# Ukrainian Innovation in a War of Attrition

*By Seth G. Jones, Riley McCabe, and Alexander Palmer*

## THE ISSUE

*Russia suffered more combat deaths in Ukraine in the first year of the war than in all of its wars since World War II combined, according to a new CSIS analysis of the force disposition and military operations of Russian and Ukrainian units. The average rate of Russian soldiers killed per month is at least 25 times the number killed per month in Chechnya and 35 times the number killed in Afghanistan, which highlight the stark realities of a war of attrition. The Ukrainian military has also performed remarkably well against a much larger and initially better-equipped Russian military, in part due to the innovation of its forces.*

## INTRODUCTION

The Prussian general and military theorist Carl von Clausewitz wrote that war is filled with unpredictability and that "in war more than anywhere else in the world things happen differently to what we had expected."[1] Just ask Russian political and military leaders in charge of the war in Ukraine today.

One of the most interesting puzzles is how Ukraine–which has a significantly smaller military, weaker military capabilities, a limited defense industrial base, and a smaller economy–was able to blunt a Russian blitzkrieg and then conduct a series of counterattacks against dug-in Russian forces. Before its invasion in February 2022, Russia had nearly five times as many military personnel as Ukraine, a defense budget eleven times larger, an economy almost eight times larger, and significantly better military capabilities. Examples of Russian capabilities included advanced fighter aircraft (such as the Su-34 and Su-35), artillery (such as the 2S7

Pion, BM-21 Grad, and 2S4 Tulpan), main battle tanks (such as the T-72 and T-90), nuclear weapons, and one of the world's most feared offensive cyber capabilities.[2] Yet Russia's preponderance of power has failed to deliver it swift victory on the battlefield.

To understand how the war has proceeded and how it may change in the future, this analysis asks three main questions: What is the current state of the war? What factors–particularly Ukrainian military innovation–have contributed to battlefield performance? What are the future prospects for continued Ukrainian innovation and the requirements for additional Western assistance in a war of attrition?

To answer these questions, this analysis adopts a mixed-methods approach. It draws on interviews with individuals involved in the war, including those who have fought on the Ukrainian side and those who have provided technical support to the Ukrainian military. It supplements these interviews with primary and secondary sources, as

well as satellite imagery. Finally, it builds an operational-level map of the Ukrainian battlefield to highlight the force disposition and territory that Ukraine has retaken throughout the war. A separate document explains the methodology used to build the battlefield map.[3]

This analysis makes three main arguments. First, the war in Ukraine has become a war of attrition characterized by dug-in forces, trenches, human-wave attacks, artillery barrages, and high casualties on both sides. Russia likely suffered more combat fatalities in Ukraine in the first year of the war than in all of its wars since World War II *combined*, including the Soviet and Russian wars in Afghanistan and Chechnya. The average rate of Russian regular and irregular soldiers killed per month in Ukraine over the first year of the war was at least 25 times the number killed per month in Russia's war in Chechnya and at least 35 times the number killed per month in the Soviet Union's war in Afghanistan.

Second, Ukraine has performed extraordinarily well against an adversary with a significant advantage in material resources. One factor that has likely contributed to Ukraine's performance is military innovation, exemplified by Ukraine's utilization of unmanned aircraft systems (UASs) in combined arms operations. Many of Ukraine's innovations have come from the bottom up, thanks to a military environment that encourages and enables junior officers to seek innovation.

Third, while military innovation will be necessary as the war continues, it will not be sufficient to outweigh the matériel needs of the Ukrainian military, such as air defense systems, long-range artillery, armored vehicles, fighter aircraft, munitions, spare parts, and logistical resources. The West, including the United States, should prepare for a protracted war and long-term support to Ukraine.

The rest of this brief is divided into four sections. First, it provides an update on the war, including through an operational map of the battlefield. Second, it examines the role of military innovation. Third, it assesses Ukrainian military innovation. Fourth, it assesses the future implications of Ukrainian innovation and foreign assistance in a war of attrition.

## WAR OF ATTRITION

The war in Ukraine has become a war of attrition.[4] Ukraine and Russia have constructed trench systems and made heavy use of artillery.[5] Russia has employed human-wave attacks against fixed Ukrainian positions, including frontal assaults that attempt to seize ground by sheer weight of numbers, rather than by superior positioning or effective combined arms employment.[6] Neither side has gained much territory since Ukraine's successful offensives in late 2022, even as casualty rates have increased.[7] Both militaries have suffered significant damage to their weapons systems. For example, Russia lost approximately 50 percent of its modern T-72B3 and T-72B3M main battle tanks since the war began, along with roughly two-thirds of its T-80BV/U tanks.[8]

The attritional nature of the fighting can also be seen in the overall disposition of Russian and Ukrainian forces, as illustrated in Figure 1. Both sides face one another along a front stretching for 500 to 600 miles. Rather than massing armored formations at decisive points, both sides have distributed infantry across the front lines, with artillery in support. Although the nature of the fighting could still change, most signs point to a prolonged war of attrition in eastern and southern Ukraine, including the Russian military's failure in February 2023 to achieve a rapid armored breakthrough near the southern town of Vuhledar.

A war of attrition is one in which the belligerents attempt to wear each other down through piecemeal destruction of matériel and personnel.[9] The essence of an attrition strategy is best described by Clausewitz, who wrote that it is a mistake to believe that there is "a skillful method of disarming and overcoming an enemy without causing great bloodshed." Instead, Clausewitz contends that "war is an act of violence pushed to its utmost bounds" and that the side "that uses force unsparingly, without reference to the bloodshed involved, must obtain a superiority if his adversary uses less vigor in its application."[10] In attrition warfare, the belligerents are mainly concerned with overpowering their adversaries in a series of bloody set-piece battles that minimize exposure to enemy fire. These battles are characterized by high casualties, huge expenditures of matériel, and minimal movement of front lines.

In attrition warfare, a successful offensive operation pushes the defender backward along a front line, much like a bulldozer. There is limited expectation of delivering a knockout blow in which a specific action
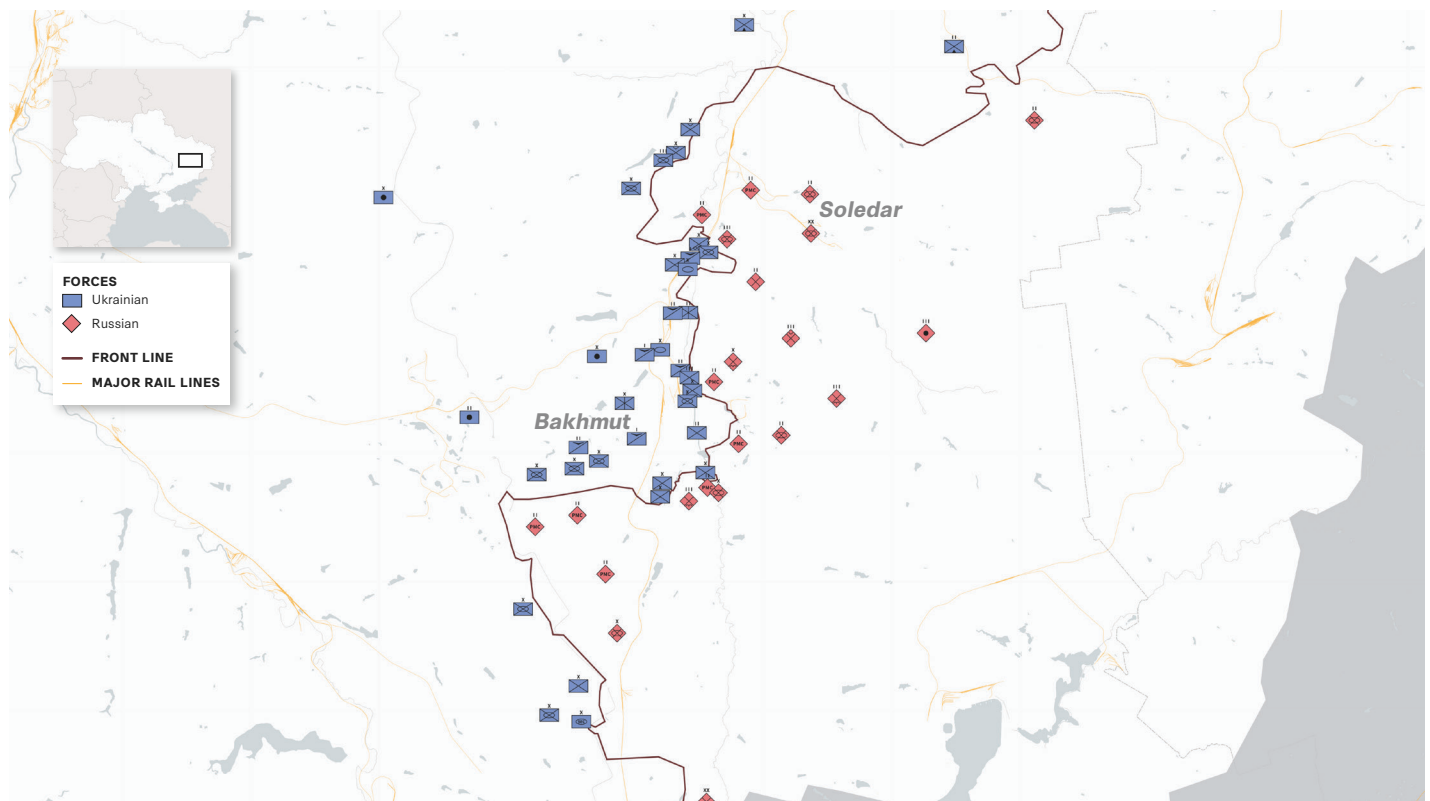
## Figure 1: Russian and Ukrainian Force Disposition, February 2023
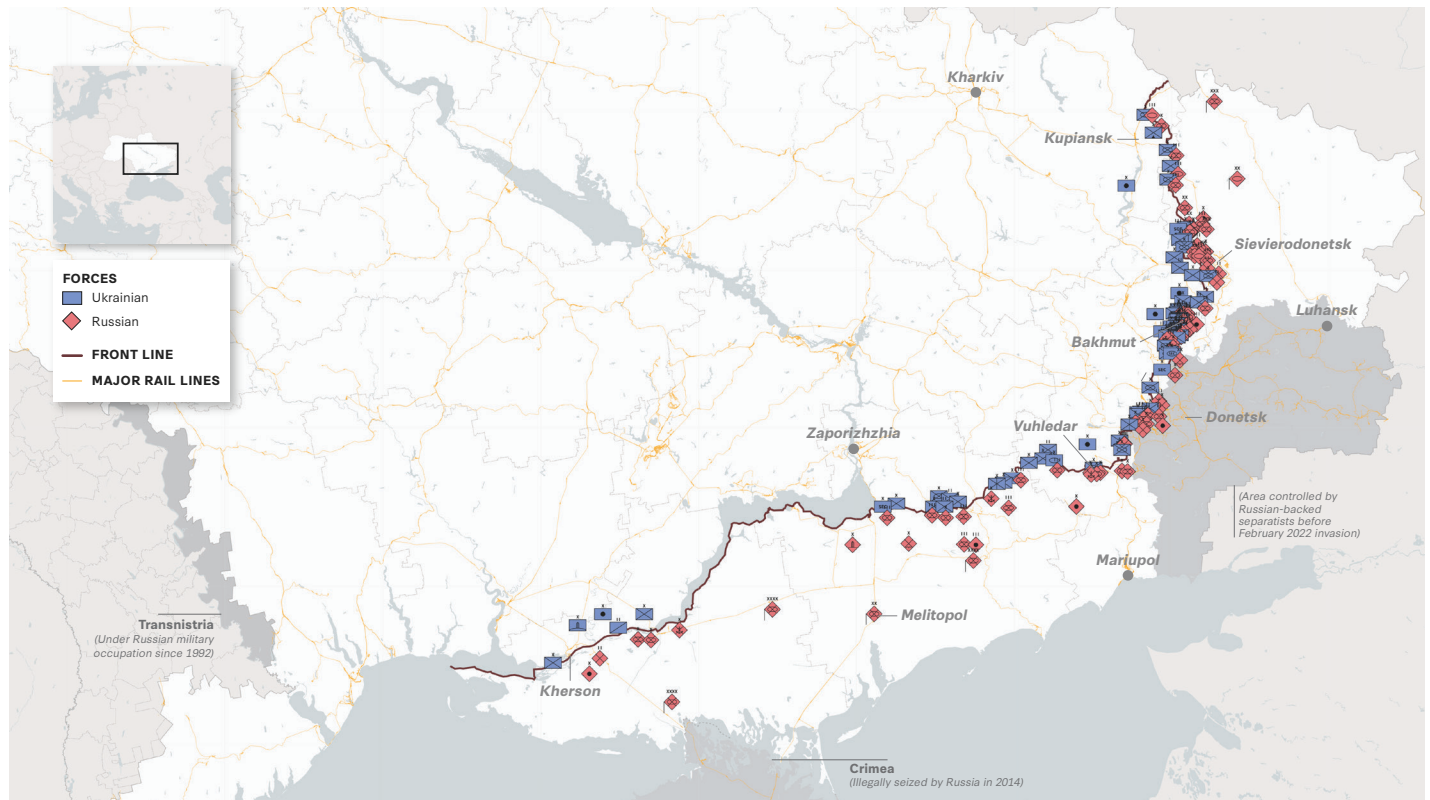


Note: This map was last updated as of February 10, 2023.

Source: CSIS compilation and analysis of multiple sources.

## Figure 2: Russian and Ukrainian Force Disposition, Bakhmut Area, February 2023



Note: This map was last updated as of February 10, 2023.

Source: CSIS compilation and analysis of multiple sources.

quickly renders the opponent unable to fight. The victorious side is instead the one that can more readily replace the soldiers and equipment–including long-range artillery and armored vehicles–that are lost in huge numbers. Even in cases when it is ultimately successful, attrition warfare carries huge costs. To win a war of attrition requires a willingness to absorb considerable casualties and significant losses of equipment.[11]

The nature of the war in Ukraine can be most clearly seen in the fighting for Bakhmut, a small city in the Donetsk region of Ukraine. For months, Russian forces have relentlessly shelled the city, fought house to house, and used human-wave attacks to overwhelm Ukrainian defenders.[12] Spearheaded in recent months by the Russian private military company Wagner Group, Russian efforts to take Bakhmut have included recruiting vast numbers of prisoners from around the country to throw at the front lines–in addition to the use of regular Russian soldiers.[13] The Russian military has utilized three waves of fighters in some areas: a first line of contractors and green conscripts, whose casualty rates are often high; a second line of replacements; and a third line of relatively competent Russian forces.[14] Russia is accepting enormous casualties in return for only small amounts of territory. Despite intense fighting throughout the winter, Russia has only captured approximately 400 square miles of Ukrainian territory across the entire eastern front since September 2022.[15] As Figures 3.1 and 3.2 show, there are numerous signs of attrition warfare, including defensive infantry trench systems, anti-tank ditches and berms, and impact craters from artillery.

Figure 3.1: Satellite Imagery of Trench System, Anti-Tank Ditches, and Impact Craters near Bakhmut, Ukraine



BAKHMUT, UKRAINE
February 11, 2023

Defensive infantry trench system

Anti-tank ditch and berm

Incomplete anti-tank ditch and berm

Impact craters throughout the fields

Copyright © 2023 by Planet

CSIS | TRANSNATIONAL THREATS PROJECT

N

Figure 3.2: Satellite Imagery of Trench System and Impact Craters near Bakhmut, Ukraine



BAKHMUT, UKRAINE
February 11, 2023

Defensive infantry trench system

Impact craters throughout the fields

Copyright © 2023 by Planet

CSIS | TRANSNATIONAL THREATS PROJECT

N

While the fighting today has devolved into a war of attrition, Russia appears to have initially employed a blitzkrieg strategy intended to win the war quickly. In February 2022, Russia concentrated ground forces at multiple points along Ukraine's borders and attempted to pierce the front lines, race deep into Ukraine's rear areas with the aid of air and naval power, and overthrow the government of Volodymyr Zelenskyy.[16] Unlike a war of attrition, a blitzkrieg strategy relies on fast-moving armored and mechanized units to penetrate into the adversary's weakly defended rear to destroy the informational, logistical, and political infrastructure on which an army depends.[17] Russia likely based its strategy on several faulty assumptions, including

that the Ukrainian population would not fight for a Zelenskyy government the Russians accused of being deeply corrupt, the Ukrainian military would be quickly overwhelmed, and the West would not support Ukraine and risk another "forever war" less than a year after the U.S. withdrawal from Afghanistan.[18]

Prior to the February 2022 invasion of Ukraine, Russia controlled approximately 7 percent of Ukrainian territory.[19] Within a month of the invasion, Russia controlled nearly 30 percent of Ukrainian territory, including large swaths of eastern Ukraine stretching from the southern Kherson Oblast to the northern Kharkiv Oblast, as well as a sizable chunk of territory reaching from Ukraine's northern border to outside the capital of Kyiv.[20]

The Russian advance soon stalled, however, and Ukrainian counteroffensives in the spring of 2022 repelled Russian forces from north of Kyiv and retook territory across much of the eastern front line, reducing total Russian territorial control to approximately 20 percent.[21] A second wave of successful Ukrainian counteroffensives liberated more territory on the Kharkiv and Kherson fronts in the late summer and fall of 2022, reducing Russian control to approximately 17 percent, where it remains today.[22] Figure 4 illustrates liberated areas of Ukraine (in blue) between March 2022 and February 2023.

The evolution of the war to one of attrition poses significant military and political challenges for Russia, especially since the Russian military is absorbing fatalities and casualties at rates it has not experienced since World War II. Estimating fatality and casualty numbers is notoriously difficult, in part because all sides have incentives to misrepresent such figures and in part because of the difficulties inherent in collecting data during active combat.

According to CSIS estimates, there have been approximately 60,000 to 70,000 Russian combat fatalities in Ukraine between February 2022 and February 2023. These estimates include regular Russian soldiers from the Russian armed forces, Rosgvardiya, Federal Security Service, and Federal Guard Service;

## Figure 4: Map of Territorial Control: March 2022-February 2023
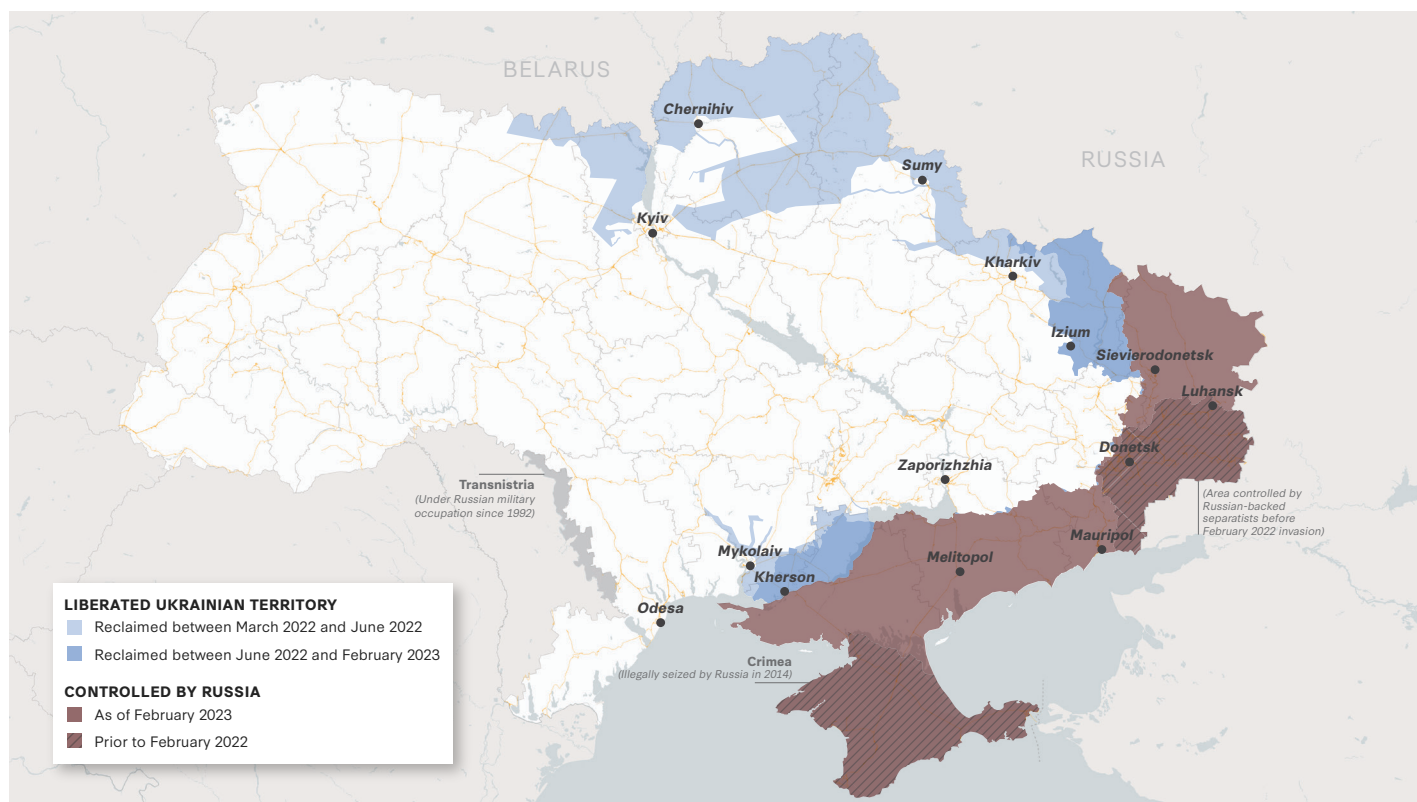


Note: This map was last updated as of February 10, 2023.

Source: CSIS compilation and analysis of multiple sources.

fighters from pro-Russian militias, such as the Donetsk People's Militia and Luhansk People's Militia; and contractors from such private military companies as the Wagner Group.[23] Overall, Russia has suffered roughly 200,000 to 250,000 total casualties–personnel wounded, killed, and missing–during the first year of the war. These casualty estimates also include regular Russian soldiers, militia fighters, and private contractors from the Wagner Group.[24]

While some types of authoritarian regimes are willing to accept hight casualties in interstate conflicts, Russian casualty numbers are unprecedented since World War II.[25] As highlighted in Table 1, the number of Russian soldiers killed in Ukraine during the first year of the war was likely greater than the entire number of Russian soldiers killed in every war Russia has fought since World War II *combined*. The number of Russian soldiers killed in Ukraine in the first year was roughly two to five times greater than the number of Russian soldiers killed in Chechnya over nearly a decade a half.

The rate of attrition is also much higher in Ukraine than in any Soviet or Russian war since World War II. Russia suffered an average of roughly 5,000 to 5,800 regular and irregular soldiers killed per month in Ukraine over the first year of the war.[26] In comparison, Russia suffered somewhere between 13,000 to 25,000 fatalities in Chechnya over a 15-year period (with a three-year pause), an average rate of between 95 and 185 soldiers killed per month.[27] The Soviet Union also suffered roughly 14,000 to 16,000 combat fatalities in Afghanistan, an average rate of between roughly 130 and 145 soldiers killed per month.[28] Vladimir Putin has thus far been willing to

Table 1: Russian Forces Killed in Selected Wars Since World War II[29]

| War | Dates | Russian Forces Killed or Missing (Regular and Irregular) |
| --- | --- | --- |
| Korea | 1950–1953 | 120 |
| Hungary | 1956 | 669 |
| United Arab Republic (Egypt) | 1962–1963, 1969–1972, 1973–1974 | 21 |
| Yemen Republic | 1962–1963 | 1 |
| Algeria | 1962–1964 | 25 |
| Vietnam | 1965–1974 | 16 |
| Mozambique | 1967, 1969, 1975–1979 | 6 |
| Czechoslovakia | 1968 | 96 |
| Sino-Soviet Border Conflict | 1969 | 58 |
| Angola | 1975–1979 | 7 |
| Ethiopia | 1977–1990 | 34 |
| Afghanistan | 1979–1989 | 14,000–16,000 |
| Chechnya (First and Second Wars) | 1994–1996, 1999–2009 | 12,000–25,000 |
| Georgia | 2008 | 64 |
| Ukraine (Crimea and Donbas) | 2014–February 2022 | 6,000–7,000 |
| Syria | 2015–Present | 264 |
| Ukraine | February 2022–Present | 60,000–70,000 |

Source: Authors' compilation. See endnote 29 for complete list of citations.

accept large numbers of Russian fatalities and casualties and has suffered limited political repercussions. But it is unclear that he will be able to do so forever.

Although Russian fatalities in Ukraine pale in comparison to the Soviet death rate in World War II, the political context is extremely different. The Soviet Union suffered between 8 and 11 million military fatalities and another 14 million civilian fatalities following Germany's invasion in 1941.[30] However, the Soviets were the defenders at the start of the war and were, therefore, fighting a war of survival. Such casualties were a necessary cost of national existence. But Russia is currently the aggressor in Ukraine, where it is engaged in a war of choice against a country that poses no meaningful threat to Russia's survival.

Although Russia invaded Ukraine from an apparent position of strength, countries with a significant material advantage–a larger population, a larger or more industrialized economy, a larger military, and greater military expenditures–are not guaranteed victory in war.[31] Russia lost to Japan during the 1904-1905 Russo-Japanese War, despite having more naval ships, guns, and people. Israel repeatedly defeated its Arab foes in the 1948 Arab-Israeli War, 1967 Six Day War, and 1973 Yom Kippur War.[32] The limits of material preponderance are true even of wars of attrition. As one study concludes, "the cost of an attrition strategy is always high" and "success is relatively uncertain."[33] As some analysts have noted, wars of attrition may sometimes favor the weaker side, including if weaker militaries can find ways to fight more innovatively than their stronger enemies.[34]

## MILITARY INNOVATION

Several factors help explain battlefield performance in conventional wars. They include a combination of the military balance (especially the quantity and quality of troops and weapons on both sides), strategy, tactics, morale, combat motivation (what some have called the "will to fight"), force employment, and political and military leadership.[35] Military outcomes are generally not easy to predict, despite Napoleon's comment that "God is on the side of the big battalions."[36]

Military innovation is likely one important factor in determining battlefield success. As used here, *military innovation* involves a change in the conduct of warfare intended to improve the ability of a military to generate combat power. A change in the conduct of warfare does not necessarily require a change in military doctrine, but it does involve change at the operational level of war. Change could occur throughout the entire military, or it could be a narrower segment, such as a military service.[37]

Yet military innovation is difficult to achieve. Over 400 years ago, Machiavelli wrote: "And it should be considered that nothing is more difficult to handle, more doubtful of success, nor more dangerous to manage, than to put oneself at the head of introducing new orders."[38] Innovation can occur during peacetime when leaders–especially military leaders–respond to changes in the international landscape and create environments that facilitate and encourage junior officers to pursue innovations and new ways of war. But it is impossible to predict the future with certainty, and militaries face incentives to avoid change or hedge between alternate futures rather than commit fully to an innovation that has not been proven in combat.[39]

Wartime allows for testing innovations against a real adversary but comes with its own obstacles. Militaries must balance the incentive to innovate against the daily need to defeat an enemy who is trying to kill their members and destroy their organizations. There is often insufficient time to assess wartime conditions, reformulate strategic conceptions, and build new forces before the outcome of a war is largely determined. Old and new methods can be tested in combat, but time constraints and limited intelligence make it difficult to take advantage of any apparent innovations in time to win the war.[40]

Nevertheless, military innovation does occur during wartime, especially when operational control is decentralized, as was the case with the U.S. Navy submarine force during World War II. Innovation does not necessarily require substantial resources; major innovations have occurred during periods of constrained resources at least as often as during periods in which budgets were large and growing. Key resources for innovation are talented military personnel, time, and information–not money. Junior officers may be particularly important. Several important wartime innovations (such as the tank and microwave radar) and organizational innovations (such as strategic targeting for U.S. bombers) were pursued from the bottom up by junior officers.[41]

# UKRAINIAN INNOVATION

Military innovation is one factor that likely explains how Ukraine has overcome its disadvantages, though it is clearly not the only factor. The Ukrainian "will to fight," political and military leadership (including that of President Zelenskyy), strategy, and force employment have all likely mattered, as has military, economic, and diplomatic support from the West. But innovation increases the ability of a weaker military to reverse the gains of a stronger one.

There is also reason to believe that innovation may grow even more important as the war grinds on. Ukraine can win a war of attrition if it can impose greater losses on Russia than it suffers in any given engagement.[42] Although continued Western aid, clever strategy, and sound force employment will contribute to such an outcome, new ways of fighting that improve the efficiency of Ukrainian forces will also be important for winning a long war of attrition.

One example of Ukrainian innovation has been the use of UASs in combined arms warfare–the blending of infantry, direct and indirect fire, aviation, and other joint capabilities to achieve political and military objectives.[43] Ukraine is hardly the first country to use UASs in conventional warfare, but its employment of a wide variety of UASs in a large number of missions and its integration of UASs into more sophisticated targeting complexes have differed significantly from what came before–particularly Azerbaijan's use of UASs against Armenia in 2020.[44]

Ukraine has operated several types of UASs in combined arms warfare. One has been the Bayraktar TB-2, a medium-altitude, long-endurance UAS, which was extensively used in the early phase of the war.[45] The TB-2 can perform a range of intelligence, surveillance, reconnaissance, and attack missions. Ukraine has operated small A1-SM Furia flying-wing UASs for day and night reconnaissance, hand-launched Leleka-100 and Spectator-M mini-UASs for artillery spotting and aerial reconnaissance, the UA Dynamics-made Punisher UAS for striking military targets, and larger PD-1s and UJ-22s.[46]

Ukrainian forces have also utilized off-the-shelf commercial UASs, such as the DJI Mavic quadcopter.[47] Mavics have been particularly useful for battlefield intelligence, surveillance, and reconnaissance for frontline forces.[48] In addition, the United States has provided Ukraine with several loitering munitions–UASs intended to locate and destroy a target by detonating against it–such as the tube-launched Switchblade 300 and the long-endurance tactical Phoenix Ghost.[49]

Ukraine has utilized these UASs to conduct several types of missions as part of combined arms warfare, such as target identification for artillery and aircraft, strike, battlefield awareness, and information operations.

- **Target Identification:** Ukraine has used UASs to identify targets for artillery and aircraft.[50] For example, Ukrainian ground forces have used forward-deployed UASs to detect Russian infantry units. This information is then distributed to command-and-control centers, who then pass it on to Ukrainian units operating 122-mm howitzers and other systems.[51]

- **Strike:** Ukraine has utilized UASs for strike missions, including against land, air, and maritime targets. Ukrainian Bayraktar TB-2 drones have struck numerous Russian targets, such as howitzers, main battle tanks, supply trucks, towed artillery, maritime vessels, command posts, logistics depots, and Buk, Tor, Strela, and ZU-23 air defense systems.[52]

- **Battlefield Awareness:** Ukraine has used UASs for intelligence, surveillance, and reconnaissance missions to monitor Russian activity and facilitate battlefield awareness. The sensors on some Ukrainian UAS platforms can collect signals intelligence, record video, and collect other information for operational use by ground and air forces. These capabilities have also allowed UASs to be useful for battle damage assessment.[53]

- **Information Operations:** Ukraine has utilized UASs for information operations, such as showing successful strikes and placing them–overtly or covertly–on social media platforms such as Twitter, Telegram, and TikTok.[54]

In addition, Ukrainian forces have utilized software packages that are often developed and deployed by volunteers. The most well-known of these applications is Kropyva, an intelligence mapping and artillery software populated by information from UASs and other sources.[55] Forward-deployed tactical units have downloaded the

## Figure 5: Kropyva Defense Mapping Software
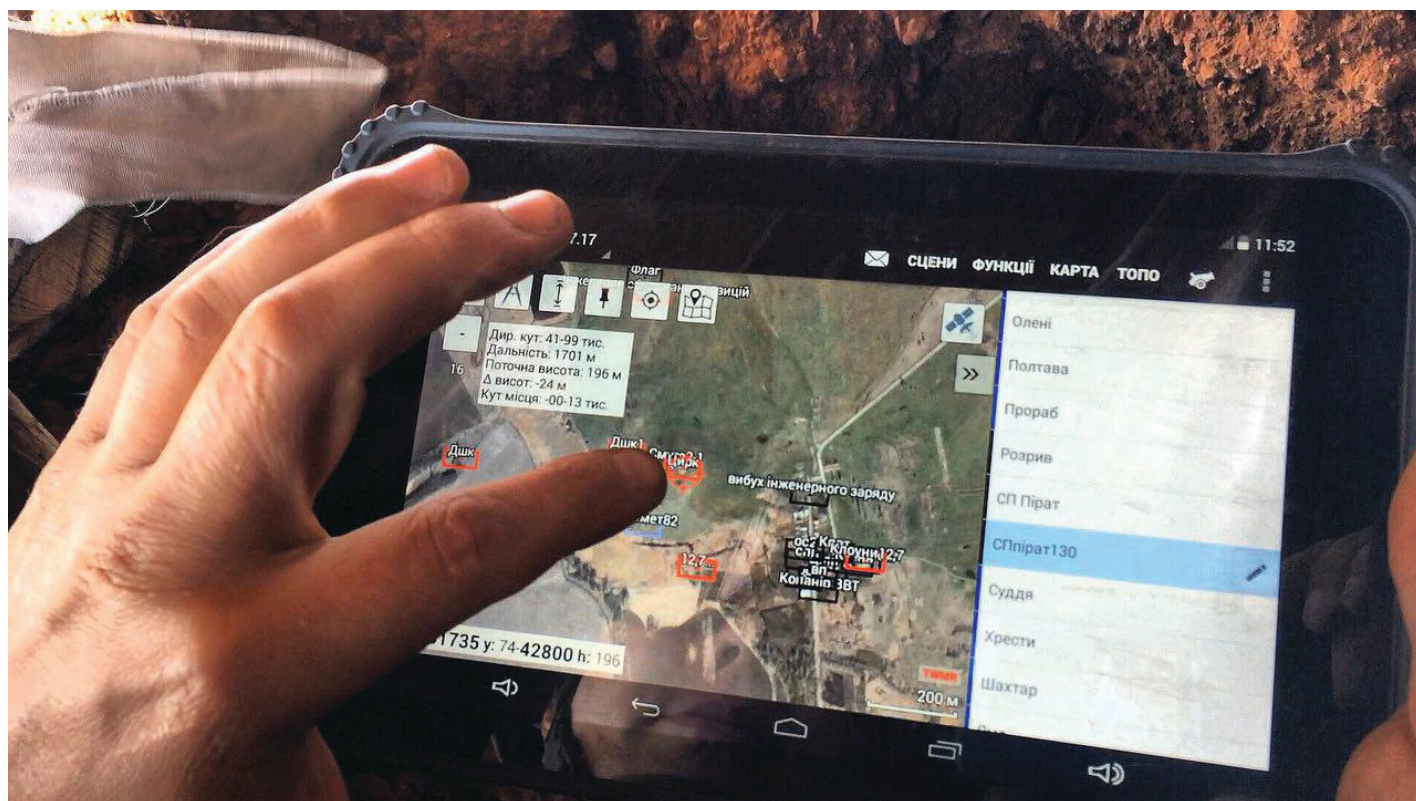


Source: Army SOS.

software and continuously updated it on handheld tablets and computers. Kropyva allows Ukrainian units to plot both enemy and friendly positions. It uses short-wave and digital radio stations compatible with the North Atlantic Treaty Organization's security communications standards and is relatively easy to use.[56] Other home-grown software solutions include GIS Arta, ComBat Vision, and the recently deployed Delta situational awareness and battlefield management system.[57]

Ukraine has also leveraged Starlink to integrate some of its systems, another tactical innovation that has allowed Ukraine to overcome Russian jamming. Starlink is a commercially owned satellite internet constellation developed by SpaceX to provide high-speed, low-latency broadband internet using advanced satellites in low earth orbit.[58] Starlink has enabled members of the Ukrainian organization Aerorozvidka, for instance, to carry out intelligence collection and fire support operations against Russian positions.[59] Some Ukrainian UASs rely on Starlink against forward-deployed Russian forces, and Ukrainian forces and civilians use Starlink to communicate using encrypted satellite communications.[60] Overall, Starlink

has helped blunt Russia's attempts to jam signals, block the internet, and undermine Ukrainian command-and-control capabilities. In addition, some Ukrainian troops have strapped Starlink user terminals to drones involved in strike operations, allowing the craft to be steered with the help of the internet connection provided by satellites.[61]

Other Ukrainian military innovations include placing Harpoon anti-ship missiles on flatbed trucks for ground-based, stand-off attack; mounting grenades and other improvised explosive devices on UASs, including Mavics; utilizing "swarming" tactics with multiple UASs; and using 3D printers to build plastic harnesses with light sensors and a mechanical clasp that snap onto UASs and carry grenades.[62] Overall, Ukraine has used its military innovations to help defend against Russian advances, conduct counterattacks in eastern and southern Ukraine, and improve overall battlefield performance.

But obstacles to innovation remain. According to CSIS interviews, the lack of official Ukrainian government support discourages adoption of volunteer-made systems, which prevents the military from scaling their use across the force. Some officers fear the consequences of using

a system they lack official permission to use. Others lack the communications hardware required to take advantage of potentially valuable software. The use of commercial quadcopters is also hampered by the makers' efforts to prevent users from integrating them into military systems, which involve firmware changes between models and increasingly restrictive application programming interfaces. The absence of government funding also means that platform usage is constrained by developers' ability to raise funds from individual donors.[63] Ukraine has begun taking positive steps to enable the innovation already happening in the country by officially sanctioning the use of the Delta management defense system on the battlefield, but a more comprehensive and systematic approach would be better.

As Ukraine attempts to maintain its innovation advantage, it should avoid apparent innovations that decrease combat power or forestall victory. Innovation is an inherently risky process. Some research suggests that the innovation process goes wrong when a military cannibalizes an old capability to create a new one, ignores the risks associated with a particular innovation, or rushes the vetting process in order to speed deployment.[64] Innovation can also fail if it contributes to a flawed theory of victory.[65] Ignoring the risks of innovation and rushing through the vetting process are real risks– and the current informality of Ukrainian innovation could exacerbate them. Volunteer developers are unlikely to have the necessary capacity to evaluate all the risks because they lack access to classified data and specific analytic expertise held by military or intelligence bodies.

## FUTURE IMPLICATIONS

The war in Ukraine is far from over. Ukraine's achievements on the battlefield have been the result of several factors, including Russian failures and Ukrainian successes. Military innovation has been–and will remain–important. But the Ukrainian military should formalize the current system of domestic innovation and create structures and organizational processes to monitor its successes and failures. To maximize the power of these innovations, Ukraine should give units the permissions necessary to formally adopt the tools they are already using. The military should also consider creating an analysis center to evaluate the impacts of bottom-up innovations on combat performance and

other measures of success. With that data and analysis in hand, the Ukrainian military can then make better-informed decisions on which innovations to scale up.

Foreign partners should also consider providing financial support to this infrastructure or the innovators themselves, who currently depend mostly on crowdfunding. Increased funding would empower Ukrainian innovators who are currently constrained by the need to support themselves while donating their time and expertise. Funding would also provide another way for governments to provide "nonlethal" aid to Ukraine if forced to do so by domestic political constraints.

As the war of attrition continues, however, it is unlikely that military innovation will be sufficient to outweigh the matériel needs of the Ukrainian military. The West, including the United States, should prepare for a protracted war and long-term support. Ukraine's needs have evolved from the initial stage of the war when it needed short-range defensive weapons, such as Javelin anti-tank and Stinger anti-air missiles, which were helpful to conduct *defensive* operations against advancing Russian forces.

Along with training and intelligence, Ukraine now needs advanced systems to conduct *offensive* operations in a protracted war, such as air defense systems, long-range artillery, armored vehicles, fighter aircraft, and munitions, along with spare parts and training. These types of munitions, weapons systems, and matériel are essential to assisting Ukrainian forces conduct effective counterattacks against dug-in Russian forces. Figure 6 shows the impact craters from artillery in yet another example of attrition warfare. Even defenders in a war of attrition need to pursue operational offensives to wear down the enemy, reduce pressure on vulnerable areas, and satisfy political audiences at home and abroad to continue support.

In addition, wars of attrition are insatiable consumers of munitions, and their heavy use takes a toll on weapons systems and platforms. On some days the Russian military has launched 50,000 artillery shells at Ukrainian military and civilian positions.[66] Supporting Ukraine through a prolonged war of attrition means supplying them with the munitions the Ukrainian military needs. Ukraine has a strong track record of innovating and integrating Western weapons systems into its military operations over the first year of the war. It should be able to effectively integrate new weapons systems into its arsenal.

Figure 6: Artillery Impact Craters near Pavlivka, Ukraine
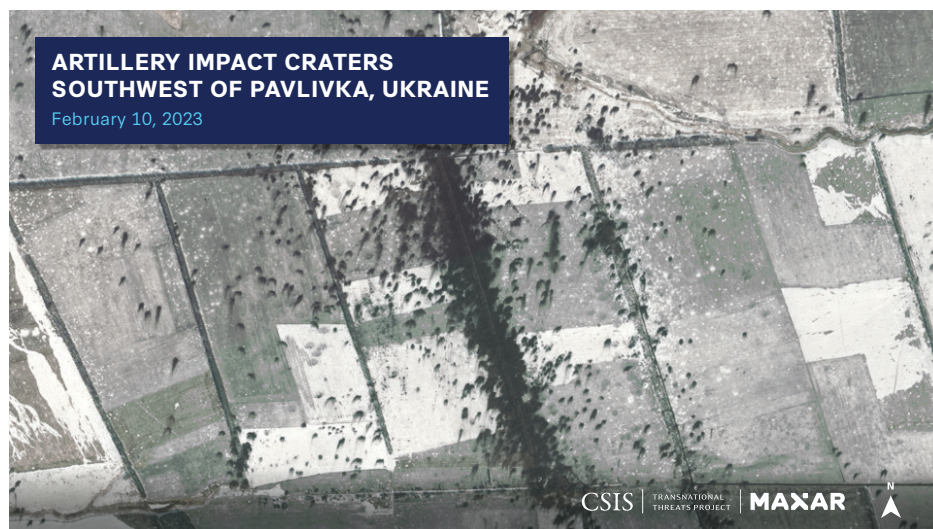


For example, more Patriot surface-to-air missile systems would be useful. So would MGM-140 Army Tactical Missile Systems (ATACMS), which are surface-to-air missiles that can be fired from a High Mobility Artillery Rocket System (HIMARS), which Ukraine already possesses. ATACMS can be fired three times the distance of standard rockets, allowing Ukrainian ground forces to move farther away from Russia's deadly long-range artillery. Tanks and infantry fighting vehicles are essential to providing fire support and carrying infantry into battle. Abrams, Challenger 2, and Leopard 2 tanks will be helpful, along with AMX-10 RC armored fighting vehicles. But continuing support for these vehicles–including spare parts, munitions, and trainers–will also be critical. MQ-1C drones would provide helpful intelligence, surveillance, reconnaissance, and strike capabilities to Ukrainian forces.

Finally, Ukraine's Soviet-era air force needs more, better aircraft to outcompete Russia in a war of attrition. Combat losses in the past five months have cost it over 50 combat aircraft out of an original fleet of approximately 124 combat aircraft.[67] With fewer aircraft available, each plane endures more sorties and wears down faster. Without replenishment from the West, Ukraine could lose the ability to defend its airspace and target Russian ground forces, potentially allowing Russia to resume its blitzkrieg. The U.S. Air Force is divesting more than 200 A-10s, F-15s, and F-16s to make room for sixth-generation fighters, hypersonic weapons, and other systems.[68] Ukraine could use some of these aircraft–along with trainers and spare parts–particularly for close air support missions to aid Ukrainian ground forces.

Ukraine needs munitions, weapons systems, logistics, training, and intelligence at the appropriate scale. Russia still has an advantage over Ukraine in the number of munitions and the quality of some weapons systems–such as long-range artillery, advanced fixed-wing aircraft, and naval capabilities–though Ukrainian military innovation has been impressive. U.S. and other Western military aid to date has been helpful, though sometimes too slow. Moving forward, the U.S. and Western defense industrial bases will be essential for a long, grinding war of attrition. ◾

*Seth G. Jones is senior vice president, Harold Brown Chair, and director of the International Security Program at the Center for Strategic and International Studies (CSIS) in Washington, D.C. Riley McCabe is a program coordinator and research assistant with the Transnational Threats Project at CSIS. Alexander Palmer is a research associate with the Transnational Threats Project at CSIS.*

# ENDNOTES

1   Carl von Clausewitz, *On War*, Book Three, Chapter VII (New York: Penguin Books, 1968), 263.

2   For data on the number of military personnel, defense budget, economy, and military capabilities, see International Institute for Strategic Studies, *The Military Balance* (London: International Institute for Strategic Studies, 2022), 164–217; "SIPRI Military Expenditure Database," Stockholm International Peace Research Institute (SIPRI), https://milex.sipri.org/sipri; and "The World Factbook," Central Intelligence Agency, https://www.cia.gov/the-world-factbook/countries/russia/#military-and-security.

3   For an overview of the methodology used to build the battlefield map, see **here**.

4   On the distinction between attrition and blitzkrieg strategies, for example, see John J. Mearsheimer, *Conventional Deterrence* (Ithaca, NY: Cornell University Press, 1985); Lawrence Freedman, *Strategy: A History* (New York: Oxford University Press, 2013), 199; Edward Luttwak, *Strategy: The Logic of War and Peace* (Cambridge, MA: Harvard University Press, 1987); and Edward Luttwak, "The Operational Level of War," *International Security* 5, no. 3 (Winter 1980/1981): 61–79, https://doi.org/10.2307/2538420.

5   Authors' interviews with multiple sources involved in fighting in eastern Ukraine, 2023. Also see, for example, Marco Hernandez and Josh Holder, "Defenses Carved into the Earth," *New York Times*, December 14, 2022, https://www.nytimes.com/interactive/2022/12/14/world/europe/russian-trench-fortifications-in-ukraine.html.

6   Authors' interviews with multiple sources involved in fighting in eastern Ukraine, 2023.

7   Ministry of Defence, Twitter post, February 11, 2023, 1:51 a.m., https://twitter.com/DefenceHQ/status/1624662553203802112.

8   John Chipman, "John Chipman's Military Balance Launch Event Remarks," International Institute of Strategic Studies, February 15, 2023, https://www.iiss.org/blogs/analysis/2023/02/john-chipmans-military-balance-launch-event-remarks.

9   Carter Malkasian, *A History of Modern Wars of Attrition* (London: Praeger, 2002), 6.

10   Clausewitz, *On War*, 102–103.

11   Mearsheimer, *Conventional Deterrence*, 34.

12   Andrew E. Kramer, "'Our Losses Were Gigantic': Life in a Sacrificial Russian Assault Wave," *New York Times*, February 13, 2023, https://www.nytimes.com/2023/02/13/world/europe/ukraine-russia-prisoners.html.

13   Anatoly Kurmanaev, Alina Lobzina, and Ekaterina Bodyagina, "Russia Freed Prisoners to Fight Its War. Here's How Some Fared.," *New York Times*, January 30, 2023, https://www.nytimes.com/2023/01/30/world/europe/wagner-convict-ukraine-russia.html.

14   Authors' interviews with multiple sources involved in fighting in eastern Ukraine, 2023.

15   Authors' estimates based on an analysis of Russian and Ukrainian control of territory.

16   Authors' interviews with U.S. and other Western government officials, 2023.

17   Mearsheimer, *Conventional Deterrence*, 35.

18   Authors' interviews with U.S. and other Western government officials, 2023.

19   "10 Facts You Should Know about Russian Military Aggression against Ukraine," Ministry of Foreign Affairs of Ukraine, December 19, 2019, https://mfa.gov.ua/en/10-facts-you-should-know-about-russian-military-aggression-against-ukraine.

20   See, for example, Pierre Breteau, "Nine Months of War in Ukraine in One Map: How Much Territory Did Russia Invade and Then Cede?," *Le Monde*, November 28, 2022, https://www.lemonde.fr/en/les-decodeurs/article/2022/11/25/nine-months-of-war-in-ukraine-in-one-map-how-much-territory-did-russia-invade-and-then-cede_6005655_8.html.

21   John Leicester and Hanna Arhirova, "Russia Claims Advances in Ukraine amid Fierce Fighting," AP, June 7, 2022, https://apnews.com/article/russia-ukraine-kyiv-moscow-411ca8f38524e0d-2b120479acef4ad56.

22   See, for example, Seth G. Jones, Jared Thompson, and Riley McCabe, "Mapping Ukraine's Military Advances," CSIS, *Commentary*, September 22, 2022, https://www.csis.org/analysis/mapping-ukraines-military-advances; authors' estimates; and "Maps: Tracking the Russian Invasion of Ukraine," *New York Times*, January 25, 2023, https://www.nytimes.com/interactive/2022/world/europe/ukraine-maps.html.

23   To estimate Russian regular and irregular fatalities, the authors took two steps. The first was a modified Delphi method, which included interviews with multiple U.S. and Western government officials. The Delphi method is a process that involves reaching a decision by surveying a group of experts, who respond to several rounds of questions. The second step involved compiling publicly available assessments of Russian combat deaths. For example, the UK government released data that forces from Russian government units (such as the Russian armed forces, Rosgvardiya, Federal Security Service, and Federal Guard Service) and private military companies (such as the Wagner Group) suffered 40,000 to 60,000 killed and 175,000 to 200,000 wounded between February 2022 and February 17, 2023. But these estimates did not include militia forces fighting with Russia, such as the Donetsk People's Militia and Luhansk People's Militia. The Ukrainian Ministry of Defence reported a high of 142,270 Russians killed, though it did not break down these numbers into Russian regular soldiers, private military company contractors, and pro-Russian militias. The authors assessed that Ukrainian estimates were too high and Russian estimates of their own combat fatalities and casualties were too low. Consequently, the authors estimate that the total number of fatalities from February 24, 2022, to February 22, 2023, includes between 50,000 and 60,000 soldiers from Russian government units and private military companies, along with approximately 10,000 soldiers from the Donetsk and Luhansk militias (for a total of 60,000 to 70,000 fatalities). On publicly availably assessments see, for example, Ministry of Defence, Twitter post,

February 17, 2023, 1:45 a.m. https://twitter.com/DefenceHQ/status/1626472945089486848; "The Total Combat Losses of the Enemy from 24.02.22 to 18.02.23," Ministry of Defence of Ukraine, February 18, 2023, https://www.mil.gov.ua/en/news/2023/02/18/the-total-combat-losses-of-the-enemy-from-24-02-22-to-18-02-23/; Helene Cooper, Eric Schmitt, and Thomas Gibbons-Neff, "Soaring Death Toll Gives Grim Insight Into Russian Tactics," *New York Times*, February 2, 2023, https://www.nytimes.com/2023/02/02/us/politics/ukraine-russia-casualties.html; and Ольга Ившина [Olga Ivshina], "В пять раз больше, чем обычно: что известно о потерях России в Украине к середине февраля" [Five Times More Than Usual: What Is Known about the Losses of Russia in Ukraine by Mid-February], BBC, February 17, 2023, https://www.bbc.com/russian/features-64680032.

24 Authors' interviews with U.S. and other Western government officials, 2023.

25 Cigdem V. Sirin and Michael T. Koch, "Dictators and Death: Casualty Sensitivity of Autocracies in Militarized Interstate Disputes," *International Studies Quarterly* 59, no. 4 (2015): 802-14.

26 Authors' interviews with U.S. and other Western government officials, 2023.

27 CSIS calculations assumed that the two phases of the Chechnya war totaled 135 months. John B. Dunlop, "How Many Soldiers and Civilians Died During the Russo-Chechen War of 1994-1996?," *Central Asia Survey* 19, no. 3/4 (2000): 329-39, https://doi.org/10.1080/02634930050057964; Simon Saradzhyan, "Army Learned Few Lessons from Chechnya," *Moscow Times*, March 9, 2005; Robert M. Kennedy, *Russia in Afghanistan and Chechnya: Military Strategic Culture and the Paradoxes of Asymmetric Conflict* (Carlisle, PA: Strategic Studies Institute, U.S. Army War College, February 2003), https://www.jstor.org/stable/resrep11653; Robyn Dixon et al., "Russia's War Dead Belie Its Slogan That No One Is Left Behind," *Washington Post*, April 8, 2022, https://www.washingtonpost.com/world/2022/04/08/russia-war-dead-soldiers-bodies/; Mark Galeotti, *The Modern Russian Army 1992-2016* (New York: Osprey, 2017); and "Chechen Official Puts Death Toll for 2 Wars at up to 160,000," *New York Times*, August 16, 2005, https://www.nytimes.com/2005/08/16/world/europe/chechen-official-puts-death-toll-for-2-wars-at-up-to-160000.html.

28 CSIS calculations assumed that the Afghan war totaled 110 months. Lester W. Grau and Michael A. Gress, eds., *The Soviet-Afghan War: How a Superpower Fought and Lost* (Lawrence, KS: University of Kansas Press, 2002), 309; Lester W. Grau, *The Bear Went Over the Mountain: Soviet Combat Tactics in Afghanistan* (New York: Frank Cass, 1998), xiv; and authors' interviews with U.S. government officials.

29 The data in the table come from G.F. Krivosheev, ed., *Soviet Casualties and Combat Losses in the Twentieth Century* (Mechanicsburg, PA: Stackpole Books, 1997), 281-90; D.S. Ryabushkin, "Mify Damanskogo" [Myths of Damansky] (Russia: AST, 2004), 151, 263-64, https://coollib.com/b/368428-dmitriy-sergeevich-ryabushkin-mifyi-damanskogo/read; "Nekotoryye maloizvestnyye epizody pogranichnogo konflikta na o. Damanskom" [Some Little-Known Episodes of the Border Conflict on Damansky Island], Voyennoye oruzhiye i armii Mira [Military Weapons and Armies of the World], accessed February 14, 2023, https://warfor.me/nekotoryie-maloiz-

vestnyie-epizodyi-pogranichnogo-konflikta-na-o-damanskom/; Grau and Gress, *The Soviet-Afghan War*; Grau, *The Bear Went Over the Mountain*, xiv; Dunlop, "How Many Soldiers and Civilians Died During the Russo-Chechen War of 1994-1996?"; Saradzhyan, "Army Learned Few Lessons from Chechnya"; Kennedy, *Russia in Afghanistan* and Chechnya; Galeotti, *The Modern Russian Army 1992-2016*; Dixon et al., "Russia's War Dead Belie Its Slogan That No One Is Left Behind"; Abdullaev, "Death Toll Put at 160,000 in Chechnya"; "Russia Lost 64 Troops in Georgia War, 283 Wounded," Reuters, February 21, 2009, https://www.reuters.com/article/us-russia-georgia-deaths/russia-lost-64-troops-in-georgia-war-283-wounded-idUKTRE51K1B820090221; "Nearly 585,000 People Have Been Killed Since the Beginning of the Syrian Revolution," Syrian Observatory for Human Rights, January 4, 2020, https://www.syriahr.com/en/152189/; "Conflict-Related Civilian Casualties in Ukraine," United Nations Human Rights, Office of the High Commissioner, January 27, 2022, https://ukraine.un.org/sites/default/files/2022-02/Conflict-related%20civilian%20casualties%20as%20of%2031%20December%202021%20%28rev%2027%20January%202022%29%20corr%20EN_0.pdf; Ministry of Defence, Twitter post, February 17, 2023, 1:45 a.m.; "The Total Combat Losses of the Enemy from 24.02.22 to 18.02.23," Ministry of Defence of Ukraine; Cooper, Schmitt, and Gibbons-Neff, "Soaring Death Toll Gives Grim Insight Into Russian Tactics"; and Ившина [Ivshina], "В пять раз больше, чем обычно: что известно о потерях России в Украине к середине февраля" [Five Times More Than Usual: What Is Known about the Losses of Russia in Ukraine by Mid-February]; and authors' estimates and interviews with U.S. and other Western officials, 2023.

30 "Research Starters: Worldwide Deaths in World War II," The National WWII Museum, accessed February 14, 2023, https://www.nationalww2museum.org/students-teachers/student-resources/research-starters/research-starters-worldwide-deaths-world-war; and "Estimated Number of Military and Civilian Fatalities Due to the Second World War per Country or Region between 1939 and 1945," Statista, accessed February 14, 2023, https://www.statista.com/statistics/1293510/second-world-war-fatalities-per-country/.

31 Stephen Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle* (Princeton, NJ: Princeton University Press, 2004).

32 Michael C. Horowitz, *The Diffusion of Military Power: Causes and Consequences for International Politics* (Princeton, NJ: Princeton University Press, 2010), 7; and Risa A. Brooks and Elizabeth A. Stanley, *Creating Military Power: The Sources of Military Effectiveness* (Stanford, CA: Stanford University Press, 2007).

33 Mearsheimer, *Conventional Deterrence*, 35.

34 Malkasian, *A History of Modern Wars of Attrition*, 7; and Lawrence Freedman, *The Revolution in Strategic Affairs* (New York: Routledge, 2020), 41.

35 See, for example, Biddle, *Military Power*; Basil Liddell Hart, *Strategy* (New York: Penguin, 1991); Michael Howard, *The Causes of War* (Cambridge, MA: Harvard University Press, 1983); Eliot A. Cohen, *Supreme Command: Soldiers, Statesmen, and Leadership in Wartime* (New York: Anchor, 2003); Mearsheimer, *Conventional Deterrence*; Ben Connable et al., *Will to Fight: Returning to the Human Fundamentals of War* (Santa Monica, CA: RAND, 2019), https://www.rand.org/pubs/research_briefs/RB10040.html; Horowitz, *The Diffusion*

*of Military Power*; Dan Reiter and Alan C. Stam, *Democracies at War* (Princeton, NJ: Princeton University Press, 2002); and Barry R. Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars* (Ithaca, NY: Cornell University Press, 1984).

36 John Bartlett, *Familiar Quotations*, 10th ed. (Boston: Little, Brown, 1919), no. 9707.

37 Michael C. Horowitz and Shira Pindyck, "What Is a Military Innovation and Why It Matters," *Journal of Strategic Studies* (March 2022): 1–30, doi:10.1080/01402390.2022.2038572. Also see, for example, Adam Grissom, "The Future of Military Innovation Studies," *Journal of Strategic Studies* 29, no. 5 (2006): 905–34, https://doi.org/10.1080/01402390600901067.

38 Niccolò Machiavelli, *The Prince* (Chicago, IL: University of Chicago Press, 1998), 23.

39 Rosen, *Winning the Next War*.

40 Ibid.

41 Frank G. Hoffman, *Mars Adapting: Military Change During War* (Annapolis, MD: Naval Institute Press, 2021); and ibid.

42 Malkasian, *A History of Modern Wars of Attrition*, 7.

43 See, for example, Gerald Gilbert, *The Evolution of Tactics* (London: Hugh Rees, 1907); and Jonathan M. House, *Toward Combined Arms Warfare: A Survey of 20th-Century Tactics, Doctrine, and Organization* (Leavenworth, KS: Combat Studies Institute, U.S. Army Command and General Staff College, August 1984), https://www.armyupress.army.mil/Portals/7/combat-studies-institute/csi-books/house.pdf.

44 See the Nagorno-Karabakh case study in Seth G. Jones et al., *Combined Arms Warfare and Unmanned Aircraft Systems* (Lanham, MD: Rowman & Littlefield, November 2022), https://www.csis.org/analysis/combined-arms-warfare-and-unmanned-aircraft-systems.

45 "Baykar Bayraktar Tactical UAS," Janes, July 29, 2022.

46 Roblin, "Russia's War in Ukraine"; "SPE 'Athlon Avia' A1-S Furia," Janes, December 4, 2018; "DeViRo Leleka-100," Janes, June 22, 2022; and Andrew E. Kramer, "From the Workshop to the War: Creative Use of Drones Lifts Ukraine," *New York Times*, August 10, 2022, https://www.nytimes.com/2022/08/10/world/europe/ukraine-drones.html.

47 Yaroslav Trofimov, "Ukraine's Drone Spotters on Front Lines Wage New Kind of War," *Wall Street Journal*, August 7, 2022, https://www.wsj.com/articles/ukraines-drone-spotters-on-front-lines-wage-new-kind-of-war-11659870805.

48 Authors' interviews with multiple sources involved in fighting in eastern Ukraine, 2023.

49 "Switchblade," Janes, July 15, 2022.

50 Vranic, "Ukraine Conflict: Russia Weaponises Orlan-10 UAV"; Zachary Kallenborn, "Seven (Initial) Drone Warfare Lessons from Ukraine," Modern War Institute, May 12, 2022, https://mwi.usma.edu/seven-initial-drone-warfare-lessons-from-ukraine/; and Alexander Freund, "Ukraine Is Using Elon Musk's Starlink for Drone Strikes," DW, March 27, 2022, https://www.dw.com/en/ukraine-is-using-elon-musks-starlink-for-drone-strikes/a-61270528.

51 Yaroslav Trofimov, "As Ukraine Holds the Line in Donbas, Russian Fire Shatters Cities in Moscow's Path," *Wall Street Journal*, August 10, 2022, https://www.wsj.com/articles/as-ukraine-holds-the-line-in-donbas-russian-fire-shatters-cities-in-moscows-

path-11660134297.

52 Laura Kahn, "How Ukraine Is Using Drones against Russia," Council on Foreign Relations, March 2, 2022, https://www.cfr.org/in-brief/how-ukraine-using-drones-against-russia; Roblin, "Russia's War in Ukraine"; and Kallenborn, "Seven (Initial) Drone Warfare Lessons from Ukraine."

53 Edmonds and Bendett, *Russian Military Autonomy in a Ukraine Conflict*.

54 Roblin, "Russia's War in Ukraine."

55 On Kropyva–including its use on Ukrainian computers and tablets–see Trofimov, "Ukraine's Drone Spotters on Front Lines Wage New Kind of War."

56 Authors' interviews with multiple sources involved in fighting in eastern Ukraine, 2023.

57 Kateryna Kistol, "Digital Weapons of War: Applications and Software That Help Ukraine to Win," Ukraine.ua, December 13, 2022, https://war.ukraine.ua/articles/digital-weapons-of-war-applications-and-software-that-help-ukraine-to-win/; "Ukraine's Defence Forces to Introduce Delta System Which Gives Advantage over Occupiers," Ukrainska Pravda, February 4, 2023, https://www.pravda.com.ua/eng/news/2023/02/4/7387937/; and Charlie Parker, "Uber-Style Technology Helped Ukraine to Destroy Russian Battalion," *The Times*, February 16, 2023, https://www.thetimes.co.uk/article/uk-assisted-uber-style-technology-helped-ukraine-to-destroy-russian-battalion-5pxnh6m9p.

58 Charlie Parker, "Specialist Ukrainian Drone Unit Picks Off Invading Russian Forces as They Sleep," *The Times*, March 18, 2022, https://www.thetimes.co.uk/article/specialist-drone-unit-picks-off-invading-forces-as-they-sleep-zlx3dj7bb.

59 Matthew Fitzgerald and Cort Thompson, "What Does Starlink's Participation in Ukrainian Defense Reveal about U.S. Space Policy?," Lawfare, April 26, 2022, https://www.lawfareblog.com/what-does-starlinks-participation-ukrainian-defense-reveal-about-us-space-policy.

60 "UkraineX: How Elon Musk's Space Satellites Changes the War on the Ground," *Politico*, June 8, 2022, https://www.politico.eu/article/elon-musk-ukraine-starlink/.

61 On the use of Starlink for offensive operations–and SpaceX concerns–see Matthew Luxmoore and Ievgeniia Sivorka, "Soldiers in Ukraine Say Some Drones Affected after SpaceX Limits Starlink," *Wall Street Journal*, February 10, 2023, https://www.wsj.com/articles/soldiers-in-ukraine-say-some-drones-affected-after-spacex-limits-starlink-321a9dd7.

62 Authors' interviews with multiple sources involved in fighting in eastern Ukraine, 2023.

63 Authors' interview with the coordinator of the ComBat Vision volunteer developers' group, January 2023.

64 Kendrick Kuo, "Dangerous Changes: When Military Innovation Harms Combat Effectiveness," *International Security* 47, no. 2 (Fall 2022): 48–87, https://doi.org/10.1162/isec_a_00446.

65 Frank Hoffman, "Defeat Mechanisms in Modern Warfare," in U.S. Army War College, *Parameters* 51, no. 4 (Winter 2021): 49–66, https://press.armywarcollege.edu/cgi/viewcontent.cgi?article=3091&context=parameters.

66    Eliot Cohen, "Putin Is Cornered," *The Atlantic*, September 20, 2022, https://www.theatlantic.com/ideas/archive/2022/09/zelensky-ukraine-west-military-aid-supplies/671485/.

67    On Ukrainian combat aircraft losses see, for example, Oryx, "List of Aircraft Losses during the 2022 Russian Invasion of Ukraine," Oryx, accessed on February 20, 2023, https://www.oryxspioenkop.com/2022/03/list-of-aircraft-losses-during-2022.html. On the original Ukrainian fleet see International Institute for Strategic Studies, *The Military Balance*, 213.

68    Valerie Insinna, "U.S. Air Force to Mothball Dozens of A-10s, F-15s, and F-16s in FY22 Budget," Defense News, May 28, 2021, https://www.defensenews.com/congress/budget/2021/05/28/us-air-force-to-mothball-dozens-of-a-10s-f-15s-and-f-16s-in-fy22-budget/.