extensive ground fortifications—in the Ukrainian case, built over years of positional conflict in the Donbas. The US Army should not plan to fight the last war, let alone a war it has not actively fought.

Ukrainian and Russian UAS-enabled RSCs, however, and the need to conduct deep strikes to attrit an RSC, will only intensify over time as RSCs become more sophisticated. The US Army will likely face near-peer conventional adversaries with a distributed reconnaissance-strike complex that has multiple redundancies and, critically, includes AI to shorten the kill chain.[40]

This future RSC will need to be tugged in or disrupted to create opportunities for US land, air, and sea power to deliver the heavy capabilities needed to break an enemy position and achieve a combat decision. The Ukrainians do not face an abstract network that they must attrit but a specific, geographically textured adversary they must hollow out. Much in the way Russian forces that mass too early are extraordinarily vulnerable to a precision strike, so too are the Ukrainian forces at risk. The United States will face a similar type of threat, albeit at a greater degree of sophistication. If it seeks to mass, it must reduce the enemy RSC's ability to hit concentrated forces—otherwise, the combat power that mass generates will be wasted.

From this reality stems the need for a fluid reconnaissance-strike complex that includes a distributed ISR system, one that enables the specific application of precision effects to hit RSC nodes in the enemy's depths. Perhaps penetrators can help, whether this assistance entails an electromagnetic pulse warhead that can knock out jammers or, in the future, directed-energy weapons used for air defense or a fires corridor akin to that of Ukraine. Unmanned aerial systems will almost certainly be part of the solution. As commercial UAS technology develops, small, cheap UAS hardened against some electronic effects will proliferate. Artificial intelligence and edge computing will reduce UAS reliance on GPS and human control, while smaller, higher-quality optics will increase the ability of unmanned aerial systems to operate undetected and identify targets at range. Satellites will also matter, especially microsatellites with advanced sensors.

The technology, however, is not the point. The Russia-Ukraine War demonstrates the intensity—in materiel, manpower, and cognitive load—

40. Amy J. Nelson and Gerald L. Epstein, "Commentary – The PLA's Strategic Support Force and AI Innovation," Brookings (website), December 23, 2022, https://www.brookings.edu/articles/the-plas-strategic-support-force-and-ai-innovation-china-military-tech/.

of combat between adversaries with actual RSCs, even if both parties suffer from obvious technical, organizational, and logistical limitations. In a conflict with a near-peer adversary, the United States will likely face a reconnaissance-strike complex with greater range, comprehensiveness, and scale. This network will likely involve units and positions on enemy territory. Ukraine, even with limits on its ability to engage targets within Russia, has managed to fight effectively, but it has been nearly helpless against the Russian strategic-strike campaign. The United States is unlikely to face an adversary it can defeat absent some consideration of strikes on its territory, at least if it hopes to win on a timescale more closely approximating months or years than a decade. Two equally sophisticated RSCs, then, can increase the likelihood of mutual territorial strikes and the potential for escalation.

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