



The “Big Three” Revisited

Initial Lessons from 200 Days of War in Ukraine

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Abstract: This article deals with the tactical lessons of the first six months of the Russian war in Ukraine. The war, which has sent seismic shocks throughout the world, was conceived by many to be a new kind of conflict, with innovative, high-technology weapons and equipment bringing a sea change to the history of warfare. However, a closer look shows a more nuanced picture. While there are many lessons to be learned from this war, it is not as much a break with the past as it is a continuation of it. For all the technology being introduced, not only do tactics remain important, but the war itself is closer in many aspects to the “classic” wars of the twentieth century than to any futuristic concept of warfare.

Keywords: Ukraine, Russia, war, drone, innovation, tank, maneuver

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Introduction

The Russian invasion of Ukraine in February 2022 shocked the Western world, for it was a kind of conflict thought to be long gone. As retired British Army general Sir Rupert Smith, former Deputy Supreme Allied Commander Europe, declared in his 2007 classic, *The Utility of Force*, “War no longer exists. Confrontation, conflict and combat undoubtedly exist all around the world. . . . Nonetheless, war as cognitively known to most non-combatants, war as battle in a field between men and machinery, war as a massive deciding event in a dispute in international affairs: such war no longer exists.”¹ Smith argued that this was because the character of war had changed, explaining that “the wars in which armoured formations could and should be used are no longer practical. This does not mean a big fight with large groups of forces and weapons is no longer possible, but it does mean that it will not be an industrial one in either intent or prosecution; industrial war no longer exists.”² Many military leaders and strategists shared this view for a long time, and with good reasons.³

The current war in Ukraine, then, without large tank battles but definitely with industrial intent and prosecution, is either an outlier—a “blast from the past”—or a different kind of war altogether. It is a high-technology war, with armed drones, satellite phones, and images showing Ukrainian antitank missiles hitting Russian equipment. Yet, while the war is unique, it is not unique in being unique, and its lessons are neither totally new nor a mere continuation of the past. This can be shown by using a framework derived from the lessons of another paradigm-changing conflict: the 1973 Yom Kippur War.

This article will compare events in the Russo-Ukrainian War to several large-scale conflicts of the past in which at least one of the sides was a Western force; all are part of what has been dubbed *second-* or *third-generation warfare*, in which mass firepower or armored maneuver ruled the battlefield.⁴ This comparison will help identify similarities and differences, separate what is new from what is not, and validate the lessons learned.

After the Yom Kippur War, U.S. Army general William E. DePuy, commander of the Army's Training and Doctrine Command (TRADOC), identified three major lessons learned:

1. "Modern weapons are vastly more lethal than any weapons we have encountered on the battlefield before."
2. "In order to cope with these weapons it is essential we have a highly trained and highly skilled combined arms team."
3. "The training of the individual as well as the team will make the difference between success and failure on the battlefield."⁵

Nearly 50 years later, the Western world was shocked by the Russian invasion of Ukraine in February 2022—first by the invasion itself, and then by the shocking tactical ineptitude of many Russian Army units that, coupled with bad planning, ignored the lessons learned in the last 20 years, from Chechnya, to Syria, to the Donbas.⁶

Map 1. Escalation of the Russo-Ukrainian War, September 2022



Source: courtesy of Viewsridge, adapted by MCUP.

Heavy Russian casualties, sometimes shown in spectacular videos displaying tanks being literally blown to bits by antitank weapons and planes falling out of the sky, led many observers to believe that the fighting in Ukraine offers an example of the nearing end of the modern combined-arms army, with its heavy tanks and fighter-bomber aircraft being defeated by less expensive antitank weapons, man-portable air-defense systems (MANPADS), and drones, maybe with the aid of cyber warfare and SatLink communications equipment.⁷

However, by digging deeper into the war, one finds that the lessons learned are more complicated. While DePuy's “big three” lessons from the Yom Kippur War are probably still relevant here, another “big three” tactical

lessons should be added. This is emphasized in the later stages of the Russo-Ukrainian War, to include the grinding attrition warfare in eastern Ukraine and the Ukrainian counteroffensives of August and September 2022.

First, this article will examine the main combat systems on which most Western countries base (or based until very recently) their combat power: tanks, aircraft, and artillery.

Tanks

As Ukrainian forces managed to inflict terrible losses on Russian armor during the opening months of the war, videos of destroyed Russian tanks with their turrets flying high into the air appeared all over the internet.⁸ While many were quick to announce the final death of the tank as a useful combat platform, others rushed to its defense.⁹

The debate is nothing new. Virtually no weapon system has been pronounced irrelevant so close to its first employment as the tank. Such pronouncements began soon after the end of World War I, and by 1936 a French armor instructions read, "In the offensive, it cannot be emphasized too strongly that today the antitank weapon is to the tank what the machine gun was to the infantry during the World War."¹⁰ Three years later, a bestselling book by a retired French Army general argued that the tank had "failed" as a breakthrough weapon, since one 75- or 77-millimeter "antitank shell, costing 150 francs, can destroy a tank costing one million francs."¹¹ Another year passed, and in May 1940, German tanks rolled into France.

A similar phenomenon occurred with combat aircraft after the first surface-to-air missile (SAM) made its presence felt. Retired Israeli Air Force

major general Ezer Weizman, the famous combat pilot who was the Israeli Army's second in command during the 1967 Six-Day War, claimed in 1975 that "the missile had folded the airplane's wing."¹² Seven years later, with the aid of electronic countermeasures and appropriate weaponry, Israel destroyed 19 Syrian SAM batteries in Lebanon without suffering a single casualty. This should serve as a cautionary tale against prematurely declaring which weapon systems are finally outdated—and it is especially true since the attrition rate in the Russo-Ukrainian War is far from being unprecedented.

In Ukraine, both sides claim significant kills. In all likelihood, their claims are exaggerated, as most claims and estimates are during wartime, before the fog of war is cleared.¹³ During the opening months of the war, the number of confirmed kills was lower both in absolute and relative terms than many wars in the past. By the end of May 2022, at least 413 Russian tanks were destroyed, 22 damaged, and 306 abandoned or captured. On the Ukrainian side, 83 tanks were destroyed, 3 damaged, and 100 abandoned or captured.¹⁴

At that time, the U.S. Department of Defense estimated that Russia had lost (including irreparable units) almost 1,000 tanks and about 350 artillery pieces—that is, about 25 to 30 percent more than minimal estimates based on open-source material.¹⁵ The number continued to grow though more slowly. As of 9 September 2022, after months of attrition warfare and a week of Ukrainian counterattacks—the biggest of the war—the Russians suffered 637 tanks destroyed, 42 damaged, and 350 abandoned or captured, while the Ukrainians suffered 135 tanks destroyed, 5 damaged, and 113 abandoned or captured.¹⁶ Not only did both sides

continue to use tanks extensively, but the losses were actually *lower* than in some intrastate wars of the past.

For comparison's sake, in the three weeks of the Yom Kippur War, waged on much smaller areas than the battles in Ukraine, 1,064 Israeli tanks were damaged in battle, 407 of which were destroyed, unrepairable, or lost.¹⁷ Arab armies lost about 2,250 tanks, including several hundred captured intact or in repairable conditions.¹⁸ During the 1991 Gulf War, the lowest estimate was that Iraq had lost at least 1,700 tanks; most estimates were much higher.¹⁹ Of course, the order of battle of the Iraqi Army was about three times the number of Russian forces initially invading Ukraine. Yet, it is clear that the attrition ratio of armored vehicles in the Russo-Ukrainian War is not without precedent. This is even more so if compared to World War II, when some U.S. armored units lost, from July 1944 to May 1945, more than 200 percent of their initial strength, or during some great tank battles in which one-half of the unit's strength could be lost during just a few days.²⁰ These losses only illustrate what is already known—that war between armies is a bloody business, with terrible casualties.²¹

But what about the tactical employment of antitank weapons? It is possible, after all, that Russian losses do not represent the inability of tanks to perform. During the opening months of the war, antitank weapons were used to good effect by Ukrainian forces to slow the Russian advance, but here too it seems that earlier reports were slightly exaggerated, just as were early reports on the AT-3 Sagger antitank missile in the Yom Kippur War.²² If one is to believe an early report claiming that the U.S. FGM-148 Javelin antitank missile had a 93-percent kill rate in Ukraine, then with the amount of missiles supplied to Ukraine there would not remain one Russian tank or

vehicle near the front.²³ This did not happen: the number of total Russian losses of all types destroyed by all means was about 4,000, including some 1,500 or more abandoned and captured units. Of course, much of that toll was not the work of antitank missiles. A senior advisor to the commander of the armed forces of Ukraine argued in April that “anti-tank missiles slowed the Russians down, but what killed them was our artillery.”²⁴ Indeed, many videos show a significant number of kills caused by artillery strikes. Either most of the Ukrainian antitank missiles had not been fired yet, or many of them did not hit their targets, or the Ukrainians were unable to fire all of their arsenal at Russian tanks, due to Russian tactics, artillery usage, or both.

The final piece of evidence of the enduring importance of armor is that both sides in Ukraine are still using tanks extensively and can find uses for more. Probably due to high losses, the Russians were seen sending ancient modified T-62 Soviet main battle tanks to Ukraine (probably for use in reserve units and low-risk areas), while Ukraine received tanks from Poland, asking for as many as it could get, and continues to use tanks on the front.²⁵ Tanks have played an important part in Ukrainian plans; during the opening months of the war, the most modern Ukrainian tanks were under-represented in confirmed kills, which hinted that the Ukrainians were keeping them as a strategic reserve for a future counteroffensive. This indeed happened with the great Ukrainian counterattacks of September 2022, in which the Ukrainian Army employed combined-arms teams, with tanks and mobile infantry appearing together, in both its attack against the Russian defensive perimeter in the south, in the Kherson area, and its rapid breakthrough in the north, near Kharkiv.²⁶ There were even a few tank battles, albeit on a small scale, and cases of Ukrainian tanks destroying

Russian armored personnel carriers.²⁷ And while Russian antitank weapons are no doubt effective, as seen in the 2006 Lebanon War and elsewhere, in Russian hands they did not manage to slow down Ukrainian advance.²⁸ As a result, not only were the attrition rates of armor in Ukraine not a sign of the end of the tank, but when the time came for mobile offensives, both sides have no substitute for tanks.

This is not to say that the great tank battles of the past will be seen again, but both the Russians and Ukrainians seem to acknowledge that the combination of protection, mobility, and firepower offered by tanks is still essential for maneuver and offensive operations. Russian armor loses, in particular, are very heavy indeed, but they are in line with the catastrophic results that a failing army suffers, and they do not offer proof that the age of the tank has gone. This, in turn, tends to be in line with General DePuy's observations: modern weapons are lethal and antitank weapons are more lethal than ever before; employing tanks in a combined-arms formation is far more effective than sending tank convoys to attack on their own; and the better-trained Ukrainian forces are using tanks more effectively in their attacks as part of combined-arms teams.

Manned Aircraft

The war in Ukraine is being fought without aerial superiority of any side, but with aerial support on both sides—with important roles for both manned aircraft and unmanned aerial vehicles (UAV). *Aerial superiority* or *air supremacy* are considered a main role of modern Western air forces; this has been so for nearly a century.²⁹ In Ukraine, neither side has held air superiority, defined as the “degree of control of the air by one force that

permits the conduct of its operations at a given time and place without prohibitive interference from air and missile threats,” nor air supremacy, defined as the “degree of control of the air wherein the opposing force is incapable of effective interference within the operational area using air and missile threats.”³⁰ Losses have been heavy for both sides.

As of late May 2022, after the first stage of Russian attacks and retreats, Russia had lost at least 28 combat aircraft (one of them on the ground), 1 transport aircraft, and 42 helicopters (including 1 damaged, 1 abandoned, and 1 captured), as well as a few more probable losses. By mid-September 2022, that number had grown to 53 combat aircraft (10 on the ground, with an additional 2 damaged) 1 transport aircraft, and 47 helicopters (including an additional 1 captured) In May, the much smaller Ukrainian Air Force had lost 22 combat aircraft (from about 100), 3 transport aircraft (1 of them on the ground), and 11 helicopters (three of which were captured).³¹ By mid-September, that number had grown to 42 combat aircraft destroyed (2 on the ground), 4 transport aircraft (1 on the ground), and 14 helicopters (of which 3 were captured).³²

This is certainly a heavy toll compared to counterinsurgency wars of the near past: between 2001 and 2009, for example, the United States lost in both Iraq and Afghanistan approximately 70 helicopters to enemy fire.³³ But again, compared to wars of the past, such a loss ratio does not stand out. In Vietnam between 1965 and 1975, the United States lost approximately 2,066 helicopters to hostile action. While there are no comparisons available on losses per 100,000 flight hours, the monthly ratio of Russian or Ukrainian air losses in Ukraine is much higher than U.S. losses in Iraq and Afghanistan and lower than U.S. losses in Vietnam. This is not to speak of conflicts such as

the Six-Day War, during which the victorious Israeli Air Force lost 46 planes and suffered serious damage to an additional 23 (about 25 percent of its total fighter and bomber aircraft strength) in less than a week of fighting but virtually wiped out the Egyptian, Syrian, Jordanian, and Lebanese air forces in the process.³⁴ Consequently, aircraft losses in the current war in Ukraine should be expected for such a high-level conflict.

The price that both sides in Ukraine have paid in aerial defense systems has also been high: by the end of May 2022, the Russians suffered 34 SAM launchers lost, 1 damaged, and 28 abandoned or captured, in addition to 4 radars lost and 2 captured. By mid-September, that number had grown to 40 SAM launchers lost, 2 damaged, and 30 abandoned or captured, as well as seven radars destroyed and eight captured. By the end of May, Ukraine had suffered 37 SAM launchers lost and 7 abandoned or captured, in addition to 10 radars lost and 7 abandoned or captured. But Ukraine lost almost nothing since—by September, only two more SAM systems and three more radars were lost, with one of the radars abandoned. Moreover, by September Russia had lost 20 self-propelled antiaircraft guns, half of them destroyed.³⁵ Losses among MANPADS teams are unknown.

While these losses are high, they have not decapitated Russia's or Ukraine's air forces. Both forces continue to operate in the field, with a high percentage of attacks being made by unguided bombs and short-range missiles, as neither Russia nor Ukraine is up to the Western standard of employing precision-guided munitions (PGMs), despite being stocked with some modern Western weapons such as the AGM-88 HARM high-speed

antiradiation missile.³⁶ Limiting factors seem to include not only the SAM threat but also logistical and ammunition problems.³⁷

This has been highlighted by two successful Ukrainian air attacks. In early May 2022, two Ukrainian Sukhoi Su-27 fighters attacked Snake Island in the Black Sea, held by Russian forces and defended by SAMs. The attack was conducted from an extremely low level, and the fighters escaped unscathed despite the fact that, the target being an island, they could not hide behind any terrain on the way there.³⁸ In another case on April 2022, two old Ukrainian Mil Mi-24 attack helicopters flew approximately 40 kilometers into Russian territory and attacked a fuel depot in the city of Belgorod.³⁹ In both instances, the attackers did not use any advanced weaponry: simple unguided bombs were employed in the first case, and antitank rockets were used in the second. Both missions were executed successfully despite the Russian anti-aircraft threat, and both displayed a lack of PGMs, for even if such munitions were available, there was no reason to risk an attack at point-blank range.

On the other side, the Russian Air Force managed to increase its daily sorties to around 300–400 in May 2022 to support a renewed attack in the Donbas, apparently without losing many more planes than it had in April.⁴⁰ Until mid-September, both sides in Ukraine continued to employ attack aircraft for close air support, losing some planes in the process but continuing to do so nonetheless. There have even been reports of aerial combat—dogfights—a rare occurrence in modern wars.⁴¹ The inability of the Russian Air Force to support Russian defenses against the recent Ukrainian counterattack seems less to do with its rigid system of targeting, based on preset targets, rather than real-time response and close air support, either

because of doctrinal reasons or poor planning, than with the SAM threat.⁴² The relative effectiveness of Iranian-made suicide drones in September 2022 offers evidence to that fact: successful as the Ukrainian SAM system may have been, even in a dense battlespace the Russians have managed to use those drones to inflict casualties on Ukrainian armor and artillery.⁴³

The SAM threat is very important, but it is only one of the determining factors of aerial operations on both sides in Ukraine. To paraphrase Major General Weizmann's quote earlier, the missile definitely scratched the wing of the plane but did not fold it completely. Of course, there is another type of aircraft available to both sides in this war: UAVs, which seem to bring a different dimension to the battlefield.

UAVs and Drones

In Ukraine, the effectiveness of UAVs and drones has had more to do with their relative contribution than their absolute contribution. The advent of UAVs and drones marked a significant change in the character of warfare since the Yom Kippur War. Though in their infancy then, they have matured in the last two decades, up to the point where, when the Russian invasion of Ukraine began, one could conclude that Ukrainian-piloted drones were destroying the majority—or at least a plurality—of Russian equipment. Videos displaying such evidence were everywhere, and one attack drone—the Turkish-made Baykar Bayraktar TB2—even got its own catchy pop song, as well as the claim that it “changed the nature of warfare.”⁴⁴ Yet as time passed, such reports dwindled, and after about 200 days of war in Ukraine, the number of confirmed reports of equipment destroyed by Bayraktar UAVs is quite low. As of mid-September 2022, the list includes only 4 tanks, 8

armored fighting vehicles, 11 artillery pieces, 15 SAMs, 10 helicopters, 6 naval craft, 2 fuel trains, 29 other vehicles, 3 command posts, and a few stationary targets.⁴⁵ This estimate seems low, and the real number is probably higher. Some have argued that Turkey wanted to downplay the amount of Russian equipment destroyed by Turkish-made drones to preserve relations with Russia.⁴⁶ However, after half a year of war and outright support for Ukraine, including the donation of Bayraktar drones, this explanation seems lacking, especially as Turkish financial interests suggest that it should emphasize the drone's capabilities.

Of course, the Bayraktar TB2 is not the only drone operating over Ukraine. Drones carrying anything from homemade bombs to antitank missiles have been seen on the battlefield, including what was probably a \$9,500 Chinese UAV converted into a flying bomb.⁴⁷ Loitering munitions, which are technically UAVs, have also added to the tally; the Ukrainians admitted that in the Kherson offensive, the 92d Mechanized Brigade alone lost four artillery pieces and two armored personnel carriers to Russian suicide drones.⁴⁸

However, at present it seems that the direct contributions of drones to target destruction is limited. This probably also has something to do with their vulnerability to ground fire and some electronic countermeasures. Drones such as the Bayraktar TB2 travel very slow (with a cruising speed of about 80 knots) and present a not-so-insignificant target, measuring 21 feet long with a wingspan of almost 40 feet. Their thermal and radar signature is lower than a nonstealth warplane but still existent. This gives the drones an edge in tracking and spotting enemy forces, but it also makes them good targets for ground fire. Indeed, out of about 20 drones in Ukrainian service

at the beginning of the war, at least 8 were destroyed by May 2022. Total confirmed losses were 42 Russian UAV destroyed, with 34 more captured, and 14 destroyed Ukrainian UAVs, with 5 more captured. By mid-September, while there were claims of hundreds of Russian UAVs shot down, the confirmed number was at least 64 Russian UAVs destroyed and 63 captured, when they flew at most 50 sorties a day; the Ukrainians suffered 25 UAVs destroyed and 9 captured.⁴⁹ Even Iranian-made Russian UAVs were spotted in Ukraine, signaling a shortage of Russian-made drones.⁵⁰

While, of course, the destruction of a UAV leaves no grieving relatives, the high percentage of destroyed drones on both sides suggest that UAVs are not operating in Ukraine with impunity, and while they are helpful, they are not a game-changer. Ukrainian president Volodymyr Zelenskyy said as much in April: "With all due respect to Bayraktar, and to any hardware, I will tell you, frankly, this is a different war."⁵¹ Indeed, the fact that Bayraktar videos began to appear on Telegram and WhatsApp channels again during the recent Ukrainian counterattacks show that their role is most important when the enemy's air defense is scarce and least important when they try to operate over a relatively stable front line with a credible anti-aircraft threat.

Drones are important not only because of their absolute capability, and not necessarily because they are "better" or more efficient than combat and reconnaissance aircraft. They do have advantages, in that they are cheaper than most modern fighter aircraft, that they need much less infrastructure to operate and can take off from improvised landing strips, that they usually have a smaller thermal and radar signature than most manned aircraft, and that they possess a slow speed, which makes them vulnerable to enemy fire but also allows them to focus on a specific target

for a long time, a feat that a fast-flying attack plane would find hard to accomplish. But the real value of a drone is not that it can do some things better than a manned aircraft—it is that it can do things that, without a drone, could not be done at all, because there is no aerial alternative.

This should serve as a warning to Western militaries who have become accustomed to complete aerial superiority. A military force with aerial superiority gains some advantages by the use of drones (e.g., improving capabilities, reducing risk to pilots, etc.), but even without using drones, it can still bring significant aerial power to the battlefield. Ultimately, it could make do without drones, maybe at a higher cost and somewhat less effectively. But a military force without aerial superiority, fighting a larger or better air force, would benefit immensely from the use of drones, as it would consequently gain a host of capabilities unavailable otherwise. It should be remembered that the difference between no capability and some capability is always greater than the difference between good capability and great capability. The bigger the aerial disparity between the opponents, the more the weaker side has to gain. This is true even without aerial superiority. Without drones, Russia could still have mounted 300 aerial sorties a day, or even more, from March to May 2022. Without drones, Ukraine, its bases under frequent attack, was limited much of the time to 5–10 sorties each day.⁵² With drones, the situation was much more balanced. The benefit of drones for Ukraine is not compared to planes—it is compared to nothing at all. The same goes for the use of Russian drones to defend the Kherson area in September 2022: with a different doctrine or a change in the method of operations, the Russian Air Force could hit real-time targets;

but for the Russian forces in Kherson, drones were a kind of air support available when regular close air support was not.

However, the most important role of UAVs and drones may not be the direct role at all, and the drone may be more fearsome when it is *not* shooting. UAVs and drones bring a different, more important change to the battlefield than simply acting as tank-killing machines: they force everyone to look up.

Nonlethal Air Support

When planes first appeared on the battlefield in the early twentieth century, not only was aerial combat invented, but land battle was changed forever, as soldiers now had to account for what was happening over their heads.⁵³ In the West, this awareness has diminished in recent years, due to the West's total aerial superiority in virtually every conflict of the last 40 years. The military forces of the United States, the United Kingdom, Israel, and similar countries had no more to look to the skies, for if something flew overhead, it surely was on their side.

This has led to the denigration of tactical air defense in many Western militaries. There were failures such as the infamous M247 "Sergeant York" self-propelled antiaircraft gun; there were successes like the FIM-92 Stinger MANPADS; but overall development has slowed due to a lack of apparent need.⁵⁴ The Stinger missile first saw combat in the 1982 Falklands War; the United States bought its last Stinger 18 years ago.⁵⁵ The German "Flakpanzer" Gepard self-propelled antiaircraft gun system, which is to be sent to Ukraine, entered service in 1976. The British Starstreak MANPADS, in service for just 25 years, is still newer than any of the above.⁵⁶ By 2006,

Israel had retired its Machbet self-propelled antiaircraft gun, carrying a 20-millimeter M61 Vulcan cannon and Stinger missiles; by 2012, it phased out the last infantry-carried Stingers. The Israeli firm Rafael Advanced Defense Systems developed a new tactical SAM system, the SPYDER, and sold it to numerous countries, but Israel was not one of them. Israel's "Iron Dome" and "David Sling" missile systems both have antiaircraft capability, though they were developed primarily to counter missiles and rockets.⁵⁷ Some Western countries have continued to develop MANPADS and tactical antiaircraft systems, such as the French "Mistral" short-range air defense system, which saw its third generation entering service in 2019; the new German IRIS-T SLM medium-range SAM system; or the Polish "Piorun" MANPADS.⁵⁸ Yet, the trend is clear: while Western aerial superiority was unquestionable for a generation or two, to the degree that some countries no longer needed tactical air defense, that era, it seems, is now over.

The main use of drones in the war in Ukraine has not been to kill the enemy, but rather to help other units or equipment do the killing.⁵⁹ Drones can be used as decoys to deceive an enemy's defense systems (the Ukrainians allegedly used drones to keep the Russian cruiser *Moskva* busy while two antiship missiles made their way toward it, damaging the cruiser and sinking it), but mostly it would be done in the "traditional" way, by collecting intelligence or serving as the "eyes" of antitank weapon teams or artillery observers.⁶⁰ The abundance of cheap drones with quality optics means that intelligence collection and reconnaissance became the domain of virtually every military unit in Ukraine. An antitank team could fire a missile toward an area where an enemy was spotted by a drone, locking onto the target once the missile was close enough, without ever seeing the

target but knowing where to look. An infantry team could plan an ambush using real-time data from a drone. An artillery observatory could target an enemy without any line of sight, using simple drones to guide the artillery.⁶¹ There have even been instances of trench-clearing aided by real-time drone-based video—twenty-first-century warfare meets World War I.

The Ukrainians, it was said, perfected this method by creating an “Uber for artillery,” which enabled real-time sharing of a target’s location and instant assignment of an appropriate weapon to hit it.⁶² In that way, a drone could share the location of a Russian convoy, and several different artillery batteries (or any other firing means) would get each its own targeting data (range, direction, etc.) based on real-time locations. It would become increasingly hard for the enemy to hide, and increasingly foolish to assume that being outside of a line of sight to the enemy means relative safety. In the 1970s, General DePuy noted, “What can be seen, can be hit. What can be hit, can be killed.”⁶³ Today, one must assume that everything can be seen; therefore, everything can be hit, and everything can be killed. Behind-the-lines supply convoys are now subject to constant attack even by forces who never embraced the U.S. Army’s AirLand Battle concept of follow-on-forces attack.⁶⁴

As of this writing, the cutting edge of drone and counterdrone technology has not been seen in Ukraine: neither drone swarms nor sophisticated antir drone equipment have been deployed, though some electronic warfare equipment being used may also have antir drone use.⁶⁵ While the vast amount of antir drone weapons in existence could surely limit the employment of drones in any future conflict, there is no reason to believe that, at this moment, full effectiveness can be reached against

drones and render them useless, much in the way that traditional aircraft still have their important role despite the SAM threat.

Sometimes communications between the drone and ground control can become jammed; oftentimes, such jamming can also affect friendly forces (though autonomous loitering munitions may not be affected at all).⁶⁶ This is even more so in the case of tank-hunting and artillery-spotting teams using cheap commercial drones to enhance their performance. Therefore, at the moment, even kilometers behind the front line, one should assume that they are exposed, that the enemy knows their movements, and that the fact that they do not see any enemy around offers little protection, even if their side enjoys “classic” aerial superiority.

This trend can be reinforced by another: the advent of real-time, open-source intelligence.

Open-Source Intelligence

Open-source intelligence will play a growing tactical and strategic role in the war in Ukraine. *Operational intelligence*, defined as “up-to-date information about the enemy that has been processed and distilled by experts from the mass of raw data received,” plays an important role in any modern military doctrine, though intelligence superiority it is not equated with victory.⁶⁷ There are several common types of intelligence, such as signals intelligence (SIGINT), derived from electronic sources; imagery intelligence (IMINT), which include photographs, videos, etc.; and human intelligence (HUMINT), such as the reports of agents and spies. Intelligence can come from classified sources or be open-source intelligence (OSINT), which is

intelligence derived from public sources of all means, to include newspapers, social networks, television, radio, and more.⁶⁸

While all intelligence remains important to military operations, the war in Ukraine has shown the rising significance of open-source intelligence and commercial intelligence. Today, it is harder than ever to hide force concentrations, as virtually anyone can buy high-resolution satellite photographs. Unless they are camouflaged very well with tight discipline, to prevent vehicle concentrations or trackable movements, military headquarters and force concentrations can be exposed to anyone looking hard enough. Deception becomes harder to execute unless it is executed by significant forces. Deception using decoys is still possible, and maybe even more effective, but creating the impression of a larger force where only a small force exists is even harder in today's military climate.

Though satellite images are only small part of available open-source intelligence, mastery of the medium makes all the difference in the world. Ukraine has enjoyed a significant advantage in this area because it had better control of what was uploaded to the internet and published on social networks and had much better operational security in general.⁶⁹ Augmented "classic" intelligence, such as SIGINT, was also used extensively: the Russians suffered badly owing to poor field security and their failure to employ an effective encrypted communication network, which forced them to use unencrypted communications and civilian cell phones that ran on Ukrainian networks, exposing both their locations and plans.⁷⁰

Moreover, the proliferation of cell phones in virtually any country in the world today means that soldiers and civilian alike are unwittingly sending to their location to anyone who may be interested. Many pictures

and videos contain global positioning system (GPS) data that offers a precise grid location; but even if one removes all file data, the picture or video would almost inevitably contain location clues. These clues could then be decrypted not only by enemy intelligence experts but also by an army of enthusiasts that is larger than any intelligence service could hope to recruit. In one early case in Ukraine, a Ukrainian man posted a video on TikTok that showed the movement of Ukrainian military equipment outside the Retroville shopping mall in Kyiv. Other videos surfaced too, as well as a photograph showing military trucks hiding under the building. The Russians, combining that information with drone-based surveillance, destroyed the mall.⁷¹

In another case, a television report on the repair of captured Russian equipment was filmed inside a building hosting a Ukrainian workshop at a Kyiv tank factory. The shape of the windows and a few other minor details were enough for members of a pro-Russian Telegram group to pinpoint the exact location of the building and post the details online. A few days later, the Russians struck the building with a PGM, destroying the workshop and killing several workers. And in one final case, a Russian television crew filmed a 2S4 Tyulpan self-propelled heavy mortar system firing on Ukrainian positions. Within 24 hours it was destroyed by Ukrainian forces, who then thanked “Russian propagandists” for the “tip” on the location of the mortar.⁷²

Being able to use open-source intelligence and the private initiative of professionals and enthusiasts who do not belong to any military force and sometimes are not related at all to either side of the conflict can be a great asset to those who know how to pull data from social media platforms and

other open sources, filter it, and use it for military purposes. On the other hand, any photograph, video, or other medium from the front lines—or even behind the lines—should be considered an intelligence report that can be used by the enemy.

Artillery

Artillery remains ever-important in the character of modern war. As the war in Ukraine has progressed, the volume and effect of artillery has increased, and Ukrainians have noted that artillery is responsible for most Russian casualties. As the Russians reorganized to some degree, evacuating the Kyiv area after their very failed attempt at regime change and *blitzkrieg*, their emphasis on artillery also increased.⁷³ Massive artillery barrages and scenes of fields with hundreds of craters are becoming more and more common. Though the Russians did not always use artillery effectively, fire support—either from relatively close range with the TOS-1 or TOS-1A thermobaric multiple-launch rocket system or from longer range with traditional artillery—now supports Russian advances *en masse*, in what seems to be a back-to-the-basics approach following their failures of the war's opening months.⁷⁴

Russian forces, like their Soviet predecessors, are extremely artillery-heavy compared to Western militaries. They also have a tendency toward using standard artillery instead of PGMs, the rational being that saturating an area with artillery is more effective to suppress enemy infantry, as it will cover the whole area when one does not know exactly where the enemy is. It is also much cheaper than killing infantry with PGMs.⁷⁵ In Ukraine, more than a month of fighting had passed before any sort of artillery usage

according to Russian doctrine was observed, and the Russians' failure to do so is probably one of the reasons for the heavy casualties of their forces. Through the summer of 2022, however, Russian heavy artillery barrages, according to their "classic" style, proved relatively effective in causing significant casualties, enabling some slow Russian advances, and slowing down Ukrainian attacks.⁷⁶

On the Ukrainian side, observers have seen an extensive use of drones to help the targeting process and achieve an impressively accuracy of non-line-of-site targets.⁷⁷ Many Russian tanks and vehicles have suffered direct or very close hits by extremely accurate artillery shelling, more so than is usually achievable without PGMs. While Russian doctrine assigns a drone to each forward observation team, the Russians did not always follow their own rules.

When on the defensive, artillery's main job is killing the enemy; when on the attack, its main job is to protect the advancing force.⁷⁸ A remarkable case of Ukrainian use of defensive artillery and a failure of Russian offensive artillery can be seen in the failed Russian bridgehead near Bilohorivka in early May 2022, where several dozen armored personnel carriers, tanks, and other vehicles were destroyed. While information on the battle is still incomplete, it seems that the Russians did employ some artillery to provide smoke cover and protect against short-range antitank teams (most of the area is wooded, with sight too limited for the employment of long-range antitank guided missiles) but failed to engage Ukrainian artillery. The Ukrainians, with the aid of drones and/or artillery observation teams, and perhaps with advanced ranging of possible crossing points, struck a Russian pontoon bridge after a full battalion tactical group had crossed and

proceeded to destroy it completely.⁷⁹ A video of Ukrainian fighters walking among the destroyed and abandoned vehicles shows that the Russians may have made camp near the crossing point, rather than spreading out, and it is possible that they abandoned their vehicles once attacked, as there were very few hints of Russian casualties. Many signs of air-burst munitions were present but hardly any sign of hollow-charge antitank guided missile hits, and some of the abandoned armored personnel carriers were open with personal equipment all around them.⁸⁰

Whereas the crossing in Bilohorivka was an exceptional case, the use of artillery in Ukraine is showing, again, that it remains the king of battlefield; mass fires are not completely replaceable by precision fires. The very successful use of guided artillery and rockets such as the M142 HIMARS (high-mobility artillery rocket system) by Ukraine is not example to the contrary. The HIMARS, expensive and precise, needs accurate intelligence to hit its targets, and has therefore been much more useful against structures such as the Antonivskyi Bridge in Kherson, Russian ammunition depots all around the front and beyond, and even high-value targets such as Russian headquarters—or, in one case, an administration building in Kherson that was hit to kill a group of pro-Russian officials meeting there, an operation showing very good tactical intelligence, probably by a behind-the-lines team.⁸¹ In that case, the participants were saved as an unexpected electrical problem in the meeting hall forced them to move the meeting a short time before the attack. But the limited number of PGMs in either side's inventory, the cost of such weapons, the need for real-time precision intelligence, and the inability of these weapons to cover large areas mean that they can be impractical in a direct fire support role, and virtually no nation can afford to

fire a guided rocket against every single piece of enemy equipment or group of enemy personnel, not to mention conducting a sustained artillery barrage. This remains true even if, as some have predicted, information dominance could make it possible to all but lift the fog of war and know precisely what is going on and where.⁸² At the present moment, this does not seem to be the case, neither in Ukraine nor elsewhere.⁸³ Therefore, in the foreseeable future, both guided and nonguided artillery will continue to have an important role to play.

Logistics

Like artillery, combat logistics continues to play an important role in the character of war. The Russian failures of the opening months of war in Ukraine were not only due to fierce Ukrainian defense and poor planning and execution but also due to failed logistics. Poor maintenance meant that even the most modern equipment in the Russian Army was prone to breakdowns, and the choices that the Russian Army made—some reasonable, some not so—meant that it did not fare well logistically in prolonged fighting. Russian logistics doctrine in Ukraine emphasized rail transport and lacked truck-based transports and other, more flexible logistical means.⁸⁴ The Russians sacrificed long-term sustainment to enable rapid mobility, mostly leaving damaged equipment in the field so that it could later be towed to a repair depot.⁸⁵ While there are merits in some of these choices, they meant that when Russia's attempt at lightning-fast regime change in Kyiv failed, the Russians forces on the ground were particularly ill-supported. An Israeli Army study that analyzed the wounds of dead Russian soldiers in the first month of the war concluded that many

soldiers died of wounds that could have been treated had the Russian deployed their medical units instead of keeping them far back behind the front lines.⁸⁶ Later in the war, two of the most important effects of the Ukrainian HIMARS was to force the Russians to move their ammunition depots farther to the rear, thereby reducing the available firepower of Russian artillery near the front lines and making logistical support more difficult, and targeting key targets such as bridges to disrupt Russian supply efforts.

Even had the Russians done everything correctly, supporting a fast-moving war is a daunting task—even more so if, as said earlier, supply convoys and rear-area depots no longer enjoy the protection of rear areas and, with the help of OSINT and drones, become prime targets for an enemy that understands that after a few days of fighting, any attack without proper logistical support will stall or simply die down. Protection and maintenance of logistical support remains a decisive factor. Military operations in Ukraine will continue to be decided by logistical factors as well as by tactical successes—and the havoc that the Ukrainians have wrecked on Russian logistics thus far should serve as a stern warning to any battlefield commander.

Conclusion

The many problems of the Russian Army in Ukraine—including logistics, training, morale, corruption, and more—show that numbers alone do not tell the whole picture. If, as the old saying goes, God favors the big battalions, those battalions still have to know what they are doing.⁸⁷ The same Soviet- and Russian-made equipment has brought about vastly

different results when the operators were Russian and when they were Ukrainian, suggesting that many of Russia's problems have more to do with the character of the Russian Army than with the quality of its equipment.

Nevertheless, it would be wrong to dismiss the lessons of the current war in Ukraine as being a unique case of Russian ineptitude. Though the Russian Army was ill-prepared at the onset, it learned and has become at least slightly better. Yet, the Ukrainians, with (now) larger, better trained, and better commanded forces, were able time and again to exploit Russian weaknesses. A stronger army than that of Ukraine would probably have fared even better in a similar scenario. But the challenges would remain basically the same, even if the exact character of war would be different. Any army not prepared to face the challenges that the Russian Army has faced in Ukraine would probably suffer a similar fate. More than a century ago, European observers described the lethal character of the Russo-Japanese War of 1904–5, which included the devastating effect of automatic weapons and the character of trench warfare. Most European militaries ignored these lessons and believed that they were irrelevant to the European theater.⁸⁸ Less than a decade later, they were proven very wrong.

Conversely, it would similarly be a mistake to assume that the war in Ukraine has changed everything; as long as maneuver is needed to achieve military and political goals, maneuver warfare will continue to exist in one form or another.⁸⁹ Much of the heralded change in the nature or character of war is hardly a change at all; for example, the “new kind” of war that the Ukrainians were waging in Kherson in September 2022—that is, forcing the Russians to hold a (hopefully) untenable position and then using massive firepower to inflict losses on their forces—is essentially a modern take on

1916-era tactics of attrition warfare, though executed with more modern means.⁹⁰

There will be, however, important changes seen in the way armies fight, or the way they are supposed to fight. The tank will not be retired soon, but it will have to act as part of a combined-arms team, supported by drones and massive smokescreens, active defense systems, and tactical air defense and antiddrone systems. As logistics and headquarters will be prime targets, soldiers must learn to include low-flying drones and UAVs in their plans and assume that the enemy has them as well. A reinvestment in tactical air defense is needed. Such defense will likely include everything from “smart” jamming systems that can enable friendly forces to employ UAV while denying the enemy the ability to do so; to missile defense; and, in the future, perhaps to laser-based defense. As everything can be seen and therefore everything can be killed, finding means to prevent this killing, especially when on the offense, is most important. Tactics will join with technology to make new threats manageable, as old threats were—but, like old threats, definitely not ignorable.

So, in the end, General DePuy’s “big three” lessons learned appear to remain relevant for today’s wars. In addition to these, another big three are important to any future force that will fight a large-scale war:

1. Look up.
2. Take care of logistics.
3. Bring lots of artillery to the fight.

¹ Rupert Smith, *The Utility of Force: The Art of War in the Modern World* (New York: Knopf, 2007), 3.

² Smith, *The Utility of Force*, 4.

³ See, for example, Martin van Creveld, *The Transformation of War* (New York: Free Press, 1991).

⁴ See William S. Lind et al., "The Changing Face of War: Into the Fourth Generation," *Marine Corps Gazette* 73, no. 10 (October 1989): 22–26.

⁵ Quoted in John P. Rose, *The Evolution of U.S. Army Nuclear Doctrine, 1945–1980* (Boulder, CO: Westview Press, 1980; New York: Routledge, 2019), 116–17, <https://doi.org/10.4324/9780429310713>.

⁶ See, for example, Fred Kaplan, "No, You're Not Imagining It: Russia's Army Is Inept," *Slate*, 28 February 2022; and Stefan Hedlund, "The Collapse of the Russian Military Machine," *GIS Reports*, 2 May 2022.

⁷ See, for example, Stephen Witt, "The Turkish Drone that Changed the Nature of Warfare," *New Yorker*, 16 May 2022; Vivek Wadhwa and Alex Salkever, "How Elon Musk's Starlink Got Battle-Tested in Ukraine," *Foreign Policy*, 4 May 2022; and Brad Howard, "How This U.S.-Made, \$176,000 Anti-Tank Weapon Could Change the War in Ukraine," *CNBC*, 29 April 2022.

⁸ See, for example, "Why Russian Tanks Are Exploding in Ukraine," *Wall Street Journal*, 6 July 2022.

⁹ See, for example, Ed Cumming, "Is This the End of the Tank?," *Telegraph*, 14 March 2022; Lewis Page, "Why the Invasion of Ukraine Spells the End of Modern Tank Warfare," *Telegraph*, 29 May 2022; Harsha Kakar, "Ukraine War: Is It the End of the Road for Tanks in Modern Warfare?," *First Post*, 21 September 2022; and Federico Borsari, "The Tank's Death Has Been Exaggerated," Center for European Political Analysis, 24 June 2022.

¹⁰ Eugenia C. Kiesling, "Resting Uncomfortably on Its Laurels: The Army of Interwar France," in *The Challenge of Change: Military Institutions and New Realities, 1918–1941*, eds. Harold R. Winton and David R. Mets (Lincoln: University of Nebraska, 2000), 18.

¹¹ Narcisse Alfred Gabriel Louis Chauvineau, *Une Invasion Est-Elle Encore Possible?* [Is an Invasion Still Possible?] (Paris: Berger-Levrault, 1939), 93–96. The answer to the rhetorical question of the book's title was "yes."

¹² Ezer Weizman, *Yours Are the Skies, Yours Is the Earth* (Tel-Aviv, Israel: Maariv, 1975), 329.

¹³ Wartime reports are typically error-prone due to intentional exaggeration for propaganda and information warfare purposes, as well as the fact that if an enemy tank was hit by two different tank crews or hit, abandoned, and then hit again, it would likely be reported as two separate hits. For example, during World War II, after the great aerial battle over Dieppe, France, in August 1942, the Allies estimated that they had shot down between 150 and 200 German planes. Later, using their best intelligence estimates, they revised that number to 96 planes shot down, 39 probably destroyed, and 135 damaged. In reality, the German *Luftwaffe* lost 48 planes, with an additional 24 damaged. See Trafford Leigh-Mallory, "Air Operations at Dieppe: An After-Action Report," *Canadian Military History* 12, no. 4 (Autumn 2003): 55–70; and Norman Franks, *The Greatest Air Battle: Dieppe, 19th August 1942* (London: Grub Street Publishing, 1992). In a more recent case, during the Kosovo War of 1998–99, the North Atlantic Treaty Organization (NATO) initially claimed that it destroyed 110 Serbian tanks, 210 armored personnel carriers, and 449 artillery pieces. Later, that number was revised to 93 tanks and 153 armored personnel carriers destroyed, but other estimates place the number at half of that or even lower. See Timothy L. Thomas, "Kosovo and the Current Myth of Information Superiority," *Parameters* 30, no. 1 (Spring 2000): 13–29, <https://doi.org/10.55540/0031-1723.1967>.

¹⁴ See "Attack on Europe: Documenting Russian Equipment Losses during the 2022 Russian Invasion of Ukraine," *Oryx*, 24 February 2022; "Defending Ukraine: Listing Russian Military Equipment Destroyed by Bayraktar TB2s," *Oryx*, 27 February 2022; and "List of Aircraft

Losses during the 2022 Russian Invasion of Ukraine,” Oryx, 20 March 2022. As these tallies are updated daily, by the time this article is published the total numbers will likely be slightly different.

¹⁵ Ellen Mitchell, “Pentagon Says Russia Racks up Personnel, Weapons Losses,” *Hill*, 26 May 2022.

¹⁶ “Attack on Europe.”

¹⁷ Most battles of the Yom Kippur War took place on two fronts, with the active fighting area being a few hundred square miles altogether.

¹⁸ These numbers are based on Israel Defense Forces declassified data. See Elhanan Oren, *The History of the Yom Kippur War* (Tel Aviv, Israel: Ministry of Defense, 2003), 537–38; and Hertz Shafir, *The Yom Kippur War: A Different View* (Ben Shemen, Israel: Maarachot, 2020), 468. The data is reliable since Israeli teams actually counted the wrecks (physically or through aerial photographs) after the war; a damaged tank that was not removed a month from the beginning of the war was in all likelihood beyond repair.

¹⁹ See “Baath Ground Forces Equipment,” GlobalSecurity, accessed 31 May 2022.

²⁰ Trevor N. Dupoy, *Attrition: Forecasting Battle Casualties and Equipment Losses in Modern War* (Fairfax, VA: Hero Books, 1990), 102–3.

²¹ In October 2022, the Ukrainian news channel Volia made an independent count and reached the conclusion that the total number of Russian soldiers killed, missing, and captured since the beginning of the war was between 60,580 and 66,487. The Ukrainian total killed, missing, and captured was between 35,366 and 37,966. See “The Butcher’s List: Russian and Ukrainian Combat Losses, 19 September–9 October,” Volia, accessed 27 October 2022.

²² While earlier reports seemed to indicate a higher lethality to the AT-3 Sagger missile, postwar Israeli analysis found that the number of Israel tanks destroyed by Sagger missiles or even by rocket-propelled grenades was less than estimated. The exact number is still classified. Moreover, Egyptian antitank operators paid a terrible price for their successes.

²³ “300 Shots Fired, 280 Russian Tanks Gone: U.S. Missiles in Ukrainian Hands,” NDTV, 4 March 2022.

²⁴ Jack Watling and Nick Reynolds, *Operation Z: The Death Throes of an Imperial Delusion* (London: Royal United Services Institute for Defence and Security Studies, 2022), 3–4.

²⁵ One may suspect that the sorry state of the German *Bundeswehr* (armed forces) is the reason that the promised tanks have not yet arrived in Ukraine. If the *Bundeswehr*’s present-day situation is similar to that in 2018, when one armored brigade had 9 operational tanks out of the 44 it was supposed to have and 3 infantry fighting vehicles out of 14, then supplying Ukraine with tanks would mean that Germany would be left with next to nothing with which it could protect itself. See Ben Knight, “German Military Short on Equipment,” Deutsche Welle, 16 February 2018.

²⁶ See, for example, “Epic Footage from the Offensive of the Ukrainian Armed Forces in the Kherson Direction,” *Telegram*, 8 September 2022.

²⁷ See, for example, DefenseWebTV, “Discover First Close Combat Tank in Ukraine between Russian T-80BV and Ukrainian T-64BV Tanks,” YouTube video, 1 October 2022; *The Sun*, “Ukrainian Tank Single Handedly Destroys Massive Russian Convoy East of Kyiv,” YouTube video, 6 April 2022; and *The Sun*, “Ukrainian Troops Blow up and Destroy Russian Z Tank,” YouTube video, 14 March 2022. It is worth noting that the titles of these videos are slightly misleading.

²⁸ See David Eshel, "Hezbollah Anti-Air Tactics and Weapons," *Defense Update*, 14 June 2007; and Yagil Henkin, "From the End of the 1990s to the Second Lebanon War (2006)," in *The Development of Combined Arms Warfare in the IDF: Past, Present and Future*, ed. Meir Finkel (Ben Shemen, Israel: Modan/Maarachot, 2022), 242–60.

²⁹ The 1926 U.S. Army Training Regulation 440-15, *Fundamental Principles for the Employment of the Air Service*, declared that the main roles of air forces are "primarily to secure the control of the air, and, secondarily, to disrupt and delay enemy communications and ground establishments." Quoted in Maj Wade S. Karren, USAF, "Lightning Strikes and Thunder Claps: The Strategic Bomber and Air Superiority," *Air and Space Power Journal* 26, no. 6 (November–December 2012): 137.

³⁰ *Countering Air and Missile Threats*, Joint Publication 3-01 (Washington, DC: Joint Chiefs of Staff, 2017), I-4.

³¹ The Russian Air Force and naval aviation forces are, of course, much larger than the Ukrainian Air Force; however, it is not clear how many Russian planes were committed to the war in Ukraine from at least 1,391 combat-capable aircraft Russia had as of 2021. See Henry Boyd, "Russia," in *The Military Balance, 2022*, ed. James Hackett (London: International Institute for Strategic Studies, 2022), 199–201. Before the war, the typical number of Russian combat aircraft positioned within range of Ukraine was about 300, but Russia has since moved some aviation regiments closer to the front.

³² "List of Aircraft Losses during the 2022 Russian Invasion of Ukraine."

³³ Mark Couch and Dennis Lindell, "Study on Rotorcraft Safety and Survivability" (unpublished report, Defense Technical Information Center, Fort Belvoir, VA, 2010), 3–4.

³⁴ "The Six Day War" [Hebrew], Israeli Air Force, accessed 27 October 2022.

³⁵ "Attack on Europe." Russian ZU-23 towed anti-aircraft guns are not included in this count because, although they are technically anti-aircraft weapons, their lack of any sophisticated targeting system means that they are virtually useless against modern aircraft, though they can hit slow-flying helicopters and drones. Three of the self-propelled guns lost (one destroyed, two captured) were BTR-ZD "Skrezhet" armored personnel carriers, which are basically ZU-23 guns mounted on airborne BMD-2 infantry fighting vehicles, and which are probably more effective in land warfare than in anti-aircraft roles.

³⁶ By the beginning of May 2022, it was said that Russia had used 2,125 precision-guided munitions (PGMs) of all kinds in Ukraine. See John Ismay, "Russian Guided Weapons Miss the Mark, U.S. Defense Officials Say," *New York Times*, 9 May 2022. This number seems large until one remembers that during the U.S.-led invasion of Iraq in 2003, Coalition forces used 14,910 PGMs. See Jim Wilson, "Smart Weapons under Fire," *Popular Mechanics* 180 (July 2003): 43. To put it another way, the number of PGMs that the United States expected to have missed their targets in Iraq during one month of war (2,982) was about 40 percent more than the total number of PGMs dropped by Russia on Ukraine during two months of war. Moreover, the rate of PGMs used by the Russians dropped after the second week of war, hinting that their stock is limited, as it is clear that they did not run out of targets. See "In Ukraine, AGM-88 HARM Missiles Were Adapted for the Su-27 Fighter," Armed Forces of Ukraine, 9 September 2022.

³⁷ By late April 2022, due to foreign aid in spare parts, Ukraine had managed to bring 20 aircraft back into operational condition. See Oren Liebermann, "Ukraine's Air Force Has Added about 20 More Operational Aircraft after Influx of Spare Parts, Senior U.S. Defense Official Says," CNN, 20 April 2022.

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- ³⁸ Speed News TV, "Ukraine Strikes Back: Su-27s Bomb Occupied Snake Island in Daring Raid," YouTube video, 8 May 2022.
- ³⁹ "War in Ukraine: Russia Accuses Ukraine of Attacking Oil Depot," BBC News, 1 April 2022; and Guardian News, "Video Appears to Show Helicopter Attack on Oil Depot in Russia," YouTube video, 1 April 2022.
- ⁴⁰ Emmanuel Grynszpan, "Russia's Air Force Makes the Difference in Donbas Breakthrough," *Le Monde*, 30 May 2022.
- ⁴¹ See, for example, Maya Carlin, "Video Shows Ukrainian Su-27 Flanker 'Dogfighting' a Russian Fighter Jet," *1945*, 23 August 2022. There have been other reports of dogfights and a few other videos, but not all of them could be verified. Both Russia and Ukraine have claimed to have shot down the other side's planes in aerial battles.
- ⁴² See, for example, Justin Bronk, "Is the Russian Air Force Actually Incapable of Complex Air Operations?," *RUSI Defence Systems*, 4 March 2022; Phillips Payson O'Brien and Edward Stringer, "The Overlooked Reason Russia's Invasion Is Floundering," *Atlantic*, 9 May 2022; and Michael Kofman et al., *Russian Military Strategy: Core Tenets and Operational Concepts* (Arlington, VA: Center for Naval Analyses, 2021), 21–25.
- ⁴³ Yaroslav Trofimov and Dion Nissenbaum, "Russia's Use of Iranian Kamikaze Drones Creates New Dangers for Ukrainian Troops," *Wall Street Journal*, 17 September 2022.
- ⁴⁴ Stephen Witt, "The Turkish Drone that Changed the Nature of Warfare," *New Yorker*, 16 May 2022.
- ⁴⁵ "Defending Ukraine."
- ⁴⁶ "IntelBrief: Turkey Treads Carefully in Ukraine Crisis," Soufan Center, 8 March 2022.
- ⁴⁷ Maksim Panasovskiy, "China's \$9,500 Mugin-5 Pro Drone May Have Been Used to Attack an Oil Refinery in Russia," *Gagadget*, 23 June 2022.
- ⁴⁸ Trofimov and Nissenbaum, "Russia's Use of Iranian Kamikaze Drones Creates New Dangers for Ukrainian Troops."
- ⁴⁹ "List of Aircraft Losses during the 2022 Russian Invasion of Ukraine"; and Brendan Cole, "Russia's Drone Crisis as Ukrainian Forces Shoot Down UAVs," *Newsweek*, 6 September 2022.
- ⁵⁰ Jon Gambrell, "In First, Ukraine Apparently Brings Down Iranian Drone Used by Russia," *Times of Israel*, 13 September 2022.
- ⁵¹ Dan Sabbagh, "War-Enabling, Not War-Winning: How Are Drones Affecting the Ukraine War?," *Guardian*, 15 May 2022.
- ⁵² "Transcript: Senior Defense Official Holds a Background Briefing," U.S. Department of Defense, 11 March 2022; and Abraham Mahshie, "Russian Sorties Rise, British Defense Minister to Meet Austin as Ukraine Aid Money Runs Low," *Air and Space Forces Magazine*, 10 May 2022.
- ⁵³ Richard Saunders and Mark Souva, "Air Superiority and Battlefield Victory," *Research and Politics* 7, no. 4 (October 2020), <https://doi.org/10.1177/2053168020972816>.
- ⁵⁴ Robert F. Dorr, "DIVAD Wasn't a 'Cure All,' after All," *Defense Media Network*, 23 October 2012; and Terry Gander, *The Bofors Gun* (Barnsley, UK: Pen and Sword Books, 2015), 241–44.
- ⁵⁵ Ethan Sterenfeld, "Raytheon CEO: Stinger Production Surge Not Coming This Year," *Inside Defense*, 26 April 2022.
- ⁵⁶ "Gepard, Cheetah, PRTL," Weapon Systems, accessed 24 October 2022; and "Starstreak Anti-Aircraft Guided Missile System," *Army Technology*, 29 October 2015.

⁵⁷ "Israeli Spyder Used to Shoot Down Pakistani Drone in Gujarat," *Business Standard*, 26 February 2019; and Yaakov Lappin, "Czech MoD Selects Rafael's SPYDER Air Defence System," *Janes*, 29 September 2020.

⁵⁸ "Mistral MANPADS," MBDA Missile System, accessed 24 October 2022; "Air Defence Systems IRIS-T SLM/SLS," Diehl Defense, accessed 24 October 2022; and Jaroslaw Adamowski, "Estonia Joins Poland in Buying Piorun Anti-Aircraft Missiles," *Defense News*, 8 September 2022.

⁵⁹ It may well be the case that a military force that is using new technology to enhance the capabilities of its "older" units and equipment has an edge over a military force that relies on the new technology alone to win a war.

⁶⁰ David Hambling, "Ukraine's Bayraktar Drone Helped Sink Russian Flagship Moskva," *Forbes*, 14 April 2022.

⁶¹ Elias Yousif, "Drone Warfare in Ukraine: Understanding the Landscape," Stimson Center, 30 June 2022. Many videos posted on Telegram and WhatsApp channels show the different uses of drones in the war.

⁶² Charlie Parker, "Uber-Style Technology Helped Ukraine to Destroy Russian Battalion," *Times*, 14 May 2022.

⁶³ *Range and Lethality of U.S. and Soviet Anti-Armor Weapons*, TRADOC Bulletin no. 1 (Fort Eustis, VA: U.S. Army Training and Doctrine Command, 1975), 2.

⁶⁴ See LtCol Michael J. Diver, AV, "NATO's Follow-On Forces Attack (FOFA) Concept: Past, Present and Future" (research paper, U.S. Army War College, Carlisle Barracks, PA, 1990).

⁶⁵ Amir Bohbot, "The Drone Squadrons of the IDF Participated in the Fighting in Gaza, and the Rules of the Game Are Expected to Change," *Walla*, 5 June 2021.

⁶⁶ One example of this is the Israeli IAI Harop loitering munition, which was used by Azerbaijan to destroy Armenian air defense systems during the 2020 Nagorno-Karabakh war and during border clashes in September 2022. See Yaniv Kobowitz, "'Suicide' UAV Made by Israeli Attacks on Anti-Aircraft Battery on Armenian Soil," *Haaretz*, 15 March 2021; and Shay Levi, "An Israeli Drone Destroys a Russian-Made Anti-Aircraft Battery," *Mako News*, 15 September 2022.

⁶⁷ Michael I. Handel, ed., *Intelligence and Military Operations* (London: Routledge, 1990), 1, 6–8, 66–69.

⁶⁸ See "Intelligence Studies: Types of Intelligence Collection," U.S. Naval War College, accessed 24 October 2022. According to this document, *measurement and signatures intelligence* (MASINT) "is a relatively little-known collection discipline that concerns weapons capabilities and industrial activities. MASINT includes the advanced processing and use of data gathered from overhead and airborne IMINT [imagery intelligence] and SIGINT [signals intelligence] collection systems." Other definitions include *geospatial intelligence*. See Mark M. Lowenthal and Robert M. Clark, eds., *The Five Disciplines of Intelligence Collection* (Thousand Oaks, CA: CQ Press, an imprint of Sage Publications, 2016).

⁶⁹ Brendan Gilbert, "Beyond Twitter: The Real Lessons from the Battle of Kyiv for the Australian Army," *Cove*, 26 May 2022.

⁷⁰ Sebastian Moss, "Ukraine: Russian Military's Own Encrypted Phones Impacted after Destroying 3G/4G Towers, Allowing Comms to Be Intercepted," *Data Center Dynamics*, 8 March 2022; Stephen Bryen, "The Fatal Failure of Russia's ERA Cryptophone System," *Asia Times*, 26 May 2022; and Jeff Schogol, "Russian Troops Are Proving that Cell Phones in War Zones Are a Very Bad Idea," *Task and Purpose*, 13 May 2022.

⁷¹ Sophia Ankel, "TikToker Arrested after Posting Clip of Ukrainian Military Vehicles Parked Near a Mall that Russia Later Blew Up," *Business Insider*, 22 March 2022.

⁷² Sebastien Roblin, "Russian TV Shows off Rare 2S4 Mega Mortar—then Ukraine Blows It Up," *Forbes*, 22 May 2022.

⁷³ Lucian Staiano-Daniels, "Why Russia Keeps Turning to Mass Firepower," *Foreign Policy*, 19 June 2022.

⁷⁴ See, for example, "War from Above: Aerial Images from Russia's Invasion of Ukraine," Reuters, 17 June 2022.

⁷⁵ Lester W. Grau and Charles K. Bartles, *The Russian Way of War: Force Structure, Tactics, and Modernization of the Russian Ground Forces* (Fort Leavenworth, KS: Foreign Military Studies Office, 2016), 241–50; Scott Boston and Dara Massicot, *The Russian Way of Warfare: A Primer* (Santa Monica, CA: Rand, 2016), 10–12, <https://doi.org/10.7249/PE231>; and "Long Live the King (of Battle): The Return to Centrality of Artillery in Warfare and Its Consequences on the Military Balance in Europe," Finabel: European Army Interoperability Centre, 29 October 2019.

⁷⁶ See, for example, Mac William Bishop, " 'They're Wiping Us from Earth': Evading Russian Artillery with a Ukrainian Military Unit," *Rolling Stone*, 12 June 2022; Siobhán O'Grady, Liz Slym and Ievgeniia Sivorka, "Ukraine Is Running out of Ammunition as Prospects Dim on the Battlefield," *Washington Post*, 10 June 2022; Thomas Gibbons-Neff, "Russia Advances behind Brutal Barrage, but Will Its Strategy Keep Working?," *New York Times*, 4 July 2022; and Brian Mann, "In the 'Gray Zone' Outside Kherson, Ukraine's Soldiers Pay a Terrible Price," NPR, 6 August 2022.

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⁷⁹ See, for example, Shweta Sharma, "Russian Army 'Lose Entire Battalion' Trying to Cross Ukraine Bridge," *Independent*, 12 May 2022; Andrew E. Kramer, "A Doomed River Crossing Shows the Perils of Entrapment in the War's East," *New York Times*, 25 May 2022; and Robert Mendick, "A Bridge Too Far for Russian Invaders as Whole Battalion Destroyed in Failed River Crossing Mission," *Telegraph*, 12 May 2022.

⁸⁰ Ukrainian Witness, "The Tank Cemetery Is All that Remains from the Forcing of Siverskyi Dons," Youtube video, 19 May 2022.

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as Pro-Russian Officials Hit by Ukraine HIMARS, Video Shows," *Newsweek*, 16 September 2022.

⁸² See Adm Bill Owens, USN, with Ed Offley, *Lifting the Fog of War* (New York: Farrar, Straus and Giroux, 2000), 97–102, 117–49; and Yedidia Yaari and Haim Asa, *Decentralized Warfare: The War in the 21st Century* (Tel-Aviv, Israel: Yediot Aharonot, 2005).

⁸³ One case in point is the Israel Defense Forces' (IDF) Operation Breaking Dawn in August 2022. The IDF's complete superiority vis-à-vis the Palestinian Islamic Jihad (PIJ) organization in Gaza enabled it to locate and kill some senior commanders who were hiding in their apartments. The PIJ, however, which is a much weaker and backward organization than its counterpart Hamas, was able to fire no less than 1,162 rockets at Israel. See "Summary of Operation 'Breaking Dawn'," IDF Online, 31 August 2022,

⁸⁴ See, for example, Alex Vershinin, "Feeding the Bear: A Closer Look at Russian Army Logistics and the Fait Accompli," *War on the Rocks*, 23 November 2021; and Grau and Bartles, *The Russian Way of War*, 322–57.

⁸⁵ Lester W. Grau and Charles K. Bartles, "Getting to Know the Russian Battalion Tactical Group", *RUSI Defence Systems*, 14 April 2022.

⁸⁶ Incidentally, the fact that Russia did not move its medical units close enough to the border before its invasion of Ukraine led to some analysts making the entirely reasonable estimate that Russia would not invade, as it lacked the medical means to support such an operation.

⁸⁷ It is worth noting that Russian has also failed to achieve numerical superiority in Ukraine, and that Ukraine's personnel superiority has played an important role in the war. See David Gendelman, "Enough Cannon Fodder, Not Enough Cannons: Russia Struggling to Equip Its Mobilized Troops," *Insider*, 13 October 2022.

⁸⁸ Yigal Sheffi, "A Model Not to Follow: The European Armies and the Lessons of the Warm," in *The Impact of the Russo-Japanese War*, ed. Rotem Kowner (London: Routledge, 2007), 253–68.

⁸⁹ The war in Ukraine may still be decided, as many prolonged wars are, by mutual attrition more than battlefield victories. See Cathal J. Nolan, *The Allure of Battle: A History of How Wars Have Been Won and Lost* (Oxford: Oxford University Press, 2017), 571–82.

⁹⁰ Phillips Payson O'Brien, "Ukraine Is Waging a New Kind of War," *Atlantic*, 8 September 2022. For more on the Battle of Verdun, see Paul Jankowski, *Verdun: The Longest Battle of the Great War* (Oxford: Oxford University Press, 2016); and Yagil Henkin, *The End of All That: The Battles of Verdun and the Somme (1916) in Retrospect* (research paper, 2018).