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Ukraine at War

Paving the Road from Survival to Victory

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Executive Summary

THIS REPORT IS an assessment of the present dynamics of the fighting in Ukraine, how Russia is employing its capabilities and what is needed to defeat Russia's invasion. It is based on fieldwork conducted in Ukraine prior to and during the invasion. This report does not cover Russia's unconventional operations or Ukraine's maritime flank.

Ukraine has **the will to achieve the operational defeat of the Russian military**. At present, however, several Russian advantages and Ukrainian weaknesses are leading to an **attritional conflict** that risks a protracted war, eventually **favouring Russia**.

- Russian electronic warfare (EW) is denying Ukraine a sufficiently fast kill chain to destroy Russia's artillery.
- Russian artillery is fixing the Ukrainian military and preventing the Ukrainians from concentrating to undertake offensive manoeuvre.
- Russian cruise missiles are imposing a high economic and political cost on Ukraine.
- A shortage of skilled infantry and armoured operators is limiting Ukraine's offensive combat power.
- Limited staff capacity is limiting Ukraine's ability to plan and execute combined operations at scale.

Ukraine's international partners have the ability to reverse these dynamics to enable Ukraine to retake its lost territory. This cannot be achieved through the piecemeal delivery of a large number of different fleets of equipment, each with separate training, maintenance and logistical needs. Instead, Ukraine's partners should rationalise the support they provide around a small number of platforms. Ukraine's key capability requirements are:

- Anti-radiation seekers for loitering munitions to suppress or destroy Russian EW complexes.
- Multiple launch rocket systems (MLRS) to target and destroy Russian logistics and ammunition stockpiles to starve Russian artillery of ammunition.
- 155-mm howitzers and ammunition to prevent Russian troop concentration and support Ukrainian troop concentrations.
- Secure communications systems.
- Anti-tank guided weapons and man-portable air-defence systems (MANPADS).
- Protected mobility to enable Ukrainian troops to manoeuvre under artillery threat.
- Point defences to protect critical infrastructure.

It is also necessary for Ukraine to receive training at scale to form new units able to undertake offensive operations and to receive staff and junior leadership training to support the orchestration of combined arms offensive manoeuvre.

Ukraine at War: Paving the Road from Survival to Victory

Introduction

FOUR MONTHS OF intense fighting in Ukraine have seen Russia's grand offensive strokes descend into a grinding attritional struggle. Ukraine's determination to resist, flawed Russian planning and execution, and the rapid delivery of arms to the Ukrainian armed forces have ensured Kyiv's survival. The support that has enabled Ukraine to survive, however, will not deliver an end to the conflict. Russia could still wear down Ukrainian ammunition stockpiles, its reserve of skilled troops and the patience of the international community to slowly claw back a path towards meeting its aims.¹ Ensuring Ukrainian survival in the longer term means enabling Ukrainian victory, and this requires a different kind of support to its forces.

International support to Ukraine over the first four months of the war has been driven by two imperatives: what Ukraine's partners have had immediately available; and what can be brought into Ukrainian service with the minimum necessary training and enablement. Given the magnitude and acuteness of the threat, this approach was justified. As the war protracts, however, there is a need to ensure that Ukraine's war effort can be sustained, and that Ukraine is armed to deconstruct Russia's system of systems, rather than produce a symmetrical stalemate that can only bring about an attritional conflict, risking Ukraine's exhaustion. Whatever capabilities are provided, it is also necessary for standardisation and for them to be provided at scale. Given that this will require orders from Western industry, it is essential that the right capabilities are prioritised.

This report seeks to outline how Russian forces are conducting their war against Ukraine through the examination of their technical capabilities and how they are being employed against the Ukrainian armed forces. By examining the tactical performance of the Russian system of warfare, the report reaches conclusions as to what international support is best placed to achieve disproportionate effect against it. The report is based on fieldwork in Ukraine both prior to and during the conflict, extensive interviews with Ukrainian military, scientific, security and intelligence personnel in both leadership and tactical positions, physical examination of captured Russian military equipment, observation of the armed forces of Ukraine on operations, interviews with Western security and military personnel, interviews with fighters in Ukraine's foreign legion, examination of Russian military documents assessing their own operations and tactics in Ukraine, and the scraping of videos, images and accounts of fighting from open sources

1. Andrew Milburn, 'Time Is Not on Kyiv's Side: Training, Weapons, and Attrition in Ukraine', Modern War Institute at West Point, 27 June 2022, <<https://mwi.usma.edu/time-is-not-on-kyivs-side-training-weapons-and-attrition-in-ukraine/>>, accessed 27 June 2022.



Destroyed Russian armour on the approaches to Kyiv, June 2022. *Courtesy of Jack Watling*

alongside a literature review of press coverage and academic writing about the war. The report takes into consideration, but largely discounts, Russian military performance and especially tactics, techniques and procedures documented during the first three weeks of fighting² because the operational context makes these anomalous. To avoid similar contextual factors leading to overly broad conclusions, the report seeks to document consistent Russian behaviours and proficiencies observed between multiple fronts, such as in Donbas, Kherson and in some areas around Kyiv. It neglects a detailed examination of Russian unconventional operations and Ukraine's maritime flank. These are important topics that should be examined separately. Instead, this report focuses on the dynamics of ground operations.

Structurally, the report focuses on four elements of Russian operations: artillery; EW and reconnaissance; ground manoeuvre; and the air war. It ends with an overview of the conclusions as to what support should be prioritised for Ukraine. Although the report is heavily based on assessments of Ukrainian military performance and deficiencies in the Ukrainian armed forces, these are detailed sparingly to avoid providing Russia with useful insight into Ukrainian capabilities and vulnerabilities.

Beneath the Iron Rain

Artillery is one of the most important components of Russian operations, and in terms of lethal capabilities it has become Russia's mission-critical force multiplier. The generally mediocre performance of Russia's ground forces has been increasingly offset by their leveraging of

2. Can Kasapoğlu, 'A Winning Strategy in Ukraine', Hudson Institute, 7 March 2022, <<https://www.hudson.org/research/17637-a-winning-strategy-in-ukraine>>, accessed 10 April 2022.

massed artillery fires to facilitate a slow and methodical advance.³ Sustained bombardment has progressively displaced the local population and levelled the settlements and infrastructure that were being defended, forcing the Ukrainian military to abandon territory after it is devastated.⁴ Furthermore, by preventing Ukrainian forces from massing to counterattack and causing considerable attrition to those units holding the line,⁵ particularly in Sievierodonetsk, Russian artillery was the key to preventing Ukrainian forces from turning the tables in the close fight as they did in the Battle for Kyiv prior to the Russian withdrawal from that axis.⁶

In the early stages of the Battle for Kyiv, the battlefield geometry prevented Russian artillery from being employed effectively. Russian forces were trapped on two main supply routes,⁷ leaving their lead elements in range of Ukrainian artillery positions while their own artillery and its ammunition were trapped behind congested friendly forces.⁸ In the south and in Donbas, by contrast, Russian forces have been able to deploy their artillery units more effectively and in a manner more consistent with Russian doctrine. Despite this, Russian artillery use reflects the Russian military being in a transitional state. It had yet to widely implement many of the doctrinal and technical innovations that it had experimented with in recent years and intended to employ at scale.⁹ While battalion tactical groups (BTGs) have their own organic artillery, mostly mortars and limited numbers of field howitzers,¹⁰ many units lacked full complements of modernised guns, with most commanders unwilling to release artillery from the artillery tactical groups generated at the brigade and divisional level.¹¹ This problem has been exacerbated by equipment losses early in the conflict,¹² and has meant that Russian artillery has largely operated

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3. Andrew S Bowen, 'Russia's War in Ukraine: Military and Intelligence Aspects', Congressional Research Service, 27 April 2022, p. 16, <<https://crsreports.congress.gov/product/pdf/R/R47068>>, accessed 27 June 2022.
 4. Richard Spencer et al., '90% of Buildings in Mariupol "Damaged or Destroyed"', *The Times*, 17 March 2022.
 5. Peter Beaumont, 'Up to 100 Ukraine Troops Could Be Dying in Donbas Each Day, Says Zelenskiy', *The Guardian*, 23 May 2022.
 6. Ukrainian forces have been forced to withdraw from Sievierodonetsk. See *BBC News*, 'Ukraine War: Kyiv Orders Forces to Withdraw from Severodonetsk', 25 June 2022.
 7. Jack Watling and Nick Reynolds, 'Operation Z: The Death Throes of an Imperial Delusion', RUSI Special Report, 22 April 2022.
 8. *The Economist*, 'Why a Huge Russian Convoy Remains Stalled North of Kyiv', 4 March 2022; Maryan Kushnir, "'Truth Is On Our Side": Ukrainian Artillery Unit Targets Russian Forces', *Radio Free Europe/Radio Liberty*, 7 March 2022, <<https://www.rferl.org/a/ukraine-russia-kyiv-artillery/31740382.html>>, accessed 19 April 2022.
 9. Lester W Grau and Charles K Bartles, 'The Russian Way of War: Force Structure, Tactics, and Modernization of the Russian Ground Forces', Foreign Military Studies Office, 2016.
 10. Nicolas J Fiore, 'Defeating the Russian Battalion Tactical Group', 2017, <<https://www.benning.army.mil/armor/earmor/content/issues/2017/spring/2Fiore17.pdf>>, accessed 27 June 2022.
 11. Author interview with A, a senior analyst in Ukrainian military intelligence, Ukraine, June 2022.
 12. Oryx, 'Attack On Europe: Documenting Russian Equipment Losses During the 2022 Russian Invasion of Ukraine', 24 February 2022, <<https://www.oryxspioenkop.com/2022/02/attack-on-europe->

independently from – rather than in close support of – its manoeuvre elements, with supportive fire missions having long delays.

A further challenge resulting from the disorganisation of the first phase of the war is that as Russian casualties have been replaced by conscripts,¹³ new short-term volunteer contractors,¹⁴ and mobilised citizens with prior military experience,¹⁵ there are fewer personnel trained to use Russia's latest fire-control and battlespace management systems. In theory, Russian fires are mediated by the AKATSIA and AQUEDUCT systems. Russian forces were moving towards a common information environment as trialled at smaller scale in Syria. Under this concept of operations, which borrowed heavily from US and NATO concepts and doctrine and has been referred to as the Reconnaissance Fires Complex,¹⁶ artillery tactical groups could, through secure channels, receive targeting information in real time from ISTAR systems and units, be flexibly tasked to provide fire support to different units, and coordinate fires from multiple gunlines and groups to provide effect on targets. However, shortages of the required secure communications systems, alongside weaknesses in the training of both new recruits and older veterans called up to replace casualties and who are not familiar with the latest modernised systems, have resulted in failures to use it correctly. Russian artillery organic to BTGs have often communicated via unencrypted communications, or have followed up signals on their fire control systems with communications via cell phone or commercially procured devices. This has caused a centralisation of the artillery system into the artillery tactical groups under the command of more senior officers and staffs with experience of the appropriate battlespace management tools and in a slowing of the kill chain and resultant reduction in effectiveness.

Despite these frictions, Russia has achieved fires dominance through the sheer volume of tactical artillery and munitions that it can bring to bear.¹⁷ In addition to vast stockpiles that the Soviet Union accumulated, and which have yet to be depleted¹⁸ – by some estimates, several years' worth still remains¹⁹ – the Russian defence industry has a significant capacity for producing artillery shells. For example, Soviet-era armaments factories based in Ukraine were fulfilling

documenting-equipment.html>, accessed 27 June 2022.

13. Polina Ivanova, 'Russia Turns to Donbas Conscripts to Fill Front Lines', *Financial Times*, 11 June 2022.

14. Mary Ilyushina, 'Russian Army Ramps Up Recruitment as Steep Casualties Thin the Ranks', *Washington Post*, 16 June 2022.

15. *BBC News*, 'Russia Scraps Age Limit for New Troops in Ukraine Push', 29 May 2022.

16. Lester W Grau and Charles K Bartles, 'The Russian Reconnaissance Fire Complex Comes of Age', University of Oxford, Changing Character of War Centre, 30 May 2018, <<http://www.ccw.ox.ac.uk/blog/2018/5/30/the-russian-reconnaissance-fire-complex-comes-of-age>>, accessed 27 June 2022.

17. Sam Cranny-Evans, 'The Role of Artillery in a War Between Russia and Ukraine', *RUSI Commentary*, 14 February 2022.

18. Though some older stockpiles have been decommissioned.

19. Author interviews with A; B, a senior Finnish intelligence officer, London, April 2022; C, a senior Estonian defence official, London, April 2022; D, a senior Ukrainian officer with previous experience of Soviet stockpile management and subsequent Ukrainian defence industry, Ukraine, June 2022.

orders for Russian forces up until 2014 with the capacity to assemble 2,000,000 152-mm howitzer shells per year in contracts that had been continued since the 1980s.²⁰ Many similar large-scale plants remain in operation inside Russia. Although the Ukrainian factory had the capacity to assemble this many shells, actual outputs were often slightly below this figure, largely because of a bottleneck in the production of explosive material for the propellant and warhead.²¹ Nevertheless, the result of this stockpile is that, at present, Russia is firing approximately 20,000 152-mm artillery shells per day compared with Ukraine's 6,000,²² with an even greater proportional disparity in multiple rocket launchers and missiles fired. Despite the prevalence of examples in the social media narrative of precision fires being delivered, the majority of artillery fires in Ukraine are conducted by traditional unguided mortars, field howitzers and MLRS. Although guided artillery ammunition has been produced and made available to Russian units, personnel and training problems have hampered implementation. This has often resulted in guided munitions being used as dumb shells. Ukrainian troops have observed Russian forces firing laser-guided artillery ammunition, for example, without using a laser designator to mark targets.²³ Similar to previous conflicts, area-effect artillery reliant on blast and fragmentation as the principal mechanisms for causing damage to targets is devastating against soft targets such as dismounted personnel and light vehicles but is of limited effectiveness against armour. Against armoured vehicles and hard targets or structures, the use of these fires tends to be to fix the defenders, which can make them susceptible to either bypass, or destruction through the employment of thermobaric artillery such as the TOS-1A MLRS. Due to poor ISTAR capability and long response times, Ukrainian artillery units have reported being able to consistently evade being subjected to effective Russian targeting and counterbattery fire.²⁴ However, when employed en masse against fixed targets, such as defended positions and urban areas, the cumulative effect of Russian artillery has proven potent.

The way that tactical artillery has been employed is roughly consistent with established doctrine, albeit lacking much of the C4ISTAR coordination as envisioned by the Reconnaissance Fire Complex and exhibiting a considerable degree of systemic friction and slowed responsiveness. Where the Reconnaissance Fire Complex has been successfully established in Ukraine – which has occurred periodically – it has been through the adoption and integration of UAV and EW ISTAR to identify targets and coordinate fires.²⁵ In terms of physical deployment, Ukrainian forces have observed that the Russians deploy their artillery systems set back from the frontline by one third of their maximum range as a protection measure; mortars are largely positioned

20. Author interviews with D; E, a senior official in Ukrainian defence industry, Ukraine, June 2022.

21. Author interview with D.

22. Author interviews with A; F, a senior adviser to the Ukrainian chief of armed forces, Ukraine, June 2022. See also Isobel Koshiw, 'We're Almost Out of Ammunition and Relying on Western Arms, Says Ukraine', *The Guardian*, 10 June 2022.

23. Author interview with G, a Ukrainian military scientist examining Russian weapons employment, Ukraine, June 2022.

24. Debrief of Ukrainian artillery personnel, June 2022.

25. Quentin Sommerville, 'Ukraine War: Russia Pushed Back from Kharkiv - Report from Front Line', *BBC News*, 11 May 2022.

1.5 km back from the forward line of own troops, artillery tactical groups subordinated to brigades 8 km back, and artillery tactical groups armed with longer-ranged systems dedicated to deep fires at 10–15 km back. There is significant variation from these distances, with artillery units often moving forward to extend their reach. Nevertheless, the principle is generally adhered to. Batteries are deployed across an area of up to 100 by 300 metres, with between 20 and 40 metres between each gun. MLRS are generally deployed in a linear gunline, with up to 150 metres between each launcher. However, some artillery batteries have been detected as being split up into dispersed subunits. This is partly due to artillery shortages at the BTG and brigade level, with pairs of, or individual, guns fulfilling a support function that should be the task of a full battery. However, some of this dispersion is due to the use of mobile fire units supported by UAVs to attack key Ukrainian targets. While limited in scale, these instances show where the Russian Army's aspirations to modernise have begun to be realised. Where they have been realised, Russian fires have been responsive, accurate and highly lethal. Russian artillery units have also set up dummy positions using one artillery piece with the remainder made up of damaged or destroyed Russian artillery, to draw Ukrainian fire. Russian MLRS are used primarily for area denial, often to constrain the movement of Ukrainian units, while field howitzers are used against specific targets, though this is not a universal rule. For counterbattery fire against artillery, Russian forces will generally task those artillery tactical groups armed with heavier, longer-ranged weapons, or Tochka-U.²⁶

According to Ukrainian artillery crews, Russian artillery is generally able to bring accurate artillery fire down on targets 3 to 5 minutes after UAV reconnaissance has identified them, but if a target is identified with EW direction finding, acoustic reconnaissance or counterbattery artillery radar, it will take Russian artillery approximately half an hour to bring inaccurate artillery fire to bear. The importance of UAVs to Russia's artillery precision and responsiveness has forced Ukraine to maintain organic MANPADS teams with their artillery, preferably armed with visually guided systems such as Starstreak and Martlet, which have proven much more effective against UAVs and helicopters. If Russian forces are able to maintain UAV reconnaissance over a target, they are able to adjust fire in near-real time even if the target is moving. When subjected to counterbattery fire themselves, Russian MLRS units will tend to relocate, whereas howitzers, whether towed or self-propelled, will usually be left in position while the crews seek cover or position themselves at a distance from their guns until incoming fire has subsided. Russian batteries often do not relocate after fire missions, but will relocate to a new position or gunline within the same approximate area if they come under attack. It was noted that when plugged into the AKATSIA fire-control architecture, Russian counterbattery fire was assigned to unengaged batteries, and was not conducted by batteries that were themselves being targeted.

One significant deviation from doctrine is that Russian forces have made extensive tactical use of the Tochka-U ballistic missile for counterbattery and tactical strikes.²⁷ Although almost entirely retired from frontline service by 2019, as they were officially replaced by Iskander-M, the reliance of Russian forces on indirect fires resulted in the Tochka-U's restoration to active service

26. Debrief of Ukrainian artillery personnel, June 2022.

27. Author interviews with F; H, a Ukrainian general officer, Ukraine, June 2022.



A Ukrainian reconnaissance UAV is launched to find Russian positions, Ukraine, June 2022. *Courtesy of Jack Watling*

and its repurposing from a long-range precision-strike system to part of the tactical artillery system. Although Tochka-U is often used by Russian forces to target EW units and command posts located in the enemy rear, it has become valued for its large high-explosive warhead, which Russian forces seem to view as effective against a wide variety of targets for which it was not originally intended. This has sometimes manifested in acutely inefficient targeting. In one engagement, a single Ukrainian M109 howitzer was targeted by three Tochka-U strikes. The crew were forced to temporarily abandon the howitzer in order to seek hard cover, but it survived with light damage that could be repaired in a few hours with some basic spare parts.²⁸

Overall, despite the deficiencies and inefficiencies of the Russian Army's artillery forces, in their present form they remain a major obstacle to Ukrainian forces, enabling continued Russian offensive operations and impeding Ukrainian counterattacks. Breaking down Russia's fires dominance is critical if Ukrainian forces are to be able to retake ground and stem their current high rate of attrition. The main weakness of the Russian artillery system is the logistics burden posed by the transportation and stockpiling of the vast quantity of shells that allows Russia to continue to manoeuvre by fire. Russian dependence on the railway network as the primary means of transporting war stocks was well understood before the war.²⁹ Due to a lack of planning time for lower echelons, Russia struggled to move materiel from rail heads to its frontline positions in the opening phase of the conflict.³⁰ During April, however, a system of contractorisation for moving materiel from railheads to the divisional rear was developed, with

28. Author interview with I, a Ukrainian soldier describing the incident, Ukraine, June 2022.

29. Alex Vershinin, 'Feeding the Bear: A Closer Look at Russian Army Logistics and the Fait Accompli', *War on the Rocks*, 23 November 2021.

30. This problem had been predicted by NATO officers. See *ibid.*

military units then shifting ammunition to large ammunition depots behind the main artillery concentrations.³¹ From there, the ammunition is shuttled to the guns. The reliance on railheads and civilian vehicles, which are largely restricted to road movement, makes key bottlenecks in Russian artillery highly predictable. Moreover, the ammunition dumps at the divisional and brigade level are large, distinct, hard to conceal or defend, and slow to relocate. Given Ukraine's limited capacity to strike at the Russian military's rear echelons and fight a deep battle, this is a weakness that is yet to be widely capitalised upon. Isolated strikes on ammunition dumps show what is possible but given the disparity in guns and the shortage of Russian precision fires, the fastest way to level the playing field is to enable Ukraine to strike Russian artillery logistics. The critical factor in this is precision, range and payload. Ukraine needs strike systems with a sufficiently powerful warhead to ignite stored ammunition or damage key logistical infrastructure, accurate enough to hit these targets precisely, and with the range to do so from beyond Russian howitzer fire. The best system for this is MLRS, although with a more powerful munition than the UK's reduced lethality unitary warhead GMLRS. These capabilities need to be provided at scale.

In breaking up the Russian fires complex, targeting ammunition would significantly reduce the volume of fire that Russia could bring to bear and thereby offer advantage to the force able to strike with greater precision. Although Ukrainian ammunition consumption may not rise to Russian levels, the destruction of Russian guns and the provision of close support to Ukrainian units will necessitate a significant number of both howitzers and shells. Given that 152-mm ammunition is in limited supply and NATO countries lack production lines for this nature, it will be necessary to provide Ukraine with a large number of 155-mm howitzers and a consistent supply of ammunition. One challenge here is that NATO standardisation is not very standardised, with different countries' howitzers not only having completely different maintenance requirements but also using different charges, fuses and sometimes shells. The current approach by which each country donates a battery of guns in a piecemeal way is rapidly turning into a logistical nightmare for Ukrainian forces with each battery requiring a separate training, maintenance and logistics pipeline. Making support to Ukraine sustainable requires the provision of one or two kinds of gun and for countries to step up production of the appropriate ammunition. It will also necessitate the establishment of second-line maintenance for these systems. Of course, these efforts will be of limited value if Ukrainian forces cannot find their targets in a timely manner, and so we must turn to the electromagnetic spectrum.

Contesting the Spectrum

If Ukraine is to defeat Russian fires through a combination of range and precision, its armed forces need a kill chain that can identify and communicate the location of Russian targets. This can either be delivered by UAVs, reconnaissance teams or electronic direction finding. All these methods, however, are hindered by Russia's EW complexes which are integral to Russian concepts of operation. It is therefore necessary to assess how these are being employed in Ukraine, their limitations and where they present tactical challenges that must be overcome.

31. Author interview with A.

The initial phase of the war in Ukraine is not indicative of Russian EW capabilities because the confusion caused by a lack of planning time led to fratricide, poor command coordination and thus many Russian EW systems being kept off. Subsequently, the Russian armed forces have started to use their EW capabilities more systematically. On 6 June 2022, for example, a field assessment of the Russian armed forces concluded that ‘the enemy’s UAVs, high-precision loitering and artillery ammunition and communications equipment rely on positioning through the reception of signals from satellite radio navigation systems’.³² To protect Russian forces from these capabilities, it was recommended that they continuously suppress access to satellite navigation through the constant operation of the Pole-21 system and the constant employment of the R330Zh, both on maximum power using omnidirectional jamming. The advice noted that these systems could be deconflicted with the employment of Orlan-10 UAVs by the Russian forces. The effect on Russian command and control was limited by the linking of command posts by ground-laid field cable,³³ which Ukrainian forces have noted is now always emplaced within hours of the Russians setting up a position.³⁴ Both Pole-21 and R330Zh are turned off prior to the commencement of Russian artillery strikes that may need to rely on accurate satellite-based positioning. In practice, while widespread, coverage is not constant because the R330Zh requires a significant supply of fuel to operate.

A more active layer in the Russian EW defence architecture is provided by Shipovnik-Aero, a truck-mounted jamming system optimised for targeting UAVs but also capable of suppressing a range of communications networks. The system has a range of 15 km and detects UAVs through their control frequency. The system takes approximately 25 seconds to analyse the control frequencies of newly encountered UAVs, and around 2 seconds to reconfirm the control frequencies of previously encountered UAVs.³⁵ It then jams the command frequency. In addition, the system overrides the positioning of the UAV so that ‘return to base’ protocols lead the UAV to land in a location designated by the Russians. The Shipovnik-Aero has two workstations and is able to engage two UAVs at a time. Its jamming effect is delivered on a bearing with a width of approximately 3 degrees, suppressing friendly and civilian signals in the targeted bands within this area.³⁶ Although these systems are not universally available to Russian formations, their presence has become widespread, limiting the airspace that Ukrainian UAVs are able to penetrate and monitor. The Shipovnik-Aero can take up to 40 minutes to set up and, like many other Russian EW systems, is therefore vulnerable to suppression through forced displacement or strike if its position can be determined.

32. Field assessment of Ukrainian capabilities and their impact on Russian forces, conducted in Donbas and circulated to Russian commanders on 6 June 2022 outlining defensive electronic warfare measures.

33. Author interviews with F; H; I; J, a Ukrainian reconnaissance officer, Ukraine, June 2022; K, a senior officer in Ukrainian military intelligence, Ukraine, June 2022.

34. *Ibid.*

35. Technical examination of the Shipovnik-Aero, Ukraine, June 2022.

36. *Ibid.*



Ukrainian troops launch a reconnaissance UAV to locate Russian positions, Ukraine, June 2022. *Courtesy of Jack Watling*

Another challenge faced by Ukrainian troops is that Russian direction finding is highly capable and where it is not possible to suppress UAVs, it is often possible to target the ground control station. The means by which ground control stations have been targeted depends on the type of UAV and its range, but has included the dedicated firing of 152-mm howitzers, 300-mm MLRS and Tochka-U at UAV operators. Between these threats and those of EW causing UAVs to crash, or interception by air-defence systems, the lifespan of Ukrainian UAVs is roughly 7 days with some variation by system.³⁷ In consequence, many Ukrainian units are forced to choose between having a live feed from their UAVs and thereby risking a high likelihood of losing the platform or sending UAVs out on pre-set flight plans and analysing the images they take on their return to a pre-set location.³⁸ The use of jamming detection and inertial navigation can mitigate against the jamming of satellite navigation for a UAV following a pre-set flight plan. However, this method imposes a significant time delay between a target being identified in a location and the capacity of Ukrainian forces to bring fires to bear. This is either because the enemy is not in the location that the UAV was pre-programmed to examine requiring subsequent UAV launches, or because of the time required to conduct the analysis and confirmation of images after the UAV has completed its flight, compounded by the analytical challenge of confirming the coordinates of targets observed when accurate satellite navigation over the target area is denied. During fieldwork, the authors observed that a UAV launched to observe Russian positions in the latter manner did not face serious interference from EW, but that a subsequent UAV flying

37. Author interviews with L, a Ukrainian UAV engineer supporting Ukrainian troops in the field, Ukraine, June 2022; M, a senior Ukrainian field intelligence officer using UAVs for reconnaissance operations, Ukraine, June 2022.

38. A dilemma observed in both planning and execution of UAV flights during operations observed in Ukraine, June 2022.

with a command link came under electronic attack as soon as it approached Russian forces. At present, it is widely observed that the Russians rarely displace from favourable positions once established. This, however, is likely a consequence of Ukraine having so few means to strike these targets, and it must be assumed that if Ukraine were to gain the means to strike – as outlined in the previous section – Russian units would begin to displace at intervals.

The Russians have had very limited success in denying Ukrainian communications. Despite Russian forces fielding EW complexes dedicated to the suppression of satellites, such as the 1RL257 Krasukha-4,³⁹ the density of the Starlink satellite architecture⁴⁰ means that Ukrainian forces are able to maintain reliable satellite connections across tactical formations.⁴¹ Cyber attacks against satellite architectures have been disruptive, but periodic, and the effect has not been something that the Russians can synchronise with other actions. Where 1RL257 has proven more effective is in the preparatory jamming of radar and other defensive systems in preparation of large-scale artillery or air strikes.⁴² Another element of the use of EW in an offensive role is the TORN-MDM signals intelligence vehicle, capable of direction finding and triangulating tactical communications within a radius of between 30 and 70 km depending on frequency. This system can also record and analyse communications, with the organic capacity to attempt decryption. Although Harris radios have been found to function despite Russian EW and to have robust encryption, Motorola radios used extensively by Ukrainian forces are more susceptible to jamming and technical examination suggests the signals are decrypted, although it takes around two hours.⁴³ Training, tactics and procedures can mitigate the risk to operational security as a result of this penetration for tactical actions but it severely limits the Ukrainian capacity to disseminate operationally relevant orders and instructions in a secure manner and is therefore a constraining factor in the scale at which Ukrainian forces can coordinate. A further complication is the Russian employment of Leer-3 EW payloads mounted on Orlan-10 UAVs to target cell phone networks. While widely employed, the effect of these systems has been limited by their protracted employment over the past 8 years in Donbas so that Ukrainian forces are familiar with the risks posed by the system and effective countermeasures to them.⁴⁴

In sum, Russian EW employment is not preventing Ukrainian communications and denying access to the electromagnetic spectrum. However, it is disrupting, limiting the accuracy of positioning, and slowing down vital kill chains and imposing significant limitations on Ukrainian reconnaissance in depth. Because long-range strike depends on precision systems, which are only available in limited numbers, Russian EW is a critical barrier to Ukrainian forces effectively

39. Technical examination of the Krasukha-4, Ukraine, June 2022.

40. Tom Simonite, 'How Starlink Scrambled to Keep Ukraine Online', *Wired*, 11 May 2022.

41. Charlie Parker, 'Specialist Ukrainian Drone Unit Picks Off Invading Russian Forces as They Sleep', *The Times*, 18 March 2022.

42. Author interview with N, a senior Ukrainian air-defence specialist, Ukraine, April 2022.

43. Author interview with Q, a Ukrainian general officer, Ukraine, February 2022.

44. Jonas Kjellén, 'Russian Electronic Warfare: The Role of Electronic Warfare in the Russian Armed Forces', FOI, September 2018, <<https://www.foi.se/rest-api/report/FOI-R--4625--SE>>, accessed 27 June 2022.

employing the highly capable Western systems that could enable them to win the firefight and undermine Russia's most important advantage. A means of countering Russian EW is thus necessary to enable Ukraine to conduct timely and accurate reconnaissance. The best method of delivering this effect is a radar-homing seeker payload for explosive-laden UAVs. Ukraine has the industrial capacity to manufacture airframes at scale,⁴⁵ and there is a significant advantage in allowing Ukraine to develop multiple wing-forms for this mission because it makes the detection, classification and destruction of the UAVs much harder for Russian forces. However, a robust, cheap and reliable seeker that can be provided at scale is the critical component to enable this capability. Even if such a system did not account for a large number of destroyed Russian EW systems, because all EW complexes must emit – save for collection systems such as the TORN-MDM – they are readily targeted in this manner. Russian forces can avoid the destruction of their systems by leaving them off or displacing. Given that most EW complexes take between 25–40 minutes to set up, however, forcing displacement is an effective means of suppression that, in turn, would create many windows of opportunity for Ukrainian UAVs and reconnaissance teams to communicate the position of Russian systems in real time and determine the exact coordinates of positively identified high-value targets. The development of a cheap seeker that can be provided to Ukraine at scale is therefore a critical capability that Ukraine's partners should immediately prioritise. If Ukraine can counter Russian EW, it becomes possible to apply accurate fires to counteract the shaping by massed Russian artillery and thereby bring about the favourable conditions for Ukrainian ground manoeuvre that are a pre-condition to the liberation of occupied Ukrainian territory.

Hectares Lost and Liberated

Ground manoeuvre is an area in which Ukraine holds significant advantages, but as these advantages are primarily related to the defence there will need to be significant support to enable Ukraine to retake lost ground. To begin with the Russian ground forces, at the beginning of the invasion, Russian units were organised into BTGs that were often understrength in their infantry component but nevertheless predominantly made up of contract soldiers.⁴⁶ Poor tactical employment combined with a shortage of infantry to support armour saw the Russians take exceedingly heavy equipment and personnel losses.⁴⁷ In the aftermath of the withdrawal from Kyiv, Russian forces have sought to reconstitute their forces in two ways. First, they have offered short-term contracts for service in Ukraine with inflated salaries. Second, the Russian government has been conducting a stealthy mobilisation of older citizens with prior military experience and with technical competences in order to reduce the training time for their integration into the force.⁴⁸ Having raised the age for eligible service, the Russian government

45. Brennan Deveraux, 'Loitering Munitions in Ukraine and Beyond', *War on the Rocks*, 22 April 2022.

46. Michael Kofman and Rob Lee, 'Not Built for Purpose: The Russian Military's Ill-Fated Force Design', *War on the Rocks*, 2 June 2022.

47. Yaroslav Trofimov, 'Ukraine's Special Forces Hold Off Russian Offensive on Kyiv's Front Lines', *Wall Street Journal*, 4 March 2022.

48. Emily Ferris, 'Victory Day Was Just a Day: Trying to Penetrate Russia's Thinking', *RUSI Commentary*, 9 May 2022.



assesses that it has 1.6 million people within its current target group for mobilisation. Ukrainian officials are predicting that 9 million Russians will be unemployed by the end of the year, potentially increasing those volunteering for service.⁴⁹ Nevertheless, the draft appears extremely unpopular and even among hard Russian nationalists is seen as a signal that the government has conducted the war incompetently. Furthermore, bottlenecks in government records, training capacity and equipment serviceability mean that the Russian government cannot pull all these individuals into uniform in a short space of time. Instead, the process of mobilisation is anticipated to be an ongoing one.

The dynamics outlined above have created several problems for Russian ground forces. First, their units are now amalgamations of troops with variable levels of training, experience and equipment and with little time spent working together. The lack of a professional non-commissioned officer corps in the Russian Army has inhibited the cohesion of these composite units. Furthermore, the massive casualties among Russia's contract soldiers – disproportionately concentrated among the airborne and special forces⁵⁰ – in the first month of the war has left many soldiers who survived to be very reluctant to embark on offensive operations.⁵¹ Thus, the most experienced troops who ought to be critical to leading newly mobilised personnel are, in many cases, the most reluctant to prosecute attacks. The result is

49. Author interview with O, a senior Ukrainian intelligence official, April 2022.

50. Olga Ivshina and Olga Prosvirova, 'BBC Investigation Reveals Confirmed Russian Military Deaths', *BBC News Russian*, 21 March 2022.

51. Pjotr Sauer, "'They Were Furious': The Russian Soldiers Refusing to Fight in Ukraine", *The Guardian*, 12 May 2022.

that Russian forces on the offensive lack momentum, and demand massive artillery preparation of their objectives as well as overwhelming numerical superiority.

Despite these deficiencies, the Russians continue to seize ground and are inflicting casualties on the Ukrainian military at an average rate of 100 per day.⁵² There are several reasons for this. First, the artillery dominance of the Russian forces prevents Ukrainian troops from concentrating much above the size of the company group. Russian forces, which are not under a comparable artillery threat, can concentrate at the decisive point and are therefore achieving localised force ratios upwards of 7:1 on their main effort.⁵³ Furthermore, by operating across a broader front, Russian forces are better able to exploit their considerable firepower and resilience than during their attempts at a *coup de main* against Kyiv. Furthermore, after taking massive casualties, the Russians have once again taken up their lessons from Chechnya⁵⁴ and Syria and begun to employ mobile storm groups to spearhead offensive operations in urban areas, built around 20-person assault teams supported by armour.⁵⁵ This tactical adaptation has enabled Russian forces to make greater progress in urban fighting, with casualty rates among Russian and Ukrainian units currently approaching parity, despite the Russians usually being on the offensive. Although Ukrainian troops are much better motivated, Russian numerical superiority and the ability to kill Ukrainian forces with artillery as they manoeuvre mean that Ukrainian units continue to cede ground and to pay disproportionately on the offensive.

Enabling Ukraine to defeat Russian ground manoeuvre forces is not just a matter of winning the artillery war. Ukrainian troops must be able to take the offensive, and here it is necessary to address some serious misconceptions about the structure and capabilities of the Ukrainian Army. US commentators have applauded excellent Ukrainian tactical proficiency and often ascribed this to Ukraine adopting a professional non-commissioned officer corps.⁵⁶ This is an impression produced by disproportionate interaction with a small number of highly capable Ukrainian units that have had long exposure to NATO. To step into the headquarters of the 95th Air Assault Brigade, for example, would be a very familiar experience for any NATO officer. The layout of the room, range of specialisms present, orders process and culture, with briefings delivered by junior officers and soldiers under the supervision of their superiors, is similar to

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52. Author interviews with K; P, a senior officer in Ukrainian military intelligence, Ukraine, June 2022. Media reports have indicated higher casualty rates, but the higher numbers were on outlier days (see *BBC News*, 'Ukrainian Casualties: Kyiv Losing Up to 200 Troops a Day – Zelensky Aide', 9 June 2022). Casualties have been averaging around 100 per day.
53. Author interviews with A; F.
54. Lester W Grau, 'Russian Urban Tactics: Lessons from the Battle for Grozny', Institute for National Strategic Studies, Strategic Forum No. 38, 2001, <<https://apps.dtic.mil/sti/pdfs/ADA394517.pdf>>, accessed 27 June 2022.
55. Author interview with A.
56. Mark Hertling, 'I Commanded U.S. Army Europe. Here's What I Saw in the Russian and Ukrainian Armies', *The Bulwark*, 11 April 2022, <<https://www.thebulwark.com/i-commanded-u-s-army-europe-heres-what-i-saw-in-the-russian-and-ukrainian-armies/>>, accessed 27 June 2022.

what prevails in the most proficient NATO command posts.⁵⁷ The 95th Brigade – and several others – also have non-commissioned officers who have interacted extensively with NATO counterparts. Speak to them about their role, however, and they are the first to admit that there is little standardisation of how non-commissioned officer posts are used by commanders across the Ukrainian Army, that professional military education for the corps was nascent before the war and that their units are not representative.⁵⁸

Most units of the Ukrainian armed forces today contain a significant proportion of civilians with limited military experience, mobilised technical specialists with considerable expertise but without rank, and small numbers of professional soldiers who have rarely operated at scale. The culture is highly egalitarian. Orders groups are more akin to debates in which the commander's statement of the mission objective results in a chaotic discussion enabling all participants to raise questions, concerns and ideas. The result is often an innovative and technically complex tactical scheme and is a large cause for Ukraine's widespread tactical successes. It is an approach that maximises the contribution of motivated soldiers with a wealth of creativity and a wide range of competences.⁵⁹ However, such a process, while viable in platoon and company groups, is not replicable at scale. In battalion- and brigade-sized actions, which is the minimum level at which full combined arms capabilities come together and is therefore the level at which offensive actions are most successfully undertaken, commanders must often make decisions that trade risk against a part of their force in exchange for advantage in another. This is a process that is not best reached by consensus but by unity of command, a clear orders process and mechanisms to oversee the implementation of orders. In many Ukrainian units, the lack of planning staffs and non-commissioned officers to manage execution of rapidly transmitted orders make the transition from defence to offence challenging.

Furthermore, because of poor pay prior to the conflict, the Ukrainian armed forces had trained vastly more technical specialists – such as mechanics, drivers and pilots – than it required to fill its order of battle. This was because of chronic retention problems.⁶⁰ Now that Ukrainian society has been fully mobilised, the force has an abundance of technical specialists, and this is supplemented by civilian engineers, programmers and skilled professionals who make the Ukrainian military creative and able to build and employ a wide range of innovative capabilities. However, while this is exceedingly useful for communications, technical surveillance and reconnaissance, EW and other functions, the core of effective offensive operations relies on not only the much-needed uplift in military equipment⁶¹ but also the infantry fieldcraft, tankmanship, tactical proficiency and the well-practised coordination of these elements into true combined

57. As observed by the authors upon visiting 95th Brigade Command Posts in Ukraine, February 2022.

58. Jack Watling and Nick Reynolds, 'Ukraine Balances Readiness for a Short and Long War', *RUSI Commentary*, 10 February 2022.

59. Author observation of Ukrainian armed forces planning processes during operations, Ukraine, June 2022.

60. Mykola Vorobiov, 'While Zelenskyy Promises Peace, Ukraine's Army Faces Serious Challenges', *Eurasia Daily Monitor* (Vol. 18, No. 42, March 2021).

61. Bowen, 'Russia's War in Ukraine', pp. 10–11.

arms manoeuvre. Troops and commanders who are highly proficient in this are in far shorter supply. To compensate for the dearth of field experience in many Territorial Defence Battalions, the Ukrainian armed forces broke up some of their best units to push experienced infantry into newly formed units. In the defence, this has led to reasonable combat performance by these troops.⁶² For the attack, however, the Ukrainian armed forces have found it necessary to bring their best units back together and have them spearhead attacks. The combination of distributing a limited supply of highly proficient professional soldiers across frontline units, and then their concentration for offensive operations, has seen disproportionate casualties among Ukraine's most-capable troops.⁶³ If Ukraine is to effectively fight a manoeuvrist war, able to withdraw from enemy concentrations and punish the Russians with fires, while setting up counterattacks to break up Russian formations, it will be necessary to improve the tactical soldiering skills across a significant number of Ukrainian troops from the various combat arms and to ensure that the staffs at brigade level are able to effectively employ these units. UK training of 10,000 infantry will help,⁶⁴ but will be insufficient without staff and junior leadership training. The survivability of Ukrainian forces while manoeuvring also requires protected mobility able to survive Russian fires. It is also important that newly trained Ukrainian troops are not filtered into units piecemeal to simply maintain troop levels but are instead held in formed units that can offer higher Ukrainian echelons available units of action to execute manoeuvre and thereby unhinge Russia's operations. If Ukraine can execute offensive manoeuvre, it will quickly take the initiative away from the Russians and thereby reduce the current massing of unfavourable force ratios at key points.

For Ukraine's international partners, enabling Ukraine to shift on to the offensive to retake its lost territories requires three lines of effort. First, there is a need to deliver infantry training to newly raised Ukrainian units at scale. Second, there is a need to deliver staff training at the brigade and divisional level to help expand the scale at which Ukraine can orchestrate operations. Third, there is a need to provide a standardised protected mobility platform with first- and second-line maintenance to give newly formed brigades the equipment to remain survivable while they concentrate. All of these are tasks that Ukraine's international partners have the capability to deliver. The US has managed to gift armoured vehicles by the acre to allies in the Middle East. Even large numbers of armoured HMMWVs would be preferable to a smorgasbord of antiquated vehicle fleets. In the Balkans, MPRI's support to Croatian forces during Operation *Storm* is a demonstration of how staff capacity can be rapidly expanded.⁶⁵

62. CNN, 'Video Shows How Ukraine Defeated Russians in Key Battle', 5 May 2022, <<https://www.youtube.com/watch?v=OM5D4vPaNOg>>, accessed 5 May 2022.

63. Author interviews with F; P, a senior Ukrainian intelligence officer, Ukraine, April and June, 2022.

64. Prime Minister's Office, 'UK to Offer Major Training Programme for Ukrainian Forces as Prime Minister Hails Their Victorious Determination', press release, 17 June 2022, <<https://www.gov.uk/government/news/uk-to-offer-major-training-programme-for-ukrainian-forces-as-prime-minister-hails-their-victorious-determination>>, accessed 27 June 2022.

65. P W Singer, *Corporate Warriors: The Rise of the Privatized Military Industry* (Ithaca, NY: Cornell University Press, 2011), p. 127.



Damage to civilian structures after fierce fighting north of Kyiv, Ukraine, June 2022. Courtesy of Jack Watling

Large-scale infantry training is something that has been conducted multiple times over the past 30 years.⁶⁶ The question is how Ukraine's partners plan to share the burden of these tasks.

A Land Without Safety

After the initial phase of operations, both the Russian Air Force and the Ukrainian Air Force have found that much of the air over enemy territory is denied to them. For Russia, a lack of pilot training for large-formation flying, limited capabilities for the suppression of air defences and the lack of unified command of air operations led to a significant number of aircraft losses and poor effects on Ukrainian territory.⁶⁷ For Ukraine, the density and lethality of Russian air defences have meant that its air force cannot routinely approach areas of active operations, while helicopters are employed sparingly,⁶⁸ only to areas confirmed to lack coverage from air defences.

Because the longer-ranged Russian air-defence systems provide protection over the frontlines, the Russians have been able to maintain a significant tempo of close air support strikes in Mariupol and Donbas. However, the density of Ukrainian MANPADS forces Russian aircraft to fly

66. Jack Watling and Nick Reynolds, *War by Others' Means: Delivering Effective Partner Force Capacity Building*, RUSI Whitehall Paper 97 (London: Taylor and Francis, 2020).

67. Justin Bronk, 'Is the Russian Air Force Actually Incapable of Complex Air Operations?', *RUSI Defence Systems* (Vol. 24, 4 March 2022).

68. *New Voice of Ukraine*, '1700 Ukrainian Soldiers Leave Azovstal, Zelensky Opens Up About Heroic Pilots Who Helped Them Survive for So Long', 20 May 2022, <<https://english.nv.ua/nation/russia-invasion-of-ukraine-day-86-1700-ukrainian-soldiers-leave-azovstal-ukraine-news-50243717.html>>, accessed 21 May 2022.

at dusk and dawn, and at higher altitudes, limiting accuracy with unguided munitions. Against helicopters, Ukrainian forces report that Igla and Stinger MANPADS are routinely defeated by Russian countermeasures.

Unfortunately, Russia's ability to strike targets deep inside Ukraine is not removed by the denial of airspace to the VKS. From the first days of the war, Russia has struck across Ukraine with cruise and ballistic missiles. The initial failure by Russia to mass these fires against Ukrainian logistics and key infrastructure enabled Ukrainian forces to reposition in the opening stages of the war and is a partial cause of the failure of Russia's attempt to seize Kyiv. Nevertheless, as the conflict protracts, Russia's ability to strike wherever it wishes has a number of effects that are detrimental to Ukraine's war effort.

First, these strikes minimise Ukraine's capacity to domestically produce defence materiel, to conduct large-scale maintenance of its combat systems, exercise new formations of troops or maintain significant fixed infrastructure. From the destruction of Yavoriv Training Base with a salvo of 30 missiles near Lviv on 13 March,⁶⁹ to the concentration of a salvo of missiles against Kyiv on 26 June,⁷⁰ Russia is capable of conducting large-scale strikes on selected targets. The persistent strikes on Ukrainian cities have an attritional effect on the confidence of the Ukrainian public in its security, the prospects for reconstruction and economic recovery, and the management of internally displaced people.

It also appears that Russia is striking targets in civilian areas to send political messages, and to hold civilian areas at risk. There is a persistent concern that Russian missile systems positioned in Belarus may move south to conduct a mass strike on the capital at short notice.

It has been widely reported that Russia is running out of these munitions.⁷¹ It is certainly true that all these long-range strike systems rely on foreign components that Western sanctions are limiting Russia's access to. It is also clear that Russia has a limited stockpile. Nevertheless, at current rates of expenditure, strikes can continue for months. So long as the capacity to deliver these effects remains, they also have a shaping function on Ukrainian forces, the economy and society.

The most destructive system employed against Ukraine is the Iskander-M quasi-ballistic missile, which is also the hardest to intercept. As it is manoeuvrable, the Iskander-M is exceedingly difficult for ballistic missile defence to plot an interception. Furthermore, it dispenses decoy emitters in its terminal phase, each approximately the size of a drinks can, which collectively expand and distort the contours and apparent trajectory of the missile when interrogated by

69. Hugo Bachega, 'Ukraine War: "Sky Turned Red" as Missiles Hit Lviv Military Base', *BBC News*, 13 March 2022.

70. Valerie Hopkins, 'Missile Strike in Kyiv Rattles Residents After Weeks of Quiet', *New York Times*, 26 June 2022.

71. Henry Foy and Felicia Schwartz, 'Russia Running Short of Precision Missiles, Say Western Officials', *Financial Times*, 29 April 2022.



Damage from a cruise missile strike against an apartment building in Kyiv, Ukraine, June 2022. *Courtesy of Jack Watling*

radar.⁷² Despite being highly effective, Iskander-M is both one of Russia's scarcer weapons systems and central to its concepts for defence against NATO, limiting the number of munitions that are used. The vast majority of strikes against Ukraine are conducted using cruise missiles, including: the 9M727 launched from the Iskander transporter erector launcher; the Kh-101 mainly launched from bombers from the north of Ukraine; the Kh-59 air- and ground-launched cruise missile; and the 3M-54 Kalibr launched in large numbers from Russian vessels in the Black Sea.⁷³ The launch method, range and payload of these munitions varies, but they also have a large number of common characteristics and components. For example, some computers for processing sensor data are common in both the 9M727 and Kalibr missiles.

The similarities between these missiles mean that they have comparable advantages and vulnerabilities. They are subsonic (though some variants can go supersonic in their terminal dive), low flying and manoeuvrable. The selection of waypoints en route to target allows these missiles to avoid detection by defensive radar if the locations of these defences have been established. Russian forces have been observed to use E95M air targets to encourage the illumination and thereby mapping of defensive radar.⁷⁴ In any case, these missiles give little warning to missile defence systems and can often approach targets from poorly defended or even undefended trajectories.

72. The authors examined these emitters and the pattern they create for radar during fieldwork in Ukraine in June 2022.

73. Remnants of all these missiles were examined by the authors during fieldwork in April and June 2022.

74. Author interview with N.

Another consequence of the manoeuvrability of these missiles is that, when they enter Ukrainian air space, their eventual destination cannot be determined – even if they are observed on a particular trajectory, they can turn to fly in a completely different direction. As a result, the Ukrainians must initiate their air raid warnings across a very wide area. However, multiple such alerts a day lead to many people ignoring the air raid warning, placing them at risk when the missiles eventually reach their targets.⁷⁵

The missiles rely on a range of sensors to guide their flight. Several have imaging capabilities and can compare the footage to pre-loaded mapping. Others use radar for a similar purpose. They also tend to have an aerial mounted on the top of the missile for receiving satellite signals and have fibre-optic gyroscopes for inertial navigation in case weather, enemy countermeasures or damage denies access to their primary sensors. Interestingly, the Iskander 9M727 cruise missile – and this may be true of the others also – relies on GPS and GLONAS for its satellite navigation and is unable to receive BeiDou signals. The GPS is the primary navigation tool for the missile, probably because Russian satellite coverage over target countries is intermittent⁷⁶ and because it is assumed that the enemy will not deny GPS signals over territory that they control. Briefings by the Pentagon have reported that a large number of Russian cruise missiles fail to either find their targets or malfunction and crash in flight.⁷⁷ As far as Ukrainian military scientists can determine, this is actually quite rare.⁷⁸ Because of their subsonic flight, Ukrainian troops can indicate to nearby units when these cruise missiles overfly them, and this has enabled Ukrainian Zu-23 gunners to prepare to engage munitions in flight. Other cruise missiles have been shot down by Ukrainian air-defence systems, including SA-11 and by fast air interceptors. Many of the downed missiles exhibit signs of having been hit in the fuselage and wing by cannon fire or fragmentation blasts, suffering damage to either their sensors or control surfaces and therefore having their stability in flight compromised.⁷⁹

Given that ground-based anti-aircraft artillery, ground-to-air and air-to-air missiles are able to knock out the majority of Russia's long-range precision-strike capabilities, it is evident that Ukraine needs two kinds of support. First, there is the need for a means to disseminate cruise missile track data more effectively. For a warning system inside Ukraine, this could be app based, with civilians encouraged to tap to indicate when a cruise missile is overflying them. The cyber security of this architecture would be critical. More importantly, however, the provision of point defences for Ukrainian critical military infrastructure would be highly beneficial. Although Ukrainian air defences have proven capable of intercepting Russian missiles, there are too few of these platforms to provide adequate coverage given that the low flight profile of cruise missiles makes the area that

75. Observed by the authors during fieldwork in April and June 2022.

76. Mark Krutov and Sergei Dobrynin, 'In Russia's War On Ukraine, Effective Satellites Are Few and Far Between', *Radio Free Europe/Radio Liberty*, 11 April 2022, <<https://www.rferl.org/a/russia-satellites-ukraine-war-gps/31797618.html>>, accessed 12 April 2022.

77. Phil Stewart, 'Exclusive: U.S. Assesses Up to 60% Failure Rate for Some Russian Missiles, Officials Say', *Reuters*, 25 March 2022.

78. Author interviews with I; H; G; F. Inspection of missile components during fieldwork, Ukraine, June 2022.

79. *Ibid.*

a given air defence battery can cover very small. Instead, capabilities such as C-RAM and some EW systems could enable Ukraine to significantly harden critical areas in its rear to expand its ability to sustain domestic war production and to secure training sites that will be critical to the ongoing reconstitution of Ukrainian ground elements. Additional stocks of air-to-air missiles also offer the prospects of the continued interception of cruise missiles by the Ukrainian Air Force.

Conclusion

Ukrainian victory is possible, but only with international support. In the absence of that support Ukraine may either be worn down through attrition and economically strangled, or else fight a protracted and bloody war over several years. International support so far has been hugely consequential in enabling Ukraine to survive but has also been piecemeal and is introducing significant logistical frictions into the Ukrainian military. The first step in delivering effective support to Ukraine is the rationalisation of the equipment being provided with standardisation of platforms and munitions supported by appropriate maintenance. Burden-sharing between Western defence industry and governments will be important. For this purpose, a committee to agree a process for rationalisation of support should be established to ensure its sustainability, where allies agree to each provide specific kinds of capability at scale, rather than each state offer small numbers of a wide range of capabilities.

This report has sought to outline Ukraine's foremost tactical requirements if it is to be able to retake the ground lost to Russia and thereby achieve the operational defeat of the Russian Army. First, Ukraine must suppress Russia's artillery advantage by destroying the logistical enablement of Russia's massed fires. Second, Ukraine must employ its own fires to prevent Russia concentrating to achieve positive force ratios. Third, the Ukrainian military must be able to strike Russia's EW architecture to enable the kill chains to win the fire fight. Fourth, this should enable Ukrainian offensive ground manoeuvre, but will require large-scale training in infantry skills, support to Ukrainian brigade and divisional planning, and the provision of protected mobility. Finally, Ukrainian training bases, critical national infrastructure and population centres need greater protection from Russian long-range precision strikes, which demands the provision of support in tracking cruise missiles and point defences.

The priorities for equipment support to Ukraine may be defined as follows:

- MLRS.
- 52-calibre 155-mm howitzers and a consistent supply of ammunition.
- Anti-radiation seekers for loitering munitions.
- Harris radios or comparably secure tactical communications.
- Anti-tank guided weapons capable of overflight or top attack, most notably NLAW, Javelin and Brimstone.
- Visually guided MANPADS such as Starstreak and Martlet.
- Protected mobility platforms.
- Point defence systems.
- Second-line maintenance support.

The scale and longevity of support that Ukraine requires is significant and will stretch many Western allies. These requirements cannot be met through the donation of existing stocks but will instead require the production of new munitions. The cost may lead Western states to slow-roll the provision of support. In practice, however, a slow attritional conflict will be much more costly in the long term. Rationalising support to Ukraine today and delivering capability at scale is essential.

If Russia is to be convinced that stopping its invasion is the best line of policy – just as the Russian military determined that it had to withdraw from Kyiv – then the Kremlin must be convinced that it cannot win through a protracted conflict that exhausts Ukrainian stockpiles and Western resolve.

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Cover image: A Ukrainian soldier keeps watch for Russians on a reconnaissance patrol, Ukraine, June 2022.
Courtesy of Jack Watling

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